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ASSESSMENT REPORT - **Project: 15247.03**

Armow Wind Power Project
Acoustic Immission Audit – R68

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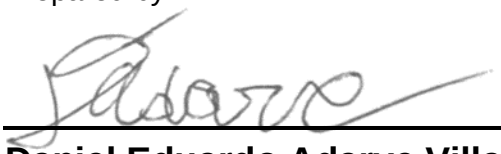

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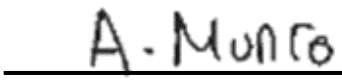

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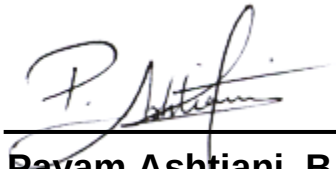

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07 February 2020

Revision History

Version	Description	Author	Reviewed	Date
1	Final Report	DEA	AM	February 7, 2020

Important Notice and Disclaimer

Executive Summary

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP to complete a RAM-I audit at receptor R68 the location of the worst-case noise receptor for the wind turbines identified in the REA as T68 and T80. AWPP operates under REA #4544-9B7MYH, issued on October 9, 2013 [1]. This report has been completed to address item 2(b) of the Scope of Work letter prepared by AWPP dated July 26, 2019.

The audit has been conducted as per the methodology outlined in Part D and E5.5 RAM-I (Revised Assessment Methodology) of the "MECP Compliance Protocol for Wind Turbine Noise" (Updated April 21, 2017). This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the MECP sound level limits.

The monitoring near receptor R68 spanned the following dates:

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
R68	September 19, 2019	January 5, 2020	15

Based on the results presented in Section 10.2 of this report, the cumulative sound impact calculated at R68 complies with the MECP sound level limits at all wind bins having sufficient data for assessment.

A summary of results for cumulative turbine-only sound impact at R68 is provided below.

R68 Assessment Table – Cumulative Turbine-only Sound Impact

Audited Receptor	Wind speed at 10-m AGL [m/s]	1	2	3	4	5	6	7
R68	Cumulative Sound Impact - Receptor Location [dBA]	-	-	40	40	40	26	-
	MECP Exclusion Limit [dBA]	40	40	40	40	40	40	43
	Compliance? (Y/N)	-	-	Yes	Yes	Yes	Yes	-

Relevant tones from AWPP turbines were not present at receptor R68 and as such no tonal adjustment is applicable.

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1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("AWPP") to complete the immission audit ("RAM-I audit") at receptor R68 the location of the worst-case noise receptor for the wind turbines identified in the REA as T68 and T80. AWPP operates under REA #4544-9B7MYH, issued on October 9, 2013 [1].

As per Section E1(2) of the AWPP REA, I-audits are to be conducted at five (5) Points of Reception for two (2) separate occasions. Acoustic immission audits have been previously conducted at receptors R165, R189, R215, R221 and V556 for AWPP in accordance with The Compliance Protocol for Wind turbine Noise published in 2011 (the "2011 Compliance Protocol"). The results of these measurements were submitted to the Ontario Ministry of Environment, Conservation and Parks (MECP) in the following reports; to fulfil the measurement requirements per Section E of the REA:

- Armow Wind Power Project – 1st Acoustic Immission Audit dated February 08, 2017, and

- Armow Wind Power Project – 2nd Acoustic Immission Audit dated February 22, 2017.

In addition to the reports submitted to fulfil the measurement requirements per Section E of the REA the MECP has required additional acoustic measurements detailed in Director's Order No. 2868-B8VRY4-1 dated June 19, 2019 (the "Order").

As per Item 2(a) of the Scope of Work letter prepared by AWPP dated July 26, 2019 to complete in satisfaction of the order; a RAM I-audit has been conducted in accordance with The Compliance Protocol for Wind Turbine Noise published April 2017 (the "2017 Compliance Protocol") regarding equipment set-up requirements, with measurement of tonality to be undertaken in accordance with ISO 1996-2:2017 at receptor R68 the location of the worst-case noise receptor for the wind turbines identified in the REA as T68 and T80. Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

The worst-case noise receptor for the AWPP from turbine T68 and T80 is receptor R68 based on the criteria of the greatest predicted noise impact, i.e. the highest predicted sound level and the receptor is in the direction of prevailing winds from the facility.

The RAM I-audit at receptor R68 was conducted from September 2019 to January 2020.

The audit has been conducted as per the methodology outlined in Part D and E5.5 RAM-I (Revised Assessment Methodology) of the "MECP Compliance Protocol for Wind Turbine Noise" (Updated April 21, 2017). This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the MECP sound level limits.

2 Facility Description

The Armow Wind Power Project is located in the municipality of Kincardine, Ontario. The site is bound by Concession 4 to the north, North Line to the south, Highway 21 to the west, and County Road 1 to the east.

The AWPP consists of 91 Siemens SWT-2.3-101 wind turbines for power generation, with a total nameplate capacity of 180 MW. Each turbine has a hub height of 99.5 meters or 80 meters, a rotor diameter of 101 meters and an individual nameplate capacity of either 2.3MW, 2.221MW, 2.126MW, 2.03MW, 1.903MW or 1.824MW. The facility operates 24 hours per day, 7 days per week. A Site Plan of the facility and the surrounding area are provided in Appendix A.1.

3 Audit Receptor Selection

3.1 Receptor Selection Criteria

As per Item 2(a) of the Scope of Work letter prepared by AWPP dated July 26, 2019 to complete in satisfaction of the order; a RAM I-audit has been conducted in accordance with The Compliance Protocol for Wind Turbine Noise published April 2017 (the "2017 Compliance Protocol") at receptor R68 - the location of the worst-case noise receptor for the wind turbines identified in the REA as T68 and T80.

The receptor R68 is situated downwind with respect to the prevailing wind direction. Further details regarding the monitoring position are provided in Section 4.2.

3.1.1 Prevailing Wind Direction

The prevailing wind direction was determined using historical weather data for the site. A wind rose showing the historical wind direction at the site is included Figure 1. The predominant wind direction is from the south/southwest, specifically 203° from True North.

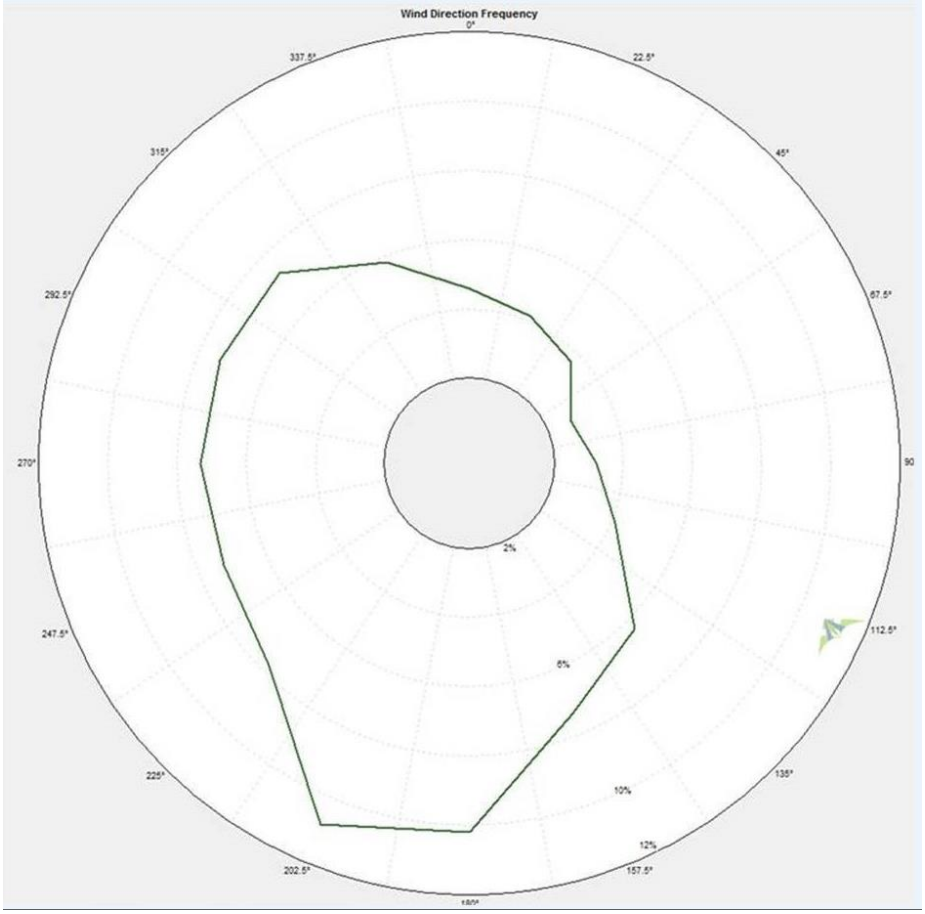

Figure 1 - Historical Wind Roses for AWPP

4 Audit Measurement Location

The following section describes the measurement location used for R68 and provides context to the ambient acoustic environment observed at the AWPP.

4.1 Existing Ambient Environment

The ambient acoustical environment measured at R68 was observed to be influenced by wind-related noise, infrequent traffic noise and natural sounds from flora and fauna. These factors are described below.

4.1.1 Wind-Related Ambient Noise

Wind-related 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 and increases with increasing wind speeds around the microphone and wind screen. Conversely, foliage noise depends on the vegetation in the area surrounding the monitor. Vegetation noise increases with increased wind speeds and wind gusts at the vegetation location. 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. Specifically, for receptor R68 there are multiple trees 30-130m away along the adjacent fence line and in the resident's backyard.

4.1.2 Traffic Noise

Occasional transient contamination from local road traffic in the vicinity of R68, specifically Sideroad 15 N, was filtered out manually by listening, described in Section 6.1.

4.1.3 Flora and Fauna

Ambient contamination from flora and fauna was present to varying degrees at the measurement location. Transient contamination (birds, animal activity etc.) was filtered out manually by listening, described in Section 6.2.

Insects, birds and noise from vegetation rustling were present to varying degrees in the environment surrounding the receptor. Insect noise was present at the beginning of the campaign and was filtered out manually by listening, described in Section 6.2.

4.2 Monitoring Location

Table 1 provides specific details of the receptor and monitoring equipment locations. The immediate surroundings of the monitor location are also described below. Photos of the surrounding area and measurement setup are included in Appendix A.3 and A.4.

Table 1: Receptor and Monitor Locations

Audit Receptor	Measurement Duration	Location	UTM Coordinates [m] (Zone 17T)	Distance to Primary Turbine, T68 [m]	Predicted Level (dBA)†
R68	*September 19, 2020 – January 5, 2020*	*Receptor*	457,717 E 4,891,395 N	630	39.3
		Monitor	457,636 E 4,891,363 N	543	39.4

† Predicted sound pressure level determined using an as-built sound model created by DNV-GL

The closest turbines to Receptor R68 are Turbine T68 (2.030MW) and T80 (2.126MW). In addition, there are 3 turbines within 1250m of receptor R68; with individual nameplate capacity of 1.903MW (T67, T77, and T48).

Monitor R68 was located roughly 370 meters south of Concession 5 Road and 543 meters to the northeast of Turbine T68. The ground cover between the measurement location and Turbine T68 was predominantly flat farmland. The noise monitor was located sufficiently far from the nearby foliage in an attempt to minimize its impact on the ambient sound levels at the monitor location. It should be noted, that because the location was chosen to reduce vegetation noise on the microphone compared to the receptor location, there will be less masking noise from vegetation at the microphone location, and thus, provide a conservative estimate of the tonal audibility of the facility at R68.

5 Measurement Methodology

The acoustic audit was conducted at receptor R68 and spanned from September 19, 2019 to January 1, 2020.

Measurements and data analyses were conducted per the Protocol. Specific details regarding the methodology are presented in this section.

5.1 Test Equipment

Measurement equipment used for the I-audit campaign, both acoustic and non-acoustic, is detailed below. Equipment specifications and measurement positions comply with MECP Protocol sections *D2 – Instrumentation* and *D3 – Measurement Procedure*, respectively. Each remote monitoring unit is comprised of the following:

- One (1) Type 1 sound level meter, with microphone and pre-amplifier installed at a height of 4.5 meters, at least 5 meters from any large reflecting surfaces.
- One (1) primary and one (1) secondary windscreen for the microphone. The 1/3 octave band insertion loss of the secondary windscreen has been tested and was accounted for in the measurement analysis.
- One (1) anemometer, installed 10 metres above ground level (“10-m AGL").

The following table lists the specific model and serial numbers for the equipment used during the measurement campaign.

Table 2: Equipment Details

Location	Equipment	Make/Model	Serial Number
R68	Sound Level Meter	NI 9234	1CAF79A
	Signal Conditioner	PCB480E09	35340/36936
	Microphone	PCB 378B02	132191
	Pre-Amplifier	PCB 426E01	178140
	Weather Anemometer	Vaisala WXT 520	P4930909

Equipment lab calibration follows the guidance provided in Section D2.3 of the Protocol for sound level meters and acoustic calibrators, and Section 6.3 of the IEC 61400-11 Edition 3.0 standard for weather anemometers.

The measurement chain was field calibrated before, during, and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator. Calibration certificates have been included in Appendix F.

5.2 Measurement Parameters

During the measurement campaign, acoustic and weather data were logged simultaneously in one-minute intervals.

Measured acoustic data includes A-weighted overall equivalent sound levels ("LA_{eq}"), 90th percentile statistical levels ("L_{90}")[1], and 1/3rd octave band levels between 20 Hz and 10,000 Hz (inclusive). Raw signal recordings were also stored for listening and post-processing. Measured weather data includes average wind direction, wind speed, temperature, relative humidity, and atmospheric pressure. The maximum and minimum wind speed for each one-minute interval was also stored.

To account for the effect of wind speed on the measured sound level, intervals are sorted into integer wind bins based on their measured 10-m AGL wind speeds. Each wind bin ranges from 0.5 m/s below to 0.5 m/s above each integer wind speed (i.e. the 5 m/s wind bin comprises all intervals having average wind speeds between 4.5 m/s and 5.5 m/s).

[1] L_{90} refers to the sound level that is exceeded for 90% of samples in the measurement interval.

6 Assessment Methodology

6.1 Data Reduction and Filtering

Data reduction procedures have been employed to remove invalid and extraneous data points from the measured dataset to form a refined assessment dataset. Specific filters are described below.

A measurement interval is excluded if any of the following criteria are not satisfied:

- The interval occurred between 10pm – 5am
- No precipitation was detected within 60 minutes before or after the interval
- The ambient temperature was above -20˚C

6.2 Manual Exclusion of Data

The application of the filtering methodology outlined in the Protocol and summarized throughout Section 6.1 of this report results in a dataset with significantly less acoustic contamination than is present in the unfiltered dataset. Despite this, it has been found that these automatic filters are not always sufficient to remove all contaminated data intervals. In situations where contamination is suspected in the assessment dataset, listening tests were conducted on the audio recordings to confirm and, if possible, to identify the contamination. Intervals containing significant contamination are manually excluded from the assessment data. This follows the guidance from the Protocol to assess sound levels without extraneous ambient noise.

Data is also manually excluded if it is suspected that any of the measurement equipment is not functioning according to its specification, which may occur during extreme weather conditions such as freezing rain.

6.3 Turbine Power & Wind Direction

Intervals that pass the filtering criteria listed above are sorted into Total Noise[2] or Background periods according to the conditions listed below. If neither Total Noise nor Background conditions are met, the data point is excluded.

- **Total Noise:** All facility turbines within 3 km must be rotating and generating power. For monitor R68 these turbines were:
    - T36, T37, T48, T66, T68, T76, T77, T78, T80, T100, andT104

- **Background:** Facility turbines must be parked and not generating power such that the predicted impact at the measurement location is less than 30 dBA. For monitor R68 these turbines were:

[2] Total Noise refers to the measured sound level with the turbines running prior to the correction for Background sound (i.e. the total sound level of the turbines plus the ambient).

- T36, T48, T67, T68, T76, T77, and T80[3];

The Protocol also requires additional criteria be met by each Total Noise data point based on the conditions of the nearest turbine to each monitor location. Specifically,

> "*Only downwind data will be considered in the analysis. With reference to the Turbine location, downwind directions are ±45 degrees from the line of sight between the Turbine and receptor/measurement location*." *{Section D5.2(4)}*

And

> *"Only data when the turbine's electrical output sound power level is approximately equal to or greater than 85% of its rated electrical power output should be included in the analysis. In addition, the turbine should also be operating at approximately 90% or more of its maximum sound power level; (percentage based on energy/logarithmic calculation)." {Section D5.2(5)}*

6.4 **Sample Size Requirements**

Section D3.8 of the Protocol requires at least 120 Total Noise intervals and 60 Background intervals in a wind bin for that bin to be deemed complete.

RAM-I analysis, described in Section E5.5 of the Protocol, is employed in cases where insufficient data is collected after an extended monitoring campaign lasting 6-weeks or more. The AWPP Phase 1 campaign lasted longer than 6-weeks and therefore RAM-I analysis was applied. The RAM-I methodologies used in this assessment, in addition to those already mentioned are detailed below. Further details regarding the data analysis methodology are provided in Section 9.1.

Section E5.5(1)

The range of wind bins which may be used to assess compliance is expanded to include a minimum of one of the following conditions:

a. *"three (3) of the wind speed bins between 1 and 7 m/s (inclusive), or*
b. *two (2) of the wind speed bins between 1 and 4 m/s (inclusive)"*

[3] Turbines shutdown to satisfy Background criterion for R68 only

Section E5.5(5)

The RAM-I assessment methodology relaxes the sample size requirements, stating:

> "*The Ministry may accept a reduced number of data points for each wind speed bin with appropriate justification. […] The acceptable number of data points will be influenced by the quality of the data (standard deviation)"*

The threshold of 60 data points for Total Noise measurements and 30 data points for Background measurements is used in this assessment.

6.5 Turbine Operating Conditions

Wind facility SCADA information was provided for the duration of the measurement campaign by the Armow Wind Power Project. This data was used to verify that the AWPP wind turbines were operational for Total Noise intervals and parked for Background intervals. The turbine operating conditions were verified by the AWPP for the duration of the campaign; see Appendix D.

6.6 Contribution from Adjacent Wind Facilities

The nearest wind facility to AWPP is Underwood Wind Farm followed by the Cruickshank Wind Farm. The closest UWF turbine to the monitoring location is Turbine T10, 12 km to the north of monitor R68. The closest CWF turbine to a monitoring location is Turbine T5, 8 km to the northwest of monitor R68. At these distances, sound impact from both UWF and CWF is considered to be negligible and thus no contributions from adjacent wind facilities were considered in this study.

7 Sound Level Limits

Sound level limits are set by the MECP and vary based on the classification of the surrounding acoustic environment as well as the measured background sound level (if available). The area surrounding the facility has been deemed in the original Noise Assessment Report to be Class III, having exclusion limits based on 10-m AGL wind speed as noted in Table 3 below.

Table 3: MECP Sound Level Limits for Wind Turbines

Wind speed at 10m height [m/s]	MECP Sound level limit [dBA]
≤ 6	40
7	43

Sections D3.5 and D6 of the Protocol state that in wind bins where the measured background sound levels are greater than the applicable exclusion limits, the sound level limit for that wind bin is the background sound level without extraneous noise sources. In effect, the exclusion limits outline the minimum sound level limit by wind bin, with increases in sound level limit permissible if it can be shown through measurements that the existing background sound level is higher than the exclusion limit. Any complete wind bins where the measured background sound level exceeded the exclusion limit are noted in Table 9.

8 Audit Results

Acoustic and weather data measured during the I-audit campaign are summarized in the following section.

8.1 Weather Conditions

General weather conditions observed in the assessment dataset during the Phase 2 I-audit are summarized in Table 4.

Table 4: General Weather Conditions – Range of Measured Values

		10-m AGL				*Hub height*
		Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]	Wind speed [m/s]
R68	Minimum	970.0	0.0	36.1	-14.8	0
	Maximum	1001.5	17.8	93.9	28.2	24.5

8.2 **Wind Direction**

A wind rose was created for R68 using the yaw angle from the nearest wind turbine (T68) and the wind speeds from the 10-m AGL anemometer. As noted in Section 6.4 of this report, RAM-I methodology is being used, and thus all wind speeds from 1-7 m/s 10-m AGL can be used in the assessment.

The wind rose is provided in Figure 2. The distribution of wind directions observed during the measurement campaign roughly agrees with the historical wind rose (see Section 3.1.1). Supplementary wind roses for the specific valid Total Noise and Background datasets are included in Appendix E.

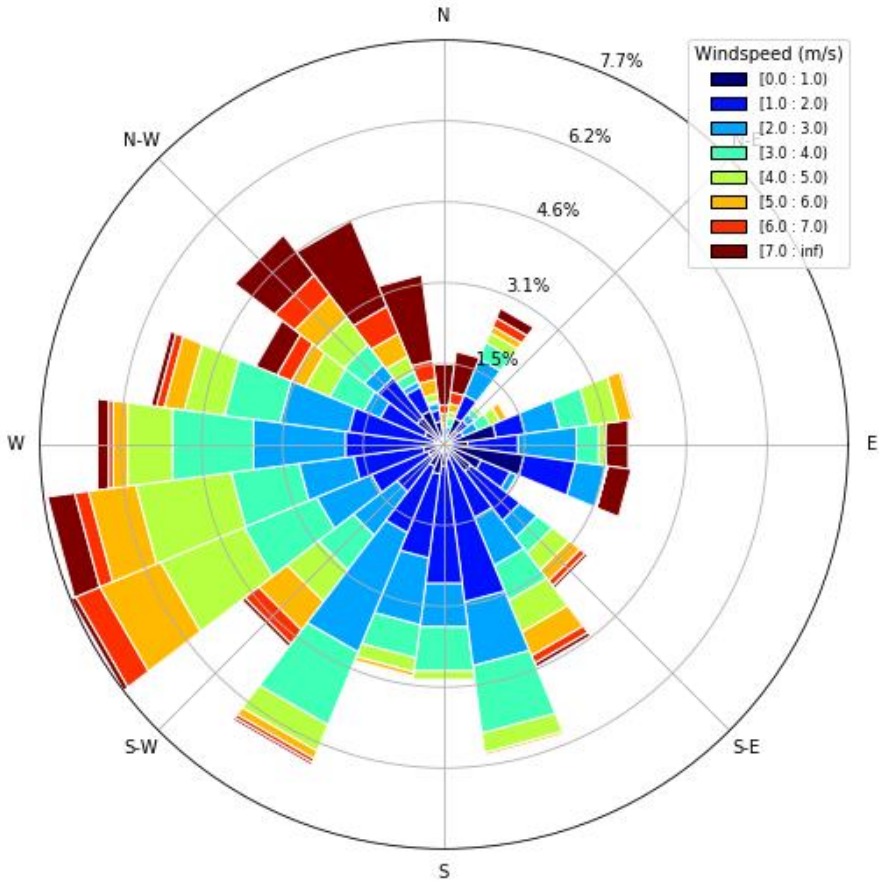

Figure 2: Measured wind rose for R68

8.3 **Measured Sound Levels**

Table 5 presents the average measured sound levels at monitor R68. Results are separated by wind bin into Total Noise and Background periods.

Table 5: Average Measured Sound Levels at R68, RAM-I Analysis

Receptor	Period	Measurement Parameter	I-audit Wind Bins (m/s) 1	2	3	4	5	6	7
R68	*Total Noise*	Number of Samples	0	0	57	308	371	260	64
		Average LAeq [dBA]	-	-	41.0	41.4	42.8	44.9	47.8
		Standard Deviation [dB]	-	-	1.1	1.1	1.3	1.4	1.9
	Background	Number of Samples	494	270	67	107	39	51	31
		Average LAeq [dBA]	28.5	29.7	33.9	36.3	39.6	44.8*	48.7*
		Standard Deviation [dB]	2.1	2.4	2.1	2.1	2.8	1.9	1.8

"-"Significantly fewer than the minimum data counts outlined in 6.4 were attained in this wind bin.
* Background sound level is greater than the applicable exclusion limit.

A visualization of the assessment datasets for R68 is presented in Figure 3 below.

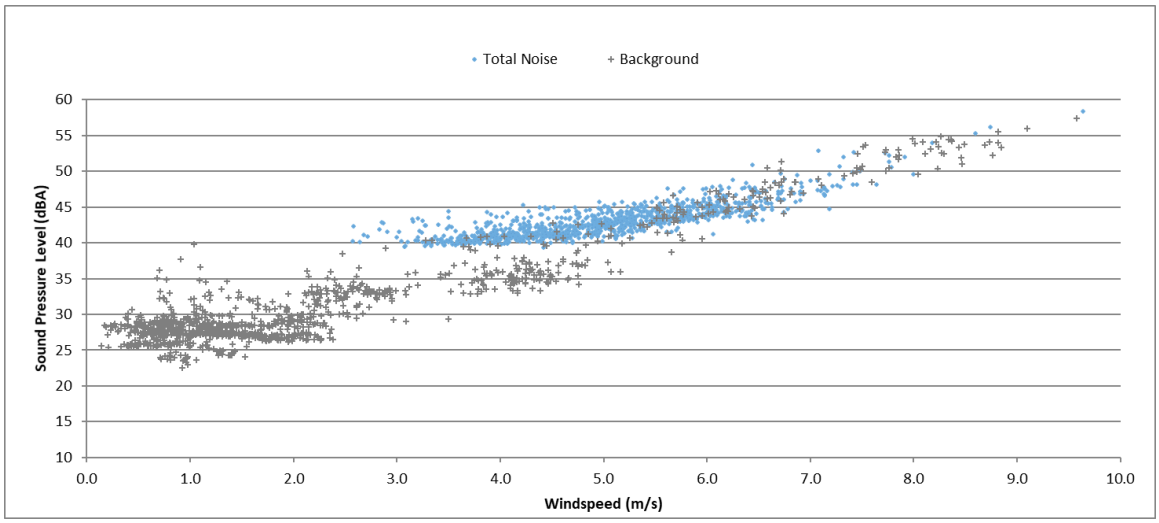

Figure 3: R68 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

8.4 **Measured Tonal Audibility**

The tonal assessment was undertaken in accordance with ISO 1996-2:2017 Annex J which applies the objective method for assessing audibility of tones in noise from ISO/PAS 20065:2016 (Acoustic-Objective method for assessing the audibility of tones in noise-Engineering Method).

Tonality analysis was completed based on 1-minute narrow band spectra, ranging from 20 Hz to 3000 Hz with a frequency resolution of 2 Hz for all intervals.

The tonality analysis results of the Emission audit measurements for T68 [4] and T80 [5] were used as a basis for the frequencies of interest at the receptor which would likely to have been generated by the closest turbines rather than an external source.

A summary of the tonal audibility results for T68 and T80 is provided in the Table below.

Table 6 Summary of Tonality Results from E-Audit

E-Audit Turbine ID	Turbine Type	Max. Tonal Audibility (dB)	Frequency (Hz)	Tonal Presence
T68	SWT-2.3-101 2.030MW (80m hub)	5.2	477	76%
T80	SWT-2.3-101 2.126MW (80m hub)	5.3	477	86%

The frequencies of interest identified are 477Hz and correspond to the maximum tonal audibility of the turbine types in the vicinity of receptor R68; as such any tones identified within ¼ the critical bandwidth centred around the frequencies of interest identified can be attributed to the nearby turbines.

Narrowband data was acquired and calculated for each 1-minute interval used in the immission analysis and binned by wind speed. The mean tonal audibility of each spectra in each wind bin was then evaluated.

For a given spectra if the Tonal audibility is greater than zero then a tone is present. For all spectra in which no tone is found, a tonal audibility of -10 dB is applied (as specified in Section 5.3.9 in ISO/PAS 20065:2016). The Mean Tonal Audibility values reported represent the energy average of all data points with an identified tone that falls within the same frequency of origin and all data points without an identified tone (-10dB).

Tonal assessment summary is provided in Table 7.

Table 7: Tonality Summary – R68 - Turbine T68 and T80 – 480Hz [452Hz - 510Hz]

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tonal Audibility >0	Tonal Presence	Mean Audibility, ΔL (dB)
1	0	0	-	-
2	0	0	-	-
3	57	1	2%	-9.3
4	308	0	0%	-10.0
5	367	0	0%	-10.0
6	259	0	0%	-10.0
7	60	0	0%	-10.0

9 Discussion

9.1 Analysis Methodology

Additional discussion of the measured sound levels and analysis methodology are provided in this section.

9.2 Sample Size Requirement and Signal to Noise Considerations

Sufficient data was collected in wind bins 4,5,6 and 7 m/s to satisfy the RAM-I sample size requirement. For all wind bins where the signal to noise ratio greater than 3 dB was achieved, compliance has been demonstrated. Regarding the 6 and 7m/s bins, the Compliance Protocol does not set expectations for the signal to noise ratio that must be achieved.

Following this, it is worth noting the following:

1. The signal to noise ratio decreases at high wind speeds because of wind-induced ambient noise (see Section 4.1.1 of report.)

2. This is typical of measurements conducted in rural areas at high wind speeds. Further detail is provided in a study of background noise levels measured during far-field receptor testing on wind turbine facilities presented at the 8th International Conference on Wind Turbine Noise in Lisbon in June 2019 [6].

3. Although sometimes achievable, it is not practical to expect signal-to-noise ratios greater than 3 dB above 6 m/s.

9.3 **Effect of Filtering**

The measurement data was assessed according to Part D of the Protocol with the incorporation of the RAM-I data reduction methodology per Section E5.5 of the Protocol. The effect of each filter on the measurement datasets, as well as the total portion of measurement data excluded from the assessment data, are summarized in Table 8.

Table 8: Effect of Data Filtering on Measurement Dataset

Data Filter	*% Data Excluded* R68
Turbine Power Threshold	91%
Wind Direction	61%
Rain	18%
Temperature	0%
Excluded from Total Noise	98%

Table 8 illustrates the proportion of measurement time during the campaign that did not meet the criteria for worst-case noise impact at each receptor. Data not excluded by automatic or manual filters are used in the assessment of compliance. It is important to note that the data remaining after these filters are applied represents the times when the turbines were generating high power output in a downwind condition without significant transient contamination or inclement environmental conditions (such as rain or low temperature). In other words, this remaining data represents the portion of time that the immission impact from the facility is at its highest for the given monitor location.

10 Assessment of Compliance

The following section presents an assessment of compliance for the AWPP based on the results of the Immission Audit.

10.1 Tonal Adjustment

Relevant tones from AWPP turbines were not present at receptor R68 and as such no tonal adjustment is applicable.

10.2 Assessment Tables

Cumulative Turbine-Only sound levels at R68 are presented in the table below. The cumulative noise impact in the table is calculated using the data presented in Table 9. Wind bins having insufficient data with which to determine the cumulative sound impact are marked with a "-". The signal-to-noise for each complete wind bin is also presented. The *Cumulative Sound Impact* is the difference between the average Total Noise and Background sound levels from Table 9, unless otherwise noted.

Table 9: R68 Assessment Table – Cumulative Turbine-only Sound Impact

Audited Receptor	Wind speed at 10-m AGL [m/s]	1	2	3	4	5	6	7
R68	Cumulative Sound Impact - Receptor Location [dBA]	-	-	40	40	40	26	**
	Signal-to-noise [dB]	-	-	7.1	5.0	3.2	0.1†	-0.9†
Background Sound Level [dBA]		-	-	34	36	40	45*	-
MECP Exclusion Limit [dBA]		40	40	40	40	40	40	43
Compliance? (Y/N)		-	-	Yes	Yes	Yes	Yes	-

"-" Significantly fewer than the minimum data counts outlined in 6.4 were attained in this wind bin.
† Signal-to-noise level less than 3 dB (see Table 5). Increased uncertainty in the determination of the Cumulative Sound Impact.
* Background sound level is greater than the applicable exclusion limit.
** Background sound level is greater than Turbine Sound Level; Facility Impact could not be determined

10.3 Assessment of Compliance

Based on the results presented in Section 10.2, the cumulative sound impact calculated at R68 complies with the MECP sound level limits at all wind bins having sufficient data for assessment.

11 Conclusion

Aercoustics Engineering Limited has completed the RAM-I audit at receptor R68 for the Armow Wind Power Project. Testing was conducted in accordance with the methodology outlined in Part D and Part E of the MECP Compliance Protocol for Wind Turbine Noise. Compliance has been demonstrated at receptor R68.

12 References

[1] V. Schroter, “Renewable Energy Approval #4544-9B7MYH”, Ontario Ministry of the Environment, Toronto, ON, October 9, 2013.

[2] Ministry of the Environment and Climate Change, *“Compliance Protocol for Wind Turbine Noise”*, Ontario Ministry of the Environment, Toronto, ON, April 21, 2017.

[3] A. Brunskill, S. Dokouzian, A. Nercessian, D. Boudreau, M.Roberge, D.Eaton, E.Crivella, “Armow Wind Farm, Onatrio – Noise Impact Assessment” GL Garraad Hassan Canada Inc, Ottawa, ON, September 9, 2013.

[4] P. Ashtiani and K. Clark, “Armow Wind Project – Turbine T68 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 25 July 2019.

[5] P. Ashtiani and A. Munro, “Armow Wind Project – Turbine T80 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 25 July 2019.

[6] D. Halstead and N. Tam, “A study of background noise levels measured during far-field receptor testing of wind turbine facilities”, Aercoustics Engineering Ltd., Mississauga, ON, June 2019.

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Mississauga, ON L4Y 0G1

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Fax 416-249-3613
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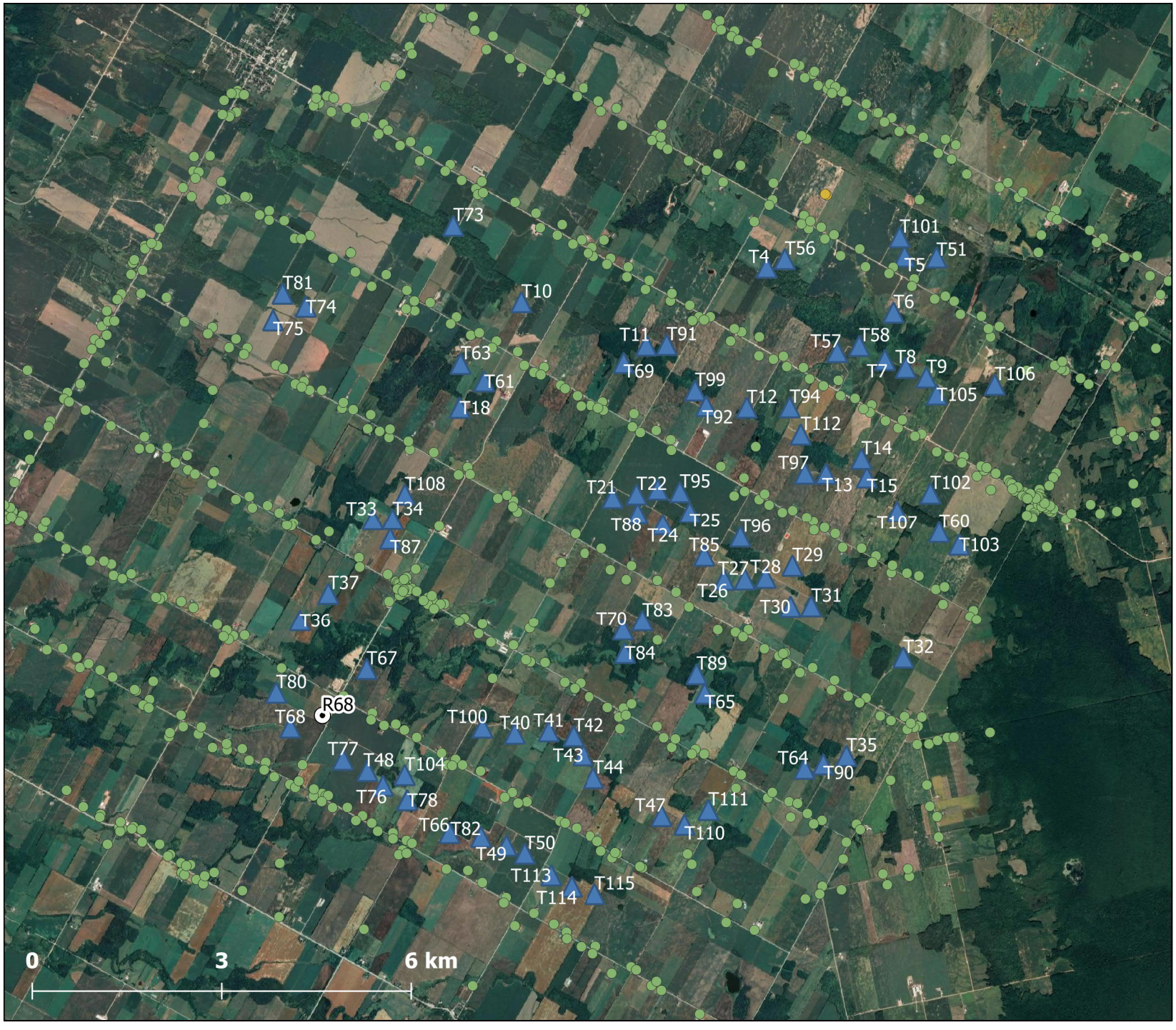
Appendix A
Location Details



Legend

- Transformers
- Receptors
- Monitor
- Turbines

N

Project ID:	15247.03
Drawn by:	DEA
Reveiwed by:	AM
Date:	Jan 18, 2020
Revision:	1
Scale:	As Indicated

Armowr Wind Project
Phase 1 R68 I-Audit Report

Appendix A.1

Site Plan Overview

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Legend

- Sideroad 15 N
- Monitor Location
- Turbines

N

Project ID:	15247.03
Drawn by:	DEA
Reveiwed by:	AM
Date:	Jan 18, 2020
Revision:	1
Scale:	As Indicated

Armow Wind Project
Phase 1 R68 I-Audit Report

Appendix A.2

Monitor and Receptor Location

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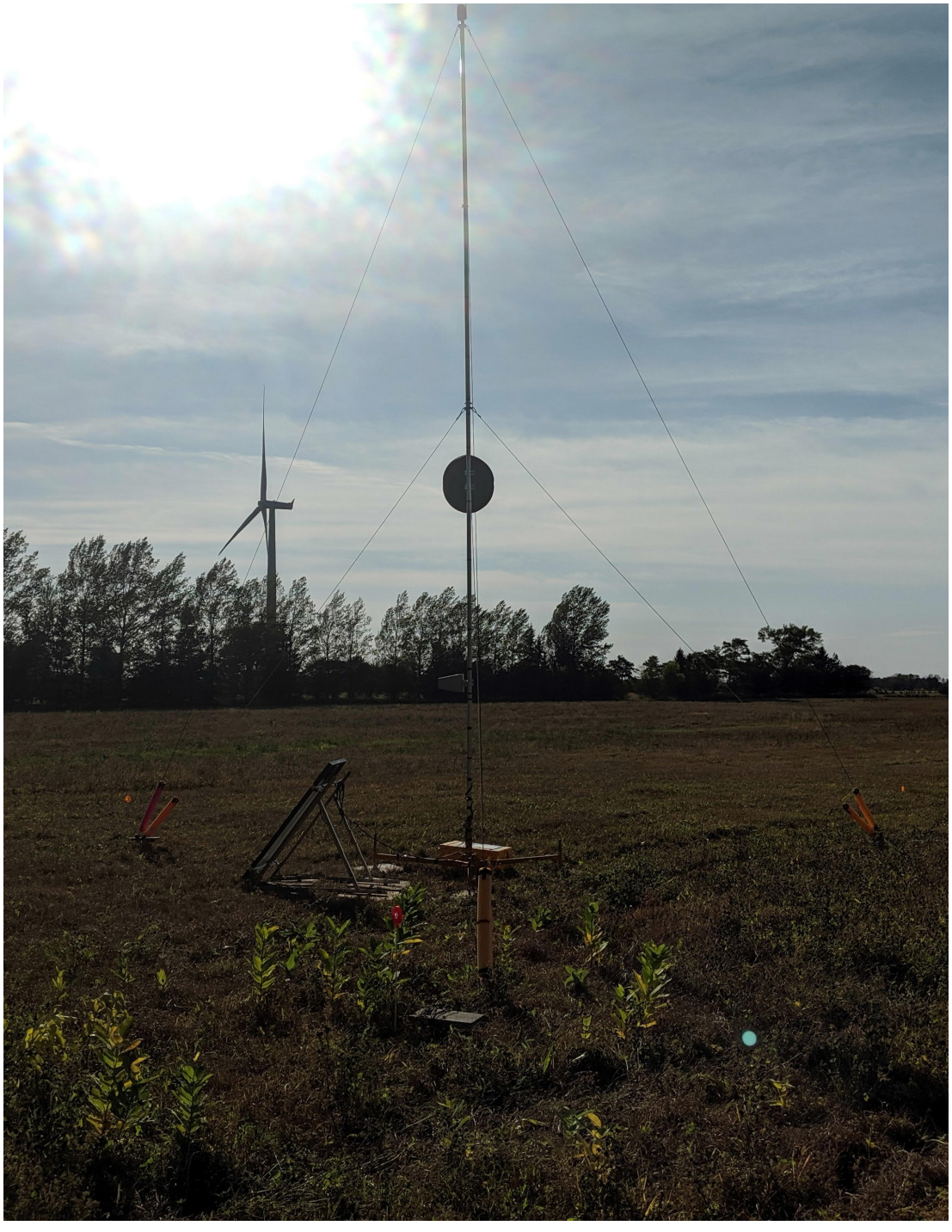

Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: Jan 18, 2020
Revision: 1

Scale: As Indicated

Armow Wind Project
Phase 1 I-Audit Report

Appendix A.3

Site Photos - Monitor R68 to T68

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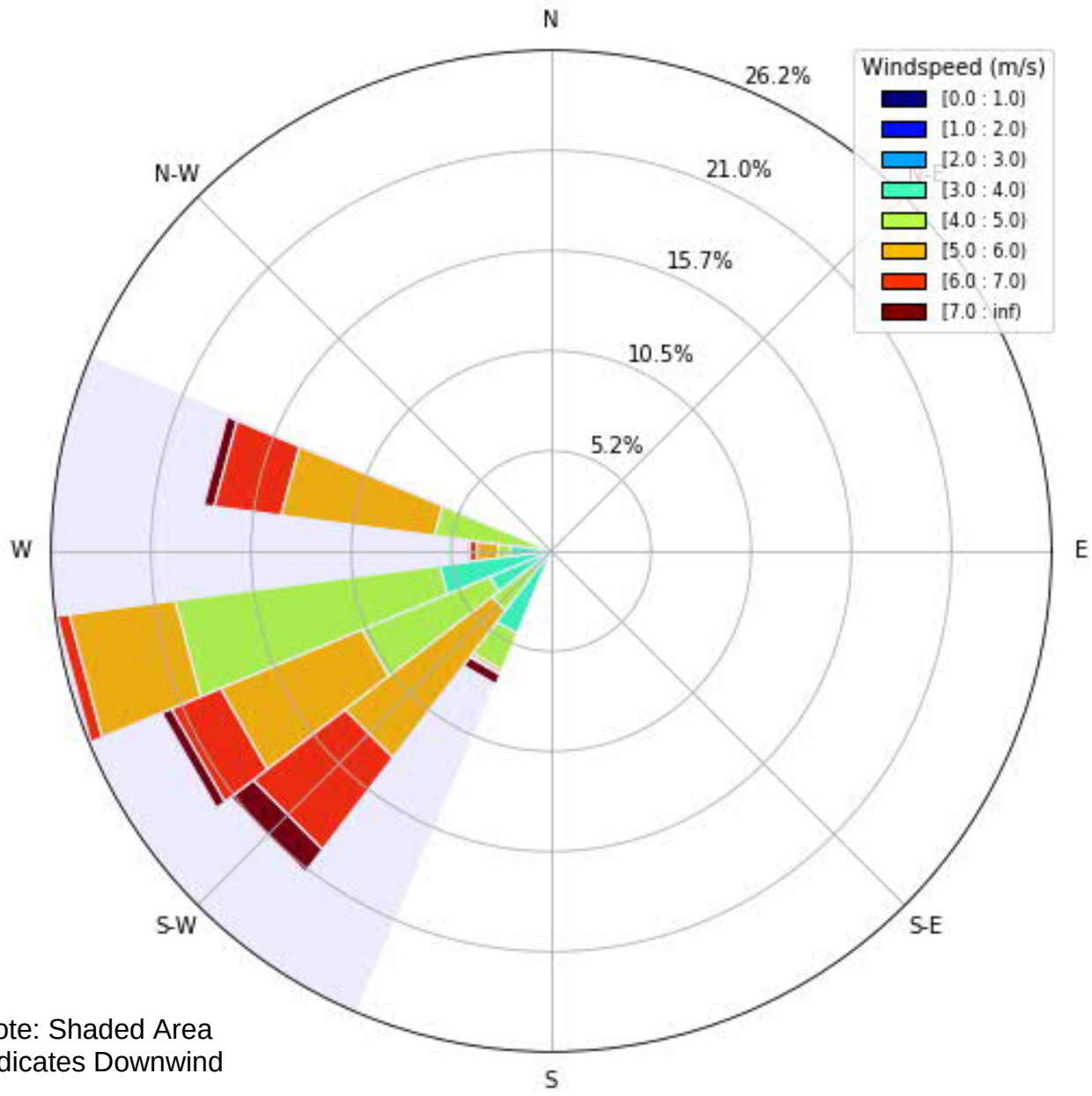
Appendix B
Wind Roses



Note: Shaded Area Indicates Downwind

Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 15, 2020
Revision: 1

Scale: As Indicated

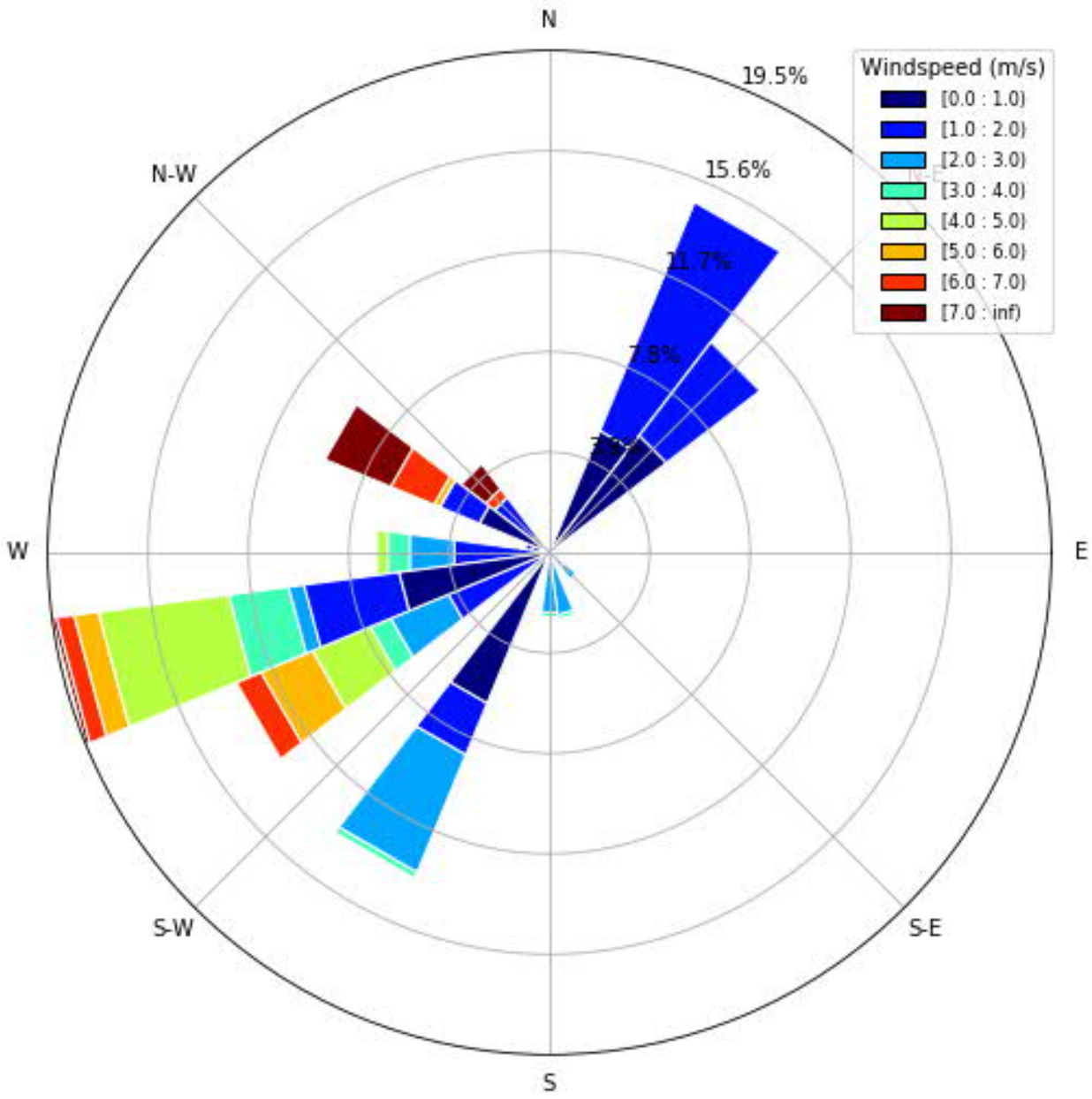
Armow Wind Project Phase 1

R68 I-Audit Report

Appendix B.1

Supplementary Wind Rose based on Assessment Data Total Noise

aercoustics



Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 15, 2020
Revision: 1

Scale: As Indicated

Armow Wind Project Phase 1

R68 I-Audit Report

Appendix B.2

Supplementary Wind Rose based on Assessment Data Background Noise

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Appendix C
Turbine Operational Statement from Operator

SP Armow Wind Ontario LP
119 Spadina Ave, Suite 502
Toronto, ON M5V 2L1

T +1 416 263 8025
www.armowwind.ca

February 13th, 2020
Director, Environmental Approvals Access and Service, Integration Branch
Ministry of the Environment, Conservation and Parks
2 St. Clair Avenue West, Floor 124
Toronto ON M4V 115

Dear Director

Please accept this letter as confirmation that all turbines tested during the sound measurement campaign conducted by Aercoustics Ltd. From September 19th, 2019 through January 5th, 2020 were operating normally for the duration of the campaign. In addition, I confirm that turbines were parked during the ambient measurements as part of this campaign.

Sincerely

Robert Boak
Facility Manager, Armow

Main
Direct +1 519-368-4701
Robert.Boak@patternenergy.com
558 Concession 2
Tiverton, Ontario N0G 2T0
patterncanada.ca

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Appendix D
Calibration Certificates

Calibration Certificates –

Details are disclosed in the table below regarding the calibration of the equipment used for the I-Audit campaign at monitor location R68. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
R68	Data Acquisition Card	NI 9234	1CAF79A	2019-08-23
	Signal Conditioner (September 19, 2019-October 29, 2019)	PCB 480E09	35340	2019-07-16
	Signal Conditioner (October 29, 2019 - January 5, 2020)	PCB 480E09	36936	2019-06-15
	Microphone	PCB 377B02	132191	2019-07-16
	Pre-Amplifier	PCB 426E01	178140	2019-07-16
	Weather Anemometer	Vaisala WXT 536	P4930909	2018-11-15

VAISALA

Test report no. H31-18490208

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A3B2B1B
Serial number	P4930909
Manufacturer	Vaisala Oyj, Finland
Test date	7 December 2018

This test report certifies that the product was thoroughly tested and inspected, and found to meet its published test limits when it was shipped from Vaisala.

Test results

Test	Result	Lower limit	Upper limit	Unit
Rain response	404	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.3	-1	1	hPa
Temperature difference	-0.02	-2	2	°C
Humidity difference	-0.48	-10	10	%RH
Heating current	0.73	0.6	0.8	A
Current (service port)	1.01	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	0.69	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 22.85 ±5 %RH, Temperature 22.24 ±1 °C, Pressure 1005.39 ±1 hPa.

Signature

Technician

 DOC233154-A.doc

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland
Phone +358 9 894 91 | Fax +358 9 8949 2227
Email firstname.lastname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

VAISALA

Calibration sheet no. H31-18490209

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	P4530016
Manufacturer	Vaisala Oyj, Finland
Test date	15 November 2018

This test report certifies that the instrument was thoroughly tested and inspected, and found to meet its published test limits when it was shipped from Vaisala.

Calibration results

Test phase of calibration process	Reference value	Observed value	Difference*	Uncertainty**
Pressure	1079.4	1079.4	0	± 0.4 hPa
Pressure	899	899.1	0.1	± 0.4 hPa
Pressure	796.7	796.7	0	± 0.4 hPa
Pressure	599.6	599.6	0	± 0.4 hPa
Temperature	59.7	59.7	0	± 0.2 °C
Temperature	-5.7	-5.7	0	± 0.2 °C
Temperature	-32.7	-32.7	0	± 0.2 °C
Temperature	24.9	24.9	0	± 0.2 °C
Temperature	-52	-52	0	± 0.2 °C
Relative humidity	29.5	29.5	0	± 2 %RH
Relative humidity	57.8	57.8	0	± 2 %RH
Relative humidity	92.1	92.1	0	± 3 %RH

*The test points for error values are polynomial fitting curve fitting points.
**The calibration uncertainty given at 95 % confidence level, k = 2

Traceability
The working standards for pressure and temperature are calibrated at Vaisala Measurement Standards Laboratory (MSL) by using MSL working standards traceable to National Institute of Standards and Technology (NIST, USA). The relative humidity values are calculated from measured temperature and dew-point temperature values. The dew-point working standards are traceable to the Finnish National Humidity Laboratory (MIKES).

Signature

Technician

Doc218938-A

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Phone +358 9 894 91 | Fax +358 9 8949 2227
Email firstname.lastname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

#A16

~ *Calibration Certificate* ~

Model Number: 480E09

Serial Number: 36936

Description: Signal Conditioner

Manufacturer: PCB

Customer:

P.O.:

Method : Comparison Method (AT103-3)

Calibration Data

Temperature: 74 °F (24 °C)

Humidity: 41%

Channel	Volts	Current (mA)	Gain X1	Gain X10	Gain X100
1	27.2	2.98	1.001	10.014	100.067

Condition of Unit

As Found: n/a

As Left: New unit, in tolerance

Notes

1. Calibration is N.I.S.T. traceable through PCB control number QC-726.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 10012-1, ANSI/NCSL Z540.3 and ISO 17025.
4. Measurement uncertainty (95% confidence level with a coverage factor of 2) for the sensitivity reading is +/- 0.2 %
5. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.

Technician: Darius Story DS

Date: 06/15/19

Due Date:

ilac-MRA A2LA ACCREDITED

CALIBRATION CERT #1862.02

PCB PIEZOTRONICS INC.

Headquarters: 3425 Walden Avenue, Depew, NY 14043

Calibration Performed at: 10869 Highway 903, Halifax, NC 27839

TEL: 888-684-0013 FAX: 716-685-3886 www.pcb.com

CAL29-3643420405

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	158022
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00035340	P. Order :	2019.07.09C
Asset # :	01222		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our Quality System system complies with the requirements of ISO-9001-2015 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jul 16, 2019 By : Petro Onasko

Cal. Due : Jul 16, 2021

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-255 J-301 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com
Phone : 800-668-7440 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: 480E09	Approved by: J. Raposo	Jun-19	Ver 2.0

Calibration Report for Certificate : 158022

Make	Model	Serial №	Asset	Cal by
PCB Piezotronics	480E09	00035340	01222	PO

Test	Setting	Input	Min	Reading	Max	In/Out

Excitation Voltage

• 1			25 Vdc	25.8 Vdc	29 Vdc		In

Constant Current Excitation

• 1			2.0 mA	2.97 mA	3.2 mA		In

Voltage Gain Accuracy at 1 kHz

• 1	1.000 V		0.98	1.00	1.02		In
• 10	0.100 V		9.80	10.01	10.20		In
• 100	0.010 V		98.0	99.9	102.0		In

CERTIFICATE of CALIBRATION

Make : PCB Piezotronics

Reference # : 158015

Model : 378B02

Customer : Aercoustics Engineering Ltd
Mississauga, ON

Descr. : Microphone System 1/2" Free Field

Serial # : 132191

P. Order : 2019.07.09C

Asset # : 01160

Cal. status : Received in spec's, no adjustment made.
Preamp System with Mic 377B02 s/n 178140

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our Quality System system complies with the requirements of ISO-9001-2015 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jul 16, 2019

By : Petro Onasko

Cal. Due : Jul 16, 2021

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-325 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST
6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 800-668-7440 Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: 378B02	Approved by: JR	Feb-16	Ver 1.0

Calibration Report for Certificate : 158015

Make			Model	Serial	Asset		
PCB Piezotronics			378B02	132191	01160		
PCB Piezotronics			426E01	051462	01160		
PCB Piezotronics			377B02	178140	01160		

Sensitivity at 250 Hz

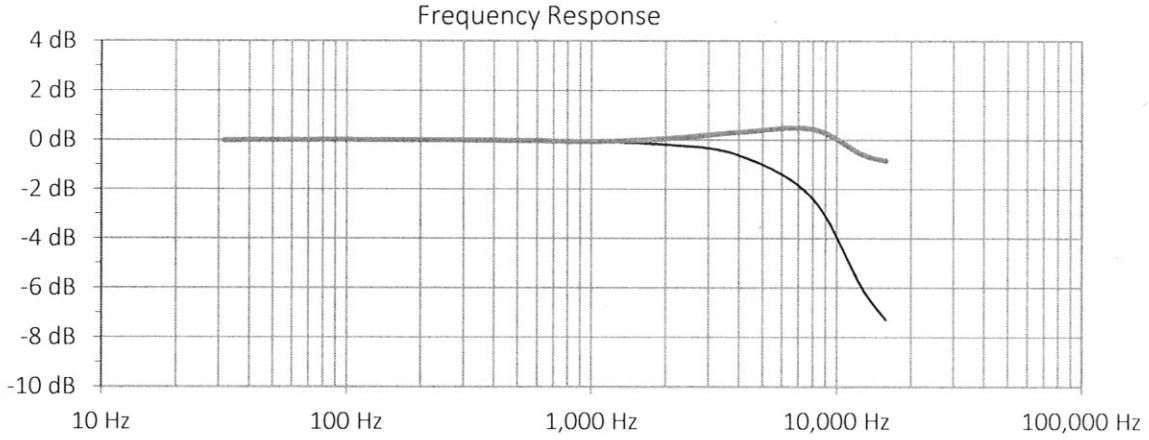
Specs Nom	Unit		Min	Reading	Max		In/Out
50	mV/Pa		39.72	48.80	62.94		In
-26.02	dB re 1V/Pa		-28.02	-26.23	-24.02		In
0	dB re 50mV/Pa		-2	-0.21	2		In

Ambient Conditions:

Static Pressure	99.3 kPa
Temperature	24.2°C
Rel.Humidity	58.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	-0.02	-0.01	
63.1	0.00	0.00	
125.9	0.00	0.01	
251.3	**0.00**	**0.00**	ref
502.5	-0.03	-0.02	
1005.1	-0.09	-0.06	
1978.7	-0.19	0.05	
3957.5	-0.61	0.31	
7914.9	-2.33	0.45	
12663	-6.01	-0.59	
15830	-7.30	-0.85	



Compliant Calibration Certificate

Certificate Number:	6125368.1	**OE Number:**	21733250
Date Printed:	23-AUG-2019	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 ONTARIO MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1CAF79A		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	23-AUG-2019	**Issued Date:**	23-AUG-2019
Procedure Name:	NI 9234	**Recommended Calibration Due:**	23-AUG-2020
Procedure Version:	3.6.1.0	**Verification Results:**	As Found: Passed As Left: Passed
Lab Technician:	Justin Rees	**Calibration Executive Version:**	4.6.2.0
		Driver Info:	NI-DAQmx:17.6.0
Temperature:	23.0° C	**Humidity:**	42.8% RH

NATIONAL INSTRUMENTS
CALIBRATED
S/N/ID 1CAF79A
DATE 23-AUG-2019
DUE 23-AUG-2020
ni.com/calibration

The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments, if the unit is functional.

As Left The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1 requirement.

The TUR (Test Uncertainty Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TUR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TUR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%.

Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'. NI Service Labs do not consider uncertainties when making statements of compliance to a specification.

This certificate applies exclusively to the item identified above and shall not be reproduced except in full, without National Instruments written authorization. Calibration certificates without signatures are not valid.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI Customer Service at Tel:(800) 531-5066 or Email orders@ni.com.

Ted Talley
Technical Manager

National Instruments Calibration Services Austin
Building A
11500 N MoPac Expwy
AUSTIN, TX 78759-3504
USA
Tel: (800) 531-5066

NATIONAL INSTRUMENTS™

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Appendix E
I-Audit Checklist

Appendix F7: I-Audit checklist

Wind Energy Project – Screening Document – Acoustic Audit Report – Immission

Information Required in the Acoustic Audit Report – Immission

Item #	Description	Complete?	Comment
1	Did the Sound level Meter meet the Type 1 Sound level meter requirements according to the IEC standard 61672-1 Sound level Meters, Part 1: Specifications? Section D2.1.1	✓	
2	Was the complete sound measurement system, including any recording, data logging or computing systems calibrated immediately before and after the measurement session at one or more frequencies using an acoustic calibrator on the microphone (must not exceed ±0.5dB)? Section D2.1.3	✓	
3	Are valid calibration certificate(s) of the noise monitoring equipment and calibration traceable to a qualified laboratory? Is the validity duration of the calibration stated for each item of equipment? Section D2.3	✓	
4	Was the predictable worst case parameters such as high wind shear and wind direction toward the Receptor considered? Section D3.2	✓	
5	Is there a Wind Rose showing the wind directions at the site? Section D7 (1e)	✓	
6	Did the results cover a wind speed range of at least 4-7 m/s as outlined in section D 3.8.?	✓	
7	Was the weather report during the measurement campaign included in the report? Section D7 (1c)	✓	
8	Did the audit state there was compliance with the limits at each wind speed category? Section D6	✓	
9	Are pictures of the noise measurement setup near Point of reception provided? Section D3.3.2 & D3.4	✓	
10	Was there justification of the Receptor location choice(s) prior to commencement of the I-Audit? Section D4.1	✓	
11	Was there sufficient valid data for different wind speeds? Section D5.2 # 3	✓	
12	Was the turbine (operational) specific information during the measurement campaign in tabular form (i.e. wind speed at hub height, anemometer wind speed at 10 m height, air temperature and pressure and relative humidity) Section D3.7	✓	
13	Were all the calculated standard deviations at all relevant integer wind speeds provided? Section D7 (2d)	✓	
14	Compliance statement	✓	
15	All data included in an Excel spreadsheet	✓	
16	If deviations from standard; was justification of the deviations provided	⊘	No Deviations

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Mississauga, ON L4Y 0G1

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Appendix F
AWPP Scope of Work

SP Armow Wind Ontario LP
2050 Derry Road Wst, 2nd Floor
Mississauga, Ontario L5N 0B0
Canada

July 26, 2019

BY EMAIL

Director
Ministry of the Environment, Conservation and Parks
Owen Sound District Office
101 17th St., 3rd Floor
Owen Sound, ON N4K 0A5
John.S.Ritchie@ontario.ca

Dear Mr. Ritchie:

SP Armow Wind Ontario GP Inc. ("Armow") v. Ontario (Environment, Conservation and Parks)
ERT File No. 19-051

We are writing with respect to Director's Order No. 2868-B8VRY4-1 dated June 19, 2019 (the "Order"), the Director's letter of June 27, 2019 and Armow's appeal of the Order to the Environmental Review Tribunal ("ERT"). Given the extremely complex technical nature of the Order, please find below the scope of work that Armow will conduct to comply with the Order:

1) With respect to Work Ordered Items Nos. 1, 2, 3 and 4 as set out in the Order, all work has been completed and no further action is required.

2) With respect to Work Ordered Item No. 5, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant conduct a RAM I-Audit, in accordance with The Compliance Protocol for Wind Turbine Noise published April 2017 (the "2017 Compliance Protocol") regarding equipment set-up requirements, with measurement of tonality to be undertaken in accordance with ISO 1996-2:2017 for the following:
   a) the wind turbines identified in the REA as T68 and T80; and
   b) the location of a worst-case noise receptor.

   Monitoring locations for both T68 and T80 may be moved southward if remaining within same line-of-sight for T68 and distance correction factor is used (the more conservative of: 20 log rule or CADNA prediction). Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

3) With respect to Work Ordered Item No. 6, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant complete tonality measurements in accordance with ISO 1996-2:2017 (and 2017 Compliance Protocol regarding equipment set-up requirements) for each of the six (6) wind turbines identified in the REA as T50, T30, T88, T102, T75 and T95 and in accordance with the following turbine-specific requirements:

a) T95 will be addressed through a receptor in the crosswind direction, or other receptor that is located at similar distance downwind from a turbine of the same model;
b) T50 and T102 will be addressed through separate respective receptors in the downwind direction (prior measurements conducted at receptor IDs V556 and R215 may be used to fulfil tonality assessments, provided data meets the requirement of: "At least five (5) one-minute measurements per wind speed bin over entire assessment range of the turbine and not limited to wind speed bins of 4-7 m/s as per Compliance Protocol"); and
c) T30, T88, T75 will be addressed through alternative surrogate receptors, as the closest respective receptors are in the upwind direction (taking into account the following factors: same turbine model type, extent to which permission for site access is provided/withheld, and minimization of noise source contamination).

Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

4) Completion of Work Ordered Item No. 7, as set out in the Order.

5) Completion of Work Ordered Item No. 8, as set out in the Order, by submitting a noise abatement action plan prepared in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

This letter describes the whole scope of work that Armow proposes to complete in satisfaction of the Order. Please confirm the foregoing will allow for compliance with the Order. If such confirmation is received, Armow will proceed to withdraw its ERT appeal and implement this scope of work.

Yours truly,

SP Armow Wind Ontario LP,
by its general partner
SP Armow Wind Ontario GP Inc.

Per: _____
Name: Frank Davis
Title: Authorized Signatory

Per: _____
Name: Jae Young Ahn
Title: Authorized Signatory