COMMERCE DEPARTMENT

May 2, 2022

ELECTRONIC FILING

Will Seuffert, Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

RE: Post-Construction Noise Monitoring Compliance Review
Freeborn Wind Project
Freeborn County, Minnesota
Docket No. IP-6946/WS-17-410

Dear Mr. Seuffert:

This filing serves as the Department of Commerce, Energy Environmental Review and Analysis (EERA) compliance review of the Post-Construction Noise Monitoring Study[1] efiled on February 1, 2022, on behalf of Xcel Energy (Permittee) for the Freeborn Wind Project.

EERA conducted this review to evaluate the Freeborn Wind Project's compliance with its Commission issued Site Permit condition 4.3 and special condition 6.2. Permit condition 4.3 requires that the Project operate in compliance with the Minnesota noise standards in Minnesota Rules Chapter 7030. This means the project cannot cause or significantly contribute to an exceedance of the Minnesota noise standards. As stated in special condition 6.2 of the Site Permit, **if total measured noise levels exceed an L50 of 50 dBA** the project's contributions cannot exceed an L50 of 47 dBA.

> **4.3 Noise**
> The wind turbine towers shall be placed such that the Permittee shall, at all times, comply with noise standards established by the Minnesota Pollution Control Agency as of the date of this permit and at all appropriate locations. The noise standards are found in Minnesota Rules Chapter 7030. Turbine operation shall be modified or turbines shall be removed from service if necessary to comply with these noise standards. The Permittee or its contractor may install and operate turbines as close as the minimum setback required in this permit, but in all cases shall comply with Minnesota Pollution Control Agency noise standards. The Permittee shall be required to comply with this condition with

[1] Xcel Energy. Compliance Filing – Post-Construction Sound Monitoring. February 1, 2022. Cover Letter eDocket ID# 20222-182341-01, Monitoring Report Part 1 of 2 eDocket ID# 20222-182341-02, and Monitoring Report 2 of 2 eDocket ID# 20222-182341-03.

respect to all homes or other receptors in place as of the time of construction, but not with respect to such receptors built after construction of the towers.

6.2 Post-Construction Noise Monitoring

If the Noise Studies conducted under Section 7.4 document an exceedance of the MPCA Noise Standards where turbine-only noise levels produce more than 47 dB(A) L50-one hour at nearby receptors, then the Permittee shall work with the Department of Commerce to develop a plan to minimize and mitigate turbine-only noise impacts.

The Post-Construction Noise Monitoring Study identified two, one - hour events that appeared to exceed the noise limits specified in the permit. Specifically, total noise levels were in excess of state nighttime noise limits (L50 50 dBA) **and** the contribution from project turbines exceeded the turbine only L50 of 47 dBA indicated under Section 6.2 of the permit as the relevant limit when total monitored noise levels exceed state noise standards.

1. Central Monitor Location - Shutdown # 9
    i. Total sound level is 51 dBA, and turbine only contribution is 49 dBA
2. West Monitor Location - Shutdown # 37
    i. Total sound level is 51 dBA, and turbine only contribution is 50 dBA

Additionally, the Post-Construction Noise Monitoring Study noted a variance of 2 to 5 dBA between the pre-construction noise modeling and post-construction noise monitoring at the Freeborn Wind Project. Both the variance between the modeled and monitored noise levels, and the range of variance at the different monitoring locations were concerning as it indicates potential unreliability in the model predicted noise levels throughout the entire project area.

Based on our initial review of the Freeborn Wind Project, on April 1, 2022, EERA recommended the temporary nighttime curtailment and shutdown of Turbines #11, #13, and #14. The Permittee implemented the recommended shutdowns of those turbines beginning on the night of April 1, 2022.

EERA has worked with our independent consultant, Aercoustics, to conduct additional review and analysis of post-construction noise monitoring data collected by RSG (Freeborn Wind LLC's consultant) at the Freeborn Wind Project. Aercoustics, Freeborn Wind – Post Construction Sound Monitoring Report Compliance Validation is attached to this letter for reference.

Summary of RSG Noise Monitoring and Analysis of Exceedances

RSG identified a period of total sound level of 51 dba during the turbine operational period associated with Shutdown #9 at the Central monitor location, and a calculated turbine-only noise level of 49 dBA based on the background total sound level of 47 dBA recorded during Shutdown #9. RSG has indicated the total sound level of 51 dBA was due to strong and gusty winds aloft, averaging 14 m/s at turbine hub height, and the significant drop in sound level from operation (51 dBA) to Shutdown #9 is (47 dBA) is primarily due to a drop in wind-induced noise

rather than from turbine operation. Because of the drop in 4 dB from operation to Shutdown #9, RSG concluded the calculation of turbine-only noise levels from this period doesn't accurately reflect the contribution of the Project. To support their conclusion RSG identified a drop in hub height wind speed of 2 m/s at the beginning of Shutdown #9, and a total drop of 4 m/s in hub height wind speed by the end of Shutdown #9. According to RSG's analysis with an average hub height wind speed of 12 m/s during Shutdown #9 the total one-hour L50 was 47 dBA, and the turbine hub height wind speed continued to drop to 10 m/s in the turbine operational period between Shutdown #9 and #10 with a recorded total one-hour sound level of 45 dBA. RSG analyzed the SCADA reported hub height wind speeds for the four turbines closest to the Central monitoring location, T-10, T-11, T-12, and T-18, during the operational period prior to Shutdown #9 and during Shutdown #9, which confirmed a rapid drop in hub height wind speeds during this time period. RSG also reviewed audio recording collected around and during Shutdown #9, and no turbine noise was discernable but noise from gusty winds was dominant.

RSG identified the West Monitor location exceedance of a total sound level of 51 dBA with a turbine only contribution of 50 dBA associated with Shutdown #37, which they indicated was due to high wind shear conditions, 10.4 m/s hub height wind speed and no ground level wind, occurring during Shutdown #37. RSG defined high wind shear conditions as periods when there is no wind a ground level, and the wind at turbine hub height are at or over 10 m/s. The binning analysis completed by RSG was completed using turbine hub height wind speeds to further analyze total noise levels and turbine-only noise levels. Per RSG's additional binning analysis, at 10 m/s hub height wind speeds the total sound level is 47 dBA, and the Turbine-only noise level is 45 dBA. Additional analysis completed by RSG identified that wind shear events occurred approximately 4 percent of the full monitoring period, and approximately 6 percent of the nighttime monitoring period. The highest total sound level of 51 dBA identified during RSG's binning analysis occurred at a hub height wind speed of 16 m/s, and the turbine-only noise level under these conditions was 21 dBA.

Aercoustics Binning Analysis

Aercoustics assessed compliance with nighttime noise levels at the noise monitoring locations by binning data by ground level wind speeds, as opposed to hub height wind speeds as RSG conducted.

Aercoustics' binning method filtered based on ground level wind speeds, and allows for an aggregation of data points that could be included in the analysis of an estimated L50 across several hours of monitoring that may otherwise be removed due to filtering metrics. Being able to capture one contiguous hour of sound data that would not be partially filtered out do anomalies, wind gusts, or precipitation events is highly unlikely to occur due to constantly changing meteorological conditions. Aercoustics binning method based the calculation of a

total noise sound levels (L50 and L10), background sound levels (L50), and turbine-only noise levels (L50) on the aggregation of at least 60 one minute data points at a given ground level wind speed.

Aercoustics utilized the data collected by RSG, and analyzed the data using the following metrics:

- appropriate filtering parameters (i.e. no precipitation, no significant wind gusts, no significant transient noise)
- ground level wind speeds below 5.5 m/s
- operation of nearest two turbines (total noise – turbines operating and background – turbines not operating)
- one-minute intervals, and
- binning based on ground level wind speed

Table 1. Aercoustics Noise Monitoring Analysis

Monitor Location	Total Noise Level (L50)	Total Noise Level (L10)	Background Sound Level (L50)	Turbine-Only Noise Level (L50)
North	47 dba	48 dba	35 dba	46 dba
Central	44 dba	46 dba	33 dba	44 dba
West	47 dba	49 dba	41 dba	46 dba
South	43 dba	44 dba	36 dba	43 dba

Additionally, Aercoustics included a Signal-to-Noise Ratio (SNR) analysis to determine the contribution of wind turbine noise to the recorded total noise levels. SNR values are calculated by subtracting the total noise level from the background sound level. A SNR value of greater than 6 dB indicates a strong acoustic signal that the wind turbine is contributing significantly, and a SNR value less than 3 dB is a very weak signal from the wind turbine.

All four monitoring locations had SNR values with strong wind turbine contribution to Total Noise Levels (L50):

- North – 11.7 dBA
- Central – 11.5 dBA
- West – 6.7 dBA
- South – 7.8 dBA

Comparison of Pre-Construction Noise Modeling and Noise Monitoring

RSG and Aercoustics both provided an analysis and comparison of the pre-construction modeled (predicted) turbine-only noise levels and post-construction noise monitoring turbine-only noise levels for the four monitoring locations within the Freeborn Wind Project.

Table 2. Turbine-Only Modeling Predictions Compared to Monitored Data Analysis

Monitor Location	Model Predicted Turbine-Only Noise Level	RSG Monitored Turbine-Only (L50)	Aercoustcis Analysis Turbine-Only (L50)
North	45 dba	50 dba	46 dba
Central	44 dba	48 dba	44 dba
West	45 dba	50 dba	46 dba
South	45 dba	47 dba	43 dba

In completing their comparative analysis RSG included their maximum calculated turbine-only noise levels for all four monitoring locations, including the maximums for the West and Central monitoring locations, which RSG had explained to be the result of strong gusty wind conditions at turbine hub height. RSG's comparative analysis of modeled turbine-only noise levels and monitored turbine-only noise levels shows a variation of 2 – 5 dBA across the four monitoring locations (refer to Table 2).

Aercoustics utilized their previously described one-minute, ground level wind speed binning method to complete their comparative analysis of the pre-construction modeled turbine-only noise levels and the post-construction noise monitoring, turbine-only noise levels. This method allows the aggregated noise data to be better analyzed for a comparison with pre-construction noise modeling, and resists monitoring outliers that cannot be used for modeling comparisons. Aercoustics comparison of modeled and monitored noise levels shows a variation range from -2 to 1 dBA, depending on monitoring location (refer to Table 2).

EERA Analysis and Recommendations

EERA's concerns identified in our April 1, 2022 letter were the result of the manner in which the RSG identified and laid out the potential noise exceedances and the modeling versus monitoring comparison in the Post-Construction Noise Monitoring Study. The Post-Construction Noise Monitoring Study provided additional context to the exceedances identified at the Central monitoring location (Shutdown #9) and West monitoring location (Shutdown #47).

For Shutdown #9, and the adjacent timeframes, at the Central monitoring location, the high Total Noise Level of 51 dBA appears to be the result of gusty winds with high turbine hub height wind speeds and little to no wind at ground level. Additionally, the calculated turbine-only noise level of 49 dBA associated with Shutdown #9 does not appear to accurately reflect the conditions when the turbine was operating prior to Shutdown #9. This is based on the significant drop in turbine hub height wind speed of 4 m/s from the time the turbines were operating prior to Shutdown #9, and the end of Shutdown #9. This is further substantiated by

Aercoustics ground level wind speed binning analysis, which indicates that the Turbine-Only (L50) at the Central monitoring location was 44 dBA.

For Shutdown #47 the West Monitor location exceedance of a total sound level of 51 dBA with a turbine only contribution of 50 dBA appears to be associated with a high wind shear event. When this exceedance occurred the hub height wind speed was 10.4 m/s and there was no ground level wind. RSG's binning analysis, indicated at 10 m/s hub height wind speeds the total sound level is 47 dBA, and the Turbine-only noise level is 45 dBA, which indicates that an exceedance is not going to occur every time the hub height wind speed hits 10 m/s. Rather the exceedance events will be rare in nature, and will likely only occur when hub height wind speeds are above 10 m/s and gusty, and there is little to no ground level wind speeds. RSG's analysis identified that wind shear events occurred approximately 6 percent of the nighttime monitoring period. However, it is important to note that only once did those windshear conditions result in an exceedance of the nighttime noise standards only one time during monitoring. The rare nature of wind shear events causing exceedance of the nighttime noise standard is further substantiated by Aercoustics ground level wind speed binning analysis, which indicates that the Turbine-Only (L50) at the West monitoring location was 46 dBA when there was no ground level wind present.

RSG's modeling versus monitoring comparison variation of 2 to 5 dBA also appears to be the result of comparing noise modeling predictions to unique or rarely occurring events, which showed higher noise levels, in particular for the Central and West monitoring locations. Wind turbine noise modeling software is not intended to anticipate or predict, unique and rare events such as gusty and rapidly changing turbine hub height wind speeds or high wind shear conditions. Noise modeling efforts are intended to show what predicted L50 noise levels will be experienced at the noise receptors within a project area under normal or typical conditions. Comparing the modeling predictions and monitored noise levels during unique meteorological conditions will inaccurately show a greater variation than what is occurring at the site.

Aercoustics ground level wind speed, binning method reduces the potential for inclusion of atypical project related noise caused by unique or rare meterological events. EERA thinks Aercoustics methodology more accurately reflects the acoustic conditions a person will experience within the Project, and their analysis shows a more accurate comparison of modeled turbine-only noise levels and monitored turbine-only noise levels.

Based on our review of the Freeborn Wind Monitoring Study and the additional detailed data analysis conducted by Aercoustics, EERA has determined there are no exceedances of the Minnesota state noise standard, and no violation of Site Permit condition 4.3. As there are no exceedances of the State noise standard, the Project is not in violation of Site Permit special condition 6.2, which, based on a simple reading of the permit language, only apply to scenarios

in which total noise levels are exceeded. Additionally, the variation between the pre-construction modeling of predicted noise levels and post-construction noise monitoring is within an acceptable range to validate the modeling predictions.

EERA recommends that no further nighttime curtailment of turbines T-11, T-13, and T-14 is necessary at this time, and full turbine operations can be resumed.

EERA staff is available to answer any questions you or the Commission may have.

Sincerely,

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Enc: Aercoustics. Freeborn Wind – Post Construction Sound Monitoring Report Compliance Validation. April 11, 2022

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Subject: Freeborn Wind – Post Construction Sound Monitoring Report Compliance Validation
Aercoustics Project #: 19228.01

Date: April 11, 2022

This memorandum presents Aercoustics' findings regarding the Freeborn Wind Sound Level Compliance Evaluation Report (the "Report") dated February 2022, prepared by RSG Inc. ("RSG"), and submitted to the Minnesota Public Utilities Commission for review.

Reviewed Documents

The following documents have been reviewed as part of this work:

- "Freeborn Wind (MN) Post-Construction Sound Monitoring", dated February 2022, prepared by RSG Inc. ["The Report"]
- Associated raw measurement data, submitted by RSG on March 22, 2022 (see "Review Methodology" section for details) ["The raw data"]

Report Methodology and Conclusion

The Report utilized a time-based method to evaluate compliance of the wind facility at four locations. Monitoring was conducted for a period of approximately 13 days in November of 2022. The wind turbines were occasionally shutdown during the monitoring period to capture ambient sound levels. Sound levels were compiled into 1-hour intervals and filtered to reduce the total dataset. After filtering, each of the remaining 1-hour intervals were evaluated individually to assess compliance with the applicable sound level limits. The maximum total sound levels at each monitor ranged between 47 and 51 dBA, with turbine-only sound levels between 47 and 50 dBA.

The monitor having a Total Noise level of 51 dBA had a calculated Turbine-Only noise level of 50 dBA, which exceeds the sound level limits[1]. Additional analysis of the data at this monitor was conducted using a binning methodology using hub-height wind speed as the basis for the binning. The results of the binning analysis indicated sound levels at this monitor ranged between 21 to 46 dBA.

The final determination of the Report was that the wind farm was in compliance with the applicable limits.

Review Methodology

To validate the assessment of compliance, Aercoustics conducted a thorough review of the analysis and raw data provided by RSG. This in-depth review was required given that all monitors have events close to or above the sound level limits, and that the measured sound levels exceeded the predicted sound levels by 2-5 dB, which is higher than expected given the modelling parameters.

Raw data provided by RSG and used by Aercoustics in its analysis included:

Data	Location	Interval
Acoustic parameters (LAeq 1/3rd octave band)	All monitoring locations	1 second
Precipitation, ground level wind speed, ground level wind direction, temperature, pressure	Local area weather station	20 minute
Ground level wind speed (average and gust)	All monitoring locations	1 minute
Power Output, Hub-height wind speed, yaw angle,	All nearby turbines	10 minute
Excluded periods*	All monitoring locations	1-minute

* An excel file was provided showing all time ranges excluded in RSG's analysis due to precipitation or anomalies.

This data was compiled into 1-minute intervals and analysed using a binning methodology, whereby data with high turbine emissions and similar environmental conditions are aggregated (i.e. "binned") by ground level wind speed to determine the average sound level at each wind speed when the facility output is at its highest. This methodology is more resistant to outliers and provides a robust determination of compliance for each dataset. The metrics used to filter each 1-minute interval are detailed as follows:

[1] Per EERA, situations where the Total Noise level exceeds 50 dBA (L50), a determination of compliance is possible if the Turbine-Only sound level is calculated to be 47 dBA or less.

- No precipitation within the last hour
  - Determined using the precipitation data from the area weather station.
  - Periods manually identified by RSG as "Precipitation" were also removed.
- No significant wind gusts
  - Determined by comparing the "gust" wind speed with the average wind speed for the same interval.
  - Intervals having a difference greater than 0.5 m/s are excluded.
  - This is particularly important given the proximity of trees or vegetation to most of the monitoring locations.
- Ground level wind speed below 5.5 m/s.
- No significant transient noise
  - Determined by comparing the average sound level (LAeq) with the minimum sound level (LA90) for a given 1-minute interval. Intervals having a difference greater than 10 dB are excluded.
  - Periods manually identified by RSG as "Anomaly" were also removed.
- Operation of nearest two turbines
  - Total Noise: turbines are producing 90% or more of their rated power output
  - Background: turbines are not generating power

Intervals that meet the above criteria are sorted into Total Noise or Background periods and binned based on their measured ground level wind speed.

The Total Noise and Background data that passed the above filters were also filtered by nighttime and downwind[2] conditions to further refine the data. It is noted that only one monitor had enough data with the downwind filter applied, indicating that downwind conditions were not prevalent during the monitoring period. For consistency, all monitors were assessed using the nighttime filter without a downwind requirement, in addition to the filtering described above.

Results and Discussion

The results of the analysis and filtering described above are summarised in the tables and graphs below. The "Total Noise Minutes of Data" column is formatted in green if at least 60 minutes (1 hour) of valid data has been acquired for a given wind bin. The SNR column is formatted in green (good signal), yellow (ok signal), and red (weak signal). For more information on SNR, see the general notes regarding the data provided at the end of this section.

[2] Downwind in this study is a 90° wedge centered on the line of sight from monitor to closest turbine.

Table 1: North Location (predicted level of 45 dBA). Nighttime conditions, all wind directions.

Wind Bin (m/s)	Total Noise Minutes of Data	Total Noise Sound Level (L50-dBA)	Total Noise Sound Level (L10-dBA)	Background Minutes of Data	Background Sound Level (L50-dBA)	Turbine-Only (L50, dBA)	SNR (dBA)
0	119	47	48	29	35	46	11.7
0.5	42	45	46	58	37	-	-
1	36	46	47	42	39	-	-
1.5	28	47	49	28	44	-	-
2	6	50	51	41	49	-	-
2.5	7	58	59	12	52	-	-
3	1	58	60	15	57	-	-
3.5	0	-	-	8	58	-	-
4	0	-	-	3	59	-	-
4.5	0	-	-	1	60	-	-
5	0	-	-	0	-	-	-

Figure 1: North Location, plot of all intervals after filtering

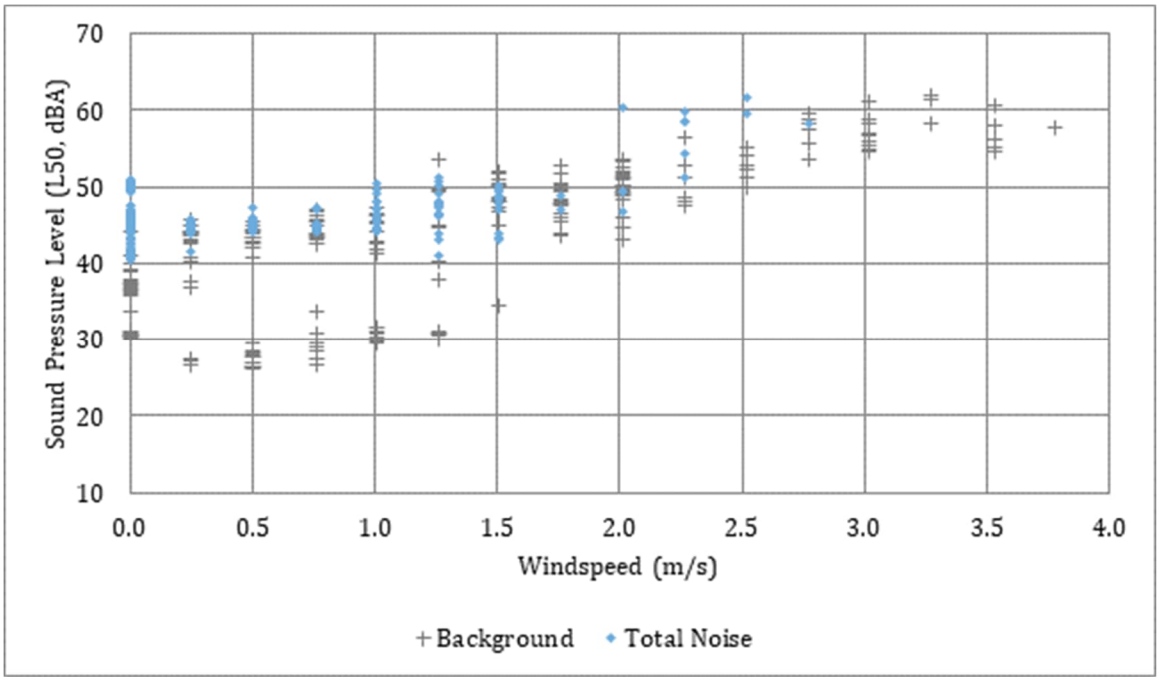
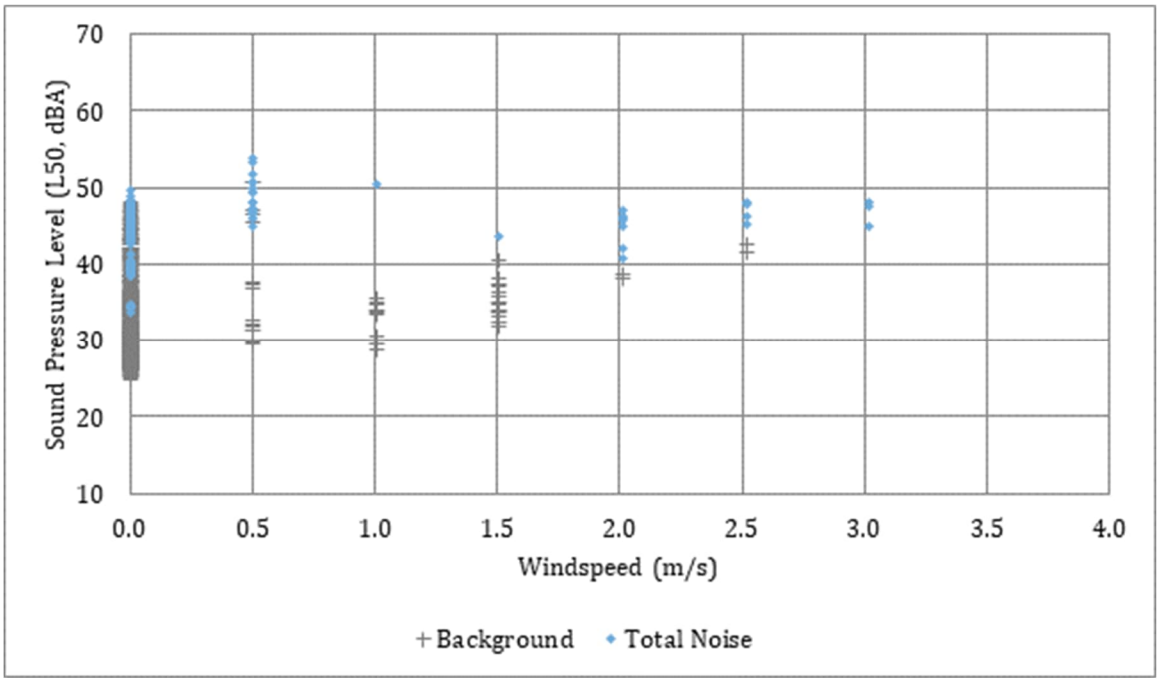


Table 2: Central Location (predicted level of 44 dBA). Nighttime conditions, all wind directions.

Wind Bin (m/s)	Total Noise Minutes of Data	Total Noise Sound Level (L50-dBA)	Total Noise Sound Level (L10-dBA)	Background Minutes of Data	Background Sound Level (L50-dBA)	Turbine-Only (L50, dBA)	SNR (dBA)
0	385	44	46	758	33	44	11.5
0.5	17	49	51	16	39	-	-
1	1	50	54	11	33	-	-
1.5	1	44	45	18	35	-	-
2	7	45	47	2	38	-	-
2.5	4	47	49	2	42	-	-
3	3	47	48	0	-	-	-
3.5	0	-	-	0	-	-	-
4	0	-	-	0	-	-	-
4.5	0	-	-	0	-	-	-
5	0	-	-	0	-	-	-

Figure 2: Central Location, plot of all intervals after filtering



NOTE: A review of the higher sound levels in the 0.5 m/s wind bin indicate that the levels coincide with higher background sound levels measured the same night.

Table 3: West Location (predicted level of 45 dBA). Nighttime conditions, all wind directions.

Wind Bin (m/s)	Total Noise Minutes of Data	Total Noise Sound Level (L50-dBA)	Total Noise Sound Level (L10-dBA)	Background Minutes of Data	Background Sound Level (L50-dBA)	Turbine-Only (L50, dBA)	SNR (dBA)
0	205	47	49	1348	41	46	6.7
0.5	60	46	48	121	40	45	6.3
1	10	46	48	5	-	-	-
1.5	1	48	49	0	-	-	-
2	0	-	-	0	-	-	-
2.5	0	-	-	0	-	-	-
3	0	-	-	0	-	-	-
3.5	0	-	-	0	-	-	-
4	0	-	-	0	-	-	-
4.5	0	-	-	0	-	-	-
5	0	-	-	0	-	-	-

Figure 3: West Location, plot of all intervals after filtering

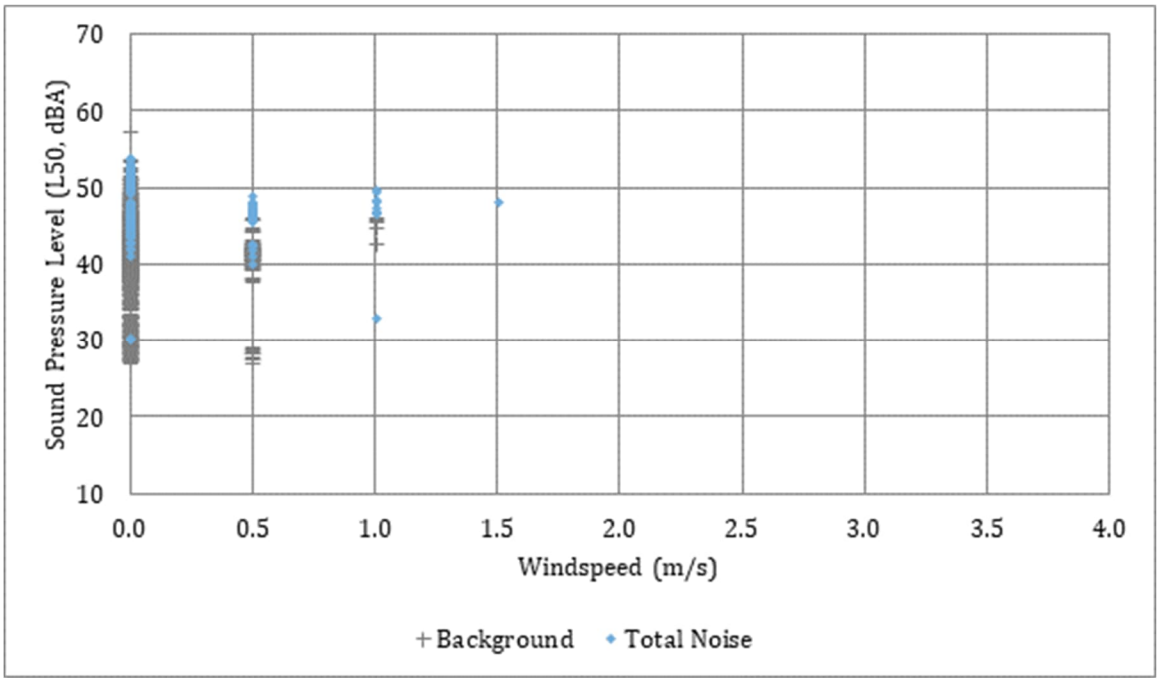
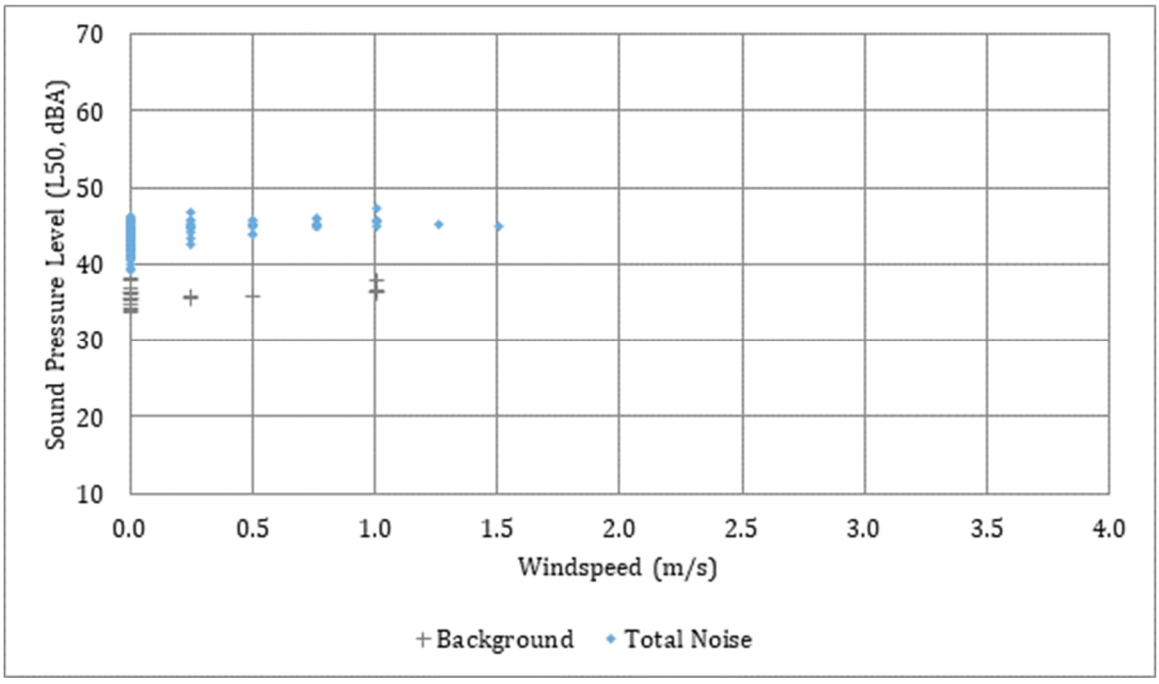


Table 4: South Location (predicted level of 45 dBA). Nighttime conditions, all wind directions.

Wind Bin (m/s)	Total Noise Minutes of Data	Total Noise Sound Level (L50-dBA)	Total Noise Sound Level (L10-dBA)	Background Minutes of Data	Background Sound Level (L50-dBA)	Turbine-Only (L50, dBA)	SNR (dBA)
0	99	43	44	13	36	43	7.8
0.5	18	45	46	3	-	-	-
1	16	45	46	4	-	-	-
1.5	2	45	46	0	-	-	-
2	0	-	-	0	-	-	-
2.5	0	-	-	0	-	-	-
3	0	-	-	0	-	-	-
3.5	0	-	-	0	-	-	-
4	0	-	-	0	-	-	-
4.5	0	-	-	0	-	-	-
5	0	-	-	0	-	-	-

Figure 4: South Location, plot of all intervals after filtering



It is noted that the closest turbine to the southern monitor is in Iowa and is therefore not considered as part of the study. The operating conditions of any Iowa turbines during the measurement period is unknown.

General Notes:

- Each single data point in this analysis is 1-minute in length. The "Minutes of Data" column is representative of both the total minutes of valid data as well as the number of data points assessed.
- "SNR" is the difference between Total Noise and Background L50 sound levels in a wind bin, measured in decibels. It is how much the sound level drops when the turbines are turned off (or vice versa). An SNR value greater than 6 dB indicates a relatively strong acoustic signal from the wind turbines, and an SNR value less than 3 dB is a very weak signal.
- Wind bins for all locations are set to 0.5 m/s wide, due to the limitation in data resolution from the weather station at these locations. The weather station has already "pre-binned" the wind speed data – visible in the scatter plots for these locations – and the analysis presented here has been adjusted to reflect that binning.
- L50 and L10 data, on which the Minnesota sound level limits are based, have been calculated in Aercoustics' assessment dataset by calculating the 1-minute percentiles from the 1-second intervals provided in the raw data. Wind bin averages are then calculated using the arithmetic mean of all valid L50/L10 levels in that bin. This result very closely approximates the true L50/L10 of the wind bin, however it does not necessarily follow the minimum sampling requirements outlined in the ANSI-ASA S12.100(2014) standard.

Summary

Measured Turbine-Only sound levels at each location are summarized in the table below. All reported sound levels are A-weighted (dBA), and the maximum level is reported only for wind bins having at least 60 Total Noise datapoints (i.e., one hour of data).

Location	Maximum Total Noise (L50)	Maximum Total Noise (L10)	Sound Level Limits (L50/L10)	Compliant? (Yes/No)	Predicted Level (L50)	Turbine-Only (L50)	SNR (dBA)
North	47	48	50/55	Yes	45	46	11.7
Central	44	46	50/55	Yes	44	44	11.5
West	47	49	50/55	Yes	45	46	6.7
South	43	44	50/55	Yes	45	43	7.8

Discussion

Total Noise L50 and L10 sound levels at all locations were found to be below the applicable limits at all wind speeds where sufficient data (at least 60 minutes) was collected. The measured L50 sound levels are also in line with the predicted sound levels, measuring at or slightly (1 dBA) above the predicted levels for all monitors except the South monitor. At the South monitor, the lower measured level may be explained by the unknown operating conditions of the nearest turbine to the receptor which resides on the Iowa state side of the facility.

The results are not filtered by wind direction, due to the general lack of available downwind conditions with which to conduct the assessment. As an exercise, the minimum required turbine power thresholds were reduced at each monitor to see if sufficient downwind data became available. The results are presented in the table below.

Location	Minimum Turbine Power Threshold (% of rated power)	60 minutes of data available?	Total Noise (L50)
North	60%	yes	44 dBA
Central	0%	no	-
West	60%	yes*	45 dBA
South	80%	yes	44 dBA

* 55 minutes of data. This is considered close enough to 1-hour to report results.

At the south monitor – the only monitor with a substantial amount of downwind data at a high turbine output – it was found that adding a downwind restriction increased the measured sound level by only 1 dBA. The West and North monitors indicated a reduction in total noise by 2 dBA, although it is possible that this is attributed to the reduced power threshold. Further, Aercoustics' research conducted on sites having similar topography found that the difference between wind directions may not to be a significant factor[3].

These findings, along with the fact that the highest measured Total Noise level was 47 dBA, indicate that the facility is likely to be in compliance with the applicable Minnesota sound level limits.

[3] Halstead, Fung, "A study of the relationship between wind direction and sound level for wind turbines measured in the far-field", *9th International Conference on Wind Turbine Noise*, Remote from Europe, May 18-21, 2021

Conclusion

Based on Aercoustics' review of the monitoring report and raw data, the assessment of the monitoring data using the binning method has resulted in sound levels at or below the applicable limits at all four locations during the measurement period. While there was not enough data to assess the downwind condition at all monitors, there is a sufficient margin of compliance at all monitors to conclude that the sound levels at all locations are likely to comply with the applicable sound level limits.

AERCOUSTICS ENGINEERING LIMITED

Duncan Halstead, B.A.Sc., P.Eng.

Payam Ashtiani, B.A.Sc., P.Eng.