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ATTN: Derek, Dudek

CC: -

Subject: Acoustic I-Audit for the Cedar Point II Wind Power Project
REA#6914-95L5JBB

Aercoustics Engineering Limited ("Aercoustics") has been retained by Cedar Point II LP to complete the acoustic audit outlined in the Renewable Energy Approval ("REA") for the Cedar Point II Wind Power Project ("Cedar Point"). Cedar Point operates under REA #6914-95L5JBB.

This letter contains responses to MECP comments received on July 9, 2019 for the Cedar Point II Wind Power Project I-audit reports which are provided below. Original MECP comment is provided in black and Aercoustics' response is provided in purple.

1 – Assessment and invalid assumptions: The concept of applying the worst-case scenarios in the report was not fully implemented in the assessment.

A) Invalid Data Point Usage in Calculations – Turbine ON: The closest wind turbines of the facility were not operating at its nominal output (or close to its nominal power generation) for a part of sound levels used in the analysis. Please see the examples below:

- *M96 – Fall Audit, ON Data: Power output of the closest wind turbines for October 5, 2016 at 5:00 am recorded as -26.1 kW (RPM of 7.9 rpm), which is an invalid data filtering assumption for a Turbine ON status.*

- M96 – Fall Audit, ON Data: Power output of the closest wind turbines for October 25, 2016 at 4:00 am recorded as 71.4 kW (RPM of 8.1 rpm), which is an invalid data for a Turbine ON status.

- M96 – Fall Audit, ON Data: Power output of the closest wind turbines for November 1, 2016 at 1:00am recorded as 12.4 kW (RPM of 7.8), which is an invalid data filtering assumption for a Turbine ON status.

- A full list of invalid data points is attached in an Excel file for reference (2% = 51/3006 of the ON data for fall audit at M96 was found to have wind turbine power output of less than 500 kW).

  An error was found in the excel export provided previously to the Ministry which incorrectly matched some data intervals with the corresponding Turbine Operational data. It should be noted that the error is limited to the excel export provided to the Ministry and does not affect the analysis. A corrected version of the excel export is included as part of the submission with this letter. It is expected that the corrected excel exports will address the above concerns.

B) **Invalid Data Point Usage in Calculations – Turbine OFF:** There are invalid data points used in the sound level calculations. A few examples are listed below:

- M96 – Fall Audit, OFF Data: Power output of the closest wind turbines for October 14, 2016 at 10:00 pm is recorded as 1513.8 kW, which is an invalid data filtering assumption for a Turbine OFF status.

- M96 – Fall Audit, OFF Data: Power output of the closest wind turbines for October 25, 2016 at 10:00 pm is recorded as 403.8 kW, which is an invalid data filtering assumption for a Turbine OFF status.

- A full list of invalid data points is attached in an Excel file for reference (0.5% 2/435 of the OFF data for the fall audit at M96 was found to have wind turbine power output of greater than 50 kW).

  An error was found in the excel export provided previously to the Ministry which incorrectly matched some data intervals with the corresponding Turbine Operational data. It should be noted that the

error is limited to the excel export provided to the Ministry and does not affect the analysis. A corrected version of the excel export is included as part of the submission with this letter. It is expected that the corrected excel exports will address the above concerns.

C) **Turbine OFF Sound Levels:** The Turbine OFF sound levels for the wind speed bin of 7m/s is not representative of the data at measured location. The exclusion limit or minimum hourly Leq was not used (i.e. the ambient Leq were not a representative of the measurement). This methodology makes the conclusion of the audit reports unacceptable. No Leq was provided beyond 10 pm to 5 am to confirm the validity of Leq used in the calculations.

Elevated sound levels during high wind speeds (6 and 7m/s) were observed at all receptors during both campaigns. The elevated sound levels are due to wind induced noise.

Wind-induced noise is comprised of two sources: self-noise and foliage noise. Self-noise results from wind blowing over objects associated with the monitoring equipment and is similar to what one might observe when wind blows over the ear on a windy day. Self-noise is present in all monitoring campaigns at high wind speeds. Conversely, foliage noise is the noise made by vegetation and foliage as it interacts with the wind. The sound level depends on the vegetation in the area surrounding the monitor. Measures to reduce the impact of wind-related noise were employed at the monitor location, as prescribed in the Protocol; a secondary wind screen was installed to reduce-self noise, and the monitoring equipment was located away from trees as much as practically possible.

All measurement data available was provided to the Ministry. The measurements are required to be conducted between 10pm and 5am. The acoustic equipment is self-contained and is powered by batteries which are sustained by a solar panel. The monitoring equipment was turned off before and after the required measurement period as a practical limitation to conserve energy.

D) **Data Filtering Beyond Acceptable Hours:** The company in email dated January 22, 2019 stated: "*The Provincial Officer's Order relates to and*

alleges non-compliance with Condition E1 of the Company's Renewable Energy Approval, which requires that the Company carry out an Acoustic Audit – Immission of the Sound Levels produced by the operation of the Equipment in accordance with Part D of the Compliance Protocol for Wind Turbine Noise. With respect to the data intervals for the acoustic audit, section D5.2 of the Protocol specifically states that "intervals must be measured between 22:00 and 5:00 (i.e. nighttime only). "Part D of the Protocol does not require that daytime measurements be taken nor reported for the purposes of the acoustic audit."

In fact, part of the data – included in the calculation – was collected outside of the acceptable time range as specified in the protocol (i.e. beyond acceptable time between 10:00 pm and 5:00 am). For example, one of the data points submitted for M1414 Fall Audit recorded on Nov. 16 2016, 05:03 AM for the Turbine OFF status is included in the calculation. First, the data shows that data beyond the specific time interval is exist but was not provided to the ministry. Secondly, this data is invalid and should not be used in the calculations.

As previously stated, all measurement data available was provided to the Ministry. The acoustic equipment is self-contained and is powered by batteries which are sustained by a solar panel. The monitoring equipment was automatically turned off before and after the required measurement period as a practical limitation to conserve energy.

The timer settings for the equipment used for the M1414 Fall audit was configured such that the sound level meter began measurements at 10:00 pm and ended measurements at 5:03 am on a daily cycle.

It should be noted that the example cited by the Ministry for M1414 Fall audit recorded on Nov. 16, 2016, 5:03am is not labelled as a Turbine OFF data point and has not been included in the analysis.

E) **Improper Listening to Audio Recordings:** The procedure of post measurement listening/analysis to the audio recordings was not properly conducted. As a result, some of Turbine OFF data points are invalid. Please see below for examples:

- M1414 Fall Audit, OFF status, Dec. 1, 2016, 10:31:00 PM, sound level at 5.1 m/s wind speed recorded as 51.2 dBA (exclude data point at same night at 5.8 m/s wind speed recorded as 41.9 dBA, about 10 dB lower than the number in the calculations). This is an invalid data point.

- M1414 Fall Audit, OFF status, Dec. 20, 2016, 4:19 AM: sound level at 7.4 m/s wind speed recorded as 49.8 dBA. This is greater than 95% of the all data collected for the same bin at the same receptor (420 data points were collected in total for Turbine ON, Turbine OFF measurements as well as the acceptable excluded number of data points). It is unclear what source(s) would cause a sound level of 49.8 dBA at 4am. This makes the analysis unacceptable.

  The MECP requested that the I-audit reports are updated to use the Energy Method Analysis which is consistent with the 2017 Compliance Protocol. (September 27, 2018 correspondence)

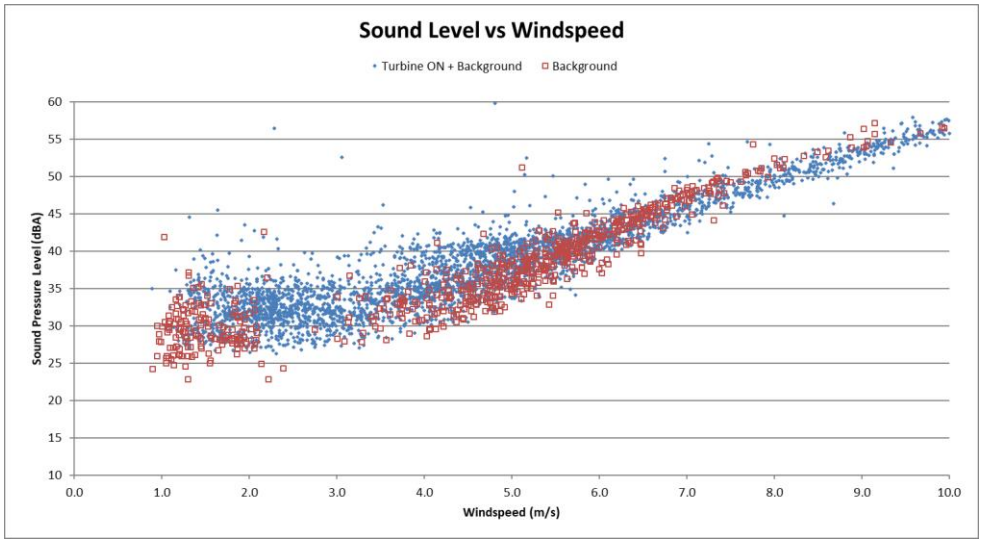
  It should be noted that the logarithmic average (energy method) of the 1-minute Leq samples is more susceptible to transient contamination when compared to the arithmetic averaging method that was previously used. Therefore, as part of the request to update the analysis to use the Energy Method analysis the acquired data was reassessed to remove contaminated data points that were not removed by the automated filters.

  Receptors M130 and M1395 for both the fall and spring audit were reassessed to remove contaminated data points that were not removed by the automated filters via listening tests and spectral analysis.

  It should be noted that the other receptors were found to have less contamination and no additional listening/filtering was applied. This includes the M1414 Fall data set highlighted in the Ministry comments above.

  The scatter plot of sound level vs wind speed for M1414 Fall audit is provided in Figure 1.

Figure 1 M1414 - 2nd Immission Audit - Turbine ON and Background



It can be seen that although outliers are included in the data, that there is little contamination in the Background data spread. There is one outlier in the background dataset which corresponds to the data point highlighted by the Ministry (M1414 Fall audit, OFF Status, Dec 1, 2016 10:31 pm – 5.1m/s and 51.2 dBA). The inclusion of this contaminated data point is considered negligible and does not affect the assessment of compliance.

The data point has been removed from the analysis and the results presented in Appendix A. The removal of the contaminated data point resulted in a 0.5 dB reduction to the background sound level in the 5m/s wind bin. Compliance is demonstrated after the removal of the contaminated data point. Furthermore, the maximum Turbine Only level in any wind bin for this monitor has a margin of compliance of 3dBA. It is unlikely that removing additional outliers would change the compliance status at this monitoring location.

It should be noted that the data point excluded in the same night at 5.8 m/s wind speed recorded as 41.9 dBA is the data interval corresponding to Dec 01, 11:52pm. This data point was excluded as not all turbines within proximity of the audit location were parked and therefore this interval is not considered ambient.

The data point for M1414 Fall Audit, OFF status, Dec 20, 2016, 4:19 am is the data point with the highest sound level in the 7m/s Turbine OFF wind bin and has been highlighted by the MECP as a contaminated data point. The source of noise is wind-related noise previously discussed in Section 1.c. It should be noted that wind induced noise is present for both Turbine ON and Turbine OFF at the 7m/s wind bin and the scatter plot confirms that the sound levels are similar in this wind bin. Measures to reduce the impact of wind-related noise were employed at the monitor location, as prescribed in the Protocol; a secondary wind screen was installed to reduce-self noise, and the monitoring equipment was located away from trees as much as practically possible. However, it is not possible to eliminate the affect of wind induced noise at very high wind speeds.

For audit location M1414 Fall the average measured Turbine OFF level in the 7m/s wind bin is greater than or equal to the Turbine ON level, this indicates that the local ambient noise sources, rather than the turbines are driving the overall sound level in this wind bin and as such an assessment of the Turbine ONLY has not been made for this wind bin.

F) **Site Curtailment Filter:** An additional filter termed “Site Curtailed: was used in the submitted data analysis. This is neither defined (protocol or audit report) nor acceptable to Ministry. Please see the example below:

- M96 Spring Audit, June 7, 2016, 10:02:00 PM for 7.3 m/s -> Sound level of 50.3 dBA and wind turbine power of 1636.6 kW (this data point and similar data points can be qualified as a ON data)

The Independent Electricity System Operator (IESO) can require a wind farm site to be curtailed. This is an involuntary reduction in the power output of the facility to match the electricity demand required at that time. Typical curtailment commands require the entire site to reduce power output to 0MW. During curtailment the turbine is operated at a reduced RPM and the acoustic output of the turbine is in turn reduced. This is not considered normal operation.

Dispatch instructions from IESO which resulted in any form of curtailment of the facility was provided to Aercoustics to confirm

periods when the turbines were not operating normally such that these periods could be excluded from the analysis.

2 – Trend of Data (reference to Table 4-9 of the audit reports): The trend of equivalent sound levels (Leq) for wind turbine ON status from one consecutive wind speed bin to the next is different from the equivalent sound levels (Leq) for wind turbine OFF status. Note that, the number of data points for collected Turbine ON status is also significantly higher than the number of data points collected for Turbine OFF status (for example, for the M96 Spring Audit for a wind speed 5 m/s, the number of ON data points is approximately three times greater than the number of OFF data points (1077 to 372 respectively), making the trend of the sound levels for Leq OFF more inaccurately impactful than the Leq ON. The selection and trend of the OFF data points were performed in a way that makes the assessment unacceptable as the changes in the Leq OFF are significantly higher than the Leq ON. For reference, a couple of example are shown below:

- M96 – Spring Audit: Observing the change from bin 5m/s to 6m/s, the difference in the Leq OFF is 4.7 dB (=42.3 -37.6) as opposed to the difference in the Leq ON of 2.7 dB (=44.1 -41.4)

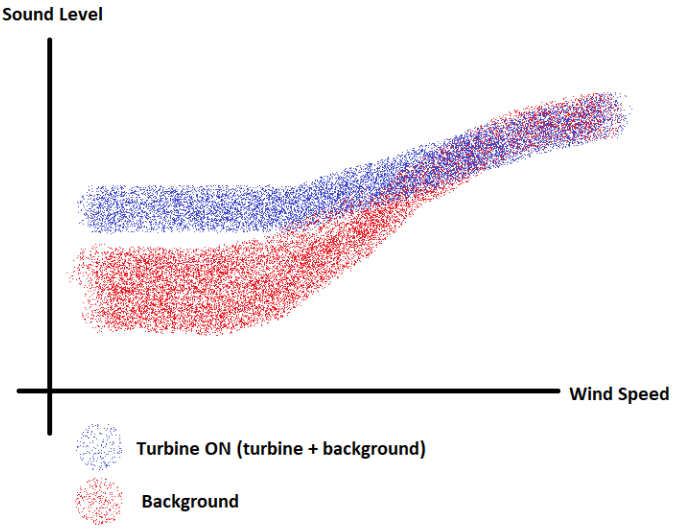
- M1414 Fall Audit: Observing the change from bin 5 m/s to 6 m/s, the difference in the Leq OFF is 4.2 dB (= 42 – 37.8) as opposed to the difference in Leq ON of 2.1 dB (= 42.4 – 40.4). This trend is not representative of the data of this monitoring location as the slope of the Turbine OFF data is twice as great as the slope of the Turbine ON data when plotting the data on a graph depicting sound levels against wind speed bins. This makes the submitted analysis unacceptable.

- M1414 Fall Audit: The Leq OFF is 46.9 dBA and is greater than the Leq ON of 46.7 dBA for a wind speed bin of 7 m/s. This makes the analysis unacceptable.

Trend analysis of wind turbine levels sound levels should be approached with caution because the relationship between ground level winds and wind-induced ambient noise is not linear, it's logarithmic [1] [2] [3]. Further, the trend of the Turbine ON levels vs. ground level wind speed has two distinct sections: at low ground level winds where the turbine noise dominates, and at high ground level

winds where the ambient noise dominates. The typical relationship between wind speed and sound level of both ambient and Turbine ON sound levels is shown in the conceptual drawing in Figure 1. The wind speed at which the ambient noise overtakes Turbine ON noise, the rate of increase of ambient noise, and the minimum sound level of ambient noise all depend on the nature of the surroundings for each monitor.

Figure 2: Example of the typical relationship between sound level and wind speed for Turbine ON and Background periods



Trend analysis will also lead to increased error in the estimation of turbine sound levels if the correlation coefficient of the data is low. For example, the IEC 61400-11 (edition 2.1) standard requires a minimum coefficient before trend analysis can be conducted; it also uses a 4th order polynomial fit to the data. Further, the subsequent revision of the IEC standard (Edition 3.0) abandoned trend analysis altogether in favour of the binning method (which is the same method used by the Compliance Protocol). Receptor-based field measurements experience more variation in measured sound level compared to IEC 61400-11 measurements, which therefore makes trend analysis even more prone to error.

3 – Missing Data Points: The part of the collected data points was not provided to the ministry. For example, only 94% of data for the Fall Audit at M96 between October 4, 2016 and December 12, 2016 was submitted, with the other 6% of the

data missing. In particular, sound levels for the night of October 12, 2016 are missing.

> As previously stated, all measurement data available was provided to the Ministry. The acoustic equipment is self-contained and is powered by batteries which are sustained by a solar panel. The monitoring equipment was turned off before and after the required measurement period as a practical limitation to conserve energy.
>
> Time intervals for Fall Audit at M96 not provided to the Ministry between October 4, 2016 and December 12, 2016 are related to equipment technical problems when the monitor was malfunctioning including communications issues or battery/power issues.

4 – Wind rose pattern: Wind rose pattern for OFF data are not similar to other patterns. This may affect the assessment. In particular, the patterns of wind rose for Excluded data points and ON data points are consistent with annual wind rose of the site. However, the patterns of OFF wind rose are inconsistent with ON/annual/Excluded wind rose. This change can be observed from the wind roses in the audit reports and from the data provided in the Excel sheets (January 22, 2019 supplementary data). This was not justified.

> The Turbine ON and Turbine OFF data has not been filtered for wind direction. The Turbine OFF (ambient sound level) data is not considered to be dependent on wind direction in any significant way at these locations and therefore has not been filtered for wind direction. There is no requirement in the 2011 Protocol for wind direction filtering for Turbine OFF data.
>
> Additionally, it should be noted that the 2017 Compliance Protocol section D.5.2 of the protocol specifically does not required the ambient noise to be filtered for wind direction.

Please do not hesitate to contact us should you have any questions or require anything further.

Sincerely,

AERCOUSTICS ENGINEERING LIMITED

A. Munro

Allan Munro, B.A.Sc., P.Eng

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

1 References

[1] O. Fégeant, "Wind-Induced Vegetation Noise. Part I: Field Measurements," *Acta Acustica,* vol. 85, no. 2, pp. 241-249, 1999.

[2] O. Fégeant, "Wind-Induced Vegetation Noise. Part II: Field Measurements," Acta Acustica, vol. 85, no. 2, pp. 241-249, 1999.

[3] A. L. Rogers and J. Manwell, "Wind Turbine Noise Issues," 2002.

Appendix A

Supporting information for M1414:
Summary of Results: 2nd I-Audit Receptor M1414

A.1 M1414 I-Audit Results

The following table details the sound levels measured at receptor M1414 during the 2nd I-Audit when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). The Turbine OFF data point corresponding to Dec 1, 2016 10:31 pm – 5.1m/s and 51.2 dBA has been assessed as contaminated and removed from the analysis. Based on the calculated Turbine only component indicated in Table A.01 the Cedar Point Wind Power Project is compliant with the MECP limits at receptor R1414.

Table A.01: R215 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY*	MECP Sound Limit
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]		
4	509	36.8	3.0	77	33.9	2.5	34	40
5	653	40.4	2.8	185	37.3	2.5	37	40
6	439	42.4	2.3	151	42.0	2.1	32	40
7	226	46.7	2.2	68	46.9	1.6	**	43

** measured turbine OFF level equal to or greater than Turbine ON level, no Turbine ONLY level could be determined

Figure A.01: M1414 - Measured Sound Levels for Turbine ON and Background vs Wind Speed