Appendix L

Sound Level Assessment Study

Sound Level Assessment for the Clydesdale Ridge Wind Farm Project

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Executive Summary

RMSenergy Dalhousie Mountain LP currently owns and operates the 51 MW Dalhousie Mountain Wind Farm in Mount Thom, Nova Scotia (or referred to as Phase I). The Dalhousie Mountain Wind Farm in has been in operation since December 23, 2009. A new company, Dalhousie Mountain Wind Farms Inc. has been created to expand the wind energy facility operation on lands west of the existing wind farm. This project will be known as Clydesdale Ridge Wind Farm (or referred to as Phase II). The Clydesdale Ridge Wind Farm Project site will have a nameplate capacity of up to 50 MW and will consist of up to 28, GE 1.6sle Series 60 hz turbines. However, sound level models were conducted for 29 turbines.

Construction sound will occur during site leveling and grading, pile driving and blasting (if required), excavation, concrete pouring and steel and component erection, and is a temporary activity and therefore was assessed qualitatively in this study.

The sound emissions related to the operational phase of the Project, however, will be longer in nature and therefore were assessed quantitatively by predicting the sound levels at each of the potentially sensitive receptors. Operational sound levels were predicted for each receptor using a sound propagation and attenuation modeling program, Cadna A, version 4.2.140, from Datakustik. Meteorology and local terrain were considered in the modeling and maximum sound power level information provided by the turbine manufacturer was used for the model. Both the operation of the existing Dalhousie Mountain Wind Farm and the proposed Project were considered in the modeling. Presently, the province of Nova Scotia does not have set sound level limits specific to wind turbine operations. For assessment purposes in this study, a limit of 40 dBA was used, which was adopted from the Ontario regulations.

The modeling demonstrated that the sound levels predicted at each of the receptor were below the adopted limit of 40 dBA, excluding one receptor whose predicted sound level was at 40 dBA.

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RMSenergy Dalhousie Mountain LP currently owns and operates the 51 MW Dalhousie Mountain Wind Farm in Mount Thom, Nova Scotia (or referred to as Phase I). The Dalhousie Mountain Wind Farm in has been in operation since December 23, 2009. A new company, Dalhousie Mountain Wind Farms Inc. has been created to expand the wind energy facility operation on lands west of the existing wind farm. This project will be known as Clydesdale Ridge Wind Farm (or referred to as Phase II). The Clydesdale Ridge Wind Farm Project site will have a nameplate capacity of up to 50 MW and will consist of up to 28, GE 1.6sle Series 60 hz turbines. However, sound level models were conducted for all 29 turbines.

Stantec Consulting Ltd (Stantec) was commissioned to conduct an assessment of the environmental impacts; this report is the evaluation of the potential sound impacts resulting from the Project.

The key issues addressed in this assessment are sound produced by the construction and operational phases of the Project. To aid in the evaluation, a set of receptors were selected (receptors 1-75), which represent the most potentially affected receptors (mainly residences) for Project-related sound emissions. Background sound measurements were not taken as a component of this study; however data collected during the Dalhousie Mountain Wind Farm Assessment has been reviewed and incorporated in this analysis to represent background conditions, along with the operation of the Dalhousie Mountain Wind Farm.

2.0 Sound Terminology

In support of the analysis and recommendations made in this report, a brief discussion of the technical terms is included below.

DEFINITIONS

Attenuation

The reduction of sound intensity by various means (*e.g.*, air, humidity and porous materials).

Audibility

Audibility is the detectability of sound by animals, including humans, with normal hearing. Audibility is affected by the hearing ability of the animal, other simultaneous interfering sounds or stimuli, and by the frequency content and amplitude of the sound.

A-Weighting

The A-weighting network is used to account for changes in level sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (6.3 kHz and above) and low (below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an established standard to simulate the relative response of the human ear. The A-weighting system is the most common network in use in environmental sound assessments and criteria.

Ambient Noise

All-encompassing sound that is associated with a given environment, usually a composite of sounds from many sources near and far.

Background Noise

All-encompassing sound of a given environment without the sound source of interest, sometimes referred to as baseline noise prior to the project.

Decibel

A logarithmic measure of any measured physical quantity and commonly used in the measurement of sound. The decibel provides the possibility of representing a large span of signal levels in a simple manner as opposed to using the basic unit Pascal. The difference between the sound pressure level for silence versus that of a painfully loud sound is a factor of over a billion to one, therefore it is less cumbersome, and more convenient in analysis, to use a small range of equivalent values: 0 to 130 decibels. A tenfold increase in sound power is equal to +10 dB.

- Change representing doubling of sound energy is 3 dB;

- Perceptible change in sound is about 3 dB in the case of relatively steady sounds, but in the case of variable sounds such as are found in nature, a perceptible change is typically of the order of 5 dB. Threshold of hearing is 0 dBA;
- Quiet rural night = 35 dBA;
- Normal conversation level = 50 dBA;
- Arterial road traffic = 60 dBA;
- Peak level of passing 18-wheeler at 50 feet = 85 dBA.

Energy Equivalent Sound Level (Leq)

The Leq is the level of a constant sound over a specific time period that has the same sound energy as the actual (varying) sound over the same period. Leq is strongly influenced by intrusive sounds and will typically be higher than the steady state sound level. It is the metric most often used in regulatory applications, sound emission rating for turbines or other machinery, and environmental monitoring. Leq should be used carefully in quantifying natural ambient sound levels because occasional loud sound levels (gusts of wind, birds, insects) may heavily influence (increase) its value, even though the typical sound levels are lower.

Existing Ambient

All sounds in a given area (includes all natural sounds as well as all mechanical, electrical and other human-caused sounds).

Hearing Range (human)

An average healthy young person can hear frequencies from approximately 20 Hz to 20,000 Hz, and sound pressure levels from 0 dB to 130 dB or more (threshold of pain). Adults hear a significantly reduced range of frequencies, often less than 10,000 Hz at the high end, and the threshold of hearing also increases with age. In terms of hearing differences in sound levels, the smallest perceptible change is 1 dB, but this would only be possible in controlled environments. Change of 3 dBA may be perceived, depending on how variable the sound is; changes of this magnitude in average levels during gusty wind conditions, for example, would generally not be noticeable, but changes in the fairly constant hum of an operating appliance would be perceived. In natural environmental sounds changes of 5 dBA would be detectible. Because of the logarithmic nature of human hearing, humans perceive a change of 10 dBA to be a doubling in volume although it represents a factor of 10 in sound energy.

Natural Ambient

Natural ambient sound is defined as all natural sounds in a given area, excluding all non-natural sounds. “Natural ambient” is considered synonymous with the term “natural quiet,” although natural ambient is more appropriate because nature is often not quiet.

Noise

Traditionally, noise has been defined as unwanted, undesired, or unpleasant sound. This makes noise a subjective term. Sounds that may be unwanted and undesired by some may be wanted and desirable by others.

Octave

An octave is the interval between two frequencies having a ratio of 2 to 1. For acoustic measurements, the octaves start at 1000 Hz center frequency and go up or down from that point, at the 2:1 ratio. From 1000 Hz, the next filter's center frequency is 2000 Hz, the next is 4000 Hz, etc., or 500 Hz, 250 Hz, etc. Octave filtering is used in measurement and analysisi, and can be full octave, one-third octave or greater subdivisions. The division of sound into frequency bands is done in analysis because the different frequencies behave differently in the atmosphere, higher frequency sound being absorbed more readily than low frequency sound.

Sound

Sound is a pressure fluctuation due to a wave motion in air, water, or other media that has the potential to be heard through the auditory mechanisms of humans or animals.

Sound Power Level (L_W)

The sound power level is the total sound energy radiated by a source per unit time. The unit of measurement is the decibel representing a ratio of acoustic watts to a reference level of watts. The acoustic power radiated from a given sound source as related to a reference power level (typically 10^{-12} watts) and expressed as decibels. A sound power level of 1 watt = 120 dB. Conventionally, the reference level = 10^{-12} watts.

Sound Pressure Level (SPL)

Sound levels are represented by the energy in the sound pressure level as defined as ten times the base-10 logarithm of the square of the ratio of the mean-square sound pressure, in a stated frequency band (often weighted), and the reference mean-square sound pressure of 20 µPa, the threshold of human hearing.

$SPL = 10*\log_{10}(p^2 / p_{ref}^2)$ (dB)

where:

> p = mean-square sound pressure; and
>
> p_{ref} = reference mean-square sound pressure of 20 µPa.

3.0 Project Overview

3.1 STUDY AREA

The proposed Project is to be located approximately between Mount Thom, Pictou County and Earltown, Colchester County, Nova Scotia. The wind farm will be constructed primarily on previously cleared woodlands generally bounded to the north and west by undeveloped land and sparsely populated residential areas; to the east by sparsely populated residential areas and the existing Dalhousie Mountain Wind Farm (Phase I); and to the south by Trunk Highway 4 and sparsely populated residential areas (refer to Figure 3.1). The Gully Lake Wilderness Area is located just southwest of the Project Study Area.

3.2 CONSTRUCTION

Construction sound will occur during site leveling and grading, pile driving and blasting (if required), excavation, concrete pouring and steel and component erection and is a temporary activity. Nova Scotia does not have any provincial regulations or guidelines to regulate sound emitted during construction and therefore guidelines from other jurisdictions are adopted for guidance. For construction impacts, these guidelines are from the Alberta EUB; for operational impacts, the guidance is from the Ministry of Environment of Ontario.

Alberta's Energy Resources Conservation Board (ERCB) Directive 038: Noise Control (Revised edition, February 16, 2007) provides regulations for energy developments in rural areas. In part, the ERCB Directive states that reasonable measures must be undertaken to reduce the effect of construction sound from new facilities (or modifications to new facilities) on nearby residences. The following mitigation measures will therefore be applied, as necessary:

- Nearby residents will be advised of significant sound generating activities and these will be scheduled to create the least disruption to receptors; and
- All internal combustion engines will be fitted with appropriate muffler systems.

The EUB allows for construction to occur 24 hours/day; however it recommends attempting to limit construction activities during the hours of 07:00 and 22:00 to reduce the potential impacts of construction sound on receptors. While an attempt should be made to adhere to this recommendation, construction activities may occur outside of this period, as required by the Project schedule. In particular, efforts should be made to limit the operation of noisier activities associated with construction (*i.e.,* impact pile driving and blasting, if required) to daytime hours.

The NSE Guideline for Environmental Noise Measurement and Assessment (NSDOE, 1989) prescribe limits for sound level by the time of day that must be followed. These limits are defined in Table 3.1.

Table 3.1 NSE Noise guidelines

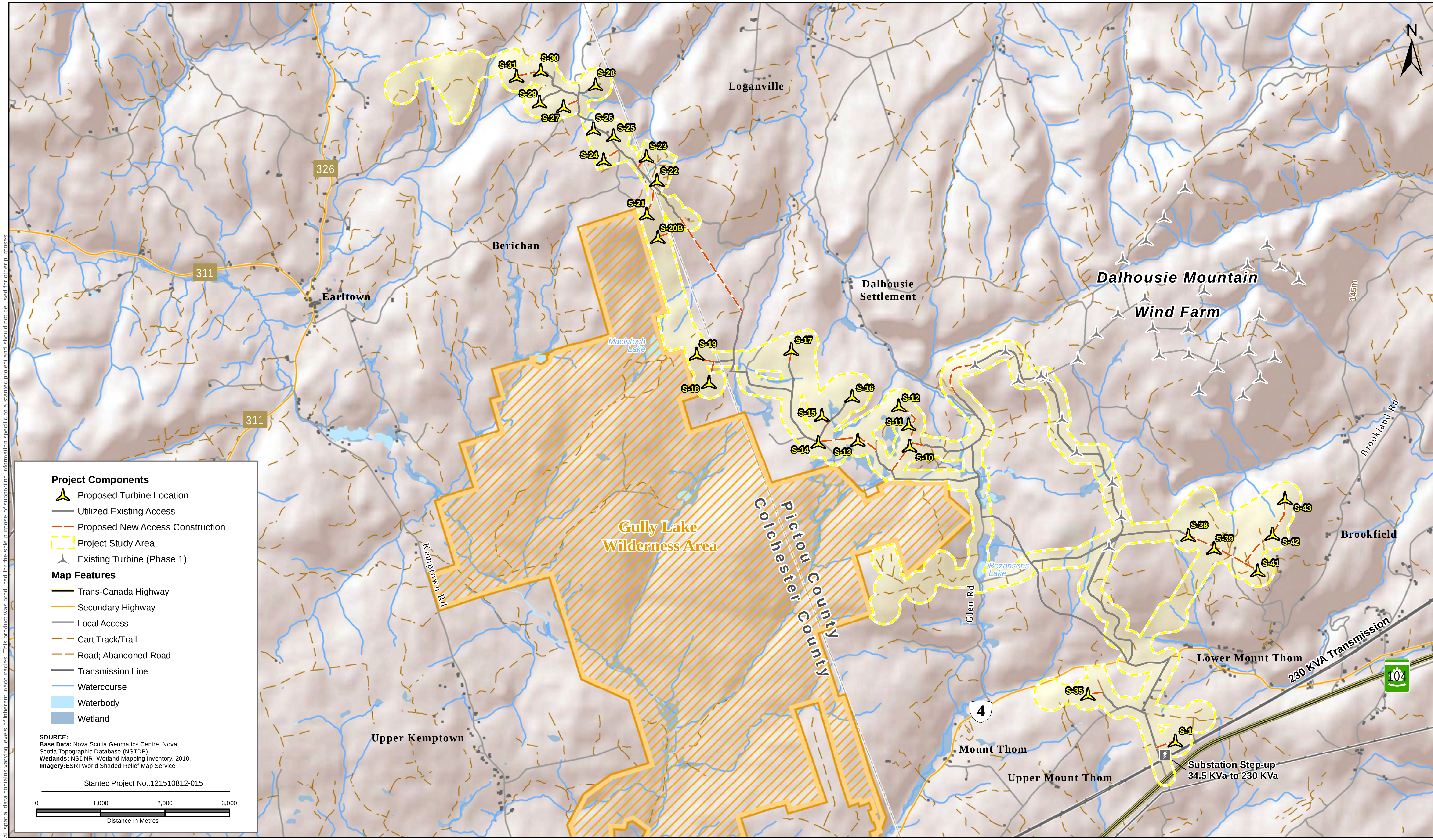
Averaging Time Period	NSE Noise Guideline (dBA)
Day (7:00 to 19:00)	65
Evening (19:00 to 23:00)	60
Night (23:00 to 7:00)	55

3.3 OPERATION

Wind turbine generators produce sound through a number of different mechanisms which can be categorized as either mechanical or aerodynamic sound sources. The major mechanical components including the gearbox, generator and yaw motors each produce their own characteristic sounds, including sound with tonal components. Other mechanical systems such as fans and hydraulic motors can also contribute to the overall sound emissions. Mechanical sound is radiated at the surfaces of the turbine, and by openings in the nacelle casing.

The interaction of air and the turbine blades produces aerodynamic sound through a variety of processes as air passes over and past the blades. The sound produced by air interacting with the turbine blades tends to be broadband sound, but is amplitude modulated as the blades pass the tower, resulting in a characteristic ‘swoosh’. Generally, wind turbines radiate more sound as the wind speed increases, eventually reaching a plateau of sound output.

To reduce sound impacts resulting from Project operations, routine maintenance of the wind turbines and associated equipment will be conducted as recommended by the manufacturer.



All spatial data contains varying levels of inherent inaccuracies. This product was produced for the sole purpose of supporting information specific to a stantec project and should not be used for other purposes.

PREPARED BY: J. Petho	Clydesdale Ridge Wind Farm Project	FIGURE NO.:	3.1
REVIEWED BY: C. Shupe		DATE:	May 16, 2012
CLIENT: Dalhousie Mountain Wind Farm	**Current Project Layout**	Stantec	

Path: V:\1215\active\121510xxx\121510812_clydesdale_ ridge\geomatics\mapping\mxd\Report Figures\ST_NS_121510812-015_Site_Plan_20120404.mxd

Coordinate System: NAD 1983 UTM Zone 20N

4.0 Sound Level Criteria

Nova Scotia does not have specific sound guidelines for assessing the acoustic impact of wind turbines on residential properties. Consequently, the sound guidelines of the Ontario Ministry of the Environment (MOE) have been used as the basis of this assessment.

Specifically, MOE guideline NPC-232 *Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)* (MOE, 1995) provides general assessment guidelines for industrial sound impacting land use that has qualities of rural areas (Class 3). Characteristics that may indicate the presence of a Class 3 area include:

- A small community with less than 1000 population;
- Agricultural area;
- A rural recreational area such as a cottage or a resort area; or
- Wilderness area.

The MOE refers to one-hour energy equivalent average sound levels (L_{eq}), in units of A-weighted decibels (dBA), which are units weighted to reflect the spectral sensitivity of human hearing. NPC-232 indicates that the applicable sound level limit for a stationary sound source is the existing background sound level. The sound level limit must be representative of the minimum background sound level that occurs or is likely to occur during the operation of a stationary source. Data from background sound monitoring conducted during times when the background sound level is at its lowest can be used to determine the lowest one hour L_{eq}, which will represent the background sound level. However, where background sound levels are low, exclusionary minimum criteria apply, with an exclusionary limit of 45 dBA specified for quiet nighttime periods, and 50 dBA specified for quiet daytime periods.

Wind turbines are unique in that they generate more sound as wind speeds increase (to an operational speed limit); and because increasing wind speed causes elevated background sound levels, MOE has set out supplementary guidance for the assessment of wind turbine generator sound in the *Interpretation for Applying MOE NPC Technical Publications to Wind Turbine Generators* (MOE, 2008). The guidance document gives criteria for the combined impacts of all wind turbine generators in an area as a function of wind speed (Table 4.1).

Table 4.1 MOE Criteria for Wind Turbines

Wind Speed (m/s)	4	5	6	7	8	9	10	11
Wind Turbine Sound Criteria, NPC-232 (dBA)	40	40	40	43	45	49	51	53

The sound level limit at a point of reception in a Class 3 area, under conditions of average wind speed above 6 m/s, expressed in terms of the hourly L_{eq}, is determined by the wind turbine sound criteria (Table 4.1) or the minimum hourly background sound level established in accordance with requirements in Publications NPC-232, whichever is higher.

In terms of the proposed Project, however, the proponent is committed to designing the Project as so that the predicted sound levels at the nearest receptors is 40 dBA or less.

5.0 Existing Sound Levels

As discussed above background sound measurements were not collected as a component of this study. Instead, this assessment relied on the approach used in Alberta and in British Columbia that recognizes that rural areas, with low housing density and local transportation noise can be characterized sufficiently by assuming nighttime background L_{eq} of 35 dBA, and daytime L_{eq} of 45 dBA. It is the experience of Stantec in numerous background sound level surveys in Nova Scotia that this assumption is valid. Based on the similarity of the landscapes of variable boreal forests, and professional experience of the Atmospheric Environment Study Team at similar areas, it was concluded that no substantive difference exists between the assumed ambient levels, such as implemented in western Canada, and the majority of the Study Area. As such, ambient sound levels within and surrounding the Study Area was assumed to be 45 dB_A during the day (0700 to 2200 hrs) and 35 dB_A during the night (2200 to 0700 hrs). Note that these assumed ambient sound levels exclude the sound associated with the operation of the Dalhousie Mountain Wind Farm, which is adjacent to the proposed Project. The Ontario guidelines consider only the incremental change associated with the operation of the wind turbines. For the purposes of this assessment, therefore, the operation of the Dalhousie turbines is not assumed to be part of the background, but a part of the cumulative wind energy development. It is considered appropriate here, and in similar situations, to consider the cumulative impact of all wind turbines at the receptors that are influenced by the proposed Clydesdale Ridge Wind Farm. Refer to Section 7.3 for information pertaining to the sound levels related to the operation of the Dalhousie Mountain Wind Farm.

6.0 Sound from Wind Turbines

The sound emitted during the routine operation of wind turbines is influenced by a number of factors including local meteorology, masking effects and tonal sounds. Each of these factors is further described below.

6.1 METEOROLOGY

Wind turbines are designed to extract energy from the layer of atmosphere that passes through the swept disk of the rotor blades. The turbines described in this analysis have a hub height of 80 m. Typically the windspeed observed by the anemometer mounted on the nacelle approximately at hub height is used to control the wind turbine; windspeeds as reported by standard meteorological stations are nearer the surface at an elevation of 10 m (30.5 feet). The surface (i.e. 10 m) windspeed is the one reported by convention in the wind turbine performance specifications with respect to electrical power generation and sound energy production. Although the surface windspeed may underestimate the hub-height windspeed in some situations, this analysis is based only on the maximum sound power output from the turbines, regardless of windspeed.

Winds in the atmosphere generally increase in speed from the surface upward due to the frictional drag of the earth's surface. During the day, the surface is heated and the warmed air rises and cold air descends to replace it. The descending air has a higher horizontal velocity, therefore this descending cooler air is often noticeable as a gust. This is the fundamental reason why the windspeed at the surface is generally higher during the day than at night. At night, the temperature profile in the atmosphere becomes stable: that is, the atmosphere is generally warmer at height than at the surface. The cooler air at the surface tends not to rise, and the warmer air does not descend, so the higher velocity in the warmer air stays aloft. When the sky is clear at night, low windspeeds are often observed at the surface due to the stable atmosphere.

In terms of wind turbine sound analysis, the IEC 61400-11 standard for measuring sound power from a wind turbine uses a relationship between the velocity at the surface anemometer and the velocity at hub height that predicts the hub height speed to be 1.39 times the surface wind speed. When the atmosphere is very stable, the factor may be greater; when the atmosphere is very unstable, the factor may be smaller. It is important to note that at higher windspeeds, the wind induced turbulence limits the degree to which the atmosphere may be very stable or very unstable.

6.2 MASKING

The meteorological discussion above is relevant to the masking effect on wind turbine sounds. Natural ambient sounds are largely wind-driven and tend to increase with increasing wind speed. It was hypothesized that the higher masking sound of the wind at higher windspeeds meant that the wind turbine could emit higher sound levels without adverse effects (van den Berg 2004). However, as discussed in the previous section, the surface wind, which is what generates the masking sound, may be lower than expected during stable atmospheric conditions. In these situations, the wind turbine sound may emit higher sound levels at higher wind speeds, but the surface winds may not be mask sound from the turbines, making the turbine sound more noticeable. This phenomenon, widely publicized in a European development, has been recognized by regulators and is now taken into account in evaluating sound at receptors. In Ontario, as discussed in section 4.1, the regulated limit for wind turbine noise was 40 dB_A at low windspeeds, and increased with windspeed to allow for the masking effect. In this assessment, 40 dB_A is used as the guideline limit even at the higher windspeeds that produce the maximum sound output from the turbines that is used in the analysis. Therefore, the analysis is considered very conservative, and is not affected by the issues of stability that were identified by van den Berg.

6.3 TONAL SOUND

Tonal sound exists when a single frequency, or small range of frequencies, is louder than others so that there is an identifiable tonal sound such as a hum, or whistle. Such sounds are considered potentially greater annoyances, and are penalized in assessments. Most turbine manufacturers work to reduce the potential occurrence of tonal sound, and those proposed for the Clydesdale Project are not tonal.

7.0 Predicted Sound Levels

7.1 MODEL DESCRIPTION

There are numerous software packages available for the modeling of transmission of sound in the atmosphere. Some use proprietary algorithms, and some are based on published methods that have international recognition. Cadna (Computer Aided Noise Abatement, version 4.2.140), produced by Datakustik in Germany, is a software program that is based on the propagation models in ISO 9613. This ISO standard is in two parts. ISO 9613-1 is concerned with the attenuation of sound by the constituents of air. ISO 9613-2 incorporates the atmospheric absorption component into a framework that models the attenuation of sound by the geometric spreading of sound in the free atmosphere (ISO 1993). Although Cadna contains other sound models, the ISO 9613 is the one that is most commonly used for wind turbine studies, and is employed in this Study.

This computerized model is capable of predicting sound levels at specified receiver positions originating from a variety of sound sources. Applicable national or international standards can also be included in its analysis, as described above.

CadnaA can also account for such factors as:

- Distance attenuation (*i.e.,* geometrical dispersion of sound with distance);
- Geometrical characteristics of the source and receivers;
- Atmospheric attenuation (*i.e.,* the rate of sound absorption by atmospheric gases in the air between sound sources and receptors);
- Ground attenuation (*i.e.,* effect of sound absorption by the ground as sound passes over various terrain and vegetation types between source and receptor);
- Screening effects of surrounding terrain; and
- Meteorological conditions and effects.

The application of the sound model requires a number of input variables. The most important variables are those that indicate the relative geometric position of the source and receiver. The source is taken to be the hub of the turbine, at the center of the disk swept by the rotation of the blades. The second important point is the location of the receiver. Like the source, the receiver coordinates are input as an x, y, and z value. The x value is the “easting” horizontal coordinate, and the y is the “northing” horizontal coordinate. The z value is the height above ground of the receiver. A height of 4 m, just over 13 feet, was used to represent the height of second story windows where sound levels are slightly higher than those at ground level.

The influences of meteorology and terrain and vegetation on sound attenuation in the Project Study Area are described in the following sub-sections.

7.1.1 Meteorological Factors

Meteorological factors, such as temperature, humidity, wind speed and direction, influence sound propagation. The effects of wind on outdoor sound propagation during different weather conditions could cause variations in Project-related sound levels measured at a receptor. If the receptor is upwind of the facility, the wind could cause greater sound attenuation, and lower sound levels at the residence. However, if the residence is downwind of the facility, the opposite effect could occur, resulting in higher sound levels at the residence. Crosswinds have less effect on outdoor sound propagation. The ISO algorithms in Cadna were designed to reflect a situation where there is a modest wind direct from the source to the receiver; that is, the receiver is always downwind. Physically, it cannot happen that every wind turbine is upwind of every receiver at the same time; however, this is another instance where the conservative, worst-case assumption is made with the intention that any errors associated with assumptions are biased toward a higher sound output, and a more protective evaluation.

The following meteorological elements that represent low air absorption of sound are customarily used and were assumed for the sound assessment:

- Temperature = 10°C (50 °F);
- Relative humidity = 70 percent; and
- Wind conditions = variable.

These meteorological parameters can be considered typical of night-time conditions in the spring and summer (when outdoor activities are more likely) and representative of the sound effects during these seasons.

7.1.2 Terrain and Vegetation

Factors such as terrain conditions, types of vegetation and ground cover can all affect the absorption that takes place when sound waves travel over land. For example, if the ground is moist or covered in fresh snow or vegetation, it will be absorptive and aid in sound attenuation. In contrast, if the ground is hard-packed or frozen, it will be reflective and will not aid in sound attenuation. There are no water bodies of significant size between the sources and potentially affected receptors in this project. Psychologically, trees and thick brush are beneficial in isolating the sound source and receiver; however, the actual degree of sound attenuation is limited. A thick growth of trees and brush about 100 feet deep will achieve a noise reduction of 3 to 4 dBA. If the vegetation is deciduous, the loss of the leaves means a loss in the attenuation properties, and the vegetation must be in the line of sight to achieve a reduction. Note also that some part of the sound energy will refract over the bush, just as it can refract over hills, and doubling the depth of the forest will not necessarily double the reduction in sound transmission. The ground in the Clydesdale area is generally vegetated, or a soil surface that may be overlain with snow in the winter season yielding surface absorption of about 80%. However, this study takes a conservative approach, assuming that there is no intervening vegetation between the sources and receivers to reduce sound levels.

In countryside with substantial terrain relief, the height of the ground changes and the sound model uses a dense grid of terrain elevation values, typically at spacings of 50 to 100 feet, to internally construct a digital terrain model. As the program executes, it is able to calculate absolute heights of the source and receiver from the data that the user provides, and from the digital terrain model of ground height. The model also uses the digital terrain model to determine if there is a clear line-of-sight from the source to the receiver, or whether topographic features interrupt this path and provide some screening effect on the sound transmission. Where there is a barrier effect due to topography, the model calculates the attenuation loss according to the standards of ISO 9613-2; typically, this attenuation will be less than 5 dBA.

7.1.3 Summary of Model Assumptions

In summary, the following conservative assumptions have been incorporated into the modeling for this development:

- Receiver height of 4 m, which represents the height of a second floor bedroom;
- Source height is equal to the hub height of the wind turbine generators;
- Local terrain effects;
- No intervening vegetation between the source and receptor;
- Receptor points are simultaneously located downwind of all turbines; and
- Ground absorption factor of 0.5%.

7.2 CONSTRUCTION

Typical construction activities that would create sound are presented in Table 7.1. The actual equipment used on site might differ from those listed below.

Table 7.1 Typical Sound Levels of Construction Equipment

Construction Equipment	Typical Sound Level at 15 m (dBA)
Earth Moving	
Loader	**85**
Bulldozer	**85**
Backhoe	**80**
Scraper	**89**
Grader	**85**
Materials Handling	
Crane (mobile)	**83**
Concrete mixer	**85**
Concrete pump	**82**
Concrete vibrator	**76**
Stationary Equipment	
Air compressor	**81**
Generator	**81**

Table 7.1 Typical Sound Levels of Construction Equipment

Construction Equipment	Typical Sound Level at 15 m (dBA)
Impact Equipment	
Jack hammer	**88**
Pile driver (impact)	**101**

SOURCE: US Department of Transportation (2006)

The level of sound will vary according to the type of construction activity and the number of pieces of equipment in operation at any given time and will be temporary in nature.

To reduce the sound pressure levels at the nearest residents a combination of mitigation measures will be employed, including but not limited to:

- Limiting the amount of construction equipment operating simultaneously;
- Ensuring all pieces of equipment have quality mufflers and are well maintained; and
- Respecting time activity and level limits of applicable guidelines and bylaws.

7.3 OPERATION

Sound modeling for the operation of the development was completed to predict the effects of the Project on the sound environment in the Study Area.

Sound associated with the operational phase of the proposed Project was modeled including the operational noise from the existing Dalhousie Mountain Wind Farm. Modeling the sound generated from the operation of the 29 GE1.6 Series - 82.5m wind turbine generators (106 dBA) included consideration of the existing Dalhousie Farm (GE1.5 sle, 104 dBA). In additional to the sound power level specifications the coordinates and tower height of the wind turbine generators were also incorporated into the model. These details are provided in Table 7.2.

Table 7.2 Wind Turbine Generator Details

Wind Turbine Identification	Sound Power Level (dBA)	UTM Coordinates		Turbine Hub Height (m)
		Easting (m)	Northing (m)	
S-1	106	502760	5040254	80
S-10	106	498623	5044837	80
S-11	106	498611	5045176	80
S-12	106	498455	5045469	80
S-13	106	497819	5044925	80
S-14	106	497205	5044901	80
S-15	106	497257	5045317	80
S-16	106	497731	5045616	80
S-17	106	496783	5046341	80
S-18	106	495504	5045830	80

Table 7.2 Wind Turbine Generator Details

Wind Turbine Identification	Sound Power Level (dBA)	UTM Coordinates		Turbine Hub Height (m)
		Easting (m)	Northing (m)	
S-19	106	495313	5046271	80
S-20B	106	494708	5048088	80
S-21	106	494534	5048453	80
S-22	106	494693	5048972	80
S-23	106	494532	5049345	80
S-24	106	493863	5049294	80
S-25	106	494018	5049672	80
S-26	106	493706	5049776	80
S-27	106	493240	5050124	80
S-28	106	493739	5050465	80
S-29	106	492865	5050194	80
S-30	106	492888	5050689	80
S-31	106	492507	5050596	80
S-35	106	501397	5040977	80
S-38	106	502956	5043450	80
S-39	106	503357	5043251	80
S-41	106	504040	5042901	80
S-42	106	504265	5043469	80
S-43	106	504464	5044023	80

To aid in the evaluation of the operation of the development a set of receptor points were selected, which represent the residents in any direction from the project with the greatest potential to exceed sound level limits. These receptors were included in the model and their locations are geographically presented in Figure 7.1 and listed in Table 7.3.

Table 7.3 Receptor Location and Details

Receptor No.	UTM Coordinates		Description
	Easting (m)	Northing (m)	
1	502260	5040819	Residence
2	502562	5040643	Residence
3	502379	5040929	Residence
4	502516	5041192	Residence
5	501154	5040481	Residence
6	493618	5051089	Residence
7	494007	5051288	Residence
8	497858	5046850	Cottage
9	498093	5046596	Cottage
10	498243	5046412	Cottage

Table 7.3 Receptor Location and Details

Receptor No.	UTM Coordinates		Description
	Easting (m)	Northing (m)	
11	498295	5046335	Cottage
12	497867	5046703	Cottage
13	497698	5047381	Cottage
14	497578	5047388	Cottage
15	497710	5047324	Cottage
16	497714	5047390	Cottage
17	497347	5047857	Cottage
18	497596	5047238	Cottage
19	497698	5047432	Cottage
20	497721	5047296	Cottage
21	497491	5047819	Cottage
22	497888	5046706	Residence
23	505581	5045217	Residence
24	505396	5044996	Residence
25	505435	5044928	Residence
26	505373	5045102	Residence
27	505611	5044318	Residence
28	505605	5044299	Residence
29	505468	5044094	Residence
30	505100	5043104	Residence
31	505281	5043709	Residence
32	505112	5043470	Residence
33	505153	5043138	Residence
34	505453	5043953	Residence
35	505111	5043421	Residence
36	505091	5043080	Residence
37	505150	5043455	Residence
38	505122	5043065	Residence
39	504748	5042474	Residence
40	503757	5041648	Residence
41	503432	5041717	Residence
42	503436	5041691	Residence
43	503725	5041648	Residence
44	503556	5041702	Residence
45	503517	5041694	Residence
46	503656	5041675	Residence
47	503786	5041642	Residence
48	504252	5041957	Residence

Table 7.3 Receptor Location and Details

Receptor No.	UTM Coordinates		Description
	Easting (m)	Northing (m)	
49	504121	5041685	Residence
50	504136	5041693	Residence
51	504206	5041771	Residence
52	504238	5041776	Residence
53	504254	5041784	Residence
54	504236	5041925	Residence
55	504289	5042067	Residence
56	503485	5041407	Residence
57	503609	5041260	Residence
58	503603	5041275	Residence
59	503387	5041548	Residence
60	503217	5041587	Residence
61	503510	5041335	Residence
62	503524	5041406	Residence
63	503300	5041406	Residence
64	503528	5041319	Residence
65	503306	5041390	Residence
66	503678	5041246	Residence
67	503581	5041361	Residence
68	503247	5041589	Residence
69	503014	5041709	Residence
70	489523	5049497	unverified
71	491134	5051720	unverified
72	491134	5051713	unverified
73	489526	5050884	unverified
74	499322	5040087	unverified
75	501214	5040148	unverified

The predicted sound levels at the receptors resulting from the operation of the Dalhousie Wind Farm and the Project combined are shown in Table 7.4. A contour map of the predicted sound levels is also presented below in Figure 7.4.

Table 7.4 Predicted Sound Pressure Levels for Project Operation

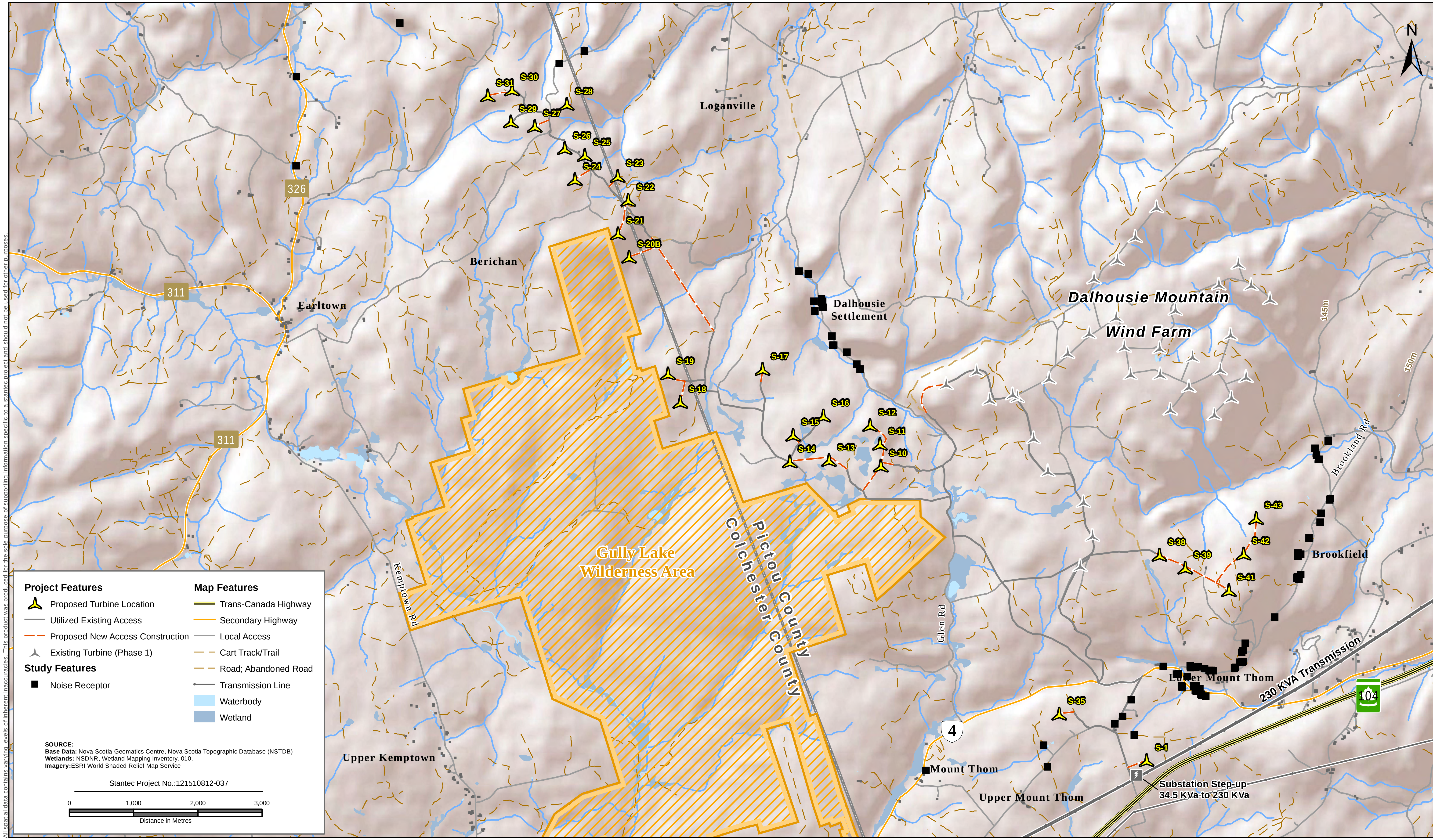
Receptor No.	Predicted Operational Sound Level (dBA)	Sound Level Limits (dBA)
1	36.3	40
2	39.7	40
3	35.7	40

Table 7.4 Predicted Sound Pressure Levels for Project Operation

Receptor No.	Predicted Operational Sound Level (dBA)	Sound Level Limits (dBA)
4	34.1	40
5	37.3	40
6	39.2	40
7	35.5	40
8	34.8	40
9	36	40
10	36.8	40
11	37.4	40
12	35.5	40
13	32	40
14	32.3	40
15	32.2	40
16	31.8	40
17	29.5	40
18	33.1	40
19	31.8	40
20	32.3	40
21	30.3	40
22	35.4	40
23	31.7	40
24	32.5	40
25	32.3	40
26	32.6	40
27	32.3	40
28	32.4	40
29	33.6	40
30	35.4	40
31	35.3	40
32	36.4	40
33	35.1	40
34	33.8	40
35	36.3	40
36	35.4	40
37	36	40
38	35.1	40
39	35	40

Table 7.4 Predicted Sound Pressure Levels for Project Operation

Receptor No.	Predicted Operational Sound Level (dBA)	Sound Level Limits (dBA)
40	30.6	40
41	31.1	40
42	31.1	40
43	30.6	40
44	31	40
45	31	40
46	30.8	40
47	30.5	40
48	32.9	40
49	30	40
50	30	40
51	30.2	40
52	30.4	40
53	31.3	40
54	32.7	40
55	33.9	40
56	31.1	40
57	30.4	40
58	30.4	40
59	31.5	40
60	32.3	40
61	31.4	40
62	31.3	40
63	31.9	40
64	30.7	40
65	31.9	40
66	31.2	40
67	31.1	40
68	32.3	40
69	31.8	40
70	20.6	40
71	27.8	40
72	27.8	40
73	20.8	40
74	22.4	40
75	33.4	40



PREPARED BY: K Keizer

REVIEWED BY: K Fraser

CLIENT: Dalhousie Mountain Wind Farm

Clydesdale Ridge Wind Farm Project

Noise Receptor Locations

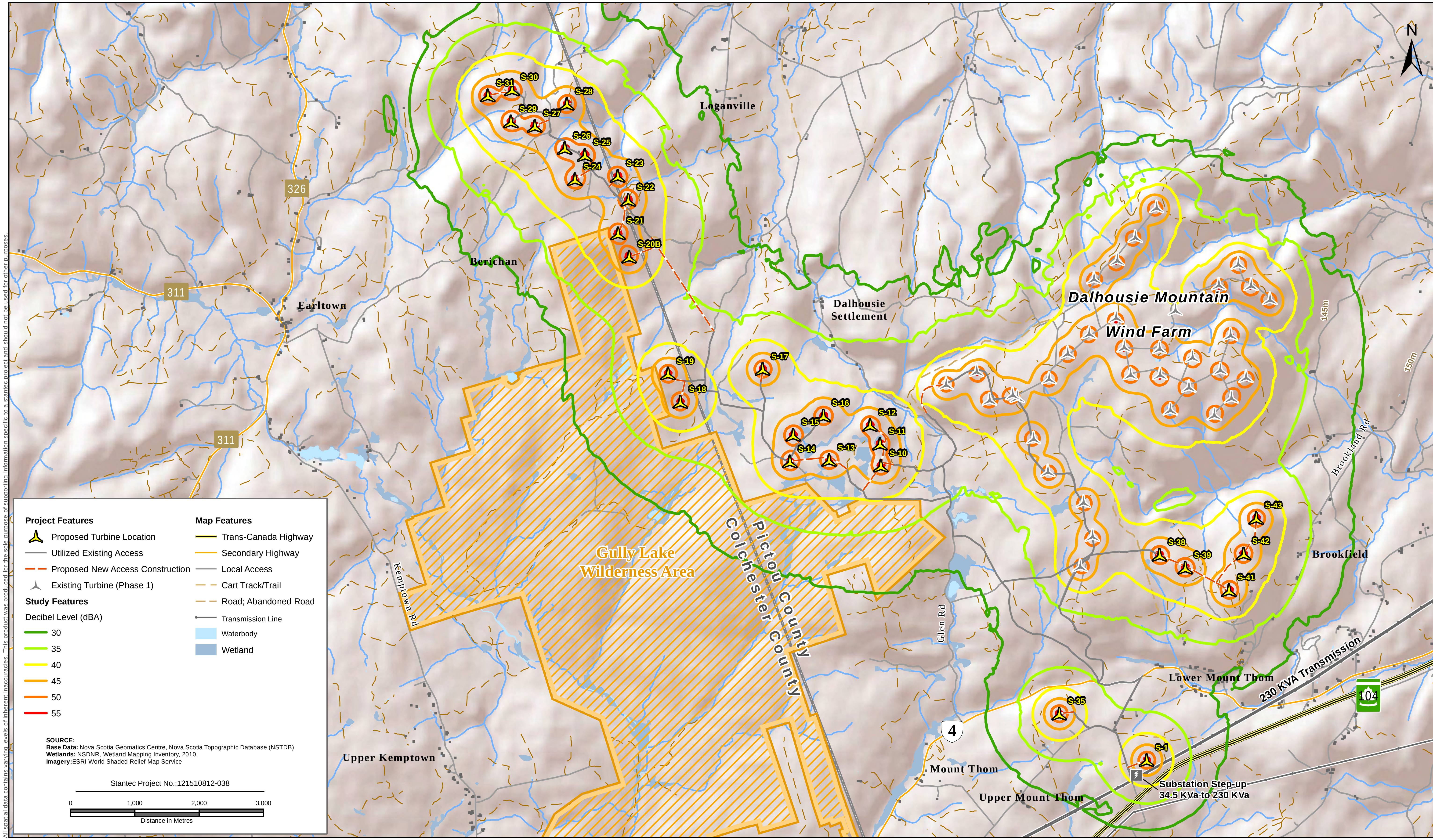
FIGURE NO.: 7.1

DATE: May 15, 2012

Stantec

Path: V:\1215\active\121510xxx\121510812_clydesdale_ ridge\geomatics\mapping\mxd\Report Figures\ST_NS_121510812-037_Noise_Receptors_20120426.mxd

Coordinate System: NAD 1983 UTM Zone 20N



PREPARED BY: K Keizer

REVIEWED BY: K Fraser

CLIENT: Dalhousie Mountain Wind Farm

Clydesdale Ridge Wind Farm Project

Sound Pressure Level Predictions

FIGURE NO.: 7.2

DATE: May 16, 2012

Stantec

Path: V:\1215\active\121510xxx\121510812_clydesdale_ ridge\geomatics\mapping\mxd\Report Figures\ST_NS_121510812-038_Noise_results_2040426.mxd

Coordinate System: NAD 1983 UTM Zone 20N

8.0 Summary and Conclusions

To evaluate the potential sound impacts resulting from the Project, Stantec Consulting Ltd (Stantec) conducted a sound level assessment. The key issues examined in this assessment were sound produced by the construction and operational phases of the Project. To aid in the evaluation, a set of receptor points were selected, which represent the locations with the greatest potential to exceed the applicable sound level limits.

Operational sound levels were predicted for each receptor using a sound modeling program called Cadna A, version 4.2.140. Meteorology and local terrain were considered in the modeling and maximum sound power level information provided by the turbine manufacturer was used for the model. Both the operation of the existing Dalhousie Wind Turbine Farm and the proposed Project were considered in the modeling. Presently, the province of Nova Scotia does not have set sound level limits specific to wind turbine operations. For assessment purposes in this Study a limit of 40 dBA was used, which was adopted from the Ontario regulations.

The modeling demonstrated that the sound levels predicted at each of the receptor meets the adopted limit of 40 dBA. The sound power levels were the maximum produced by the wind turbines, and the sound levels will be lower much of the time when the wind speed does not reach a maximum.

9.0 References

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