

Report to Canadian Wind Energy Association

An Introduction to Wind Energy Development in Canada

Prepared By:



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1.0 INTRODUCTION

The Canadian Wind Energy Association (CanWEA) has developed *An Introduction to Wind Energy Development in Canada* (document) to assist wind energy developers in identifying and addressing practical issues associated with wind energy developments in Canada. This document is intended to provide broad information to the general public and government representatives regarding how wind energy developments are located, and some of the general areas that are evaluated and assessed when planning, developing and operating wind energy projects. The information presented in this document is not intended to be a checklist, nor is the document designed as a stand-alone resource. It should be used in concert with other resources, many of which are listed on the CanWEA website (www.canwea.ca) or are referenced in this document, and in addition to qualified professional advice.

The potential involvement of multiple levels of government—federal, Aboriginal Peoples, provincial/territorial, municipal—coupled with the wide range of wind energy project sizes, land tenure arrangements and project ownership configurations can create a complicated development pathway. There are many factors that influence the location, and ultimately the viability of a modern wind energy development. Five basic requirements that must be met for any successful wind energy project are:

- Availability of a sufficient wind resource to justify the investment;
- Access to land to host the wind energy development;
- Broad support within the host community;
- Access to transmission capacity that will carry the power to the grid; and,
- A customer for the power produced.

While these are necessary conditions for wind energy project development (and there are numerous locations that meet these conditions across Canada), they are not sufficient to ensure that wind energy projects will be developed sustainably and responsibly.

Wind energy developers must seek out and obtain numerous permits and approvals that are designed to ensure that projects are economically viable, socially acceptable and environmentally sustainable. This document focuses on the issues that typically are addressed by all wind energy projects in different permitting and approval contexts. This document is meant to provide an overview of these issues and, at a general level, to describe how these issues are studied and addressed in wind energy developments. It is CanWEA's intention that this document will provide a broad stakeholder group (government officials, regional planners and municipal officials and the broader public) with greater insight into the issues that often are considered and addressed when seeking approval for a new wind energy development, and the actions the wind energy industry commonly undertake to ensure that wind energy development projects can be permitted, approved, constructed and operated in a responsible and sustainable manner.

Respectful community consultation, public outreach, and Aboriginal Peoples engagement are critical components of successful wind energy development in Canada. In recognition of the importance of these critical issues, CanWEA has developed Best Practices for Community Engagement and Public Consultation (CanWEA 2011; www.canwea.ca/pdf/canwea-communityengagement-report-e-final-web.pdf). The practices outlined in this guide are an important part of the wind energy development and siting process.

2.0 WIND ENERGY BASICS

2.1 OVERVIEW OF DEVELOPMENT PROCESS

This document is focused on large-scale, land-based wind energy development, generally composed of multiple, 1 megawatt (MW) or greater individual wind turbine generators. A wind energy development generally is designed to generate wholesale electricity to utilities or an electricity market. Individual wind turbines are connected to one another and to a substation via an electrical collection system. The substation is connected to the electrical transmission or distribution system at a point of interconnection switch yard. Wind energy projects are generally developed, owned and operated by utilities, communities or independent power producers, who traditionally sell their power to electric utilities or into deregulated energy markets.

Although most wind energy developments follow a standard set of preliminary steps, it is important to note that the process often varies depending on the developer, the size and location of the project, the regulatory jurisdiction, lender requirements, and other factors. Some of the steps mentioned below are beyond the scope of this document but are introduced briefly in this section to provide a broader context for overall wind energy siting considerations in the larger decision-making process.

2.2 SITE IDENTIFICATION

A site may be identified for further investigation if there are initial indications that the location has an adequate wind resource, sufficient land area, and the potential to connect to the transmission or distribution grid. At this stage, a developer may conduct preliminary site characterization activities to determine the suitability of the site. Preliminary site characterization activities also can be useful for performing an alternatives analysis of multiple potential sites. Some examples of steps involved in this initial stage include, in no particular order:

- **Wind Resource Analysis** – A developer will hire a meteorology firm or use in-house expertise to review the available wind data to determine the wind speed and reliability within the proposed development site. Site-specific information should be collected and generally is obtained through meteorological towers and for remote sensing equipment (Light Detection and Ranging [LIDAR] or Sonic Detection and Ranging [SODAR]) installed within or close to the development site. From study inception, this process takes at least one year, and typically is conducted over an 18-month to 36-month period.
- **Transmission Feasibility Analysis** – A developer must determine if the existing transmission system has the capacity to support the proposed development and to locate the lowest cost point of interconnection. A developer may hire a consultant or use in-house expertise to work with the local independent system operator, regional transmission operator, or utility to conduct a transmission capacity analysis. A developer should also determine the interconnection requirements and process, schedules and budget for the proposed wind energy development.
- **Initial Economic Feasibility Analysis** – A developer will determine whether the project has the potential to be economically viable. This typically involves the identification of the expected internal rate of return of the development, which is a rate of return used in capital budgeting to measure and compare the profitability of investments. Another important issue to consider as part of this economic analysis is a screening for constructability. This screening can provide important information regarding, among other things, site access, potential construction methods, and ground suitability. The preliminary cost estimates derived from this screening can then be incorporated into the economic feasibility analysis. This analytical step is dependent upon a developer's business model, and is thus highly variable.
- **Preliminary Site Assessment** – As part of the initial development screening process, a developer may hire an environmental engineering firm to conduct a preliminary site assessment (alternatively called critical issues analysis or fatal flaw analysis) in order to better understand the possible engineering, environmental and land use constraints in the development area (Section 4.1). Some developers may choose to perform this site assessment prior to or simultaneously with other screening and feasibility efforts in an attempt to avoid expending effort in exploring a site that is undevelopable for environmental, social or cultural reasons.

- **Permit Plan Development** – Regulatory requirements may vary depending on project location and size, as well as the resources affected by the proposed development. A developer must identify the federal, provincial, and local regulatory requirements that apply to the project early in the development process. This step is often conducted in conjunction with the preliminary site assessment described above.
- **Phase I Environmental Site Assessment** – During the early stages of a project, some developers may perform a Phase I Environmental Site Assessment (ESA) to assess potential sources of environmental liabilities associated with the project area and adjoining lands. In Canada, CSA Standard Z768-01 is used to conduct Phase I ESA due diligence investigations on properties.
- **Public Acceptability Assessment** – Effective community engagement and public consultation are cornerstones for a successful wind energy development. The public outreach process is best initiated in the early stages of development and maintained throughout the entire development process and operation. CanWEA produced *Best Practices for Community Engagement and Public Consultation* (www.canwea.ca/pdf/canwea-communityengagement-report-e-final-web.pdf) that provides early stage public acceptability assessment guidance.

2.3 SCALE

There are two scales of wind power that are commonly recognized in Canada: large-scale and small-scale wind energy developments. Large scale includes commercially operated wind energy developments that typically have a capacity greater than 300 kW. CanWEA defines Small Wind energy as “a wind energy conversion system consisting of a wind turbine, a tower, and associated control or conversion electronics, which has a rated capacity of not more than 300 kW, and which is intended to provide electrical power for use on-site (either behind the meter or off-grid) and generally is not intended or used to produce power for resale” (Rhoads-Weaver et al. 2006). There are mini turbines (with a rated power output from 300 - 1000 W), small wind turbines (above 1 kW to 30 kW), and medium wind turbines (above 30 kW to 300 kW). These turbines are less than a third of the height of a typical large-scale wind turbine. Small Wind projects can be used for a range of purposes from supplementing a percentage of a home or business’ energy use to powering a small community of several houses or a campus of commercial users. Generally speaking, Small Wind projects have a less rigorous siting process than larger-scale wind energy developments. However, installation of a Small Wind system remains a significant investment and requires research and planning to be optimally successful. CanWEA has developed a Small Wind step-by-step planning guide (www.canwea.ca/swe/planning.php?id=3). The guide provides information on assessing whether Small Wind is a viable option, if incentives are available, how to select a turbine technology, whether to connect to the grid, how to go through the siting and permitting process, and what to expect during installation and operations.

While wind energy projects are often developed by utilities and independent power producers (i.e., non-utility generators), local communities may also be involved in the development of large- or small-scale wind energy projects. CanWEA defines community wind projects as projects that are locally owned by landowners, farmers, investors, businesses, schools, utilities, or other public or private entities and optimize local benefits. Local community members must have a significant, direct financial stake in the project beyond land lease payments and tax revenue. Community wind energy developments may be small or large in scale, but typically consist of a single turbine or a small cluster of turbines.

2.4 COMPONENTS OF A WIND ENERGY DEVELOPMENT PROJECT

Modern wind energy developments consist of: wind turbines mounted on towers supported by deep foundations, an electrical collection system, transmission/interconnection facilities, public road improvements and access roads, operations and maintenance (O&M) buildings, and temporary and permanent meteorological towers. In addition, it is important to consider temporary construction workspace and component storage, as well as construction spoil material handling and disposal when planning the space and permissions required for a wind energy development.

Wind Turbines

A wind turbine consists of three major mechanical components: tower, nacelle, and rotor (*Figure 1*). Wind turbines require a foundation typically constructed of concrete and rebar; the type of foundation, spread footing or deep pile, is dependent on local geology and terrain stability (*Figure 2*).

Electrical Collection System

Electricity produced by each wind turbine is transferred to a transformer located in the nacelle or adjacent to the base of the turbine to raise the voltage of electricity produced by the turbine to the level required by the collection system. The electrical collection system consists of underground and/or overhead cables that carry electricity from and within groups of wind turbines and transport it to a substation where the voltage is often stepped up again, and to a point of interconnection switchyard, where the electricity generated by the project is transferred to the grid.

Public Road Improvements and Access Roads

Transportation loads for wind turbine components and construction equipment are often longer, wider and heavier than some rural public roads were designed to handle. As a result, some wind energy developments may require public road improvements prior to the delivery of turbines. In addition, new access roads running from the public roads to turbine locations must be built for every wind energy development. These roads are used for construction and for service access during operation.

Operations and Maintenance (O&M) Buildings

Wind energy developments generally require O&M buildings for monitoring project operations and storing equipment and supplies required during operation. O&M buildings can be located on- or off-site and some include control functions such as the supervisory control and data acquisition (SCADA) system.

Temporary and Permanent Meteorological Towers

Meteorological towers, or wind measurement systems, include three major components: 1) anemometers, which are sensors that measure wind speed and direction, 2) a data logger, and 3) a meteorological mast (*Figure 3*). These towers may be temporary to assess the wind resource prior to the development of a project, or permanent to assist in operation of the development by transmitting information about wind speed and direction to each wind turbine and to the control facility. In Canada, meteorological towers may require a permit from Transport Canada, depending on the tower height, which describes requisite marking or lighting.

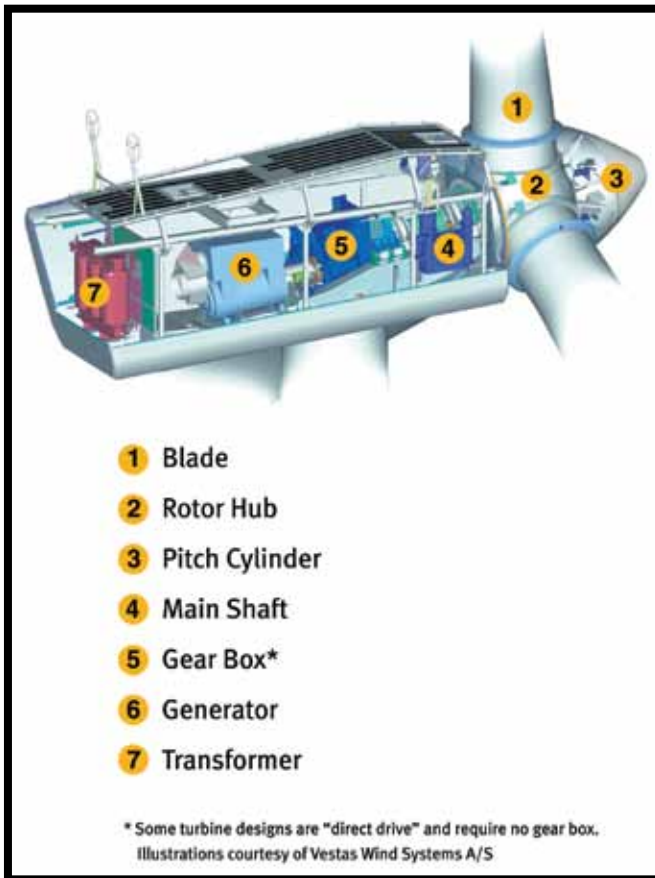


Figure 1. Major wind turbine component parts.



Figure 3. Meteorological tower. Image courtesy of Zephyr North Limited.



Figure 2. Example of a foundation. Image courtesy of Don Pettit, Peace photoGraphics.

3.0 GENERAL REGULATORY CONSIDERATIONS

3.1 FEDERAL AND PROVINCIAL JURISDICTIONAL RESPONSIBILITIES

The Constitution of Canada establishes the division of powers between the federal government and the provinces and territories. Among other things, the federal government has the authority to regulate activities pertaining to Crown land, international trade and commerce, certain environmental issues (e.g., air quality, fisheries), transportation (e.g., air navigation systems), and land under treaty rights or land claims. When wind energy development affects any of these areas, federal regulations may be triggered. The provinces and territories in Canada have primary jurisdiction over electricity, most natural resources, and property and civil rights. Most commercial activity relating to wind energy development will be regulated by the provinces and territories.

In Canada, the environmental approval process is composed of two important and separate steps: environmental assessment (EA) and regulatory permitting. Provincial and territorial governments have substantial EA requirements and processes and, largely due to their jurisdictional authority over electricity and most natural resources, the provincial processes typically take precedence over the federal process. In general, provincial and territorial EAs follow a similar framework to the federal process; however, describing these processes in detail is beyond the scope of this document. Several provinces have cooperation agreements with the federal government that, in theory, are designed to help streamline the EA process and minimize duplication of effort. In practice, however, the federal and provincial EA processes tend to remain distinct from each other.

Regulatory permitting follows federal and provincial approval of their respective EAs and includes the submission of specific documents and applications to acquire necessary construction and operations approvals. Although the actual submission of the permit applications cannot occur until after the finalization of the EA, it is important to understand the permit requirements early in the development process to minimize the potential for schedule delays and unnecessary expenditures. These permits and approvals are provided by a wide range of organizations within federal, provincial and municipal governments, as well as electric utilities and system operators, and as a result vary widely among jurisdictions. Although this document does not discuss these permits and approvals in exhaustive detail, it does strive to identify key statutes and regulations (and the agencies responsible for them) as a guide through the environmental approval, permitting, and wind energy development process.

3.2 REGIONAL AND MUNICIPAL JURISDICTIONAL RESPONSIBILITIES

Municipal governments have a wide variety of regulatory authority, which can include building permits or the enforcement of noise by-laws. Some provinces have regional management agencies (e.g., Conservation Authorities in Ontario) that have limited but important jurisdictional responsibilities and mandates. It is incumbent upon a developer to understand how regional- and municipal-level regulations interact with federal and provincial regulations for a proposed wind energy development.

4.0 EFFECT ANALYSIS

4.1 SITE ASSESSMENT AND CONSTRAINTS MAPPING

Early in the siting and development process, developers typically conduct a preliminary site assessment to assess site suitability from an environmental, engineering, regulatory, and constructability perspective. The site assessment is a desktop review performed by professionals with expertise in various disciplines. It is very useful to supplement the desktop review with a site reconnaissance visit to verify the quality of the desktop information. If completed by a third party, a site assessment report may be prepared documenting the results and providing recommendations for next steps in the development process. Developers can then use this report to determine whether to proceed with project development. The report can be used to develop plans, schedules, and budgets for conducting additional studies and to obtain permits and approvals. Site assessment reports also may be reviewed by potential project partners, investors, or purchasers as part of their project due diligence.

Examples of components of a typical preliminary site assessment include:

- Community demographics and socioeconomics;
- A permit matrix with jurisdictions, schedules, and required information;
- Biological resources including, but not limited to:
 - Federally and provincially listed threatened and endangered species as well as species of conservation concern
 - Sensitive areas (e.g., Important Bird Areas)
 - Protected areas (e.g., National Wildlife Areas)
 - National, provincial, and local parks
 - Migratory and resident birds (including raptors)
 - Migratory and resident bats (including known bat caves in project proximity)
 - Vegetation communities
 - Wetlands, waters, and floodplains
 - Wildlife habitats
- Aboriginal Peoples' interests and considerations;
- Cultural, archaeological, and historical resources;
- Land development constraints (e.g., noise limits, zoning considerations);

- Community facilities and services (e.g., location of parks and schools);
- Visual and aesthetic concerns;
- Telecommunications interference;
- Aviation concerns;
- Engineering considerations (e.g., slope, subsurface conditions);
- Transmission access and capacity/interconnection issues; and,
- Constructability considerations (e.g., topography, transportation, adequacy of work space).

Once the requisite data has been gathered, a constraints map is produced. A constraints map depicts the developable project area and will aid in the development of the initial project layout (*Figure 4*). A well-executed constraints map will include environmental site characteristics (e.g., topography, land cover), land tenure characteristics (e.g., private versus public, easements), and recommended or mandated setbacks from infrastructure, existing uses, and protected resources. Constraints may be imposed by physical setbacks from:

- Non-participating landowner property boundaries;
- Sensitive buildings (e.g., occupied homes, schools, churches) and other structures (e.g., barns, garages, outbuildings);
- Roads, trails, and recreational areas;
- Existing energy infrastructure (e.g., transmission lines, oil and gas wells);
- Sensitive environmental and cultural resources;
- Airports or air traffic corridors;
- Shipping channels (for offshore development);
- Areas of known geotechnical instability; and,
- Communication towers or pathways.

Setbacks depicted on a constraints map primarily serve to inform the turbine layout. Not all setbacks will apply to all components of a development or will not apply to the same degree. For example, prohibitions for installing tall structures, such as wind turbines or transmission lines, typically do not extend to the siting of roads or collection systems.

If, after completing the initial site assessment and constraints mapping, a site is deemed feasible for further development, the typical next step is to perform detailed assessments of the identified critical issues. As part of these detailed assessments, it is important to simultaneously move forward in addressing regulatory and permitting requirements and schedules, which may require additional assessments previously not identified in the initial site assessment.

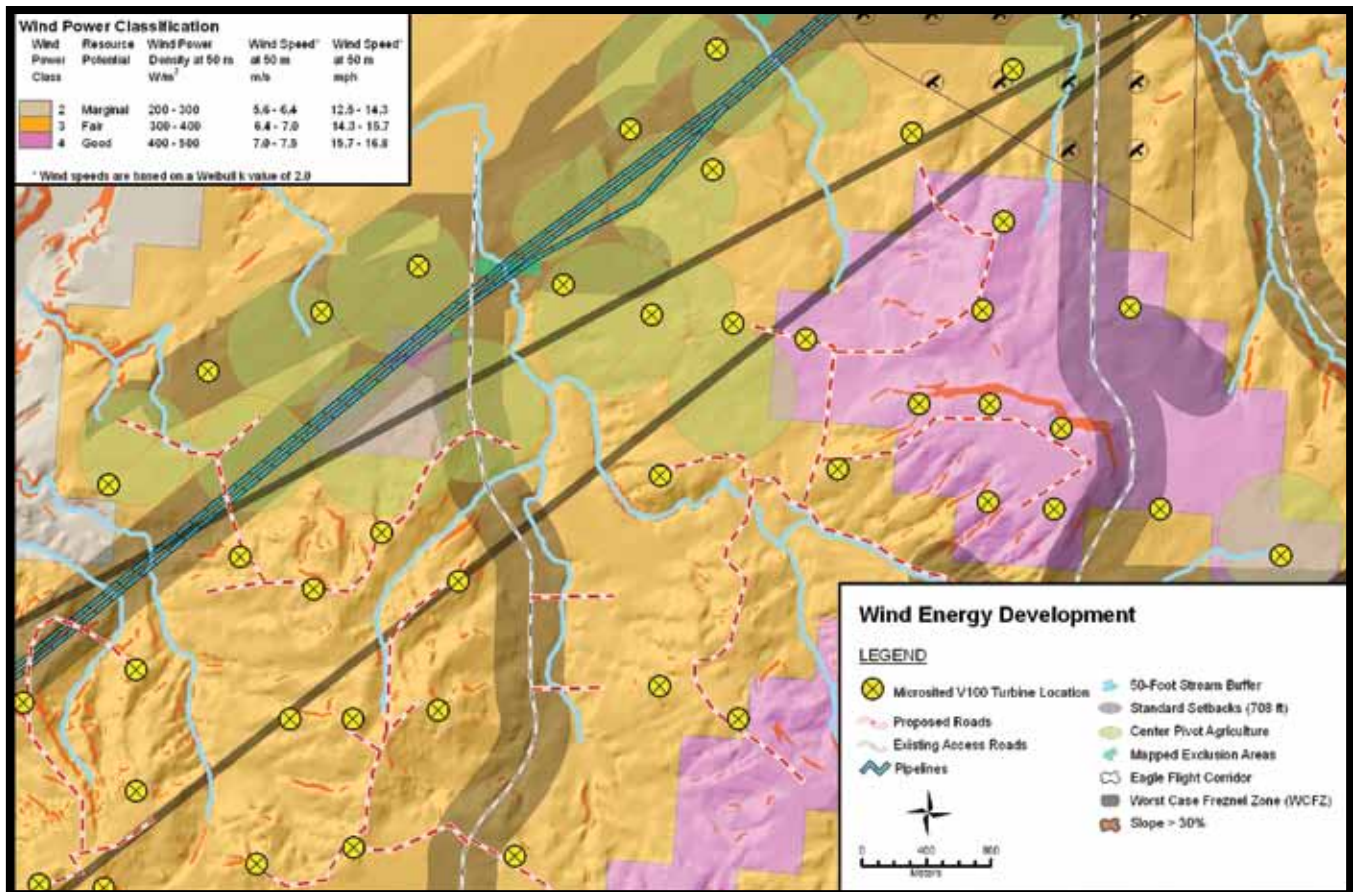


Figure 4. Hypothetical constraints map. Image courtesy of Tetra Tech.

4.2 WILDLIFE AND FRESHWATER FISH

4.2.1 PRE- AND POST-CONSTRUCTION MONITORING

The purpose of pre-construction monitoring is to assist the environmental assessment practitioner to identify, assess, and predict potential project-related risks to wildlife, wildlife habitats and vegetation. The studies needed at a particular project location often are dictated by permitting requirements and are refined through agency coordination and consultation. The general purpose of post-construction monitoring is to determine actual project impacts and, where required, to use this information to implement an adaptive management strategy; it may also be useful to guide the siting of future projects. Post-construction monitoring efforts at wind energy developments typically focus on mortality monitoring: standardized carcass searches at operational turbines designed to account for scavenger activity (i.e., the removal of carcasses from the project area by scavengers) and searcher efficiency (i.e.,

the proportion of carcasses available to be found that are actually found). In addition, post-construction monitoring activities may include the continuation of pre-construction surveys to assess their predictive ability and active monitoring of wildlife responses (e.g., disturbance or habitat avoidance) to an operational wind energy development.

Environment Canada and several provincial jurisdictions have developed standard protocols for pre- and post-construction wildlife monitoring that should be incorporated into the project development process. This includes following the protocols outlined in *Recommended Protocols for Monitoring Impacts of Wind Turbines on Birds* (EC 2007) and *Wind Turbines and Birds: A Guidance Document for Environmental Assessment* (EC 2006), both developed by the Canadian Wildlife Service. Additionally, provincial or territory-specific protocols, should be used where available; for example, Alberta's *Wildlife Guidelines for Alberta Wind Energy Projects* (ASRD 2006), Ontario's *Birds and Bird Habitats: Guidelines for Wind Power Projects* (OMNR 2010a), and British Columbia's *Inventory Methods for Forest and Grassland Songbirds* (RIC 1999). Several provinces have developed standard protocols for pre- and post-construction bat monitoring that should be

incorporated into the project development process. This includes protocols outlined in Ontario's *Bats and Bat Habitats: Guidelines for Wind Power Projects* (OMNR 2010b), Alberta's *Bats and Wind Turbines. Pre-siting and pre-construction survey protocols* (Lausen et al. 2008), and British Columbia's *Inventory Methods for Bats* (RIC 1998).

Bird Studies Canada has led an effort (in collaboration with Environment Canada and CanWEA) to create a Wind Energy Bird and Bat Monitoring Database (www.bsc-eoc.org/birdmon/wind/about.jsp). The broad objectives of this collaboration are to improve our understanding of the potential impacts of wind energy development on birds and bats, to improve data collection consistency, and to inform refinements of the EA process. This collaboration follows in the spirit of other collaborations among the wind industry, government agencies, universities, and non-governmental organizations, such as the American Wind-Wildlife Institute (www.awwi.org) and the Bats and Wind Energy Cooperative (www.batsandwind.org).

4.2.2 REGULATORY CONSIDERATIONS

Provincial and territorial regulations that govern wildlife and fisheries resources vary among jurisdictions. As with the EA process (Section 3.1), provincial and territorial wildlife statutes typically are the primary drivers relative to federal statutes, with the exception of the federal *Fisheries Act*. One of the main considerations is to understand the scope and authority of a province or territory's endangered species legislation. Some provinces (e.g., Ontario) have enacted endangered species legislation with associated protections; others have developed lists of provincial species at risk but rely on the federal *Species at Risk Act* (SARA) or other provincial statutes to afford protection (e.g., British Columbia's *Wildlife Act*). Understanding the interaction between federal and provincial wildlife regulations and among provincial wildlife statutes early in the development process is recommended.

Federal regulations that should be considered include the *Fisheries Act*, SARA, and *Migratory Birds Convention Act, 1994* (MBCA). Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat in Canada. Under section 35(1) of the federal *Fisheries Act*, works that result in the harmful alteration, disruption or destruction (HADD) of fish habitat must be authorized in advance by DFO. If a DFO Authorization is required, it can take anywhere from one month to several years to obtain an Authorization, depending on the type of approval required, the complexity of the project, and any associated field studies. Other project activities (e.g., construction of crossing structures [culverts] through fish

habitat, any work in or about a fish-bearing watercourse that may disturb, alter or destroy fish habitat) will require an Authorization under the *Fisheries Act* if they result in a HADD.

Section 6 of the Migratory Bird Regulations (under the MBCA) prohibits the disturbance, destruction, and taking of a nest or egg of a migratory bird. Under the current Migratory Bird Regulations, no permits can be issued for the incidental take of migratory birds caused by development projects or other economic activities.

Under Section 32 of SARA, it is prohibited to kill, harm, harass, capture, take, possess, collect, buy, sell or trade an individual (or any part of an individual) of a wildlife species that is listed as endangered, threatened, or extirpated (see www.sararegistry.gc.ca for a current species list). It is also prohibited under Section 33 of SARA to damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered or a threatened species. In general, the prohibitions under SARA only apply on federal lands, but are always applicable to aquatic species and birds that are protected under the MBCA, regardless of location.

4.2.3 WILDLIFE HABITAT AND VEGETATION

The construction and operation of a wind energy development can affect wildlife habitat in three general ways. First, wildlife habitat can be lost. Habitat loss can occur as a direct result of project construction and can be quantified as the habitat permanently converted to the development footprint. The permanent development footprint consists of all access roads, turbine pads, substations, operations and maintenance facilities, right-of-way under the transmission line, and any other ancillary facilities. Habitat loss can also occur as a result of avoidance behaviours; if wildlife avoids an operational wind energy development, then any habitat within a given species' avoidance or tolerance zone could be considered lost to that species.

Second, wildlife habitat adjacent to an operational wind energy development can be altered by the presence of the development. Examples of habitat alteration pathways include the introduction of non-native plant species during construction and maintenance and the alteration of hydrological regimes as a result of road construction and changes to surface water permeability (e.g., gravel roads and turbine pads).

Third, project features can fragment wildlife habitat. Habitat fragmentation is the process by which, contiguous habitat patches are converted into smaller, less connected patches. In particular, linear project features (e.g., roads,

power lines) can have significant fragmentation effects; the significance of these effects is dependent on the specific habitat fragmented and the species present. Habitat fragmentation effects are manifested in three inter-related ways. One, species with specific habitat area requirements may no longer be able to persist in the smaller habitat patches and may be unwilling to cross newly created gaps between habitat patches. Two, individuals of species unwilling to cross patches of land that are not their normal habitats will be separated from other individuals of the same species, effectively reducing both population size and reproductive potential. Three, the introduction of roads into previously unbroken environments can create the potential for edge effects (e.g., predators using roads as travel corridors).

As with wildlife habitat loss, potential impacts to vegetation communities and rare plants are proportional to the size of the permanent development footprint, as well the type and amount of pre-existing disturbances. For example, in forested regions, selective tree clearing may be required prior to project construction and on-going maintenance requirements (e.g., preventing excess growth in transmission corridors). The timing and need for tree trimming and clearing should be evaluated in a wildlife and vegetation community context. Finally, the growth of invasive or weedy plant species that thrive in disturbed areas may compound project effects.

Once a general understanding has been developed of which wildlife species and vegetation communities are present in the vicinity of a proposed wind energy development and what their sensitivities and habitat preferences are, a strategy to minimize the potential effects of habitat loss, alteration and fragmentation can be developed. Two successful minimization strategies include appropriate project siting at both the macro (e.g., selection of project area; Kiesecker et al. 2011) and micro (e.g., turbine and road layout adjustment) scales, as well as the adoption of construction and operation best management practices designed to minimize project effects (e.g., development and implementation of an invasive species management plan).

4.2.4 BIRDS

Collisions

Birds have been identified as a wildlife group at risk because of documented collisions with wind turbines and power lines (Erickson et al. 2005, Drewitt and Langston 2006, Arnett et al. 2007). In particular, migrant songbirds (specifically nocturnal migrants) are found more often during post-construction mortality monitoring than are other bird groups (Erickson et al. 2001, Johnson et al. 2002, Drewitt and Langston 2006, Arnett et al. 2007, Strickland and Morrison 2008). Despite the relative

abundance of songbirds among fatalities, a very small proportion of the total migratory songbird population is affected; a combined analysis of radar bird passage data and mortality monitoring data suggests that less than 0.01 percent of migrant songbirds that pass over operational wind energy developments are killed (Erickson 2007). As a rule, songbirds breeding in the vicinity of an operational wind energy development tend to experience lower mortality rates than do migrants, largely as a result of spending less time flying at turbine rotor swept heights. Documenting the presence of species whose behaviours (e.g., commuting among resource patches) may place them at particular risk of turbine collisions is a critical step in the pre-construction assessment process.

Raptor mortality at wind energy developments with newer generation turbines is much lower than the mortality observed at previous generation developments, although there is substantial regional variation (Erickson et al. 2002, 2004, Johnson et al. 2002, Kerns and Kerlinger 2004, Barclay et al. 2007, Jain et al. 2007). However, as mortality has not been eliminated by advances in turbine technology (e.g., turbine height, tower structure), local micro-siting, site evaluation efforts and the adaptive management of operational parameters remain critical components of responsible wind energy development practices.

In addition to collisions with operational wind turbines, birds can also collide with transmission and distribution lines. In particular, large-bodied birds, such as geese and cranes, appear prone to colliding with power lines (e.g., Brown et al. 1992, Janss and Ferrer 2000, Drewitt and Langston 2006, Martin and Shaw 2010). The majority of newer generation wind energy facilities bury at least part of their electrical collection systems, thereby reducing the potential for collision within the boundaries of the development. For above-ground power lines, collision risk can be minimized through a combination of micrositing (e.g., avoiding habitats utilized by collision-prone species), installation of bird diverters on lines, increasing the spacing between lines, and altering the placement of non-conducting groundwires (Brown and Drewitt 1995, Janss and Ferrer 1998, APLIC 2006).

Displacement

Concerns have been raised that some bird species may avoid areas near turbines and other project facilities once a wind energy development is operational (e.g., Drewitt and Langston 2006). Such a behavioural displacement would result in the functional loss of any habitats within the avoidance area. Several studies have presented observations that the activity, density and abundance of birds is lower in the vicinity of operational wind energy developments than it is in the surrounding landscape (e.g., Leddy et al. 1999, Larsen and Madsen 2000; but see Devereux et

al. 2008). Additional studies have highlighted the potential displacement effects of other anthropogenic structures (e.g., roads, power lines; Pitman et al. 2005, Lammers and Callopy 2007, Pruett et al. 2009) highlighting the need to assess the potential effects of all components of an operational wind energy development, and not just the wind turbines themselves. The assessment of a potential displacement effect has been hampered by a lack of data collected before the construction of a wind energy development to establish a comparative baseline and a relative lack of long-term post-construction data that would allow for an assessment of whether these potential effects are temporary or permanent.

Electrocution

Large birds can be prone to electrocution at transmission and power lines because their wingspans are large enough to span the distance between energized transmission components (Harness and Wilson 2001). The majority of electrocutions occur on lower-voltage distribution lines, presumably because of the narrower clearance between conductors on these lines compared to larger, higher-voltage transmission lines. Electrocution risk can be minimized with many of the same strategies implemented to reduce collision risk. In addition, simplification of pole structure (e.g., limiting the number of auxiliary devices such as fused cutouts and capacitors) and improved insulation techniques can reduce the potential of electrocutions (APLIC 2006, Lehman et al. 2007). Research into the effectiveness of perch deterrents has yielded equivocal results (Harness and Garrett 1999, Janss 2000, Dwyer 2004), highlighting the need for additional studies.

4.2.5 BATS

Wind energy developments have experienced varying levels of bat mortality (Kunz et al. 2007), both as a result of direct turbine strikes and from barotrauma (Baerwald et al. 2008). In contrast to bird mortality patterns, bat mortality appears to be higher at newer generation developments (Barclay et al. 2009). Species with the highest risk of fatalities at wind energy developments appear to be tree, foliage, or cavity roosting migratory bats (Kunz et al. 2007, Arnett et al. 2008, Baerwald 2008, Baerwald and Barclay 2011). Nearly 75 per cent of all bat fatalities have been associated with migratory tree bats including hoary bat (*Lasiurus cinereus*), eastern red bat (*Lasiurus borealis*) and silver-haired bat (*Lasionycteris noctivagans*). Migratory bats travel long distances at altitudes occupied by wind turbine blades, making them susceptible to collisions. Several variables may contribute to the fatalities of bats at wind energy developments including, but not limited to, biology of the bat species, season, region, and turbine

design (Kunz et al. 2007). For example, the probability of mortality events increases on nights with low wind speeds (<6 m/s) and immediately before and after passage of storm fronts (Arnett et al. 2008, Baerwald and Barclay 2011).

There is a seasonal trend with bat fatalities at wind energy developments, with spikes occurring in the late summer and early autumn which coincide with fall migration or dispersing juveniles that may be more prone to collisions with structures (Johnson 2004, 2005; Kunz et al. 2007). There are geographic differences in fatalities among bat species, with the highest number of fatalities being reported along forested ridges in the eastern United States (Arnett et al. 2008, Baerwald and Barclay 2009). However, bat fatalities have been reported from the agricultural regions of northern Iowa (Jain 2005), the mixed-grass prairie of north-central Oklahoma (Piorkowski and O'Connell 2010) and the grasslands of south-western Alberta (Baerwald and Barclay 2009, 2011). Therefore, caution must be taken in assuming that only developments in forested and mountainous areas have the potential to produce high numbers of bat fatalities because of the relatively small number of studies with publically available data and the possibility of other regions being underrepresented.

As with birds, project siting can be an important way to avoid or minimize effects on bats. Projects and turbines should be located away from areas likely or known to be used by large numbers of bats (e.g., caves, roosting aggregations), and consideration should be given to avoiding habitats frequented by bats (e.g., open water, riparian habitats). In addition to siting considerations, several innovative options to minimize or mitigate potential impacts to bats are available to developers. For example, the observations that (a) bats tend not to fly when wind speeds exceed 6 m/s and (b) bats do not collide with turbine towers or non-spinning turbine blades (Horn et al. 2008a) led researchers to hypothesize that increasing the wind speed at which turbines begin generating power (i.e., the turbine cut-in speed) might reduce bat fatalities. This hypothesis has been supported by experimental data collected in Alberta (Baerwald et al. 2009) and Pennsylvania (Arnett et al. 2011). Other minimization strategies currently under investigation include the use of deterrent devices to create acoustic environments in which bats do not want to fly (e.g., Horn et al. 2008b) and investigations into the role that turbine colour may play in attracting insects (and, therefore, bats) to spinning turbine blades (e.g., Long et al. 2010).

4.2.6 OTHER WILDLIFE AND FRESHWATER FISH

In addition to potential habitat-related effects (Section 4.2.3), wildlife species other than birds and bats (e.g., terrestrial mammals, amphibians, reptiles) can be affected by project development in several ways: collisions with construction, operations, and maintenance vehicles; disturbance resulting from project operations (e.g., shadow flicker mimicking shadows of predators of small mammals); displacement as a result of project avoidance; and new roads acting as travel corridors for predators.

The creation of new roads and the upgrading of existing roads will increase the potential for vehicle collisions with wildlife, both as a product of roads traversing previously unbroken areas and of increased travel speeds along upgraded roads. The application and enforcement of project road speed limits, coupled with worker education on wildlife and road issues, can greatly reduce the potential for these impacts. The creation of new roads also can lead to increased access to formerly inaccessible areas for hunters, poachers, and tourists.

The primary concerns for ungulates and large carnivores are that wind energy developments may disrupt migratory movements among seasonal use areas or may prevent the use of an important habitat as a result of a species' disturbance sensitivity. Studies conducted at Foote Creek Rim in Wyoming documented no measured displacement effects of pronghorn antelope that use the site year round (Johnson et al. 2000), and a study of elk in Oklahoma indicated no adverse effect (Walter et al. 2006); it is important to note that the latter study focused on a non-migratory population of elk that was living in an already highly disturbed landscape. Studies focused on other forms of energy development suggest that negative effects are possible. For example, Sawyer et al. (2006, 2009) have documented displacement and local population declines of mule deer in relation to natural gas facilities. Strategies to avoid and minimize effects to large mammals include careful project siting and timing of construction or maintenance activities (e.g., road building, turbine erection, component replacement) to avoid periods of high wildlife use. The wind industry continues to research this area to improve the understanding of possible effects on ungulates and large carnivores.

Wind energy development can have direct and indirect effects on amphibians, freshwater fish and fish habitat, and water quality during construction and operation. Stream crossings developed to access and operate a wind energy development can result in the loss of fish habitat during

construction, the loss of riparian cover, and the deposition of sediment into waterbodies from surface erosion of disturbed areas. Stream crossing structures can alter the hydraulic regime of waterbodies and wetlands resulting in impoundment upstream, erosion of stream banks downstream, and restrictions to fish passage. These effects can be mitigated through the proper sizing of crossing structures or avoided by installing clear-span structures. Roads can also lead to fragmentation and dewatering of wetlands. Sediment control methods such as silt fencing and soil bioengineering can be installed and maintained until a permanent vegetation cover has established and the disturbed areas have stabilized. Wetlands should be avoided if possible but, if not, equalization culverts should be installed and road grades should be sufficient to avoid the need to dewater wetlands. Access roads can result in sediment deposition from road dust and maintenance activities during the operation phase. These effects can be mitigated by avoiding direct connections between the road drainage ditches and waterbodies. Drainage ditches can be directed into surrounding vegetation to disperse the flow energy and to allow the sediment to settle-out of the water. Spills of deleterious substances can be avoided through the development and implementation of a spill prevention and response plan. Roads also provide public access to waterbodies which can result in increased fishing pressures. Where possible, roads should be gated and access to potential parking areas near waterbodies should be blocked.

4.3 WATER RESOURCES

4.3.1 REGULATORY CONSIDERATIONS

The federal government has protective powers of water pertaining to federal lands, fisheries, navigation, and international relations. These powers include responsibilities related to the management of boundary waters, agriculture, health, environment, supporting aquatic research and technology, and ensuring national policies are in place on environmental and health-related issues. On federal lands, the Government has committed to “no net loss” of wetlands (Government of Canada 1991). In practice, however, federal responsibilities only cover a small proportion of Canadian surface waters and wetlands. As a result, most regulatory responsibility for water is provincial in nature. Furthermore, many provinces have either legislation mandating the protection of surface waters (e.g., British Columbia *Water Act*, Alberta *Water Act*) or provincially developed wetland guidance (e.g., Saskatchewan Water Policy) or both. All waters released from a site must comply with federal, provincial, or site specific criteria as identified during the permitting process.

Federal and provincial approvals, licenses or permits may require site-specific restrictions, water quality criteria or the creation of new wetlands or habitats as compensation. These can be required under both federal (e.g., fish habitat compensation plans) and provincial initiatives (e.g., the New Brunswick Wetland Compensation Program). Fish habitat, including fish-bearing wetlands, is protected under the federal *Fisheries Act* (Section 4.2.2; Government of Canada 1985a).

In areas where surface water is in low abundance, all potential sources of groundwater are protected under legislation against reduction of groundwater sources (e.g., in Alberta). This can limit both the land uses considered suitable for an area and the activities permitted (e.g., excavation) due to possible contamination, modification of, or reduction in groundwater amounts or flow. In particular, if blasting is required during construction, special attention must be paid to protecting groundwater resources.

4.3.2 SURFACE WATERS & WETLANDS

Surface waterbodies include lakes, rivers, streams, ponds and other bodies of water that can be seen or accessed above ground. Wetlands are lands that are saturated with water long enough to promote wetland or aquatic processes. These are characterized by poorly drained soils and hydrophytic vegetation and important wildlife habitat for organisms adapted to a wet environment (NWWG 1988). Fourteen per cent of Canada's total land area is covered by wetlands, over 1.2 million square kilometres (127 million hectares) (WCL 1993).

The construction and operation of wind energy developments have the potential to affect regulated surface waters and wetlands. For example, the creation of access roads could affect local hydrology, including alteration of drainage and flow into local wetlands. Identifying, defining, and mapping wetlands and surface water resources in the region of the proposed project area is often conducted as part of the preliminary site assessment and constraints analysis process. The habitat area for aquatic species of concern, animals that rely on wetlands (e.g., many migratory birds), size and amount of surface water, and wetlands in the project area can affect the economic viability of the development. Abundant surface waters and wetlands in a project area have the potential to affect the design, restoration/mitigation, economic and regulatory perspectives of the project.

Preliminary wetland identification typically occurs through desktop review and visual reconnaissance methods. Wetlands and surface waters can be identified using

general mapping review, provincial and national mapping databases, such as aerial photographs, the National Land Cover map, Surficial Soils map, Protected Areas maps, and provincial databases. These steps are recommended in the site assessment stage of a development; however, this type of desktop review does not substitute for site-specific field investigations. As development proceeds from conceptual to final design, delineation of wetlands may be required. Detailed field investigations that determine the type of wetland and its boundaries must be completed by a qualified individual; investigations also must comply with accepted or recommended methods as directed by federal, provincial and/or municipal authorities.

Mitigation and restoration practices may be required to reduce or offset effects from the project during construction, operation and closure. Examples of these practices include redesigning project facilities to avoid potential effects, special construction practices when working in or near wet areas, water quality sampling during operations, and wetland restoration. Development of a stormwater and erosion control plan often is required. Examples of special construction mitigation measures and best practices include, but are not limited to, fuel storage, handling, and refuelling restrictions, the use of wetland mats, silt fences and erosion control blankets, and corresponding water sampling. All practices must comply with accepted or recommended methods and practices as directed by federal, provincial or municipal authorities. Land use modifications, including the restoration of affected surface waters and wetlands, are regulated by provincial governments and must be implemented in accordance with provincial requirements. These may include the creation of new wetlands, enhancement of current systems, or restoration of affected wetlands.

4.3.3 GROUNDWATER

Groundwater is water that has infiltrated below the ground surface into the soil and rock. An aquifer is a subsurface seam of water-bearing permeable rock or unconsolidated gravel, sand, or silt from which groundwater can be extracted. Groundwater is an important part of the hydrological cycle and an integral component in the maintenance of surface waters, wetlands, and associated ecosystems (Government of Canada 2003). In addition to the importance of ground water to the environment, approximately one third of Canadians rely on groundwater for potable water, agriculture and industrial uses. Contamination of groundwater can impact both human health and environmental systems. Due to importance of groundwater to human health and the environment, groundwater should be protected from contamination, degradation and damage.

Identifying groundwater resources in the region of a proposed project area should be completed prior to siting a wind energy development. Important sources of groundwater can be identified either by desktop review or hydrogeologic investigation. Groundwater and groundwater wells in the region can be identified using provincial, federal, educational institutions, and local resources, such as general mapping review, provincial and national mapping databases, water well databases, hydrologic atlases, surficial and bedrock quadrangle maps, water resources investigations, and information generated by educational institutions.

Initial investigations of local hydrogeology to assess the potential impact on groundwater from wind energy development, construction and operation will aid in identifying (a) the need for project modifications and (b) which mitigation measures or best practices to employ during construction and operation. Spill response plans and waste management programs should be developed for the storage, use and handling of materials that may affect groundwater during the construction and operation of the wind energy development.

4.3.4 SOIL EROSION AND WATER QUALITY

Soil erosion is a natural process by which soil particles are moved by wind or water. Soil and contaminants can migrate off-site and into local water bodies, which can cause degradation of water quality and possible harm to aquatic wildlife, habitat and recreational uses, and can alter or create new drainage pathways. Potential effects on water quality from wind energy development should be taken into consideration prior to construction and operation, with a goal of avoiding or at least mitigating potential impacts to local water quality. A developer should engage a qualified individual to assist with early recognition of potential water quality effects.

Soil erosion prevention and control measures typically are required to reduce or offset effects from a project during the construction, operation and closure. These mitigation measures often are described in a stormwater and erosion control plan.

4.4 PUBLIC HEALTH, SAFETY, AND QUALITY OF LIFE

Potential impacts on public health, safety, and quality of life should be addressed early in the development process. If impacts cannot be avoided by project micro-siting, developers may need to create project mitigation or emergency

action plans in coordination with local officials. Effective mitigation and emergency plan development and implementation can ensure safe project construction and operation.

4.4.1 VISUAL

Concern over visual and aesthetic impacts of wind energy developments is a common point of contention. Perception of what constitutes a visual impact varies among communities and individuals, and can be influenced by the experiences, preferences and perceptions of the viewer, as well as the properties of the landscape. The aesthetic effect of wind energy developments may include effects on the scenic qualities of a landscape, particularly because wind energy developments are often situated on open or high elevation environments. The level of visual contrast (e.g., differences in line, colour, texture) between project facilities and the landscape, as well as the viewer's perception of the visual contrast, influences the level at which the development will be viewed as a visual intrusion on the landscape (Bishop and Miller 2007). The large size of newer generation wind turbines creates visual contrast, which can be further influenced by turbine spacing and number, uniformity, physical markings, location and layout of powerlines and substations, colour and materials used, lighting, nature of the background, and the orientation and proximity of viewpoints.

A visual impact assessment typically is completed as part of the early site assessment process. There are currently no standardized methods for visual impact assessments in Canada; however, individual jurisdictions may have regulations or best management practices. Visual impact assessments typically include characterization of the existing conditions, the extent of visual contrast, identification of qualities and visual sensitivities of a particular area, identification of site specific impacts and changes, and recommended mitigation and siting input. Computer simulations are often used as a tool in this process to show "before" and "after" visual representations of the proposed project. These simulations are used as the basis for determining the extent of visual contrast on the landscape and to gauge public perception of the alteration of a viewshed (*Figure 5*).

Early consultation and engagement with members of the public is essential in the visual impact assessment process. Community open houses and public information sessions are an opportunity for the public to identify locally significant landscapes, and historic and cultural resources (University of Guelph 2009). A visual simulation model can be an important tool for public consultation (Bishop and Miller 2007). Public concerns may be addressed to some extent through micro-siting and the creation of

aesthetic uniformity. Other mechanisms that may improve public acceptance include burying power lines, harmonizing structures (i.e., harmonize structure materials with those that have become an accepted part of the landscape), control erosion, avoid extensive mixed arrays to create aesthetic uniformity, and consider colour options to minimize visual contrast (Gipe 1995).



Figure 5. *Computer simulation of views shed before and after project development. Image courtesy of Shawn Jackson/Tetra Tech.*

4.4.2 SHADOW FLICKER

Shadow flicker occurs when the moving turbine blades cast shadows in direct sunlight. These shadows appear to flicker on and off as the turbine blades rotate. The magnitude of the shadow flicker effect is dependent on several environmental variables, such as the position and height of the sun, wind speed and direction, geographical location, cloud cover, and proximity of the turbine to a sensitive receptor (e.g., a residential property) (DECC 2011). Other variables include the turbine hub-height and rotor diameter, the time of year, and the position of the receptor relative to the turbine(s). Shadow flicker does not occur when cloud cover is high, when wind turbines are not operating, or when the sun angle is high relative to the landscape.

There is no evidence that modern wind turbines pose health risks related to shadow flicker. Individuals with photosensitive epilepsy (PSE), which occurs in 1 in 4,000 of the population, may be sensitive to flicker from rapidly rotating blades (e.g., the interruption of light by rotating helicopter blades) (Harding et al. 2008). Modern turbines typically rotate at a frequency between 1 and 1.75 Hz, which is below the flicker frequency that may trigger PSE (Harding et al. 2008). There is no evidence that shadow flicker has a negative impact on livestock.

Shadow flicker may be considered a nuisance by neighbours of wind energy developments. Currently, there are no provincial or federal regulations in Canada regarding shadow flicker. Shadow flicker analysis is completed using computer-based modeling and mapping. This analysis is performed during project development to calculate the flicker frequency, timing, and duration on a specific receptor. Some guidelines (e.g., WEA-Schattenwurf-Hinweise 2002) recommend that individuals are not exposed to shadow flicker for more than 30 hours per year, or 30 minutes per day, as an astronomical maximum. Following the analysis, mitigation measures such as increasing turbine setbacks or installation of window coverings and vegetative buffers can offset the effects of shadow flicker on residents living adjacent to wind farms. Turbine controls may also be employed to feather turbines on sunny days during the minutes of the morning and evening when they would otherwise cast offending shadows.

4.4.3 SOUND

There are two principal sound sources from an operating wind turbine: mechanical and aerodynamic sound. Mechanical sound is generated at the gearbox, generator, and cooling fan and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. Aside from upset conditions that may result in abnormal mechanical noise emissions, the dominant noise generating component of large-scale wind turbines is aerodynamic. Aerodynamic sound is related to air flow and the interaction with the tower structure and rotor blades when in motion. The typical “swoosh” that is often cited with wind energy is technically termed “amplitude modulation”, and occurs during the compression and decompression of air as the blades complete their rotations. Sound from a wind turbine is negligible when the rotor is at rest, typically increases with rotor tip speed, and generally is constant once rated power output and full rotational speed is reached. As an offset, as wind speeds increase, the background ambient sound levels likely will continue to increase by the normal sound of wind blowing through trees and around buildings, resulting in acoustic masking effects. The local wind profile and stability factor have been shown to have an effect on ambient sound and potential masking effects at certain times, generally under stable atmospheric conditions; the stability factor is commonly referred to as the wind shear value (van den Berg 2004).

Health effects from high sound levels can include speech interference and task interference (Colby et al. 2009). Additionally, prolonged, unprotected exposure to noise levels greater than 90 decibels presents a hearing loss risk.

This is in contrast to the low-level sound produced by wind energy developments at typical setback distances employed between wind turbines and sensitive receptors such as residences. As such, it is reasonable to conclude that there is no direct risk of hearing loss from exposure to wind turbine sound (Colby et al. 2009). Several studies have concluded that the levels of low frequency sound from wind turbines are negligible (Colby et al. 2009), and that at typical setback distances employed in siting large-scale wind energy developments, the low-frequency noise is theoretically below hearing threshold (Berglund and Hassmen 1996). In addition, the Chief Medical Officer of Health for Ontario concluded wind turbine noise has no direct effect on human health, when sited in accordance with provincial regulations (CMOH, 2010).

Annoyance is a subjective response that varies among people to many types of sounds. The level of annoyance may be strongly correlated to the sound characteristics (e.g., swooshing, whistling, pulsating) (Colby et al. 2009). Individual response to low-level wind turbine sound is not easily predictable and may depend on several technical and non-technical factors including, among other things, predetermined perceptions of the wind energy development, individual and community economic incentives, existing background sound levels, and the proximity of the listener to a single or grouping of wind turbines. Several studies have indicated that visual and/or aesthetic interference may influence noise annoyance (e.g., Pederson and Wayne 2004).

Many factors should be considered when evaluating wind turbine sound: source and receiver characterization, source directivity, screening by topography and obstacles, terrain complexity and ground effects, and influence of different meteorological conditions. Evaluation of wind turbine sound is often completed in the form of an acoustic modeling analysis. Depending on the project and regulatory requirements, a baseline sound survey may also be conducted to document the existing acoustic environment prior to project construction. In some instances, follow-up surveys may be required once the project is operational. Conducting a pre-construction survey of this nature can serve to protect nearby residents and the project itself by helping to isolate operational project sound. In addition to early site analysis and community engagement, establishing noise limitations can reduce the potential effect of sound produced by a wind energy development. For example, the Ontario Ministry of the Environment released *Noise Guidelines for Windfarms* (MOE 2008), which establishes sound level limits based on the type of area (e.g., rural); in Ontario, a Noise Assessment Report is prepared as part of the Environmental Screening Process. CanWEA has commissioned the development of

sound guidelines and best practices (HGC Engineering 2007 www.canwea.ca/images/uploads/File/CanWEA_Wind_Turbine_Sound_Study_-_Final.pdf) which provides additional information and guidance. This document is currently being updated, and a new version will be released October 2011.

4.4.4 ELECTROMAGNETIC FIELDS (EMF)

An EMF is a combination of an electrical field (created by voltage or electrical charge) and a magnetic field (created by an electrical current) and are present everywhere in our environment. They occur naturally (e.g., light) and as a result of human activity (e.g., cell phones, radio towers) (CMOH 2010). There are four potential sources of EMFs associated with wind energy developments: the associated transmission line, wind turbine generators, generator transformers, and underground cables. The potential for long-term health effects resulting from EMF exposure has been studied for several decades, and there is little evidence to support that EMF causes long-term health issues (SCENIHR 2007).

Wind turbines are not considered a significant source of EMF exposure due to low emission levels (Rideout et al. 2010). Transmission lines associated with wind energy developments are similar to other powerlines and generate low levels of EMF. Project developers should follow applicable guidelines and industry standards when installing new transmission lines in order to minimize EMF exposure. Turbine generators are located within the turbine's central housing, which is located well above ground and results in little to no EMF emissions at ground-level. Underground cables also generate little to no EMF at the surface. Generator transformers likely generate the highest level of EMF at a wind energy development.

4.4.5 AIR QUALITY

The operation of wind turbines does not result in air emissions, unlike most traditional forms of electricity generation. Temporary impacts to air quality may occur during construction, and during routine maintenance activities (e.g., dust, particulate matter during excavation and construction activities, and emissions from construction equipment and vehicular traffic). Construction air quality effects are temporary in nature, and can be mitigated through implementation of a dust management program and by requiring that construction equipment is well maintained and properly operated. Air quality management requirements can be addressed during the siting and/or permitting process.

4.4.6 SOLID AND HAZARDOUS WASTES

Unlike some conventional methods of electricity generation, an operating wind energy development produces negligible solid and hazardous waste. During construction, potential sources of waste may include, but not be limited to, oil, packing and crating materials, hydraulic fuels, lubricants, insulating fluids, paint, and general refuse. Small amounts of lubricating oils, hydraulic fluids, and insulating fluids also may be used during operations and maintenance activities.

To reduce the risk of construction and operation wastes being introduced into the environment, all refuse must be managed and disposed of in accordance with applicable regulations and permit requirements. Development of a waste management plan for construction activities will help to support this effort, and should include a spill plan. In addition, spill response kits should be available on site during construction activities.

4.4.7 ICE SHEDDING

Ice shedding occurs when ice accumulates on turbine blades as a result of specific temperature and humidity conditions. As temperatures rise, ice will melt from the turbines and pieces of ice may fall to the ground. Modern turbines are equipped with a number of mechanisms to detect ice buildup, which triggers operational procedures to reduce the area potentially affected by ice shedding. Ice buildup creates an imbalance that triggers a complete shutdown of modern turbines, which would enable any melting ice to fall directly to the ground (CanWEA 2007). If the rotor is moving, ice may be projected off the turbine blade, which poses a potential risk to public safety if wind turbines are not properly sited, or members of the public are trespassing/accessing restricted areas. During icy conditions, operations and maintenance staff working beneath and inside wind turbines must take proper precaution to protect themselves and their vehicles from falling ice. Steps that can be taken to reduce risk to both the public and to operational staff include:

- Conduct an ice throw risk assessment to determine ice accretion periods when turbines are operational and to identify other risk factors that should be considered;
- Roads, transmission lines, buildings, snowmobile trails and other winter time public access facilities should be sited an appropriate distance from wind turbines;
- Use of warning signals to alert operational personnel of risk;

- Use of warning signage to highlight hazards associated with ice build up to members of the public;
- Appropriate fencing;
- Curtail turbine operation during periods of icing;
- Implement turbine features which prevent ice accretion or operation during icy periods; and,
- Educate staff about ice accretion conditions, areas of risk, and protocols and procedures to follow when ice accretion is likely to occur.

4.4.8 BLADE FAILURE

Blade failure events, where all or part of the turbine blade detaches from the rotor, are very rare. The main causes of blade failure typically are related to three events: 1) human interference with a control system leading to an overspeed situation, 2) lightning strike, and 3) manufacturing defect in the blade (CanWEA 2007). Overspeed situations are rare due to the implementation of strict operational standards for control systems, including backup systems, to control rotor speed. Lightning protection systems and best practice standards have led to a significant reduction in blade failure in the event of a lightning strike. Manufacturing defects have also been reduced through improved quality and experience in the industry, including the development of standards by the International Electrotechnical Commission (e.g., IEC 2005). To be certified under these standards, full-scale strength and load testing must be conducted for every turbine blade (CanWEA 2007). The progression in industry standards and technology (i.e., improved mechanical braking systems) has considerably reduced the probability of blade failure and blade loss. The probability of injury due to blade failure or loss can be further reduced through establishment of adequate setbacks from structures and adjacent uses, including public roads, transmission lines, buildings and recreational trails.

4.4.9 FIRE

Fire hazards associated with wind energy developments are limited mostly to the construction phase of projects, where there is an increased number of construction personnel in the area, use of machinery, as well as the storage and handling of combustible materials. Operational wind turbines have the potential to cause a fire, but these instances are rare and are typically caused by faulty construction, poor maintenance, or lightning strikes. The risk of fire can be reduced by a variety of factors that typically are standard operating procedure at modern wind energy facilities: burial of electrical collection systems, fire prevention plans, close coordination with and training of local firefighters, and adherence to regular and appropriate maintenance schedules. All on-site personnel should be trained, and provided with a fire prevention and emergency response plan.

4.4.10 STRAY VOLTAGE

Stray voltage typically is defined as a low-level electrical current or shock (typically under 10 volts) that results primarily from an improperly grounded or, in some cases an ungrounded, electrical distribution system (www.canwea.ca/pdf/talkwind/StrayVoltageFactSheet.pdf). Stray voltage can be found in any electrical system if the system is improperly grounded, or when there is a change in the pattern in the distribution line (in which case it is a distribution issue, not a source issue). Wind turbines must comply with utility standards and grid standards, and the distribution system should be separate from the power interconnection and collection system. As such, stray voltage resulting from a wind energy development should not occur, so long as industry standards are applied. For example, in Ontario, the Transmission System Code and the Distribution System Code is regulated by the Ontario Energy Board, and outlines the standards required for transmission and distribution facilities, compliance, inspection, and monitoring.

4.4.11 LIGHTNING STRIKES

Wind turbines can be attachment points (the place where the lightning flash touches or to which it ‘attaches’) because of their height, their position in exposed locations, and because favourable locations for wind energy developments (such as along ridges and in open fields) often coincide with areas of thunderstorm activity (Glushakow 2007). Lightning strikes may lead to turbine failure and blade damage, and can also pose a safety hazard to personnel working at wind energy developments.

All wind turbines have a built-in grounding system to dissipate the energy from a lightning strike into the ground. If a worker is adjacent to the turbine or working in it when a lightning strike occurred, there would be some risk of electrocution from voltage traveling between the ground and the tower or between two spots on the ground. This risk can be reduced considerably by implementing lightning protection systems in turbine design, and through following appropriate safety protocols in the event of a thunderstorm. These safety protocols include stopping work inside of turbines if there is a thunderstorm warning or watch, safety training, designated shelters, lightning prediction and warning systems, and evacuation protocols in the event of a thunderstorm.

4.5 CULTURAL AND HISTORICAL RESOURCES

There is great cultural diversity in Canada and a great diversity of cultural heritage values. With over 600 distinct Aboriginal communities in Canada, speaking over 50 languages, and a national history based on immigration and an official federal policy of multiculturalism, governments across Canada are aware of the potential effects of wind energy development upon cultural heritage resources. Moreover, various federal, provincial, territorial and municipal laws protect cultural heritage resources.

Cultural heritage resources constitute a broad range of tangible and intangible resources representing places, resources and objects of cultural and historical significance. These resources may include artifacts, historical sites, buildings, documents, cemeteries, archaeological sites, art work, traditional use sites, cultural landscapes, spiritual sites, and land uses or areas possessing traditional cultural values, and can cross multiple cultural boundaries and ethnic communities. Cultural heritage resources tend to be classified as contemporary, historic (this date varies significantly across Canada) or pre-historic in nature. Understanding the nature of cultural heritage resources in a given locale and how these could be affected by a wind energy development is a crucial step in a developer’s due diligence process prior to commencing the permitting and construction phases of development. The discovery of archaeological sites can significantly delay or, in some cases, can present a fatal flaw to the construction and operation of a wind energy development. Engaging consultants or individuals familiar with the project area and its local history will help avoid unnecessary delays.

In most jurisdictions in Canada, where wind energy developments are under consideration, there are legal requirements to conduct cultural heritage resource assessments to determine the potential impact the development could have upon these resources, as well as to ascertain the significance of the cultural heritage resources themselves. Notably, the majority of wind energy developments tend to be located in rural areas. As a result, developers are more likely to find their projects of significance to rural populations, notably Aboriginal Peoples. Whether urban or rural, however, the process for assessing cultural heritage resource values is generally consistent across the country, in both federal and provincial jurisdictions.

Determining the significance of cultural heritage resources associated with a wind development project requires conducting an impact assessment followed by an evaluation of mitigation alternatives and compensation costs in situations where an effect or effects have been identified. Examples of potential effects include proximity of a wind energy development to a designated heritage property, an impact to an archaeological site from a proposed road right-of-way, location of facilities impeding access to a traditional berry-picking or root harvesting area, or tower placement infringing upon a spirit questing area or cherished cultural landscape.

Preliminary assessments typically take the form of literature reviews, desktop studies, archaeological overview assessments and Aboriginal community overview assessments. Preliminary assessments are pre-feasibility scoping studies, designed to determine if there are any significant cultural heritage resources located in the area under investigation. National and provincial heritage site registries, archival and ethnographic research are often employed at this stage. More detailed assessments include field surveys, traditional use studies, archaeological impact assessments, ethnographic research, and consultations with local historians, archivists and representatives of local Aboriginal communities.

If nothing notable is identified during a preliminary assessment, then a developer may not be required to complete a more detailed cultural resource impact assessment, other than to implement a monitoring plan during construction. The purpose of such a plan is to monitor for unanticipated discoveries during construction. For example, if a cultural heritage resource, such as a human burial, were to be unearthed during construction, permitting processes are typically in place outlining the procedures for working in and around such discoveries.

Alternatively, if potential evidence of cultural heritage resources is identified during the preliminary assessment, a more detailed assessment and mitigation process can be triggered to determine the extent of that particular resource and how to preserve its integrity. For example, archaeological impact assessments (AIAs) generally are conducted in areas that have potential for finding archaeological remains. AIAs are performed by certified archaeological consultants and typically involve field surveys, test excavations and consultations with local Aboriginal Peoples. AIAs are a systematic scientific means of validating the location, nature and extent of archaeological sites, whether these are historic or pre-historic in nature.

In Canada, archaeological and historic sites are protected by law, and all archaeological investigations require investigation permits. Obtaining an investigation permit can take four to six weeks or longer. With the exception of sites on federal lands, notably federal parks and Crown land, archaeological resources are the jurisdiction of provincial and territorial governments. In addition, many Aboriginal communities in Canada have their own archaeological and/or heritage resource investigation permitting systems and related heritage policies. For wind energy developments located on Crown lands, the Crown is obligated to consult with Aboriginal Peoples; in reality, the responsibility to consult with representatives of local Aboriginal communities usually is passed on to the wind energy developers.

4.6 SOCIOECONOMICS

Socioeconomic issues are important when a community is trying to understand how a wind energy development will affect the local economy, infrastructure, community services, recreational uses and general land use. Some jurisdictions require that developers conduct a socio-economic impact and effects assessment when a wind energy development is proposed. An assessment of socioeconomic effect stemming from a wind energy development typically includes three general categories: demands on local services, effects on the local economy, and land use.

4.6.1 DEMANDS FOR LOCAL SERVICES

Most wind energy developments have an effect on a community's amenities. It is critical in assessing the effect of a wind energy development to understand the demand that construction and operation will create for local services, infrastructure and workers.

In order for developers to gauge the potential effects their project may have in a particular region or community, an analysis of local services and workforce availability can be conducted which would aid in determining where these services and skills can be obtained and at what cost. The range of local socioeconomic services needed over the course of a wind project is comprehensive and typically includes access to: public health services such as medical, dental, hospitals; police, firefighting, emergency response and criminal justice services; schools; housing; retail and commercial outlets for shopping; and recreational facilities and cultural venues for entertainment.

Wind energy developments have recently been estimated to provide approximately 14.1 person-years of employment (PYE) per MW of nameplate capacity, of which 10.5 PYE will be realized during development and construction (ClearSky Advisors 2011); for a typical 100-MW wind energy development, this translates to 141 PYE. The skills required to work on wind energy developments encompass a broad range of professions and trades: welders, electricians, heavy machine operators, cement and aggregate extraction and production, truck drivers, crane operators, labourers, engineers, scientists and other professional services. Census, employment and business data is often used to determine the availability of many of these skills and services. Information on demographics, housing stock, educational attainment, occupations and unemployment must all be considered prior to beginning construction.

Developers are encouraged to source local products and services as much as possible, which may reduce project cost and construction time, due to reduced transportation needs. Adequate housing for temporary construction workers can be challenging in remote locations. Different types of accommodation typically are required which may include short-term house and apartment rentals hotels, RV and trailer parks, bed and breakfast establishments, camp grounds and, when needed, temporary project housing camps (which typically require separate permitting not considered in this document).

In remote communities, the construction contractor often must arrange for catering, janitorial, security, medical, transportation, waste disposal, and other services required by the temporary work force. Aboriginal communities often have the opportunity to play an important role, both as business operators, business partners, service providers and as a source of labour.

4.6.2 EFFECTS ON THE LOCAL ECONOMY

Wind energy developments inject significant amounts of capital into the area where they are built. Local economic benefits include tax revenue or payments in lieu of taxes, lease payments and royalties to the host landowners, neighbour agreements, construction-related economic contributions (such as public road improvements, the creation of jobs and expenditures on local goods and services), and jobs created/goods and services purchased during project operations. As most wind energy developments are built in agricultural and remote areas, the dollars associated with wind energy development often

present a rare opportunity for significant rural economic development and job creation. In addition to this, opportunities for spin off industries, such as tourism, may also be realized (Riddington et al. 2008).

Employment

Job creation is a significant benefit arising from the construction and operation of a wind energy development. Although every wind energy development is different, the types of jobs created by these projects often include legal, real estate, scientific and engineering jobs during project development; transportation, supply, construction, and service jobs during construction, and management and technician jobs during operations. Each phase requires a different amount of time to complete the work: planning and permitting (~2-5 years), construction (~1-2 years), and operations (~20-30 years).

Direct Economic Benefits

Direct economic benefits result when a person or company buys real or personal property or services. Typical direct expenditures include salaries and benefits for locally hired employees, cash paid for land rights and royalties, cash paid for goods associated with construction (e.g., fuel, concrete, aggregate), cash paid for services associated with construction (e.g., local subcontractors, transportation services, restaurants) and other purchases that are made in the local economy. Increasing the use of local services generally increases local investments, thereby contributing to the growth of the local economy.

Indirect and Induced Economic Benefits

In addition to direct economic benefits, wind energy developments can have indirect effects (i.e., effects associated with local supplies and suppliers, increased wind-based tourism, corporate event or sports team sponsorships) and induced effects (i.e., effects associated with increased household incomes of local workers and business owners). Input-output economic models can be used to extrapolate these data and provide reliable information on typical economic indicators such as employment, gross domestic product, household income, and various federal, provincial and municipal tax revenues.

Taxation

Taxes cover a broad spectrum of levies and fees across all levels of government: municipal (e.g., property, school, hospital, transit), provincial (e.g., royalties, sales, personal) and federal (e.g., GST or HST depending on province). Developers should take federal, provincial, and municipal

taxes into account when determining the costs of investing in a particular community, region or province. Varying financial incentives or the variable tax rates for goods and services can make certain jurisdictions more or less attractive.

Property Values

Residents of areas proposed for wind energy development often are concerned that local property values will be adversely affected by project development and operation. Over the past decade there have been many studies examining the effect of wind energy development on the property values of the communities that host them. The studies differentiate between potential effects on property values prior to the construction of an approved wind energy development (i.e., anticipation stigma) and effects on property values relative to operational wind energy development (i.e., area stigma). The results of these studies have varied widely from conclusions of no effects of wind energy development (e.g., Canning and Simmons 2010) to development-stage-specific positive and negative effects (e.g., Hoen et al. 2009, Hinman 2010) to reductions in property values (e.g., Heintzelman and Tuttle in review). The range of study results reflect regional variation in property value drivers (i.e., none of the studies were conducted in the same regions) and variation in analytical procedures and data selection criteria. Historically, property value effect investigations relied on paired sales analysis; however, the current accepted methodology relies on more robust and defensible multiple linear regression techniques. Regardless of the reason for the variation, however, the potential of an effect (positive or negative) on property value exists and developers should be aware of the potential for these effects.

4.6.3 LAND USE PLANNING

In general, there are three land use issues of interest affecting the siting of new wind energy developments: the nature of existing uses and infrastructure within close proximity to the proposed development; existing tenure that can restrict development; and, permits needed to explore for, construct and operate a development. The nature of wind energy developments is that they require a small dedicated footprint within a larger project area, which also can accommodate other concurrent land uses and potential resource development opportunities. Because wind energy developments can cover hundreds to thousands of hectares, a single project may coexist with multiple residential, commercial, agricultural and recreational land uses. The types of affected land uses vary depending on the region and the nature of topography,

ecological values and historical land uses in the area. Wind energy developments are compatible with most uses when appropriate siting considerations are employed, such as setbacks for public safety and prevention of nuisance.

Infrastructure

The construction and operation of a wind energy development requires the presence or creation of adequate infrastructure. For example, wind energy developments require transmission lines to transport the power produced at the facility to demand centres. The presence or absence of infrastructure attributes (e.g., major highway, bridge crossings, utility crossings) can significantly influence the cost and timing of construction. When access is limited or non-existent, the improvement of existing or construction of new infrastructure may be required. Infrastructure improvements required for wind energy developments (e.g., widening roads or improving intersections) often provide benefits to the entire community.

Competing Tenures

One of the biggest challenges affecting the siting of new wind energy developments is competition from other developers or tenure holders for access to the land base. Before a wind energy development can be planned or constructed, it is critical to determine what other types of land tenure exist in a particular area or are under consideration (e.g., oil and gas development, mining, recreation, conservation). Standard land use definitions are more often than not sub-divided into various site-specific terms to reflect a distinct type of activity or tenure beyond the traditional uses such as industrial, commercial or residential.

It is becoming increasingly common to see land use plans established in many jurisdictions to assist regulators in managing tenure access for certain types of development activities. Some land use plans restrict development while others encourage a more integrated approach. Inherent in land use planning is a more sophisticated method to manage the interactions between multiple user groups and stakeholders, and to accomplish this in a more environmentally and complementary manner. Historical settlement patterns have significantly affected the types of tenures across Canada, and hence the percentage of private property ownership. The farther west one travels, the more Crown land is controlled by provincial governments; in British Columbia, for example, 94 per cent of the land base is owned by the Crown compared to 60 per cent in Ontario.

4.7 COMMUNICATIONS INFRASTRUCTURE

4.7.1 MICROWAVE AND RADAR SYSTEMS (WEATHER, AIR NAVIGATION, LONG-RANGE SURVEILLANCE)

Potential interference with microwave and radar systems is an issue for wind energy development, as interference may affect basic communication services, safety and national security. Radar systems work by transmitting radio waves in a sweeping or bursting pattern that reflect off objects in the vicinity and back to an antenna. Filtering these radio waves allows the radar operator to identify the range and size of objects on the landscape (Radio Advisory Board of Canada [RABC] 2010). Large, rotating turbines may interfere with these waves, and therefore may result in radar echoes or clutter (scattering), create their own Doppler signature, or the turbine structure may block an entire section of the radar beam (RABC 2007). Such effects become problematic for radar operators when a wind energy development is located in the line of sight of a radar system (RABC 2007). Interference with radar systems can affect the radar tracking of weather systems (Canadian Weather Radar Network), the airline industry (Air Traffic Control systems), and national defence radar systems (Air Defence Radars, Canadian Coast Guard radar network) (RABC 2010).

As with all stakeholders, early consultation with radar operators and users during project planning, as well as proper siting of a wind energy development is critical in avoiding interference with existing radar systems. CanWEA and the RABC have developed a recommended process for wind project proponents to follow in order to evaluate consultation zones for disclosed and non-disclosed radar system operators (RABC 2010; www.canwea.ca/pdf/municipalities/canwea_rabc_guidelines-en.pdf). Early consultation with stakeholders is recommended to ensure that unacceptable interference does not result from a wind development installation. The locations of existing, disclosed radar systems within a given search area or consultation zone can be found by performing a radio frequency search using the Industry Canada Spectrum Direct internet-based service tool. In addition, national, provincial and municipal contact should be made to identify and assess non-disclosed database records for non-disclosed radar locations (e.g., NAV CANADA Primary Service Radars, National Defence surveillance radars; RABC 2010).

4.7.2 TV BROADCAST SIGNAL SYSTEMS

Television signals may be distorted by the presence of wind turbines through two mechanisms: static interference (“ghosting”) or dynamic interference (Levert and Munro 2006). During the planning phase of a project, measures can be taken to reduce or eliminate the interference of wind turbines with TV broadcast signals. All local broadcasting towers should be identified in the early phases of the project in order to place turbines in areas that will avoid significant interference with tower signals. Following wind project construction, relocation of the receiving antenna and/or transmitter site, or replacement of the affected TV broadcast system with satellite or digital cable will also correct interference effects (Levert and Munro 2006). The RABC (2010) identifies the radius of consultation zone around over-the-air reception systems as 15 km from the closest wind turbine for analog TV stations and 10 km from the closest wind turbine for digital TV stations.

4.7.3 RADIO COMMUNICATION SYSTEMS

Radio communication systems, including broadcast-type systems (e.g., cellular networks) and point-to-point systems (e.g., local microwave) can be affected by the installation of wind turbines (RABC 2010). For example, point-to-point radio communication requires “line-of-sight” clearance (i.e., any obstruction in the optical path between two towers will make the path unusable).

For point-to-point systems, local microwave, studio to transmitter links, and transmitter to transmitter links should be identified in order to avoid the communication path between towers, which will eliminate the potential for interference. If an operational wind project is interfering with these systems, replacement of the receiver antenna with one that better discriminates against unwanted signals, relocation of the transmitter or the receiver, or switching to a new type of transmission (e.g., fibre optic) may reduce or eliminate interference (RABC 2007). The RABC (2010) identifies the radius of consultation zone around a point-to-point system (above 890 MHz) as 1 km plus a cylinder of diameter (L_c) between the transmit and receive locations, and 1 km for stations below 890 MHz.

For broadcast-type networks, siting the wind turbines outside of the network signal path and the population it serves will eliminate or reduce the potential for interference. For operational wind energy development, changing the network’s system parameters, modifying the antenna

system, or switching to an alternate means of receiving the off-air signal should reduce or eliminate interference (RABC 2007). The RABC (2010) identifies the radius of consultation zone around a broadcast transmitter as 5 km for a single tower and 15 km for a direction (multiple tower) antenna system for AM stations, and 2 km for FM and TV stations.

4.7.4 LMR SYSTEMS

A land mobile radio (LMR) system is a collection of portable and stationary radio units that are designed to communicate with each other over predefined frequencies. Examples of LMR systems include police departments, fire departments, medical responders, and construction sites. These systems can be independent or use a cellular network, but typically will use a central dispatch console or base station to control communications between the handheld or mobile units in the field. The range of communications coverage is extended by placing repeaters on towers and other tall structures, which may be affected in a manner similar to the mechanisms outlined in Section 4.7.3. The RABC (2010) identifies the radius of consultation zone around a LMR as 1 km. Repositioning LMR repeaters or adding repeaters to a LMR system may also help to reduce interference from operational wind energy developments.

4.8 TRANSPORTATION AND TRAFFIC

4.8.1 GROUND TRANSPORTATION AND TRAFFIC

The effect of transportation of wind turbine components, heavy construction equipment, and cement trucks to a wind energy development typically include effects on the transportation system itself (e.g., the physical properties of the road system) and the users of the transportation system (e.g., dust and noise). These effects mainly are limited to the construction phase. Transportation routes to the project and within the project area should be evaluated during the initial siting of a project.

As soon as the origin of the turbine components is identified, delivery methods, including ports of entry and transportation routing, can be planned. In turbine supply agreements, transportation of turbines to the project site is often the responsibility of the turbine manufacturer. Turbines typically travel from port of entry to the project area over large transportation arteries that are designed to handle oversized loads. Even so, impacts and modifications to the transportation system may be required and, depending upon the turbine supply agreement, may be the

responsibility of the project developer. Route assessment should take into account road capacity and traffic volume, as well as seasonal, size, and weight restrictions. Developers who address transportation issues early in the development process will have time for inquiries into effects, associated risk, road specific restrictions, permitting requirements, and scheduling of transportation.

It is recommended that a desktop review be completed to document the general conditions of the roadways within the development area prior to component delivery or the commencement of construction activities. Information collected typically includes speed limits, roadway widths, load and height restrictions of roads, bridges and culverts, horizontal and vertical curvature, intersection geometry, drainage structures, presence of utilities and any locally significant features (e.g., wetlands/waterways, or monuments). Determining areas of a particular road or road segment that may require modification for transport of equipment and components of the wind energy development should be highlighted during this review.

Following the desktop review, a field inspection of the transportation route documenting existing road conditions and identifying any additional areas of concern should be performed. The scope of the visit typically includes all aspects evaluated during the desktop review with a few additions, such as an evaluation of the condition of the roadway pavement, major roadway intersection configurations, primary route selection, determination of alternate or secondary routes, and development of preliminary mitigation measures. The field evaluation should include: a review of available design and construction drawings for each of the structures along the route; field observations of the condition of each structure; measurement of the wall thickness, height, width, length, and soil cover depth for culverts; and comparison of the proposed loadings with the design loadings for each structure. Where drawings or previous inspection reports are not available for existing bridges, a detailed survey may be required to determine safe load carrying capacity.

The transportation improvements and modifications required for project development can range from minor work, such as moving signage and utility poles, to major construction of enhanced transportation infrastructure, such as widening roadways and intersections and fortifying bridges. All applicable laws and regulations should be followed (e.g. *Fisheries Act* during work near wetlands/waterways) and effort should be made to avoid or minimize impacts during implementation. After construction, road authorities typically inspect area roadways to ensure that the transportation infrastructure has not been damaged by construction.

Traffic Impact Analysis

The potential effects of construction activity on the traffic network and users also must be investigated. Traffic data for the proposed transportation route and project area should be reviewed for operating conditions (e.g., speed, traffic flow, travel time, intersection timing,) and design (e.g., passing lanes). Locations with high accident rates should be identified and appropriate safety measures should be incorporated into subsequent plans. This data is often obtained directly from provincial and municipal government offices. During construction, local traffic may experience minor traffic delays due to the presence of slow-moving equipment delivery vehicles, and the construction of infrastructure improvements.

The primary mitigation measure for potential traffic-related effects is avoidance. A Traffic Management Plan (TMP) can be used to identify safe, optimal routing and typically includes various routing options, needed or suggested road and intersection modifications, guidelines for timing of transport, accident prevention strategies, safety considerations and signage/traffic plans. Developers should anticipate changes in construction schedules or patterns, and make any necessary changes in the TMP. Areas with high potential for traffic-related effects (e.g., congested intersections, over-capacity on roadways) should be avoided or mitigation measures should be implemented (e.g., construction of road improvements). The TMP should be reviewed with the appropriate municipal, provincial or federal authorities and, depending on the project location, the TMP may also require approval by the appropriate authorities. Associated authorizations and permits must be obtained prior to the transport of any components.

4.8.2 AIRBORNE TRAVEL AND TRAFFIC

A wind energy development can have potential effects on aeronautical activities, such as the creation of collision risks or disturbances to radio signals. A desktop aviation study should be completed during the site screening phase in order to determine if construction and operation of a wind energy development in the project area could create hazards to air traffic. The *Aeronautic Act* (Government of Canada 1985b) allows Transport Canada to prevent disruption of aeronautic activity by protecting the surrounding areas from harmful activities. Air traffic requirements in a project area could include agriculture, commercial, or recreational. The installation of a wind energy development may interfere with these uses, including safety concerns, underscoring the need for early engagement and consultation.

A desktop review should cover a general land and water use investigation, air travel corridors, and the locations of airports and private air strips. Regional air transportation authorities also should be contacted for information on airports, certified and registered airstrips, usage classification, site-specific restrictions, and local airport zoning restrictions. Private airstrips that are not registered with Transport Canada also may exist in the area but are not necessarily protected from airport zoning rules. Maps, photos and aerial photographs also should be reviewed to gather additional insight into aviation uses and locations of possible air strips.

Mitigation may include avoidance of or appropriate setbacks from airports and air strips, and areas used by agricultural aerial applicators. Aviation safety marking and lighting of wind turbines is specified by Transport Canada regulations. Additional investigations and mitigation measures may be required based on consultation with airport authorities. All facilities must be installed according to Canadian Air Regulations and Standards (e.g., Aerodrome Standards and Recommended Practices). Although there are no regulations mandating setbacks from radar installations in Canada, early consultation with NAV CANADA and the Department of National Defence, as well as other spectrum users, is recommended (see RABC 2010 for list of spectrum users).

4.9 PROJECT DECOMMISSIONING

The development of a project decommissioning plan can be required as part of a provincial EA process (e.g., Ontario's Renewable Energy Approval process). Decommissioning plans generally include three components:

- Procedures for dismantling or demolishing the development, including access roads and transmission lines;
- Activities related to land or water restoration; and,
- Procedures for managing excess material and waste.

The development and presentation of a carefully conceived decommission plan can be an important part of a wind energy development's public outreach and community consultation efforts.

4.10 CUMULATIVE EFFECTS ASSESSMENT

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present or future actions by humans (Hegmann et al. 1999). Investigations into the cumulative effects of

projects are required for projects that are subjected to the *Canadian Environmental Assessment Act* and other provincial acts, such as the British Columbia Environmental Assessment Act. A cumulative effects assessment (CEA) should be completed as part of a wind energy development's overall environmental impact assessment. For wind energy developments, cumulative effects typically are addressed for wildlife and wildlife habitats, soil and water quality, as well as human health, socioeconomics, and quality of life considerations (e.g. sound propagation, cumulative visual effects).

The Canadian Environmental Assessment Agency has produced a few guidance documents pertaining to the design and development of a CEA (e.g., the Cumulative Effects Assessment Practitioners Guide; Hegmann et al. 1999), addressing cumulative environmental effects (Federal Environmental Assessment Review Office 1994a), and determining if the project is likely to cause adverse environmental effects (Federal Environmental Assessment Review Office 1994b).

As recommended by the Cumulative Effects Assessment Practitioners Guide (Hegmann et al. 1999), a CEA should identify:

- Effects of the proposed project in the context of the surrounding regional planning area;
- Effects relative to the existing transportation network and the potential for future linkages created by the Project;
- Effects on Valued Ecosystem Components (VECs) due to interactions with other projects and not just the effects of the single action under review;
- Other past, existing, or currently identified planning initiatives; and,
- The significance of other indirect or extended effects.

The final scope of the CEA is determined in consultation with regulatory agencies.

In addition to defining the scope of what cumulative effects are to be included in the CEA, it is critical to identify clearly the spatial and temporal boundaries effects analysis. In general terms, the spatial boundary should encompass all areas subjected to potential project effects. For projects in which individual potential effects have differing spatial scales (e.g., visual effects versus sound effects), the usual practice is to set the spatial scale of the project's CEA as the largest area of effect, although this scale can be adjusted for the assessment of individual potential effects. The temporal boundary of the CEA typically is the length of the project's operational period. Additional information that can be included is knowledge gathered from discussions during

community engagement programs, provincial and federal agency meetings, and information obtained in the course of the Aboriginal Peoples consultation for the development.

4.11 ENVIRONMENTAL COMPLIANCE

4.11.1 CONSTRUCTION ENVIRONMENTAL COMPLIANCE

Wind energy developments typically are subject to multiple permits with specific conditions in each that must be implemented during project construction. It is important that the selected construction contractor understand and comply with stipulated permit conditions and applicable legal and regulatory requirements that may be incorporated by reference into permit authorizations. Construction contractors must also understand and implement any mitigation plans developed for the project. A construction environmental compliance program is helpful in communicating requirements to construction contractors and assisting the construction team in completing the project within legal and regulatory parameters.

An environmental construction compliance program typically consists of several components including, but not limited to:

1. **Planning** – Prior to the start of construction, a developer should thoroughly review the project's environmental permits, plans and any generally applicable laws/ordinances to extract all environmental requirements that would apply during construction. It is important to document which requirements will be the responsibility of the construction contractor and whether any additional guidance or tools will be required for the contractor's successful implementation of the permit conditions. These requirements may be expressed to the construction contractor as contract specifications during the bid process so that there are no surprises (e.g., environmental compliance-related change orders) during construction. In addition, the requirements should be compiled into a construction environmental management implementation manual for the construction team. This manual often includes the following sections: Roles and Responsibilities, Project Contact List, Pre-construction Coordination, Construction Operations, Post-construction Activities, Safety, Human and Industrial Sanitation, Environmental Compliance Program (including monitoring criteria, compliance approach, compliance levels, training,

communication, reporting, corrective action, and variance processes), and Appendices, including copies of documents that must be at the project site (e.g., permits, authorizations, plans, and any other documents that create or describe environmental requirements for construction and restoration).

2. **Training** – Prior to construction, project permits may require that all contractors and subcontractors attend an environmental training program during which the environmental construction compliance program is explained in detail. Typically, the development and implementation of this training session is the responsibility of an environmental compliance monitoring contractor who is hired by the developer to assist the construction contractor in complying with project requirements. Condensed training opportunities should be provided to new construction crews as they arrive at the project site. If compliance issues arise during construction, retraining should be provided as necessary.
3. **Preconstruction Coordination** – At least one week prior to the start of construction at any given site the environmental compliance monitor, contractor and any subcontractors should conduct a site walkover of areas to be affected by construction activities. During the walkover, this group identifies landowner restrictions, sensitive resources (e.g., biological, geological, and cultural), limits of clearing, proposed stream crossings, location of drainage features, and layout of sediment and erosion control features. A pre-construction checklist is typically completed during the walkover so that nothing is missed and that agreement of all parties on approach is documented. In addition, wetlands and any other sensitive resource features are flagged in the field prior to construction as are any limits to work areas. If practical difficulties in complying with permit requirements are identified by the construction team, the environmental compliance monitor will have time to evaluate alternative measures with the appropriate authorities.
4. **Inspection During Construction Operations** – The environmental compliance monitor typically visits each construction work site at least once per day and is present during construction activities in environmentally sensitive areas. Environmental compliance monitors have a significant role to play in suggesting methods to bring construction activity into compliance and should have the authority to temporarily halt certain activities they believe could cause irreparable harm to protected or sensitive resources. Environmental compliance monitors should keep

a log of all of the project sites they visit and record whether the construction activities they observed were in compliance. The environmental compliance monitor should meet with construction management every morning in order to be kept current on all project construction issues and schedules.

5. **Weekly Reporting and Agency Audits/Inspections** – Depending upon reporting requirements associated with the permits, the environmental compliance monitor's daily logs may be converted into weekly, monthly, or quarterly reports for the federal, provincial, and local agencies that have requested or required compliance on a given project. Some regulatory agencies conduct periodic compliance audits at project sites. In addition, compliance tours can be arranged for local, provincial, and federal officials.
6. **Restoration** – As construction activities approach completion, the environmental compliance monitor should conduct a restoration walk over with the construction contractors to ensure that restoration activities occur as required. A restoration checklist is a useful tool for documenting required activities. Permits and bond-release provisions often require project proponents to conduct a multi-year post-construction monitoring program of restoration efforts.

4.11.2 OPERATIONAL ENVIRONMENTAL COMPLIANCE

As discussed above, wind energy developments typically are subject to multiple permits with specific conditions that also must be implemented during project operations. Similar to the process described above, the project developer must review permits, plans, and applicable laws to determine the environmental requirements that apply during the operations phase of the development. These requirements should be compiled into a project operations environmental compliance plan.

In addition to post-construction monitoring of restoration efforts, most project proponents will be required to conduct post-construction monitoring of potential wildlife impacts (Section 4.2.1). These post-construction monitoring activities usually involve the development of an adaptive management program that outlines plans of action, and roles and responsibilities should project effects be higher than predicted during the environmental assessment, permitting, and consultation process.

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