Hessler Associates, Inc.
*Consultants in Engineering Acoustics*

3862 Clifton Manor Place
Suite B
Haymarket, Virginia 20169 USA
Phone: 703-753-1602
Fax: 703-753-1522
Website: www.hesslernoise.com

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# ENVIRONMENTAL SOUND SURVEY AND NOISE IMPACT ASSESSMENT

## DUTCH HILL WIND POWER PROJECT

COHOCTON, NY

PREPARED FOR:

**UPC Wind Management, LLC**

Prepared by:

COMMONWEALTH OF VIRGINIA
DAVID MARK HESSLER
No. 034626
PROFESSIONAL ENGINEER

David M. Hessler, P.E., INCE
Principal Consultant
Hessler Associates, Inc.

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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 Dutch Hill Wind Power Project, which is located in the Town of Cohocton, NY. The project area is several miles north of the town center on an elevated ridge known locally as Dutch Hill.

Current plans call for the erection of 16 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. A prototype of this turbine 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.

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 tend to 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 noise source, such as a large-scale, modern wind turbine, 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 15 day survey period. 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 3 or 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 during the sound measurement survey at a met tower near the north end of the Dutch Hill project area for later correlation to the sound data.

## 2.2 SITE DESCRIPTION AND MEASUREMENT POSITIONS

Dutch Hill is essentially a discrete hill or ridge, running north to south that rises anywhere from 300 to 600 ft. above the surrounding valleys. The northern and eastern flanks of the ridge are fairly precipitous whereas the western side has a more gradual slope incised with several ravines. Turbines are proposed along the crest of the ridgeline. The flanks of the hill are almost completely wooded while the summit is fairly flat and plateau-like in most places and consists largely of open agricultural land and pastures interspersed with wooded areas.

In general, the site area, particularly on top of the ridge, is sparsely populated. There is a cluster of about a half dozen homes and farms on the high ground at the northern end of the ridge but all other residences that might potentially be impacted by project noise mostly lie at around the base of the ridge or in the lower parts of the ravines on the western flank. The small community of Atlanta is situated in a valley at the base of the northern end of the ridge roughly 1600 ft. from the nearest turbines horizontally but some 600 ft. vertically below the base elevation of the units.

As illustrated in Figure 2.2.1 below, three monitoring positions, designated as North, Central and South, were selected to measure background sound levels at key locations representative of the nearest potentially sensitive receptors.

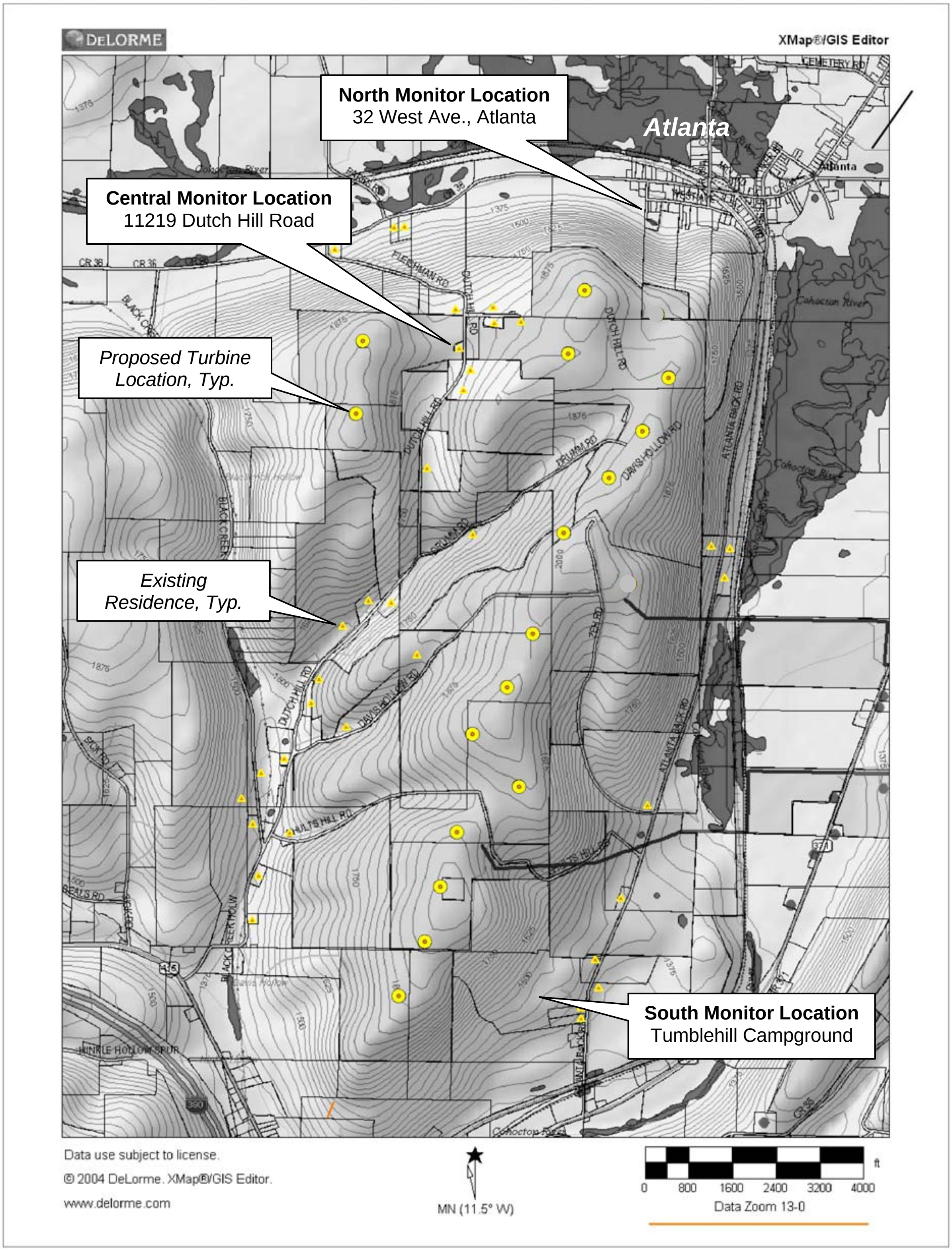


**Figure 2.2.1** *Site Vicinity Map Showing Background Sound Level Measurement Positions*

The North position, shown in Figure 2.2.2, was in the rear yard of the closest residence to the project in the village of Atlanta at 32 West Avenue.

**Figure 2.2.2** *North Monitoring Position Looking SE*

The Central monitoring location was on the summit of Dutch Hill in an open area adjacent to the group of homes in the northern part of the site area. More specifically, the monitor was located on a fence behind the home of a project participant at 11219 Dutch Hill Road (see Fig. 2.2.3).

**Figure 2.2.3** *Central Monitoring Position Looking SE*

The South position was located near the base of the hill on the Tumblehill Campground property with the owner's permission. Apart from the campground, which is obviously an outdoor recreational use area, there are also a number of homes in this general vicinity and a small park on east side of the Altanta Back Road. As illustrated in Figure 2.2.4, the monitor was located on a utility pole in an area of the campground removed from any actual campsites or activity areas to avoid picking up a significant amount of man-made noise. The objective was to measure the minimum natural background level. The homes in the background of the photograph are seasonal and were not occupied during the survey period.

**Figure 2.2.4** *South Monitoring Position Looking S*

## 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 |
|---|---|---|
| North | Rion NL-32 | 1 |
| Central | Rion NL-06 | 2 |
| South | Rion NL-22 | 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 6 p.m. on 4/11/06 and continued 24 hours a day for 15 days, or until 4/26/06.

The microphones were protected from rain and self-induced wind noise by waterproof double windscreens. All the microphones were located 1 to 2 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 weatherproof plastic cases.

All equipment was field calibrated with a Bruel & Kjaer Type 4230 calibrator at the beginning of the survey and again at the end of the survey. The maximum observed calibration drift was +0.1 dB at the South position. The other two monitors showed no change in calibration over the survey period.

## 2.4 SURVEY WEATHER CONDITIONS

The weather conditions during the survey were generally clear and mild with high temperatures ranging from 55 to 73 deg. F. There were several period of light rain (on 4/12, 4/14 and 4/22) but no heavy downpours. One brief thunderstorm passed over the area around 9 p.m. on 4/12.

Most of the time winds were light but two periods of relatively high winds occurred on 4/15 and 4/21 through 4/22. It is important to note that the trees were just beginning to bud but were still essentially bare throughout the survey.

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

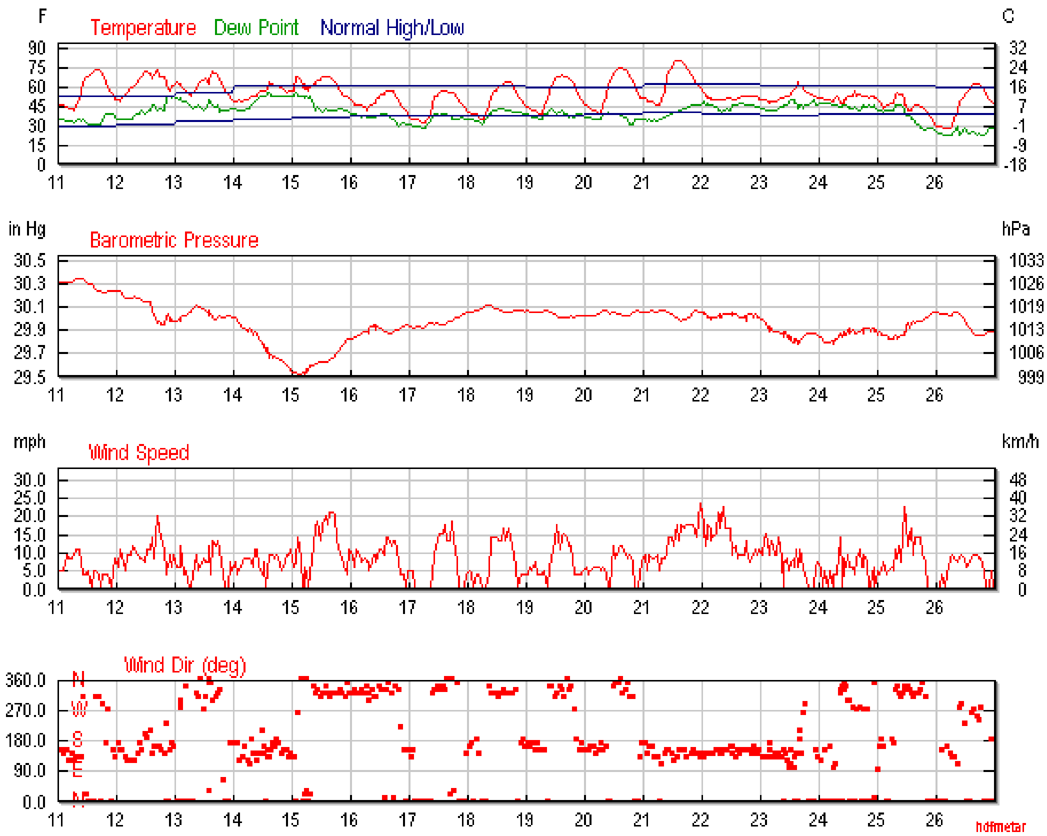


**Figure 2.4.1** *General Weather Data for the Survey Period as Observed in Dansville, NY*

The wind speed at the site itself was measured at met tower 4727 “Cohocton 6” in the northern part of the site on top of the hill (located at N 42deg 32.699’, W 77deg 29.28’). Figure 2.4.2 below shows the hourly average wind speeds directly measured by the mast top anemometer at an elevation of 48.5 m above local ground level and the normalized wind speed a standard height of 10 m above ground level calculated per IEC Standard 61400 (Ref. 1).

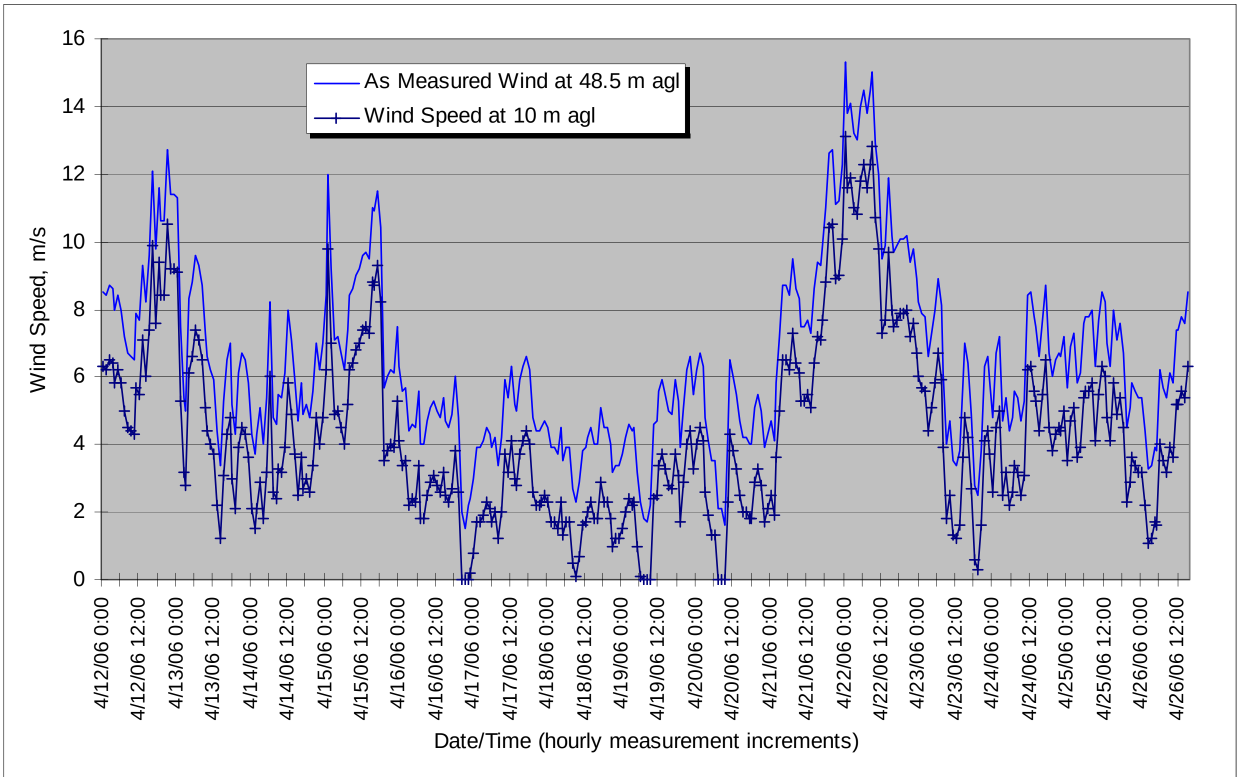


**Figure 2.4.2** *Wind Speed Measured at On-Site Met Tower during the Survey Period*

This figure illustrates that on-site wind conditions were generally at or above the turbine maximum operating speed of 8 m/s only a small percentage of the time during the survey. It can also be seen that winds of less than 4 m/s occurred a little more than half the time. Below this “cut in” wind speed the turbines do not operate at all, meaning that during this particular 15 day period, the turbines would be off line and making no noise whatsoever about 50% or more 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.

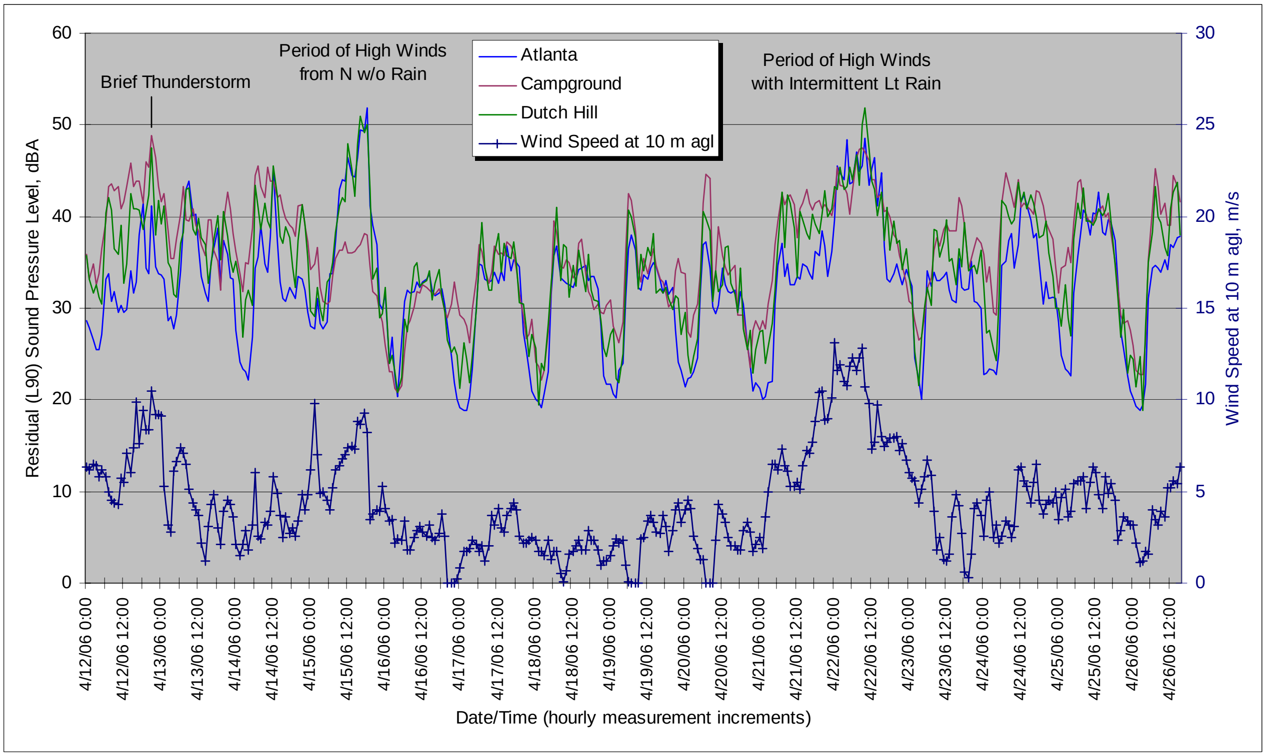


**Figure 2.5.1** *Hourly Residual Sound Levels at All Positions vs. Wind Speed (11/17 to 12/8/05)*

What is notable about this plot is that the sound levels at all three locations, some miles apart, closely follow the same temporal trends and are clearly influenced by wind induced environmental sounds. During calm periods, such as from 4/16 to 4/21, the sound levels at all positions follow a pattern of relatively high levels during the day and much quieter levels around 1 to 3 a.m. During windy periods this daily pattern is disrupted and sound levels increase at all locations as a function of wind speed and irrespective of time of day.

Under either condition, calm or windy, the magnitude of the sound levels is remarkably close at all locations demonstrating that a uniform background level, usually described as a "macro-ambient", exists over the entire project area. This implies that the sound level at any location within the immediate project area would be similar at any given moment to that observed at the three monitoring locations. Thus the monitor levels reasonably represent the level at any given receptor location in the project area.

## 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.

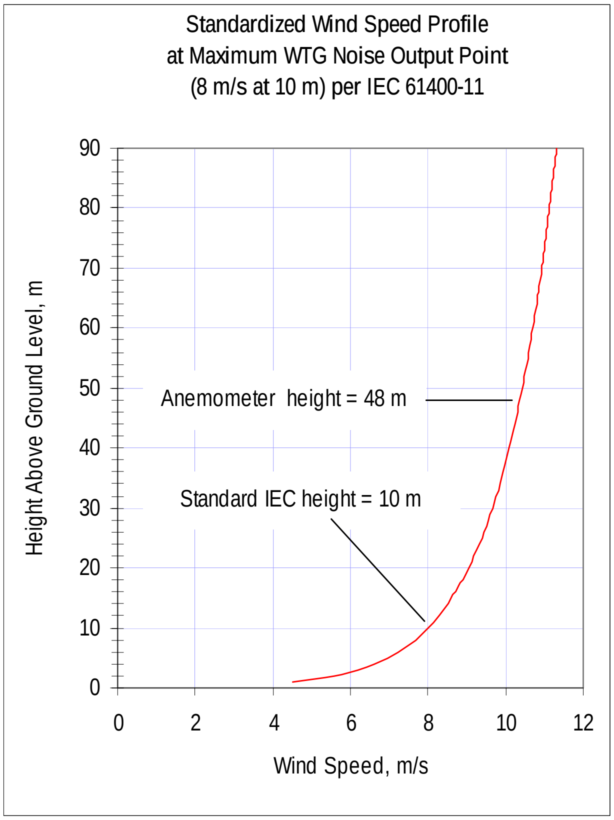


**Figure 2.5.1** *Wind Speed Profile above the Surface*

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 13 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 plot below quantifies the relationship between wind speed normalized to the reference height of 10 m and hourly residual sound levels at all measurement locations.

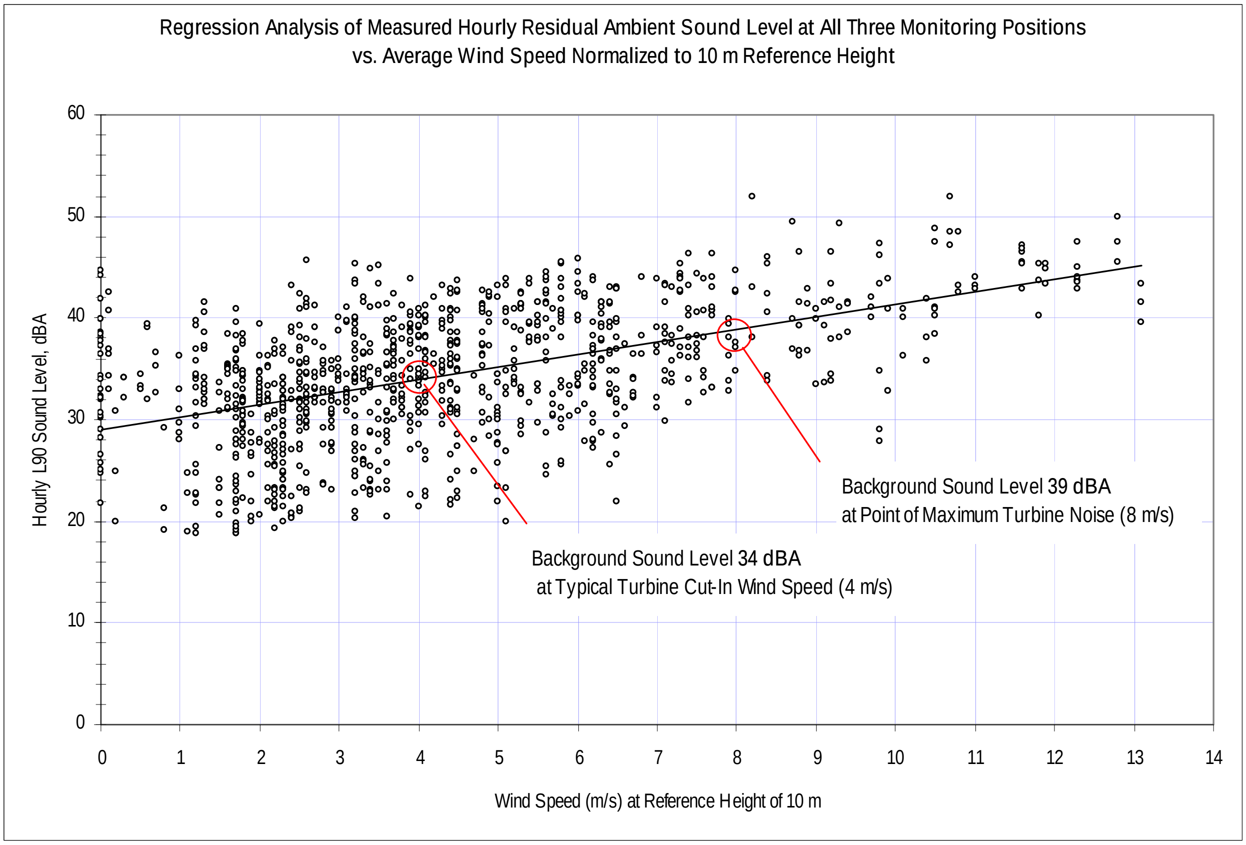


**Figure 2.7.1** *Wind Speed – Sound Level Regression*

Fundamentally, this plot illustrates a clear trend of increasing background sound levels with wind speed. A mean value for the residual ambient can be predicted with reasonable accuracy from the trend line shown at any wind speed. In this case, the value of primary importance is the background sound level during a wind speed of 8 m/s, which is associated with the maximum turbine noise level. From the plot above it can be seen that a level of 39 dBA would be expected under these conditions. A lower level of 34 dBA would occur at a typical cut in speed of 4 m/s.

For design purposes a value of **39 dBA** will be used to quantify the background sound level consistently available to mask project noise at all locations when the turbines are operating at their maximum noise point in an 8 m/s wind.

## 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) noise 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 closer analysis would be required. For this project, the measured background level of 39 dBA (during an 8 m/s wind) plus a project-only noise level of **44 dBA** would equal a total cumulative level of 45 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 (44 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.

## 3.2 TURBINE NOISE LEVEL

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 still in development. 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** |

This level 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 minor tones in the measured frequency spectrum of the prototype, illustrated in Figure 3.2.1.

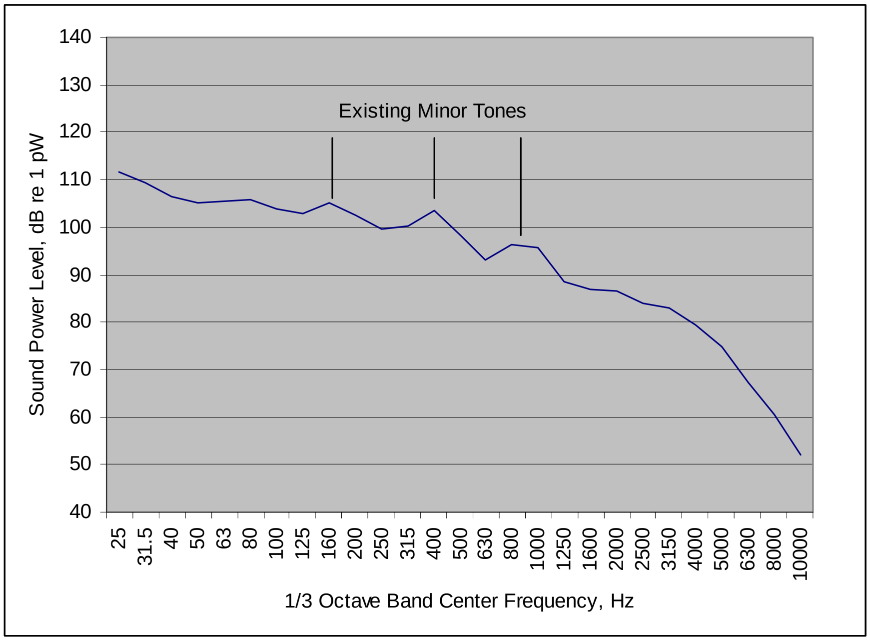


**Figure 3.2.1** *Current 1/3 Octave Band Sound Power Level Spectrum for the Clipper C96 Wind Turbine*

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. **Annex A** is a letter received by the project from Clipper explaining the known origins of the current tones 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.

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.

## 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, which in this case are significant, to be realistically modeled in three-dimensions. The 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).

In the NYSDEC First Level modeling analysis, which is essentially a simple screening test, only distance loss is considered; i.e. the inevitable loss in acoustic energy and drop in sound level with distance as sound waves spread out over an ever increasing surface area.

In the Second Level analysis the objective is to realistically predict the actual sound levels that might occur considering all relevant propagation factors such as ground absorption and terrain features. For this model a highly 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 fields or 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 specifically 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 omni-directional 8 m/s wind is assumed. This approach yields a contour plot that essentially shows the theoretical maximum 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

A NYSDEC First Level sound contour map is shown in **Plot 1**. Sound contour lines, which reflect only project noise and do not include any contribution from natural environmental noise, are carried out to 44 dBA, or the point where a 6 dBA cumulative increase would theoretically occur. Recall that the background sound level of 39 dBA measured in the survey plus a project sound level of 44 dBA would yield a total cumulative sound level of 45 dBA (a 6 dBA increase above the background). A First Level contour map does not represent the actual expected sound levels from the project, but rather is a screening tool to see if a further, more detailed analysis is required to evaluate potential impacts. Plot 1 shows that there are about 7 homes in the northern part of the site, mostly along Dutch Hill Road, that are inside the 44 dBA sound level contour. The existence of these homes triggers the need for a more detailed Second Level analysis.

A Second Level evaluation is shown in **Plot 2**. Again a project-only sound level of 44 dBA has been established as the effective threshold for potentially adverse impacts. Anyone outside this line is unlikely to clearly hear or notice any noise from the project, whereas the nearest turbines may be audible above background noise inside this area, with the degree of perceptibility dependent on how close the observer is to one or more turbines. On the outer fringe of this area, in the 44 to 45 dBA range, the audibility of the project is likely to be minimal and intermittent, if project noise is audible at all.

As can be seen from the plot, there are essentially 2 homes, denoted as A and B (both of which are project participants), on or just inside the 44 dBA sound level contour line but all other residences lie outside the potentially affected area. As mentioned immediately above, the perceptibility of project noise in the vicinity of the 44 dBA contour is likely to be intermittent in nature. For the predicted sound level to have any chance of actually occurring at these two houses the following conditions would be necessary:

- The wind would need to be blowing from the east (opposite of the prevailing wind direction)
- 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 39 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 45 dBA outside completely inaudible inside.

In summary, the model predictions ostensibly indicate that project noise might be audible at up to two houses but the circumstances required for this to occur would rarely, if ever, happen. Consequently, no significant adverse impact is expected at any home in the project vicinity due to project noise.

## 3.5 COMPLIANCE WITH THE TOWN OF COHOCTON NOISE ORDINANCE

The Town of Cohocton Noise 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. **Plot 3** shows the 50 dBA sound level contour, calculated under the conservative conditions described above, relative to the land parcels owned by project participants. Apart from two small areas near Turbines 14 and 16, 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 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.

The second condition of the Ordinance limits project noise to 45 dBA outside any non-participating residences. As illustrated in Plot 2, the maximum predicted sound level at any residence is 44 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 does exhibit some tonal content – although actions are planned by the manufacturer to significantly reduce or eliminate these tones before this turbine model is put into commercial production. The table below lists the specific frequencies and values of the existing tonal 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. At distances of 1000 to 2000 feet or more these tones are likely to become substantially less prominent.

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

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

As can be seen from this table, the current tonal peaks in the power level spectrum are already well within the permissible limits. With, or even without, the planned mitigation in place it is anticipated that the project will comply with the tonal restrictions contained in the Cohocton Noise 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 leaf-on (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 April before any trees leafed out.

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. 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. 2) 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 Plot 2, is 59 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 POTENTIAL NOISE IMPACTS DURING LOW WIND CONDITIONS

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.

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 Figure 2.7.1 and tabulated below, the background sound level was found to follow this same trend, increasing by 5 dBA between wind speeds of 4 and 8 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 | **34** | **35** | **36** | **38** | **39** | **40** |

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 since the behavior of C96 noise at wind speeds below 8 m/s is not yet known it is unclear if this relationship would hold true in this case. Consequently, there is a potential for a slight increase in the audibility of project noise, relative to the maximum case evaluated in the noise model, at wind speeds in the 4 to 7 m/s range.

## 3.9 CUMULATIVE NOISE FROM THE ADJACENT COHOCTON WIND PROJECT

A similar but somewhat larger wind energy project, the Cohocton Wind Farm, is currently planned across a valley to the east of the Dutch Hill project on an elevated plateau. 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 Dutch Hill project area due to the other project.

Quantitatively, the sound level from the Cohocton 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 39 dBA that was found to exist at this wind speed - meaning that noise from the other project would be completely inconsequential and inaudible at the Dutch Hill site even without the Dutch Hill turbines in operation.

## 3.10 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 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. 3]) are tabulated below in Table 3.9.1. Also shown are the maximum total sound levels that might temporarily occur at the closest residences (at least a 1000 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 1000 ft., dBA | Distance Until Sound Level Decreases to 40 dBA, ft. |
|---|---|---|---|---|
| **Road Construction and Electrical Line Trenching** | | | | |
| Dozer, 250-700 hp | 88 | 92 | 63 | 5500 |
| Front End Loader, 300-750 hp | 88 | | | |
| Grader, 13-16 ft. blade | 85 | | | |
| Excavator | 86 | | | |
| **Foundation Work, Concrete Pouring** | | | | |
| Piling Auger | 88 | 88 | 59 | 4200 |
| Concrete Pump, 150 cu yd/hr | 84 | | | |
| **Material and Subassembly Delivery** | | | | |
| Off Hwy Hauler, 115 ton | 90 | 90 | 61 | 4800 |
| Flatbed Truck | 87 | | | |
| **Erection** | | | | |
| Mobile Crane, 75 ton | 85 | 85 | 56 | 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 may be significant at distances of less than 3400 to 5500 feet. There are only 4 or 5 homes within 3400 ft. of any turbine locations and about twice that many within 5500 ft. Most residences in the valleys surrounding the project will be too far away to experience any significant noise from construction equipment.

At the very worst, sound levels ranging from 56 to 61 dBA might temporarily occur over several working days or more at some of the nearest homes on Dutch Hill Road. 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 might be comparable to a distant tractor or piece of farm machinery and as such may well go unnoticed.

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.

## 4.0 CONCLUSIONS

A field survey of existing sound levels at the Dutch Hill Wind Power site indicates that background sound levels are variable and dependent on wind speed. A regression analysis of hourly residual (L90) sound levels vs. wind speed shows that the background sound level likely to exist over the entire site area during a wind that generates maximum turbine noise (8 m/s) is **39 dBA**.

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 **44 dBA**.

A "Second Level" modeling study carried out per the NYSDEC guideline showed that, while most residences were well beyond the 44 dBA contour and unlikely to be able to hear project noise under most normal circumstances, there were two homes, both belonging to project participants, that may experience levels in the 44 to 45 dBA range. In theory these levels mean that project noise may be audible above the typical minimum background sound level but it should be pointed out that the modeling is conservative in two important respects:

- The background design sound level of 39 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 or more turbines (such as key Receptors A and B in Plot 2) cannot possibly be downwind from all units at the same time.

Given these conservative assumptions and the fact that sound levels in the vicinity of 45 dBA 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 one residence 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.

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 11 dBC below the threshold for perceptible vibrations due to airborne sound.

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 audible at only a handful of homes on a temporary basis while the vast majority of residents in the area should not be affected in any way by construction noise.

In general, no permanent and significant adverse impacts from operational noise are anticipated for this project largely due to the fact that very few people live on the summit of Dutch Hill. The distances to most homes in the project area from any of the turbines are sufficient – and often augmented by topography - that rotor noise should be comparable to or below the existing natural environmental sound level during windy conditions.

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

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