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REPORT NO. 1755-010606-D

DATE OF ISSUE: NOVEMBER 15, 2006

ENVIRONMENTAL SOUND SURVEY AND NOISE IMPACT ASSESSMENT

COHOCTON WIND FARM PROJECT

COHOCTON, NY

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1.0 INTRODUCTION

Hessler Associates, Inc. has been retained by UPC Wind Management, LLC to evaluate potential noise impacts from the proposed Cohocton Wind Project on residents in the vicinity of the project area, which lies mainly to the east of the town of Cohocton, NY but also contains a small separate section on Brown Hill south of town.

Current plans call for the erection of 36 wind turbines, each with a nominal output of 2.5 MW. It is anticipated that Model C96 wind turbine generators manufactured by Clipper Windpower Technology, Inc. will be used. This model has a 96 m diameter, three-bladed rotor mounted on 80 m tubular steel towers. As is currently the case with most wind turbine models in the 2.5 MW size class, the C96 is not yet in commercial production but rather is still in the development phase. The first commercial models are being installed by UPC Wind at the “Steelwinds” project near Lackawanna, NY. Installation is expected to be completed in December of 2007. A prototype of the C96 has been built for testing and design refinement purposes at a site in the Western United States and preliminary sound power level measurements have been taken of this unit. As the only available information, these measurements have been used in the modeling portion of this assessment although it is anticipated that the final noise level of the production version will be lower than the current sound level of the prototype, which does not yet include certain noise abatement features. Once the modifications have been made and new sound tests are complete, an addendum will be added to this study to report the results.

The study essentially consisted of two phases: a background sound level survey and a computer modeling analysis of future turbine sound levels. The field survey of existing sound levels at the site was necessary to determine how much natural masking noise there might be - as a function of wind speed - at the nearest residences to the project. The relevance of this is that high levels of background noise due to wind induced natural sounds, such as tree rustle, would reduce or preclude the audibility of the wind farm while low levels of natural noise would permit operational noise from the turbines to be more readily perceptible. For a broadband, atonal noise source, such as the proposed wind turbines, the audibility of and potential impact from the new noise is a function of how much, if at all, it exceeds the pre-existing background level.

In the second phase of the project an analytical noise model of the project was developed to predict the sound level contours associated with the project over the site area and thereby determine if any nearby residents might be able to hear the turbines above the pre-existing background level and, if so, what the likelihood of an adverse impact might be.

The primary basis for evaluating potential project noise is the Program Policy *Assessing and Mitigating Noise Impacts* issued by the New York State Department of Environmental Conservation (NYCDEC), Feb. 2001. This assessment procedure is incremental in the sense that a simplified “first level noise impact evaluation” is initially carried out to determine if any residential receptors *may* experience a noticeable increase in sound level followed by a more in depth “second level noise impact evaluation” if any sensitive receptors are identified as being possibly affected. The procedure essentially defines a cumulative increase in overall sound level of 6 dBA as the threshold between no significant impact and a potentially adverse impact.

2.0 BACKGROUND SOUND LEVEL SURVEY

2.1 OBJECTIVE AND MEASUREMENT QUANTITIES

The purpose of the survey was to determine what minimum environmental sound levels are consistently present and available at the nearest potentially sensitive receptors to mask or obscure potential noise from the project. A number of statistical sound levels were measured in consecutive 1 hour intervals over the entire survey. Of these, the average (Leq) and residual (L90) levels are the most meaningful.

The average, or equivalent energy sound level (Leq), is literally the average sound level over each measurement interval. While useful and informative, this measure needs to be viewed with some caution when the survey objective is to quantify the mean minimum background level - since it can, and often is, influenced by noise events that are relatively loud in magnitude but short in duration, such as a car passing close by the monitoring position. For example, one such event can significantly elevate the average level over a short to moderate integration period and yield a result that may well be unrepresentative of the quieter times during the sample.

In order to avoid this pitfall, the residual, or L90, statistical sound level is commonly used to quantify background sound levels. The L90 is the sound level exceeded during 90% of the measurement interval and has the quality of filtering out sporadic, short-duration noise events thereby capturing the quiet lulls between such events. It is this consistently present "background" level that forms a conservative basis for evaluating the audibility of a new source. If the source does not exceed this relatively low background threshold by more than about 3 to 5 dBA the source is highly unlikely to be perceived as a noise nuisance - if it is even audible at all.

An additional factor that is important in establishing the minimum background sound level available to mask potential wind turbine noise is the natural sound generated by the wind itself. Wind turbines only operate and produce noise when the wind exceeds a minimum cut-in speed of about 4 m/s (measured at a reference elevation of 10 m). Turbine sound levels increase with wind speed up to about 8 m/s when the sound produced reaches a maximum and no longer increases with wind speed. Consequently, at moderate to high speeds when turbine noise is most significant the level of natural masking noise is normally also relatively high due to tree or grass rustle thus reducing the perceptibility of the turbines. In order to quantify this effect wind speed and direction were measured over the entire sound level survey period at a number of wind measurement (met) towers distributed over the site area for later correlation to the sound data.

2.2 SITE DESCRIPTION AND MEASUREMENT POSITIONS

The proposed Cohocton Wind Farm consists of a main site area covering roughly 20 square miles located in the hills just to the east of the Towns of Cohocton and N. Cohocton. In addition, to this main area there is also a small outlying section of the project 4 miles south of Cohocton just off of Brown Hill Road where four closely grouped wind turbines are planned.

The main site area can generally be characterized as an elevated, undulating plateau intersected by ravines, or hollows. Much of the land on top of the plateau is agricultural in nature and therefore largely open. Trees mainly occur in intermittent patches of woods or close to houses. In contrast, the lower valleys and hollows are mostly wooded. In order to take best advantage of the wind, the proposed wind turbines are all essentially located on the crests of hills or in high open places.

The distribution of private residences and farms within the project area is somewhat non-uniform in the sense that only a minority of homes are located in the relatively open uplands in a landscape similar to that of the turbines while most are situated in hollows more protected from the wind.

In an effort to evaluate existing background sound levels in both types of environments (i.e. high exposed and lower protected) sound level recording monitors were placed at homes typical of each: two in higher locations and one in a hollow. The three measurement positions are illustrated in **Graphic A** (attached at the end of the report text) and described below.

Main Site North Position – 5754 Kirkwood-Lent Hill Road
High Elevation Location
Rear yard of house on the edge of a large open field. Distant from any large trees.

Figure 2.2.1 *Main Site North Location – Looking N*

Figure 2.2.2 *Main Site North Location – Looking SW*

Main Site South Position – 9826 Wagner Gully Road
Low Elevation Location
Between house and barn on a utility pole in close proximity to several large trees.

Figure 2.2.3 *Main Site South Location – Looking S*

Figure 2.2.4 *Main Site South Location – Looking N*

Brown Hill Position – 3621 Brown Hill Road
High Elevation Location
In side yard of house near several large trees on the edge of a large open field.

Figure 2.2.5 *Brown Hill Location – Looking SW (towards proposed turbines)*

Figure 2.2.6 *Brown Hill Location – Looking NE*

2.3 INSTRUMENTATION AND SURVEY DURATION

Three similar but slightly different types of sound level monitors were used in the survey as listed in the table below.

Table 2.3.1 *Measurement Equipment by Location*

Position	Meter Make and Type	ANSI Type
Main Site N	Rion NL-32	1
Main Site S	Rion NL-22	2
Brown Hill	Rion NL-06	2

Each of these instruments is intended for service as a long-term environmental sound level data logger measuring the A-weighted sound level. The meters were all set to continuously record a number of hourly statistical parameters, such as the average (Leq), minimum, maximum, and residual (L90) sound levels. The survey period began at noon on 11/17/05 and continued 24 hours a day for 12 days, or until 11/29/05 (dictated by external battery life). Beyond that date the Main Site N instrument continued to operate for 4 more days and the Brown Hill monitor ran for another 9 days until 12/8/05.

The microphones were protected from rain and self-induced wind noise by waterproof double windscreens. All the microphones were located 2.5 m above local ground level on booms that positioned them away from the instrument box and away from any nearby reflective surfaces. The instrumentation itself was enclosed in plastic cases and attached to existing poles.

All equipment was field calibrated at the beginning of the survey and again at the end of the survey. The maximum observed calibration drift was -0.3 dB at the North position. The South and Brown Hill meters showed a divergence of 0 and -0.2 dB, respectively.

2.4 SURVEY WEATHER CONDITIONS

The weather conditions during the survey were generally cold and overcast with frequent periods of snow flurries with little or no accumulation. One significant rain event occurred during a period of warmer weather between the hours of 11 a.m. and 7 p.m. on November 29. This same storm also generated the highest wind speeds recorded during the survey, which were elevated for a period of almost 3 days prior to any precipitation. There were also a number other periods when wind speeds equaled or exceeded 8 m/s (18 mph), which is of interest because it is the speed that causes wind turbines of the kind proposed for this project to operate at maximum speed.

The general weather parameters of temperature and barometric pressure for the survey period, as observed in Dansville, NY, are illustrated in the graph below.

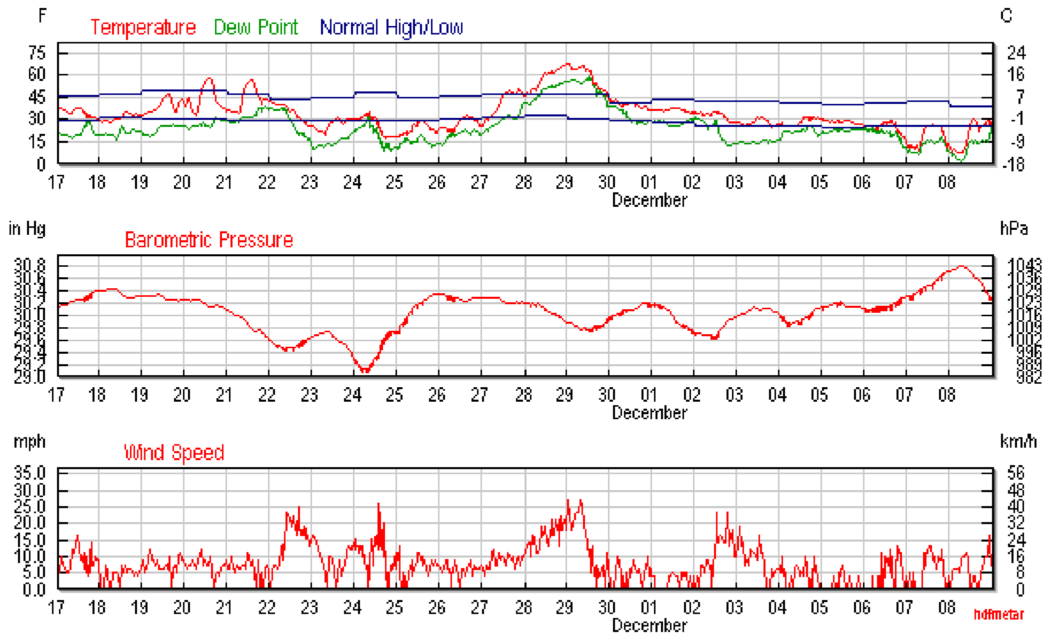

Figure 2.4.1 *General Weather Data for the Survey Period as Observed in Dansville, NY*

The wind speed at the site itself was measured at four met towers distributed over the main site area and one at Brown Hill. Figure 2.4.2 below shows the hourly average wind speeds directly measured by the mast top anemometers at elevations ranging from 48 to 59 m above ground level (agl) normalized to a standard height of 10 m per IEC Standard 61400 (Ref. 1).

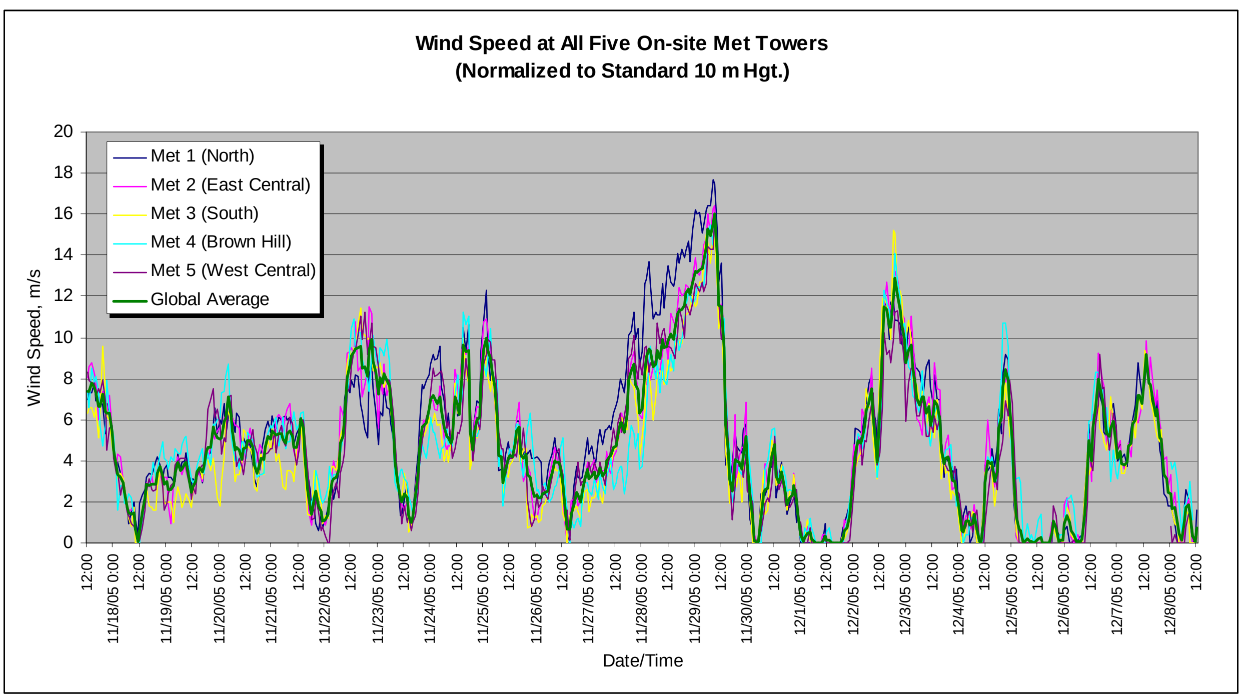

Figure 2.4.2 *Wind Speed Measured at On-Site Met Towers During the Survey Period*

This figure illustrates that on-site wind conditions were generally at or above the turbine maximum operating speed of 8 m/s about one third of the time during the survey. It can also be seen that winds of less than 4 m/s occurred roughly half the time. Below this "cut in" wind speed the turbines do not operate at all, meaning that during this particular 21 day period, the turbines would be off line and making no noise whatsoever about 50% of the time. No credit has been taken in the acoustical assessment for this fact since, when on, the turbines may operate for extended periods of time. Nevertheless, it is a positive factor unique to wind farms that when wind conditions are calm and ambient sound levels are at their lowest level there is no potentially intruding noise - whereas with any other type of power plant the facility would normally be operating during these tranquil times.

2.5 Overall Survey Results

As discussed above in Section 2.1 the L90, or residual, sound level is a conservative measure of background sound levels in the sense that it filters out short-duration, sporadic noise events that cannot be relied upon to provide consistent and continual masking of potential turbine noise. This level represents the quiet lulls between all relatively short duration events, such as cars passing by or tractor activity in a neighboring field. The hourly L90 sound levels for all three measurement positions are plotted below against the average on-site wind speed at 10 m for the entire survey period.

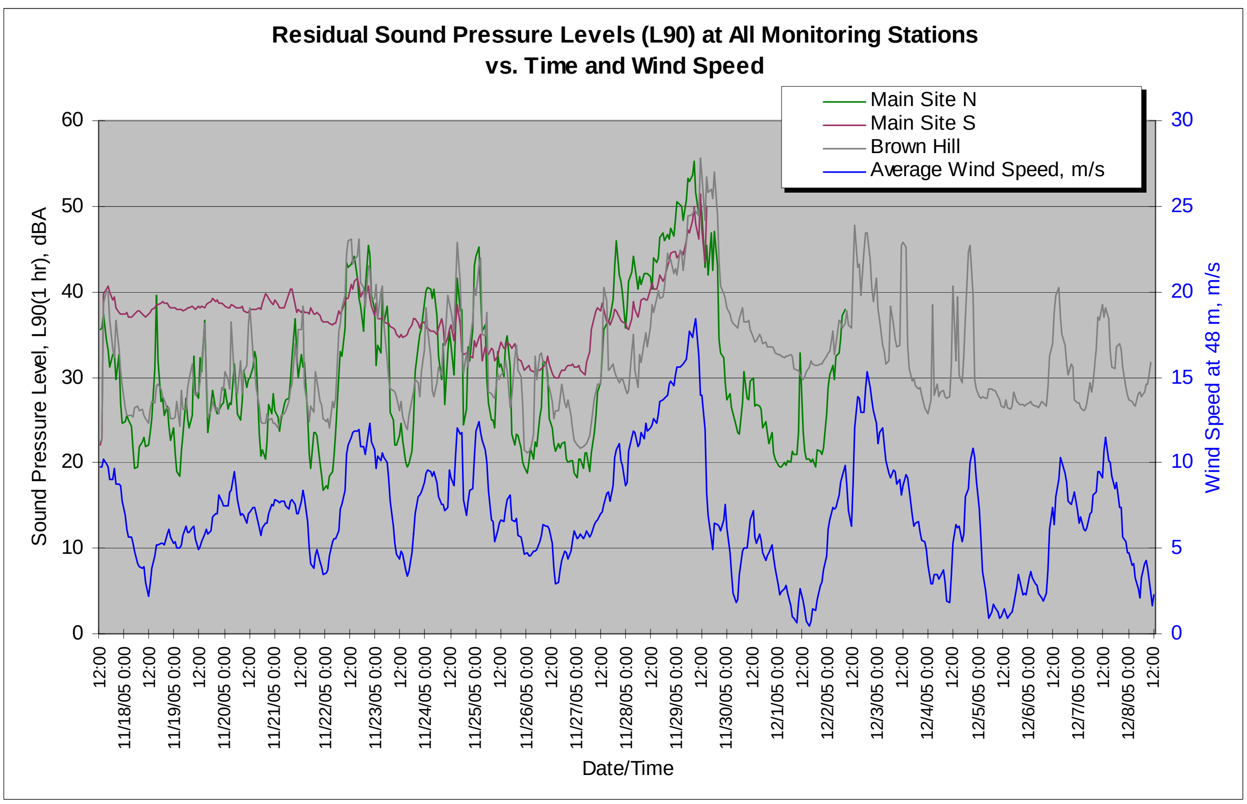

Figure 2.5.1 *Hourly Residual Sound Levels at All Positions vs. Wind Speed (11/17 to 12/8/05)*

What is notable about this plot is that the sound levels at all three locations, each miles apart, are clearly influenced, if not dominated by wind induced environmental sounds. In addition, it can be seen that the two monitoring stations in high, exposed locations – Main Site North and Brown Hill – are nearly equivalent in magnitude at all times and closely follow wind speed whereas the sound level at the Main Site South position, located in a sheltered valley, follows a different trend that is far less dependent on wind speed and where the sound level during calm periods does not appreciably diminish.

The *average* hourly sound levels, Leq(1 hr), are plotted below against wind speed. Looked at from this perspective, the mean levels at all locations generally overlap; however the greater variability in the sound levels at the high elevation locations and the relative consistency in sound level at the sheltered position is still evident.

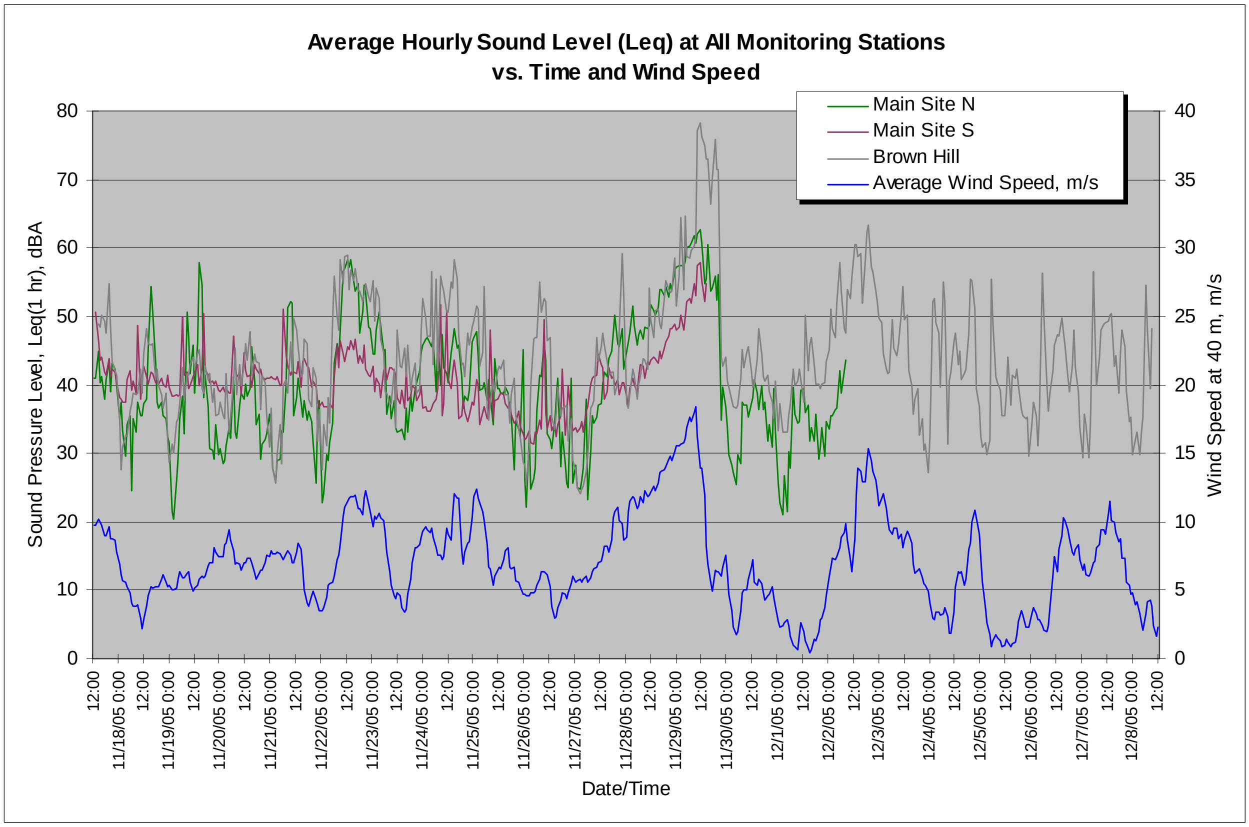

Figure 2.5.2 *Hourly Average Sound Levels at All Positions vs. Wind Speed (11/17 to 12/8/05)*

In the plots below the residual sound level measured at each location is shown with the wind speed measured at the nearest single met tower to the monitoring location.

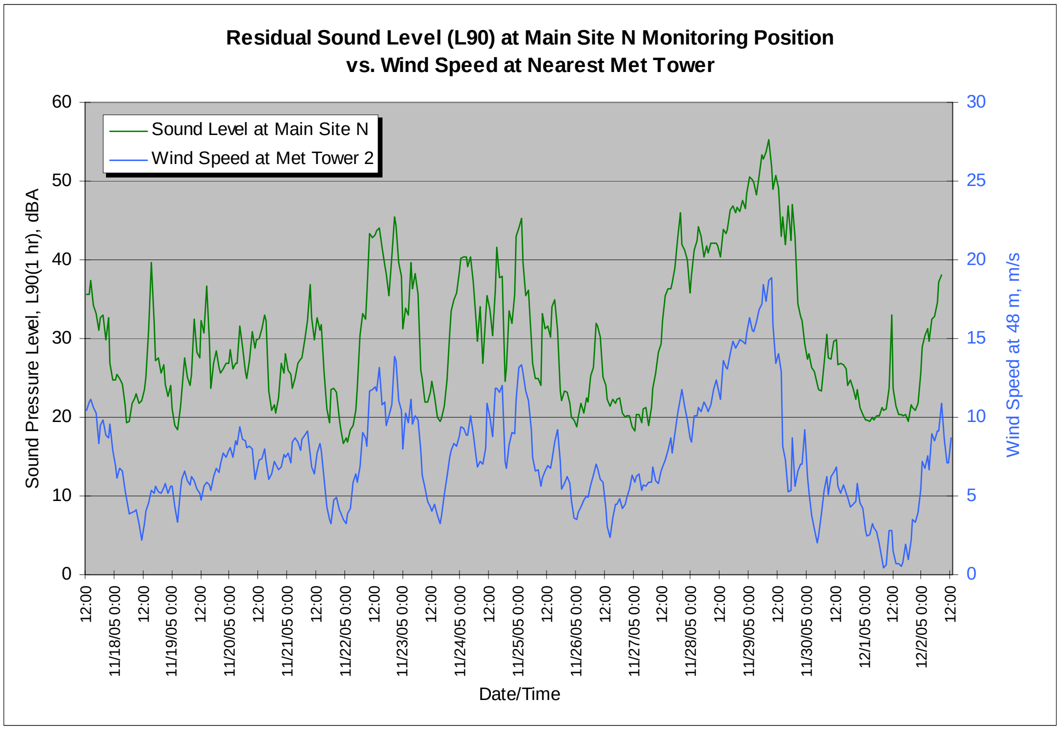

Figure 2.5.3 *Hourly L90 Sound Levels at the Main Site North Position vs. Wind Speed at Met Tower 2*

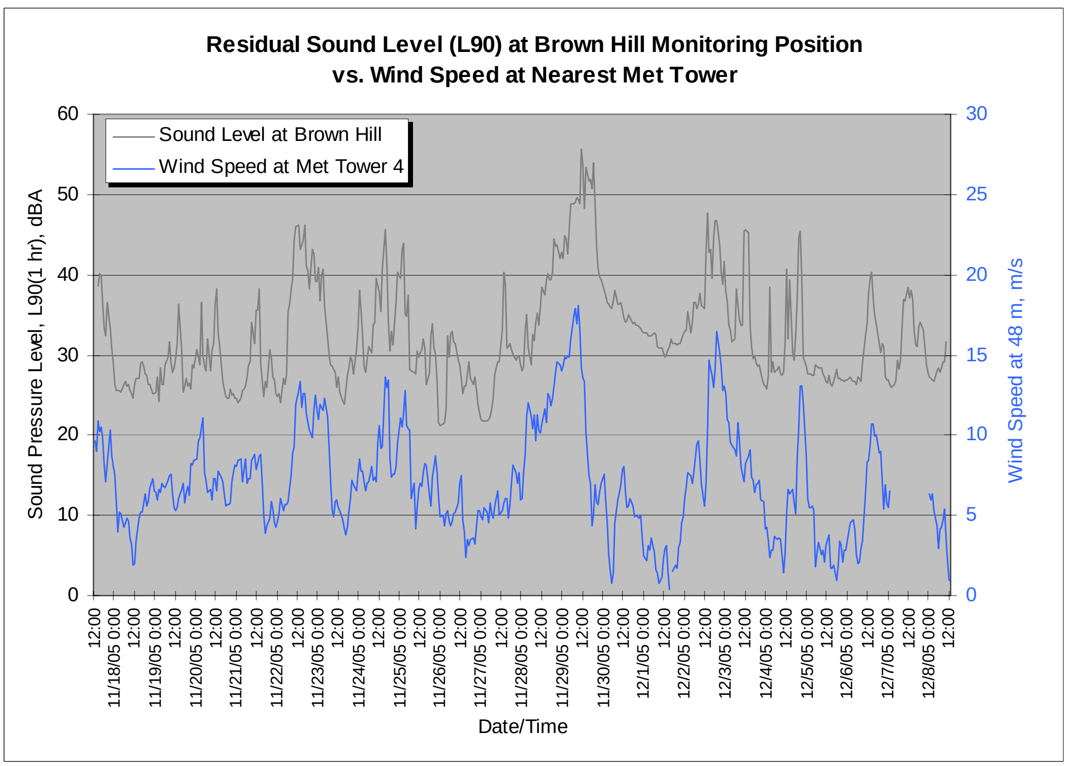

Figure 2.5.4 *Hourly L90 Sound Levels at the Brown Hill Position vs. Wind Speed at Met Tower 4*

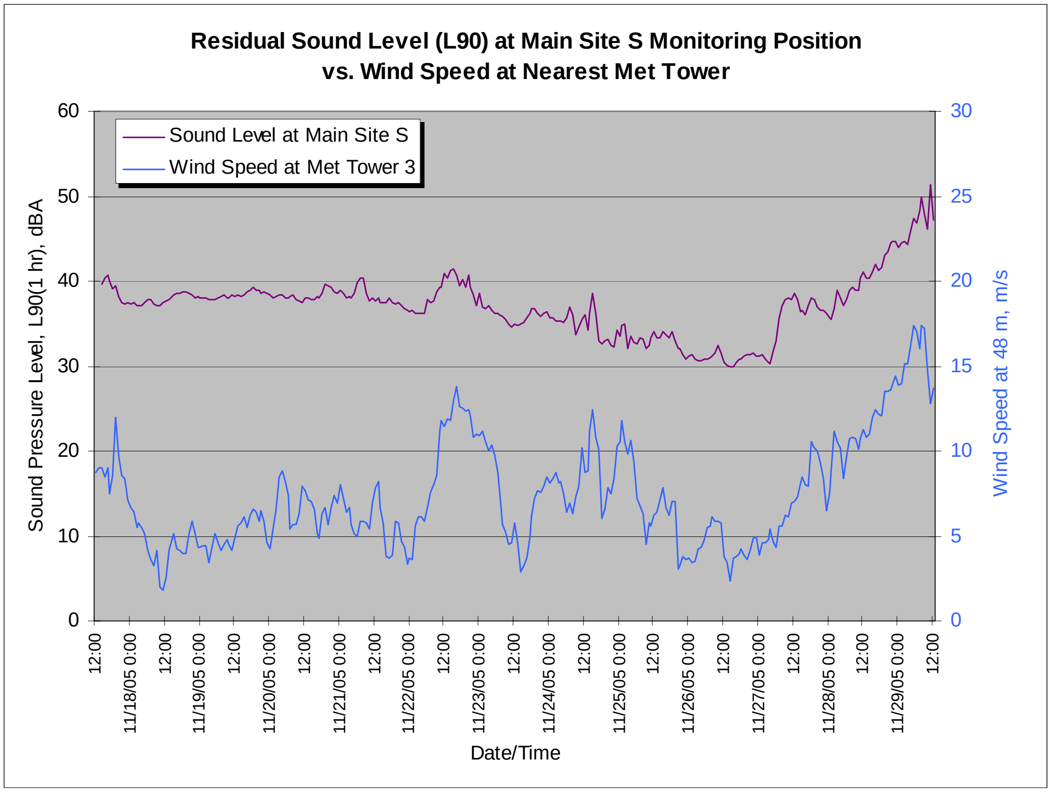

Figure 2.5.5 *Hourly L90 Sound Levels at the Main Site South Position in Wagner Gully vs. Wind Speed at Met Tower 3*

The similarity between Figures 2.5.3 and 3.5.4 and the different behavior of the sound levels in Figure 2.5.5 indicates that all high and exposed areas probably experience similar environmental sound levels that are highly dependent on wind speed and that a steadier background sound level generally exists at homes located in valleys protected from the wind.

2.6 Wind Speed as a Function of Elevation Above Ground Level

Below about 100 m, wind speed varies with elevation above the ground due to friction with the ground surface and obstacles such as trees. Because this roughness varies from place to place measurements of wind turbine sound power levels and concurrent wind speeds carried out in accordance with IEC Standard 61400-11 (Ref. 1) are normalized to and reported at a reference height of 10 m. This enables the nominal noise level of different makes and models of wind turbines to be compared on a uniform basis. The conversion of wind speed at one elevation to the related speed at another elevation is calculated from a formula in the standard (Equation (7), Section 8), which describes a logarithmic profile. For the specific parameters relevant to this project the wind profile resulting from the Eqn.(7) is shown graphically below for an example case where the wind is normalized to a speed of 8 m/s at 10 m.

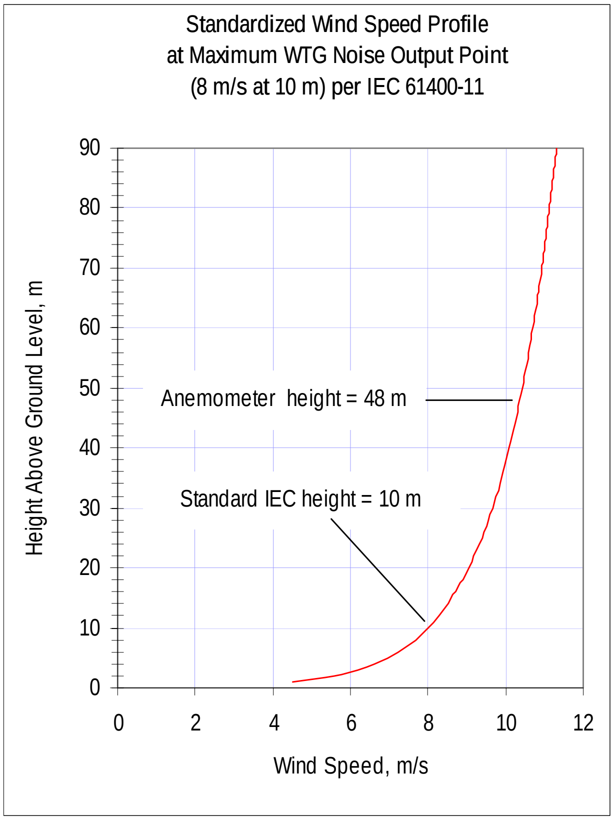

Figure 2.5.1 *Wind Speed Profile above the Surface*

In this example, a standardized wind speed of 8 m/s at the reference height of 10 m would correspond to wind speed of just over 10 m/s at an anemometer height of 48 m. A normalized wind speed of 8 m/s at 10 m is significant in that it is the wind speed associated with maximum turbine noise. At the turbine cut in speed of 4 m/s at 10 m the shape of the profile would remain largely the same only the entire curve would shift 4 units to the left.

The key point to note from this is that a wind speed measured at an anemometer height of 48 m is about 2.2 m/s faster than the nominal wind speed at the reference height of 10 m.

2.7 Sound Levels as a Function of Wind Speed

From the data collected over the survey period it is possible to determine the A-weighted residual sound level that is likely to occur over all wind speeds up to about 16 m/s (as measured at the reference height of 10 m). The wind speed range of interest with respect to wind turbine noise is from the cut in speed of 4 m/s at 10 m, when the turbines just begin to operate up to about 8 m/s at 10 m when the noise level essentially levels off at a constant, maximum value after increasing from zero.

The regression plots below quantify the relationship between wind speed normalized to the reference height of 10 m and hourly residual sound levels at the high elevation measurement locations (Main Site North and Brown Hill) and at the sheltered location (Wagner Gully).

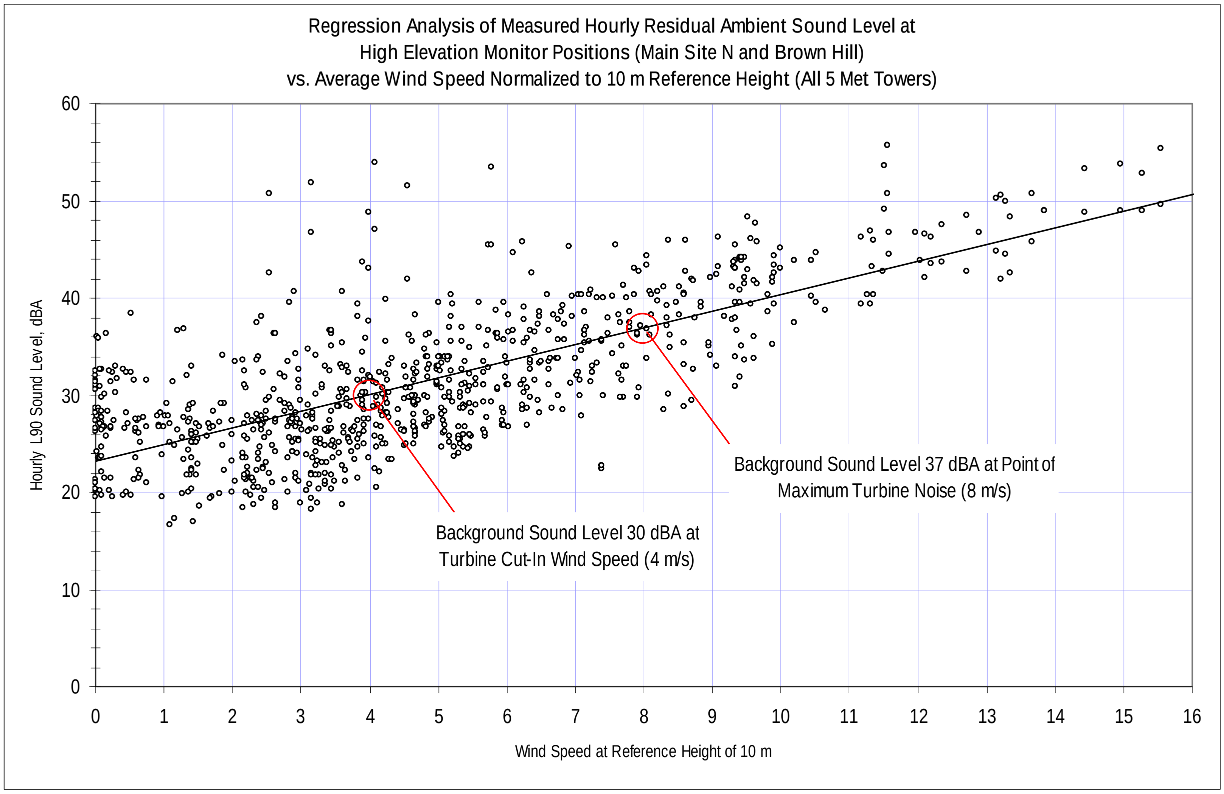

Figure 2.7.1 *Wind Speed – Sound Level Regression: High Elevation Monitoring Locations*

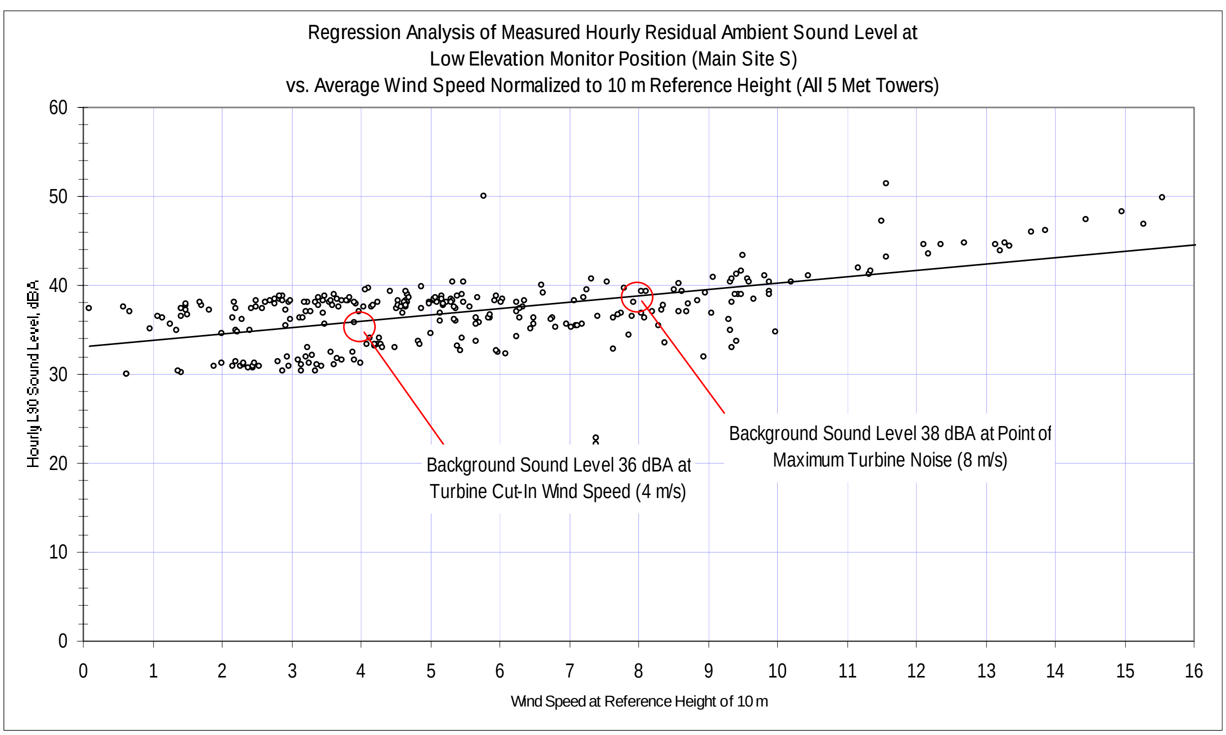

Figure 2.7.2 *Wind Speed – Sound Level Regression: Sheltered Monitoring Location*

Fundamentally, these plots illustrate a clear trend of increasing background sound levels with wind speed. For each of the two environments (exposed and sheltered), a mean value for the residual ambient can be predicted with reasonable accuracy from the trend line shown at any wind speed.

For the high elevation case, the key points on the line noted in red identify a background sound level of 30 dBA that is associated with the cut in speed of the turbines (4 m/s) and 37 dBA when the turbines would reach maximum power and when noise levels would reach their maximum value (8 m/s). Beyond this wind speed background noise, as can be seen in the plot, would continue to increase while turbine noise would remain constant. Consequently, during periods of very high wind turbine noise would be progressively less perceptible above natural background sounds. From the regression the following background sound levels can be expected at the following wind speeds.

Table 2.7.1 *Measured A-Weighted Background Sound Levels at High Elevation Locations as a Function of Normalized Wind Speed*

Integer Wind Speed at Standardized Height of 10 m, m/s	4	5	6	7	**8**	9
Background Sound Level, L90, dBA	30	32	34	35	**37**	39

The second regression in Figure 2.7.2 also shows an increase in sound levels with increasing wind speed at the more sheltered measurement location but the rate of increase is significantly lower than in the previous plot. This is largely due to the fact that the background sound level remained much more constant and was not as strongly influenced by wind speed. In this case, a sound level of 36 dBA might be expected at the turbine cut in speed of 4 m/s and a level of 38 dBA would be associated with an 8 m/s wind. What this generally indicates is that when the turbines, which are all positioned on hilltops above the residences in the sheltered valleys, produce maximum noise at wind speeds of 8 m/s or higher, a masking sound level of at least 38 dBA can be expected at these receptors.

For design purposes the more conservative value of **37 dBA** will be used to quantify the background sound level consistently available to mask project noise at all locations. This is the sound level that can reasonably be expected when the turbines are operating at maximum speed and producing the most noise.

3.0 PROJECT NOISE MODELING AND IMPACT ASSESSMENT

3.1 ASSESSMENT CRITERIA

There are two metrics against which to compare the predicted noise from the project and thereby determine if any adverse environmental impacts might result from it. The first of these measures is a local regulatory noise limit and the second is a set of noise assessment guidelines published by the New York State Department of Environmental Conservation (NYSDEC).

3.1.1 REGULATORY NOISE LIMITS

A local (Town of Cohocton) wind ordinance has been established that limits noise from any wind energy conversion facility to a maximum of 50 dBA “at the boundaries of all abutting parcels that are owned by persons other than the owner of the parcel on which each turbine is located”. Other restrictions include a maximum allowable project sound level of 45 dBA outside any non-participating residence and a numerical limit on tonal noise. Unacceptable pure tones are "defined to exist when a one-third (1/3) octave band noise level exceeds the arithmetic average of the two adjacent one-third (1/3) octave band levels by the following:

Band Range	Exceedance
31.5 – 125 Hz	15 dB
160 – 400 Hz	8 dB
500 – 8000 Hz	5 dB"

There are no other overarching state or federal noise regulations that would apply to the project.

3.1.2 NYSDEC GUIDELINES

In the Program Policy *Assessing and Mitigating Noise Impacts* published by the New York State Department of Environmental Conservation (2001) a methodology is described for evaluating potential community impacts from any new noise source. As opposed to an absolute noise limit at property lines, the NYSDEC method is fundamentally based on the perceptibility of the new source above the existing background sound level at the nearest houses where people actually reside. The likelihood of someone being regularly present at the extreme edge of their property seems much lower than their being in or near the residence. Consequently, the dwelling itself is considered the more relevant location to examine the potential for disturbance from project noise.

It is a well established fact for a new broadband, atonal noise source, such as a wind turbine, that a cumulative increase in the total sound level of about 5 or 6 dBA at a given point of interest is required before the new sound begins to be clearly perceptible or noticeable to most people. Cumulative increases of between 3 and 5 dBA are generally regarded as negligible or hardly audible. Lower sound levels from the new source are completely "buried" in the existing background sound level and are totally inaudible. The specific language relating to these perceptibility thresholds in the NYSDEC program policy (Section V B(7)c) is a follows:

> Increases ranging from 0-3 dB should have no appreciable effect on receptors. Increases from 3-6 dB may have potential for adverse noise impact only in cases where the most sensitive receptors are present. Sound pressure increases of more than 6 dB may require closer analysis of impact potential depending on existing SPL's [sound pressure levels] and the character of surrounding land use and receptors.

What this essentially says is that a cumulative increase in the total ambient sound level of 6 dBA or less is unlikely to constitute an adverse community impact. From a practical standpoint, because decibels add logarithmically, this threshold means that noise from the project could exceed the existing background level by up to 5 dBA (before these is a need for closer analysis). For this project, the measured background level of 37 dBA (during an 8 m/s wind) plus a project-only noise level of **42 dBA** would equal a total cumulative level of 43 dBA – or 6 dBA above the original level.

The program policy outlines an incremental approach towards evaluating cumulative increases and potential impacts. Once the background sound level is established by means of a field survey a **First Level Noise Impact Evaluation** is carried out where noise from the future project is modeled in an extremely simple and conservative manner considering only the reduction in sound level with distance in accordance with the inverse square law. All other natural forms of sound propagation loss, such as from intervening terrain, vegetation, etc., are ignored and the ground surface is assumed to be completely reflective as though it were the surface of a large placid lake. The purpose of this analysis is to simply identify the area, defined by the 6 dBA cumulative increase contour line (42 dBA in this instance), that needs to be looked at in greater detail to see if any sensitive receptors are present.

If any residences or other potentially sensitive receptors are identified as being within the area of potential concern a **Second Level Noise Impact Evaluation** noise modeling study is carried out realistically considering all normal sound propagation loss mechanisms (in addition to pure distance losses). In this case, any receptors outside the 6 dBA cumulative increase contour are considered to have a low probability of disturbance while any receptors inside the contour might be adversely impacted and some form of mitigation should be investigated.

Preliminary noise modeling carried out in the earlier design phase of the project to help optimize the turbine layout with respect to potential community noise impacts indicated that, irrespective of subsequent minor changes to the site plan, there would be homes present within First Level Impact area. Consequently, the modeling discussed below begins with a Second Level Impact analysis.

3.2 TURBINE NOISE LEVELS

The sound power level of the production version of the Clipper C96 wind turbine is not definitively known at this time because this model is not yet in commercial operation. The first commercial units are expected to be operational at the UPC Wind "Steelwinds" project in late 2007. A prototype, with a slightly smaller rotor diameter of 93 m, has been built for testing and design refinement purposes and preliminary sound power level measurements have been taken of this unit. As the only currently available information, the power level spectrum measured during this sound test, which was carried out in May and June of 2006, has been used in the modeling portion of this assessment. Table 3.2.1 shows the octave band sound power level spectrum and the overall A-weighted power level.

Table 3.2.1 *Preliminary Clipper C96 Sound Power Level Spectrum Used for Modeling Purposes*

Octave Band Center Frequency, Hz	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Sound Power Level, dB re 1 pW	**114.5**	**110.2**	**108.8**	**105.8**	**105.0**	**99.3**	**90.7**	**85.1**	**68.3**	**104.7**

Additional sound power level data will be collected by Clipper in the future. Once this information is available an addendum to this report will be prepared.

The sound level in Table 3.2.1 is considered conservative because several noise abatement features or improvements had not yet been implemented at the time of the testing and the final noise level is expected to be lower than that given above. The principal impetus for these additional noise mitigation features was the presence of several slightly prominent 1/3 octave bands in the measured frequency spectrum of the prototype, illustrated in Figure 3.2.1. A smooth, featureless spectrum is generally desired.

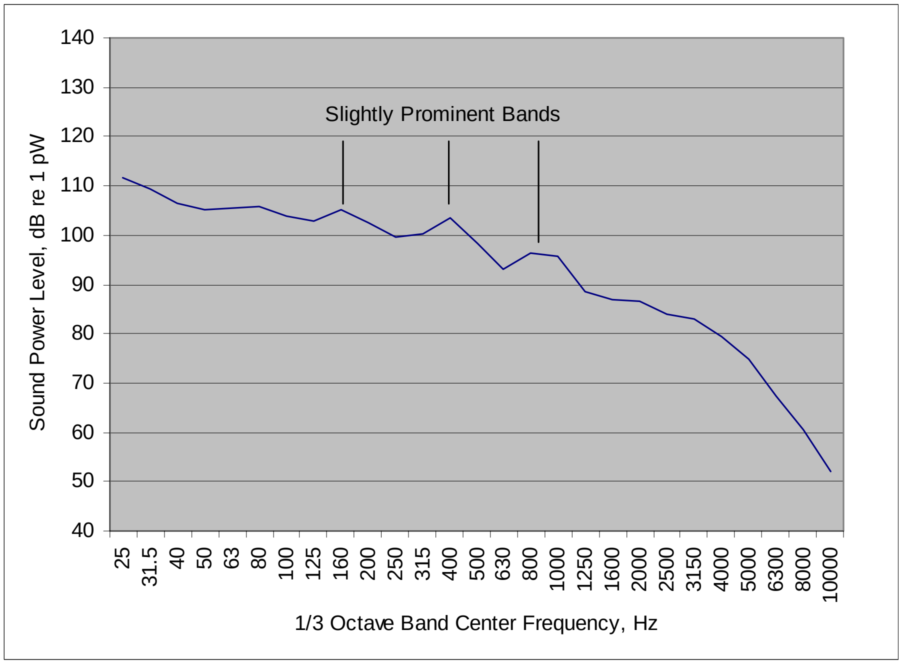

Figure 3.2.1 *Current 1/3 Octave Band Sound Power Level Spectrum for the Clipper C96 Wind Turbine*

Since tones, or any other identifiable characteristics, make noises more readily noticeable and more likely to be disturbing, Clipper is working to severely diminish or eliminate any tonal content from the frequency spectrum of the turbine – even the very minor spikes that appear in preliminary spectrum. **Annex A** is a letter received by the project from Clipper explaining the known origins of the current spikes and the steps they are planning to take to eliminate this characteristic before the unit goes into commercial production.

In general, an overall sound power level of 104.7 dBA is below average for a wind turbine of this size and power output. If the small tonal spikes visible in the 1/3 octave band sound power level spectrum plotted in Figure 3.2.1 are literally smoothed out, as is the intention, the overall A-weighted level should be tangibly reduced because these tones occur in the mid-frequency region of the spectrum that strongly affects the overall level. Figure 3.2.2 on the following page shows that even a moderate suppression of these three small peaks in the spectrum would lead to an overall reduction in sound power level of 2 dBA.

For the purposes of this assessment, however, the existing noise level without further improvement has been assumed.

Because a complete noise measurement survey of the C96 performed in accordance with IEC Standard 61400 has not yet been possible, no information is currently available on the relationship between wind speed and the sound emissions of the turbine. The reported power level above is associated with a wind speed of 8 m/s (measured at 10 m above grade), which is typically the wind speed at which almost all similar turbines produce peak sound levels. Judging from other similar turbines, such as the Gamesa G87, lower wind speeds result in lower turbine sound levels down to the cut in wind speed of approximately 3 or 4 m/s (below which the unit does not operate). At this wind speed turbine sound levels are typically about 5 dBA quieter than at their maximum operating point.

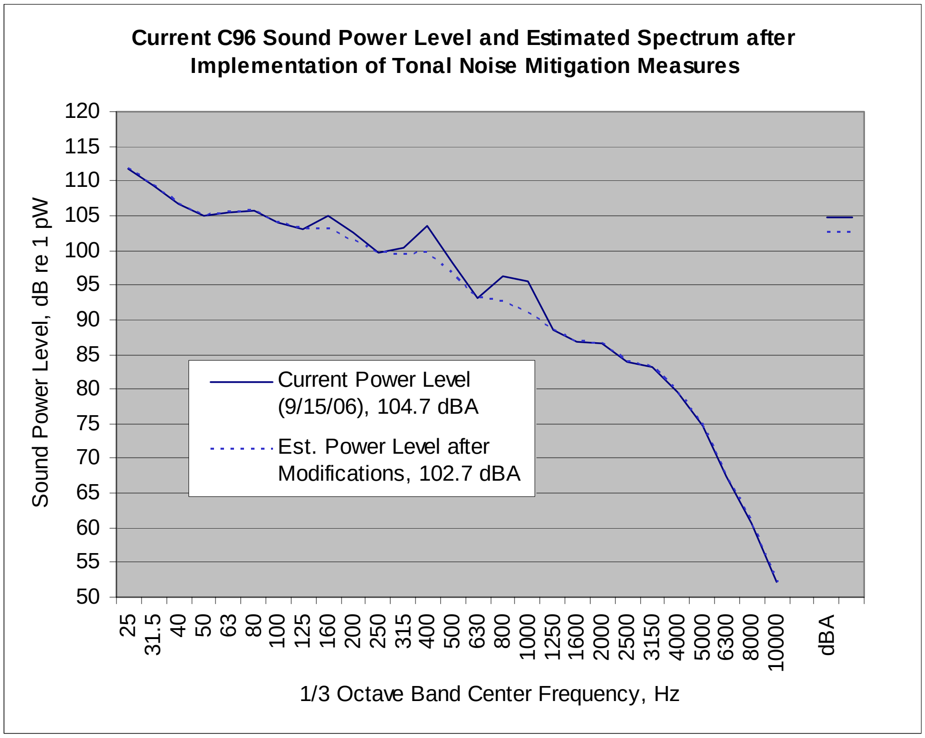

Figure 3.2.2 *Current 1/3 Octave Band Sound Power Level Spectrum for the Clipper C96 Wind Turbine and Estimated Spectrum after Implementation of Planned Noise Mitigation Measures*

3.3 NOISE MODELING METHODOLOGY

Using the sound power level spectrum in Table 3.2.1 above, a worst-case, maximum noise level contour plot for the site was calculated using the "Cadna/A", ver. 3.5 noise modeling program developed by DataKustik, GmbH (Munich). This software enables the project and its surroundings, including terrain features, to be realistically modeled in three-dimensions. The somewhat complex hill and valley topography of this site was digitized into the noise model from USGS maps. Each turbine is represented as a point noise source at a height of 80 m above the local ground surface (design hub height).

The site plan used in the analysis is the product of several preliminary noise mapping studies, which were performed to identify any undesirably high noise impacts on project area residents and relocate to the extent practical the turbines responsible for those sound levels.

A somewhat conservative ground absorption coefficient of 0.5 has been assumed in the model since all of the intervening ground between the turbines and potentially sensitive receptors essentially consists of open farm fields or pasture land with a few wooded areas. Ground absorption ranges from 0 for water or hard concrete surfaces to 1 for absorptive surfaces such as farm fields, dirt or sand. Consequently, a higher ground absorption coefficient on the order of 0.7 to 0.9 would be fully justified here; however, for conservatism the value of 0.5 has been used. In addition, any additional attenuation that might result from wooded areas has been completely neglected in all calculations.

Although wind direction effects can be modeled with this software, to be conservative the noise level from each turbine is assumed to be the downwind sound level in *all directions simultaneously*. In other words, although physically impossible, an omnidirectional 8 m/s wind is assumed. This approach yields a contour plot that essentially shows the maximum possible sound level at any given point and sometimes also shows levels that cannot possibly occur – such as between two or more adjacent turbines, since the wind would have to be blowing in two opposing directions at the same time. In a more realistic scenario with, for example, a wind out of the west the contour lines would occur closer to the turbines on the west side and would remain as shown on the east.

At the risk of significantly overestimating potential project sound levels, the various conservative assumptions in the Second Level modeling analysis have been applied to ensure that the impact of project noise on the community does not exceed predicted levels. Sound levels that are substantially lower than those predicted in the modeling plots are actually expected to occur. The model represents a theoretical worst-case condition that would require a practically impossible convergence of wind direction, wind speed, low ground porosity and favorable atmospheric sound propagation conditions to occur.

3.4 Model Results

Preliminary noise modeling indicated that the potential for community noise impacts exists with this project. This early modeling work essentially performed the function of the First Level Noise Impact Assessment in the NYSDEC assessment procedure and made it immediately clear that a Second Level assessment was necessary. A Second Level noise model considers the actual circumstances of the site including any attenuation that might be afforded by such factors as terrain, vegetation or man made barriers.

The overall results of the Second Level model for the main site area are shown in **Graphic B**. This plot, based on the most recent site plan (from mid-September 2006), represents a conservative view of what can be expected with all turbines operating at their maximum noise point assuming an omnidirectional 8 m/s wind. Non-participating residences are represented by yellow triangles and green boxes indicate the homes of project participants.

The area inside of the 42 dBA sound contour (shown in green) represents the region where noise from the project may be audible above the residual (L90) background level; i.e. where the cumulative sound level is expected to be 6 dBA or more above the pre-existing level. While the majority of homes in the project area lie outside this region there are clearly a number of homes within this potential impact zone. Theoretical exposures range from 42 to 44 dBA in most cases while a few participating residences might experience a project sound level as high as 45 dBA when the wind is blowing directly from a nearby turbine towards the house.

In general, small changes of 1 to 3 dBA in sound level are very hard to subjectively perceive so it is not a foregone conclusion that someone experiencing a project-only sound level of 44 dBA, for example, would react any differently to sounds from the turbines than someone projected to see a level of 42 dBA. The dividing line between an acceptable and adverse impact from wind turbine noise in particular is more indistinct than it is with other types of noise sources, such as a conventional power station, and much of it has to do with an individual's general attitude towards the project and aspects of it that have nothing to do with noise. As a result, it would be incorrect to assume that everyone within the 42 dBA sound contours will find project noise objectionable. Instead, it might be more accurate to say that mild annoyance may be felt in a few instances but strongly adverse reactions are considered improbable since the maximum sound level at any receptor is not expected to exceed 45 dBA. In absolute terms, a sound level of 45 dBA is normally considered "quiet" and is a value that commonly appears in regulatory standards and guidelines worldwide (U.S. EPA, HUD, World Bank, World Health Organization, etc.) as an acceptable nighttime noise level.

The expected, worst-case sound levels from the four units planned for installation on Brown Hill are also shown as an inset in Graphic B. In this instance, the only residences potentially affected by turbine noise are essentially those of the participating landowners. There is one non-participant dwelling right on the 42 dBA contour to the south of the turbines but the farms and residences along Brown Hill Road to the north of the units are expected to see project sound levels that are comparable to or below the normal background level. Consequently, project noise should not be noticeable or significant at these houses.

In general, the perceptibility of project noise in the vicinity of the 42 dBA contour is likely to be intermittent in nature. For the predicted sound levels in the contour plots to have any chance of actually occurring at residences with predicted levels of 42 dBA or more the following conditions would be necessary:

- The wind would need to be blowing from the nearest turbines towards the house
- The wind would need to be blowing a speed of 8 m/s or greater at 10 m above ground level (lower wind speeds would be associated with lower project sound levels)
- The ground surface would need to be semi-reflective (as might happen when it is frozen or partially covered with ice or glazed snow)

The perceptibility of turbine noise under these conditions would also require that a background sound level of 37 dBA or less is occurring at the point of observation and that the observer is standing outside. Higher background levels would obscure project noise and the 15 to 20 dB attenuation afforded by any house would make a project sound level of 42 dBA outside completely inaudible inside.

In summary, the model predictions ostensibly indicate that project noise might be audible at a number of houses but the circumstances required for this to occur would happen only rarely at best. Consequently, no significant or sustained adverse impact is expected at any home in the project vicinity due to project noise.

3.5 COMPLIANCE WITH TOWN OF COHOCTON WIND ORDINANCE

The Town of Cohocton Wind Ordinance limits noise exclusively from the project to 50 dBA at the property line of any parcels of land belonging to non-participants in the project. **Graphic C** shows the 50 dBA sound level contour, calculated under the conservative conditions described above, relative to the land parcels owned by project participants in both the main site and Brown Hill areas. Apart from two corners of non-participating properties near the southernmost turbines on Brown Hill, this graphic illustrates that sound levels of 50 dBA or more will essentially be confined to participating properties. There are no houses or farm structures anywhere near the areas with sound levels in excess of 50 dBA on Brown Hill so it appears unlikely that anyone would be present on these properties on any sort of regular basis to notice or be affected by project noise. It is also important to note that these sound levels would only occur intermittently during windy conditions and there would be no noise whatsoever from the project at these property boundaries during calm or low wind conditions.

Graphic D illustrates where the 50 dBA might fall if the small improvements associated with the planned noise abatement measures illustrated in Figure 3.2.2 are realized. This plot is based on an *estimated* sound power level of 102.7 dBA re 1 pW, or 2 dBA less than the current measurement of the unattenuated prototype.

The second condition of the Ordinance limits project noise to 45 dBA outside any non-participating residences. As illustrated in **Graphic B**, the maximum predicted sound level at any non-participating residence is just under 45 dBA so compliance is anticipated at all residences under all wind conditions.

Finally, the Ordinance limits tonal noise to a set of specific 1/3 octave band exceedances applicable in different regions of the frequency spectrum (see Section 3.1.1). As illustrated above in Figure 3.2.1, at the present time the C96 sound power level spectrum contains several slightly prominent frequency bands – although actions are planned by the manufacturer to significantly reduce or eliminate these before this turbine model is put into commercial production. The table below lists the specific frequencies and values of the existing peaks in the power level spectrum and compares them to the Ordinance limits. It should be noted that the sound power level spectrum represents the frequency spectrum that occurs fairly close to the turbine. Beyond the minimum setback distance of 1500 feet these minor spikes are likely to substantially diminish.

Table 3.5.1 *Existing Slightly Prominent Frequency Bands in Clipper C96 Sound Power Level Spectrum (Prior to Planned Noise Abatement Measures) Relative to Ordinance Tonal Limitations*

Nominal Frequency, Hz	1/3 Octave Band Sound Power Level of Prominence and Two Adjacent Bands, dB re 1 pW	Exceedance above Average of Adjacent Bands, dB	Applicable Cohocton Ordinance Limit for Tones, dB (as Observed at a Prop. Line or Residence)
160	103.0	2.2	8
	105.0		
	102.6		
400	100.3	4.3	8
	103.6		
	98.3		
800	93.2	1.4	5
	96.3		
	95.6		

As can be seen from this table, the current peaks in the power level spectrum are already well below the allowable limits for tones.. With, or even without, the planned mitigation in place it is anticipated that the project will fully comply with the tonal restrictions contained in the Cohocton Wind Ordinance.

3.6 Seasonal Influences on Potential Noise Impacts

Experience in conducting ambient sound level surveys at all times of year indicates that, as might be intuitively obvious, background levels are lowest in winter when the leaves are off the trees. The sound of the wind rustling through leaves or over fields of crops or grass is most prominent in the mid to high frequencies, which is the region of the audible frequency spectrum that the human ear is most sensitive to. Since the purpose of "A-weighting" is to make a measured sound level agree with normal subjective perception, a summertime A-weighted background sound level, rich in mid to high frequency sound, is usually noticeably louder than the typical wintertime background level – such as that measured during this survey in late November.

The relevance of this to potential noise impacts from a wind farm is that relatively high levels of wind-induced background masking noise are normally available in summer whereas lower levels exist in winter. Consequently, the perceptibility of turbine noise, which itself is unaffected by the seasons, is lower in summer and higher in winter for an outdoor observer. However, because people are generally indoors with the windows closed in the wintertime the greater perceptibility of turbine noise in winter does not automatically mean that the likelihood of disturbance or annoyance will also increase. Inside a typical house at a typical setback distance of hundreds of feet turbine noise is essentially inaudible so, in general, the potential for any significant noise impact from turbine operation is largely confined to the warmer months of the year when outdoor activities occur and windows might be open. Coincidentally, this is the time when background levels during windy conditions are relatively high making it more difficult to hear any turbine noise.

3.7 Low Frequency Noise

Modern wind turbines of the type proposed for this project do not generate low frequency or infrasonic noise to any significant extent and no impact of any kind is expected from this. Early wind turbines with the blades downwind of the support tower were prone to producing a periodic noise each time a blade passed the tower wake but this effect no longer exists with the upwind blade arrangement used today. Concerns about excessive low frequency noise from proposed wind farms are commonly voiced but they have apparently grown out of misinformation or anecdote without any basis in fact. An interesting paper on this subject - “How the ‘mythology’ of infrasound and low frequency noise related to wind turbines might have developed” - by Geoff Leventhall, a highly respected acoustician in the field of low frequency noise, is attached as **Annex B**.

From a quantitative perspective, low frequency noise - best quantified in terms of C-weighted sound levels – can produce perceptible vibrations in frame structures or rattle windows if the magnitude is high enough. One of the few sources of noise that is capable of generating sufficient low frequency energy is a simple cycle gas turbine. In ANSI Standard B133.8 *Gas Turbine Installation Sound Emissions* (Ref. 5) a threshold level of 75 to 80 dBC is given as the approximate on-set point for vibrations. Our own field experience with numerous low frequency combustion turbine noise problems indicates that a lower threshold value of 70 dBC is a somewhat better indicator of the absolute minimum level that might lead to perceptible vibrations.

The maximum predicted C-weighted sound level for downwind conditions at the receptor with the maximum predicted A-weighted sound level, noted as Receptor A in Graphic B, is 63 dBC – well below the threshold where any vibrations would start. Consequently, no adverse impact is expected at any receptors from low frequency noise.

3.8 Assessment of Potential Noise Impacts During Low Winds

The modeling assessment above focuses on the maximum noise level associated with this turbine model and its potential impact on nearby residences when normal environmental sound levels are elevated by the same 8 m/s wind necessary to drive the turbines at their full capacity. As wind speed decreases the background sound level also decreases diminishing the amount of masking noise available to obscure project noise. If the noise level produced by the turbines does not also fall in parallel with the background level a situation could develop where the prominence of turbine noise above the background level increases relative to the maximum noise case evaluated in the modeling study.

Unfortunately, it has not yet been possible to measure the sound power level of the Clipper C96 turbine as a function of wind speed so the rate of decrease in turbine noise level with diminishing wind speeds is not known. Consequently, it is not possible at this time to quantitatively evaluate possible project impacts under low wind conditions. Once the sound power level of the improved machine is known an addendum to this report will be produced.

In general, however, it is commonly the case with similar turbines that sound levels increase by about 5 dBA from a point just after they begin to operate (in a wind of about 3 to 5 m/s measured at 10 m) to their maximum noise point at a wind speed of about 8 m/s. As illustrated in Figures 2.7.1 and 2.7.2 and tabulated below, the background sound level does decrease with wind speed below 8 m/s. At high and exposed locations the drop is on the order of 7 dBA and in more sheltered locations there is a much smaller decline of about 2 dBA (between 8 and 4 m/s).

Table 3.8.1 *Measured A-Weighted Background Sound Level as a Function of Wind Speed*

Integer Wind Speed at Standardized Hgt. of 10 m, m/s	**4**	5	6	7	**8**	9
Background Sound Level, L90, dBA – *High Locations*	**30**	**32**	**34**	**35**	**37**	**39**
Background Sound Level, L90, dBA – *Sheltered Locations*	**36**	**36**	**37**	**37**	**38**	**39**

For high locations, this indicates that turbine noise levels and the amount of background noise available to mask them may remain *generally* proportional at wind speeds below the 8 m/s maximum but there is a possibility that turbine noise might be somewhat more prominent (relative to the model case) at very low wind speeds just after the blades begin to turn.

In the more sheltered locations background masking noise diminishes only slightly in low wind conditions – from 38 dBA down to 36 dBA at turbine cut in – meaning that turbine noise would be much less perceptible in these areas during low wind conditions than it is on the hilltops.

3.9 CONSTRUCTION NOISE

Noise from construction activities associated with the project is likely to temporarily constitute a moderate unavoidable impact at some but certainly not all homes in the project area. Assessing and quantifying these impacts is difficult because construction activities will constantly be moving from place to place around the site leading to highly variable impacts with time at any given point. In general, the maximum potential impact at any single residence might be analogous to a few days to a week of repair or repaving work occurring on a nearby road. More commonly, the sounds from project construction are likely to be faintly perceived as the far off noise of diesel-powered earthmoving equipment characterized by such things as irregular engine revs, back up alarms, gravel dumping and the clanking of metal tracks.

Construction of the project is anticipated to consist of several principal activities:

- Access road construction and electrical tie-in line trenching
- Site preparation and foundation installation at each turbine site
- Material and subassembly delivery
- Erection

The individual pieces of equipment likely to be used for each of these phases and their typical noise levels as reported in the *Power Plant Construction Noise Guide* (Empire State Electric Energy Research Corp., 1977 [Ref. 6]) are tabulated below. Also shown are the maximum total sound levels that might temporarily occur at the closest residences (at least 1500 ft. away) and the distance from a specific construction site at which its sound would drop to 40 dBA. A level of 40 dBA is generally considered so quiet (about the sound level in a library) that it is not objectionable even when the background sound level is negligible. Background masking for construction phase noise has no dependence on wind speed so there will be times when construction is occurring during calm and quiet periods.

Table 3.9.1 *Construction Equipment Sound Levels by Phase*

Equipment Description	Typ. Sound Level at 50 ft., dBA (Ref. 6)	Est. Maximum Total Level at 50 ft. per Phase, dBA*	Max. Sound Level at a Distance of 1500 ft., dBA	Distance Until Sound Level Decreases to 40 dBA, ft.
Road Construction and Electrical Line Trenching				
Dozer, 250-700 hp	88	92	58	5500
Front End Loader, 300-750 hp	88			
Grader, 13-16 ft. blade	85			
Excavator	86			
Foundation Work, Concrete Pouring				
Piling Auger	88	88	54	4200
Concrete Pump, 150 cu yd/hr	84			
Material and Subassembly Delivery				
Off Hwy Hauler, 115 ton	90	90	56	4800
Flatbed Truck	87			
Erection				
Mobile Crane, 75 ton	85	85	51	3400

* Not all vehicles are likely to be in simultaneous operation. Maximum level represents the highest level realistically possible at any given time.

What the values in this table generally indicate is that, depending on the particular activity, sounds from construction equipment are likely to be significant at distances of less than 5500 to 3400 feet – which encompasses most of the homes in the immediate project area. At the very worst, however, sound levels ranging from 51 to 58 dBA might temporarily occur over several working days or more. Such levels would not be generally considered acceptable on a permanent basis or outside of normal daytime working hours (when all project construction is planned), but as a temporary, daytime occurrence construction noise of this magnitude may go unnoticed by many in the project area. For others, project construction noise may be an unavoidable temporary impact.

Noise from the very small amount of daily vehicular traffic to and from the current site of construction should be negligible in magnitude relative to normal traffic levels (even given the rural nature of the roads in the project area) and temporary in duration at any given location.

3.10 CUMULATIVE NOISE FROM THE ADJACENT DUTCH HILL WIND POWER PROJECT

A similar but somewhat smaller wind energy project, the Dutch Hill Wind Power Project, is currently planned across a valley to the west of the main project area on Dutch Hill. Since the nearest turbines in this other project are roughly 3000 m away, the noise from the two projects will not be additive; i.e. there will not be any cumulative increase in noise at any receptor location within the Cohocton project area due to the other project.

Quantitatively, the sound level from the Dutch Hill project at 3000 m will be on the order of 25 dBA or less when the turbines are operating at their maximum noise point (at a wind speed of 8 m/s). Such a sound level is well below the natural background level of 37 dBA that was found to exist at this wind speed - meaning that noise from the other project would be completely inconsequential and inaudible everywhere within the Cohocton site area even without the Cohocton turbines in operation.

4.0 CONCLUSIONS

A field survey of existing sound levels at the Cohocton Wind Farm site indicates that background sound levels are variable and strongly dependent on wind speed in the high and exposed parts of the site where the turbines are being sited. In the more sheltered valleys and hollows that crisscross the site, and where most residents live, there is less of a dependency between environmental sound levels and wind speed and the general sound level remains much more constant over time.

A regression analysis of hourly residual (L90) sound levels vs. wind speed shows that the background sound level likely to exist in the higher locations during a wind that generates maximum turbine noise (8 m/s) is 37 dBA. In the valleys a slightly higher level of 38 dBA was measured during this same wind. For design purposes a background level of 37 dBA was assumed for the entire site – including both the main site area and the remote Brown Hill area.

In the New York State Department of Environmental Conservation's Program Policy *Assessing and Mitigating Noise Impacts* a cumulative increase in total sound level up to 6 dBA is characterized as having "potential for adverse noise impact only in cases where the most sensitive of receptors are present" and is suggested as a threshold for determining what areas might be adversely impacted by a new noise source and what areas should see "no appreciable effect". For this site a 6 dBA cumulative increase is associated with a project-only sound level of 42 dBA.

A "Second Level" modeling study carried out per the NYSDEC guideline showed that, while most residences were beyond the 42 dBA contour and unlikely to be able to hear project noise under most normal circumstances, there were a number of homes that may experience levels in the 42 to 44 dBA range and few that might see levels as high as 45 dBA. In theory these levels mean that project noise may be clearly audible above the typical minimum background sound level but it should be pointed out that the modeling is conservative in several important respects:

- The background design sound level of 37 dBA is the residual, L90 level, which represents the quietest lulls between wind gusts, cars passing by, dogs barking, etc. As such, this level quantifies the a very low value for masking environmental noise. Most of the time (90% of the time) a somewhat higher background sound level will exist during an 8 m/s wind condition.

- The noise model assumes that an 8 m/s wind is blowing simultaneously from all directions and that the turbine sound level experienced at any given point is the sound level that would occur downwind from all nearby turbines. Such a sound level is a physical impossibility in many situations. For example, a receptor between two turbines cannot possibly be downwind from both units at the same time.

- The sound power level used for the Clipper C96 wind turbine is the preliminary value measured on a prototype that has not yet been fitted with a number of noise mitigation measures. The actual sound level of the production model is expected to be less than the value used in the noise modeling.

Given these conservative assumptions and the fact that sound levels in the 42 to 45 dBA range are not particularly loud in absolute terms, a significant adverse reaction to project noise is not expected. The maximum sound level of 45 dBA, projected for several (participating) residences, is a level that would normally be considered an acceptable design limit; i.e. numerous regulatory standards and guidelines commonly use a nighttime noise limit of 45 dBA for new projects.

Analysis indicates that all provisions of newly adopted town ordinance will be met by the project. In particular, noise levels at or below 50 dBA are anticipated at the boundaries of all non-participating properties within the main site area and only two small corners of non-participating land are potentially affected in the Brown Hill section of the project. Sound levels due exclusively to the project are not expected to exceed 45 dBA at any residences and, finally, the frequency content of the C96 turbine will not exceed the tonal noise limits defined in the Ordinance.

Although concerns are sometimes raised with respect to low frequency noise emissions from wind turbines, no adverse impact of any kind related to low frequency noise is expected from this project. The maximum C-weighted sound level at any receptor is at least 7 dBC below the minimum threshold of perception.

Unavoidable but mild noise impacts may occur during the construction phase of the project. Construction noise, sounding similar to that of distant farming equipment, is expected to be sporadically audible at most homes within the immediate project vicinity on a temporary basis. The maximum magnitude of construction noise at the nearest homes to individual turbine locations is not expected to exceed 51 to 58 dBA depending on the particular activity.

REFERENCES

1. International Electromechanical Commission (IEC) 61400-11:2002(E) *Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques*, Second Edition 2002-12.

2. Not used.

3. U. S. Environmental Protection Agency, Report NTID300.3 *Community Noise*, Washington, DC, 1971.

4. Not used.

5. American National Standards Institute (ANSI) B133.8-1977 *Gas Turbine Installation Sound Emissions*, Appendix B, 1989.

6. Empire State Electric Energy Research Corporation, *Power Plant Construction Noise Guide*, Bolt Beranek and Newman Report 3321, May 1977.