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TECHNICAL REPORT

Title: Prevailing Wind Park Sound Testing Data Review and Assessment

Project: Prevailing Wind Park, Docket EL 18-026
Location: Hutchinson County, SD
Prepared For: South Dakota Public Utilities Commission
Prepared By: David M. Hessler, P.E., INCE
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Attachments: - -

1.0 Introduction

Condition 42 of the South Dakota Public Utilities Commission's *Final Decision and Order Granting Permit to Construct Facilities and Notice Entry for the Prevailing Wind Park Project – EL18-026* (November 28, 2018) (Final Decision), requires verification of the sound level requirement at four specific non-participating Intervenor residences within 60 days of the date the Project commences full operation. This deadline was extended after July 1, 2020, in the Commission's Order Granting Extension of Time Due to COVID-19 (May 5, 2020).

Condition 27 of the Final Decision establishes the sound level criteria as follows:

> 27. The Project, exclusive of all unrelated background noise, shall not generate a long-term sound pressure level (L10), as measured over a period of at least two weeks, defined by Commission staff, that includes all integer wind speeds from cut in to full power, of more than 40 dBA within 25 feet of any non-participating residence unless the owner of the residence has signed a waiver, and 45 dBA of any participating residence unless the owner of the residence has signed a waiver. Applicant shall, upon Commission formal request, conduct field surveys or provide post-construction monitoring data verifying compliance with specified noise level limits using applicable American National Standards Institute (ANSI) methods. If the long-term average level exceeds 40 dBA at any non-participating residence, or

> 45 dBA at any participating residence where the owner of the residence has not signed a waiver, then the Applicant shall take whatever steps are necessary in accordance with prudent operating standards to rectify the situation. Sound monitoring will not be repeated in a representative area during any five-year period unless operational or maintenance changes result in a reasonable assumption of higher turbine sound levels.

The verification field survey mandated by these conditions was carried out by Jacobs Engineering Group, Inc. on behalf of the project owner, sPower, between July 15 to August 4, 2020. Hessler Associates, Inc. has been engaged by the SDPUC to independently:

- Review and approve the protocol for the test (drafted by Jacobs)
- Oversee the selection of specific measurement locations
- Independently review the raw data collected during the survey and assess the results
- Review the survey report submitted by Jacobs and assess the validity of its conclusions

All of these tasks have been completed. This report focuses on the latter two bullet points above.

In general, our review of the survey report and evaluation of the test data indicates that the survey was carried out in a manner consistent with the highest professional standards and we concur with its general conclusion that the Project is meeting the required sound level of 40 dBA at the four specified test locations.

2.0 Discussion and Independent Assessment

The sound emissions from wind turbines at typical setback distances to residences are quite difficult to measure and quantify. This is because the natural environmental sound level during the windy conditions necessary for the project to operate are similar to and often higher than the project-only sound level. Consequently, it can be generally stated as a fact that the total observed sound level at any given location under virtually all wind and weather conditions is not the project sound level, but rather is a combination of the project sound level and the natural ambient sound level that would otherwise exist. During high wind conditions the project component of the total sound level essentially becomes negligible and is completely drowned out by wind-induced sounds, either actual, such as trees or crops rustling, or artificial, as in microphone distortion from wind.

In this instance, this basic difficulty is heavily compounded by the use of the L10 statistical to define the allowable sound level. Very briefly, the L10 is the sound level exceeded 10% of the measurement period, which was 15 minutes in this survey. What this level effectively represents, then, is the near maximum sound level since it was quieter than the L10 90% of the time. As a practical matter, this statistical measure essentially captures and quantifies contaminating noise

events unrelated to the subject of the survey, such as from birds, noise from wind gusts, vehicles, dogs barking, summer insects, etc. The impetus behind the use of this measure can be attributed to the belief by certain investigators that it is an effective way of placing a limit on short-term noise excursions from wind turbines due to phenomena such as turbulence, wind shear, and temperature inversions. While wind turbine sound emissions are variable at times, the inevitable presence of contaminating and unrelated noises at typical setback distances defeats the purpose of using the L10, which invariably yields a result that is dominated by background noise and that, if taken at face value as a direct measure of project noise, unfairly suggests that the project is much louder than it actually is.

In an effort to overcome this difficulty, the test procedure specifically includes the use of multiple, short-duration project shutdowns to enable the measurement of the total sound level (project + background) and the background level alone within a short time span so that the wind and atmospheric conditions are held reasonably constant. The project-only sound level, which is the quantity subject to the regulatory limits, can then be derived by logarithmically subtracting the background level from the total level with the project on. However, even this ostensibly simple approach does not always yield a valid, or any, answer because it only works when the differential between the on and off levels is significant, or at least about 3 to 4 dB. In practice, such a large signal (project sound) to noise (background noise) ratio is rarely seen because the project sound level is intentionally designed to be low at sensitive receptors while the natural sound level increases almost indefinitely with wind speed. When the signal to noise ratio is lower than about 4 dB a valid project-only sound level cannot be calculated. Even though the entire project was shutdown 53 times during this two week survey, there were only a handful on instances when the sound level actually decreased by a significant amount while the turbines were off. In most cases there was no measurable change, or the total L10 sound level was higher during the shutdown than during the operational periods immediately before or after.

A further and significant complication was encountered during this survey where high frequency summertime insect and bird sounds largely drowned out the project on most days during the evening and overnight hours. Contaminating sounds that are continuous or nearly continuous cannot be filtered out by any percentile-based measure over a 10 or 15 minute period. In order to overcome this additional difficulty, Jacobs, to their credit, went to the extreme of applying L_{ai} weighting to each 1 second average (Leq) measurement that was also recorded during the survey in the addition to the 15 minute percentiles. L_{ai} weighting, or the A-weighted sound level adjusted for insects, eliminates all frequency bands above a certain cut-off point, usually 1 to 2 kHz, and recalculates the A-weighted sound level based on the logarithmic sum of the remaining 1/3 octave bands without the obvious high frequency contamination. For six positions measured over roughly two weeks, this somewhat complex mathematical adjustment had to be applied to over 7.2 million measurements. Because wind turbines don't produce any significant high frequency noise, the elimination of this data does not reduce or have any real effect on the Project sound level at distant receptor locations. This technique acts as a kind of x-ray vision into the data that clears away the contamination and makes the underlying Project sound level more visible.

Rather than recalculate the results at the four test locations for all 53 shutdown events, we have independently plotted the results for two more or less randomly selected curtailments, Numbers 11 and 46, that occurred when the wind speed conditions were most favorable to getting the clearest results, around 9 or 10 m/s at hub height and fairly calm at microphone height.

The graphics discussed below show, for each position and shutdown, the measured L10, Leq and L90 sound levels, the electrical output of the nearest unit and the wind speeds at 5 ft. and at hub height for a three hour period centered on the shutdown. In addition, the L10 sound level is shown for the closest control position, which essentially illustrates the temporary drop in Project sound emissions measured close to a nearby turbine. These plots are compared to the Jacobs figures showing the same shutdowns and including the 1 minute resolution L_{ai} sound levels.

2.1 Position 1 – Pazour Residence

2.1.1 Curtailment 11

Figure 2.1.1.1 shows the 15 minute sound levels, wind speeds, etc. through Shutdown 11 at 2:15 a.m. on July 23. The regulated sound level, the L10, at the residence is the dark blue solid line.

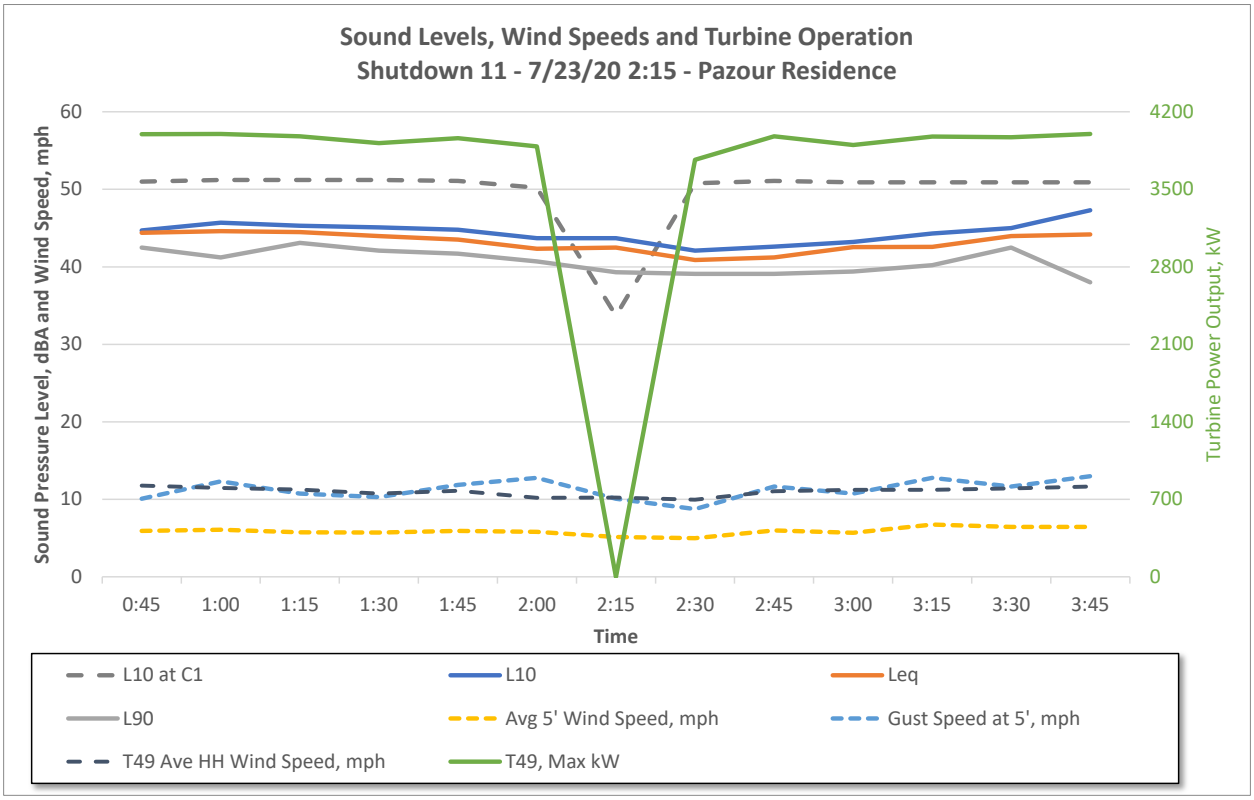

Figure 2.1.1.1

The measurements show that the shutdown of the Project had no effect whatsoever on the L10 sound level or on any of the other statistical measures. Consequently, the L10 level of about 43 dBA measured before, during and after the shutdown cannot be interpreted as being generated exclusively by the Project and as a violation of the noise limit. Indeed, the lack of any change during the shutdown implies that the Project level is non-contributory to the total and is substantially lower than 43 dBA - on the order of 10 dBA, or more, lower. When two sound sources of different magnitudes exist the lower one becomes insignificant when its value is about 9 to 10 dBA below the higher one. For example, if the sound from the louder source is, say, 50 dBA and the sound level from a second is 40 dBA, the total observed sound level will be 50 dBA and the lower source will be inaudible.

In this instance, the essentially continuous sound level of 43 dBA through the sampling period is apparently due to natural environmental sounds, such as nocturnal cicadas or crickets. This suspicion can be confirmed by reviewing the Jacobs analysis of the 1 second sound levels after elimination of the higher frequencies and the recalculation of the L_{ai} sound level shown in Figure REC-024 Curtail #11 from Appendix F of the report reproduced below.

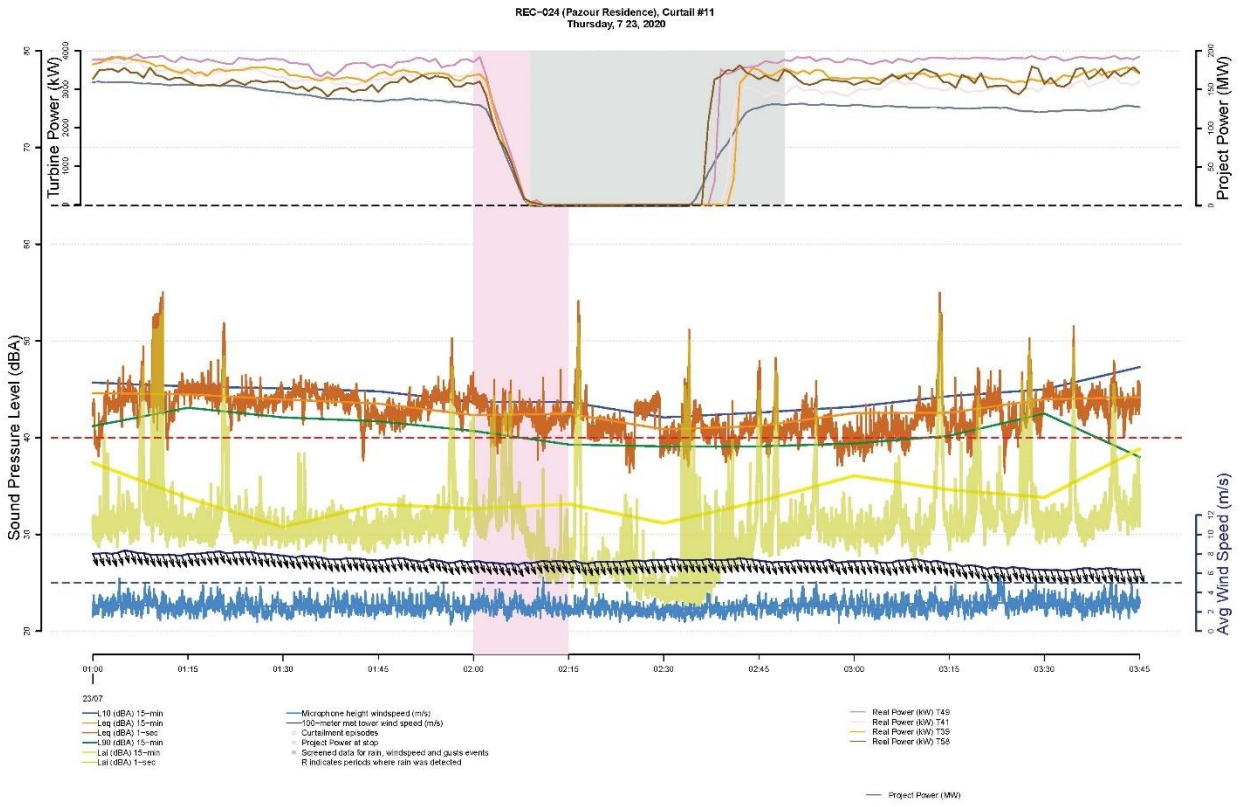

Figure 2.1.1.2

Although somewhat difficult to read at a reduced size, the light gold trace that oscillates around roughly 32 dBA before and after the shutdown is the A-weighted sound level after the elimination of the higher frequency bands exclusively containing the nocturnal insect noise. This level does drop significantly, to roughly 25 dBA, during the curtailment indicating that it is sensitive to the Project's sound emissions. The subtraction of the background level from the project-on level yields a nominal Project-only sound level of 31 dBA. This sound level 12 dBA below the measured L10(15 min) agrees with the conjecture discussed above that the Project must be at least 10 dBA below the measured total because it did not change at all when the Project was curtailed.

2.1.2 Curtailment 46

Figure 2.1.2.1 shows our plot of the relevant data during Curtailment 46 at the Pazour residence.

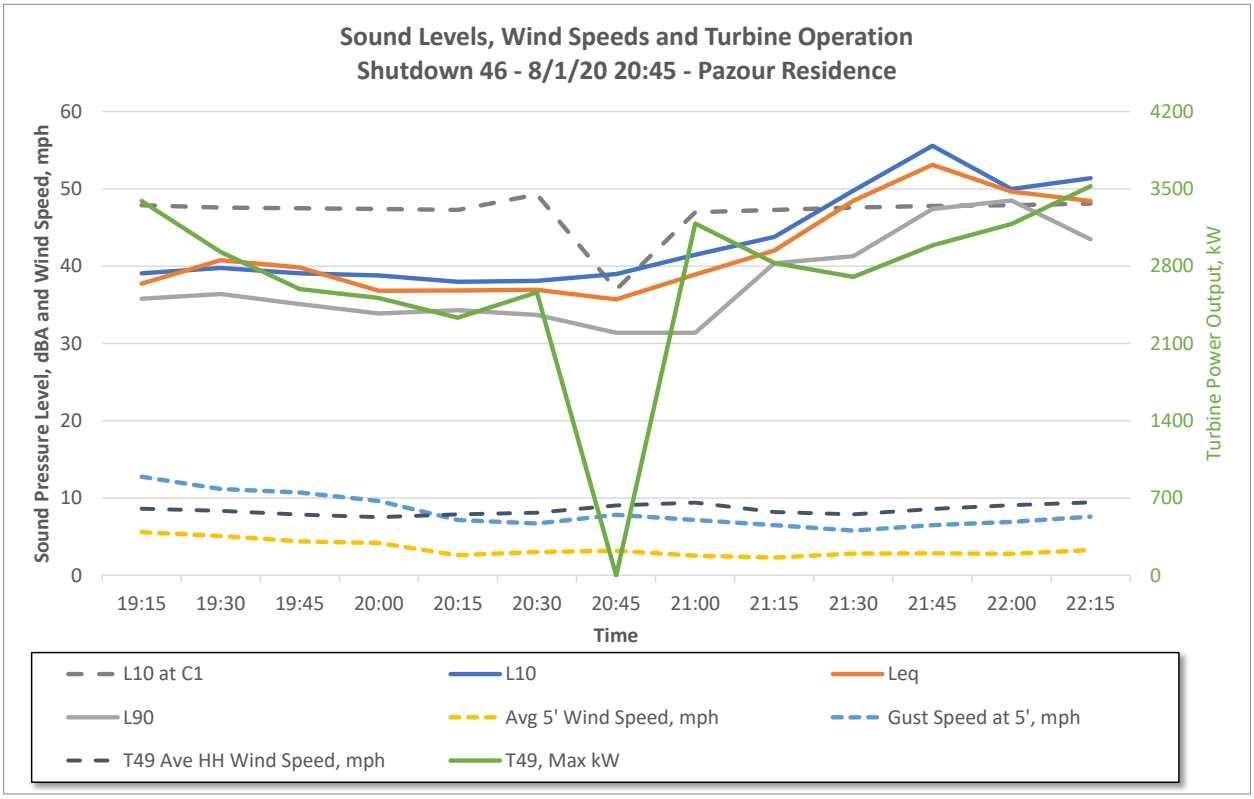

Figure 2.1.2.1

As with the previous case, the L10(15 min) sound level does not drop during the curtailment at 8:45 p.m. on August 1, indicating that the Project sound level is insignificant as a component of the total measured level of about 39 dBA before and during the shutdown. After the shutdown insect noise appears to have started in earnest and the overall sound level increases to about 55 dBA.

A review of the Jacobs L_{ai}(1 sec) data shown in Figure 2.1.2.2 suggests that the Project-only sound level was conservatively in the 30 to 31 dBA range prior to the curtailment ignoring any background contribution – or essentially the same Project sound level that was observed during Curtailment 11. During the intense and noisy insect activity peaking around 9:45 p.m. after the curtailment the L_{ai} level excluding that contamination remains low at about 32 dBA.

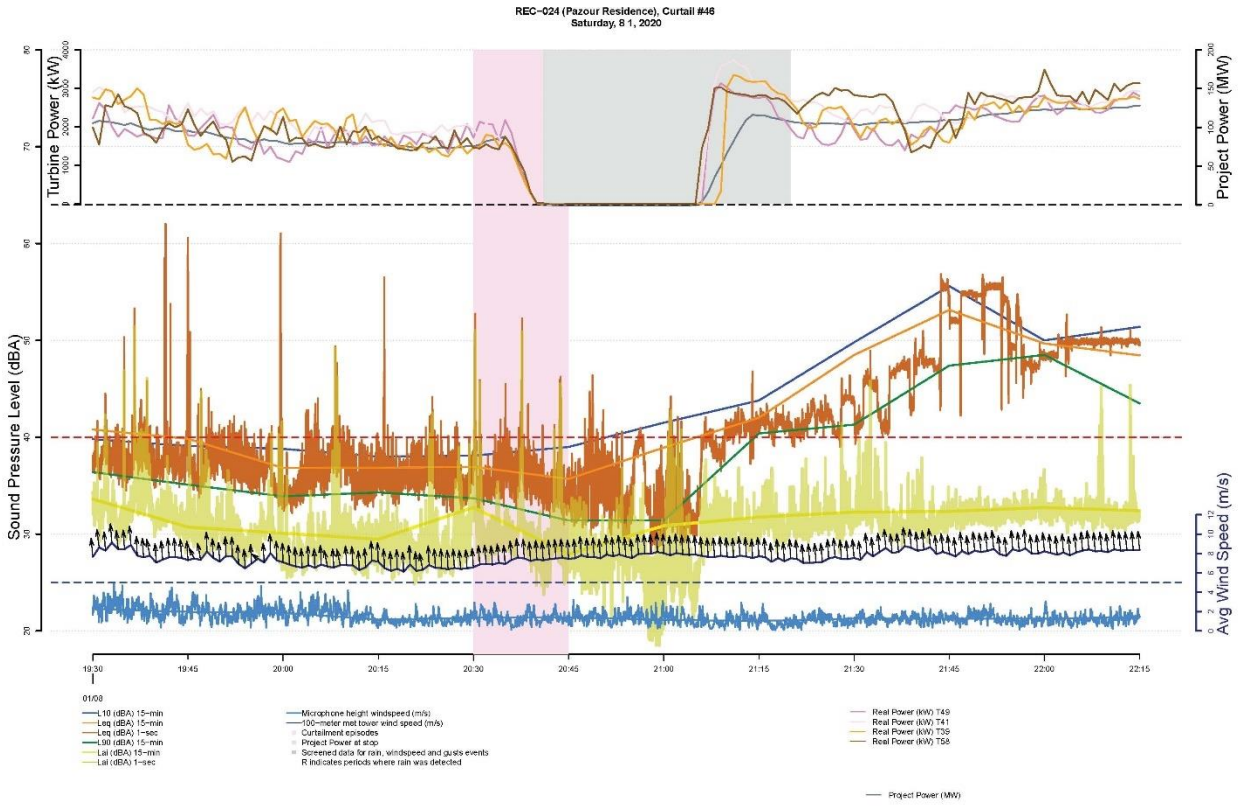

Figure 2.1.2.2

In general, we would conclude that the Project sound level at this location is, conservatively, about 31 or 32 dBA and solidly in compliance with the 40 dBA permit limit.

2.2 Position 2 – Fuerniss Residence

2.2.1 Curtailment 11

During Shutdown 11 at the Fuerniss Residence the total measured sound levels, including the L10, exhibited some sensitivity to the Project's sound emissions and dropped by 6 dBA during 2:15 a.m. curtailment on 7/23. This differential allows the ostensible Project-only level to be calculated at 40 dBA (41 dBA total prior to shutdown – 36 dBA with the Project off = 40 dBA Project-only). Of course, this calculation assumes that background noise has no influence on the measured levels, which is not the case, so the 40 dBA value is an over-estimation.

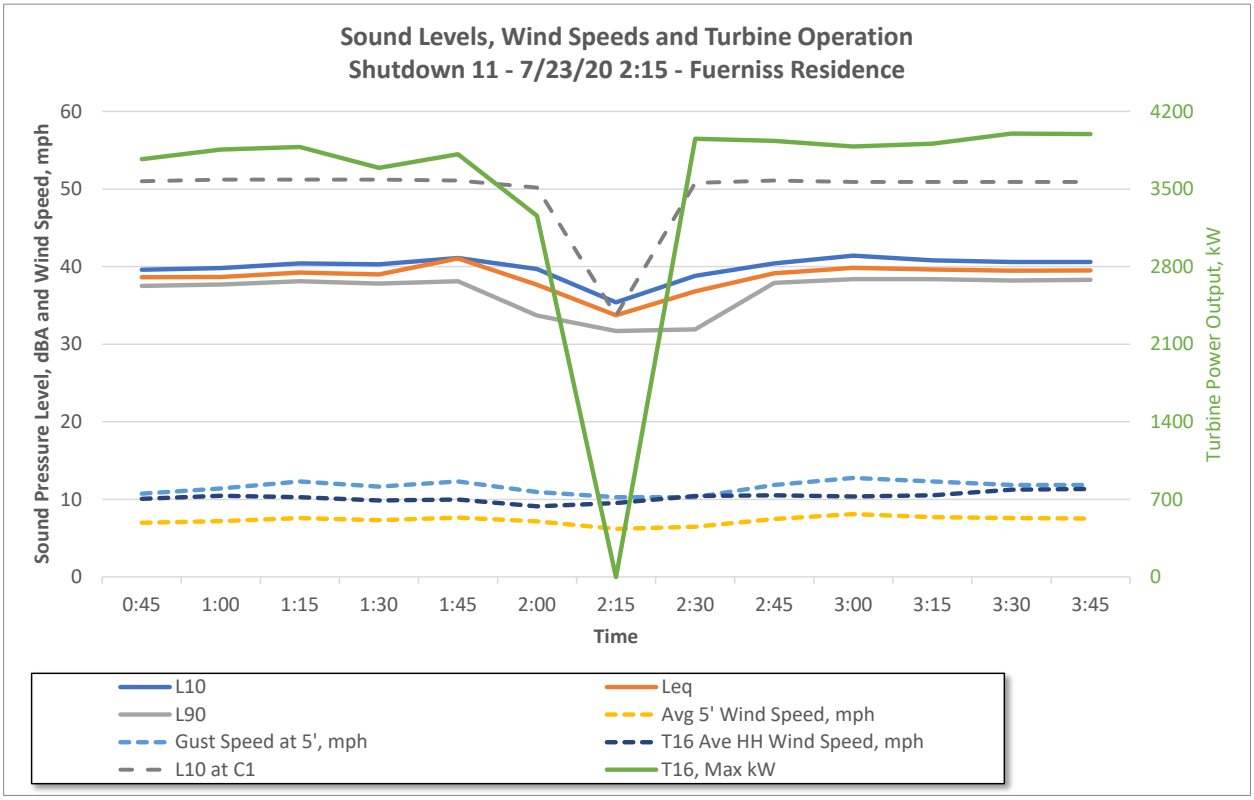

Figure 2.2.1.1

As at the Pazour residence, nocturnal insect was present during this shutdown period. An examination of the Jacobs L_{ai}(1 sec) data (Figure 2.2.1.2) shows that without high frequency insect noise the total sound level was about 35 dBA prior to and after the Project shutdown, and around 27 dBA when it was idle. This sizable differential allows the Project-only sound level to be calculated at 34 dBA.

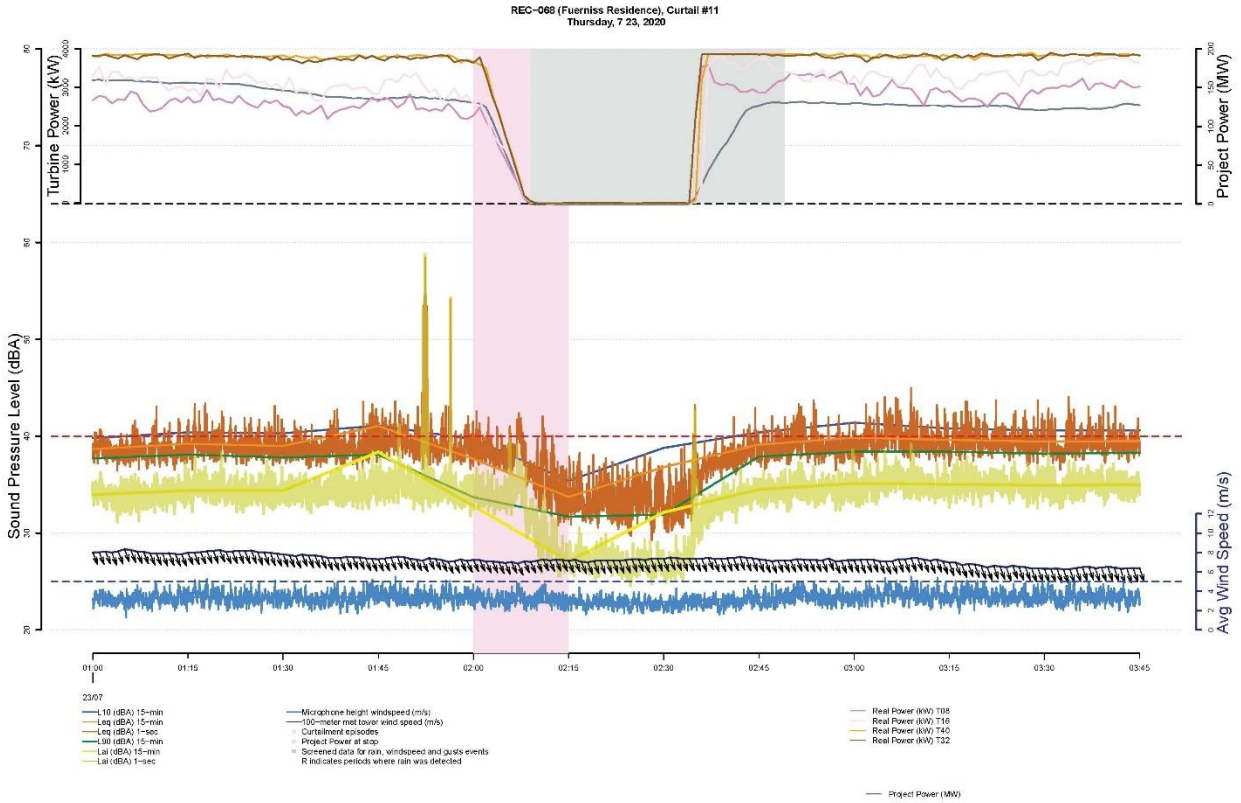

Figure 2.2.1.2

2.2.2 Curtailment 46

Prior to Curtailment 46 a series of sporadic noise events were occurring that elevated the average and L10 levels significantly (see Figure 2.2.2.1). These noises largely stopped right after the shutdown had been initiated and the L10 dropped to about 38 dBA. Once operations began again the L10 sound level rose to about 41 dBA, suggesting a Project-only sound level in the high 30's.

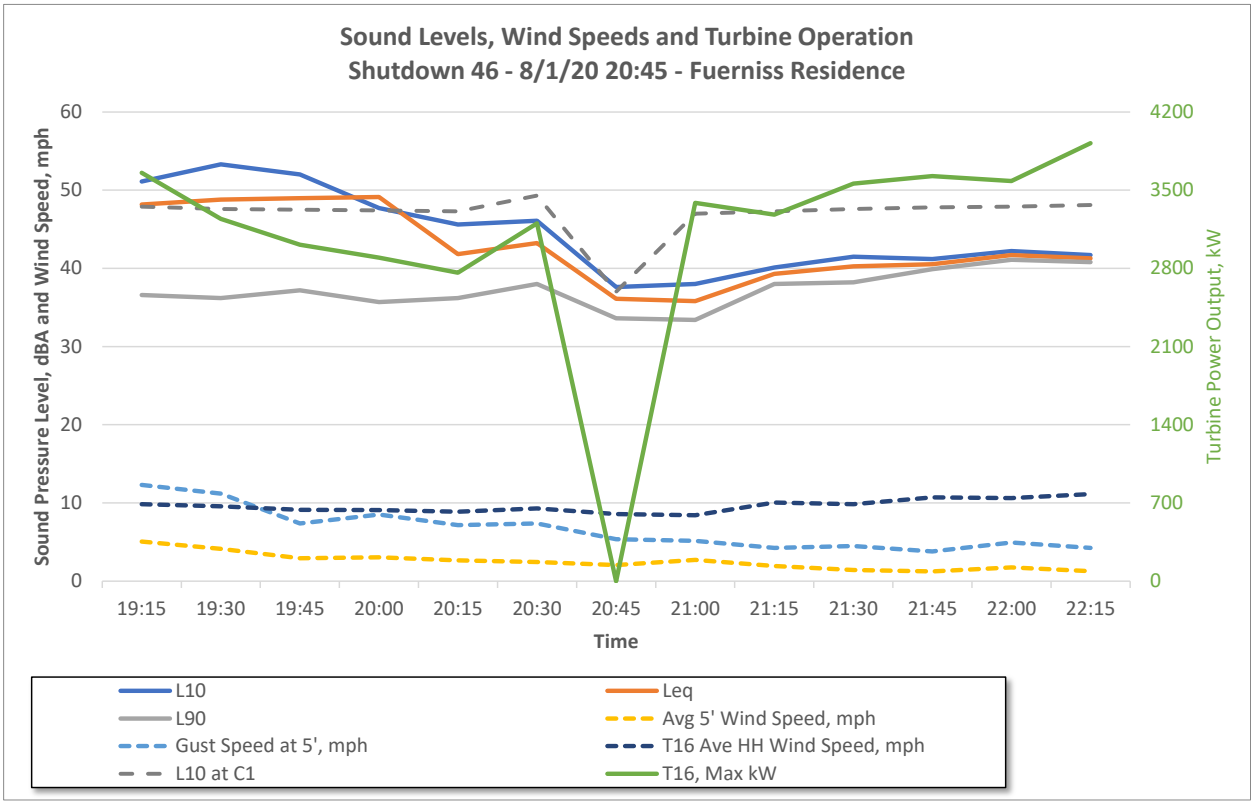

Figure 2.2.2.1

The Lai(1 sec) data for this time period (Figure 2.2.2.2) shows that most of this sound was due to insects because of the large differential (about 8 or 9 dB) between the un-adjusted 1 second average (Leq) level and the 1 second Lai levels.

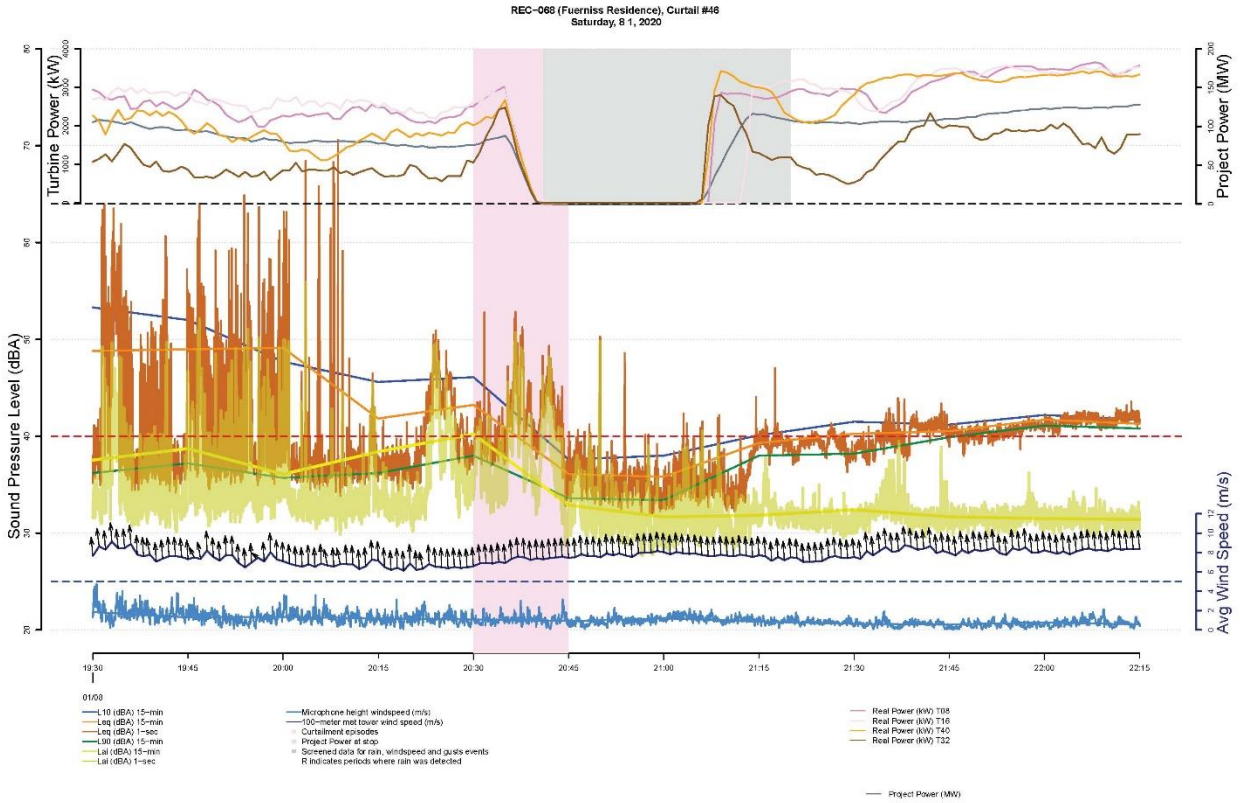

Figure 2.2.2.2

Without insect contamination the sound level once the Project restarted was about 33 dBA, or slightly lower than the 34 dBA observed before and after Curtailment 11 when the Project was operating at full power. The somewhat lower power output of roughly 90% of maximum after the restart probably explains the 1 dBA reduction in sound level.

In general, we would conclude that the Project sound level is about 34 dBA at this location during full power operation and well below the 40 dBA permit limit.

2.3 Position 3 – Jenkins Residence

2.3.1 Curtailment 11

The 15 minute L10 sound level before and after Curtailment 11 at 2:15 a.m. on 7/23 was well above the 40 dBA limit and does not clearly drop when the Project was temporarily shut down (Figure 2.3.1.1). This suggests that other noise unrelated to the Project is responsible for the measured sound levels.

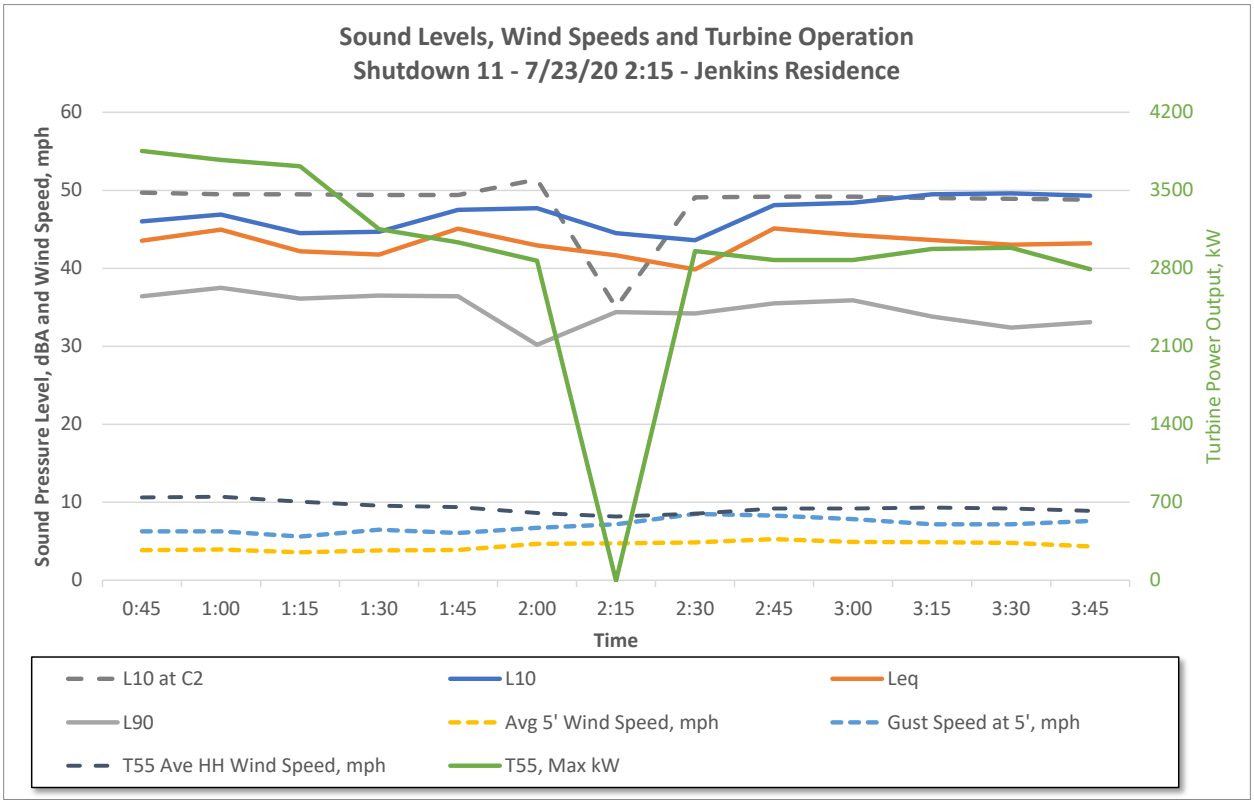

Figure 2.3.1.1

Indeed, the 1 second data (Figure 2.3.1.2) shows that intermittent but very pronounced insect noise occurred during this period.

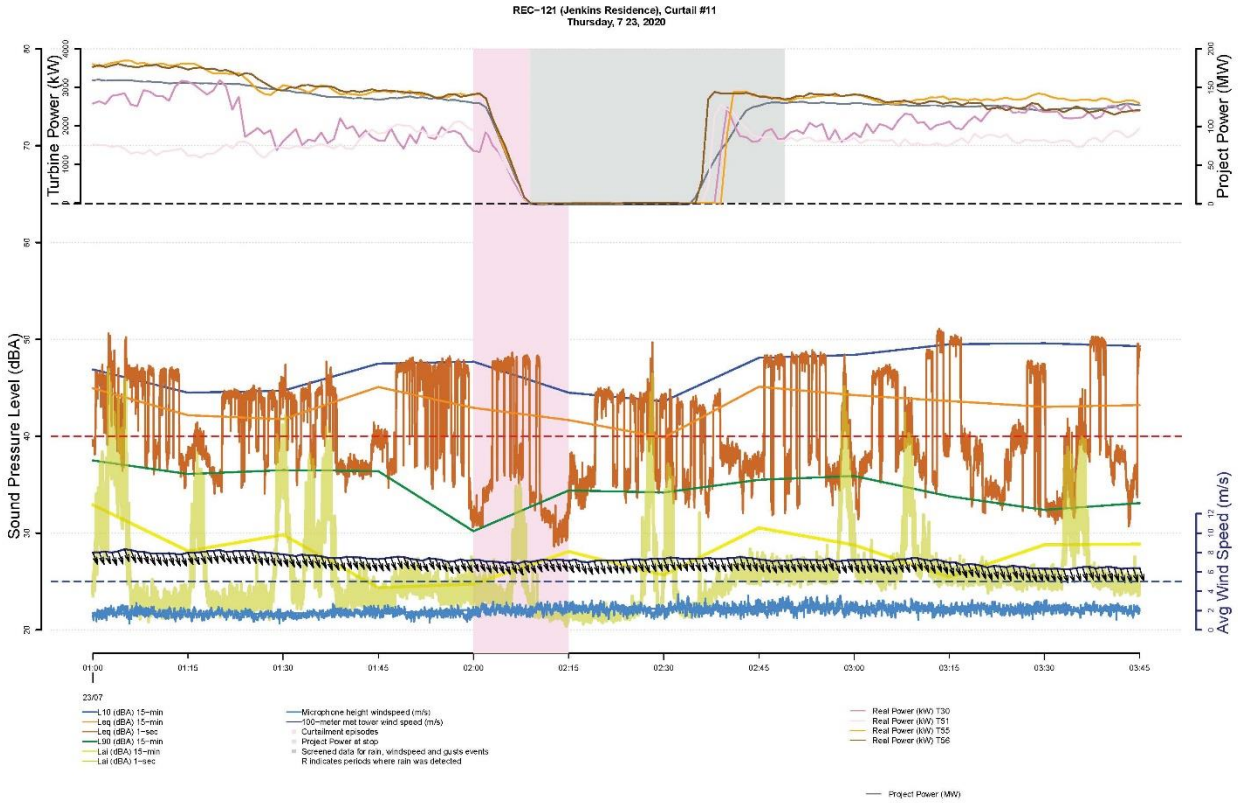

Figure 2.3.1.2

There is a dramatic difference between the unadjusted 1 second average (Leq, brown trace) and the 1 second level after elimination of the higher frequency insect noise (L_{ai}, light gold). The L_{ai} is extremely low both before and after the curtailment in the 24 to 26 dBA range, which indicates that the Project was practically undetectable at this location, which makes sense since the nearest unit is over 5400 ft. away. Although essentially all of this meager sound was probably attributable to general background noise (rural environments are rarely quieter than this), a Project level of only about 25 dBA can be very conservatively estimated from this data as an absolute maximum.

2.3.2 Curtailment 46

As with the previous shutdown, the Project was also practically undetectable during Curtailment 46 on 8/1. The 15 minute data (Figure 2.3.2.1) shows no clear reduction or effect of any kind when the Project was shut down, although the total L10 sound level was below the 40 dBA permit limit for the entire 2 hour period prior to the shutdown unequivocally indicating compliance.

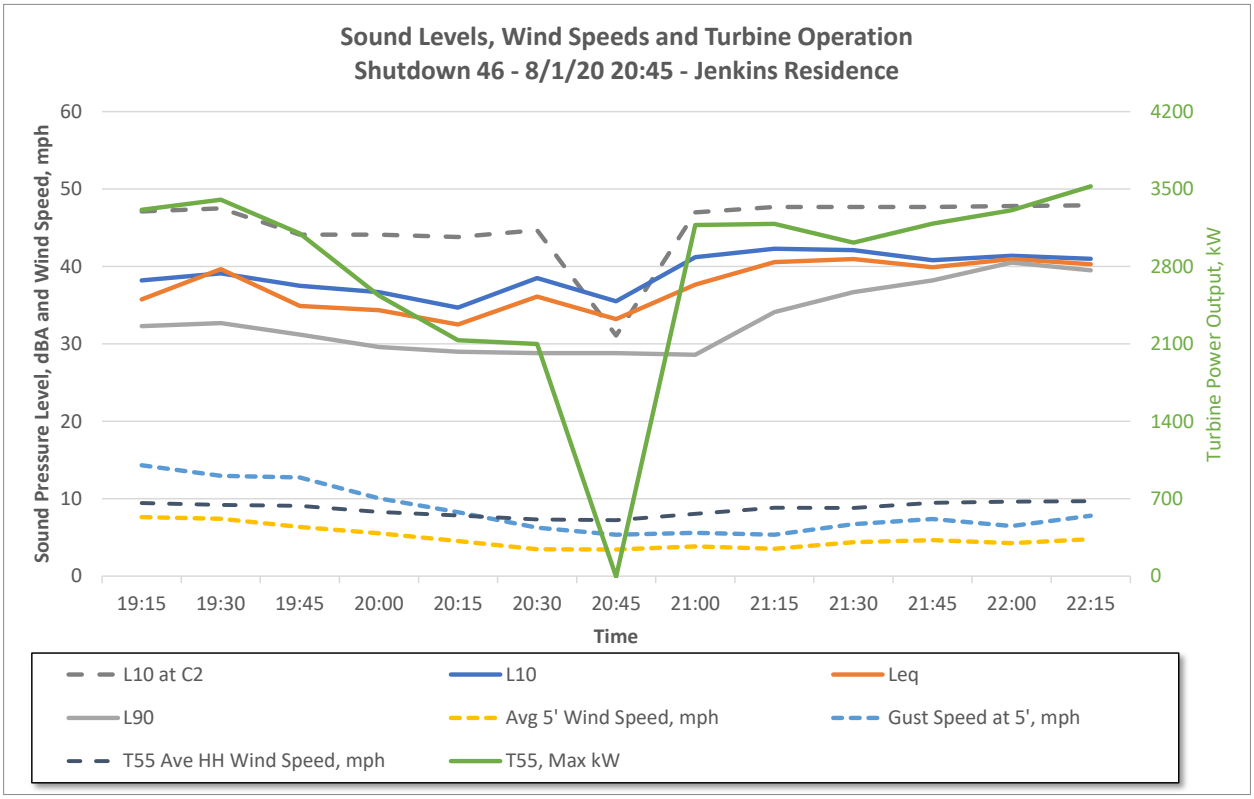

Figure 2.3.2.1

The 1 second data (Figure 2.3.2.2) shows that the sound level was highly variable with many sporadic noise events occurring during this period, which dominated the L10 (15 min) statistical.

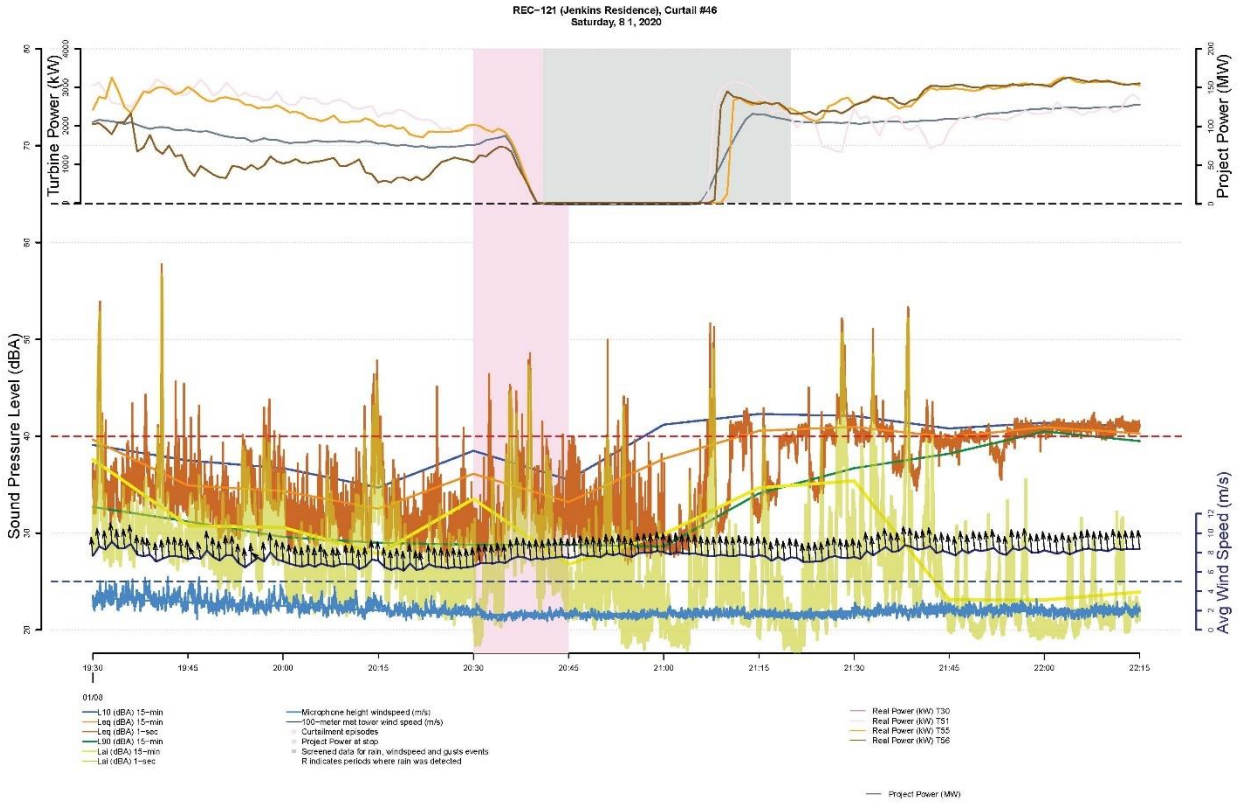

Figure 2.3.2.2

The Project-only level, conservatively represented by the L_{ai}(1 sec), is difficult to discern due to presence of many intruding noise events. The clearest result is probably the last half hour of this sampling period when the L_{ai} was more or less steady at about 21 dBA while the actual sound level including insect noise was just above 40 dBA.

In summary, the Project was essentially undetectable at this position, which is not surprising because the nearest turbine is over 1 mile away. At worst, it appears that the Project may be producing a sound level of about 25 dBA, which is clearly in compliance with the permit limit.

2.4 Position 4 – Schoenfelder Residence

2.4.1 Curtailment 11

During Curtailment 11 at 2:15 a.m. on 7/23 the L10 sound level remained completely steady at 46 dBA before, during and after the Project shutdown indicating that other noise unrelated to the Project was driving the total sound level.

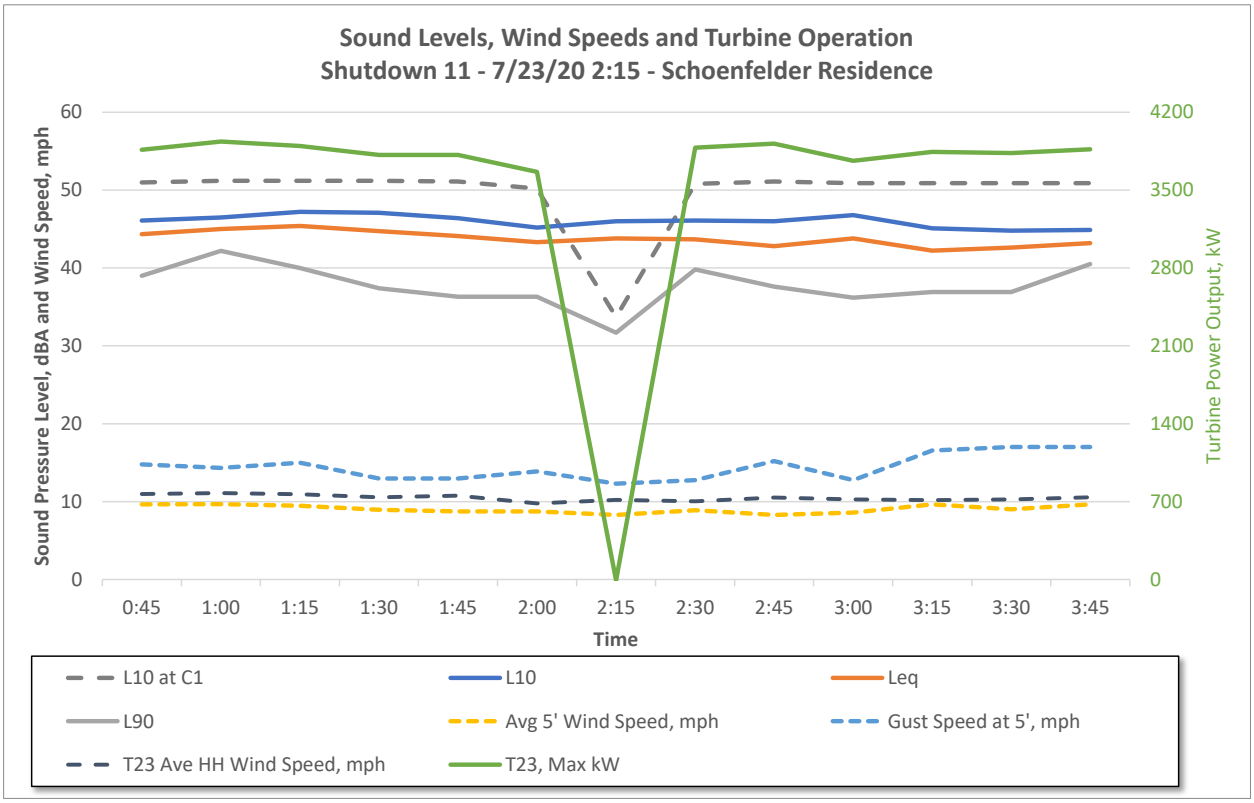

Figure 2.4.1.1

An examination of the 1 second resolution data that Jacobs developed (Figure 2.4.1.2) explains what was happening.

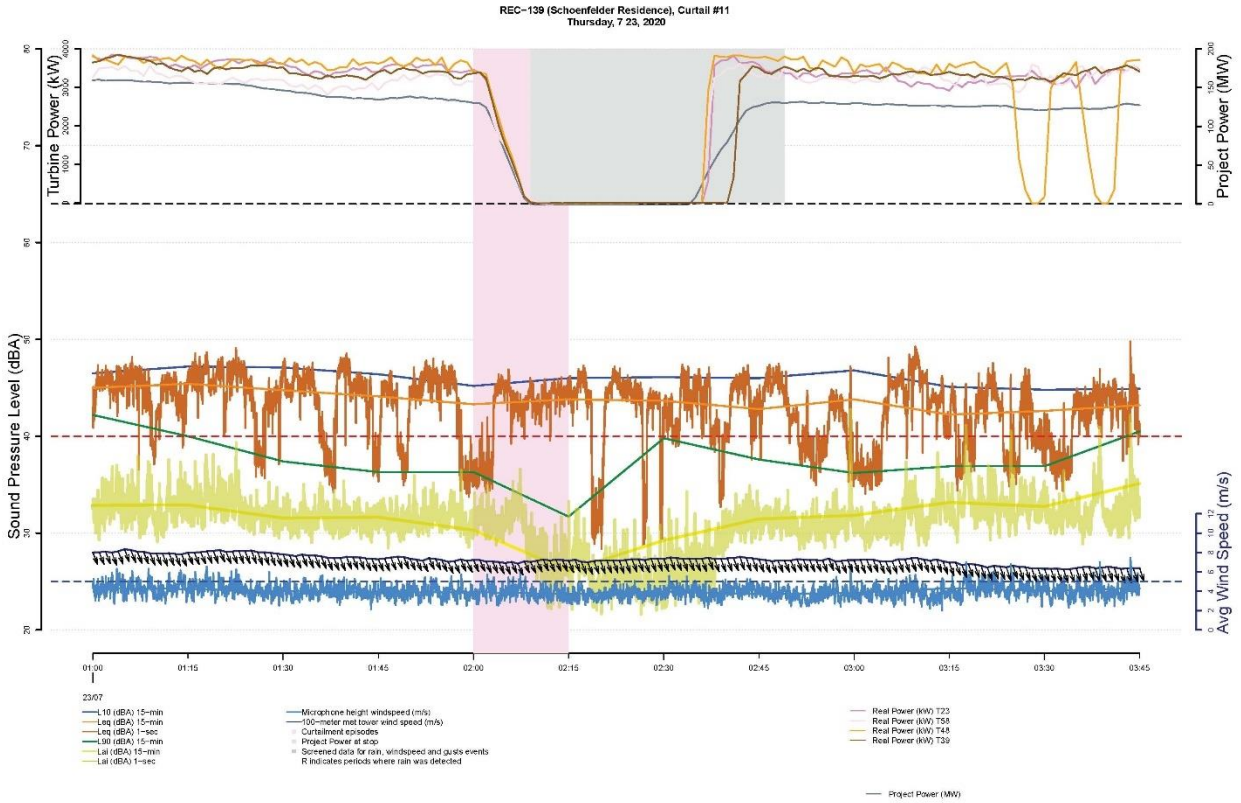

Figure 2.4.1.2

The overall Leq(1 sec) (brown trace) shows that insect noise with a magnitude of about 46 dBA occurred almost constantly over this sampling period with only occasional short pauses. With this contamination removed, the L_{ai}(1 sec) (light gold) levels show that the underlying sound level was actually about 33 dBA before and after the shutdown and about 26 dBA during the curtailment. This implies a Project-only sound level of about 32 dBA.

2.4.2 Curtailment 46

The 15 minute data recorded through Curtailment 46 on 8/1 shows no clear pattern or dip when the Project was shutdown.

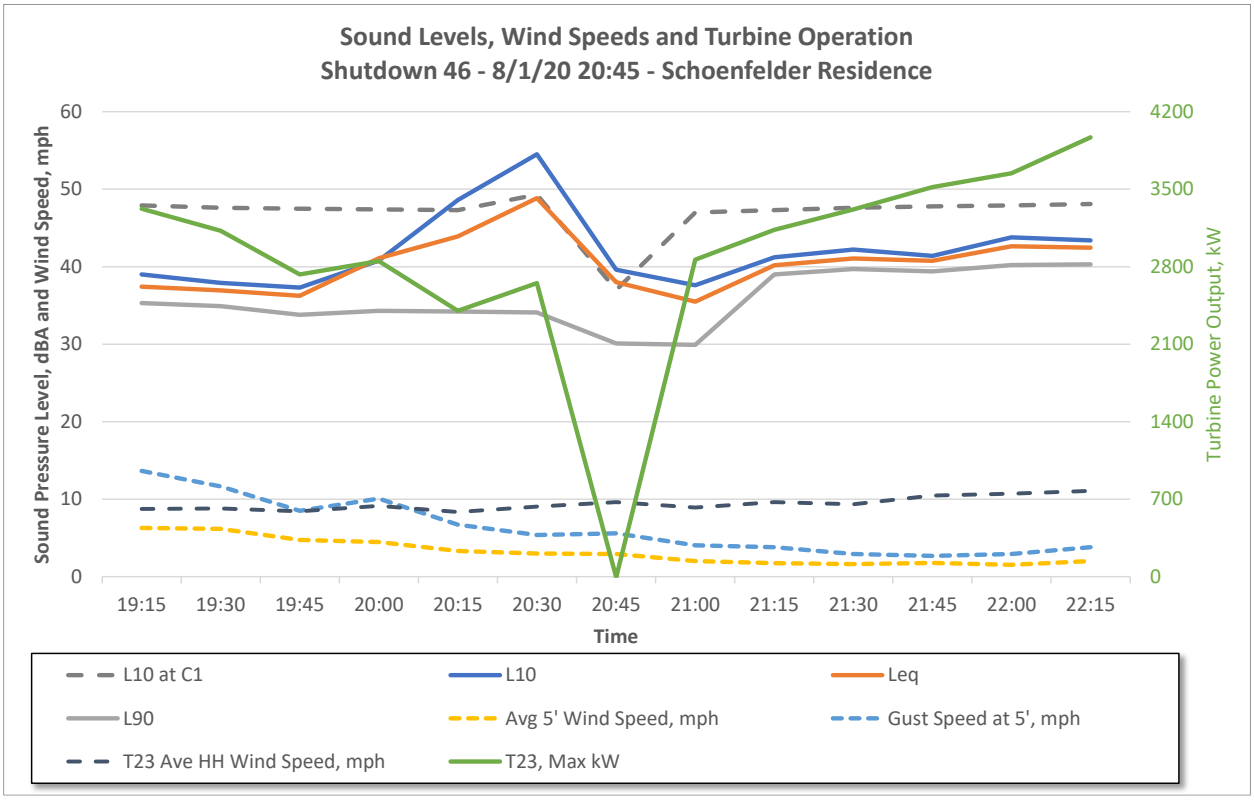

Figure 2.4.2.1

The 1 second data (Figure 2.4.2.2) sheds some light on the situation.

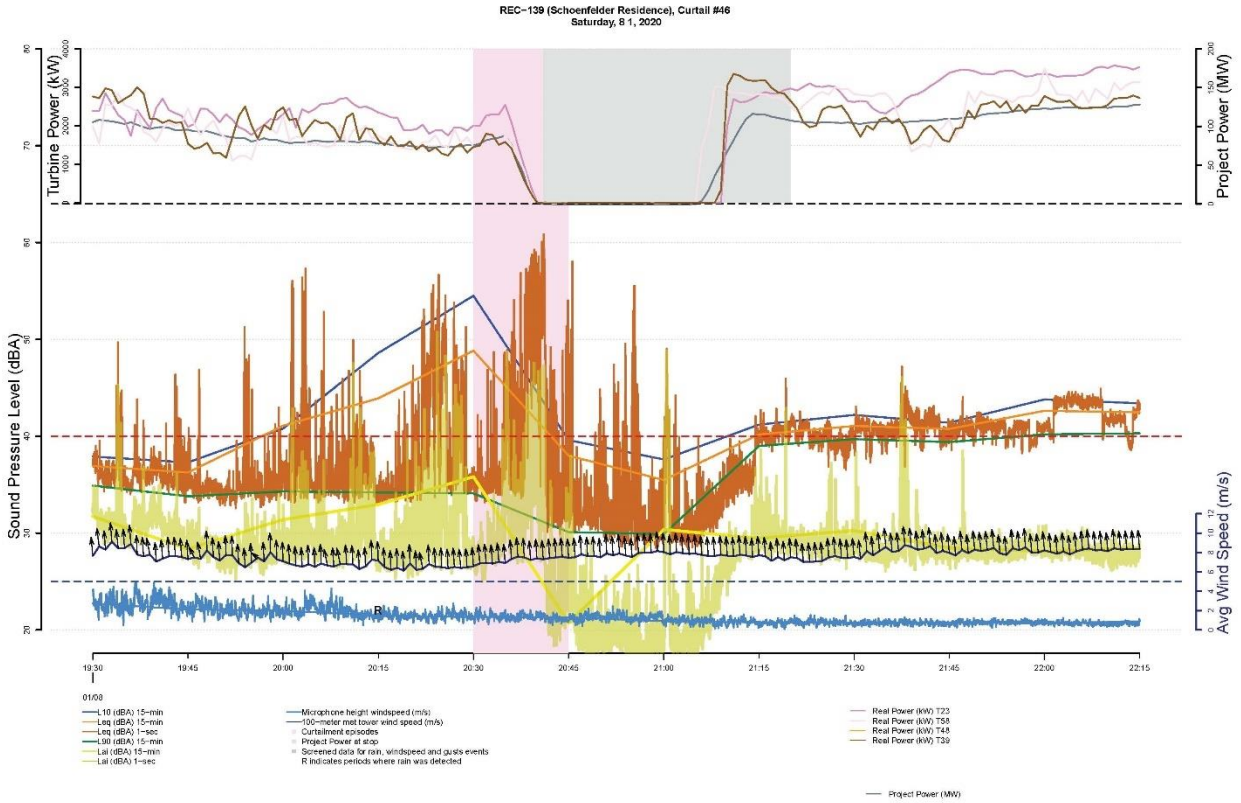

Figure 2.4.2.2

A number of nearly continuous noise spikes occurred during the hour leading up to the shutdown and continued about halfway through it – showing that they are not related to Project operation. This accounts for the L10(15 min) value of 54 dBA at the beginning of the shutdown. After the shutdown the situation stabilized to where high frequency insect was essentially steady at about 41 dBA as shown by the Leq(1 min) trace. When this high frequency contamination is removed the adjusted Lai level (light gold) shows that the underlying sound level was steady at about 30 dBA. This level may be ascribed to the Project since the background level during the shutdown was only about 20 dBA, or insignificant and non-contributory to the total.

Consequently, the data indicate that the Project sound level at this location is apparently in the 30 to 32 dBA range, which is clearly in compliance with the 40 dBA permit limit.

3.0 Conclusions

We have reviewed the sound test report prepared by Jacobs Engineering evaluating the sound levels generated by the Prevailing Wind Park Project relative to the noise limits contained in the permit conditions. In general, the survey was executed to the highest professional standards and Jacobs went above and beyond what was called for in the test protocol to mathematically correct over 7.2 million 1 second measurements to eliminate contamination from summertime insect noise. This massive data processing effort allowed the sound attributable to the Project to be reasonably discerned and quantified, whereas without this adjustment the measurements would have erroneous suggested that the Project was much louder than it actually is. We concur with Jacobs' fundamental conclusion that the Project sound levels are below the permissible limit of 40 dBA L10 at the four Intervenor test locations prescribed in Condition 42 of the permit. More specifically, we would assess that the Project is not exceeding the following sound levels at the four test points.

Table 3.0.1
Summary of Measured Project Sound Levels at the Prescribed Test Locations

Test Residence	Pazour	Fuerniss	Jenkins	Schoenfelder
Distance to Nearest Turbine, ft.	3330	3375	5465	4085
Maximum Apparent Project-only Sound level, dBA	32	34	25	32