

3.8 HEALTH AND SAFETY

A number of comments submitted for the scoping process for the Desert Claim project EIS addressed concerns relating to potential health and safety issues. Specific topics indicated in these comments included certain possible hazards that are uniquely associated with wind turbines, such as blade throw and ice throw; health and safety issues associated with electrical and magnetic fields; more common hazards such as fire; and the incidence and impacts of shadow flicker, another phenomenon specific to wind turbines. **Section 3.8** addresses these wide-ranging health and safety topics that have been identified as concerns for the environmental review.

3.8.1 Affected Environment

3.8.1.1 Mechanical Hazards

The existing conditions and uses in and near the proposed project area include some identifiable mechanical and electromechanical hazards. In general, these are the types of hazards associated with everyday living, working and traveling in a rural area typified by agricultural and low-density residential uses.

The Kittitas County Fire Marshall provided scoping input indicating that the project site is historically a high fire hazard area, with a high incidence of recent fires that included arson events. Agricultural machinery and vehicles operate in areas of agricultural crops, grassland and scrub brush, creating the potential for fire caused by malfunction or contact of combustibles with hot catalytic converters. The dry climate of the Kittitas Valley contributes to the potential for wildfires.

Paved and unpaved roads traverse the properties included within the project boundary. While traffic volumes are low and no unusual traffic hazards have been identified, local traffic creates the potential for impacts between vehicles, as well as vehicles impacting people and structures.

A number of high- and low-voltage overhead power lines cross the project area. These lines create the potential for electrical safety hazards in the immediate vicinity of the lines and the potential for personal injury, property damage or fire in the event of transmission line failure or tower/pole collapse.

A number of residences are located within or close to the project area. Residential occupancies are linked to hazards associated with electrical appliances, powered yard and garden tools, stored fuels, indoor and outdoor burning, and other domestic activities.

The affected environment for Alternative 1 (the Wild Horse site) with respect to mechanical and related hazards is similar to that described for the Desert Claim site. The primary differences are that the Wild Horse site currently is used almost exclusively for grazing, and does not have cultivation or rural residential uses within the site or adjacent areas, and the Wild Horse site is not served directly by public roads. Therefore, the variety and degree of hazards associated with agricultural practices, domestic activities and vehicle traffic operations is considerably less for the Wild Horse site, compared to the Desert Claim project area. The shrub-steppe rangeland that comprises the Wild Horse site is similarly subject to wildfires that can spread rapidly, although the level of human activity and associated potential for human-caused fires is considerably less. The Wild Horse site appears to receive more recreational use than the Desert Claim project area, primarily in the form of hunting for elk and mule deer, and would have a correspondingly higher incidence of hunting-related accidents.

Existing conditions in the areas that would be affected under Alternative 2 (the Springwood Ranch site near Thorp) are quite similar to those described for the Desert Claim project area. The primary differences are that the area around the Springwood Ranch site is served by a road network that includes larger highways, such as I-90, SR 10 and the Thorp Highway, that carry significantly larger volumes of traffic than the county roads near the Desert Claim site. The Springwood Ranch site also includes more cultivated land and grassland, and less shrub steppe than the Desert Claim site.

3.8.1.2 Electrical Hazards

A number of high- and low-voltage overhead power lines cross the Desert Claim project area. Multiple transmission lines operated by the Bonneville Power Administration (BPA) at voltages up to 500 kV cross the project area in a generally east-to-west direction, and there is a large BPA substation located west of Wilson Creek Road and just to the north of the northeastern corner of the project area. Two transmission lines operated by Puget Sound Energy (PSE) also cross through or near the Desert Claim project area. These lines create the potential for electrical safety hazards in the immediate vicinity of the lines and the potential for personal injury, property damage or fire in the event of transmission line failure or tower/pole collapse. Transmission lines also create electric and magnetic fields in their vicinity. Household electrical wiring and appliances represent similar hazards and also create electric fields.

Existing electric and magnetic fields within the Wild Horse site (for Alternative 1) are limited to those produced by the earth itself and the antennae and other equipment comprising the communications facility located on Cribb Peak. There are no existing electric transmission lines crossing the site, and no other constructed facilities that typically produce electric and/or magnetic fields.

The BPA Schultz-Vantage 500-kV transmission line passes in a southeast-northwest direction through the area to the west of the Wild Horse site; at its closest point, this line is approximately 2 miles from the southwest corner of the Alternative 1 site. In 2004 BPA will begin constructing the Schultz-Wautoma 500-kV line parallel to the existing 500-kV line. An existing PSE 115-kV transmission line follows a generally east-west route that passes approximately 4 miles to the south of the Wild Horse site.

Existing electrical facilities within the Springwood Ranch site (for Alternative 2) include low-voltage electrical distribution lines serving rural residences in the local area. The BPA transmission corridor with multiple lines (discussed previously) passes approximately 2 miles to the north of this site.

3.8.1.3 Shadow Flicker

The Desert Claim project would be located in a rural area consisting primarily of farming and ranching uses. Existing sources of shadows on and near the project site include houses and other structures, traffic on local roadways and occasional aircraft flying overhead. While some of these sources are moving, none of the existing sources create shadows with the strobe effects known as shadow flicker. There are 32 residences located inside or within 1,000 feet of the project area boundary, and approximately 80 are located within about 1 mile of the project area.

The Wild Horse project site is located in a rural area with a low population density. There are no existing residences within the project area. The closest residence is located approximately 2 miles from the edge of the project area. There are scattered rural residences several miles to the west of the site, generally concentrated in the vicinity of the Vantage Highway and Parke Creek Road.

The Springwood Ranch site is also in a rural area with a low population density, with an overall level of development that is generally similar to the Desert Claim project area. Potential shadow flicker receivers for this site include scattered developed sites near Taneum Creek to the south of the site; nearby residences to the east along the Thorp Highway and school and residential uses within the nearby community of Thorp; and the Sunlight Waters residential/recreational community near the northwest corner of the site. Potential receivers in Thorp and along the Thorp Highway are approximately 1.5 miles or more away from the project area. Two receptor locations near Taneum Creek are within 1,000 feet of the project boundary for Alternative 2, while several other receptors in this area are at least 2,000 feet distant. One receptor location near SR 10 and the east bank of the Yakima River is approximately 2,000 feet from the nearest turbine location, while other residences near the junction of SR 10 and the Thorp Highway are about 4,000 feet or more distant. Several residences along the eastern edge of Sunlight Waters are within approximately 500 feet of the Alternative 2 site.

3.8.2 Environmental Impacts of the Proposed Action

3.8.2.1 Mechanical Hazards

Construction and operation of a wind energy facility would create some potential for health and safety hazards common to constructing, operating and maintaining large electromechanical systems. These hazards are well documented in the literature, and systems of design and construction standards to mitigate these hazards have evolved to a large extent. The lead organization for development of international standards for wind turbine generating systems is the International Electrotechnical Commission (IEC), and the most broadly applied standard covering machinery and structures is IEC 61400-1: *Wind Turbine Generator Systems – Part 1: Safety Requirements (IEC Edition 2 1999)*. In the U.S., the American Wind Energy Association (AWEA) is the designated organization for participation on IEC committees.

Independent agencies are retained by wind turbine manufacturers to certify that the design and construction of a given turbine/tower assembly conform to accepted standards in terms of design load assumptions, construction materials and methods, control systems and safety measures. This is a generalized type of certification provided at manufacturers' expense. Once a specific system make and model are selected, the user then customarily funds a second independent certification attesting to the applicability of the system design and construction to the site-specific conditions.

The applicant has identified the turbine/tower system to be used in the proposed action as the General Electric Wind Energy (GEWE) 1.5sl, with a nameplate capacity of 1.5 MW. The selected unit has a tower hub height of 65 meters (212 feet) and a 77-meter rotor diameter. These dimensions are well within the 80-meter hub height and 80-meter rotor diameter analyzed as the maximum turbine envelope in the Draft EIS.

The following discussion refers to systems and nomenclature described in the technical descriptions and specifications for the GEWE 1.5s/1.5sl wind turbine generators, modified as appropriate for consistency with the project's maximum turbine envelope and the applicant's identification of the specific turbine model. Other makes of wind turbines have similar systems and functionality. The discussion addresses the impact of credible failures and mishaps due to the presence of the proposed wind generating facility.

Failure of Machinery and/or Structures

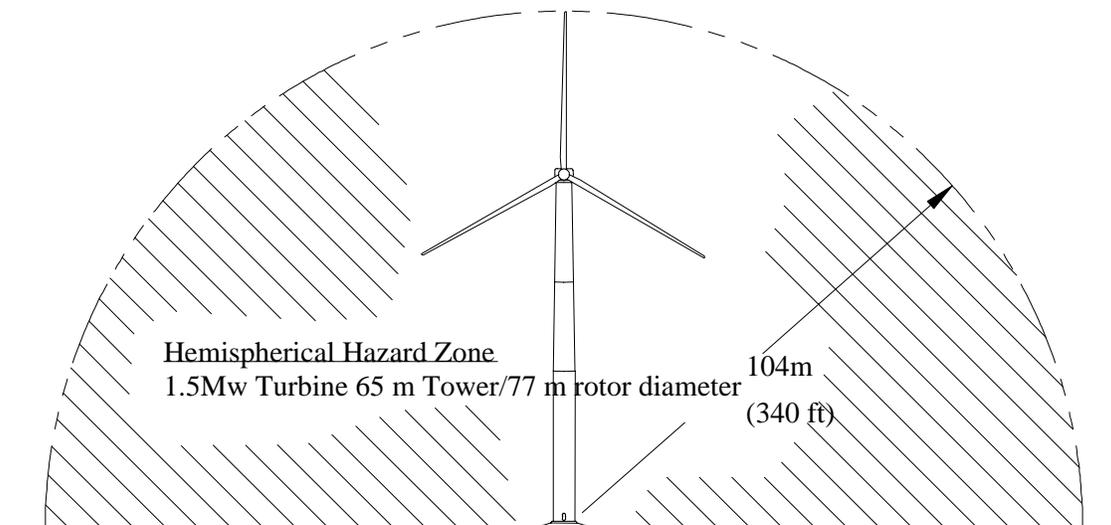
Determination of the area potentially affected by a failure of wind turbine machinery or structures is dependent upon the specific type of failure that might occur. The types of mechanical failures identified through scoping include tower collapse and blade throw.

Tower Collapse

Collapse of a turbine tower that has been constructed in accordance with international standards and local building codes is an extremely remote possibility. EFSEC (2003a) documents a personal communication with an insurance industry executive (whose company insures over 12,000 wind turbines worldwide) indicating that he was not aware of any case of a tubular wind tower collapsing. EFSEC (2004) subsequently documented testimony from a wind turbine manufacturing company executive concerning a tower collapse in France (due to an overspeed condition) and another in Germany (resulting from a weak weld in the tower flange). A wind-energy related website posts an article describing a malfunction of a wind turbine at Havoygavlen, Norway that resulted in the nacelle and rotor assembly being severed from the tower (Ventus Vigor 2003). Other websites display photos of the collapsed turbine in the German case referenced above.

In the unlikely event of a tower collapse, persons, animals and facilities within the affected environment could be at risk of being struck by the tower, the nacelle or the turbine rotor blades. Each of these items weighs many tons, so it is reasonable to expect that being struck would result in damage, injury or death. A tower collapse onto live electrical circuitry could conceivably start a fire.

Failure of a tower at its base, or of its anchorage to the foundation, would create a hemispherical hazard zone with a radius approximately equal to the tower height (to the rotor hub) plus one half of the rotor diameter (**Figure 3.8-1**). Persons, animals and facilities within this radius would be at risk of being struck by the tower, generator assembly or rotor blades. For the maximum turbine envelope, the maximum radius of the hazard zone under this scenario would be 120 meters (393 feet); this relates to a circular area at ground level of 11.2 acres per tower. For the selected GE 1.5sl, the hazard zone radius would be 103.5 meters (340 feet) and the circular area at ground level would be 8.3 acres per tower. Alternatively, a tubular steel tower could buckle at some point along its length. This failure mode would result in a smaller hazard zone due to the reduced radius.



**Figure 3.8-1
Tower Collapse Hazard Zone**

Blade Throw

Scoping comments indicated concerns over the possibility that rotor blades or blade fragments might be thrown from operating wind turbines. Persons, animals and facilities within the blade throw hazard zone could be at risk of being struck by a falling blade or blade fragments. It is reasonable to expect that being struck could result in damage, injury or death. A thrown blade or blade fragment falling on live electrical circuitry could conceivably start a fire.

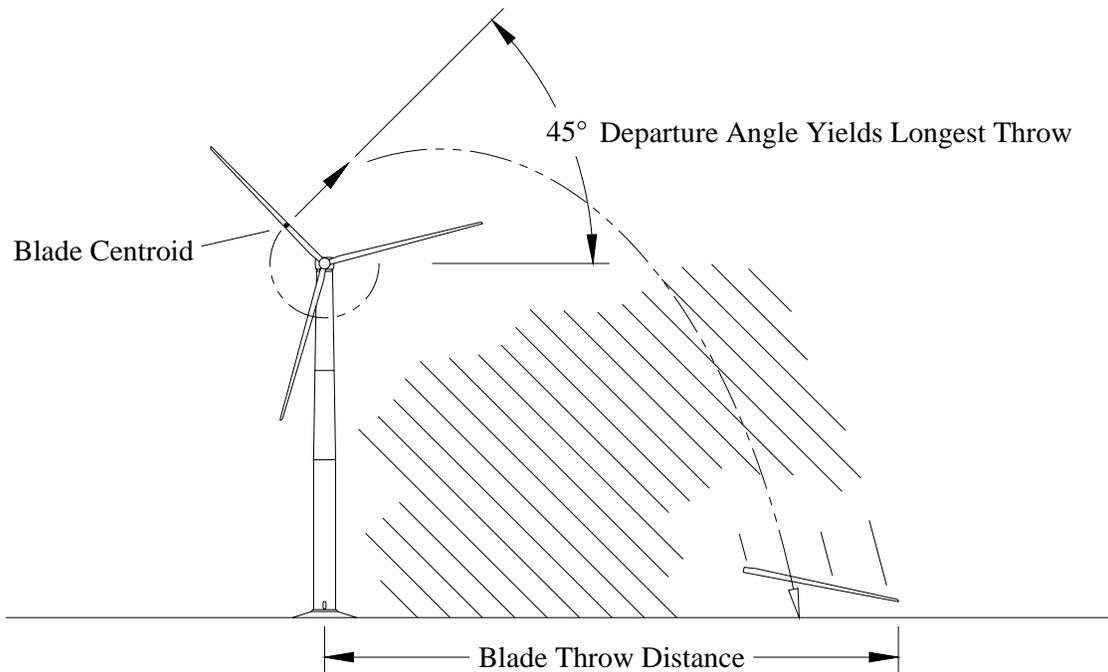
During normal operation, wind turbine rotor blades are exposed to centripetal, gravitational, and aerodynamic forces. In the course of each revolution, these forces create a cyclical combination of axial, bending and torsional stress at each part of the blade. If all or any part of a blade detaches from the rotor, its trajectory will be dependent upon the loading and stress state at the time of failure, and on the type and progression of failure before separation. An extensive literature search on this potential hazard indicated that no advanced analytical modeling has been accomplished; this is likely due to the complexity of the analysis, coupled with the extremely low incidence of blade throw reports. Only two documented incidents of blade throw were found in the research reviewed to prepare the Draft EIS (Resoft, 2003). One was directly linked to improper assembly, resulting in immediate failure upon startup, and one resulted from a blade being struck by lightning. A subsequent EIS published by EFSEC (2004) documents a case of blade throw from a wind turbine in Denmark, in which a blade was thrown 50 to 75 meters. A number of Internet websites also include the same references to reported incidents of blade throw in Wales, Spain and Germany, but the articles do not include source documentation to substantiate the reports. Acts of vandalism such as gun shots could conceivably damage rotor blades and cause a blade fragment to be thrown, although such cases have not been documented.

Nevertheless, it is useful to perform simplified evaluations of two extreme subsets of blade throw: loss of an entire blade at its attachment to the rotor, and loss of tip fragments. These simplified cases will establish worst-case sizing of the hazard zone.

The simplified worst-case loss of a whole blade would occur with the blade rotating at maximum speed, when oriented at 45° from the vertical and rising. This is the classic maximum trajectory case from standard physics texts (Zemansky and Francis, 1970) and yields the results in **Table 3.8-1** as illustrated in **Figure 3.8-2**. Review of these data indicates that for the maximum turbine envelope (which is larger than the turbine selected for the project), the worst-case blade throw distance is 150 m (491 ft.) from the tower to tip of the fallen blade. For the selected turbine, the GEWE 1.5sl, the worst-case distance is 135 m (443 ft.). The simplifications employed in this calculation tend to over-estimate the distance traveled. Specifically, aerodynamic drag is completely ignored, the blade center of gravity (CG) is estimated as if the blade were of uniform thickness (in reality the blade CG is closer to the hub, so the initial kinetic energy of the blade is lower than estimated and the thrown distance will be less), and finally, it is assumed that the blade travels and lands oriented parallel to its flight path and in-plane with the plane of rotation. Downwind blade acceleration would not be significant because the tendency for the blade to feather into the wind would result in extremely low downwind force relative to the mass (several tons) of a rotor blade and the short flight time (approximately 7 seconds).

**Table 3.8-1
Blade Throw Distances**

Turbine Model	Rotor Diameter	Rotor Speed	Tower Height	Blade Throw
GEWE 1.5sl	77 m (253 ft.)	20 RPM (max.)	85 m (279 ft.)	144 m (472 ft.)
			80 m (262 Ft)	142 m (466 ft.)
			64.7 m (212 ft.)	135 m (443 ft.)
GEWE 1.5s	70.5 m (231 ft.)	22 RPM (max.)	85 m (279 ft.)	145 m (476 ft.)
			80 m (262 Ft)	142 m (466 ft.)
			64.7 m (212 ft.)	136 m (446 ft.)
Maximum Project Turbine Envelope	80 m (262 ft.)	20 rpm (assumed maximum)	80 m (262 Ft)	150 m (491 ft.) Project Maximum



**Figure 3.8-2
Blade Throw Hazard Zone**

The loss of a tip fragment could be evaluated in the same way, but tip fragments will have minimal torsion and bending stresses and be relatively small, so the effect of drag on a fragment will be comparatively large. This observation makes it reasonable to conclude that the trajectory of a blade tip fragment and the resulting hazard area will be analogous to the issue of ice throw in the following paragraph. Also note that a blade fragment cannot develop initial radial velocity (the “sling shot” effect) prior to release, so evaluation of ice throw distance can reasonably be considered more conservative.

Similar to the previous discussion of possible throws of entire turbine blades, there are selected reports in literature and popular media of instances of turbine blade fragments being thrown considerable distances. Articles on such events have not included citations for authoritative source documents substantiating the reports, however, so these incidents cannot be verified. A contact with State regulatory staff in Minnesota, which has permitted a number of wind energy facilities, indicates that there have been cases of lightning strikes causing turbine blades to delaminate, but the blades have not come apart or thrown fragments (personal communication, L. Hartman, Minnesota Environmental Quality Board, St. Paul, Minnesota, August 3, 2004). Staff with the American Wind Energy Association (which, as noted previously, is the designated American participant on International Electrotechnical Commission activities relating to developing industry standards) indicate that cases of blade or blade fragment throw are generally associated with older wind turbine technology and have been essentially unheard-of with modern utility-scale turbines for approximately the past decade (personal communications, L. Jodziewicz and T. Gray, American Wind Energy Association, Washington, D.C., August 3, 2004).

Sound engineering design and quality control in the manufacture, construction and operation of wind turbines are the most appropriate and effective means for reducing blade throw potential (Manwell et al. 2002). Blade throw has occurred when conditions cause structure design limits to be exceeded, such as with older-generation turbines using less-advanced materials and designs and much more rapid blade speeds. Modern turbine braking systems, pitch controls and other speed controls should prevent design limits from being exceeded. Permitting agencies have also applied required setbacks from residences, public roads and adjacent property lines to provide safety buffers from potential blade throw.

Ice Throw

Under certain conditions ice can form on wind turbine towers and rotor blades in a variety of ways. Many of these do not present an ice throw hazard; an example of this would be normal light frosting of a stopped blade. It has been observed that moving rotor blades are subject to heavier buildups of ice than stationary structures through the mechanism of rime icing (Morgan et al., 1998). Rime icing occurs when a sub-freezing structure is exposed to moisture-laden air with significant velocity. If the ice then becomes detached while the blades are rotating, there is the possibility of “ice throw” over a considerable distance from the turbine. Persons, animals and facilities within the ice throw hazard zone could theoretically be at risk of being struck by falling ice fragments which could result in damage, injury or death.

The study of ice throw and its related risks is one of three areas of work in a project entitled “Wind Energy in Cold Climates (WECO)” funded by the European Commission and the UK Department of Trade and Industry. As part of this work, WECO has developed analytical modeling techniques for determination of the probabilistic ice throw hazard in the vicinity of a turbine using variables for turbine and tower geometry, rotor speed, gravity, fragment dimensions and aerodynamic lift and drag. Risk is expressed in terms of the number of expected strikes per square meter per year.

Based on weather records at the Ellensburg airport, icing conditions in the vicinity of the proposed wind energy facility that may present an ice throw hazard have been estimated to occur 4 to 5 times per year (EFSEC 2003b). This is characterized as light-to-moderate frequency by WECO, and the WECO model predicts that there would be a risk of approximately .001 strikes per square meter per year at a distance of 100 m (328 ft.) from each tower of a GEWE 1.5s turbine at the proposed site. At 300 meters (984 ft.) under the same assumptions, the modeled risk goes down to approximately .000001 strikes per square meter per year. This last risk calculation means that a 1600 square foot house located 1000 ft. from a tower at this project would have a risk of less than 3 in 1,000 of being struck by ice in a 20-year period.

Because of the large number of variables and the need for established guidelines in risk assessment, WECO has supplemented this modeling effort with continuation of an information outreach program originally initiated by the German Wind Energy Institute (DEWI) and the Finnish Meteorological Institute (FMI). This effort consists of gathering experiential data from a large number of wind turbine operators regarding occurrence of icing, and details of any ice throw events. WECO team members presented findings from this effort at the BOREAS IV wind energy symposium in 1998. Significant findings included that (a) ice fragments ranged from 0.1 to 1.0 kg. in size and (b) no ice throw distances over 100 meters had been reported (Morgan et al., 1998; Tammelin and Seifert, 2001). Morgan et al. (1998) also observed that there have been no reported injuries resulting from ice thrown by wind turbines. Coupled with the analytical conclusions described above, this suggests that the risk of being struck by ice becomes diminishingly small at distances greater than 100 meters from each tower at the proposed facility.

Experience with wind turbines in Minnesota (noted for its cold climate and harsh winters) has not identified ice throw as a problem. With newer turbine designs, control sensors typically detect the additional weight and slower movement on blades with ice buildup and stop the rotors; the rotors are restarted after the ice has been shed (personal communication, L. Hartman, Minnesota Environmental Quality Board, St. Paul, Minnesota, August 3, 2004). Ice throws have not been reported for Minnesota wind projects, and known incidents involving ice are limited to ice shed onto a project vehicle parked underneath a turbine.

It should be noted that, similar to blade throw, the ice throw hazard area extends in a direction normal to the prevailing wind direction and downwind from the turbine. There is essentially zero ice throw hazard as little as 25 meters upwind from the plane of the rotor (Pligavko, 2003) (see **Figure 3.8-3**).

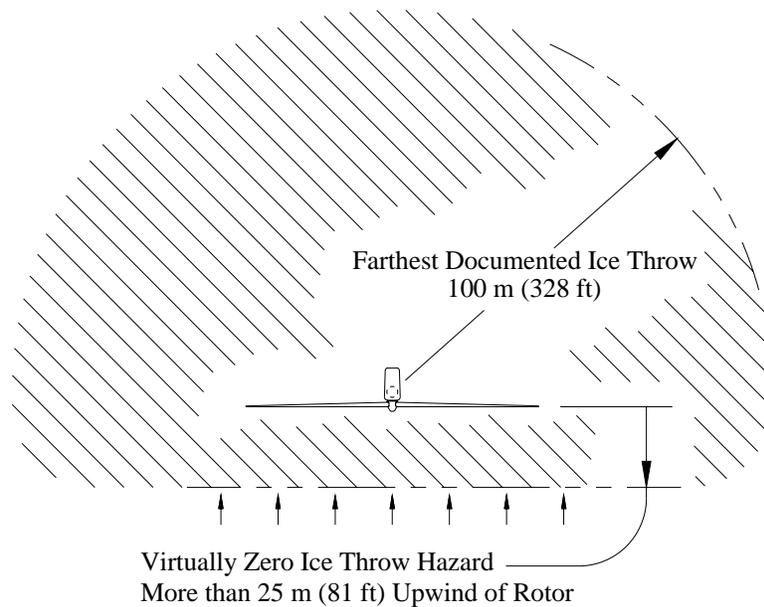


Figure 3.8-3
Ice Throw Hazard Zone

Fire Hazards

Project Construction

During the construction period of the project, construction activities and personnel would pose some increase in the fire hazard. This would result from the increased number of workers in the area, operation of powered machinery, and storage and handling of fuel. The Kittitas County Fire Marshall has identified fire hazards during construction as an area needing appropriate mitigation measures.

Fire Started by Wind Turbines

Fires have been directly or indirectly attributed to operating wind turbines, with suspected fire causes including sparks or flames resulting from substandard machine maintenance, improper welding practices, electrical shorts, equipment striking power lines and lightning (Manwell et al. 2002). Instances of electromechanical failures in wind turbine generators that resulted in fire have been documented (Ventus Vigor, 2003; Essential Information, 2003). For the most part, they have been traced to the electrical side of the systems, but mechanical malfunctions such as overheated bearings can conceivably cause a fire. The nacelle of many turbine generators, including the GEWE 1.5s/sl is made of combustible materials and contains combustibles, including approximately 80 gallons of oil (GE Power Systems, 2003). It is conceivable that a fire could penetrate the nacelle allowing burning materials to fall to the ground. Similarly, ground level equipment or maintenance activities could be a source of ignition.

Several comments on the Draft EIS referenced an incident involving a fatal accident and fire at a wind farm operated by *enXco, Inc.*, at Altamont Pass, California. The specifics of that incident are summarized as follows (personal communication, J. Fahrendorf, *enXco, Inc.*, North Palm Springs, California, April 15, 2004):

On September 18, 2003 an *enXco* employee was involved in a fatal accident at the Tres Vaqueros Wind Farm near Byron, California. At the time of the accident the employee was performing a manual switching operation on a pad-mounted electrical transformer. There was nothing unusual about the specific assignment and it was well within the employee's experience and usual job responsibilities. Nevertheless, an explosion occurred during the switching operation. The employee died the following day from injuries sustained in the explosion. The explosion ignited a fire at the base of the turbine, for which the California Department of Forestry (CDF) was immediately notified. A CDF fire crew arrived at the site within 30 to 35 minutes of notification, by which time the fire had been approximately 90 percent contained by *enXco* personnel using company equipment stored at the project site. CDF and *enXco* personnel then completely extinguished the fire, which was limited to an area of approximately 7 acres.

CalOSHA, the state agency with jurisdiction over occupational safety and health standards, was notified immediately after the accident and conducted an investigation that was completed on December 8, 2003. CalOSHA concluded that no applicable standard, rule order or regulation had been violated in connection with the subject accident, and that the accident was the result of worker error and not company policy.

The Tres Vaqueros Wind farm was constructed in 1985 with Howden 330 kW variable-pitch turbines and Balteau Standard 550 kVA transformers. This type of transformer requires the operator to perform a "hot stick" procedure for disconnecting and de-energizing an individual transformer and turbine from the project's electrical system. This transformer design and procedure are common to wind farms built during the 1980s, but are not characteristic of modern wind farms. The proposed Desert Claim project would use current-generation pad-mounted transformers designed to 2004 electrical and safety standards. With the equipment proposed for the Desert Claim project, operators can electrically isolate an individual turbine or transformer on either side of the transformer using manually-operated isolation switches, which eliminates use of the "hot stick" procedure required on older transformers such as those at Tres Vaqueros. In addition, the current transformer models have virtually eliminated all exposed conductors by

locating them within locked safety enclosures, which further protects the operator during operation and maintenance procedures.

In summary, the equipment and operating procedure characteristics of the Tres Vaqueros Wind Farm are significantly different from those of the proposed Desert Claim project, and the Tres Vaqueros incident is not indicative of the operating experience that should be expected for the Desert Claim proposal. The Tres Vaqueros event is an example that worker errors and associated accidents do happen, although the specific type of accident that occurred at Tres Vaqueros could not happen at Desert Claim because the applicable hazard has been eliminated from the equipment design. The Tres Vaqueros event also is not indicative of *enXco* policy or operating practice that results in abnormal safety and/or fire hazard. *enXco* has more than 20 years of expertise in the wind power generation industry. *enXco*'s occupational health and safety program has resulted in achieving a total lost workday record of less than ½ of 1% during the most recent 5-year period.

The site certification application for the Wild Horse Wind Power Project (Wind Ridge Power Partners LLC 2004) provides broad-based experiential data from the insurance industry concerning fires associated with operating wind energy projects. Wind Ridge quotes a company that has insured over 17,000 individual wind turbines over a 15-year period and experienced an average of 2 to 3 fires per year among that portfolio, which represents a long-term rate of 1 fire per 4,000 to 6,000 turbines. The insurance company indicated that approximately 85 to 90 percent of the fires were associated with turbines dating from 1995 or earlier. More significantly, the company reported that those fires had resulted in a single third-party damage claim, for a burned haystack on an adjacent property.

Fire hazards associated with operating wind farms can be minimized through a variety of measures that are typically incorporated within project design and operating procedures. As noted by Manwell et al. (2002) and the National Wind Coordinating Committee (2002), "The single most effective fire hazard avoidance measure is to underground all electrical wiring between turbines and the project substation;" this feature has been incorporated into the modified project configuration described in **Section 2.2**. Other typical measures include fire prevention plans, fire training programs, regular maintenance and monitoring of equipment, and adherence to proper operation and maintenance procedures. As described in **Section 2.2.4**, the operation and maintenance program for the Desert Claim project includes monitoring and maintenance schedules, control systems, safety plans and training programs that would minimize the potential for the project to start a fire.

If failure of wind turbine machinery or support equipment resulted in a fire that reached the ground, the size of the impact on the environment would depend on a variety of factors including fuel availability, climatological conditions, speed and strength of fire-fighting response, and location and efficacy of fire stops. Fuel availability within most of the project area would be essentially the same as at present, because current uses (primarily agricultural and grazing) would continue on lands outside of the permanent footprint of the project-element (e.g., turbine, pad-mounted transformer, etc.). The cleared area immediately surrounding the transformers and towers would consist of concrete and gravel, which would limit the potential for accidental sparks or flames to contact vegetation and spread. The network of project access roads would serve as an extensive system of fire breaks throughout the project area, which would also help to retard the spread of fire. Because the project would be monitored and patrolled on a round-the-clock basis, it is likely that any fires within the project area (whether caused by natural events, project facilities, or ongoing land use activities) would be observed and reported within a short time, promoting a prompt response. Project operations workers would have fire-response training and would have appropriate fire equipment available on site; therefore, they would provide the first response to any fire in

the project area. The applicant would presumably execute a fire-service contract with a local fire district, under which fire district crews would respond to incidents at the project as needed. Existing service providers in the vicinity of the project have adequate capacity to respond to and control the types of fires that could occur in association with project operation. (See **Sections 3.14.1.1** and **3.14.2.1** for discussion of fire protection resources and services.)

Based on the project conditions and operating measures discussed above, it is considered unlikely that the project would cause a fire that would create extensive damage, particularly in areas outside of the project area boundary. Several factors would contribute to the ability of project workers and fire district personnel to respond quickly to any event and contain the damage to a limited area. The brush fire resulting from the explosion at the Tres Vaqueros Wind Farm, as described above, is likely indicative of the response and consequences that might be expected from a project-related fire. Consequently, the project is not anticipated to result in significant long-term impacts related to fire hazards.

Wind Turbine Influence on Fire

For the case of a brush fire passing through the proposed wind generating facility, it is unlikely that the presence of turbine generators would materially affect the fire. This is because the “turbulence” created by the presence of turbines is mild and the bottom of the flow stream spiral is approximately 40 meters above ground (as evidenced by wind tunnel smoke tests; National Renewable Energy Laboratory, 2003). Because the function of turbines is to extract kinetic energy from the wind as it passes, the First Law of Thermodynamics requires that the air leaving a turbine must have lower kinetic energy, i.e., lower velocity (VanWylen and Sontag, 1969, Ch. 5.7) Furthermore, the turbines can be stopped to assure zero turbulence and to facilitate use of aerial fire fighting techniques; under normal conditions it takes up to 2 minutes to stop turbine rotation thorough the remote control system, but actuation of local emergency stop controls will stop the turbines in 5-10 seconds. Aerial fire fighting with planes and helicopters would be somewhat affected by the presence of the turbines, because lines of flight and altitudes would be limited by the presence of the towers. The existence of such hazards would need to be accounted for in planning and executing fire operations, similar to the hazards presented by the existing transmission lines in the project area. The extent of this effect would be limited to the 5,000-plus acres within the project area, as the turbines would be set back 487 feet from the property lines and the project area boundary.

Ground-level systems and facilities made of combustible materials could prolong a fire by adding fuel. Examples include office buildings, fuel storage facilities and certain types of transformers. As noted above, these facilities would be situated within cleared and graveled areas, and they would be isolated from other structures.

Effect of Fire on Wind Turbine Facility

It is highly unlikely the wind turbine tower, nacelle or rotor would be impacted by a passing brush fire. This is because of the relatively low fuel density at the proposed site, steel tower construction and the separation distance of the nacelle and rotor from the fire below. Note that for the GEWE units described herein, the rotor blade tip is 26.2 m (86 ft.) above ground at its lowest point for the worst-case combination of tower height and rotor diameter.

Ground-level systems and facilities made of combustible materials could be damaged or destroyed by fire. Examples include office buildings, fuel storage facilities and certain types of transformers.

3.8.2.2 Electrical Hazards

For purposes of addressing health and safety issues related to electrical effects from the proposed project, the electrical facilities for the proposed project consist of three components distinguished by their operating voltage: the turbines that would produce electric power at 575 volts (V), the collection system that would operate at 34.5 kilovolts (kV, thousand volts); and the interconnecting transmission system that would operate at 115- or 230-kV. The transmission system that receives the power would determine the voltage of the interconnecting transmission line. Transformers, protection equipment and control equipment would be located in a fenced substation. The power would enter the substation on the 34.5-kV collection lines, be increased to the transmission voltage by the transformers, and flow out of the substation on the overhead interconnection transmission line.

As with all facilities involving electricity, there are safety concerns regarding potential harm to humans. Contact with transmission lines or any electrical line can kill or seriously injure people. Furthermore, electric fields near high voltage transmission lines can cause perceivable nuisance shocks. Large metal structures such as wind turbines and transmission towers can cause interference with reception of broadcast television and radio signals. This section describes public health and safety concerns such as electrical shocks, the effects of electric and magnetic fields, and electromagnetic interference related to wind turbines and the electrical facilities.

Transmission lines, like all electric devices and equipment, produce *electric and magnetic fields (EMF)*. Voltage, the force that drives the current, is the source of the electric field. Current, the flow of electric charge in a wire, produces the magnetic field. The strength of electric and magnetic fields depends on the design of the line and on distance from the line. Field strength decreases rapidly with distance.

Electric and magnetic fields are found around any electrical wiring, including household wiring and electrical appliances and equipment. Electric fields are measured in units of volts per meter (V/m) or kilovolts per meter (thousands of volts per meter, kV/m). Magnetic fields are measured in units of gauss (G) or milligauss (thousandths of a gauss, mG).

Accurate estimates of the expected electric and magnetic fields from transmission and distribution lines require detailed electrical and physical information. Such information is not yet available for the collector system and interconnection line of the proposed project. Therefore, estimates of fields and impacts are based on fields from existing lines at similar voltage levels.

Throughout a home, the electric field strength from wiring and appliances is typically less than 0.01 kV/m. Under transmission lines, such as the existing lines on the project site, electric fields can exceed 8 kV/m under the 500-kV lines and 3 kV/m under the 230-kV lines. Under the 115-kV lines the field is less than 2 kV/m, while under low voltage distribution lines, the fields are much lower.

Typical household magnetic field levels range from less than 1 mG to above 100 mG near certain appliances. Average magnetic fields in homes are about 1 mG. Under the existing transmission lines on the project site, the field varies as the current on the line varies. Under the existing 500-kV lines maximum magnetic fields can exceed 200 mG at maximum current, under the 230-kV lines they can exceed 150 mG, and under the 115-kV lines, 100 mG. The predicted field levels are only indicators of how the proposed project might affect the magnetic-field environment. They are not measures of risk or impacts on health.

Potential health and safety impacts associated with project electrical hazards include those that could affect construction workers, operation and maintenance personnel, agricultural and other workers, the public, and others who have occasion to enter the project area.

Impact Levels

Impact levels are dependent on public and occupational use of the land. The potential for public health and safety impacts increases in areas where human activities take place.

- A **high** impact would occur if the project-related EMF concerns precluded the use of the area for pre-existing activities.
- A **moderate** impact would occur if the project altered pre-existing activities.
- A **low** impact would occur if the project would not produce a change in activities.

Potential Impacts During Construction

During construction and installation of underground and overhead electrical lines, there is a risk of fire and injury associated with the use of heavy equipment, hazardous materials such as fuels, cranes, helicopters, potential bedrock blasting for towers or access roads, and other risks associated with working near high-voltage lines. Connection of conductors might be accomplished using implosion fittings, which could be a source of injury to construction personnel. In addition, there are potential safety issues with more traffic on the highways and roads in the project area during construction. These hazards are addressed in more detail in other sections of the EIS. Electrical hazards during project construction would primarily be associated with use of equipment near existing electrical lines; the project would not be energized during the construction period prior to commissioning the turbines and switchyard, and would not itself be a source of electrical hazards at that time.

Potential Impacts During Operation and Maintenance

Electrical Safety

Power lines, like electrical wiring, can cause serious electric shocks if certain precautions are not taken. These precautions include building the lines to minimize shock hazard. All the lines should be designed and constructed in accordance with the applicable codes. The National Electrical Safety Code (NESC) applies to the collection and transmission systems. The NESC (IEEE 2002a) specifies the minimum allowable distance between the lines and the ground or other objects. These requirements determine the edge of the ROW and the height of the line; i.e., the closest point houses, other buildings, and vehicles are allowed to the line.

People must take precautions when working or playing near power lines. It is extremely important that a person not bring anything, such as a TV antenna, irrigation pipe, or water streams from an irrigation sprinkler too close to the lines. The BPA, which operates high-voltage transmission lines crossing the project area, provides a free booklet that describes safety precautions for people who live or work near transmission lines (*Living and Working Safely Around High Voltage Power Lines*).

Electrical safety issues apply to both the 34.5-kV power collection line system and the 115- or 230-kV interconnection line for the project. These lines would be located primarily on private property where such lines are already present in the form of the existing distribution and transmission lines. Landowners in and near the project area should already be familiar with precautions necessary around the new lines associated with the proposed Desert Claim project.

The underground power collection cables would not be accessible to the public or landowners. The 575-V cables from the wind turbine to the transformer connecting to the collection lines would not be accessible to the public. The underground collection cables would be buried at a depth of 4 feet, making accidental contact difficult. The substation would be fenced and accessible only to authorized personnel. Consequently, the project would not result in significant safety impacts associated with the introduction of new or additional electrocution hazards.

Electric and Magnetic Fields

Possible effects associated with the interaction of electric and magnetic fields from transmission lines (or similar electrical sources) with people on and near overhead lines fall into two categories:

- short-term effects that can be perceived and may represent a nuisance, and
- possible long-term health effects.

Short-term effects and the levels of electric and magnetic fields near the proposed transmission lines are discussed below. In addition, the U.S. Department of Energy provides a booklet on this topic (*Questions and Answers about EMF*, published in 1995).

The issue of whether there are long-term health effects associated with exposure to fields from transmission lines and other sources has been investigated for several decades. There is little evidence that electric fields cause long-term health effects. Estimates of magnetic-field exposures have been associated with certain health effects in studies of residential and occupational populations. Research in this area is continuing to determine whether such associations might reflect a causal relationship.

National and international organizations have established public and occupational EMF exposure guidelines (IEEE 2002b) on the basis of short-term stimulation effects, rather than long-term health effects. In so doing, these organizations did not find data sufficient to justify the setting of a standard to restrict long-term exposures to electric or magnetic fields.

Electric and magnetic fields associated with the Desert Claim project would be comparable to those already present on the site. The power collection lines connecting major areas of the project with the project substation would be located underground and away from residences within existing right-of-ways. Similarly, the overhead line used to connect the project substation with an existing transmission line operated by either BPA or PSE would not be located close to residences or human activity areas. Incremental changes in exposures to electric and magnetic fields would be small to non-existent for the public. Therefore, impacts associated with electric and magnetic fields on possible long-term health effects are highly unlikely.

Short-Term Effects, Electric Fields: Electric fields from high-voltage transmission lines can cause nuisance shocks when a grounded person touches an ungrounded object under a line or when an ungrounded person touches a grounded object. These effects are generally associated with lines operating

at voltages of 345-kV or higher. If the interconnection transmission line voltage is 230 kV, there is a possibility for perception of nuisance shocks; at 115 kV the potential for nuisance shocks would be minimal. Grounding fences and other metal structures on the ROW would limit the potential for nuisance shocks, especially if the line operated at the higher voltage. Since the line would be remote from residences and other human activity it is highly unlikely that the above-mentioned effects would impact residents.

The electric fields from 34.5-kV overhead connector lines (if any sections of overhead line are needed, based on site-specific constraints) would be similar to those from existing distribution lines on the site. These fields are too low to have an impact. As discussed above, the principal safety concern for the distribution lines and the collector lines is inadvertent contact with the lines. The underground collector facilities and the 575-V cables from the turbines would not produce electric fields.

Short-term Effects, Magnetic Fields: Magnetic fields from transmission lines can induce currents and voltages on long conducting objects parallel to the lines. These voltages can also serve as a source of nuisance shocks. However, the effects are well understood and can be mitigated by grounding and other measures. The interconnection line for the Desert Claim project, which would have a maximum length of approximately 300 feet, would be too short for such effects to occur.

Magnetic fields from transmission lines (and other sources) can distort the image on computer monitors. The threshold for interference depends on the type and size of monitor. Historically, this phenomenon is reported at magnetic-field levels at or above 10 mG, but some more sensitive monitors may exhibit image distortion at lower levels. For 115- and 230-kV transmission lines, interference from magnetic fields is generally not a problem except very close to the right-of-way. The proposed interconnection would be located well away from residences on existing rights-of-way and this type of interference is not anticipated. Magnetic fields from the 34.5-kV collection system are anticipated to be lower than those from the transmission line, and of insufficient magnitude to interfere with monitors.

Stray Voltage and Lightning

A number of review comments on the Draft EIS expressed concern over other aspects of electrical hazards, specifically stray voltage and lightning. In general, these comments questioned whether the project would produce electrical currents that would be noticeable on adjacent properties, and/or whether the project would create additional lightning strike hazards that would also affect adjacent properties.

“Stray voltage” is defined as a potential difference (voltage) between two points that can be accessed by a person or animal. Stray voltages in dairy barns have been studied extensively because of their potential for affecting cow behavior and productivity, leading to the identification of specific levels of concern. The level of concern for stray voltages in Wisconsin is established as 1.0 volt, which can cause a 2-milliampere (mA) current to flow through a 500-ohm resistance, representative of the resistance of a cow. An example of stray voltage in a dairy barn would be a voltage between the floor and a watering trough. Stray voltages can arise from unbalanced neutral currents flowing into the earth through ground rods, pipes or other conducting objects, or from faulty wiring or faulty grounding of conducting objects in a facility. Thus, stray voltage is generally associated with the distribution system that provides electric power to a farm and nearby areas, and/or with wiring on the farm.

Electric power from the proposed wind turbines would be balanced, three-phase power that is fed directly into the electric transmission system. In the balanced three-phase system there would be very little or no

unbalanced current to return through the earth. In addition, the power collection and interconnection system would be separate from the distribution system serving the local area, and would not contribute to currents associated with that system. Consequently, no stray voltage effects related to the Desert Claim project are anticipated.

Lightning is a relatively infrequent occurrence in the Kittitas Valley, with an annual average of approximately 10 thunderstorm days per year. More importantly, lightning protection systems and the physical characteristics of the project and local utility electrical systems would serve to protect local residents from increased lightning hazards.

Protection against lightning strikes is built into the electrical systems of all wind turbine projects. All wind turbines have a lightning protection system that includes grounding of the towers (See **Section 2.2**). The grounding system installed as part of the foundation is also used for lightning protection. The preferred resistance to neutral earth for the grounding system is 2 ohms or less (GEWE, 2002). Surge protection is provided as standard on the low-voltage side of the transformer, based on this resistance to ground. If the resistance to earth is higher than the preferred value, then a larger surge protector is required, based on the actual resistance to earth. The project lightning protection system would dissipate lightning strokes into the ground. Consequently, a person standing next to a turbine when a lightning strike occurred would be at some risk that a ground potential rise could result in a voltage between the ground and the tower or between two spots on the ground. This risk would only apply to project operations workers, and would be counteracted by safety procedures instructing workers not to stand near turbines during lightning activity.

The electrical system of the wind turbine project would be completely independent of the residential distribution system in the project vicinity. Therefore, any faults or surges on the project's electrical system due to lightning strike or other causes would not extend to the local distribution system that provides power to residences in the area, and the project would not increase long-term lightning hazards for residents in the project vicinity.

Communications Interference

Telecommunications can be affected by electromagnetic interference (EMI), such as that associated with corona on transmission lines, and by physical blocking or reflection of the signal. This latter effect can be caused by large metallic structures such as transmission towers, large metal buildings or wind turbine towers.

Electromagnetic noise caused by corona on transmission lines (the electrical breakdown of the insulating properties of air very near to the surface of a high-voltage conductor) can interfere with reception for some types of communications. Cable and satellite television systems are not affected by electromagnetic interference associated with transmission and distribution lines. This source of EMI for radio signals is primarily of concern for lines with voltages above 230-kV, such as the existing 500-kV lines that cross the project. Corona is a well-understood phenomenon and transmission lines are designed to mitigate it as a source of EMI. For the Desert Claim project, EMI due to corona noise would be minimal because the proposed transmission line would be short (less than 0.3 miles) and would be operated at 115- or 230-kV, where corona levels are generally low. Arcing on lower-voltage overhead distribution lines can also be a source of EMI. However, EMI from sparks across air gaps in hardware on overhead 34.5-kV collector lines (if any were constructed) would be eliminated by the use of modern hardware and construction techniques. Other telecommunications systems such as FM radio reception, cellular telephones, and

emergency response communications operate at higher frequencies and would not be affected by electromagnetic interference from the interconnection and collector lines associated with the Desert Claim project.

Physical blocking or reflection of radio or television signals by wind turbine towers might occur and could affect reception quality. Similarly, blocking of signals could affect reception of other types of communication signals in very close proximity to towers, as discussed below.

Both wind turbines and steel transmission structures can block or cause unwanted reflections of broadcast signals. Reflections from structures can result in ghosting of television images. This would require that the towers be in a near line-of-sight between the transmitter and the antenna. The wind turbines would be located 1000 feet from the nearest residence, which should provide sufficient separation to eliminate interference. Similarly, the location of transmission structure on existing right-of-way and the use of wood poles or steel pole structures should eliminate transmission towers as a source of interference with reception. The use of fiberglass rotors also eliminates the problem of reflection of signals from the rotor blades. Therefore, it is unlikely that television interference would occur as a result of the project.

Radio communications used by emergency services responders are typically operated at higher frequencies (above 30 megahertz) that are not affected by corona-generated electromagnetic noise from transmission lines. Blocking of these communication signals very near or inside structures could occur. However, this occurrence would be no different than similar signal interference caused by metal structures such as barns, silos or industrial facilities. In the case of wind turbines and other structures, a slight change in physical location by the operator of the communication device can eliminate the interference.

Signals to/from cellular telephones or other personal communication devices could be blocked or partially blocked in very close proximity to the wind turbine towers. However, as with poor radio reception near other structures, improved reception can be achieved by slight changes in physical location.

Prior to final placement of the wind turbines, a study would be conducted to investigate possible blocking of microwave signals by individual turbines. This entails determining the paths that microwave signals follow from antennas in the region and comparing these with the locations of the wind turbines. Federal law does not permit interference with registered microwave transmission pathways; thus, it would be mandatory that any interfering wind turbines would be eliminated or relocated outside the microwave pathways.

3.8.2.3 Shadow Flicker

Shadow flicker caused by wind turbines is defined as alternating changes in light intensity due to the moving blade shadows cast on the ground and objects, including receptor windows; shadow-flicker is not the sun seen through rotating wind turbine blades or moving through the shadows of a wind farm, such as while driving. Because wind turbines are located relatively far away from receptors, shadow-flicker usually only occurs at sunrise or sunset when the cast shadows are long.

Shadow flicker does not occur when fog or clouds obscure the sun, because no shadow is then cast on the ground or on objects. A wind turbine also has to actually be operating for the shadow to move (flicker). The amount of time shadow flicker occurs depends not only on the location of the wind turbine and shadow-flicker receptor, but also which direction the wind is coming from. When the rotor plane is in-line

with the sun seen from the receptor, then the cast shadow will be very narrow (because of the blade thickness) and the intensity very faint, especially at great distances. The shadow will also pass the receptor very fast, whereas when the rotor plane is perpendicular to the line between the receptor and the sun the shadow is wider (based on the rotor diameter).

Modeling Approach

The shadow-flicker results presented in the EIS have been modeled using standard assumptions, terrain input, turbine dimensional data, etc. No site-specific assessments have been made to confirm the shadow-flicker model results. The modeled results therefore represent essentially the worst case that might be expected. There are several scenarios reflected in the model analysis:

- When obstacles are present (terrain, trees, buildings etc.) between the wind turbines and a potential shadow-flicker receptor, then shadow-flicker time and/or intensity is reduced (or not applicable) at such receptors; this factor is not incorporated in the model.
- The model considers terrain around the project boundaries but only to a distance of approximately 2 miles out. The terrain in this range around the project is rolling to mountainous, and it is likely that part of the shadow-flicker time derived is actually after sunrise and sunset (dusk/twilight). The lowest angle of the sun considered in the model is 3 degrees, however, and the effect of the mountain terrain on shadows might already be covered.
- In most areas cloud cover (or fog), if present, is likely to occur in the morning and evening hours rather than during the day. The applied cloud cover (or fog) inputs are averages (hours per day) and the model therefore cannot distinguish between cloud cover in the daytime and mornings/evenings.
- Wind turbine run hours are also averages (stated in hours per day). Wind patterns change over the day, however, while the model considers the calm wind periods (where turbines do not run) to be distributed equally.

Shadow Flicker Intensity

An important aspect of the shadow-flicker phenomenon that is often not known or not discussed is the *intensity* of the shadow-flicker. The intensity is defined as the difference between the lightness of a given spot when shadow is present and when it is not. Some considerations are outlined below:

- The wind turbine blade is narrow at the blade tip and wide closer to the nacelle/hub. If a wind turbine is located close to a shadow-flicker receptor, then the wider blade portion might be wide enough to cover most of the sun's disk seen from the receptor. During such time the flickering intensity is high, whereas when a wind turbine is located far away from the receptor the blades cover only part of the sun's disk and the intensity will therefore be reduced.
- Because of the blade width explained above, the shadow-flicker changes in intensity as the shadow of the wind turbine rotor moves from the tip of the blades (one side) through the tower/nacelle to the other side. The greatest intensity will be when the cast shadow of the nacelle/hub hits the receptor, if this indeed occurs.
- At times the cast shadow is from the top part of the rotor only. This would be the case where a receiver only experiences low numbers of shadow-flicker hours. In other words, a

low number of shadow-flicker hours in the model results also means those hours occur at low intensity.

- During weather conditions with low visibility (but still sunlight), the shadow-flicker intensity will be lower than at normal conditions and good visibility.
- At longer distances between the wind turbine and shadow-flicker receptor, the cast shadow is far more ‘out of focus.’ This does not contribute to lower intensity, but the flickering is less distinct.
- Shadows are fainter in a lighted room. Consequently, switching lights on in a dark room will lower the intensity of shadow-flicker in a room during the times shadow-flicker occurs.
- Covering a window where shadow-flicker occurs (with curtains, blinds or shutters) will prevent shadow-flicker from occurring within the room.

The above mitigating aspects are not considered in the applied shadow-flicker model; the model results only identify flicker or no-flicker conditions. Consequently, it is entirely likely that affected receptors would not actually experience significant shadow flicker, even though the report tables and plots indicate shadow-flicker time; receptors indicated in the results as marginally affected are likely not to actually experience shadow flicker at all. At times when shadow flicker would likely occur, the intensity is likely to be very low. Under those conditions the available remedies are easy to identify and implement, and include measures such as installing curtains, blinds and shutters within residences or planting trees between turbines and windows.

Model Inputs and Outputs

The shadow-flicker model (which is also a function of the WindPRO software used for the noise analysis) requires the following input:

- 1) Turbine locations (coordinates);
- 2) Shadow flicker receptor locations (coordinates);
- 3) USGS 1:24,000 topo map;
- 4) USGS DEM (height contours);
- 5) Rotor diameter;
- 6) Hub height;
- 7) Joint wind speed and direction frequency distribution; and
- 8) Sunshine hours (monthly averages)

The model calculates the shadow-flicker time for (a) each receptor, (b) everywhere (all defined areas) or both (a) and (b). A receptor is defined as a window at the residence. The azimuth of windows has been estimated for each receptor residence (north, south, east and west, or 90, 180, or 270 degrees from the nearby access road) and the window size is set to 1 meter by 1 meter. The software calculates the sun’s path from the turbine location and the cast shadow derived over the day. Then the run-time for the turbine is derived from the wind speed data. From the wind direction data, the direction of the wind turbine (seen from the receptor) is calculated and the reduced shadow-flicker time. Finally the extent of cloudiness is applied (no direct sun means no shadow flicker would occur).

The amount of computation depends highly on the chosen output parameters (a, b or both a and b described above). Usually a map with line contours showing the number of hours of shadow flicker is the preferred output; this requires computations for areas sized at 50 by 50 meters. The outputs are:

1. Turbine locations and elevations;
2. Calculated shadow-flicker time at selected receptors;
3. Tabulated and plotted time of day with shadow flicker at selected receptors;
4. Listing of turbines causing shadow flicker at each selected receptor; and
5. Map showing turbine locations, selected shadow-flicker receptors and line contours indicating projected shadow-flicker time (hours per year).

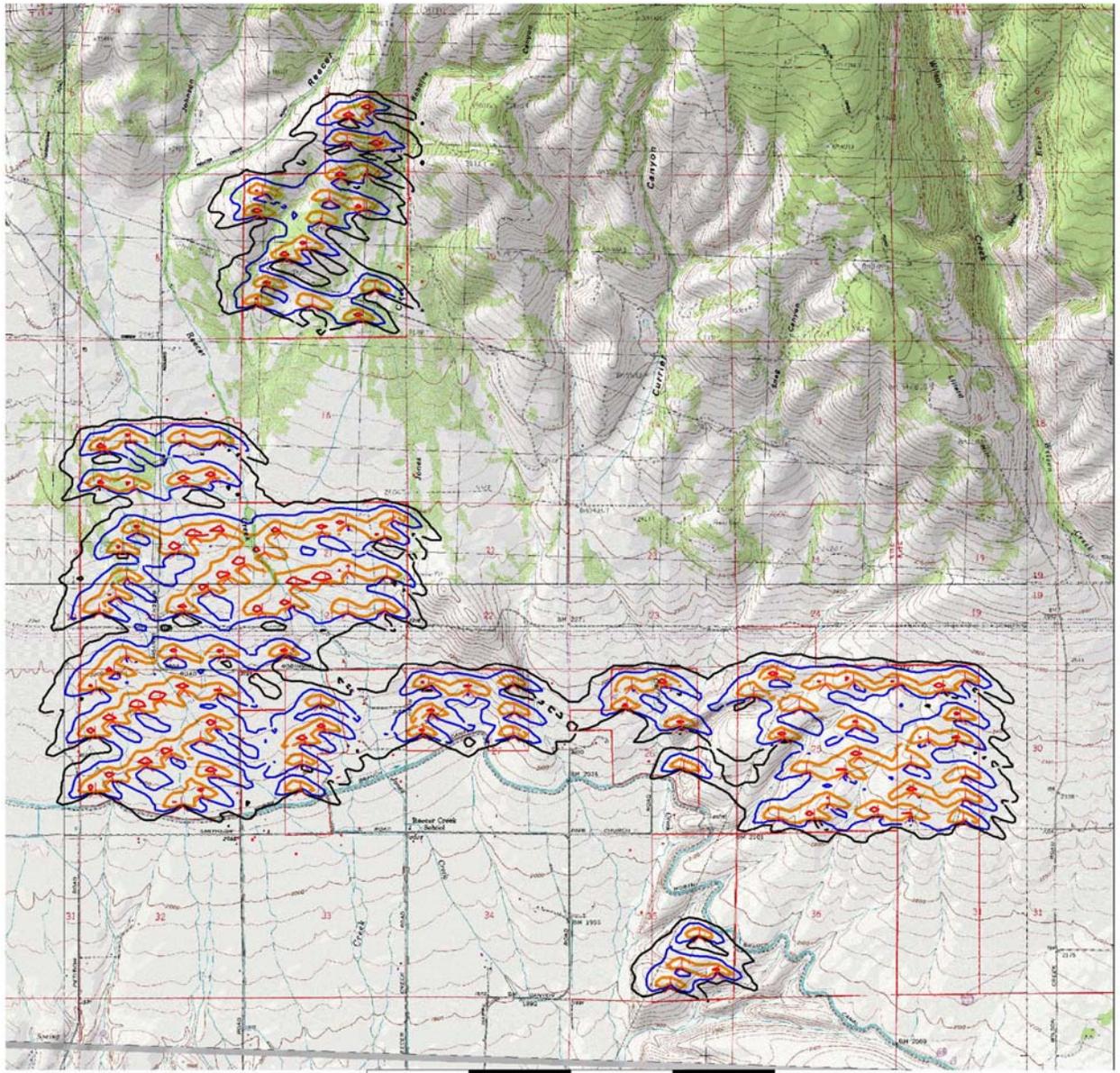
Impact Results

All potential residential receptors for the Desert Claim project, based on their distance range from the project, have been included in the model. Only shadow-flicker receptors in the immediate neighborhood of turbines have been included in each segment of the model. There are 7 segments (local areas) modeled for this project. Shadow-flicker receptors directly north and south of proposed wind turbines would not be likely to receive shadow-flicker at all, because the shadows cast by the turbines are short in the north and south directions.

Detailed output from the model analysis is provided in **Appendix E**. **Figure 3.8-4** is a contour map showing areas of shadow-flicker exposure per year (in hours) relative to turbine and receptor locations. (Because this is a small-scale map covering the entire project vicinity, the receptor symbols are small and difficult to discern. **Exhibit 2** of **Appendix E** includes seven larger-scale contour maps for different sectors of the study area for this analysis, on which receptor locations are more distinct.)

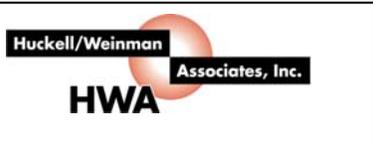
Table E1 in **Appendix E** summarizes the modeled shadow-flicker results for all 78 receptors potentially within range of shadow flicker during operation of the project. The shadow flicker analysis included in the Final EIS differs from that documented in the Draft EIS because the analysis in the Draft EIS included results for 45 potential receptor locations. The larger number of receptors in the Final EIS analysis is based on an updated inventory of residences near the project and an expanded distance limit for the analysis. The model analysis included in the Final EIS indicated that the number of potential receptors increased, while the maximum potential exposure decreased by one day. This analysis indicates that 65 of these receptors would potentially experience shadow flicker for some time during the year, while 13 of the receptors would not be exposed to shadow flicker. The theoretical maximum number of days per year on which a specific receptor might experience shadow flicker (from at least one window) would range from 21 days (receptor 127) to 260 days (the west side of receptor 11). This result could only occur with the sun actually shining on every day for which the sun angle would make shadow flicker possible, and with the contributing turbine(s) always running when shadow flicker is possible; actual sunshine and wind conditions would reduce the number of actual shadow-flicker days to well below the theoretical maximums. Similarly, the theoretical maximum duration of shadow flicker in any day at any receptor would range from 6 minutes (receptors 14 and 127) to 2 hours 18 minutes (receptor 6).

The model applies average reductions for cloud cover and calm wind periods to the theoretical maximum days and hours of shadow flicker time to derive the expected duration of shadow flicker time per year on each side of each receptor. These net model results indicate annual hours of shadow-flicker exposure at the 65 affected receptor locations ranging from about 1/2 hour per year (at receptors 5, 127, 145, 146 and 147) to over 50 hours per year (receptor 11). The distribution of the results is summarized in **Table 3.8-2**.



Map: 040711 DCWPP USGS, z13, 31250, overlays, Print scale 1:60,000, Map center UTM NAD27 Zone: 10 East: 684,932 North: 5,222,014
 ▲ New WTG
 Isolines showing shadow in Shadow hours per year. Real value calculation.
 — 25 — 50 — 100 — 200

Source: Wind Engineers, Inc.



**Kittitas County
 Desert Claim Wind Power
 Project EIS**

**Figure 3.8-4
 Shadow Flicker Contour Map**

**Table 3.8-2
Summary of Shadow Flicker Duration and Receptors**

Expected Duration (Hours/year)	Number of Receptors
0-5	44
5-10	13
10-20	14
20-30	4
Over 30	3

Most (73 percent) of the potential receptors would experience less than 10 hours of shadow flicker per year, while only 7 (9 percent) would experience more than 20 hours per year. Given the conservative factors used in the modeling approach, these results likely approximate the worst-case scenario for shadow flicker; i.e., the actual frequency and duration of shadow flicker at any given location would likely be less than indicated in the model results.

The highest shadow-flicker exposure modeled, at over 50 cumulative hours per year, would occur at receptor 11. In this case nine different turbines located north, east, south and west of the receptor would contribute to shadow flicker at varying times of the year and day. The majority of the 50-plus hours would occur in the evening every day (depending on weather conditions) from March through October, with some additional exposure in morning hours at varying times of the year. The maximum daily shadow-flicker time for this receptor would be 1 hour 18 minutes, which would occur on evenings from May through August.

The second highest shadow-flicker level modeled is approximately 40 to 45 hours per year at receptor 24. Here the main contributors are again a suite of nine turbines arrayed to the north, east, south and west of the receptor. Most of the shadow-flicker hours would occur in the evening from March through November, and most of the shadow flicker would be from the north and west. The maximum daily shadow-flicker time for this receptor would also be 1 hour 18 minutes, which could occur in evenings in May through August.

The third highest shadow-flicker level modeled is 35 to 40 hours per year at receptor 19. The contributing turbines are 66, 67, 70 and 71, located primarily west and north of the receptor. Virtually all shadow flicker at this receptor would occur in the early evening (around 7 to 8 p.m.) from May through July.

The model results indicate that shadow flicker would affect relatively few residential receptors on a frequent basis, and their exposure would generally occur for a limited total duration in a year. Determining the significance of those impacts is a subjective question and would likely vary considerably based on the perspective of the evaluator.

Given the physical characteristics of shadow flicker, movement of turbine locations a relatively short distance can often result in a substantial reduction in the frequency and/or duration of shadow flicker at a specific receptor. Conversely, the same minor shift in location of a turbine could also result in comparable increase at another receptor. Nevertheless, the WindPRO model provides a tool to test the ability to reduce shadow flicker impacts through micro-siting.

Shadow flicker could also be noticed by people or animals outdoors at locations other than residences near the project area. Because the model requires analysis of specific mapped locations, it does not include possible instances in which people driving, walking or performing other functions away from residences might be exposed to shadow flicker. The shadow flicker contour map presented in **Figure 3.8-4** indicates the potential extent of non-residential shadow flicker exposure, however. As discussed in **Section 3.11**, recreational users within approximately 2,000 feet of an operating turbine might at times experience shadow flicker. These occurrences would be confined to rare and very specific conditions (lack of cloud cover, sufficient wind for turbine operation, low sun angles at the beginning or end of the day, etc.), would be limited to short durations when they did occur (typically on the order of one-half hour or less per occurrence), and would occur for a limited total duration (a maximum of about 50 hours per year, based on the analysis results for residential receptors). For a person engaged in outdoor activity, exposure to shadow flicker would likely be a transitory experience that amounted to an annoyance or distraction, and that could usually be avoided by moving out of the relatively narrow band of the turbine shadow. The same observations would apply to animals, such as horses being ridden for recreational or ranching purposes. For motorists traveling on local roads, it is likely that the rapid movement of the vehicle through the shadow band of the rotor would typically prevent drivers or passengers from noticing the shadow flicker.

Shadow Flicker Consequences

Scoping comments indicated concerns that people exposed to shadow flicker could suffer adverse health consequences. The potential for shadow flicker to create adverse health effects appears to depend primarily on the frequency of the flickering.

The shadow-flicker frequency is related to the rotor speed and number of blades on the rotor. The rotor speed for the GE 1.5s model is about 20 RPM, which translates to a blade pass frequency of 0.87 Hz (less than 1 alternation per second). Such low frequencies are considered to be harmless with respect to adverse human health consequences. For example, the Epilepsy Foundation (2004) notes that epilepsy affects more than 2.5 million Americans and that about 5 percent of these people can experience seizures triggered by lights flashing at certain intensities, or by some types of flickering. Variables that appear to influence photosensitive reactions include the frequency of the flash or flicker, brightness, level of background lighting and whether a person's eyes are open or closed. The foundation indicates that lights flashing at frequencies of 5 to 30 Hz are most likely to trigger epilepsy seizures, and recommends that flash rates be kept below 2 Hz to reduce the likelihood of a photosensitive reaction. Strobe lights with frequencies higher than 3 Hz but below 10 Hz are widely used in nightclubs.

Given the low frequency of shadow flicker from wind turbines, this phenomenon does not appear likely to be capable of triggering epileptic seizures. In addition, an adverse photosensitive reaction is more likely with a bright or high-intensity light source at a close distance, while shadow flicker would typically be relatively dim and distant. Based on these characteristics of shadow flicker relative to known causal factors in photosensitive reaction, there is no basis to conclude that shadow flicker from the Desert Claim project would be likely to result in adverse human health consequences for the local population.

Comments on the Draft EIS also noted concerns that shadow flicker could cause startle effects to horses or vehicle drivers that could lead to accidents. Comprehensive literature sources on wind energy development and environmental issues, such as Manwell et al. (2002) and NWCC (2002), do not identify such events as problems in their discussion of shadow flicker, nor does there appear to be documented evidence of such incidents actually occurring. Based on the discussion above, outdoor exposure to shadow flicker appears to be a potential event of low probability. Given that drivers must and generally

do adapt to all manner of distractions and external events, such as sun glare and particularly other traffic, it is not reasonable to conclude that rare and fleeting potential exposure to shadow flicker would constitute a significant accident risk. While horses are commonly considered to spook rather easily, that characteristic alone is not a sufficient basis to postulate a probable or significant hazard to horse riders resulting from possible exposure to shadow flicker from the project.

3.8.2.4 Other Health and Safety Issues

Some comments submitted during scoping for the EIS and the review of the Draft EIS expressed concern that the project might result in declines in the raptor population that would lead to an increase in the population of rodents that are prey species for raptors. Because certain rodents such as deer mice are carriers of hantavirus, which is an airborne pathogen that can be contracted by humans, the concern was that this indirect impact on rodents could result in increased risk of human exposure to hantavirus. Similarly, Draft EIS comments suggested the prospect that postulated declines in bird and/or bat populations could cause an increase in the mosquito population and a corresponding increased risk that humans might contact West Nile virus.

The impact analyses for avian species and mammals (including bats; see previous discussion in **Section 3.4.2**) determined that the Desert Claim project would have a low mortality rate for raptors, other birds and bats, particularly bats that are resident to the local area. In all cases, the level of mortality would not have a measurable effect on the population of the species. Consequently, there is no basis to assume there would be a corresponding increase in the rodent or mosquito populations, or more widespread exposure to hantavirus or West Nile virus.

It is also worth noting that both diseases have a very low incidence in Kittitas County. As of early 2004, 26 cases of hantavirus pulmonary syndrome had been reported in Washington (Centers for Disease Control 2004). The source did not indicate how many of those cases might have been from Kittitas County, although the County website does not include hantavirus among seven public health concerns listed with links to information. As of March 2004, no (0) human cases of West Nile virus disease had been reported in Washington State (CDC 2004). Washington Department of Health (2004) information indicates that testing in 2002, 2003 and 2004 has not identified any West Nile virus positive cases in birds, horses or humans in Kittitas County. Statewide testing in 2003 included 4 horses, 2 birds and 2 mosquito pools from Kittitas County, and none of the tests yielded positive results. Public health agencies at the federal, state and local level have recently distributed extensive public information about both hantavirus and West Nile virus.

Some comments on the Draft EIS also expressed concern relating to use of hazardous substances in project construction or operation and the damages that could occur from potential spills of such substances. Because surface water or groundwater would be the medium through which any spilled hazardous substances would disperse, this issue is addressed in **Section 3.3**.

3.8.3 Impacts of the Alternatives

3.8.3.1 Alternative 1: Wild Horse Site

Mechanical Hazards

The types of mechanical and related hazards applicable to Alternative 1 would be the same as those described in **Section 3.8.1.2** for the proposal. Likewise, the probability and extent of those hazards would be the same as for the proposed action. The possible consequences of those hazards, however, would be considerably different as a result of the differences in land use patterns between the Desert Claim and Wild Horse sites. There are no residential uses or public roadways within or immediately adjacent to the Wild Horse site. Consequently, the numbers of residents and visitors to the site who would be subject to hazards such as tower collapse, blade throw and ice throw would likely be considerably less under Alternative 1 than for the proposed action. The primary uncertainty with respect to this issue concerns whether hunting would be allowed to continue on the Wild Horse site under Alternative 1. Based on the Zilkha Renewable Energy proposal for the Wild Horse Wind Power Project, and the current popularity of big-game hunting on the Wild Horse site and adjacent WDFW lands, it is conceivable that hunting might be allowed to continue on the site (with some limitations) under Alternative 1. In that event, hunters would be exposed to potential turbine-related hazards for a limited duration during the annual hunting season(s).

Electrical Hazards

Alternative 1 would require construction and operation of the same types and voltages of electrical facilities as the proposed action, and involve the same types of electrical safety, electric and magnetic fields and electromagnetic interference issues discussed previously in **Section 3.8.2.2**. Electrical safety issues would apply primarily to people undertaking project construction or operation activities, as there would not typically be landowners or other residents present on the Wild Horse site. As for the proposed action, electric and magnetic fields associated with Alternative 1 would be comparable to those already present near the transmission lines that exist in the vicinity of the site. Incremental changes in public exposure to electric and magnetic fields would be small to non-existent, because of both the relatively lower voltage of the proposed interconnection facilities (115- or 230-kV) and the lack of human activity along the transmission feeder line routes for Alternative 1.

Shadow Flicker

The distance threshold for shadow flicker impacts is approximately 2,000 feet; potential receptors beyond that distance from a wind turbine would not be subject to shadow flicker (personal communication, C. Taylor, Zilkha Renewable Energy, Portland, Oregon, September 18, 2003). Because there are no residences closer than 2 miles from a proposed wind turbine location on the Wild Horse site, no permanent receptor locations would be affected by shadow flicker from a wind energy project at this site. If continued limited access to the project area for hunting were permitted, some hunters might approach within 2,000 feet of a wind turbine and might experience brief or intermittent shadow flicker under specific weather and sun-angle conditions. No evidence of shadow flicker impacts on wildlife has been documented (personal communication, C. Taylor, Zilkha Renewable Energy, Portland, Oregon, September 18, 2003). Therefore, shadow flicker impacts under Alternative 1 would be minimal to nonexistent.

3.8.3.2 Alternative 2: Springwood Ranch Site

Mechanical Hazards

The types of mechanical and related hazards applicable to Alternative 2 would be the same as those described in **Section 3.8.1.2** for the proposal. Likewise, the probability and extent of those hazards would be the same as for the proposed action. The possible consequences of those hazards, however, would be somewhat different as a result of the differences in land use patterns between the Desert Claim and Springwood Ranch sites. There are some residential uses or public roadways within or immediately adjacent to the Springwood Ranch site, although the density level is somewhat less than for the Desert Claim project area. Consequently, the numbers of residents and visitors to the site who would be subject to hazards such as tower collapse, blade throw and ice throw would likely be less under Alternative 2 than for the proposed action. The primary area of concern for Alternative 2 would likely be the Sunlight Waters community to the northwest of the site, where some residences would be within approximately 500 feet of identified turbine locations.

Electrical Hazards

Impacts of Alternative 2 with respect to potential electrical effects would be essentially the same as those described for the proposed action and Alternative 1. No significant impacts of this type would be expected.

Shadow Flicker

A model analysis for the potential shadow flicker impacts of Alternative 2 has not been conducted because a number of needed model inputs are not available for the Springwood Ranch site. Based on the 2,000-foot distance threshold referenced above, however, it is likely that some residences near the site would be exposed to shadow flicker under Alternative 2. The potential receptor locations most likely to be affected include two receptor locations near Taneum Creek, within about 1,000 feet identified turbine locations for Alternative 2; one receptor location near SR 10 and the east bank of the Yakima River, approximately 2,000 feet from the nearest turbine location; and several residences along the eastern edge of Sunlight Waters, within approximately 500 feet of Alternative 2 turbine locations. The Taneum Creek receptor locations are to the south of the project site, indicating they might experience little if any shadow flicker. The receptor location near SR 10 would only be subject to shadow flicker during late afternoon hours, while the Sunlight Waters residences would only experience shadow flicker during morning hours. Aside from those limitations, the frequency and duration of shadow flicker conditions at these locations might be similar to the analysis results for the Desert Claim site.

3.8.3.3 No Action Alternative

Under the no action alternative, the proposed action would not be implemented and the potential mechanical hazards associated with this utility-scale wind energy project would not be introduced to the project area. Other similar developments are in various stages of planning at nearby sites. If none of these facilities were constructed, existing hazards would likely continue for the foreseeable future, with some possible change in character (e.g., nature and frequency) with likely increasing rural residential development in the area.

Existing electric and magnetic field levels in the project area would continue under the no action alternative at levels the same as or higher than for the existing facilities, as a result of modifications to the BPA substation and construction of a new transmission line. No change in public health and safety impacts for residents in the project vicinity would be expected.

Under the no action alternative, the potential shadow flicker impacts associated with a utility-scale wind energy project would not be introduced to the project area. Existing shadow conditions in the project area would likely continue for the foreseeable future.

3.8.4 Cumulative Impacts

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

3.8.5 Mitigation Measures

3.8.5.1 Mechanical Hazards

A broad array of measures are available to mitigate the potential hazards associated with the project and the exposure of persons, animals and facilities to the hazards. These measures can generally be classified as preventive, exclusionary or corrective actions.

Primary among the means of preventing hazards would be adherence to appropriate design and construction protocols such as IEC 61400-1. This would assure that the load assumptions, design, construction standards and safety features are in accordance with industry norms and benefit from the experience of many manufacturers and operators. Other important prevention measures are establishment of a skilled workforce and implementing effective facility-wide maintenance, surveillance and security programs. These measures would be incorporated into the proposed Desert Claim facilities and operation, as discussed in **Section 2.2**.

Every hazard identified herein decreases as some function of distance. In many cases, therefore, it is possible to reduce or eliminate hazards to persons and facilities by prohibiting or controlling presence in the area potentially affected by the hazard. Where multiple hazard areas overlap, the largest distance should govern. The fact that all of the project facilities are located on posted private property would facilitate management of access to the facility by persons unaware of safety setbacks.

Even when conditions have developed to the point where a significant hazard is imminent, it is often possible to take immediate action to prevent an environmental impact. An example of this would be actuation of a fire suppression system upon detection of heat or smoke within the turbine nacelle.

Wind turbine generators such as the GEWE 1.5s/sl are equipped with multiple safety systems as standard equipment. As examples: rotor speed is controlled by a redundant pitch control system and an automatic backup disk brake system; critical components have multiple temperature sensors and a control system to shut the system down and take it off-line if an overheat or overspeed condition is detected. Lightning protection is standard.

Tower Collapse

The selected wind turbine generator/tower combination, the GEWE 15.sl, would be subjected to engineering review to assure that the design and construction standards are appropriate for the Kittitas County site. This review would include consideration of code requirements under various loading conditions and give a high degree of confidence of structural adequacy of the towers.

Even so, it is possible that during the life of a wind turbine it would be exposed to unanticipated load combinations that could cause failure. For this reason, even with a unit certified to IEC and building code standards, human access should be restricted and high-value facilities should not be built within a distance from each tower equal to 110 percent of the tower height plus half the rotor diameter. Based on the turbine model proposed for this project, this would mean a setback of 416 feet from each tower. In response to direction from Kittitas County and comments on the Draft EIS, the applicant modified the project to include a 487-foot performance-based safety zone setback. That setback is large enough to provide a sufficient safety zone for potential tower collapse.

The applicant also modified the project to locate power collection cables under ground wherever feasible to eliminate the possibility of certain indirect impacts described above.

Blade Throw

Certification of the wind turbine to the requirements of IEC 61400-1 would assure that the static, dynamic and defined-life fatigue stresses in the blade would not be exceeded under the combined load cases expected at the project site. The standard includes safety factors for normal, abnormal, fatigue and construction loads. This certification, together with regular periodic inspections, would give a high level of assurance against blade failure in operation.

Nevertheless, it is conceivable that that all or part of a blade could become detached from the turbine. For this reason, even with a unit certified to IEC standards, human access should be restricted, and high-value facilities should not be built, within a distance from each tower equal to 110 percent of the maximum calculated blade throw, which would be 540 ft. for the maximum turbine envelope size. Based on the shorter turbine model preferred by the applicant, the maximum blade throw safety zone would be 487 feet. Consistent with direction from Kittitas County, the applicant modified the project to include this 487-foot performance-based safety zone setback, which is large enough to provide sufficient setback for potential blade throw from the GEWE 1.5sl.

The applicant also modified the project to locate power collection cables under ground wherever feasible to eliminate the possibility of certain indirect impacts described above.

Ice Throw

Ice throw over 100 m has not been documented as a hazard and an ice throw injury has not been reported. GEWE recommends an ice throw exclusion zone with a radius of 125 m (410 feet) on the downwind side of the tower, which they cite as 125 percent of the largest recorded throw distance (Pligavko, 2003). Note that for large wind turbines such as the GEWE 1.5s/sl, observance of the tower collapse hazard area or the blade throw hazard area restriction would keep unauthorized persons out of the ice throw hazard zone. The 487-foot performance-based safety zone setback, included in the modified proposal is large enough to provide sufficient setback for potential ice throw from the GEWE 1.5sl.

Also, in light of the few days of icing conditions expected at the Kittitas County site, it might be practical to shut down selected turbines when the danger of icing exists. Alternatively, icing sensor systems are available and could be installed on specified turbines to accomplish this purpose.

Certain manufacturers have heated rotor blades in development testing. This would not be a practical consideration for the proposed facility due to the low hazard and low frequency of icing.

Fire Hazards

The applicant's plans for the proposed project include a number of design and operational measures intended to prevent fires and minimize the consequences of any fires that might occur (see discussion in **Sections 2.2** and **3.8.2.1**). The Kittitas County Fire Marshal has also established a list of requirements that would mitigate fire hazards associated with the project (personal communication, D. Gaidos, Kittitas County Fire Marshal, September 22, 2003 and January 29, 2004). Measures to address these requirements would include the following (see also **Section 3.14.5**):

- During the construction period, it would be necessary to give all workers fire safety training and to implement a work plan that minimizes the risk of fire. Appropriate fire suppression equipment must be available to designated employees trained in its use.
- Use of mufflers and spark arrestors on all construction equipment.
- Required construction shutdowns consistent with area-wide industrial precautions, and limitations on "hot" work when necessary.
- In normal operation, regular maintenance, including review of real time and stored temperature sensor readings, would highlight developing problems and facilitate prevention of equipment-caused fire. Large wind generators such as the GEWE 1.5s/sl have such systems as standard equipment.
- Installation and maintenance of a fire suppression system in each turbine nacelle would supplement standard fire prevention measures and eliminate the possibility of burning objects falling to the ground.
- Location of transformers and electrical equipment below ground would harden them against tower collapse, blade throw and vandalism, thereby reducing the fire hazard.
- Establishment of a contract with a local fire district for fire protection service to the project.
- Development and adoption of fire prevention and fire control plans for the project.
- Maintenance of updated emergency contact information and coordination procedures.

3.8.5.2 Electrical Hazards

The following mitigating measures would help minimize potential health and safety risks associated with electrical hazards that might exist with the project:

- Prior to starting construction, the contractor would prepare and maintain a safety plan in compliance with Washington requirements. This plan would be kept on-site and would detail how to manage hazardous materials such as fuel, and how to respond to emergency situations.
- During construction, the contractors would also hold crew safety meetings at the start of each workday to go over potential safety issues and concerns related to working on electrical facilities.

- At the end of each workday, the contractor and subcontractors would secure the site to protect equipment and the general public.
- Employees would be trained, as necessary, in tower climbing, cardiopulmonary resuscitation, first aid, rescue techniques, and safety equipment inspection.
- If implosion bolts are used to connect the conductors, they should be installed in such a way as to minimize potential health and safety risks to workers.
- Project workers should stay on established access roads during routine operation and maintenance activities.
- Vegetation would be trimmed to avoid contact with collection and interconnection lines.
- The project would construct and operate the new collection and transmission lines to meet the National Electrical Safety Code.
- Installation crews would clearly mark the location of all buried collection cables.

Mitigating measures available to address potential telecommunications interference associated with electromagnetic or physical conditions that might exist with the project include the following:

- Conduct a study of potential microwave interference prior to final location of turbines, and move or eliminate turbines that would block microwave pathways.
- Conduct baseline monitoring of television reception quality in the near vicinity of the project and investigate claims of diminished signal quality as a result of the project. Means to accomplish this can range from contracted studies by qualified professionals to simple before-and-after videotaping.

3.8.5.3 Shadow Flicker

Several types of mitigation measures are available to address shadow flicker impacts. In general, they involve (1) potential changes to project operations or (2) physical modifications that could be undertaken at receptor locations.

Because shadow flicker can only occur when turbine blades are moving, shadow flicker could (in principle) be prevented by shutting down specific turbines at times when weather and sun conditions would otherwise be expected to result in shadow flicker at specific receptor locations. Implementing this specific measure in practice would likely be quite difficult, however. While the model analysis discussed in **Section 3.8.2.3** predicts the time and duration of shadow flicker at each receptor, it does this based on average sun and wind conditions and is not a simulation of actual conditions over a given period. It would not be feasible to use the WindPRO software to develop a program to shut down specific turbines in advance of specific times when they were capable of producing shadow flicker at specific receptor locations.

An operational measure discussed in the Draft EIS and identified in some comments on the Draft EIS would be to develop a telephone hotline system. In such a system, receptor locations identified as susceptible to shadow flicker could be provided with a specific number by which they could connect to project staff at the operations and maintenance facility, to request temporary turbine shutdowns at times when shadow flicker was troublesome. The viability of this option with respect to project operational costs, logistical feasibility and flexibility appears to be uncertain at best. If such a system were to be included in the terms of a development agreement, Kittitas County would need to take responsibility as the initial point of contact for such calls. Given the short duration of most shadow flicker events and the

early-morning and late-afternoon times at which they would occur, it is likely that the shadow flicker event would have ceased by the time an operational response could be made.

Several practical options exist for controlling or preventing shadow flicker at the receptor location, rather than at the source. Because shadows are fainter in a lighted room, switching lights on in a dark room will lower the intensity of shadow-flicker in a room during the times shadow-flicker occurs. Similarly, covering a window with curtains, blinds or shutters will prevent shadow flicker from occurring within the room. Depending on site-specific conditions, it might also be possible to block shadow flicker by planting trees between affected windows at the receptor locations and the turbines capable of causing shadow flicker. Consequently, an alternative set of mitigation measure would be for the applicant to develop and implement a program including the following possible actions at affected receptor locations:

- distribute educational materials to potentially affected receptors with instructions on how to block or reduce shadow flicker, such as turning on lights in the affected room;
- provide and install curtains, blinds or shutters on windows at affected receptor locations; and/or
- plant trees at receptor locations where they could block or screen shadow flicker at affected windows.

3.8.6 Significant Unavoidable Adverse Impacts

All of the potential health and safety environmental impacts that derive from the electromechanical nature of a wind energy facility could be mitigated at the proposed site by prevention, establishment of safety zones and proper operating procedures. In particular, the potential health and safety impacts that derive from the possible mechanical hazards of a wind turbine (tower collapse, blade throw and ice throw) would be mitigated by incorporation of a 487-foot performance-based safety zone in the modified project layout. Therefore, the potential impacts could be mitigated to insignificant levels, and no significant unavoidable impacts would remain.

The potential health and safety impacts of the electrical facilities of the proposed project would be low, and similar to those from the existing electrical transmission and distribution lines in the project area. Nearby residents and other members of the public would be isolated from project electrical safety hazards, and would not experience elevated electric and magnetic fields associated with project facilities. Electromagnetic or physical interference with telecommunications is not expected to be significant, and could be resolved through mitigation if it occurred. Therefore, no significant adverse unavoidable impacts related to electrical systems would remain after mitigation.

The model analysis conducted for the shadow flicker issue indicated that the proposed project would be capable of causing shadow flicker for some time during the year at an estimated 65 residences near the project area. While these receptor locations would experience shadow flicker only under specific weather and wind conditions and for relatively limited daily durations, the affected individuals would likely consider these impacts to be significant. Shadow flicker impacts would represent a nuisance or annoyance effect; shadow flicker experienced in the vicinity of the project is not expected to result in adverse public health or safety consequences. Mitigation measures are available that would drastically reduce or eliminate the shadow flicker impacts. Therefore, with mitigation, the proposed project would not create significant unavoidable health and safety impacts associated with shadow flicker.