ACOUSTIC STUDY OF THE NANTUCKET HIGH SCHOOL WIND TURBINE

June 2010

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ACOUSTIC STUDY OF THE NANTUCKET HIGH SCHOOL WIND TURBINE

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TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

Nantucket Public Schools proposes to locate one 100-kW wind turbine at its High School on Surfside Road. A study of the noise effects from a NW100 wind turbine with a 37 meter hub height was performed. The turbine will be located behind the High School on an access road between the baseball field and the running track. Acoustic modeling was done for the design wind speed operating conditions (8 m/s at hub height). Existing sound levels on the site and in nearby residential areas were measured during the six-day period of June 22-28, 2010. The study's conclusions are as follows:

- The study results are conservative for three reasons: 1) Turbine maximum sound power levels were assumed that include uncertainty margins; 2) The acoustic model assumed favorable sound propagation with a ground-based temperature inversion, such as might occur on a clear night; and 3) winter frozen ground conditions were assumed with no attenuation from trees or vegetation.
- Existing L_{90}[1] sound levels in the project area during times when winds are high enough for wind turbine operation at maximum sound power are in the range of 44.0 A-weighted decibels (dBA) to 53.0 dBA. The minimum L_{90} sound level of 44.0 dBA was used as the ambient sound level, as required by the MassDEP Noise Policy.
- Maximum outdoor wind turbine sound levels at the closest residences will be 35.5 dBA to 44.6 dBA for the NW100 wind turbine and the wind turbine will comply with the Nantucket Zoning Code limit of 45 dBA.
- The predicted increase in the ambient sound level at the nearest residences ranges from 0.6 dBA to 3.3 dBA and complies with the DEP Noise Policy limit of +10 dBA.
- Maximum outdoor sound levels at the High School will be in the range of 40 to 45 dBA. On the school athletic fields, the maximum sound levels will be in the range of 40 to 50 dBA. These maximum sound levels are consistent with the EPA outdoor daytime noise guideline of 55 dBA for school yards.
- The proposed Nantucket High School wind turbine complies with the Nantucket Zoning Code and with the DEP Noise Policy.

[1] The L_{90} sound level represents the quietest 10 percent of any 1-hour period.

2.0 COMMON MEASURES OF COMMUNITY SOUND

All sounds originate with a source – a human voice, vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person's ears as sound waves, which are minute variations in air pressure. The loudness of a sound depends on the sound pressure level, defined as the ratio of two pressures: the measured sound pressure from the source divided by a reference pressure (the quietest sound we can hear). The unit of sound pressure is the decibel (dB). The decibel scale is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. On this scale, the quietest sound we can hear is 0 dB, while the loudest is 120 dB. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 dB to 100 dB.

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 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB), not a doubling to 140 dB. In terms of the human perception of sound, a halving or doubling of loudness requires changes in the sound pressure level of about 10 dB; 3 dB is the minimum perceptible change for broadband sounds, i.e. sounds that include all frequencies. Typical sound levels associated with various activities and environments are presented in Table 1. The distance to a major road often determines the acoustic environment in an area. Existing sound levels near the proposed wind turbine site are primarily from local roadway traffic, chillers at the nearby ice rink, and natural sounds (wind in the trees and birds).

Sound exposure in a community is commonly expressed in terms of the A-weighted sound level (dBA); A-weighting approximates the frequency response of the human ear. Levels of many sounds change from moment to moment. Some are sharp impulses lasting one second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. To establish the background ambient sound level in an area, the L_{90} metric, which is the sound level exceeded 90 percent of the time, is typically used. The L_{90} can also be thought of as the level representing the quietest 10 percent of any time period and is a broadband sound pressure measure. The L_{eq}, or equivalent sound level, is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the average sound level. Sound level measurements typically include an

analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines eleven octave bands from 16 to 16,000 Hz.

TABLE 1

VARIOUS INDOOR AND OUTDOOR SOUND LEVELS

Outdoor Sound Levels	Sound Pressure (μPa)		Sound Level (dBA)	Indoor Sound Levels
	6,324,555	-	110	Rock Band at 5 m
Jet Over-Flight at 300 m		-	105	
	2,000,000	-	100	Inside New York Subway Train
Gas Lawn Mower at 1 m		-	95	
	632,456	-	90	Food Blender at 1 m
Diesel Truck at 15 m		-	85	
Noisy Urban Area--Daytime	200,000	-	80	Garbage Disposal at 1 m
		-	75	Shouting at 1 m
Gas Lawn Mower at 30 m	63,246	-	70	Vacuum Cleaner at 3 m
Suburban Commercial Area		-	65	Normal Speech at 1 m
Quiet Urban Area -- Daytime	20,000	-	60	
		-	55	Quiet Conversation at 1m
Quiet Urban Area--Nighttime	6,325	-	50	Dishwasher Next Room
		-	45	
Suburban Area--Nighttime	2,000	-	40	Empty Theater or Library
		-	35	
Rural Area--Nighttime	632	-	30	Quiet Bedroom at Night
		-	25	Empty Concert Hall
Rustling Leaves	200	-	20	Average Whisper
		-	15	Broadcast and Recording Studios
	63	-	10	
		-	5	Human Breathing
Reference Pressure Level	20	-	0	Threshold of Hearing

Notes:
μPa - Micropascals describe sound pressure levels (force/area).
dBA - A-weighted decibels describe sound pressure on a logarithmic scale with respect to 20 μPa.

3.0 NOISE REGULATIONS AND CRITERIA

3.1 Massachusetts DEP Noise Policy

The Department of Environmental Protection (DEP) regulates noise through 310 CMR 7.10, "Air Pollution Control". The regulations are included in Appendix A. In these regulations "air contaminant" is defined to include noise and a condition of "air pollution" includes the presence of an air contaminant in such concentration and duration as to "cause a nuisance" or "unreasonably interfere with the comfortable enjoyment of life and property". Regulation 7.10 prohibits "unnecessary emissions" of noise. The DEP Noise Policy (Policy Statement 90-001, July 1, 1990) interprets a violation of this noise regulation to have occurred if the sound source causes either:

1) An increase in the broadband sound pressure level of more than 10 dBA above the ambient, or

2) A "pure tone" condition.[2]

The ambient background level is defined by DEP as the lowest L_{90} level measured during equipment operating hours.

3.2 Town of Nantucket Zoning By-Law

The project site is in the R-10 residential district. Section 101-4 of the Town of Nantucket Zoning Code sets a limit on sound from the project at 45 dBA (L_{10}) at night for impacts on nearby residences. Whereas the sound from the proposed wind turbine when it is operating will be continuous, the L_{10} and L_{eq} sound levels are identical and the effective limit is 45 dBA L_{eq}.

[2]A "pure tone" condition occurs when any octave band sound pressure level exceeds both of the two adjacent octave band sound pressure levels by 3 dB or more.

4.0 AMBIENT SOUND LEVEL AND WIND MEASUREMENTS

For the NW100 wind turbine examined in this report, maximum sound power occurs at the design wind speed, 8 m/s at hub height. To estimate hub height (37 m) wind speeds, the 10 m wind speeds from Nantucket airport were extrapolated to hub height using the power law wind profile[3] with a power law exponent of 0.23 measured by the Renewable Energy Research Laboratory at its Nantucket wind monitoring site.[4] The result of this calculation states that wind speeds at the 37-meter hub height are on average 1.35 times greater than 10-meter wind speeds. Thus a hub height wind speed of 8 m/s equates to a 10-m wind speed of 5.9 m/s (14 mph). Sound levels measured during hours when winds at hub height were at or approaching 8 m/s were used to determine the ambient sound level for the MassDEP Noise Policy.

The Northwind NW100 turbine produces a maximum sound power level[5] of 93.8 dBA +/- 1.0 dBA at the design wind speed. For acoustic modeling, the tested maximum sound power level plus uncertainty level was used, namely 94.8 dBA. The turbine will be located behind the High School on an access road between the baseball field and the running track. Figure 1 illustrates the long term sound monitoring location and the five short-term sound monitoring locations near residential lots: Location 1 on First Way; Location 2 on Anna Drive; Location 3 on Cobble Court; Location 4 on Sparks Avenue; and Location 5 on Cow Pond Lane. Measured wind data are presented in Table B-1 in Appendix B.

Long-term sound level monitoring was performed from 12 noon June 22 to 4 a.m. June 28, 2010[6] to document L_{90} and L_{eq} hourly sound levels, day and night, over a range of wind conditions. Ten meter average wind speeds were at or close to the turbine design wind speed for X hours in the seven-day monitoring period. When the long-term sound monitoring station was set up, skies were partly cloudy, the temperature was about 73^0 F and the winds were 8 mph from the southeast. The monitoring locations are labeled on Figure 1, and are listed below in Table 2.

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[3] International Electrotechnical Commission, International Standard IEC 61400-11, "Wind turbine generator systems- Part 11: Acoustic sound measurements techniques," 2006, page 20.

[4] Renewable Energy Research Laboratory, "Wind Data Report, Nantucket, MA, July 2005 to August 2006," December 2006.

[5] National Renewable Energy laboratory, "Wind Turbine Generator System Acoustic Noise Test Report for the NW100 Wind Turbine," October 2002.

[6] The sound monitoring station was taken down on June 29Battery power to the equipment ran out on June 28.

TABLE 2

RESIDENTIAL AREA SOUND MEASUREMENT LOCATIONS

Sound Monitoring Location	Number
Long Term – South of High School	1
First Way	2
Anna Drive	3
Cobble Court	4
Sparks Avenue	5
Cow Pond Lane	6

All sound level measurements were taken with Larson Davis Model 824 and CEL Model 593 real-time sound level analyzers, which are equipped with precision condenser microphones having an operating range of 5 dB to 140 dB, and an overall frequency range of 3.5 to 20,000 Hz. These meters meet or exceed all requirements set forth in the American National Standards Institute (ANSI) Standards for Type 1 for quality and accuracy. Prior to and immediately following both measurement sessions, the sound analyzers were calibrated (no level adjustment was required) with an ANSI Type 1 calibrator which has an accuracy traceable to the National Institute of Standards and Technology (NIST). All instrumentation was laboratory calibrated per ANSI recommendations. For all measurement sessions, the microphone was fitted with an environmental windscreen to negate wind noise and mounted at a height of 1.3 meters above grade. Measurements were made away from any vertical reflecting surfaces in compliance with ANSI Standard S12.9.[7] The sound data are summarized in Appendix B.

Appendix B-1 summarizes the hourly measurements of L_{90} sound levels at the monitoring stations and the estimated hourly average wind speed at hub height. The values that are in bold text in Table B-1 correspond to hours when the wind turbine would likely have been operating at maximum sound power (hub height wind speeds at or above 8 m/s).

[7] Acoustical Society of America, ANSI Standard S12.9-1997/Part 2, "Quantities and Procedures for Description and Measurement of Environmental Sound. Part 2: Measurement of Long-Term Wind-Area Sound."

The data in Appendix B reveal existing L_{90} sound levels in the residential area near the site during times when winds are high enough for wind turbine operation at maximum sound power are in the range of 44.0 to 53.0 dBA. The lowest L_{90} sound levels corresponding to design wind speed operating conditions and maximum wind turbine sound power was 44.0 dBA measured from 11 a.m. to noon on June 22. This is the ambient sound level used for the DEP compliance analysis under the wind turbine design operating condition.

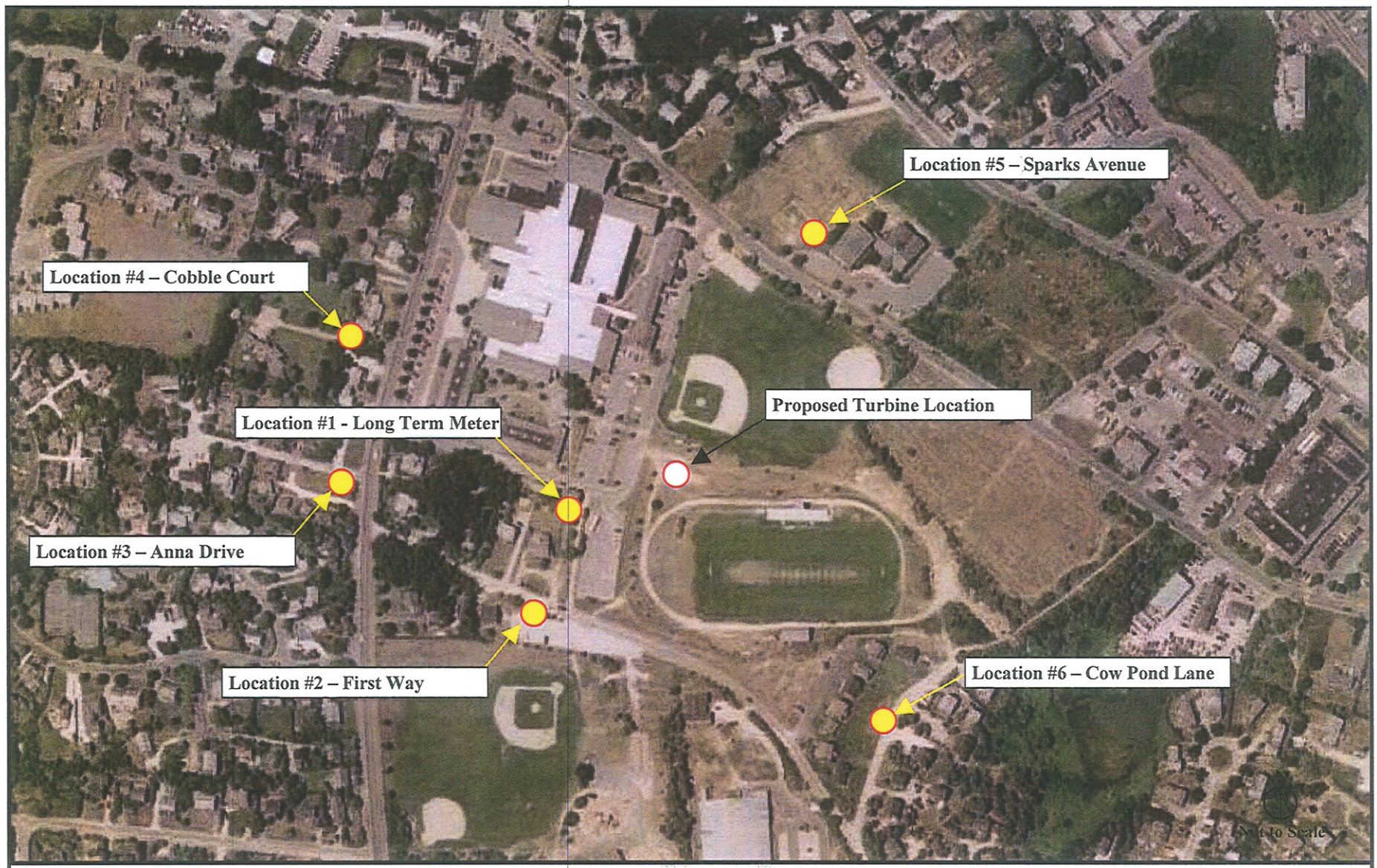

Figure 1.

Sound Monitoring Locations
Nantucket High School Wind Turbine
Nantucket, MA

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5.0 CALCULATED FUTURE SOUND LEVELS

5.1 Methodology

The Nantucket High School wind turbine sound levels at the nearest residences were calculated with the Cadna/A acoustic model. Cadna/A is a sophisticated 3-D model for sound propagation and attenuation based on International Standard ISO 9613[8]. Atmospheric absorption, the process by which sound energy is absorbed by the air, was calculated using ANSI S1.26-1995.[9] Absorption of sound assumed standard day conditions and is significant at large distances. Ground surfaces were assumed to be mixed ground consisting of both hard and porous (vegetated) surfaces.[10] This is a reasonable worst-case assumption and approximates winter frozen ground conditions in the area between the turbine and the nearest homes, with no attenuation from trees or vegetation. The model assumes favorable sound propagation as occurs with a ground-based temperature inversion, such as might occur on a clear night. At other times, atmospheric turbulence and wind shadow effects will reduce sound levels by 5 to 20 dBA from those presented below.

5.2 Results and Conclusions

Figure 2 shows color-coded decibel contours (5 feet above ground level) for the operation of the NW100 wind turbine. Note that Figure assumes the sound receiving location is always downwind of the wind turbine, and the figures present a composite worst-case in which all locations are simultaneously downwind of the wind turbine.

The acoustic modeling results are summarized in Table 3, and provide the highest predicted turbine sound level at each of the nearest residential areas and the maximum increase in the ambient sound level under the DEP Noise Policy. Maximum outdoor wind turbine sound levels at the closest residences will be 35.5 to 44.6 A-weighted decibels (dBA). Predicted maximum sound levels for the NW100 turbine ("Maximum Project Sound" column in Table 3) comply with the Nantucket Zoning

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[8] International Standard, ISO 9613-2, Acoustics -- Attenuation of Sound During Propagation Outdoors, -- Part 2 General Method of Calculation.

[9] American National Standards Institute, ANSI S1.26-1995, American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere, 1995.

[10] Ground absorption factor G set equal to 0.5 in Cadna-A.

Code limit of 45 dBA at the nearest residences. Predicted sound level increases above the ambient level of 44.0 dBA are 0.6 to 3.3 dBA and comply with the DEP Noise Policy limit of +10 dBA. An examination of octave band sound power data for the NW100 reveals it will not produce a pure tone, as defined in the DEP Noise Policy. Maximum outdoor sound levels at the High School will be in the range of 40 to 45 dBA. On the school athletic fields, the maximum sound levels will be in the range of 40 to 50 dBA. These maximum sound levels are consistent with the EPA outdoor daytime noise guideline of 55 dBA for school yards.

TABLE 3

DEP NOISE POLICY COMPLIANCE AT NEARBY RESIDENCES FOR THE NW100 WIND TURBINE DESIGN WIND SPEED CONDITION (dBA)

Residential Location	Ambient L_{90} Level	Maximum Project Sound	Combined Sound Level	Net Increase
31 First Way	44.0	44.6	47.3	3.3
First Way, Teen Center	44.0	40.7	45.7	1.7
Anna Drive	44.0	36.4	44.7	0.7
Cobble Court	44.0	35.5	44.6	0.6
Sparks Avenue, B&G Club	44.0	38.3	45.0	1.0
Cow Pond Lane	44.0	39.2	45.2	1.2

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA.

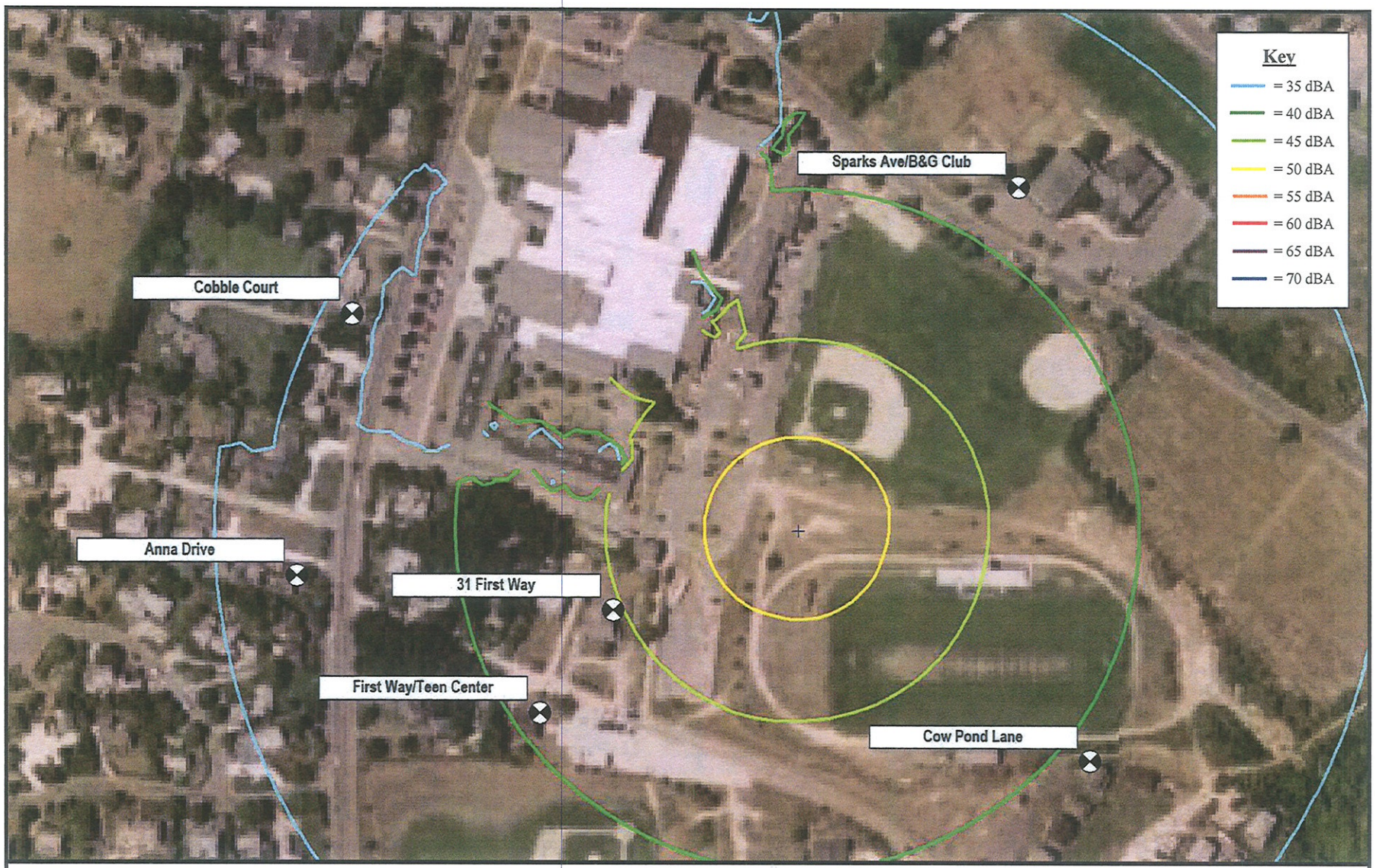

Figure 2.

Maximum Project Sound Levels (dBA)
NW 100 Turbine at Site 3
Nantucket High School, Nantucket, MA

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APPENDIX A

MASSACHUSETTS DEP NOISE POLICY

MADEP NOISE POLICY

Sound

Background

Sound is a type of air pollution that results from sounds that cause a nuisance, are or could injure public health, or unreasonably interfere with the comfortable enjoyment of life, property, or the conduct of business. Types of sounds that may cause sound include:

- "Loud" continuous sounds from industrial or commercial activity,demolition, or highly amplified music;
- Sounds in narrow frequency ranges such as "squealing" fans or other rotary equipment; and
- Intermittent or "impact" sounds such as those from pile drivers, jackhammers, slamming truck tailgates, public address systems,

etc.

Policy

A sound source will be considered to be violating the Department's sound regulation (310 CMR 7.10) if the source:

1. Increases the broadband sound level by more than 10 dB(A) above ambient,

or

2. Produce a "pure tone" condition – when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

These criteria are measured both at the property line and at the nearest inhabited residence. "Ambient" is defined as the background A-weighted sound level that is exceeded 90% of the time, measured during equipment operating hours. "Ambient" may also be established by other means with consent of the Department.

For more information:
For complaints about specific sound sources, call the Board of Health for the municipality in which the sound source is located. To learn more about responding to sound, odor and dust complaints or to request state assistance or support, please contact the service center in the nearest DEP regional office.

- Central Region, Worcester: (508) 792-7683
- Northeast Region, Wilmington: (978) 661-7677
- Southeast Region, Lakeville: (508) 946-2714
- Western Region, Springfield: (413) 755-2214

This Policy was originally adopted by the MA Department of Public Health in the early 1970's. It was reaffirmed by DEP's Division of Air Quality Control on July 1, 1990, and has remained in effect.

APPENDIX B

MEASURED SOUND LEVEL AND WIND DATA

Table B-1.
Measured Sound Levels and Wind Speeds

Meterological Data						Sound Monitoring Data								
	Hour Starting	KACK	Wind Speed	Wind Speed	Wind Speed		Hour Starting	Location #1		Location #2	Location #3	Location #4	Location #5	Location #6
Date	Time (EST)	Data	10-m (mph)	10-m (m/s)	37-m Hub (m/s)	Date	Time (EST)	Time	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)
22-Jun-10	12:00	8 /SE	8	3.6	4.8	22-Jun-10	12:00	11:38:16	50.0					
22-Jun-10	13:00	6 /SE	6	2.7	3.6	22-Jun-10	13:00	12:38:16	50.6					
22-Jun-10	14:00	9 /SE	9	4.0	5.4	22-Jun-10	14:00	13:38:16	49.7					
22-Jun-10	15:00	8 /SE	8	3.6	4.8	22-Jun-10	15:00	14:38:16	50.4					
22-Jun-10	16:00	8 /SE	8	3.6	4.8	22-Jun-10	16:00	15:38:16	50.8	51.0	53.0			
22-Jun-10	17:00	6 /SE	6	2.7	3.6	22-Jun-10	17:00	16:38:16	51.4			51.0	47.0	
22-Jun-10	18:00	5 /SE	5	2.2	3.0	22-Jun-10	18:00	17:38:16	51.4					44.0
22-Jun-10	19:00	5 /SE	5	2.2	3.0	22-Jun-10	19:00	18:38:16	51.1					
22-Jun-10	20:00	8 /S	8	3.6	4.8	22-Jun-10	20:00	19:38:16	50.7					
22-Jun-10	21:00	9 /SE	9	4.0	5.4	22-Jun-10	21:00	20:38:16	50.2					
22-Jun-10	22:00	8 /S	8	3.6	4.8	22-Jun-10	22:00	21:38:16	50.2					
22-Jun-10	23:00	6 /S	6	2.7	3.6	22-Jun-10	23:00	22:38:16	49.7					
23-Jun-10	0:00	6 /S	6	2.7	3.6	22-Jun-10	0:00	23:38:16	49.9					
23-Jun-10	1:00	7 /S	7	3.1	4.2	23-Jun-10	1:00	0:38:16	38.0					
23-Jun-10	2:00	8 /SE	8	3.6	4.8	23-Jun-10	2:00	1:38:16	38.6					
23-Jun-10	3:00	12 /SE	12	5.3	7.2	23-Jun-10	3:00	2:38:16	39.6					
23-Jun-10	4:00	10 /S	10	4.5	6.0	23-Jun-10	4:00	3:38:16	54.4					
23-Jun-10	5:00	13 /S	13	5.8	7.8	23-Jun-10	5:00	4:38:16	50.0	49.0	47.0			
23-Jun-10	6:00	12 /S	12	5.3	7.2	23-Jun-10	6:00	5:38:16	50.5			45.0	45.0	
23-Jun-10	7:00	14 /S	14	6.2	8.4	23-Jun-10	7:00	6:38:16	51.4					45.0
23-Jun-10	8:00	15 /SW	15	6.7	9.0	23-Jun-10	8:00	7:38:16	52.9					
23-Jun-10	9:00	15 /SW	15	6.7	9.0	23-Jun-10	9:00	8:38:16	50.5	47.0				
23-Jun-10	10:00	15 /SW	15	6.7	9.0	23-Jun-10	10:00	9:38:16	48.0		53.0	49.0		
23-Jun-10	11:00	16 /W	16	7.1	9.6	23-Jun-10	11:00	10:38:16	47.3				50.0	44.0
23-Jun-10	12:00	15 /SW	15	6.7	9.0	23-Jun-10	12:00	11:38:16	48.3					
23-Jun-10	13:00	13 /SW	13	5.8	7.8	23-Jun-10	13:00	12:38:16	47.4					
23-Jun-10	14:00	12 /SW	12	5.3	7.2	23-Jun-10	14:00	13:38:16	47.3					
23-Jun-10	15:00	12 /SW	12	5.3	7.2	23-Jun-10	15:00	14:38:16	47.2					
23-Jun-10	16:00	12 /SW	12	5.3	7.2	23-Jun-10	16:00	15:38:16	47.1					
23-Jun-10	17:00	10 /SW	10	4.5	6.0	23-Jun-10	17:00	16:38:16	47.4					
23-Jun-10	18:00	13 /W	13	5.8	7.8	23-Jun-10	18:00	17:38:16	48.5					
23-Jun-10	19:00	12 /W	12	5.3	7.2	23-Jun-10	19:00	18:38:16	50.0					
23-Jun-10	20:00	10 /W	10	4.5	6.0	23-Jun-10	20:00	19:38:16	50.2					
23-Jun-10	21:00	10 /W	10	4.5	6.0	23-Jun-10	21:00	20:38:16	47.1					
23-Jun-10	22:00	13 /W	13	5.8	7.8	23-Jun-10	22:00	21:38:16	46.9					
23-Jun-10	23:00	10 /W	10	4.5	6.0	23-Jun-10	23:00	22:38:16	47.0					
24-Jun-10	0:00	8 /SW	8	3.6	4.8	23-Jun-10	0:00	23:38:16	48.2					
24-Jun-10	1:00	5 /SW	5	2.2	3.0	24-Jun-10	1:00	0:38:16	49.1					
24-Jun-10	2:00	5 /SW	5	2.2	3.0	24-Jun-10	2:00	1:38:16	48.0					
24-Jun-10	3:00	6 /SW	6	2.7	3.6	24-Jun-10	3:00	2:38:16	35.0					
24-Jun-10	4:00	5 /SW	5	2.2	3.0	24-Jun-10	4:00	3:38:16	35.7					
24-Jun-10	5:00	5 /SW	5	2.2	3.0	24-Jun-10	5:00	4:38:16	40.4					
24-Jun-10	6:00	8 /SW	8	3.6	4.8	24-Jun-10	6:00	5:38:16	50.0					
24-Jun-10	7:00	8 /SW	8	3.6	4.8	24-Jun-10	7:00	6:38:16	50.7					
24-Jun-10	8:00	7 /S	7	3.1	4.2	24-Jun-10	8:00	7:38:16	52.4					
24-Jun-10	9:00	10 /SW	10	4.5	6.0	24-Jun-10	9:00	8:38:16	52.2					
24-Jun-10	10:00	8 /SW	8	3.6	4.8	24-Jun-10	10:00	9:38:16	51.7					
24-Jun-10	11:00	13 /SW	13	5.8	7.8	24-Jun-10	11:00	10:38:16	49.1					
24-Jun-10	12:00	12 /SW	12	5.3	7.2	24-Jun-10	12:00	11:38:16	47.4					
24-Jun-10	13:00	10 /SW	10	4.5	6.0	24-Jun-10	13:00	12:38:16	50.8					
24-Jun-10	14:00	15 /SW	15	6.7	9.0	24-Jun-10	14:00	13:38:16	51.8					
24-Jun-10	15:00	16 /SW	16	7.1	9.6	24-Jun-10	15:00	14:38:16	52.0					
24-Jun-10	16:00	16 /SW	16	7.1	9.6	24-Jun-10	16:00	15:38:16	51.1					
24-Jun-10	17:00	17 /SW	17	7.6	10.2	24-Jun-10	17:00	16:38:16	51.3					

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Measured Sound Levels and Wind Speeds

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Date	Time (EST)	Data	10-m (mph)	10-m (m/s)	37-m Hub (m/s)	Date	Time (EST)	Time	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)
24-Jun-10	18:00	18 /SW	18	8.0	10.8	24-Jun-10	18:00	17:38:16	53.0					
24-Jun-10	19:00	20 /SW	20	8.9	12.0	24-Jun-10	19:00	18:38:16	52.6					
24-Jun-10	20:00	14 /SW	14	6.2	8.4	24-Jun-10	20:00	19:38:16	50.3					
24-Jun-10	21:00	16 /SW	16	7.1	9.6	24-Jun-10	21:00	20:38:16	48.8					
24-Jun-10	22:00	13 /W	13	5.8	7.8	24-Jun-10	22:00	21:38:16	47.1					
24-Jun-10	23:00	10 /W	10	4.5	6.0	24-Jun-10	23:00	22:38:16	45.8					
25-Jun-10	0:00	10 /W	10	4.5	6.0	24-Jun-10	0:00	23:38:16	45.8					
25-Jun-10	1:00	8 /W	8	3.6	4.8	25-Jun-10	1:00	0:38:16	45.1					
25-Jun-10	2:00	10 /NW	10	4.5	6.0	25-Jun-10	2:00	1:38:16	42.8					
25-Jun-10	3:00	12 /N	12	5.3	7.2	25-Jun-10	3:00	2:38:16	41.2					
25-Jun-10	4:00	13 /N	13	5.8	7.8	25-Jun-10	4:00	3:38:16	41.4					
25-Jun-10	5:00	10 /N	10	4.5	6.0	25-Jun-10	5:00	4:38:16	37.9					
25-Jun-10	6:00	8 /NW	8	3.6	4.8	25-Jun-10	6:00	5:38:16	37.8					
25-Jun-10	7:00	12 /N	12	5.3	7.2	25-Jun-10	7:00	6:38:16	40.5					
25-Jun-10	8:00	14 /NW	14	6.2	8.4	25-Jun-10	8:00	7:38:16	45.1					
25-Jun-10	9:00	14 /N	14	6.2	8.4	25-Jun-10	9:00	8:38:16	45.8					
25-Jun-10	10:00	14 /N	14	6.2	8.4	25-Jun-10	10:00	9:38:16	46.0					
25-Jun-10	11:00	12 /N	12	5.3	7.2	25-Jun-10	11:00	10:38:16	44.4					
25-Jun-10	12:00	12 /NE	12	5.3	7.2	25-Jun-10	12:00	11:38:16	45.2					
25-Jun-10	13:00	10 /NE	10	4.5	6.0	25-Jun-10	13:00	12:38:16	45.5					
25-Jun-10	14:00	-	-	-	-	25-Jun-10	14:00	13:38:16	44.5					
25-Jun-10	15:00	-	-	-	-	25-Jun-10	15:00	14:38:16	45.1					
25-Jun-10	16:00	8 /SE	8	3.6	4.8	25-Jun-10	16:00	15:38:16	50.2					
25-Jun-10	17:00	8 /SE	8	3.6	4.8	25-Jun-10	17:00	16:38:16	50.3					
25-Jun-10	18:00	6 /S	6	2.7	3.6	25-Jun-10	18:00	17:38:16	50.6					
25-Jun-10	19:00	6 /SW	6	2.7	3.6	25-Jun-10	19:00	18:38:16	50.5					
25-Jun-10	20:00	5 /SW	5	2.2	3.0	25-Jun-10	20:00	19:38:16	51.2					
25-Jun-10	21:00	3 /SW	3	1.3	1.8	25-Jun-10	21:00	20:38:16	51.2					
25-Jun-10	22:00	7 /S	7	3.1	4.2	25-Jun-10	22:00	21:38:16	51.1					
25-Jun-10	23:00	6 /SW	6	2.7	3.6	25-Jun-10	23:00	22:38:16	50.8					
26-Jun-10	0:00	7 /SW	7	3.1	4.2	25-Jun-10	0:00	23:38:16	50.6					
26-Jun-10	1:00	6 /SW	6	2.7	3.6	26-Jun-10	1:00	0:38:16	50.5					
26-Jun-10	2:00	8 /S	8	3.6	4.8	26-Jun-10	2:00	1:38:16	50.3					
26-Jun-10	3:00	7 /S	7	3.1	4.2	26-Jun-10	3:00	2:38:16	50.1					
26-Jun-10	4:00	9 /S	9	4.0	5.4	26-Jun-10	4:00	3:38:16	50.3					
26-Jun-10	5:00	8 /S	8	3.6	4.8	26-Jun-10	5:00	4:38:16	38.2					
26-Jun-10	6:00	9 /S	9	4.0	5.4	26-Jun-10	6:00	5:38:16	39.3					
26-Jun-10	7:00	8 /S	8	3.6	4.8	26-Jun-10	7:00	6:38:16	42.0					
26-Jun-10	8:00	10 /S	10	4.5	6.0	26-Jun-10	8:00	7:38:16	50.4					
26-Jun-10	9:00	12 /SW	12	5.3	7.2	26-Jun-10	9:00	8:38:16	50.5					
26-Jun-10	10:00	12 /S	12	5.3	7.2	26-Jun-10	10:00	9:38:16	50.8					
26-Jun-10	11:00	13 /SW	13	5.8	7.8	26-Jun-10	11:00	10:38:16	49.9					
26-Jun-10	12:00	9 /SW	9	4.0	5.4	26-Jun-10	12:00	11:38:16	47.9					
26-Jun-10	13:00	10 /SW	10	4.5	6.0	26-Jun-10	13:00	12:38:16	49.1					
26-Jun-10	14:00	12 /SW	12	5.3	7.2	26-Jun-10	14:00	13:38:16	47.1					
26-Jun-10	15:00	9 /SW	9	4.0	5.4	26-Jun-10	15:00	14:38:16	48.4					
26-Jun-10	16:00	9 /SW	9	4.0	5.4	26-Jun-10	16:00	15:38:16	48.3					
26-Jun-10	17:00	7 /SW	7	3.1	4.2	26-Jun-10	17:00	16:38:16	52.1					
26-Jun-10	18:00	10 /SW	10	4.5	6.0	26-Jun-10	18:00	17:38:16	51.3					
26-Jun-10	19:00	8 /SW	8	3.6	4.8	26-Jun-10	19:00	18:38:16	50.2					
26-Jun-10	20:00	9 /W	9	4.0	5.4	26-Jun-10	20:00	19:38:16	47.4					
26-Jun-10	21:00	10 /W	10	4.5	6.0	26-Jun-10	21:00	20:38:16	45.9					
26-Jun-10	22:00	8 /W	8	3.6	4.8	26-Jun-10	22:00	21:38:16	47.1					

Table B-1.
Measured Sound Levels and Wind Speeds

Meterological Data						Sound Monitoring Data								
	Hour Starting	KACK	Wind Speed	Wind Speed	Wind Speed		Hour Starting	Location #1		Location #2	Location #3	Location #4	Location #5	Location #6
Date	Time (EST)	Data	10-m (mph)	10-m (m/s)	37-m Hub (m/s)	Date	Time (EST)	Time	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)	L_{90} (dBA)
26-Jun-10	23:00	5 /W	5	2.2	3.0	26-Jun-10	23:00	22:38:16	47.6					
27-Jun-10	0:00	7 /W	7	3.1	4.2	26-Jun-10	0:00	23:38:16	36.7					
27-Jun-10	1:00	7 /SW	7	3.1	4.2	27-Jun-10	1:00	0:38:16	36.1					
27-Jun-10	2:00	3 /SW	3	1.3	1.8	27-Jun-10	2:00	1:38:16	35.6					
27-Jun-10	3:00	6 /W	6	2.7	3.6	27-Jun-10	3:00	2:38:16	46.4					
27-Jun-10	4:00	8 /N	8	3.6	4.8	27-Jun-10	4:00	3:38:16	49.3					
27-Jun-10	5:00	0	0	0.0	0.0	27-Jun-10	5:00	4:38:16	50.3					
27-Jun-10	6:00	6 /SE	6	2.7	3.6	27-Jun-10	6:00	5:38:16	50.0					
27-Jun-10	7:00	8 /SE	8	3.6	4.8	27-Jun-10	7:00	6:38:16	49.7					
27-Jun-10	8:00	12 /S	12	5.3	7.2	27-Jun-10	8:00	7:38:16	42.6					
27-Jun-10	9:00	9 /SE	9	4.0	5.4	27-Jun-10	9:00	8:38:16	43.8					
27-Jun-10	10:00	7 /S	7	3.1	4.2	27-Jun-10	10:00	9:38:16	46.6					
27-Jun-10	11:00	9 /S	9	4.0	5.4	27-Jun-10	11:00	10:38:16	50.1					
27-Jun-10	12:00	8 /SW	8	3.6	4.8	27-Jun-10	12:00	11:38:16	50.0					
27-Jun-10	13:00	9 /S	9	4.0	5.4	27-Jun-10	13:00	12:38:16	50.2					
27-Jun-10	14:00	6 /S	6	2.7	3.6	27-Jun-10	14:00	13:38:16	51.0					
27-Jun-10	15:00	6 /S	6	2.7	3.6	27-Jun-10	15:00	14:38:16	49.2					
27-Jun-10	16:00	6 /S	6	2.7	3.6	27-Jun-10	16:00	15:38:16	49.1					
27-Jun-10	17:00	7 /S	7	3.1	4.2	27-Jun-10	17:00	16:38:16	50.3					
27-Jun-10	18:00	8 /SW	8	3.6	4.8	27-Jun-10	18:00	17:38:16	49.5					
27-Jun-10	19:00	6 /S	6	2.7	3.6	27-Jun-10	19:00	18:38:16	50.6					
27-Jun-10	20:00	8 /S	8	3.6	4.8	27-Jun-10	20:00	19:38:16	50.6					
27-Jun-10	21:00	5 /S	5	2.2	3.0	27-Jun-10	21:00	20:38:16	39.9					
27-Jun-10	22:00	8 /S	8	3.6	4.8	27-Jun-10	22:00	21:38:16	40.3					
27-Jun-10	23:00	12 /S	1	0.4	0.6	27-Jun-10	23:00	22:38:16	39.3					
28-Jun-10	0:00	8 /SW	8	3.6	4.8	27-Jun-10	0:00	23:38:16	46.8					
28-Jun-10	1:00	10 /SW	10	4.5	6.0	28-Jun-10	1:00	0:38:16	48.5					
28-Jun-10	2:00	6 /SW	6	2.7	3.6	28-Jun-10	2:00	1:38:16	48.1					
28-Jun-10	3:00	5 /SW	5	2.2	3.0	28-Jun-10	3:00	2:38:16	48.4					
Wind speeds in bold are at or above the design wind speed of 8 m/s.								MIN	45.1					
								MAX	53.0					
								AVERAGE	49.8					

Name	M.	ID	Level Lr Day (dBA)	Height (m)	Coordinates X (m)	Y (m)	Z (m)
Loc #1 - 31 First Way		1_31First	44.6	1.52	533621.1	30264.79	12.21
Loc #2 - First Way/Teen Center		2_FirstWay	40.7	1.52	533589.4	30220.43	12.78
Loc #3 - Anna Drive		3_AnnaDr	36.4	1.52	533484.2	30279.77	13.01
Loc #4 - Cobble Court		4_CobbleCt	35.5	1.52	533508.3	30393.07	13.17
Loc #5 - Sparks Ave/B&G Club		5_SparksAve	38.3	1.52	533796.5	30448.2	9.37
Loc #6 - Cow Pond Lane		6_CowPondLn	39.2	1.52	533827.5	30199.51	8.63