SOUND LEVEL ASSESSMENT REPORT

Antrim Wind Energy Project
Antrim, NH

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1.0 INTRODUCTION AND SUMMARY

The Antrim Wind Energy Project is a 30 megawatt (MW) wind power generation facility proposed for Hillsborough County, New Hampshire. The Project will be entirely within the Town of Antrim, generally located on Tuttle Hill south of NH Route 9. The wind farm will have ten (10) 3.0 MW Acciona AW116/Class II/3000 wind turbines using a hub height of 92 meters, and a rotor diameter of 116 meters.

This sound level assessment included a sound-monitoring program to determine existing sound levels in the vicinity of the Project, computer modeling to predict future sound levels when the wind turbines are operational, and a comparison of the worst-case operational sound levels associated with the wind turbines to accepted criteria. Every residence is at least 2,600 feet (one-half mile) from the nearest wind turbine. Therefore, worst-case sound levels will be 41 dBA or less at any residence. There are no federal or existing local noise regulations that apply to this project. However, the results of this sound level impact assessment show that the Project will easily comply with recent NH SEC decisions on comparable wind turbine projects in Lempster and Groton, NH, community noise guidelines published by the World Health Organization, and noise guidelines put out by the US Environmental Protection Agency.

2.0 SOUND METRICS

There are several ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the noise measurement terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a three-decibel increase (to 53 dB), not a doubling to 100 dB. Thus, every three dB change in sound levels represents a doubling or halving of sound energy. Related to this is the fact that a change in sound levels of less than three dB is imperceptible to the human ear.

Another property of decibels is that if one source of noise is 10 dB (or more) louder than another source, then the total sound level is simply the sound level of the higher source. For example, a source of sound at 60 dB plus another source of sound at 47 dB is 60 dB.

The sound level meter used to measure noise is a standardized instrument.[1] It contains "weighting networks" to adjust the frequency response of the instrument to approximate that of the human ear under various circumstances. One network is the A-weighting network (there are also B- and C-weighting networks). The A-weighted scale (dBA) most closely approximates how the human ear responds to sound at various frequencies, and is the accepted scale used for community sound level measurements. Sounds are frequently reported as detected with the A-weighting network of the sound level meter. A-weighted sound levels emphasize the middle frequency (*i.e.,* middle pitched – around 1,000 Hertz sounds), and de-emphasize lower and higher frequency sounds. A-weighted sound levels are reported in decibels designated as "dBA." Sound pressure levels for some common indoor and outdoor environments are shown in Figure 2-1.

Because the sounds in our environment vary with time they cannot simply be described with a single number. Two methods are used for describing variable sounds. These are exceedance levels and the equivalent level, both of which are derived from a large number of moment-to-moment A-weighted sound level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n, where n can have a value of 0 to 100 percent. Several sound level metrics that are commonly reported in community noise monitoring are described below.

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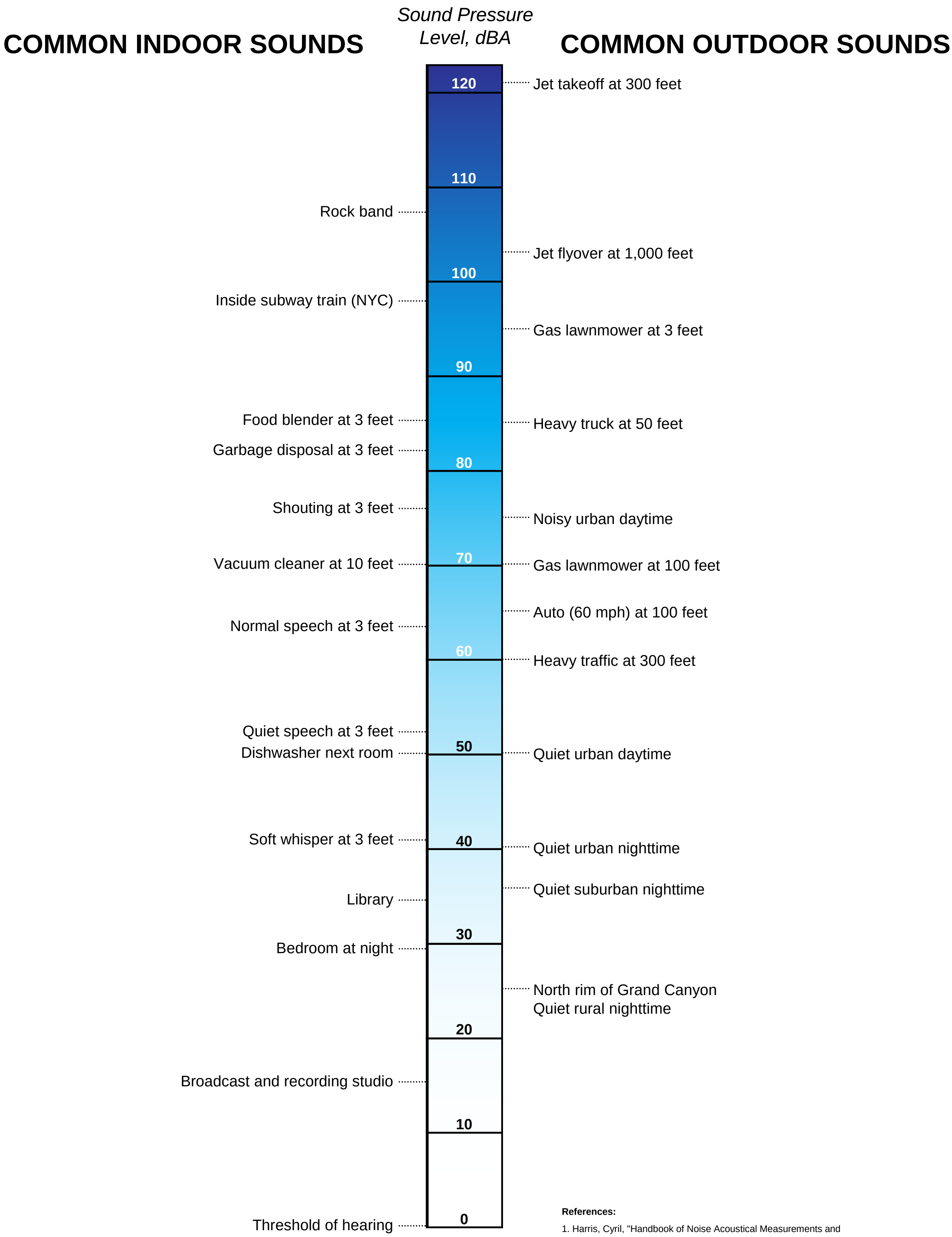
1 *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983, published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during the measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.

- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is also A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Figure 2-1

Common Indoor and Outdoor Sound Levels

3.0 NOISE REGULATIONS

3.1 Federal Regulations

There are no federal community noise regulations applicable to wind farms.

3.2 New Hampshire State Regulations

There are no State of New Hampshire Community noise regulations applicable to the wind farm.

Noise may be reviewed as part of the NH Site Evaluation Committee (SEC) process which applies to any wind energy project over 30 MW. As part of the SEC approval for the Lempster (NH) Wind Farm, several noise conditions were implemented via the Agreement with the Town of Lempster. Similar conditions were subsequently adopted for the Groton (NH) Wind Farm.

<u>Lempster Wind – Noise conditions</u>

1. Audible sound from the project shall not exceed 55 dBA measured at 300 feet from any existing occupied building, or at the property line if the property line is less than 300 feet from an existing occupied building for non-participating landowners.

2. Sound pressure levels shall not be exceeded for more than 3 minutes in any hour of the day, for non-participating landowners.

3. If the existing ambient sound pressure level exceeds 55 dBA, the standard shall be ambient dBA plus 5 dBA.

4. Sound from the project immediately outside any residence of a non-participating homeowner shall be limited to the greater of 45 dBA or 5 dBA above the ambient sound level, for non-participating landowners.

5. These thresholds implemented via the Town of Lempster were modified by the NH SEC to a level of 45 dBA.

<u>Groton Wind – Noise conditions</u>

1. Sound levels generated by the Project at the outside facades of homes should not exceed 55 dBA or 5 dBA greater than ambient, whichever is greater, in daytime and 45 dBA or 5 dBA greater than ambient, whichever is greater, at night.

2. Sound levels generated by the Project shall not exceed 40 dBA or 5 dBA greater than ambient, whichever is greater as measured within current boundaries of the Baker River Campground.

3. Any landowner may waive the noise restriction set forth in the SEC Certificate by signing a waiver of their rights, or by signing an agreement that contains provisions providing for a waiver of their rights.

3.3 Local Regulations

Epsilon is not aware of any applicable noise standards in Antrim, NH.

3.4 Other Criteria for Comparison

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, Geneva, 1999). This document states that daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open.

Another useful guideline for comparing sound levels is the "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" (U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, DC, 550/9-74-004, March 1974). This document, often referred to as the "Levels" document, identifies an L_{dn} of 55 dBA outdoors in residential areas as the maximum level below which no effects on public health and welfare occur due to interference with speech or other activities. This level includes a 10 dBA "penalty" for sound levels at night (10 p.m. to 7 a.m.). This level will permit normal speech communication, and would also protect against sleep interference inside a home with the windows open. A constant sound level of 48.6 dBA 24 hours per day would be equal to an L_{dn} of 55 dBA.

4.0 SOUND FROM WIND TURBINES

A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.[2] A few points are repeated herein. Wind turbine noise can originate from two different sources; mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine noise. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical noise. Aerodynamic noise has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction.

Aerodynamic noise, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

Infrasound (sound at frequencies below about 20 Hz) can be neglected in the assessment of modern upwind turbines such as those at the Antrim Wind Farm. Low frequency sound (approximately 10 Hz to 200 Hz) has been reduced to low levels in modern wind turbines and is generally not an issue.[3] [4]

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2 Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Wind Turbine Acoustic Noise, June 2002, amended January 2006.

3 Leventhall, Geoff, "How the 'mythology' of infrasound and low frequency noise related to wind turbines might have developed," First International Meeting on Wind Turbine Noise, Berlin, Germany, 2005.

4 O'Neal, R.D., R.D. Hellweg, Jr., and R. M. Lampeter, "Low frequency noise and infrasound from wind turbines," Noise Control Engineering Journal, March-April 2011, **59**(2), 135-157.

5.0 EXISTING SOUND LEVELS

5.1 Overview

The wind turbine project is located at Tuttle Hill in the Town of Antrim, Hillsborough County, New Hampshire, south of Keene Road (Route 9). The wind farm will have ten (10) 3.0-megawatt (MW) Acciona AW116/Class II/3000 wind turbines using a hub height of 92 meters, and a rotor diameter of 116 meters. The coordinates for each wind turbine were provided by Antrim Wind Energy, LLC.

5.2 Sound Level Environment

An ambient sound level survey was conducted to characterize the current acoustical environment under varying wind conditions in the community. Current noise sources in the project area include: noise from wind blowing through vegetation, birds, traffic, running water from brooks, aircraft, insects, vehicular traffic on local roads and Route 9 (for some locations), construction activities, and mechanical noise/boats on Gregg Lake.

5.3 Sound Level Measurement Locations

The selection of the sound monitoring locations was intended to be representative of nearby residences in various directions from the wind farm. Figure 5-1 shows the proposed wind turbine locations as well as the actual measurement locations overlaid upon an aerial photograph of the surrounding area. Each sound level monitoring location is described below. The coordinates for the sound level measurement locations were obtained by Epsilon staff in the field using a Global Positioning System (GPS) instrument with an accuracy of 3 meters or less. All distances shown are rounded to the nearest 100 feet.

- Location L1 – 354 Keene Road (Route 9)
  - Approximately 2,900 feet to the closest proposed wind turbine (#1). This location is representative of the nearest residents to the north of the wind farm along Route 9.
- Location L2 – 47 Loveren Mill Road
  - Approximately 5,500 feet to the closest proposed wind turbine (#1). This location is representative of the nearest residents to the north of the wind farm along Loveren Mill Road, set far back from traffic on Route 9.
- Location L3 – Salmon Brook Road
  - Approximately 4,200 feet to the closest proposed wind turbine (#5). This location is representative of the nearest residents to the west of the wind farm along Salmon Brook Road.

- Location L4 – 72 Reed Carr Road
  - Approximately 3,600 feet to the closest proposed wind turbine (#1). This location is representative of the nearest residents to the east and northeast of the wind farm along Reed Carr Road and Craig Road.
- Location L5 – Gregg Lake Road
  - Approximately 8,700 feet to the closest proposed wind turbine (#8). This location is representative of the residents to the southeast of the wind farm along Gregg Lake Road to the north of Gregg Lake.

Table 5-1 lists the GPS coordinates for the five sound level measurement locations. The 2-meter meteorological tower at Location L5 was located in the vicinity of these coordinates, which are presented in WGS 1984 format.

Table 5-1 GPS Coordinates – Sound Level Measurement Locations

Location	Latitude	Longitude
Location L1 – Keene Road	43.07548	-72.00855
Location L2 – Loveren Mill Road	43.07901	-72.02127
Location L3 – Salmon Brook Road	43.05612	-72.03526
Location L4 – Reed Carr Road	43.07005	-71.99473
Location L5 – Gregg Lake Road	43.04306	-71.98836

5.4 Sound Measurement Methodology

A comprehensive sound level measurement program was developed to quantify the ambient sound levels around the wind farm. Over two weeks of ambient sound level measurements were taken from Friday, September 16, 2011 through Tuesday, October 4, 2011. Continuous sound level measurements were made at all five locations, and ground-level wind speeds were continuously measured and logged at one location. A 60-meter-high meteorological tower located approximately 50 feet from turbine #2 also measured and logged wind speeds during the sound level measurement period. Meteorological data from the nearby Jaffrey Municipal Airport Silver Ranch National Weather Service (NWS) station were also archived for the duration of the measurement period. These data are included in Appendix B.

Sound levels were measured at a height of approximately five feet above the ground at locations where there were no large reflective surfaces to affect the measured levels. Below is a description of the measurement program for each location.

5.4.1 Location L1 – Keene Road (Route 9)

One continuous programmable unattended sound level meter was placed on the side of the driveway at #354 Keene Road approximately 150 feet back from the street, at the edge of the woods. This setback is comparable to those of nearby houses due west along Keene Road. This meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics from 10:00 a.m. Friday, September 16 until 10:20 a.m. Tuesday, October 4, for a total of 432 hours. Field personnel checked on the integrity of the equipment during the first day and third night of monitoring, and during an interim field visit on September 23.

5.4.2 Location L2 – Loveren Mill Road

One continuous programmable unattended sound level meter was placed about 20 feet north of the driveway at #47 Loveren Mill Road approximately 50 feet back from the street. This meter continuously measured and stored broadband (A-weighted) sound level statistics from 10:50 a.m. Friday, September 16 until 11:50 a.m. Tuesday, October 4, for a total of 433 hours. Field personnel checked on the integrity of the equipment during the first day and third night of monitoring, and during an interim field visit on September 23.

5.4.3 Location L3 – Salmon Brook Road

One continuous programmable unattended sound level meter was placed in the woods just south of Salmon Brook Road beyond the driveway at #156. This meter, approximately 125 feet beyond a red metal gate, continuously measured and stored broadband (A-weighted) sound level statistics from 11:40 a.m. Friday, September 16 until 9:50 a.m. Tuesday, October 4, for a total of 430 hours. Field personnel checked on the integrity of the equipment during the first day and third night of monitoring, and during an interim field visit on September 23.

5.4.4 Location L4 – Reed Carr Road

One continuous programmable unattended sound level meter was placed in the backyard of #72 Reed Carr Road near a garden facing the ridgeline where the proposed turbines will be located. This meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics from 1:10 p.m. Friday, September 16 until 10:40 a.m. Tuesday, October 4, for a total of 429 hours. Field personnel checked on the integrity of the equipment during the first day and third night of monitoring, and during an interim field visit on September 23.

5.4.5 Location L5 – Gregg Lake Road

One continuous programmable unattended sound level meter was placed just east of the covered picnic tables at the Antrim Town Beach on Gregg Lake Road. This meter continuously measured and stored broadband (A-weighted) sound level statistics from 2:00 p.m. Friday, September 16 until 11:00 a.m. Tuesday, October 4, for a total of 429 hours. In addition, continuous ground-level wind speed measurements were made at this location, at a height of two meters above ground level (AGL). Field personnel checked on the integrity of the equipment during the first day and third night of monitoring, and during an interim field visit on September 23.

5.5 Measurement Equipment

Two Larson-Davis (LD) model 831 Sound Level Analyzers, equipped with an LD Type 1 Preamplifier, an LD 377B20 half-inch microphone, and an environmental protection kit were used to collect continuous A-weighted (dBA) and one-third octave band ambient sound pressure level data at Locations L1 and L4. Three Larson Davis Model 820 sound level meters were used for the continuous A-weighted (dBA) ambient monitoring at Locations L2, L3, and L5. Each meter was tripod-mounted at a height of five feet above ground and set to log data every ten minutes along with a one-minute time history ("fast" response).

All meters meet Type 1 ANSI S1.4-1983 standards for sound level meters and were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology. These calibrations were conducted by an independent laboratory within the past 12 months. Each meter has data logging capability and was programmed to log statistical data every ten minutes for the following parameters: L_1, L_{10}, L_{50}, L_{90}, L_{max}, L_{min}, and L_{eq}. All measurement equipment was calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator which meets the standards of IEC 942 Class 1L and ANSI S1.40-1984.

5.6 Measured Sound Levels

A brief summary of the measured sound levels and noise sources from each location is provided below. Several weather events were notable during the 18-day measurement program, including 18 periods of precipitation which resulted in short-term increases in sound levels. These periods were excluded from the analysis.

5.6.1 Location L1 – Keene Road (Route 9)

Sound levels at the L1 monitor were influenced by vehicular traffic on Route 9, steady fan or water noise, leaf rustle, insect noise, and bird calls. The range of sound levels from the continuous measurements are summarized below, and presented graphically in Appendix A. The diurnal fluctuations in sound level (Leq) are very apparent at this location, driven mainly by engine and tire noise from traffic on Route 9, with a range of about 15 dBA between daytime and nighttime hours. Some short-term increases in sound levels can be seen immediately following rain events.

- The continuous steady-state (L_{90} dBA) measurements ranged from 27 to 63 dBA;
- The continuous equivalent level (L_{eq} dBA) measurements ranged from 30 to 68 dBA.

5.6.2 Location L2 - Loveren Mill Road

Sound levels at the L2 monitor were influenced by a traffic noise along Route 9, aircraft, birds chirping, insect noise, and rustling vegetation. The range of sound levels from the continuous measurements are summarized below, and presented graphically in Appendix A. The sound levels at this location are primarily controlled by the insect and bird noise in the area as well as vehicular traffic on local roads. Some short-term increases in sound levels can be seen immediately following rain events.

- The continuous steady-state (L_{90} dBA) measurements ranged from 21 to 68 dBA;
- The continuous equivalent level (L_{eq} dBA) measurements ranged from 23 to 77 dBA.

The L_{90} of 68 dBA was likely caused by rain. More typical L_{90} values were from about 25 to 50 dBA. The L_{eq} of 77 dBA was likely caused by a passing vehicle. More typical L_{eq} values were from about 25 to 55 dBA.

5.6.3 Location L3 – Salmon Brook Road

Sound levels at the L3 monitor were influenced by flowing water from a nearby brook, aircraft, distant traffic noise from Route 9, crackling branches, and bird noise. The range of sound levels from the continuous measurements are summarized below, and presented graphically in Appendix A. The sound levels at this location are primarily controlled by typical forest sources including water noise and bird calls. Some short-term increases in sound levels can be seen immediately following rain events.

- The continuous steady-state (L_{90} dBA) measurements ranged from 22 to 68 dBA;
- The continuous equivalent level (L_{eq} dBA) measurements ranged from 23 to 70 dBA.

The L_{90} of 68 dBA was likely caused by rain. More typical L_{90} values were from about 25 to 50 dBA. The L_{eq} of 70 dBA was likely caused by a passing vehicle. More typical L_{eq} values were from about 25 to 45 dBA.

5.6.4 Location L4 – Reed Carr Road

Sound levels at the L4 monitor were influenced by insect noise, distant vehicular traffic on Route 9, occasional vehicles passing on Reed Carr Road, and bird calls. Daytime sound levels during the first week were influenced by deck construction at the residence. No construction took place at night. The range of sound levels from the continuous measurements are summarized below, and presented graphically in Appendix A.

- The continuous steady-state (L_{90} dBA) measurements ranged from 23 to 60 dBA;
- The continuous equivalent level (L_{eq} dBA) measurements ranged from 25 to 66 dBA.

The L_{90} of 60 dBA was caused by rain. More typical L_{90} values were from about 25 to 55 dBA. The L_{eq} of 66 dBA was likely caused by a passing vehicle. More typical L_{eq} values were from about 30 to 60 dBA.

5.6.5 Location L5 – Gregg Lake Road

Sound levels at the L5 monitor were influenced by traffic on Gregg Lake Road, insects, birds, distant dogs barking, and mechanical noise from across the lake to the east. The range of sound levels from the continuous measurements are summarized below, and presented graphically in Appendix A.

- The continuous steady-state (L_{90} dBA) measurements ranged from 19 to 54 dBA;
- The continuous equivalent level (L_{eq} dBA) measurements ranged from 20 to 74 dBA.

The L_{90} of 54 dBA was caused by rain. More typical L_{90} values were from about 20 to 50 dBA. The L_{eq} of 74 dBA was likely caused by a passing vehicle or boat. More typical L_{eq} values were from about 25 to 55 dBA.

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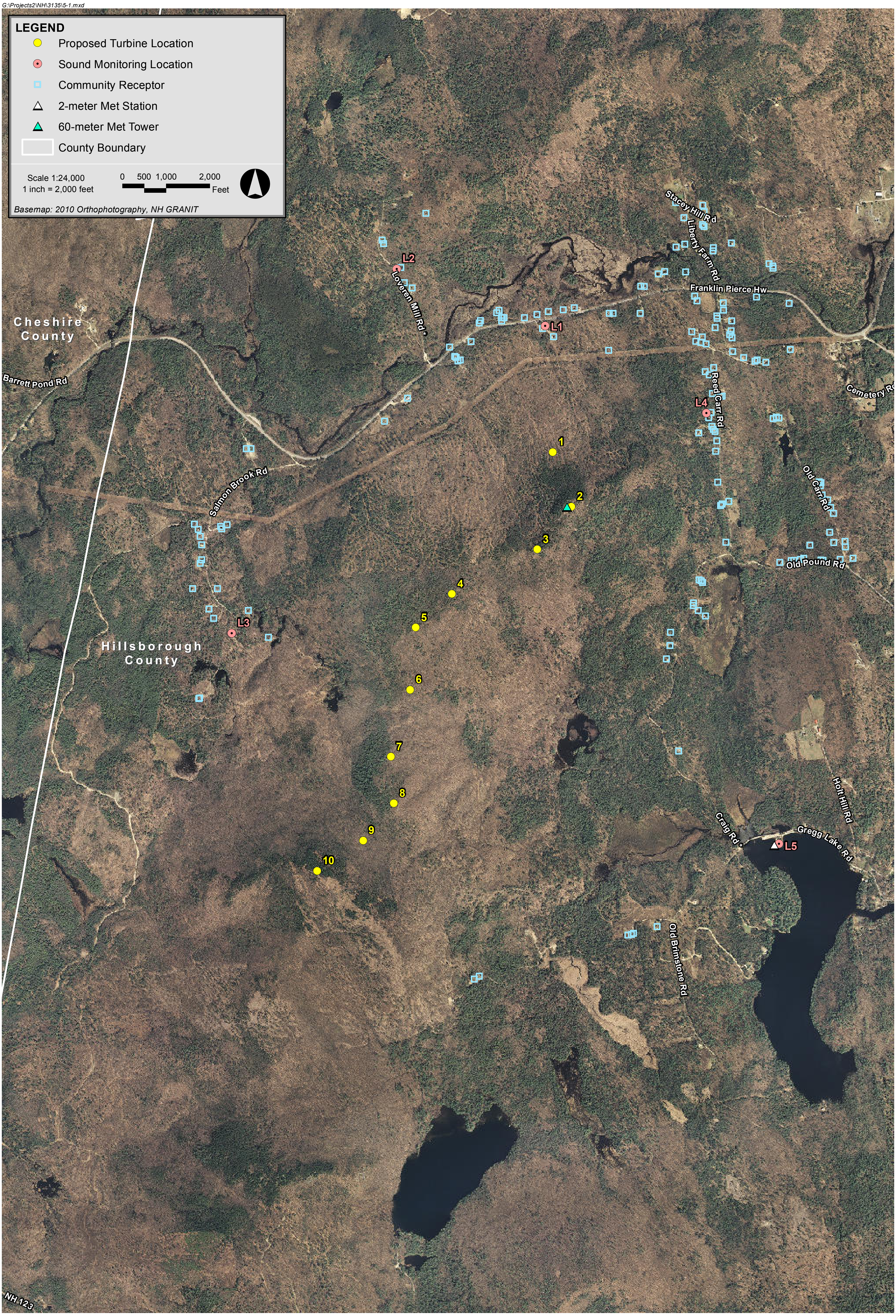


Antrim Wind Antrim, New Hampshire

Epsilon ASSOCIATES INC.

Figure 5-1
Aerial Locus

6.0 EXISTING WIND SPEEDS

6.1 Wind Speed Measurement Equipment

Wind speed can have a strong influence on ambient sound levels. In order to understand how the existing sound levels are influenced by wind speed, continuous wind speed and direction data were recorded at two locations. A NovaLynx Model 110-WS-16 modular weather station with tripod and data logger was used to continuously measure the wind speed and wind direction. The wind sensors were mounted at a height of 2 meters above ground level, and data were logged every 10 minutes. Figure 6-1 shows the wind speed equipment setup at Location L5 (Antrim Town Beach). This wind instrument has a measurement range of 0 to 57 m/s (125 mph) and an accuracy of +/- 0.5 m/s (1.0 mph). The starting threshold is 0.4 m/s (0.8 mph). The wind direction measurement range is 0 to 360 degrees, with an accuracy of +/- 3%. In addition to the portable weather station, an on-site meteorological tower measured and logged wind speeds at a height of 57 meters above ground level every 10 minutes. The location of the 57-meter tower is approximately 50 feet west of proposed wind turbine #2.

6.2 Measured Wind Speeds

The wind speeds measured from September 16, 2011 to October 4, 2011 during the ambient program at one sound level measurement location and the 57-meter on-site met tower are presented in Figure 6-2. Overall, ground-level winds were generally light (below 3 m/s); however there were 60 to 80 dry periods (depending on location) during which elevated wind speeds correlated to maximum turbine sound emissions.

6.3 Existing Sound Levels under Worst-Case Wind Speeds

International Electrotechnical Commission (IEC) standard IEC 61400-11, Wind Turbine Generator Systems-Part 11; Acoustic Noise Measurement Techniques specifies that a manufacturer provide sound level data as a function of wind speed at a standard reference height of 10 meters above ground level. Wind speeds measured at a height other than 10 meters shall be corrected to 10 meters by assuming wind profiles follow the logarithmic profile in equation (7) from the IEC standard, shown here:

$$V_s = V_z \left[\frac{\ln\left(\frac{z_{ref}}{r_{0ref}}\right)\ln\left(\frac{H}{z_0}\right)}{\ln\left(\frac{H}{z_{0ref}}\right)\ln\left(\frac{z}{z_0}\right)} \right]$$

where:

z_{0ref}	is the reference roughness length of 0.05 m;
z_0	is the roughness length;
H	is the rotor center height;
Z_{ref}	is the reference height, 10 m;
z	is the anemometer height

Worst-case reference sound data provided at a 10-meter reference height for the Antrim wind turbines (see Section 7 of this report) indicates that 7 m/s winds will produce the worst-case sound levels (107.4 dBA sound power level). This corresponds to hub height wind speeds of 9.9 m/s (22 mph) and above using the IEC logarithmic profile.

A wind speed of 9.9 m/s at hub height (92 meters AGL) using the IEC procedure described above corresponds to a wind speed at the 57-meter height AGL at the meteorological tower of 9.3 m/s. This was confirmed using a power-law wind shear profile and a client-provided site-specific wind shear coefficient of $\acute{\alpha}$ = 0.13. Therefore, a measured 57-meter wind speed of 9.3 m/s would be expected to produce worst-case sound levels from the Acciona wind turbines. There were 10 to 13 hours per location of 9.3 m/s (or higher) wind speeds at the 57-meter height during the background measurement program, excluding precipitation. The corresponding L_{eq} and L_{90} sound levels at the worst-case wind speed (9.3 m/s and above) were then identified for each of the five sound level measurement locations. The minimum, maximum, average and median background sound levels for each location under the highest wind turbine sound producing conditions without precipitation are summarized in Table 6-1 (L_{eq}) and Table 6-2 (L_{90}).

Table 6-1 Ambient Background L_{eq} Sound Levels

Location	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)	Median L_{eq} (dBA)	Average L_{eq} (dBA)
Location L1 – Keene Road	43	61	59	58
Location L2 – Loveren Mill Road	27	54	45	45
Location L3 – Salmon Brook Road	25	51	44	43
Location L4 – Reed Carr Road	30	63	46	44
Location L5 – Gregg Lake Road	32	54	43	43

Table 6-2 Ambient Background L_{90} Sound Levels

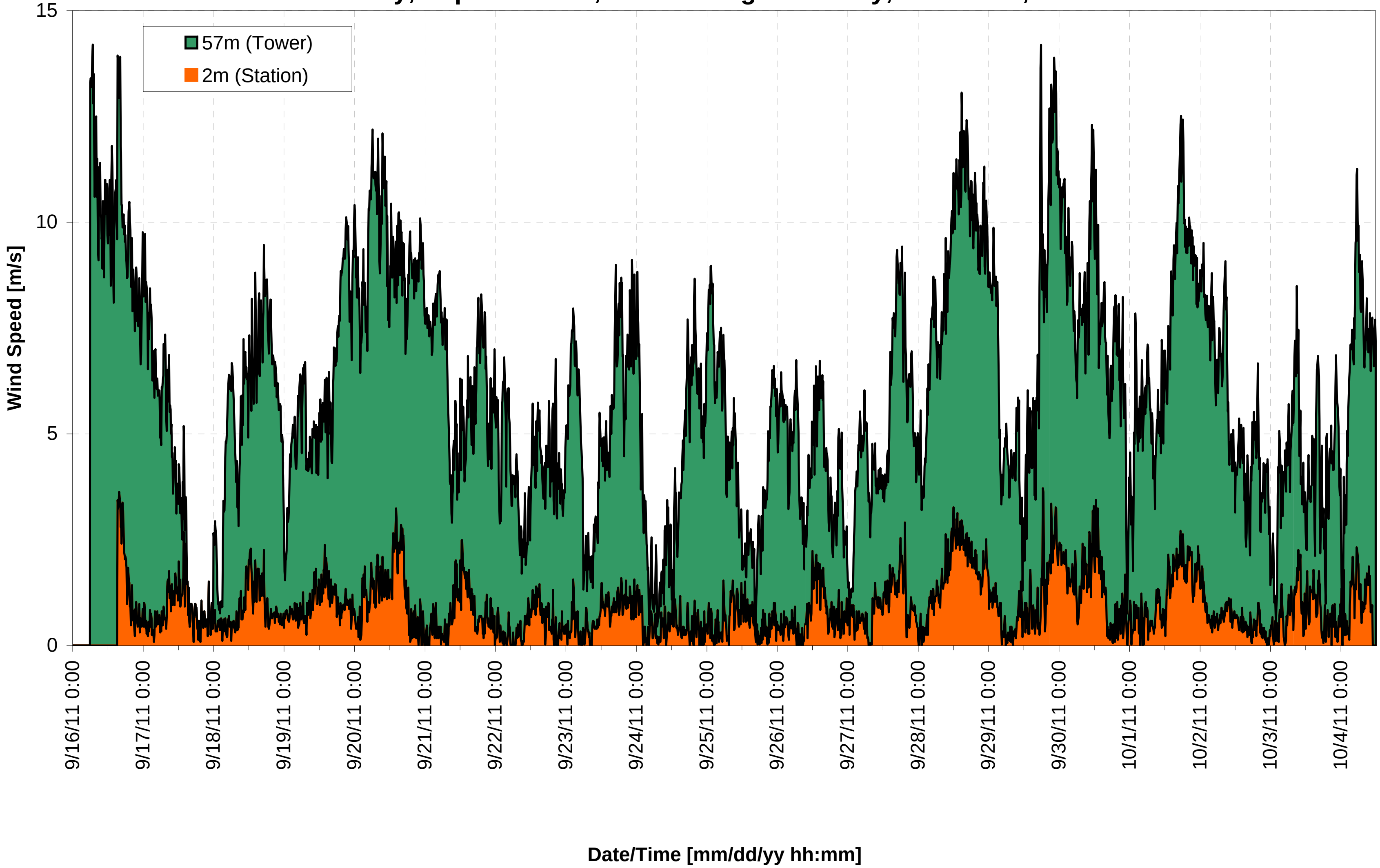
Location	Minimum L_{90} (dBA)	Maximum L_{90} (dBA)	Median L_{90} (dBA)	Average L_{90} (dBA)
Location L1 – Keene Road	27	50	44	44
Location L2 – Loveren Mill Road	24	46	39	39
Location L3 – Salmon Brook Road	24	46	38	37
Location L4 – Reed Carr Road	24	51	41	40
Location L5 – Gregg Lake Road	31	45	37	37

Figure 6-1 Wind Measurement Equipment Setup – Location L5 Gregg Lake

Figure 6-2

Measured Wind Speed Data at 2 meters and 57 meters

Friday, September 16, 2011 through Tuesday, October 4, 2011



7.0 FUTURE CONDITIONS

7.1 Equipment and Operating Conditions

The ten (10) wind turbines modeled for this project are Acciona AW116/Class II/3000 wind generators, conservatively selected to represent the largest and loudest unit the project is likely to employ. Each wind turbine will have three blades and will be placed on a 92-meter-high tower, with a rotor diameter of 116 meters. Table 7-1 shows the manufacturer-provided broadband sound power level with respect to wind speed. Under peak noise producing operating conditions (hub height wind speed of 9.9 m/s) each turbine has an A-weighted sound power level of 107.4 dBA.

Table 7-1 Acciona AW116 / Class II / 3000 Sound Power Levels vs. Wind Speed

Wind Speed at 10-meter-height (m/s)	6	7	8	9	10
Wind Speed at 92-meter hub height (m/s)*	8.5	**9.9**	11.4	12.8	14.2
Sound Power Level (dBA re 1 pW)	106.6	**107.4**	107.2	107.1	106.9

*Calculated from standardized wind speed at 10m using IEC 61400-11 logarithmic profile

The sound power levels for the Acciona AW116/Class II/3000 were estimated based on empirical engineering models at blade level and subject to an uncertainty value of 2 dB according to IEC TS 61400-14. No octave-band sound power levels were provided by the manufacturer.

7.2 Modeling Scenarios

The noise impacts associated with the proposed wind turbine generators were predicted using the Cadna/A noise calculation software (DataKustik Corporation, 2005). This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. Cadna/A differs with noise predictions that are based on spreadsheet calculations. Spreadsheet methods offer more of a screening-level approach, since they do not typically include the effects of topography, various ground attenuations, and multiple building reflections.

The Cadna/A software allows for octave band calculation of noise from multiple noise sources, as well as computation of diffraction around building edges, and multiple reflections off parallel buildings and solid ground areas. The turbine locations and terrain height contour elevations in the surrounding area were directly imported into Cadna/A. Elevations in the surrounding area were obtained from data provided by Geographic Information System (GIS) data sets. This allowed for consideration of terrain shielding where appropriate. In this manner, all significant noise sources and geometric propagation effects are accounted for in the noise predictions. The software was run with meteorology conditions of 10 degrees C (50 degrees F), and 70% relative humidity. The modeled results, especially at the closest receptors, are not very sensitive to the relative humidity or temperature settings, varying only a few tenths of a decibel. For this analysis the "Alternative Method" of calculation for A-weighted sound pressure levels was used, which corresponds to "Not Spectral" ground attenuation within the Cadna/A configuration settings. This method yields more conservative results (i.e., higher sound levels). The wind turbine sound power levels of 109.4 dBA (including the 2 dB uncertainty value) were input into Cadna/A to model turbine-generated sound levels at worst-case sound levels (hub height wind speed of 9.9 m/s or higher).

Sound levels due to operation of all ten wind turbines were modeled at 154 of the closest community receptors. All residences are 2,600 feet or more (one-half mile) from the nearest wind turbine. In addition to these specific locations provided by the client, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart. The grid covered an area approximately 8 km by 10 km for a total of over 200,000 grid points. This made it possible to create sound level "contours" for the wind farm as a whole. Sound levels were computed assuming that the receptors are always located directly downwind from all turbines simultaneously. This is a physical impossibility but provides conservative results and is required by the ISO 9613-2 calculation methodology. In addition, the five monitoring locations were covered by the modeling points.

7.3 Sound Level Results

Table 7-2 shows the predicted sound levels due to full wind turbine operations, as modeled by the Cadna/A program. The table shows the turbine sound levels at all 154 discrete modeling receptors representing the closest noise sensitive areas under worst-case operational conditions. Table 7-3 shows the predicted sound levels due to full wind turbine operations, as modeled by the Cadna/A program at the five monitoring locations.

The turbine-only sound level modeling results are also shown as color contour lines in Figure 7-1. The contour lines shown in Figure 7-1 shows the sound level contours for worst-case wind turbine operational sound levels. These are "Project-only" sound levels, and do not include any contribution from existing background sounds.

Table 7-2 Cadna/A Modeling Sound Level Results

Modeling Location	Structure Type	Broadband [dBA]
1	Trailer	40
2	Commercial	40
3	House	40
4	House	40
5	Shed	40
6	Shed	40
7	House	40
8	House	39
9	Trailer	39
10	Trailer	39
11	Trailer	39
12	House	39
13	House	39
14	Barn	39
15	House	36
16	House	36
17	House	35
18	State Misc.	37
19	Shed	37
20	House	41
21	House	41
22	House	39
23	Shed	39
24	Hunting Camp	41
25	House	38
26	House	38
27	House	37
28	Barn	37
29	House	37
30	Barn	37
31	House	35
32	House	35
33	House	35
34	House	36
35	House	38
36	House	38
37	House	38
38	House	36
39	House	36
40	Barn	36
41	Shed	36
42	House	36
43	House	35

Modeling Location	Structure Type	Broadband [dBA]
44	House	35
45	House/Trailer	35
46	House	35
47	Barn	36
48	House	36
49	Barn	37
50	House	37
51	House	39
52	House	39
53	House	40
54	House	40
55	House	39
56	House	38
57	Shed	38
58	House	39
59	Shed	39
60	Barn	40
61	House	39
62	House	39
63	House	39
64	House	39
65	House	39
66	House	39
67	Shed	39
68	House	39
69	House	39
70	Shed	40
71	House	40
72	Shed	39
73	Shed	39
74	Trailer	40
75	Trailer	40
76	House	40
77	House	39
78	House/Trailer	38
79	House	41
80	Hunting cabin	43
81	House	38
82	House	38
83	Shed	38
84	Barn	36
85	House	36
86	House	36

Table 7-2 Cadna/A Modeling Sound Level Results (Continued)

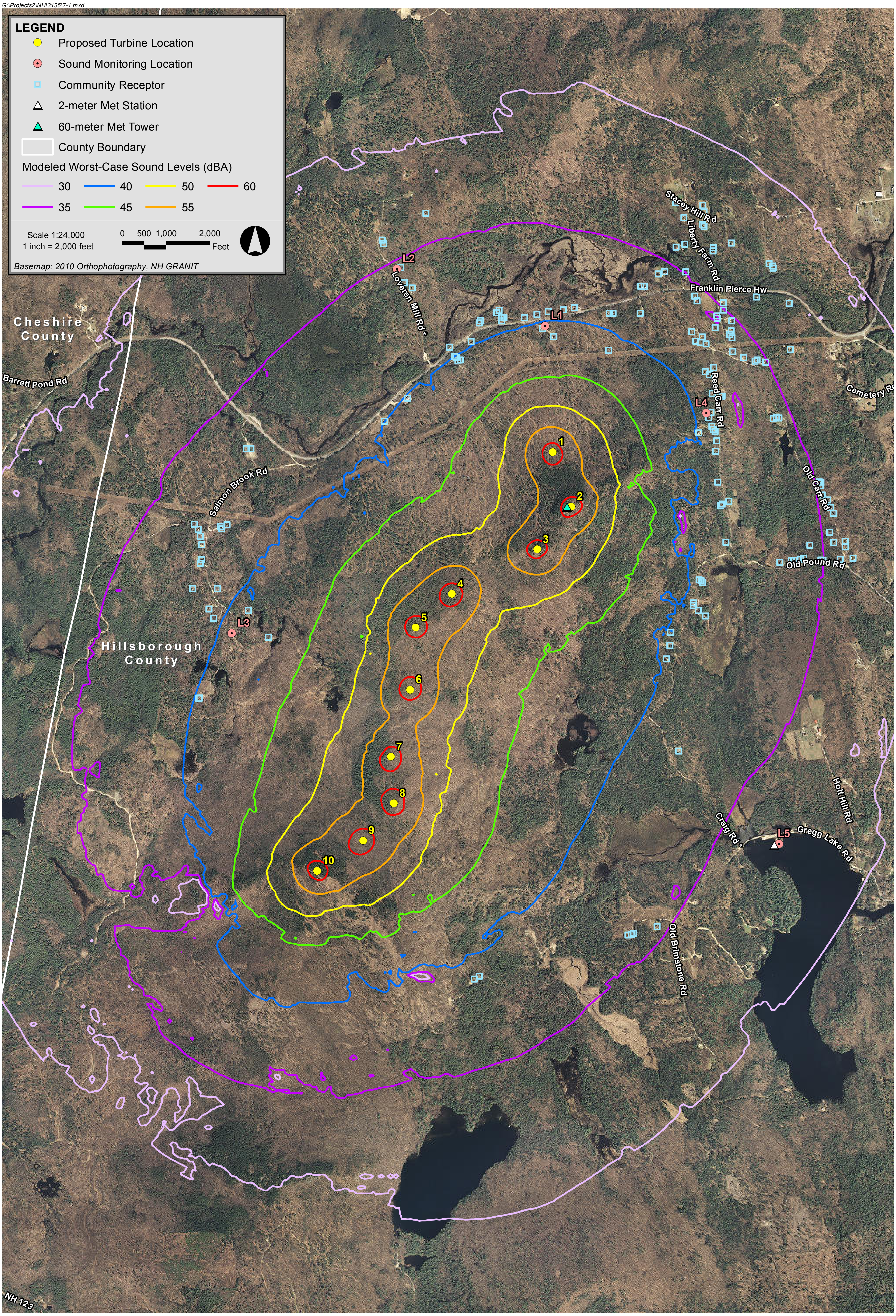
Modeling Location	Structure Type	Broadband [dBA]
87	House	35
88	Trailer	39
89	House	40
90	Shed	40
91	House	39
92	Camp	40
93	Circ Hut, UnkUse	38
94	Camp	39
95	Camp	39
96	Barn	34
97	House	34
98	House	34
99	House	33
100	House	33
101	House	34
102	Shed	34
103	Garage	33
104	House	33
105	Garage	34
106	House	34
107	House	33
108	Barn	32
109	House	33
110	House	32
111	House	32
112	Shed	32
113	House	34
114	House	32
115	House	34
116	House	36
117	House	35
118	Shed	35
119	House	39
120	House	36

Modeling Location	Structure Type	Broadband [dBA]
121	House	36
122	Barn	36
123	House	35
124	Barn	35
125	Garage	35
126	House	35
127	House	35
128	House	35
129	House	34
130	House	34
131	House	34
132	House	34
133	House	37
134	House	36
135	Barn	36
136	House/Trailer	36
137	House	36
138	House	36
139	House	35
140	Garage	35
141	House	34
142	House	35
143	House	35
144	House	38
145	Barn	38
146	House	38
147	House	37
148	Shed	37
149	House	37
150	House	40
151	House	39
152	Barn	36
153	House	39
154	House	39
155	House	39

Table 7-3 Cadna/A Modeling Sound Level Results – Ambient Monitoring Locations

Location	10 Wind Turbines (dBA)
Location L1 – Keene Road	40
Location L2 – Loveren Mill Road	35
Location L3 – Salmon Brook Road	42
Location L4 – Reed Carr Road	39
Location L5 – Gregg Lake Road	33

G:\Projects2\NH\3135\7-1.mxd



Antrim Wind Antrim, New Hampshire

Epsilon ASSOCIATES INC.

Figure 7-1
Modeled Worst-Case Sound Levels (dBA)

8.0 EVALUATION OF SOUND LEVELS

8.1 Previous NH SEC Criteria

As discussed in section 3, there are no State of New Hampshire community noise regulations applicable to the wind farm. Noise may be reviewed as part of the NH SEC process which applies to any wind energy project over 30 MW. As part of the SEC approval for the Lempster (NH) and Groton (NH) Wind Farms, several noise conditions were implemented. The most stringent of these was a limit of 45 dBA at the exterior of an inhabited residence.

The predicted worst-case sound levels from the Antrim Wind Energy Project will be below 45 dBA at all occupied buildings. A review of Figure 7-1 shows that the closest structure within the site (#80) will be approximately 43 dBA, and this structure is a hunting cabin which is not generally occupied. All other residences will be at or below 41 dBA under worst-case operating conditions. Therefore, the Antrim Wind Energy Project will easily meet the noise criteria applied to the Lempster and Groton wind projects.

8.2 World Health Organization Guidelines

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, Geneva, 1999). Daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. This translates to an indoor guideline value for bedrooms of 30 dBA L_{eq} for a continuous noise. All participating and non-participating residences will be below 45 dBA for exterior sound from the Antrim Wind Energy Project.

8.3 Pure-Tone Considerations

Since no octave-band sound power data was provided by the turbine manufacturer, no quantitative "pure tone" analysis was performed. However, Epsilon's experience with wind turbines of similar capacity indicates that it is unlikely that there will be a "pure tone," based on the following reasons:

- Modern wind turbines with upwind blades do not have prominent discrete tones from aerodynamic sources. [Pedersen and Persson Waye, JASA 2004 [5]]

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[5] Eja Pedersen and Kerstin Persson Waye, Dept of Environmental Medicine, Goteborg University, Sweden, "Perception and annoyance due to wind turbine noise-a dose-relationship," published by the Journal of the Acoustical Society of America, Melville, NY. JASA 116(6), December 2004, pgs 3460-3470.

- Mechanical equipment associated with the wind turbine may emit prominent discrete tones; however, tones due to mechanical equipment can be reduced "efficiently". [Pedersen and Persson Waye, JASA 2004 [4]]

- For larger wind turbines, the aerodynamic noise dominates (blade/wind interaction). Even if there were mechanical tones, they would be masked by aerodynamic noise resulting in no prominent discrete tones.

- There have been no prominent discrete tones from any of the recent wind turbine sound level data received from manufacturers, which Epsilon Associates has used in other wind turbine projects. These new wind turbines ranged in size from 1.5 to 2.3 MW.

There have been no prominent discrete tones in any of the recent Epsilon field testing of utility-scale wind turbines. As noted in section 4, low frequency sound from modern upwind wind turbines has been studied and is not an issue.

9.0 CONCLUSIONS

A comprehensive sound level assessment was conducted for the Antrim Wind Energy Project. Baseline sound levels were measured to characterize the existing background sound levels within the area. Turbine-only sound levels were then predicted throughout the entire wind farm, and off-site, so as to determine the future sound levels expected under worst-case operations.

Sound levels due to wind turbine operation are expected to be less than 45 dBA at all participating and non-participating residences. These sound levels are expected to meet previously approved noise conditions from the NH SEC, the World Health Organization's 45-dBA nighttime guideline for residential locations, and the US EPA guideline of 48.6 dBA which is equal to an L_{dn} of 55 dBA.

Appendix A

Continuous Sound Level Measurements

Figure A-1

A-Weighted Sound Pressure Levels & Wind Speeds - Location L1

Friday, September 16, 2011 through Tuesday, October 4, 2011

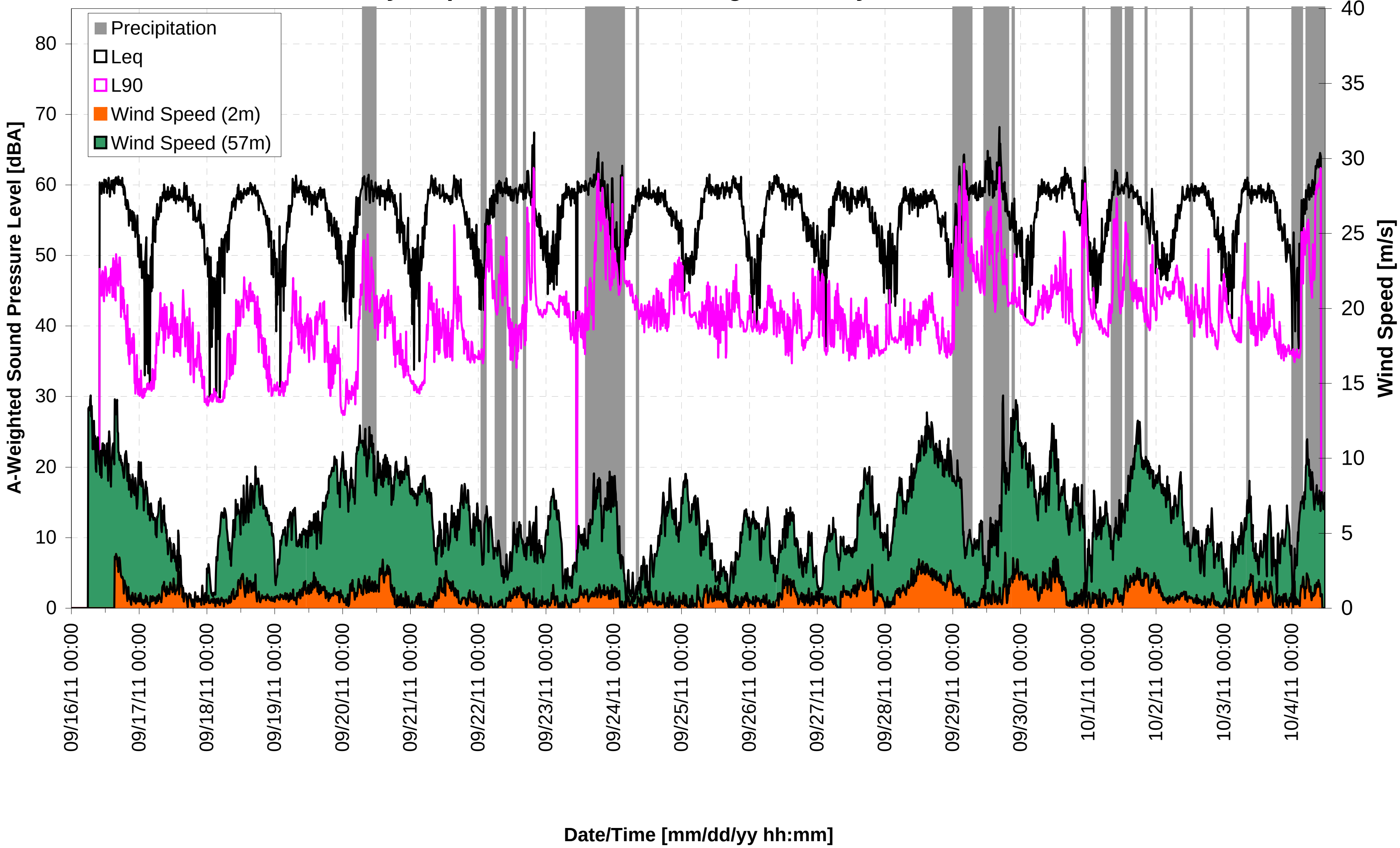


Figure A-2

A-Weighted Sound Pressure Levels & Wind Speeds - Location L2

Friday, September 16, 2011 through Tuesday, October 4, 2011

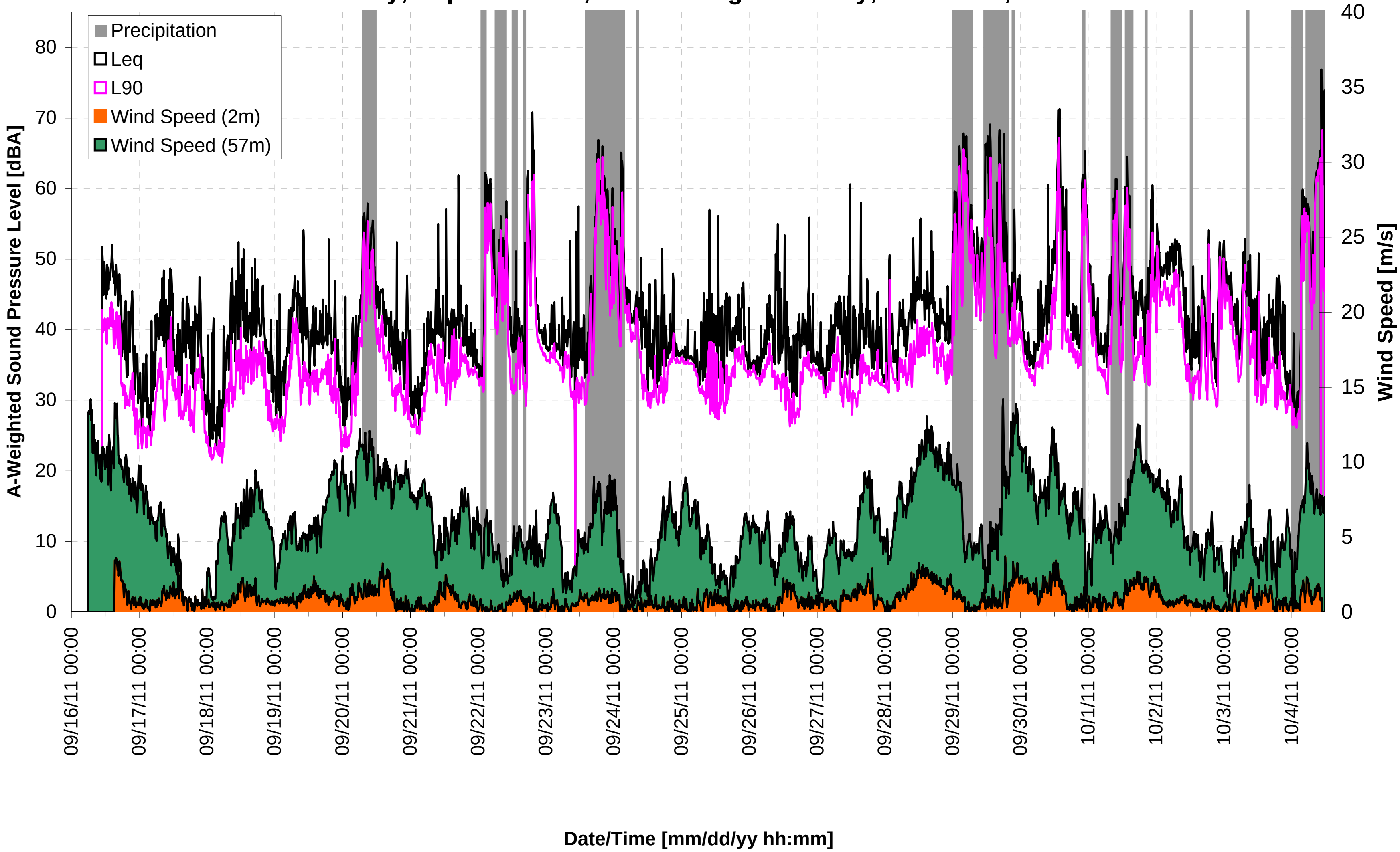


Figure A-3

A-Weighted Sound Pressure Levels & Wind Speeds - Location L3

Friday, September 16, 2011 through Tuesday, October 4, 2011

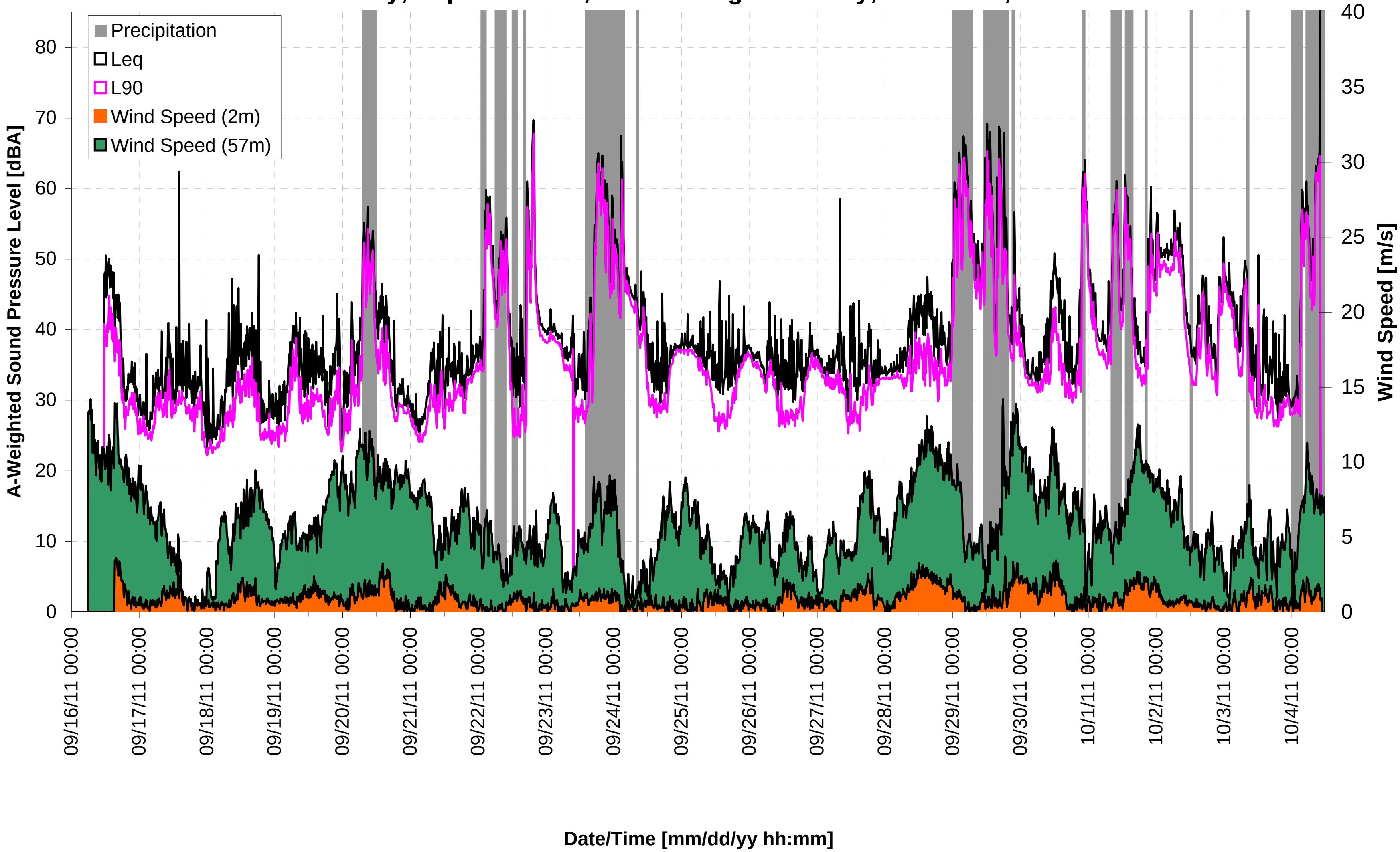


Figure A-4

A-Weighted Sound Pressure Levels & Wind Speeds - Location L4

Friday, September 16, 2011 through Tuesday, October 4, 2011

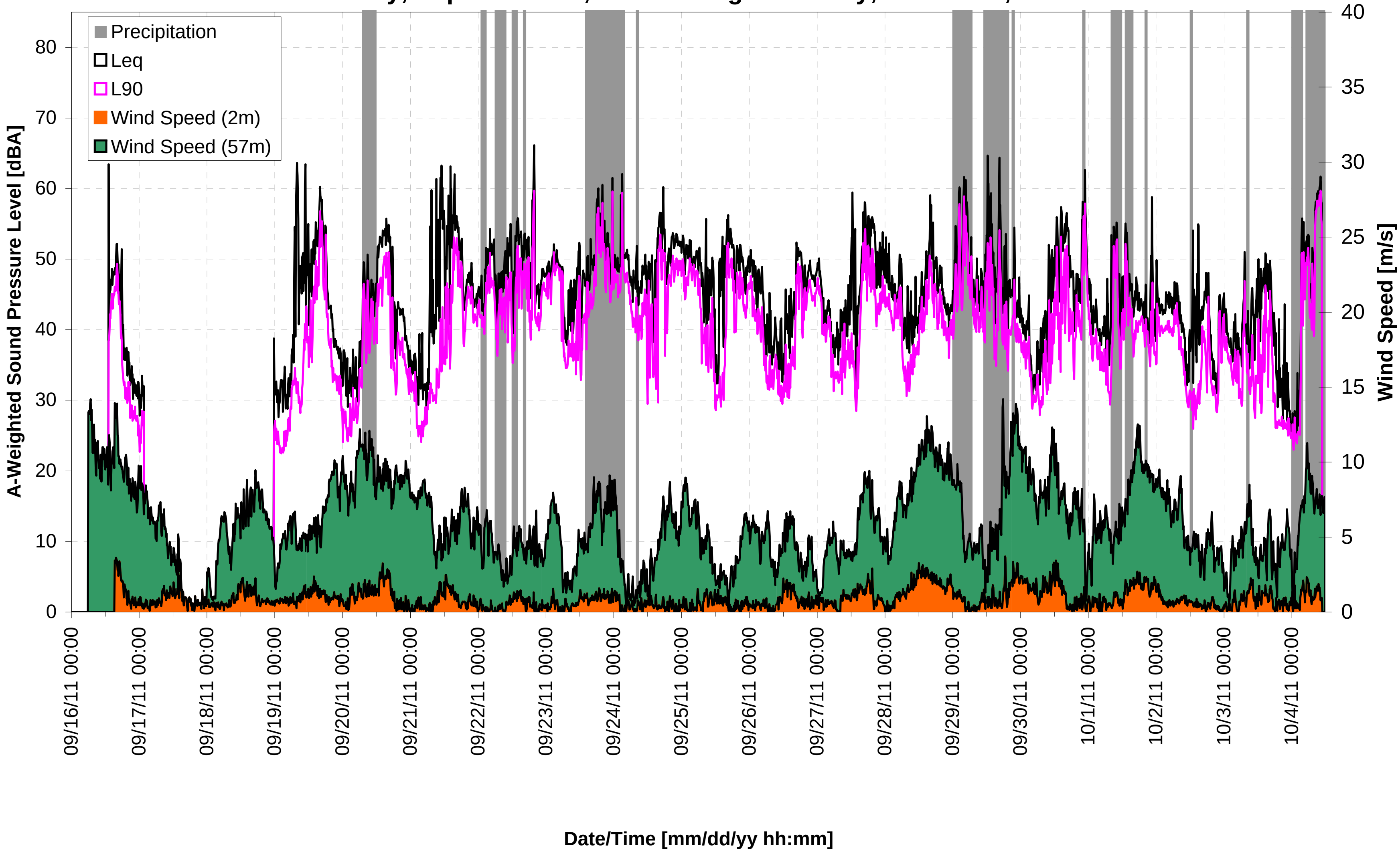
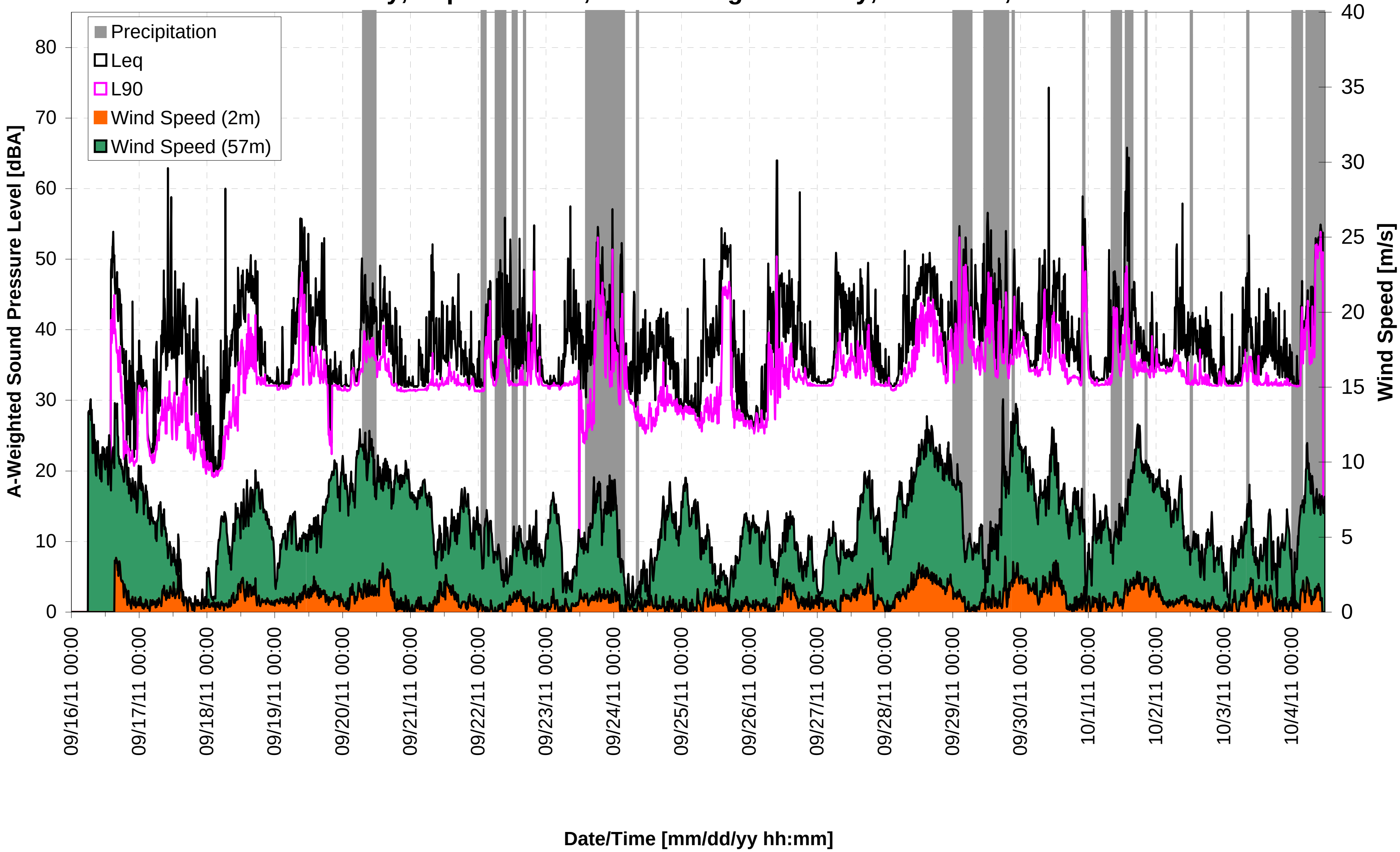


Figure A-5

A-Weighted Sound Pressure Levels & Wind Speeds - Location L5

Friday, September 16, 2011 through Tuesday, October 4, 2011



Appendix B

NWS Meteorological Data – Jaffrey Muni Airport Silver Ranch

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/16/2011 0:00	46.9	74	0	6.9	0	6.9	
9/16/2011 1:00	46	76	0	4.6	320	4.6	
9/16/2011 2:00	45	76	0	5.75	0	5.75	
9/16/2011 3:00	44.1	73	0	6.9	0	6.9	
9/16/2011 4:00	43	76	0	6.9	340	6.9	
9/16/2011 5:00	44.1	70	0	8.06	330	8.06	
9/16/2011 6:00	44.1	70	0	11.51	330	29.92	
9/16/2011 7:00	45	70	0	6.9	0	19.56	
9/16/2011 8:00	46.9	68	0	8.06	320	8.06	
9/16/2011 9:00	48.9	63	0	5.75	0	5.75	
9/16/2011 10:00	51.1	54	0	8.06	320	8.06	
9/16/2011 11:00	53.1	48	0	8.06	340	16.11	
9/16/2011 12:00	55	43	0	10.36	290	16.11	
9/16/2011 13:00	55.9	40	0	10.36	280	21.87	
9/16/2011 14:00	57	40	0	10.36	290	19.56	
9/16/2011 15:00	57	40	0	6.9	0	6.9	
9/16/2011 16:00	57.9	36	0	8.06	310	8.06	
9/16/2011 17:00	55.9	37	0	0	0	0	
9/16/2011 18:00	52	50	0	0	0	0	
9/16/2011 19:00	45	76	0	0	0	0	
9/16/2011 20:00	42.1	85	0	0	0	0	
9/16/2011 21:00	41	89	0	0	0	0	
9/16/2011 22:00	39	93	0	0	0	0	
9/16/2011 23:00	39	93	0	0	0	0	
9/17/2011 0:00	37	96	0	0	0	0	
9/17/2011 1:00	37	96	0	0	0	0	
9/17/2011 2:00	36	96	0	3.45	180	3.45	
9/17/2011 3:00	36	96	0	0	0	0	
9/17/2011 4:00	35.1	96	0	0	0	0	
9/17/2011 5:00	34	100	0	0	0	0	
9/17/2011 6:00	35.1	96	0	0	0	0	
9/17/2011 7:00	37.9	97	0	0	0	0	
9/17/2011 8:00	46.9	74	0	3.45	0	3.45	
9/17/2011 9:00	52	61	0	4.6	10	4.6	
9/17/2011 10:00	53.1	54	0	3.45	0	3.45	
9/17/2011 11:00	57	49	0	0	0	0	
9/17/2011 12:00	59	44	0	6.9	0	6.9	
9/17/2011 13:00	59	42	0	3.45	340	3.45	
9/17/2011 14:00	60.1	39	0	4.6	270	4.6	
9/17/2011 15:00	60.1	39	0	3.45	0	3.45	
9/17/2011 16:00	60.1	40	0	0	0	0	
9/17/2011 17:00	57	59	0	0	0	0	
9/17/2011 18:00	54	77	0	0	0	0	
9/17/2011 19:00	50	86	0	0	0	0	
9/17/2011 20:00	46.9	90	0	0	0	0	
9/17/2011 21:00	46.9	93	0	0	0	0	
9/17/2011 22:00	46.9	93	0	0	0	0	
9/17/2011 23:00	46.9	93	0	0	0	0	
9/18/2011 0:00	46.9	93	0	0	0	0	

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/18/2011 1:00	46	96	0	0	0	0	
9/18/2011 2:00	46	93	0	0	0	0	
9/18/2011 3:00	45	97	0	0	0	0	
9/18/2011 4:00	45	93	0	0	0	0	
9/18/2011 5:00	44.1	96	0	0	0	0	
9/18/2011 6:00	44.1	96	0	0	0	0	
9/18/2011 7:00	46	96	0	0	0	0	
9/18/2011 8:00	48	89	0	0	0	0	
9/18/2011 9:00	52	74	0	4.6	30	4.6	
9/18/2011 10:00	57	62	0	4.6	0	4.6	
9/18/2011 11:00	59	47	0	6.9	0	6.9	
9/18/2011 12:00	61	42	0	5.75	0	5.75	
9/18/2011 13:00	61	44	0	3.45	0	3.45	
9/18/2011 14:00	61	48	0	6.9	0	6.9	
9/18/2011 15:00	59	53	0	0	0	0	
9/18/2011 16:00	61	48	0	3.45	0	3.45	
9/18/2011 17:00	59	51	0	3.45	0	3.45	
9/18/2011 18:00	54	61	0	0	0	0	
9/18/2011 19:00	50	74	0	0	0	0	
9/18/2011 20:00	45	90	0	0	0	0	
9/18/2011 21:00	42.1	96	0	0	0	0	
9/18/2011 22:00	41	96	0	0	0	0	
9/18/2011 23:00	39	96	0	0	0	0	
9/19/2011 0:00	37.9	97	0	0	0	0	
9/19/2011 1:00	37	96	0	0	0	0	
9/19/2011 2:00	36	96	0	0	0	0	
9/19/2011 3:00	35.1	96	0	0	0	0	
9/19/2011 4:00	35.1	96	0	0	0	0	
9/19/2011 5:00	34	96	0	0	0	0	
9/19/2011 6:00	33.1	96	0	0	0	0	
9/19/2011 7:00	37	96	0	0	0	0	
9/19/2011 8:00	46.9	83	0	0	0	0	
9/19/2011 9:00	54	66	0	0	0	0	
9/19/2011 10:00	57	53	0	3.45	30	3.45	
9/19/2011 11:00	59	44	0	3.45	0	3.45	
9/19/2011 12:00	60.1	42	0	4.6	0	4.6	
9/19/2011 13:00	62.1	41	0	5.75	0	5.75	
9/19/2011 14:00	62.1	44	0	5.75	0	5.75	
9/19/2011 15:00	63	44	0	0	0	0	
9/19/2011 16:00	62.1	46	0	8.06	200	8.06	
9/19/2011 17:00	61	56	0	4.6	170	4.6	
9/19/2011 18:00	55	74	0	0	0	0	
9/19/2011 19:00	51.1	86	0	0	0	0	
9/19/2011 20:00	48.9	93	0	0	0	0	
9/19/2011 21:00	48	96	0	0	0	0	
9/19/2011 22:00	48.9	93	0	0	0	0	
9/19/2011 23:00	48.9	93	0	3.45	210	3.45	
9/20/2011 0:00	48.9	93	0	0	0	0	
9/20/2011 1:00	51.1	89	0	4.6	210	4.6	

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/20/2011 2:00	51.1	92	0	0	0	5.75	
9/20/2011 3:00	51.1	96	0	4.6	210	4.6	
9/20/2011 4:00	51.1	96	0	4.6	200	4.6	
9/20/2011 5:00	52	97	0	6.9	210	6.9	
9/20/2011 6:00	53.1	96	0	5.75	210	5.75	
9/20/2011 7:00	54	97	0.01	6.9	210	6.9	Light Rain
9/20/2011 8:00	55	93	0.04	8.06	200	8.06	Light Rain
9/20/2011 9:00	55	96	0.06	11.51	200	17.26	Moderate Rain
9/20/2011 10:00	55.9	97	0.03	6.9	210	9.21	Light Rain
9/20/2011 11:00	57	93	0.01	9.21	230	9.21	Light Rain
9/20/2011 12:00	57	96	0	5.75	0	5.75	
9/20/2011 13:00	57.9	93	0	5.75	210	5.75	
9/20/2011 14:00	59	93	0	4.6	0	4.6	
9/20/2011 15:00	60.1	90	0	5.75	210	8.06	
9/20/2011 16:00	62.1	86	0	3.45	0	3.45	
9/20/2011 17:00	61	90	0	3.45	240	3.45	
9/20/2011 18:00							
9/20/2011 19:00	59	96	0	5.75	190	5.75	
9/20/2011 20:00							
9/20/2011 21:00							
9/20/2011 22:00	53.6	100	0	0	0	0	Mist
9/20/2011 23:00							
9/21/2011 0:00							
9/21/2011 1:00							
9/21/2011 2:00	54	100	0	0	0	0	Fog
9/21/2011 3:00							
9/21/2011 4:00							
9/21/2011 5:00	52	100	0	5.75	160	5.75	Fog
9/21/2011 6:00	52	100	0	0	0	0	Fog
9/21/2011 7:00	52	100	0	3.45	170	3.45	Fog
9/21/2011 8:00	54	100	0	3.45	170	3.45	Fog
9/21/2011 9:00	57.9	97	0	4.6	170	4.6	
9/21/2011 10:00	64	80	0	6.9	170	6.9	
9/21/2011 11:00	66	75	0	8.06	170	8.06	
9/21/2011 12:00	69.1	65	0	4.6	170	4.6	
9/21/2011 13:00	70	59	0	6.9	180	6.9	
9/21/2011 14:00	72	49	0	4.6	0	4.6	
9/21/2011 15:00	72	57	0	6.9	210	6.9	
9/21/2011 16:00	71.1	57	0	4.6	210	4.6	
9/21/2011 17:00	69.1	73	0	0	0	0	
9/21/2011 18:00	63	90	0	0	0	0	
9/21/2011 19:00	61	93	0	0	0	0	
9/21/2011 20:00	59	96	0	0	0	0	
9/21/2011 21:00	60.1	96	0	0	0	0	
9/21/2011 22:00	62.1	93	0	3.45	180	3.45	
9/21/2011 23:00	62.1	93	0	3.45	180	3.45	
9/22/2011 0:00	63	93	0	3.45	190	3.45	
9/22/2011 1:00	62.1	96	0.03	0	0	0	Light Rain
9/22/2011 2:00	62.1	100	0.15	3.45	180	3.45	Light Rain

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/22/2011 3:00	63	100	0.01	3.45	190	3.45	
9/22/2011 4:00	64	96	0	4.6	190	4.6	
9/22/2011 5:00	64	100	0	3.45	200	3.45	
9/22/2011 6:00	64	96	0.05	3.45	180	3.45	Moderate Rain
9/22/2011 7:00	64	96	0.1	0	0	0	Moderate Rain
9/22/2011 8:00	64.9	97	0.06	0	0	0	Light Rain
9/22/2011 9:00	66	96	0	4.6	170	4.6	Light Rain
9/22/2011 10:00	68	90	0.01	0	0	0	
9/22/2011 11:00	70	81	0	4.6	200	4.6	
9/22/2011 12:00	69.1	87	0.01	0	0	0	Light Rain
9/22/2011 13:00	69.1	90	0.01	0	0	0	Light Rain
9/22/2011 14:00	72	84	0	0	0	0	
9/22/2011 15:00	72	82	0	4.6	0	4.6	
9/22/2011 16:00	71.1	87	0	0	0	3.45	Light Rain
9/22/2011 17:00	69.1	93	0.01	3.45	210	3.45	
9/22/2011 18:00	68	96	0.01	0	0	0	
9/22/2011 19:00	68	96	0	0	0	0	
9/22/2011 20:00	68	96	0	0	0	4.6	
9/22/2011 21:00	68	96	0	0	0	0	
9/22/2011 22:00	68	96	0	3.45	190	3.45	
9/22/2011 23:00	68	96	0	4.6	200	4.6	
9/23/2011 0:00	68	96	0	0	0	3.45	
9/23/2011 1:00	66.9	97	0	5.75	210	5.75	Mist
9/23/2011 2:00	66	100	0	3.45	210	3.45	
9/23/2011 3:00	66	96	0	0	0	4.6	
9/23/2011 4:00	66	96	0	0	0	0	
9/23/2011 5:00	64	100	0	0	0	3.45	Mist
9/23/2011 6:00	63	100	0	0	0	0	Mist
9/23/2011 7:00	64	96	0	0	0	0	
9/23/2011 8:00	66.9	93	0	0	0	0	
9/23/2011 9:00	69.1	87	0	0	0	0	
9/23/2011 10:00	71.1	84	0	0	0	3.45	
9/23/2011 11:00	71.1	81	0	3.45	0	3.45	
9/23/2011 12:00	71.1	79	0	3.45	110	3.45	
9/23/2011 13:00	70	84	0	0	0	3.45	
9/23/2011 14:00	69.1	90	0	0	0	0	Light Rain
9/23/2011 15:00	69.8	88	0.01	0	0	3.45	Light Rain
9/23/2011 16:00	68	96	0.07	0	0	0	Moderate Rain
9/23/2011 17:00	66.9	97	0.34	0	0	0	Heavy Rain
9/23/2011 18:00	66.9	97	0.29	0	0	0	Moderate Rain
9/23/2011 19:00	66	100	0.29	0	0	0	Heavy Rain
9/23/2011 20:00	66.9	97	0.08	0	0	0	Light Rain
9/23/2011 21:00	66.9	97	0.04	0	0	3.45	Moderate Rain
9/23/2011 22:00	66.9	97	0.05	3.45	0	3.45	Light Rain
9/23/2011 23:00	66	100	0.02	0	0	0	Light Rain
9/24/2011 0:00	66	100	0.02	0	0	3.45	Light Rain
9/24/2011 1:00	66	100	0.01	0	0	0	Light Rain
9/24/2011 2:00	66	96	0.06	0	0	0	Light Rain
9/24/2011 3:00	66	96	0.02	0	0	0	Moderate Rain

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/24/2011 4:00	64.9	100	0.04	0	0	0	
9/24/2011 5:00	64.9	100	0	0	0	0	Mist
9/24/2011 6:00	64.9	100	0.01	0	0	0	Mist
9/24/2011 7:00	64.9	100	0	3.45	40	3.45	Mist
9/24/2011 8:00	66	96	0.01	0	0	0	Light Rain
9/24/2011 9:00	69.1	93	0	0	0	3.45	
9/24/2011 10:00	70	93	0	0	0	0	
9/24/2011 11:00	72	91	0	4.6	0	4.6	
9/24/2011 12:00	73	90	0.02	0	0	6.9	
9/24/2011 13:00	73.9	85	0	5.75	180	8.06	
9/24/2011 14:00	75	79	0	4.6	0	4.6	
9/24/2011 15:00	75	79	0	4.6	200	4.6	
9/24/2011 16:00	73.9	85	0	4.6	200	4.6	
9/24/2011 17:00	73	90	0	4.6	200	4.6	
9/24/2011 18:00	71.1	93	0	3.45	190	3.45	
9/24/2011 19:00	69.1	96	0	0	0	0	
9/24/2011 20:00	68	96	0	3.45	190	3.45	
9/24/2011 21:00	66.9	97	0	0	0	0	
9/24/2011 22:00	66	96	0	0	0	0	
9/24/2011 23:00	64.9	97	0	0	0	0	
9/25/2011 0:00	64.9	97	0	0	0	0	
9/25/2011 1:00	64	100	0	0	0	0	
9/25/2011 2:00	64	100	0	0	0	0	
9/25/2011 3:00	64	100	0	0	0	0	
9/25/2011 4:00	64	96	0.01	3.45	170	3.45	
9/25/2011 5:00	64	96	0	0	0	0	
9/25/2011 6:00	63	100	0	0	0	0	
9/25/2011 7:00	63	100	0	0	0	0	
9/25/2011 8:00	66	93	0	0	0	0	
9/25/2011 9:00	66.9	93	0	0	0	0	
9/25/2011 10:00	69.1	87	0	0	0	0	
9/25/2011 11:00	72	79	0	5.75	0	5.75	
9/25/2011 12:00	75	64	0	3.45	0	3.45	
9/25/2011 13:00	75.9	64	0	3.45	0	3.45	
9/25/2011 14:00	77	60	0	0	0	0	
9/25/2011 15:00	79	47	0	0	0	0	
9/25/2011 16:00	73	76	0	0	0	0	
9/25/2011 17:00	71.1	90	0	0	0	0	
9/25/2011 18:00	69.1	93	0	0	0	0	
9/25/2011 19:00	66.9	97	0	0	0	0	
9/25/2011 20:00	64.9	100	0	0	0	0	
9/25/2011 21:00	64	100	0	0	0	0	
9/25/2011 22:00	63	97	0	0	0	0	
9/25/2011 23:00	63	97	0	0	0	0	Mist
9/25/2011 23:00	62.6	100	0	0	0	0	Fog
9/26/2011 0:00	62.1	96	0	0	0	0	Mist
9/26/2011 1:00	61	100	0	0	0	0	Fog
9/26/2011 2:00	60.1	100	0	0	0	0	Mist
9/26/2011 3:00	59	100	0	0	0	0	Mist

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/26/2011 4:00	59	100	0	0	0	0	Fog
9/26/2011 5:00	57.9	100	0	0	0	0	Mist
9/26/2011 6:00	57	100	0	0	0	3.45	Mist
9/26/2011 7:00	59	100	0	0	0	0	
9/26/2011 8:00	64	90	0	0	0	0	
9/26/2011 9:00	70	78	0	0	0	0	
9/26/2011 10:00	72	71	0	3.45	180	3.45	
9/26/2011 11:00	75	62	0	5.75	280	5.75	
9/26/2011 12:00	78.1	56	0	4.6	0	4.6	
9/26/2011 13:00	79	52	0	0	0	0	
9/26/2011 14:00	80.1	47	0	0	0	0	
9/26/2011 15:00	79	47	0	0	0	0	
9/26/2011 16:00	79	50	0	0	0	0	
9/26/2011 17:00	73.9	74	0	0	0	0	
9/26/2011 18:00	68	93	0	0	0	0	
9/26/2011 19:00	66	96	0	0	0	0	
9/26/2011 20:00	64	96	0	0	0	0	
9/26/2011 21:00	64	96	0	0	0	0	
9/26/2011 22:00	63	97	0	0	0	0	
9/26/2011 23:00	62.1	96	0	0	0	0	
9/27/2011 0:00	60.1	96	0.01	0	0	0	Mist
9/27/2011 1:00	59	96	0	0	0	0	
9/27/2011 2:00	57.9	97	0	0	0	0	
9/27/2011 3:00	57.9	100	0	0	0	0	Mist
9/27/2011 4:00	59	100	0	0	0	0	Fog
9/27/2011 5:00	57	100	0	0	0	0	Mist
9/27/2011 6:00	57	100	0	0	0	0	Fog
9/27/2011 7:00	57	100	0	0	0	0	Mist
9/27/2011 8:00	60.1	96	0	0	0	0	
9/27/2011 9:00	66.9	76	0	0	0	0	
9/27/2011 10:00	70	68	0	0	0	0	
9/27/2011 11:00	73	66	0	3.45	360	3.45	
9/27/2011 12:00	77	60	0	4.6	0	4.6	
9/27/2011 13:00	75.9	62	0	3.45	80	3.45	
9/27/2011 14:00	77	60	0	4.6	0	4.6	
9/27/2011 15:00	75	66	0	0	0	0	
9/27/2011 16:00	73.9	69	0	0	0	0	
9/27/2011 17:00	70	73	0	0	0	0	
9/27/2011 18:00	66.9	81	0	0	0	0	
9/27/2011 19:00	64.9	81	0	0	0	0	
9/27/2011 20:00	64	84	0	0	0	0	
9/27/2011 21:00	64	84	0	0	0	0	
9/27/2011 22:00	63	90	0	0	0	0	
9/27/2011 23:00	62.1	93	0	0	0	0	
9/28/2011 0:00	62.1	90	0	0	0	0	
9/28/2011 1:00	61	93	0	3.45	120	3.45	
9/28/2011 2:00	61	93	0	0	0	0	
9/28/2011 3:00	61	97	0	0	0	3.45	Mist
9/28/2011 4:00	61	93	0	0	0	0	

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/28/2011 5:00	61	90	0	0	0	0	
9/28/2011 6:00	61	87	0	0	0	0	
9/28/2011 7:00	61	83	0	3.45	0	3.45	
9/28/2011 8:00	62.1	80	0	3.45	0	3.45	
9/28/2011 9:00	64.9	73	0	3.45	0	3.45	
9/28/2011 10:00	66.9	66	0	3.45	0	3.45	
9/28/2011 11:00	69.1	61	0	6.9	0	6.9	
9/28/2011 12:00	70	57	0	8.06	120	8.06	
9/28/2011 13:00	71.1	55	0	0	0	0	
9/28/2011 14:00	70	53	0	5.75	0	5.75	
9/28/2011 15:00	70	55	0	5.75	0	5.75	
9/28/2011 16:00	69.1	54	0	4.6	0	4.6	
9/28/2011 17:00	64.9	73	0	0	0	0	
9/28/2011 18:00	63	81	0	4.6	0	4.6	
9/28/2011 19:00	62.1	84	0	4.6	0	4.6	
9/28/2011 20:00	61	87	0	4.6	0	4.6	
9/28/2011 21:00	61	90	0	0	0	3.45	
9/28/2011 22:00	60.1	93	0	3.45	0	3.45	
9/28/2011 23:00	60.1	93	0	6.9	0	6.9	
9/29/2011 0:00	59	96	0.12	0	0	5.75	Light Rain
9/29/2011 1:00	59	96	0.1	4.6	90	4.6	Heavy Rain
9/29/2011 2:00	59	93	0.18	3.45	0	4.6	Light Rain
9/29/2011 3:00	59	96	0.11	0	0	0	Light Rain
9/29/2011 4:00	59	96	0.15	3.45	20	3.45	Heavy Rain
9/29/2011 5:00	59	96	0.05	0	0	0	Light Rain
9/29/2011 6:00	59	96	0.03	0	0	0	Light Rain
9/29/2011 7:00	59	100	0	0	0	0	Mist
9/29/2011 8:00	60.1	96	0.02	0	0	0	Mist
9/29/2011 9:00	61	97	0	0	0	3.45	Mist
9/29/2011 10:00	63	97	0	0	0	3.45	Mist
9/29/2011 11:00	63	97	0	0	0	0	Light Rain
9/29/2011 12:00	62.1	100	0.11	0	0	4.6	Light Rain
9/29/2011 13:00	62.1	100	0.03	0	0	6.9	Light Rain
9/29/2011 14:00	63	97	0.05	3.45	0	3.45	Light Rain
9/29/2011 15:00	63	100	0.07	0	0	0	Light Rain
9/29/2011 16:00	64	100	0.06	0	0	3.45	Moderate Rain
9/29/2011 17:00	66	96	0.01	6.9	0	6.9	Light Rain
9/29/2011 18:00	64.9	87	0.01	13.81	210	23.02	Light Rain
9/29/2011 19:00	61	93	0	6.9	220	6.9	Light Rain
9/29/2011 20:00	60.1	93	0.01	5.75	0	5.75	
9/29/2011 21:00	59	96	0.12	5.75	0	6.9	Heavy Rain
9/29/2011 22:00	57	93	0.01	3.45	240	6.9	
9/29/2011 23:00	55.9	97	0	6.9	210	6.9	
9/30/2011 0:00	55.9	97	0	9.21	200	9.21	
9/30/2011 1:00	55.9	97	0	6.9	210	6.9	
9/30/2011 2:00	55	96	0	8.06	210	8.06	
9/30/2011 3:00	55	96	0	6.9	200	6.9	
9/30/2011 4:00	54	100	0	6.9	200	6.9	
9/30/2011 5:00	54	97	0	4.6	210	5.75	

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
9/30/2011 6:00	54	93	0	0	0	0	
9/30/2011 7:00	54	97	0	0	0	3.45	
9/30/2011 8:00	55	93	0	9.21	190	9.21	
9/30/2011 9:00	59	81	0	8.06	200	8.06	
9/30/2011 10:00	63	70	0	14.96	200	19.56	
9/30/2011 11:00	63	70	0	8.06	200	8.06	
9/30/2011 12:00	66	65	0	10.36	200	10.36	
9/30/2011 13:00	68	63	0	9.21	220	16.11	
9/30/2011 14:00	69.1	63	0	6.9	200	16.11	
9/30/2011 15:00	70	61	0	5.75	200	5.75	
9/30/2011 16:00	70	61	0	4.6	190	4.6	
9/30/2011 17:00	66.9	73	0	5.75	170	5.75	
9/30/2011 18:00	62.1	90	0	0	0	0	
9/30/2011 19:00	63	84	0	4.6	0	4.6	
9/30/2011 20:00	64	84	0	4.6	160	4.6	
9/30/2011 21:00	64	84	0	0	0	0	
9/30/2011 22:00	60.1	90	0.01	0	0	4.6	Light Rain
9/30/2011 23:00	59	93	0.03	3.45	180	3.45	
10/1/2011 0:00	57.9	97	0	0	0	0	Mist
10/1/2011 1:00	57.9	100	0	0	0	0	Mist
10/1/2011 2:00	57.9	97	0	0	0	0	
10/1/2011 3:00	57	96	0	0	0	0	
10/1/2011 4:00	55.9	100	0	0	0	0	Mist
10/1/2011 5:00	57	96	0	0	0	0	Mist
10/1/2011 6:00	57	100	0	0	0	0	Mist
10/1/2011 7:00	57.9	100	0	0	0	4.6	Mist
10/1/2011 8:00	59	100	0.02	3.45	0	3.45	Light Rain
10/1/2011 9:00	60.1	96	0.1	0	0	0	Moderate Rain
10/1/2011 10:00	60.1	100	0.03	4.6	0	4.6	Light Rain
10/1/2011 11:00	61	97	0	3.45	0	4.6	Light Rain
10/1/2011 12:00	61	97	0.02	4.6	0	5.75	
10/1/2011 13:00	61	97	0	3.45	0	4.6	Light Rain
10/1/2011 14:00	60.1	96	0.02	0	0	0	Light Rain
10/1/2011 15:00	57.9	97	0.03	4.6	0	4.6	Light Rain
10/1/2011 16:00	55.9	97	0.01	4.6	0	4.6	
10/1/2011 17:00	53.1	96	0	3.45	350	3.45	
10/1/2011 18:00	50	96	0	6.9	0	6.9	
10/1/2011 19:00	48	96	0	0	0	0	
10/1/2011 20:00	48	96	0	3.45	0	3.45	Light Rain
10/1/2011 21:00	46.9	100	0	4.6	360	4.6	Mist
10/1/2011 22:00	46.9	100	0	3.45	0	3.45	Mist
10/1/2011 23:00	48	100	0.01	3.45	20	3.45	Mist
10/2/2011 0:00	48	100	0	3.45	0	3.45	Mist
10/2/2011 1:00	48	100	0.01	4.6	0	4.6	Mist
10/2/2011 2:00	48.9	97	0	0	0	3.45	Mist
10/2/2011 3:00	48.9	100	0.01	3.45	0	3.45	Mist
10/2/2011 4:00	50	100	0	3.45	0	4.6	Mist
10/2/2011 5:00	51.1	100	0	3.45	0	3.45	Mist
10/2/2011 6:00	51.1	100	0.01	0	0	0	Mist

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
10/2/2011 7:00	52	97	0	0	0	4.6	Mist
10/2/2011 8:00	52	100	0.01	4.6	0	4.6	Mist
10/2/2011 9:00	53.1	100	0	3.45	0	4.6	Mist
10/2/2011 10:00	53.1	100	0	3.45	0	4.6	Fog
10/2/2011 11:00	54	100	0	4.6	10	4.6	Mist
10/2/2011 12:00	54	100	0	4.6	0	4.6	Light Rain
10/2/2011 13:00	55	100	0	4.6	0	4.6	Mist
10/2/2011 14:00	55.9	97	0	0	0	6.9	Mist
10/2/2011 15:00	57	93	0	3.45	0	3.45	Mist
10/2/2011 16:00	55.9	100	0	3.45	20	3.45	Mist
10/2/2011 17:00	55.9	97	0	0	0	3.45	
10/2/2011 18:00	55.9	97	0	4.6	0	4.6	
10/2/2011 19:00	55	100	0	4.6	0	4.6	
10/2/2011 20:00	55	96	0	0	0	0	Mist
10/2/2011 21:00	55	100	0	0	0	0	Mist
10/2/2011 22:00	55	100	0.01	0	0	0	Mist
10/2/2011 23:00	55	100	0	0	0	0	Mist
10/3/2011 0:00	55	96	0	0	0	0	
10/3/2011 1:00	54	100	0	0	0	0	
10/3/2011 2:00	54	97	0	0	0	0	
10/3/2011 3:00	54	97	0	0	0	0	
10/3/2011 4:00	53.1	100	0	0	0	0	
10/3/2011 5:00	53.1	96	0	0	0	0	
10/3/2011 6:00	53.1	100	0	0	0	0	
10/3/2011 7:00	54	97	0	0	0	0	
10/3/2011 8:00	54	97	0	0	0	0	Light Rain
10/3/2011 9:00	55.9	90	0.01	5.75	190	5.75	
10/3/2011 10:00	55.9	84	0	10.36	190	10.36	
10/3/2011 11:00	57	74	0	4.6	250	5.75	
10/3/2011 12:00	59	58	0	6.9	180	6.9	
10/3/2011 13:00	59	60	0	5.75	200	5.75	
10/3/2011 14:00	57.9	67	0	5.75	0	5.75	
10/3/2011 15:00	57	72	0	4.6	220	4.6	
10/3/2011 16:00	55.9	75	0	5.75	210	5.75	
10/3/2011 17:00	53.1	86	0	0	0	0	
10/3/2011 18:00	51.1	92	0	0	0	0	
10/3/2011 19:00	48.9	97	0	0	0	0	
10/3/2011 20:00	48	96	0	0	0	0	
10/3/2011 21:00	48	96	0	0	0	0	
10/3/2011 22:00	48	100	0	0	0	0	
10/3/2011 23:00	48.9	97	0	0	0	0	
10/4/2011 0:00	48.9	97	0	0	0	0	Light Rain
10/4/2011 1:00	48.9	97	0.01	0	0	0	Light Rain
10/4/2011 2:00	48.9	97	0.09	0	0	0	Moderate Rain
10/4/2011 3:00	48.9	100	0.08	0	0	0	Light Rain
10/4/2011 4:00	48.9	100	0.01	3.45	0	3.45	Mist
10/4/2011 5:00	50	100	0.01	3.45	50	4.6	Light Rain
10/4/2011 6:00	51.1	96	0.01	0	0	3.45	Moderate Rain
10/4/2011 7:00	51.1	96	0.03	4.6	0	4.6	Light Rain

Time (EDT)	Temp [F]	RH [%]	Precip [in]	Wind Speed [mph]	Wind Direction [◦]	Gust Speed [mph]	Observations
10/4/2011 8:00	50	100	0.17	3.45	0	3.45	Heavy Rain
10/4/2011 9:00	50	100	0.29	3.45	0	3.45	Heavy Rain
10/4/2011 10:00	51.1	96	0.18	4.6	0	5.75	Moderate Rain
10/4/2011 11:00	52	97	0.15	4.6	0	4.6	Light Rain

Appendix C

Modeling Receptor Locations

Receptor ID	Structure Type	Map_Lot	Name	Address	POINT_X	POINT_Y
1	Trailer	222-003	JACQUIN RICHARD	KEENE ROAD	271037.601065	63320.3351437
2	Commercial	222-002	TUTTLE MOUNTAIN LEASING LLC	408 KEENE ROAD	271199.030611	63480.5924214
3	House	211-003	DUBRINO TR BONNIE A	398 KEENE ROAD	271549.487523	63740.0401095
4	House	211-003	DUBRINO TR BONNIE A	398 KEENE ROAD	271565.957085	63747.8128026
5	Shed	211-003	DUBRINO TR BONNIE A	398 KEENE ROAD	271538.092918	63766.0098061
6	Shed	211-003	DUBRINO TR BONNIE A	398 KEENE ROAD	271527.522516	63771.8504217
7	House	211-002	VAYENS SUSAN M	372 KEENE ROAD	271642.211737	63874.2835253
8	House	211-034	FEDERAL NATIONAL MTGE ASSOC	367 KEENE ROAD	271854.778608	64020.1860692
9	Trailer	211-034	FEDERAL NATIONAL MTGE ASSOC	367 KEENE ROAD	271859.643533	64044.5704233
10	Trailer	211-034	FEDERAL NATIONAL MTGE ASSOC	367 KEENE ROAD	271853.234675	64040.8113767
11	Trailer	211-034	FEDERAL NATIONAL MTGE ASSOC	367 KEENE ROAD	271872.095135	64042.1090794
12	House	211-033	HUTCHINSON TED & CAMPBELL DIANA L	363 KEENE ROAD	271837.470623	64092.0746229
13	House	211-032	BAKER-SALMON CHRIS	375 KEENE ROAD	271697.837295	64003.9683451
14	Barn	211-032	BAKER-SALMON CHRIS	375 KEENE ROAD	271707.183814	64020.3058814
15	House	211-028	LEARN, DANA R & CHRISTY L	LOVEREN MILL ROAD	271230.208686	64248.0734678
16	House	211-027	WALSH DAVID P	45 LOVEREN MILL ROAD	271176.998574	64284.8824049
17	House	211-026	SCHAEFER JAMES B & BEVERLY	47 LOVEREN MILL ROAD	271150.823629	64390.8856025
18	State Misc.	222-010	STATE OF NEW HAMPSHIRE	KEENE ROAD	270108.133304	63128.7746520
19	Shed	222-010	STATE OF NEW HAMPSHIRE	KEENE ROAD	270074.873646	63129.1132327
20	House	212-032	ROWLAND DOUGLAS & LISA	362 KEENE ROAD	272139.472394	63965.9785129
21	House	212-027	OTT MICHAEL JAMES HUTCHINS	354 KEENE ROAD	272217.257115	63910.1414205
22	House	212-026	COUTURIER MARCEL J	344 KEENE ROAD	272603.899156	64071.8153898
23	Shed	212-026	COUTURIER MARCEL J	344 KEENE ROAD	272631.354948	64072.2248294
24	Hunting Camp	212-026	COUTURIER MARCEL J	344 KEENE ROAD	272600.408928	63813.9552223
25	House	212-024	HOLMES ROBERT & DENISE	340 KEENE ROAD	272820.859383	64071.7672225
26	House	212-016	COLE JAMES A & MICHELLE L	7 BRACKETT RD	273208.470717	63877.6674294
27	House	212-016	COLE JAMES A & MICHELLE L	7 BRACKETT RD	273243.711104	63869.4273804
28	Barn	212-016	COLE JAMES A & MICHELLE L	7 BRACKETT RD	273252.166468	63908.3249041
29	House	212-016	COLE JAMES A & MICHELLE L	7 BRACKETT RD	273278.862385	63857.9212641
30	Barn	212-016	COLE JAMES A & MICHELLE L	7 BRACKETT RD	273179.222488	63943.5082735
31	House	212-019	COLE JAMES A SR & JAMES A JR	130 REED CARR ROAD	273341.877168	63972.6501302
32	House	212-020	COLE JAMES & KATHRYN E	134 REED CARR ROAD	273353.917629	64054.1334075
33	House	212-020	COLE JAMES & KATHRYN E	134 REED CARR ROAD	273355.987827	64038.2024537
34	House	212-022	STONE DOUGLAS S & ZALUKI AMY	334 KEENE ROAD	273199.769838	64192.7927498
35	House	212-010	R J C REALTY TRUST	95 REED CARR ROAD	273332.514597	63694.1563624
36	House	212-012	CONSTANTINE JAMES I	90 REED CARR ROAD	273302.317716	63643.9675495
37	House	212-013	MORRISON ROBERT A & CHARLENE	92 REED CARR ROAD	273273.490159	63664.8361629
38	House	212-008	COLE BRIAN A	5 BRACKETT ROAD	273541.150889	63762.1897638
39	House	212-007	NH HOUSING FINANCE AUTHORITY	121 REED CARR RD	273463.522101	63806.2591058
40	Barn	212-006	CLINGENPEEL JAMES & TINA	123 REED CARR ROAD	273460.441940	63901.1013051
41	Shed	212-006	CLINGENPEEL JAMES & TINA	123 REED CARR ROAD	273443.271801	63923.1069926
42	House	212-005	CASTELLANO SYLVIA & MARK	127 REED CARR ROAD	273453.754606	63950.3411658
43	House	212-004	COLE JAMES A JR & MICHELLE L	131 REED CARR ROAD	273458.152824	64018.3295536
44	House	212-003	DUMONT GERARD R	135 REED CARR RD	273401.908229	64093.4096764
45	House/Trailer	212-002	NH HOUSING FINANCE AUTHORITY	139 REED CARR ROAD	273398.745319	64144.2130453
46	House	212-052	SNOW ALEXANDER & CAROL J	331 KEENE ROAD	273136.532339	64359.8744954
47	Barn	212-051	THE SISSEL I. PERRY REVOCABLE TRUST	335 KEENE RD	272991.033320	64362.9777756
48	House	212-051	THE SISSEL I. PERRY REVOCABLE TRUST	335 KEENE RD	272945.732445	64345.7918755
49	Barn	212-050	BUXTON PHILIP L & LORRIE A	339 KEENE ROAD	272849.181971	64259.5072244
50	House	212-050	BUXTON PHILIP L & LORRIE A	339 KEENE ROAD	272824.950908	64260.5487469
51	House	212-044	VOYDATCH STEVEN & MAHALA	345 KEENE ROAD	272361.485135	64109.7970735
52	House	212-040	BARRY ROBERT W	351 KEENE RD	272179.115547	64085.0859139
53	House	212-039	MOOTE WAYNE A	355 KEENE ROAD	272100.696511	64063.0840528
54	House	212-038	RAIMONDI DAVID C & ELIZABETH	359 KEENE ROAD	272014.075086	64041.4028769
55	House	221-010	COLANGELO DANIEL P & PATRICIA	80 REED CARR ROAD	273324.864018	63513.0099519
56	House	221-011	CLARK, BRUCE	REED CARR ROAD #21	273391.082386	63494.1150595
57	Shed	221-011	CLARK, BRUCE	REED CARR ROAD #21	273379.345289	63493.5396839
58	House	221-009	BERWICK BRUCE E & BARBARA I	REED CARR ROAD 72	273313.642587	63381.7301677
59	Shed	221-009	BERWICK BRUCE E & BARBARA I	REED CARR ROAD 72	273296.808468	63344.2445619
60	Barn	221-008	JACQUIN RICHARD	66 REED CARR ROAD	273227.798654	63238.3623698
61	House	221-008	JACQUIN RICHARD	66 REED CARR ROAD	273319.688616	63284.0128537
62	House	221-008	JACQUIN RICHARD	66 REED CARR ROAD	273330.440908	63262.5472104
63	House	221-008	JACQUIN RICHARD	66 REED CARR ROAD	273342.615938	63248.3383393
64	House	221-006	TAYLOR SCOTT R & DANIELLE M	58 REED CARR ROAD	273347.276779	63110.3874537
65	House	221-004	GARRETT C SPENCER & JOANN H	38 REED CARR ROAD	273360.408422	62895.1572701
66	House	221-003	IVEY III TRUSTEE SHELLEY	20 REED CARR ROAD	273380.766462	62733.3210812
67	Shed	221-003	IVEY III TRUSTEE SHELLEY	20 REED CARR ROAD	273391.925503	62742.5474428
68	House	221-002	SKRABLE KENNETH	6 REED CARR RD	273417.136135	62477.4835207
69	House	226-010	CRAIG CLARK A JR	224 CRAIG RD	273192.253330	62054.8200224
70	Shed	226-010	CRAIG CLARK A JR	224 CRAIG RD	273189.778968	62036.1601611
71	House	226-002	CRAIG MARY A	235 CRAIG RD	273255.345795	62195.5825180
72	Shed	226-002	CRAIG MARY A	235 CRAIG RD	273276.219436	61962.4849612
73	Shed	226-002	CRAIG MARY A	235 CRAIG RD	273223.455544	62001.6896408
74	Trailer	226-002	CRAIG MARY A	235 CRAIG RD	273231.521922	62213.7406012
75	Trailer	226-002	CRAIG MARY A	235 CRAIG RD	273244.109239	62209.5037393
76	House	226-008	TURCOTTE WILLIAM R	118 CRAIG ROAD	273027.426239	61757.6171141
77	House	226-007	BACHILAS LEO F & ANNA	112 CRAIG RD	273003.689489	61664.4102996
78	House/Trailer	235-016	CRAIG STEVEN M & JAMES P	CRAIG ROAD	273088.373321	61021.2006496

Projection: NAD 1983 State Plane New Hampshire FIPS 2800 (Meters):

Receptor ID	Structure Type	Map_Lot	Name	Address	POINT_X	POINT_Y
79	House	224-002	LONGGOOD JANICE	156 SALMON BROOK ROAD	270088.734345	62000.8913221
80	House	224-003	MICHELI LYLE J & ANNE J	SALMON BROOK ROAD	270229.116968	61814.3711925
81	House	223-001	CARTER RICHARD & TERESSA	68 SALMON BROOK ROAD	269895.159800	62587.5125554
82	House	223-001	CARTER RICHARD & TERESSA	68 SALMON BROOK ROAD	269903.872782	62570.2263776
83	Shed	223-001	CARTER RICHARD & TERESSA	68 SALMON BROOK ROAD	269941.359397	62598.8002210
84	Barn	240-014	LYNCH THOMAS F. MARY L.	53 BRIMSTONE CORNER RD	272733.777952	59740.2813655
85	House	240-014	LYNCH THOMAS F. MARY L.	53 BRIMSTONE CORNER RD	272759.083887	59743.1366694
86	House	240-014	LYNCH THOMAS F. MARY L.	53 BRIMSTONE CORNER RD	272772.698159	59752.7060692
87	House	240-013	SHARBY NEIL P & MARGARET	55 BRIMSTONE CORNER ROAD	272938.574250	59798.5556262
88	Trailer	211-030	CORNERSTONE OUTREACH MINISTRIES	KEENE ROAD	271491.326726	63836.8973794
89	House	224-005	MICHELI LYLE J	200 SALMON BROOK ROAD	269749.542814	61392.4564399
90	Shed	224-005	MICHELI LYLE J	200 SALMON BROOK ROAD	269742.582687	61387.3251506
91	House	224-008	CHATMAN JOHN L, TRUSTEE ET AL	SALMON BROOK ROAD #157	269814.824949	62012.3505812
92	Camp	224-008	CHATMAN JOHN L, TRUSTEE ET AL	SALMON BROOK ROAD #157	269847.866821	61946.2254560
93	Circ Hut, UnkUse	224-009	IMPERATO EVAN M	127 SALMON BROOK RD	269700.629813	62152.8386971
94	Camp	239-001	WHITTEMORE ETAL ARTHUR F	103 CAMP ROAD - PVT RD 38	271664.483314	59431.9365873
95	Camp	239-001	WHITTEMORE ETAL ARTHUR F	103 CAMP ROAD - PVT RD 38	271698.238782	59452.3587272
96	Barn	211-010	BLOCK RICHARD & LORANNE	BLUEBERRY BUSH DRIVE	271032.129156	64557.9906980
97	House	211-010	BLOCK RICHARD & LORANNE	BLUEBERRY BUSH DRIVE	271021.233941	64581.5162891
98	House	211-009	DURLING REV TR MARION E	71 LOVEREN MILL ROAD	271327.381217	64768.1561147
99	House	208-001	Avery, David & Irene Blinn	50 Liberty Farm Road	273068.343193	64843.5724900
100	House	208-002	BURDETTE CLIFTON R & LYNN H	LIBERTY FARM ROAD #48	273124.204072	64739.3152387
101	House	212-053	MANGIERI JEANNETTE G	14 LIBERTY FARM RD	273070.583896	64532.5678907
102	Shed	212-053	MANGIERI JEANNETTE G	14 LIBERTY FARM RD	273131.164733	64554.4591553
103	Garage	212-059	GIAMMARINO BRIAN	11 STACY HILL ROAD	273254.384944	64689.8510881
104	House	212-059	GIAMMARINO BRIAN	11 STACY HILL ROAD	273265.923216	64677.2374732
105	Garage	212-060	FEIGE FRANZ & DIANA	15 LIBERTY FARM ROAD	273329.577631	64530.2298721
106	House	212-060	FEIGE FRANZ & DIANA	15 LIBERTY FARM ROAD	273328.894283	64506.2676631
107	House	212-058	MARTIN CHARLES & MARTHA	17 STACY HILL RD	273456.493626	64561.2240214
108	Barn	212-054	DUNLAP DEBORAH E	8 STACY HILL ROAD	273256.577737	64823.9391796
109	House	212-054	DUNLAP DEBORAH E	8 STACY HILL ROAD	273264.738417	64779.6627539
110	House	213-011	DUNN WALTER K & BINDA HILARY J	STACY HILL ROAD #33	273746.974893	64387.7497906
111	House	213-011	DUNN WALTER K & BINDA HILARY J	STACY HILL ROAD #33	273718.635756	64416.8264908
112	Shed	213-011	DUNN WALTER K & BINDA HILARY J	STACY HILL ROAD #33	273744.845222	64400.9854765
113	House	212-001	FOSTER SUSAN A	151 REED CARR ROAD	273630.418122	64185.3608502
114	House	213-009	GALE JR MARSHALL W	286 KEENE ROAD	273858.948061	64141.6424011
115	House	212-009	COLE ELIZABETH J & GEORGE E	119 REED CARR ROAD	273866.776214	63820.1288778
116	House	212-009	COLE ELIZABETH J & GEORGE E	119 REED CARR ROAD	273621.461995	63739.4284546
117	House	212-009	COLE ELIZABETH J & GEORGE E	119 REED CARR ROAD	273634.486790	63747.1821173
118	Shed	212-009	COLE ELIZABETH J & GEORGE E	119 REED CARR ROAD	273694.979219	63730.7574750
119	House	221-014	IVEY III REVOCABLE TRUST SHELLY	15 REED CARR ROAD	273438.576412	62762.0818550
120	House	220-012	MCKINLAY SONJA M	50 OLD CARR ROAD	273746.570563	63338.0032102
121	House	220-012	MCKINLAY SONJA M	50 OLD CARR ROAD	273787.699518	63341.6496087
122	Barn	220-012	MCKINLAY SONJA M	50 OLD CARR ROAD	273769.001417	63348.8489499
123	House	220-015	GREGSAK ANNE	43 OLD CARR ROAD	274076.435027	62871.2964260
124	Barn	220-015	GREGSAK ANNE	43 OLD CARR ROAD	274079.647523	62890.4561492
125	Garage	220-015	GREGSAK ANNE	43 OLD CARR ROAD	274068.679767	62897.8271954
126	House	220-016	DREW BENJAMIN T & HALLEN JOCELYNN	39 OLD CARR ROAD	274088.303750	62806.3222149
127	House	220-017	PITCHARD ANDREW S	35 OLD CARR ROAD	274127.154455	62771.6779154
128	House	220-018	TITCOMB GLEN R & JEANNE	31 OLD CARR ROAD	274146.752087	62717.7424900
129	House	220-019	GROSS SUSAN C	27 OLD CARR RD	274166.370824	62677.4758988
130	House	220-021	WHITTEMORE JR BARRY & MELINDA	15 OLD CARR ROAD	274248.664596	62483.1157195
131	House	220-022	SHOFIELD III EARL C	9 OLD CARR RD	274250.274122	62443.5682459
132	House	220-023	MCLAY TODD W & VIRGINA E	5 OLD CARR RD	274303.011453	62365.0795741
133	House	220-002	BOULE PAUL L	117 OLD POUND RD	273793.828962	62336.1183831
134	House	220-003	STANLEY TRUSTEE EDWARD A	115 OLD POUND ROAD	273873.055679	62348.6221923
135	Barn	220-003	STANLEY TRUSTEE EDWARD A	115 OLD POUND ROAD	273891.630701	62350.1828339
136	House/Trailer	220-004	SOLOD VICTOR S	113 OLD POUND RD	273937.363645	62356.0908823
137	House	220-004	SOLOD VICTOR S	113 OLD POUND RD	273959.236529	62364.9310359
138	House	220-005	WARDMAN MARY E	111 OLD POUND RD	274003.319075	62457.1458989
139	House	220-006	MARTEL DONNA & LAWRENCE J	109 OLD POUND RD	274093.759407	62351.2514339
140	Garage	220-006	MARTEL DONNA & LAWRENCE J	109 OLD POUND RD	274079.869849	62353.2104785
141	House	220-008	KIRWIN CONSTANCE F	103 OLD POUND RD	274213.474720	62357.0778404
142	House	220-009	TROW ERIC	12 OLD CARR ROAD	274169.662868	62475.3850304
143	House	220-010	HILL BRIANNE L	16 OLD CARR ROAD	274141.730646	62546.1457679
144	House	223-003	CORAZZINI RICHARD R & KATHLEEN L	117 SALMON BROOK ROAD	269753.555420	62331.4362502
145	Barn	223-003	CORAZZINI RICHARD R & KATHLEEN L	117 SALMON BROOK ROAD	269764.148896	62355.4915192
146	House	223-004	PATTEN RAYMOND E.	107 SALMON BROOK ROAD	269764.057420	62459.2338632
147	House	223-005	SMITH HOWARD L	103 SALMON BROOK ROAD	269754.107086	62517.0982678
148	Shed	223-006	HENNINGER KENNETH	99 SALMON BROOK ROAD	269712.134374	62603.1956487
149	House	223-006	HENNINGER KENNETH	99 SALMON BROOK ROAD	269738.999972	62566.5018759
150	House	236-010	CRAIG CLARK A JR	224 CRAIG ROAD	273031.280128	61847.9884337
151	House	221-007	PHILLIPS TENA MARIE	62 REED CARR ROAD	273353.682967	63183.4916792
152	Barn	212-022	STONE DOUGLAS S & ZALUKI AMY	324 KEENE ROAD	273217.011752	64159.2165906
153	House	UNKNOWN	UNKNOWN	LOCATED WITHIN PRIVATE ROAD 73	272283.746596	64096.2376150
154	House	211-033	HUTCHINOSN TED & CAMPBELL DIANA L	363 KEENE ROAD	271819.356830	64075.5500377
155	HOUSE	224-001	SCHAEFER MARK J	128 SALMON BROOK ROAD	269873.536680	62153.0844445

MEMORANDUM

Date: January 17, 2012

To: John Soininen, Antrim Wind Energy LLC

From: Cory Emil, INCE, and Robert O'Neal, INCE, Epsilon Associates, Inc.

Subject: Antrim Wind Sound Level Assessment Report Addendum No. 1
Antrim Collector Substation, Antrim, NH

Epsilon Associates, Inc. (Epsilon) has conducted a desktop sound level assessment of the collector substation associated with the Antrim Wind Project. The transformer will be located on the property of Michael James Hutchins Ott south of Keene Road (Route 9) in Antrim, NH, approximately one half mile NNE of the nearest wind turbine.

The proposed transformer is rated at 24/32/40 megavolt-ampere (MVA). A transformer has various cooling mechanisms which have a modest impact on their sound levels. Typical transformers utilize ONAN (oil natural air natural), ONAF1 (oil natural air forced stage 1), and ONAF2 (oil natural air forced stage 2) for cooling. The worst-case for sound is the maximum MVA rating and forced air stage 2 cooling. This was the condition assumed for the sound modeling of this substation. In the absence of manufacturer-provided sound power data, Epsilon has estimated the sound emissions using the techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers. Table 1 summarizes the sound power level data used in the modeling.

Future sound levels of the collector substation transformer were modeled using Cadna/A software, which included the effects of terrain shielding. To be conservative, the worst-case cooling condition data were used and no barrier walls around the transformers were included in the modeling. A detailed discussion of Cadna/A is found in section 7.2 of the Sound Level Assessment Report prepared by Epsilon Associates, Inc. dated November 17, 2011.

Based on a review of the modeling results and an aerial orthophoto, the nearest occupied residence (#21) is located 675 ft (206 m) WNW of the proposed transformer and the cumulative impact from the substation here is less than 1 dBA when combined with wind turbine emissions. Figure 1 presents transformer-only sound level contours out to 25 dBA around the proposed substation site.

Epsilon ASSOCIATES INC.

Worst-case sound levels at the nearest receptors resulting from substation operation, presented in Table 2, are shown to be much less than the contributions from the nearest wind turbines and well below the 45 dBA guideline value put forth in the November 17, 2011 Epsilon report. No significant noise impact is therefore expected from the proposed substation at any residences.

Table 1 Sound Power Levels (dB) – Collector Substation Transformer, Antrim, NH

Max Rating	dBA	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz
40 MVA	92	89	95	97	92	92	86	81	76	69

Table 2 Modeled Sound Levels (dBA) and Collector Substation Impact

Modeling Location	Structure Type	Broadband [dBA]			
		Wind Turbines Only	Substation Only	Combined Turbines & Substation	Substation contribution
24	Hunting Camp	41.4	34.0	42.1	0.7
21	House	41.3	33.3	41.9	0.6
51	House	39.0	31.2	39.7	0.7
153	House	39.2	30.8	39.8	0.6
22	House	38.7	30.2	39.3	0.6
23	Shed	38.6	29.6	39.1	0.5
20	House	40.5	29.6	40.8	0.3
52	House	39.3	28.6	39.7	0.4
53	House	39.5	27.5	39.8	0.3
54	House	39.5	25.9	39.7	0.2
25	House	38.0	25.7	38.2	0.2

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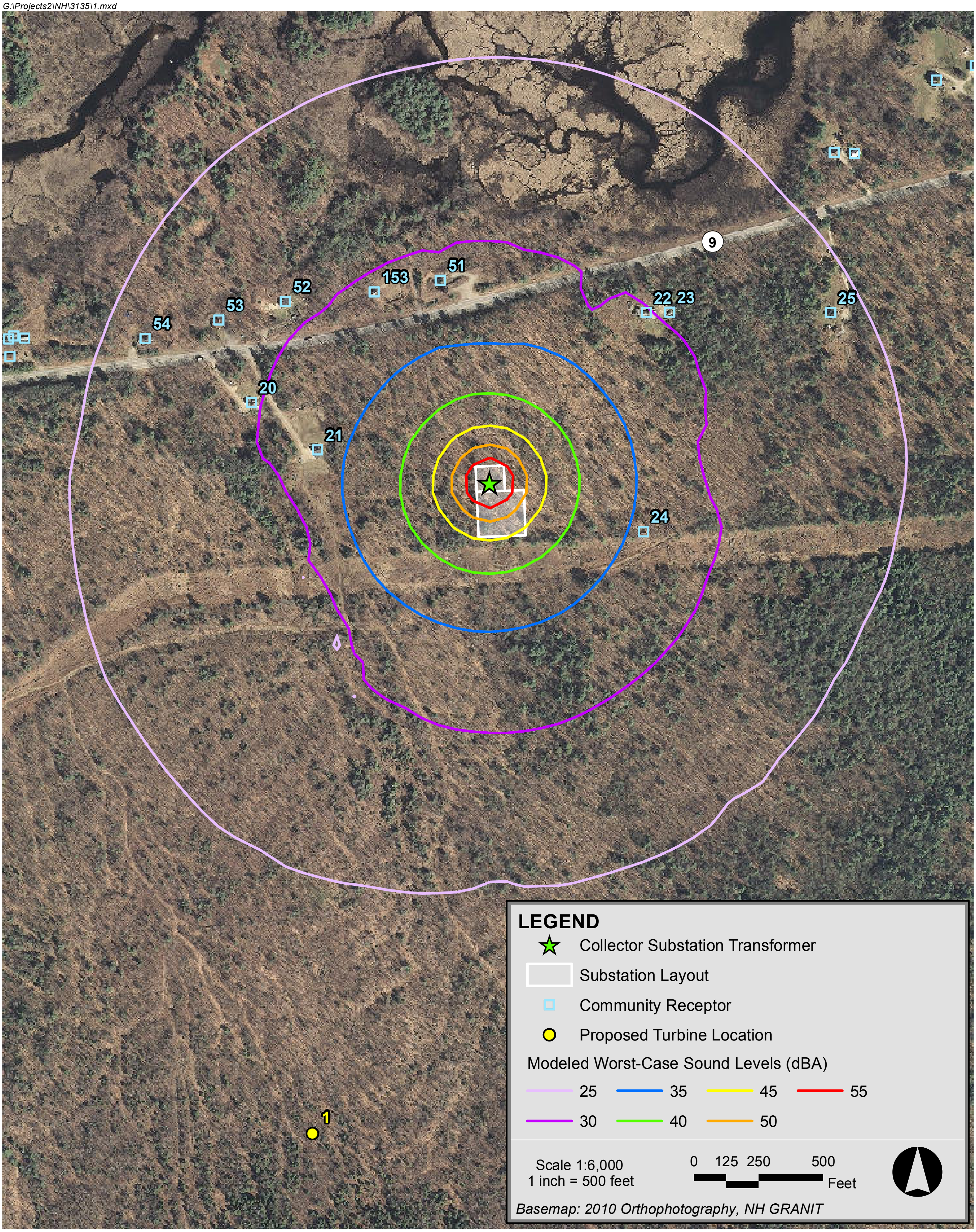

Antrim Wind **Antrim, New Hampshire**

Epsilon ASSOCIATES INC.

Figure 1

Modeled Collector Substation Only Sound Levels (dBA)

APPENDIX 13B
SHADOW FLICKER TECHNICAL MEMORANDUM

SARATOGA ASSOCIATES

ANTRIM WIND ENERGY PROJECT
SHADOW-FLICKER TECHNICAL MEMORANDUM

Prepared for:
Antrim Wind Energy LLC
155 Fleet Street
Portsmouth, NH 03801

December 16, 2011

Landscape Architects, Architects,
Engineers and Planners, P.C.

#2011-039.10M

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1.0 INTRODUCTION

Antrim Wind Energy LLC (AWE) proposes a wind-powered electrical-generating facility consisting of 10 turbines with a maximum combined generation capacity of 30 megawatts (MW). The proposed Antrim Wind Energy Project (hereafter referred to as the "Project") will be located in the Town of Antrim, New Hampshire.

To address the potential impacts of shadow-flicker, AWE has retained Saratoga Associates, Landscape Architects, Architects, Engineers, and Planners, P.C. (Saratoga Associates).

2.0 PROJECT DESCRIPTION

AWE proposes to develop a wind energy generation facility in the Town of Antrim, Hillsborough County, New Hampshire. The Project is proposed to be located in the sparsely populated northwest portion of Antrim and includes privately owned property that extends from the east summit of the Tuttle Hill ridgeline westward to Willard Mountain. Located north of the Project is the PSNH electrical transmission corridor, which contains 34.5kV and 115kV transmission lines, and the Franklin Pierce Highway (NH State Route 9). The Project will consist of ten wind turbine generators, the construction of an access road an electrical substation along with collector lines, a meteorological tower (free standing lattice structure), a small operation and maintenance facility, a construction equipment laydown yard, and temporary work trailers. AWE sited the Project to avoid sensitive wildlife habitats and the potential for impacts to neighboring properties to the greatest extent possible.

The installed capacity of the Project is expected to be between 25 and 30 MW. The exact turbine model is yet to be selected, but it is anticipated that each turbine will have a generating capacity between 2.5 and 3.0 MW and that total turbine height from a minimally exposed foundation to blade tip will not exceed 500 feet. Access to the turbines will be made possible through the construction of an access road originating on NH State Route 9 and proceeding up the northern ridgeline of Tuttle Hill, then extending to the northeast and southwest to reach all turbine positions. The Project proposes to interconnect the generated electrical power to the PSNH 115 kV line and will include buried collector lines along the extent of the turbine string and pole-mounted along the access road from the collector system bus to the point of interconnection. Collectively, the turbine foundations, construction pads, access roads, and electrical upgrades are anticipated to directly impact an area of less than 65 acres.

3.0 SHADOW-FLICKER DEFINITION

For the purpose of this analysis, shadow-flicker shall be defined as:

Rotating blades of wind turbines will result in shadows moving across nearby structures and the surrounding landscape. When the repeating change of light intensity falls across a narrow opening, such as a window, it can cause a flicker effect within the structure (hereafter referred to *as "receptors"), as the shadow appears to flick on and off. This effect is known as shadow-flicker and only occurs within a structure.* [1]

4.0 BACKGROUND

Shadow-flicker will only occur when certain conditions coincide. This would include:

- The turbine blades are rotating during daylight hours (sunrise to sunset), as shadow-flicker will not occur at night. Also, shadow-flicker will not occur when the turbine is not in operation.
- The sun is low in the sky (e.g. shortly after sunrise or shortly before sunset) so that the shadows are cast.
- Shadow-flicker will not occur on foggy or overcast days when daylight is not sufficiently bright to cast shadows.
- A receptor is within ten rotor diameters of the turbine. Evidence from operational turbines suggests that the intensity of shadow-flicker is only an issue at short distances. Beyond ten rotor diameters, a person should not perceive a wind turbine to be chopping through sunlight, but rather as an object with the sun behind it.[2] It is generally accepted that shadow-flicker will have a minimal to unperceivable affect on properties at a distance greater than ten turbine rotor diameters[3] from the turbine.
- Turbine shadows can enter a structure only through unshaded windows that face the turbine.

Although shadow-flicker is only considered inside structures, it should be noted that shadows outside of the structure might be apparent. These shadows are not considered a nuisance since outdoor ambient lighting is typically higher and the shadows rarely contribute to significant changes in light intensity. As such, outdoor impacts are not further evaluated in this analysis.

Because of constantly changing solar aspect and azimuth, shadows will be cast on specific days of the year and may pass a stationary receptor relatively quickly. Shadow-flicker will not be an everyday event or be of extended duration when it does occur. Additionally, shadow-flicker is most likely to occur during early morning or late afternoon hours, thus specific receptors may experience shadow-flicker, but the occupants of the receptor may either be inactive or absent. For example, receptors such as residential dwellings located to the west of a turbine, will fall within the shadow zone shortly after sunrise when affected residents are typically asleep with shades drawn. Receptors located to the east of a turbine will fall within the shadow zone shortly before sunset (see Figure 1 for typical shadow pattern). In this case, receptors such as schools or office buildings are likely to be unoccupied during this time.

When the rotor plane is in-line with the sun and receptor (as seen from the receptor), the cast shadows will be very narrow (see Image 1), of low intensity, and will move more quickly past the stationary

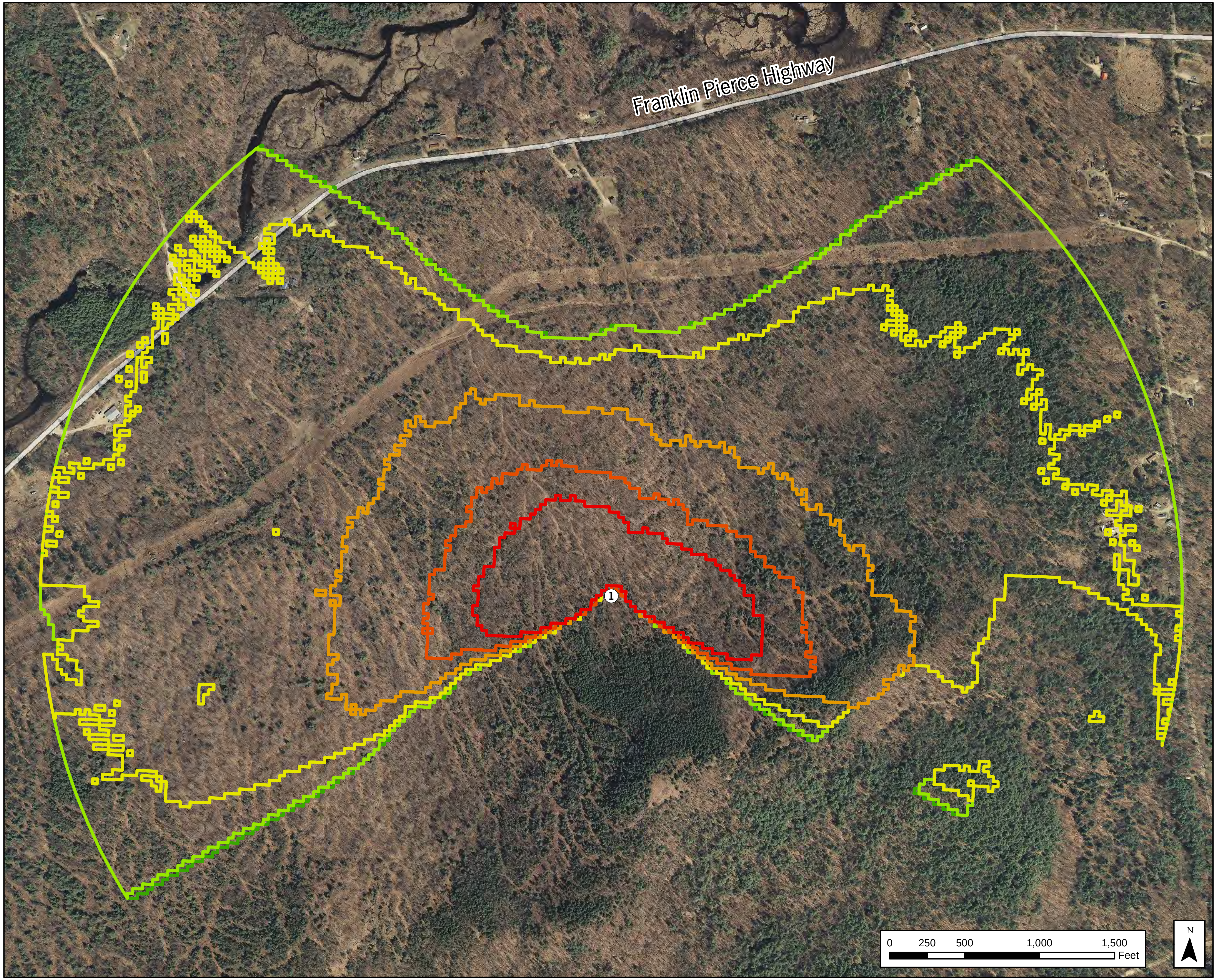
[1] *Onshore Wind Energy Planning Conditions Guidance Note – A Report for the Renewables Advisory Board and BERR (October 2007).*
[2] http://webarchive.nationalarchives.gov.uk/tna/+/http://www.dti.gov.uk/renewables/renew_3.5.1.4.htm/ (Website last accessed on August 17, 2010).
[3] *Planning for Renewable Energy - A Companion Guide to PPS22 Queen's Printer and Controller of Her Majesty's Stationery Office 2004.*

receptor. When the rotor plane is perpendicular to the sun-receptor "view line," the cast shadow of the blades will move within a larger elliptical area (see Image 2).

Image 1 - Aligned Rotor Plane

Image 2 - Perpindicular Rotor Plane

The distance between a wind turbine and a receptor directly affects the intensity of the shadows cast by the blades, and therefore the intensity of flickering. Shadows cast close to a turbine (e.g. 250 meters from the turbine) will be more intense, distinct and "focused" compared to the same shadow further away (e.g. 1,000 meters from the turbine). This is because a greater proportion of the sun's disc is intermittently blocked. Similarly, flickering is more intense if created by the area of a blade closer to the rotor and further from the tip. Beyond ten turbine diameters the intensity of the blade shadow is considered negligible and at such a distance there will be virtually no, or limited, distinct chopping of the sunlight.



Antrim Wind Energy Project

Figure 1 - Typical Shadow Pattern

December 2011

KEY

① Proposed Wind Turbine

Shadow Hours Per Year

- Less than 2
- 2 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- Greater than 40

Major Road

PROJECT # 2011 - 11039

Preliminary analysis is based on real scenario and will undergo further review and analysis, and adjusted accordingly. This figure shall not be used for project permitting.

This map is computer generated using data acquired by Saratoga Associates from various sources and is intended only for reference, conceptual planning and presentation purposes. This map is not intended for and should not be used to establish boundaries, property lines, location of objects or to provide any other information typically needed for construction or any other purpose when engineered plans or land surveys are required.

File Location: B:\2011\11039\Maps\ShadowFlicker111031\TypicalShadowDuration.mxd

SARATOGA ASSOCIATES

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ANTRIM WIND ENERGY LLC

4.1 SHADOW-FLICKER METHODOLOGY

The Projects shadow-flicker analysis was conducted using *WindPRO 2.7 Basis* software (WindPro) and associated shadow module. This is a widely accepted modeling software package developed specifically for the design and evaluation of wind power projects.

4.1.1 Data Input and Assumptions

Variables and assumptions used in calculating shadow-flicker include:

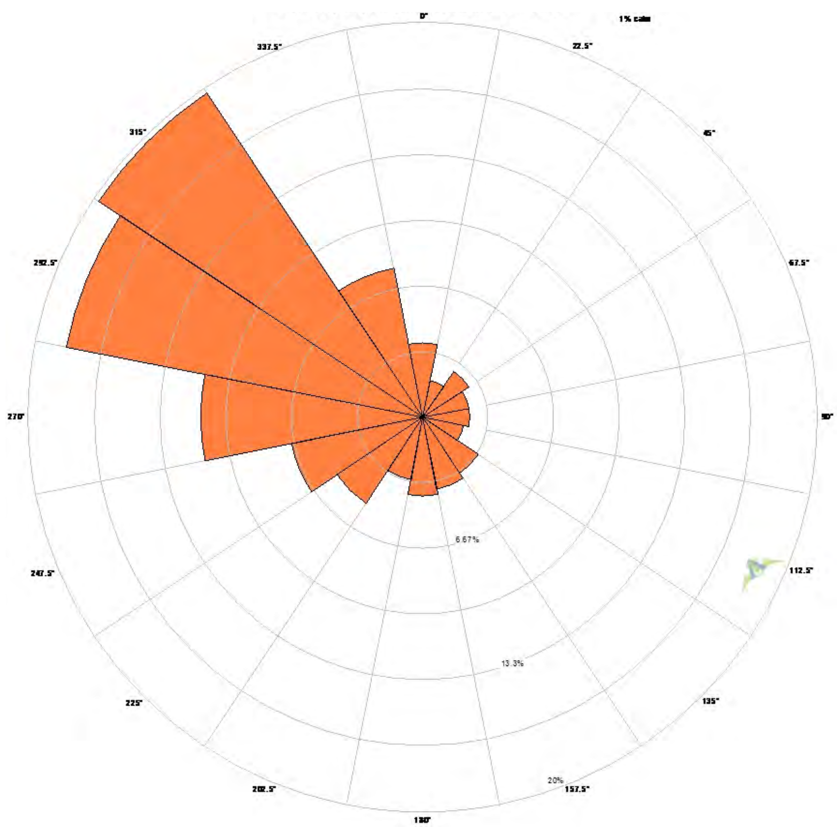
- Terrain – The terrain within the Project area was developed using a digital elevation model (DEM) obtained through the United States Geological Survey in 1/3 arc second resolution (approximately 10 meters). This data was interpolated and exported at 5-meter interval contours for use in WindPro.
- Latitude and Longitude – WindPro considers the azimuth and altitude of the sun in relation to the proposed turbine. For this analysis, the Project coordinates were specified by using Universal Transverse Mercator coordinate system (UTM) North American Datum (NAD) 83 Zone 18 (reflecting the appropriate zone for this region of New Hampshire).
- Turbine Dimensions and Blade Rotation Speed – For the purpose of this analysis, each turbine was modeled using the dimensions of an Acciona AW3000/116. That is, the analysis assumed a hub height of 92 meters (302 feet) and a rotor diameter of 116 meters (380 feet). The frequency of flickering is directly related to the rotor speed and number of blades on the rotor. The shadow-flicker analysis assumed a three-bladed wind turbine rotating at 12.3 revolutions per minute (RPM), which is the maximum operating speed of the Acciona AW3000/116 turbine.
- Sun Coverage – Shadow-flicker will occur when more than 20 percent of the sun is blocked by the turbine blade. Less than 20 percent will not result in a noticeable shadow.
- Sun Angle – The angle of the sun over the horizon will be at least three degrees. A lower angle will result in the light passing through atmosphere becoming too diffused to form a coherent shadow.[4]
- Receptor Locations – Locations of structures (referred to as "receptors"), within the Project area, were provided by AWE. These locations were first derived from interpretation of aerial photographs and then field verified to determine type and occupancy status. The location of each receptor is shown in Figure 2. The shadow-flicker analysis was conducted for all receptors located within a 1,160-meter (3,806 feet or 0.72 miles) radius of each proposed turbine. Within this distance 36 residential locations were identified.
- Receptor Windows – It was conservatively assumed that every receptor had windows (one meter by one meter) one meter above ground, in all directions. WindPro refers to this as the "Green house" mode.
- Sunshine probabilities (percentage of time from sunrise to sunset with sunshine) – The WindPro model calculated shadow frequency based on monthly sunshine probabilities. The

[4] WindPro (EMD International A/S).

following sunshine probabilities were used for this analysis and are based on 58 years of historic meteorological data for Concord, New Hampshire (closest major metropolitan area to the Project).[5]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
52%	55%	53%	53%	55%	58%	62%	60%	56%	53%	42%	47%

- Screening from Vegetation and Structures – Results from WindPro assume that the area lacks vegetation and structures. This assumption is considered conservative, as shadows should not occur in areas where the turbine is substantially screened by vegetation and/or structures.[6]
- Operational Time/Rotor Orientation – The WindPro model was given the number of hours per year that the turbine might be operating for every wind direction identified below. The total hours in the table below are 8,760 hours/year, or approximately 100% of the hours in one calendar year. Moreover, the orientation of the rotor (determined by wind direction) affects the size of a shadow cast area. To more accurately calculate the amount of time a shadow will be over a specific location (based on rotor orientation), the WindPro model considers typical wind direction. These hours are used to determine average annual shadow hours for the year. The operational time (hours per year [hrs/yr]) of wind direction is based on meteorological data collected by AWE from January 1, 2010 to December 31, 2010 and is illustrated in the following windrose and in the table contained in Appendix A.



[5] http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctpos.txt (data for Concord, New Hampshire) (Website last accessed on September 16, 2011)
[6] It is important to note that the closer vegetation is to the receptor the higher probability it will screen potential shadow-flicker.

4.2 SHADOW-FLICKER ANALYSIS

Using the variables identified above, WindPro calculated the expected number of hours per year the shadow of a rotor would theoretically fall at any given location within the 1,160-meter radius of each turbine. Each of the 36 receptors identified in Figure 2 were evaluated to determine potential shadow-flicker impact (see Table 1).[7]

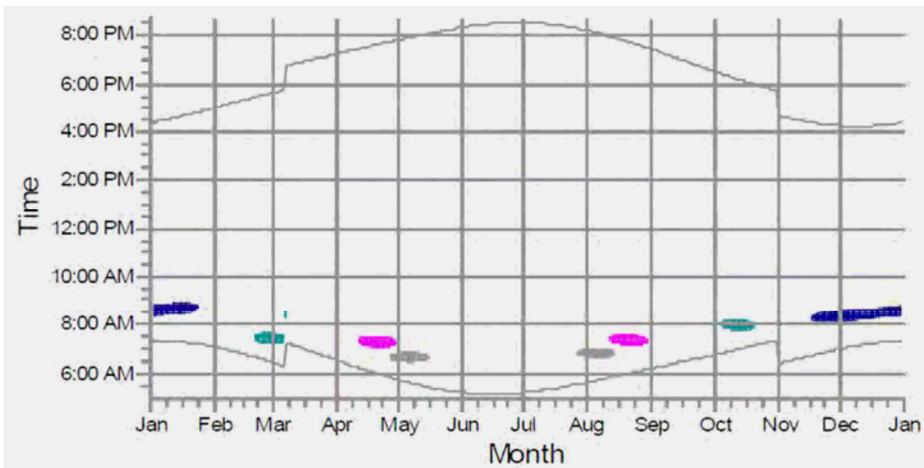
Map ID	Expected Potential Shadow Hours per Year	Is the Project Visible?
3	14:52	No
4	15:25	No
7	4:52	Yes
8	0:00	Yes
9	0:00	Yes
10	0:00	Yes
11	0:00	Yes
12	0:00	No
13	0:00	Yes
20	0:00	No
21	0:00	Yes
22	0:00	No
25	0:00	No
51	0:00	Yes
52	0:00	Yes
53	0:00	Yes
54	0:00	Yes
58	9:17	No
61	9:28	No
62	9:19	No
63	9:14	Yes
64	9:40	No
65	11:00	No
66	13:25	No
68	11:40	No
69	10:58	No
71	5:41	No
74	5:46	No
75	5:38	No
76	2:54	No
80	21:28	No
119	11:10	No
150	0:00	No
151	9:16	No
153	0:00	Yes
154	0:00	No

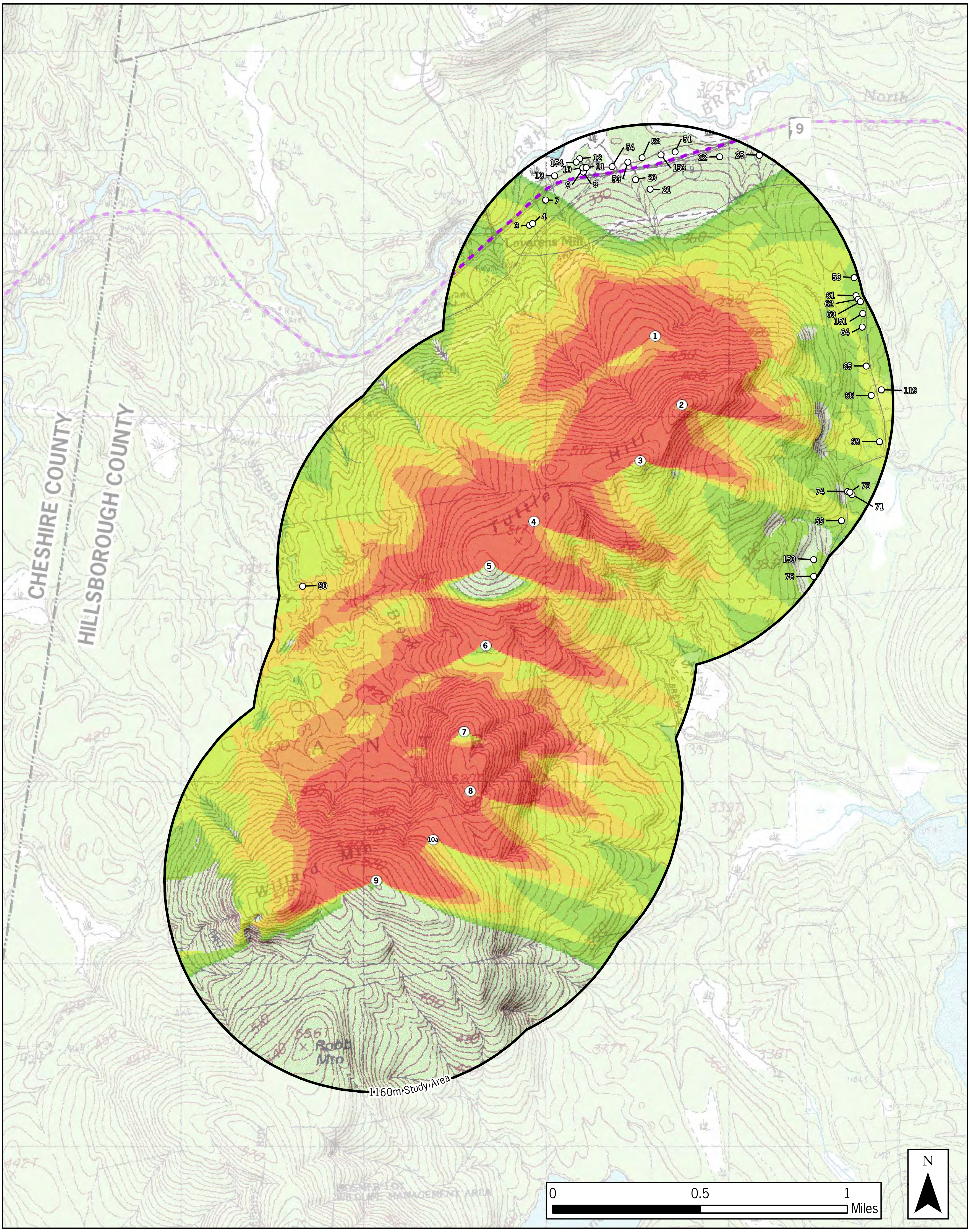
Project visibility was identified using the vegetated viewshed analysis discussed in the *Antrim Wind Energy Project Visual Impact Analysis* (Saratoga Associates). This simply determines whether there is a potential that a turbine will or will not be visible. As discussed above, if the receptor will be screened by vegetation it may not be affected by shadow-flicker.

Included below is a graph, generated by WindPro, illustrating the general times of the day and year that shadows are likely at Receptor 80, which has the highest expected duration of shadow-flicker. The graph does not include potential adjustments for sunshine probability[8], vegetative screening, or Project operating hours that may occur from year to year. Actual average hours therefore may be less than this graph shows, but the graph is useful because it illustrates when the shadows are physically possible to occur.

[7] Hours for each receptor do not take into account activities within the receptor (i.e. rooms of primary use or enjoyment versus less frequently occupied rooms) or account for the direction/location of windows.
[8] The average amount of sunshine will change yearly.

Receptor 80 – Shadow-flicker is possible at this location during (i) mid November to the middle of January between 8:00 AM and 9:00 AM from turbine 5, (ii) late February to early March between 7:00 AM and 8:00 AM (with a limited time between 8:00 AM and 9:00 AM) and again at the beginning of October to the middle of October between 7:30 AM and 8:30 AM from turbine 6, (iii) mid April to the end of April and again mid August to the end of August between 7:00 AM and 8:00 AM from turbine 7, and (iv) end of April to mid May between 6:00 AM and 7:00 AM and again from the end of July to mid August between 6:30 AM and 7:30 AM from turbine 8.





Antrim Wind Energy Project

Figure 2 - Shadow-Flicker Analysis
Topography Only

Turbine locations reflect September 8, 2011 data

December 2011

KEY

Proposed Wind Turbine

Shadow Receptor

Road Class

Local Road

Highway

Divided Highway

Town Boundary

County Boundary

Shadow Hours Per Year

Less than 2

2 - 10

10 - 20

20 - 30

30 - 40

Greater than 40

This map is computer generated using data acquired by Saratoga Associates from various sources and is intended only for reference, conceptual planning and presentation purposes. This map is not intended for and should not be used to establish boundaries, property lines, location of objects or to provide any other information typically needed for construction or any other purpose when engineered plans or land surveys are required.

File Location: B:\2011\11039\Maps\ShadowFlicker111031\TopographicFlickerDuration.mxd

SARATOGA ASSOCIATES

Landscape Architects, Architects, Engineers, and Planners, P.C.

New York City > Saratoga Springs > Syracuse

ANTRIM WIND ENERGY LLC

5.0 SUMMARY

Based on the expected values, of the 36 receptors located within 1,160-meters of any turbine:

- 17 (47.2%) do not fall within the shadow zone;
- 0 (0.0%) have an expected shadow duration of less than 2 hrs/yr;
- 11 (30.6%) have an expected shadow duration of 2-10 hrs/yr;
- 7 (19.4%) have an expected shadow duration of 10-20 hrs/yr;
- 1 (2.8%) have an expected shadow duration of 20-30 hrs/yr;
- 0 (0.0%) have an expected shadow duration of 30-40 hrs/yr; and
- 0 (0.0%) have an expected shadow duration of greater than 40 hrs/yr.

The Town of Antrim and State of New Hampshire do not have published regulations or guidelines that establish an acceptable degree of shadow-flicker impact on a potential receptor or suggested mitigation strategies. However, many European countries have identified 30 hours of shadow-flicker as an allowable threshold; anything above this would be considered a nuisance and require mitigation. Absent rule or state guidance, 30 hours per year has been used as the threshold in which mitigation measures may be considered in potentially reducing the amount of shadow hours on a particular Receptor. This threshold has been used in many municipalities across the United States.

Based on the limited number of receptors within the study area and the relatively low number of expected annual shadow hours, it appears that the Anrtim Wind Farm will operate without significant issues from shadow-flicker. As discussed above, shadow-flicker will not be an everyday event or be of extended duration when it does occur. Shadow-flicker is most likely to occur during early morning or late afternoon hours, thus specific receptors may experience shadow-flicker, but the occupants of the receptor may either be inactive or absent. For those where shadow-flicker hours are predicted to be greatest, the shadows might be considered an annoyance by some, and unnoticed by others. Potential mitigation options should be evaluated on a case-by-case basis, and may include the use of window shades, awnings and/or strategically placed vegetation.

Appendix A

Operational Time/Rotor Orientation

Based on the windrose shown on page 6, the following number of hours per year that the turbine might be operating for every wind direction is identified in the table below.

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
450	271	336	289	303	450	462	450	765	1,262	2,285	1,424