aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 1M4

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

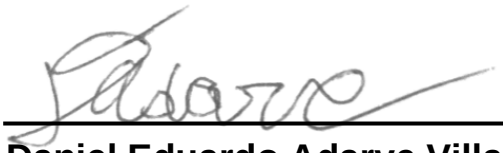
ASSESSMENT REPORT - **Project: 15247.03**

Armow Wind Power Project
Tonality Assessment Report – R165

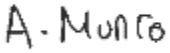
Prepared for:

SP Armow Wind Ontario LP.
2050 Derry Road West, 2nd Floor
Mississauga, Ontario
L5N 0B9

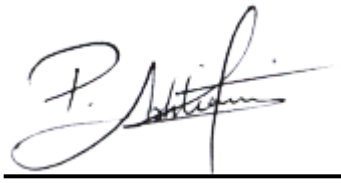
Prepared by:



Daniel Eduardo Adarve Villanueva. B.Eng., E.I.T.



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



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

07 February 2020

Revision History

Revision Number	Description	Date
1	Tonality Investigation Noise Report	07/02/2020

Table of Contents

List of Tables

List of Figures

List of Appendices

Executive Summary

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow turbines identified in the REA as T50, **T30**, T88, T102, T75 and T95. This report is specific to Turbine T30. The tonality assessment has been conducted at the worst-case receptor for turbine T61 which is the same turbine model as T30 (SWT-2.3-101 2.126MW, hub 99.5) as agreed to by the MECP and as per section 3.c of the Armow Scope of Work document dated July 26, 2019.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location R165. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4-1 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH, issued on October 9, 2013.

The tonality investigation has been completed as per the methodology outlined in Parts D 3.8.3 of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

No tone was present at R165 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T61, T30 and turbines of the same type (SWT-2.3-101 2.126MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

1 Introduction

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow turbines identified in the REA as T50, **T30**, T88, T102, T75 and T95. This report is specific to Turbine T30. The tonality assessment has been conducted at the worst-case receptor for turbine T61 which is the same turbine model as T30 (SWT-2.3-101 2.126MW, hub 99.5) as agreed to by the MECP and as per section 3.c of the Armow Scope of Work document dated July 26, 2019.

An alternative surrogate Turbine was chosen as the closest respective receptors to turbine T30 are in the upwind direction.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location R165. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4-1 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH, issued on October 9, 2013.

The tonality investigation has been completed as per the methodology outlined in Parts D 3.8.3 of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

This report outlines the measurement methodology, results, and a comparison of the measured turbine tonal audibility to the tonal adjustment structure from ISO1996-2:2007 Annex C.

2 Noise Source Summary

Aercoustics was retained before this assessment to conduct E-Audits to verify the noise emission of turbines at the Armow Wind Power Project.

The purpose of the E-Audits was to confirm whether equipment was operating as per manufacturer's specifications and satisfies the sound power level specified in the REA Appendix B. The E-Audits reports have been prepared to facilitate submission to the MECP, in compliance with acoustic audit conditions outlined in the REA (Specifically, Section F – Wind Turbine Acoustic Audit – Emission).

Wind Turbine Generator T30 was audited utilizing International Standard IEC 61400-11 (Edition 3.0, released 2012-11), "Wind Turbine generator systems – Part 11: Acoustic Noise Measurement Techniques".

Table 1 Summary of Wind Turbine Noise Emission Audit

Turbine ID	Turbine Model	Report ID
T30	Siemens SWT-2.3-101 2.126MW, hub 99.5m	15247.00.T30.RP3

Detailed measurement reports for T30 (Report ID: 15247.00.T30.RP3) outline the apparent sound power level, measurement uncertainties and tonal audibility results.

2.1 Tonal Audibility Results from E-Audit

Results of the tonality assessment of the acoustic audit for T30 is summarised in Table 2.

Table 2 – T30 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
7.5	No reportable tones were detected					
8	469	-2.8	-0.5	78	148	53%
8.5	120	-4.6	-2.6	107	154	69%
8.5	475	-0.7	1.5	124	154	81%
9	116	-3.5	-1.5	117	137	85%
	476	1.5	3.8	137	137	100%
9.5	116	-3.1	-1.1	99	115	86%
	477	2.8	5.1	115	115	100%
10	116	-3.4	-1.4	50	55	91%
	477	4.3	6.6	55	55	100%
10.5	119	0.2	2.2	66	66	100%
	489	3.0	5.2	61	66	92%
11	119	0.1	2.1	61	62	98%
	492	3.1	5.4	57	62	92%
11.5	120	0.2	2.2	42	42	100%
	494	2.8	5.1	42	42	100%

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
12	120	0.3	2.3	15	16	94%
	495	3.2	5.5	14	16	88%
12.5	120	-0.7	1.3	11	11	100%
	499	2.3	4.6	11	11	100%

Table 3 presents a summary of the relevant tones for this assessment noted from the E-Audits and includes the frequency range, tonal audibilities and the corresponding turbine operational parameters during which elevated tonal audibility levels were observed.

Table 3 Summary of Relevant Tones T30

Turbine ID	Frequency Range (Hz)	Tonal Audibility (dB)	Hub Height Wind Speed Range (m/s)	Electrical Power Output Range (kW)
T30	477 Hz [448Hz – 506Hz]	1.5 – 6.6	8.5 – 12.5	1311 - 2125
	495 Hz [466Hz – 524Hz]	1.5 – 6.6	8.5 – 12.5	1311 - 2125

3 Tonal Assessment Details

The acoustic audit was conducted at receptor R165[1]. This location is closest to turbine T61. Turbine T61 is the same model turbine as T30 (SWT-2.3-101 2.126MW, hub 99.5m) and was chosen as the alternate surrogate turbine as the closest receptors to turbine T30 are in the upwind direction compared to the predominant wind direction for the Armow Wind Power Project.

Monitoring at R165 spanned the following dates, summarized in Table 4.

Table 4: Monitoring Period for Receptor R165 (DD/MM/YYY)

Location	Monitoring Start Date	Monitoring End Date
R165	04/10/2019	14/12/2019

[1] Receptor IDs taken from the Noise Assessment Report by A. Brunskill, D. Eaton and E.Crivella dated September 9, 2013 [3]

3.1 Test Equipment

The measurement equipment used for the Tonal Assessment, both acoustic and environmental, is detailed below. Equipment specifications and measurement positions comply with MECP Compliance 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 mounted 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 data analysis.
- One (1) anemometer, mounted at a height of 10 metres above ground level ("10 m AGL").

Table 5 provides the specific model and serial numbers for the measurement equipment used during the measurement campaign.

Table 5: Equipment Details

Location	Equipment	Make/Model	Serial Number
R165	Sound Level Meter	NI 9234	1CAF718
	Microphone	PCB 378B02	118497
	Pre-Amplifier	PCB 426E01	037483
	Weather Anemometer	Vaisala WXT 520	J3040014
	Signal Conditioner	PCB 480E09	33659

The measurement chain was calibrated before and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator.

3.2 Measurement Methodology

For the duration of the measurement campaign, acoustic and anemometer data was logged simultaneously in one-minute intervals. The acoustic data included A-weighted overall equivalent sound levels (LAeq), percentile statistical levels (L90), and 1/3 octave band levels between 20 Hz and 10,000 Hz. The recorded weather data included average wind direction, wind speed, temperature, relative humidity, and atmospheric pressure. The maximum wind speed for each one-minute interval was also stored.

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

3.3 Data Reduction and Filtering

The data reduction procedures used on the measurement data to remove invalid data points from the assessment are detailed below. These procedures are in accordance with Section D5.2 of the Protocol and in accordance with the measurement equipment specifications. An additional filter based on the difference between LAeq and L90 level is included to automatically exclude transient noise contamination.

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

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

The purpose of the filters listed above is to exclude intervals where the data quality is reduced due to extraneous events (such as vehicle pass-bys), unusable environmental conditions (such as rain), or equipment operating outside of its specifications. Intervals that pass the filtering criteria listed above are sorted into Turbine ON or Background periods based according to the conditions listed below. If neither Turbine ON or Background conditions are met, the data point is excluded.

- Turbine ON: Armow turbines must be rotating and generating power
- Background: Armow turbines must be parked and not generating power

The Protocol also requires additional criteria be met by each Turbine ON data point based on the conditions of the nearest turbine to each receptor. 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)}*

The following additional power filter was applied to specifically assess operational conditions when the highest tonal audibility values were measured during the I-audit testing at T61.

Table 6: Power Filtering Summary

Location	Turbine	Power Output (kW)
R165	T61	≥ 1311

3.4 Measurement Location

Monitoring was conducted at the lot receptor R165. R165 has a predicted impact of 39.5 dBA as per level predicted from an "As Built" noise model based on the original CadnaA noise prediction model. The following table provides a summary of the receptor

location. Detailed site plans showing the receptor and audit location is attached in Appendix A.

Table 7: Receptor Measurement Locations

	Audit Receptor ID Turbine ID	R165 T61
Receptor	UTM Coordinates (X,Y)	17T 460727mE 4897135mN
	Distance to Turbine (m)	707
	Receptor Height (m)	4.5
	Predicted Level (dBA)*	39.2
Monitor	UTM Coordinates (X,Y)	17T 460668mE 4897048mN
	Distance to Turbine (m)	606
	Monitor Height (m)	4.5
	Predicted Level (dBA)*	39.6

*Predicted Level from Aercoustics' acoustic model

3.5 Sample size Reporting Requirements

As per Section D3.8.3 Tonality (tonal assessment) of the MECP protocol, at least 5 one-minute intervals are required for wind turbine noise and background noise (wind turbines parked). These intervals shall be as close as possible to the integer wind speed. In addition, the MECP has required that the five (5) one-minute measurements per wind speed bin are to include the entire assessment range of the turbine and is not limited to wind speed bins of 4-7 m/s.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by Pattern Operation Control Centre. Measurement data at receptor was filtered to include only intervals when all turbines in the immediate vicinity were operational, or, in the case of the ambient noise measurements, were not operational. The turbines included in this study were chosen such that when they are turned off, the partial impact of the remaining Armow turbines was less than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were T10, T18, T61, T63, and T69.

4 Tonal Assessment Results

Acoustic and weather data measured during the Tonal Assessment are summarized in the following section.

4.1 Weather Conditions

General weather conditions measured over the course of the tonality investigation are summarized in Table 8.

Table 8: General Weather Conditions – Range of Measured Values

	10-m AGL			
	Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]
Minimum	960	0.0	36	-9
Maximum	999	19.5	92	17

4.2 Wind Direction

A Wind rose representing the recorded wind directions during the audit is reported in Appendix B. Wind direction recorded from the turbine yaw angle, and wind speeds measured from the 10-m AGL anemometer, were combined to prepare the wind roses. The wind speeds from 1-7 m/s at 10-m AGL represent the I-audit wind bins as per Section E5.5 of the Protocol.

4.3 Measured Sound Levels

Table 9 details the sound levels measured at the receptor when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). The Turbine ON and Turbine OFF sound level presented are filtered as per the filters detailed in Section 3.3.

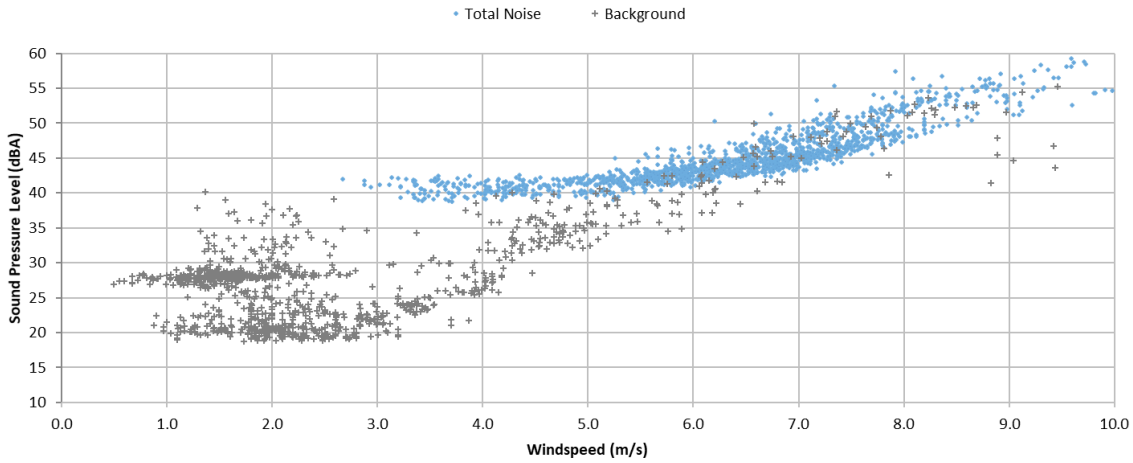
Table 9: R165 Sound levels measured for Turbine ON and OFF (Downwind – T61)

I-Audit Wind Bins (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
1	0	-	-	205	28.0	3.5
2	0	-	-	486	27.8	4.5
3	32	40.7	1.0	155	25.5	3.6
4	124	40.7	0.9	84	31.8	4.3
5	184	41.5	1.0	67	36.1	2.2
6	429	43.4	1.3	33	40.8	2.7
7	486	46.3	2.0	25	47.3	3.0

The following figure presents the scatter plot showing each valid 1-minute interval measured sound levels at R165 when all the nearby turbines were ON (Turbine ON +

Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON and Turbine OFF sound level presented was using the filter outlined in section 3.3.

Figure 1: R165 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind – T61)



4.4 **Measured Tonality**

The tonal assessment has been completed using ISO/PAS 20065:2016 (Acoustic-Objective method for assessing the audibility of tones in noise-Engineering Method) and the tonal penalty structure taken from ISO 1996-2:2007 Annex C. Namely, Section 5.1 of the compliance protocol states:

> *If a tonal assessment … indicates a tonal audibility value that exceeds 4 dB, the Ministry will require that a tonal penalty be applied at all Receptors in accordance with the penalties described in Annex C of ISO 1996-2, Reference [2]*

The tonality analysis results of the Emission audit measurements for T30 were used as a basis for tones at receptors which were likely to have been generated by the closest turbine rather than an external source.

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.

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 spectra in each wind bin was then evaluated to determine if a tonal adjustment would be applicable.

For a given spectra if the Tonal audibility is greater than 0dB 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 with the inclusion of data points with unidentified tones (i.e. -10 dB). A sample tone plot is provided in Appendix D.

4.4.1 Tonal Assessment – 10m wind speed

The presence of tones in the I-audit data binned by 10m wind speed was determined.

Tonal assessment summary table is provided in Table 10 and Table 11.

Table 10: Tonality Summary – R165 – 477Hz – 448-506 Hz

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tonal Audibility >0	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
1	0	0	0%	-	-
2	0	0	0%	-	-
3	32	0	0%	-10.0	0.0
4	124	0	0%	-10.0	0.0
5	184	0	0%	-10.0	0.0
6	429	0	0%	-10.0	0.0
7	486	0	0%	-10.0	0.0

Table 11: Tonality Summary – R165 – 495Hz – 466-524 Hz

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tonal Audibility >0	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
1	0	0	0%	-	-
2	0	0	0%	-	-
3	32	0	0%	-10.0	0.0
4	124	0	0%	-10.0	0.0
5	184	0	0%	-10.0	0.0
6	429	0	0%	-10.0	0.0
7	486	0	0%	-10.0	0.0

Relevant tones from T61 (477Hz and 495Hz) were not present at receptor R165. No tonal adjustment was found to be applicable at receptor R165 at any 10m wind speed bin.

4.4.1 Tonal Assessment - hub-height wind speed

The presence of tones in the I-audit data as a function of hub height wind speeds was also determined. The tonal analysis covered the same hub height wind speed range as the sound power level measurement of the E-audit test for Turbine T75. The turbine electrical power filter was removed, and all spectra were sorted into half-integer hub height wind speed bins using the methodology for the E-audit (IEC 61400-11 Ed 3.0) adapted for I-audit measurements. The results of this analysis provide the mean tonal audibility over the entire assessment range of the turbine (8m/s to 12.5m/s).

Table 12 Tonality Assessment at each half-integer hub-height wind speed 477 Hz [448 to 506Hz]

Hub Height Wind Bin (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Turbine Power Output (kW)
7.5	303	0	0%	-10	994
8	301	0	0%	-10	1196
8.5	304	0	0%	-10	1425
9	225	0	0%	-10	1654
9.5	177	0	0%	-10	1817
10	175	0	0%	-10	1979
10.5	25	0	0%	-10	2038
11	42	0	0%	-10	2096
11.5	78	0	0%	-10	2109
12	103	0	0%	-10	2121
12.5	112	0	0%	-10	2123

Table 13 Tonality Assessment at each half-integer hub-height wind speed 495 [466Hz to 524Hz]

Hub Height Wind Bin (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Turbine Power Output (kW)
7.5	303	0	0%	-10	994
8	301	0	0%	-10	1196
8.5	304	0	0%	-10	1425
9	225	0	0%	-10	1654
9.5	177	0	0%	-10	1817
10	175	0	0%	-10	1979
10.5	25	0	0%	-10	2038
11	42	0	0%	-10	2096
11.5	78	0	0%	-10	2109
12	22	0	0%	-10.0	2293
12.5	16	0	0%	-10.0	2296

Similar to the tonal assessment binned by 10m wind speed, relevant tones from T61 (477 Hz and 495 Hz) were found not to be present at receptor R165 for all hub-height wind bins compared to measurements at the E-audit location.

5 Assessment of Compliance

As per Section D5.6 of the Protocol, if a tone is identified at any of the wind speed bins, the average tonal audibility correction shall be added to the final noise contribution of the wind turbine at those wind speed bins.

No tone was present at R165 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T61, T30 and turbines of the same type (SWT-2.3-101 2.126MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

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.

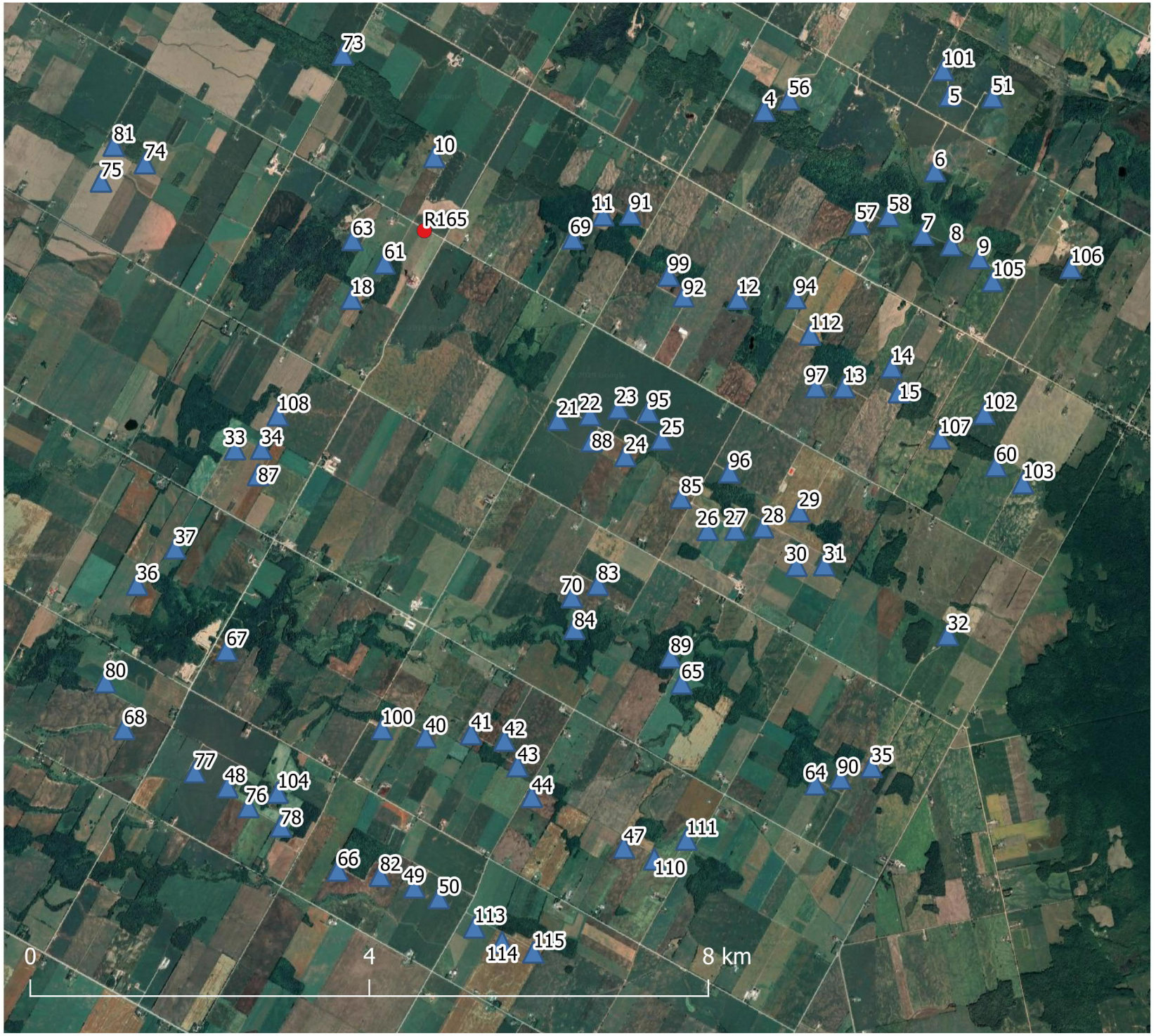
[3] A. Brunskill, D. Eaton and E.Crivella , “Armow Wind Farm, Ontario Noise Impact Assessment ”, GL Garrad Hassan, 9 September 2013.

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix A
Location Details



Legend

- Armow Turbines
- R165

N

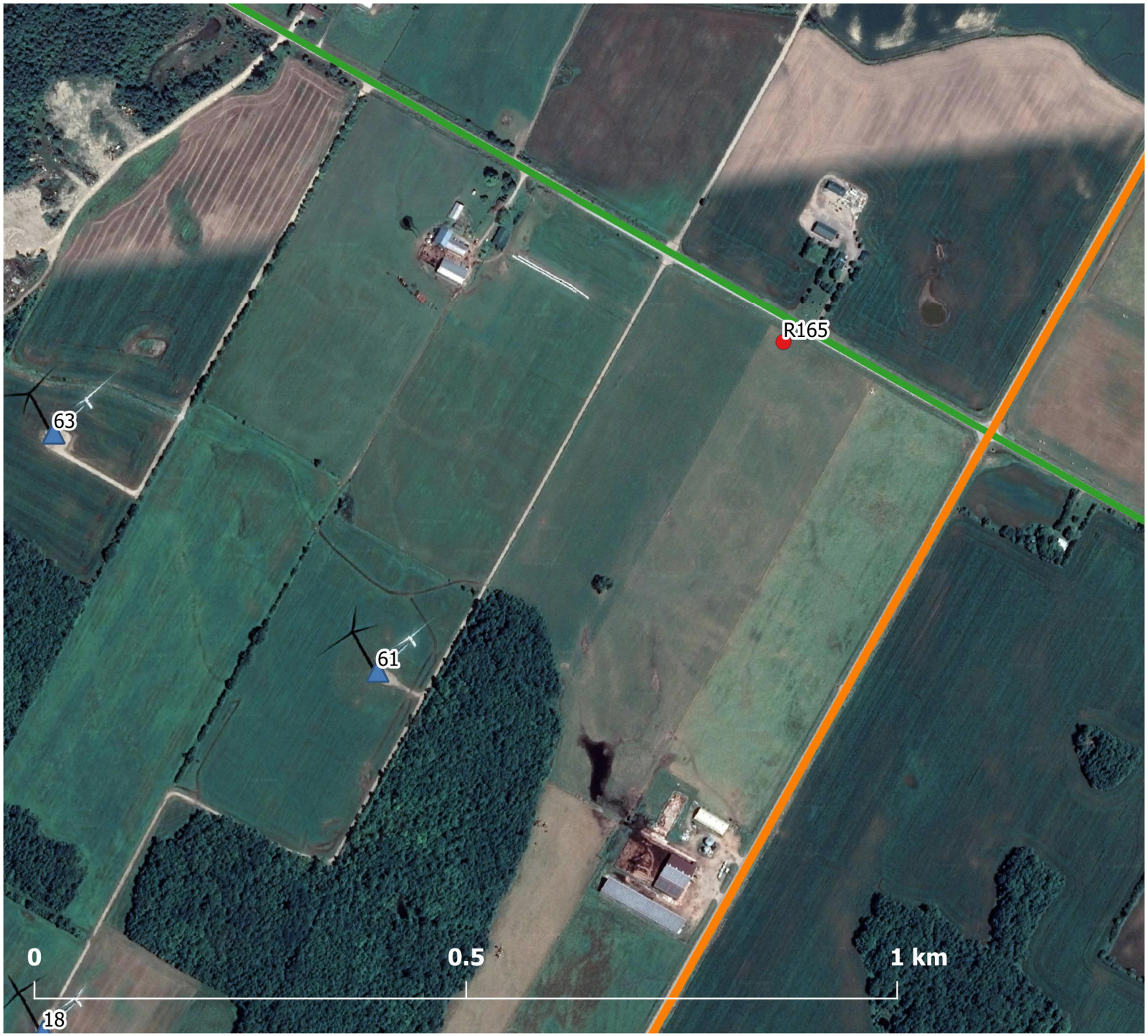
Project ID:	15247.03
Drawn by:	DEA
Reveiwed by:	AM
Date:	January 15, 2020
Revision:	1
Scale:	As Indicated

Armow Wind Power Project
Tonal Assesment R165

Appendix A.1

Site Plan Overview

aercoustics



Legend

- Armow Turbines
- R165
- Concession Rd 11
- Sideroad 15 N

N

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

Armow Wind Power Project
Tonal Assessment R165

Appendix A.2

Measurement Locations

aercoustics

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

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R165

Appendix A.3

Site photo

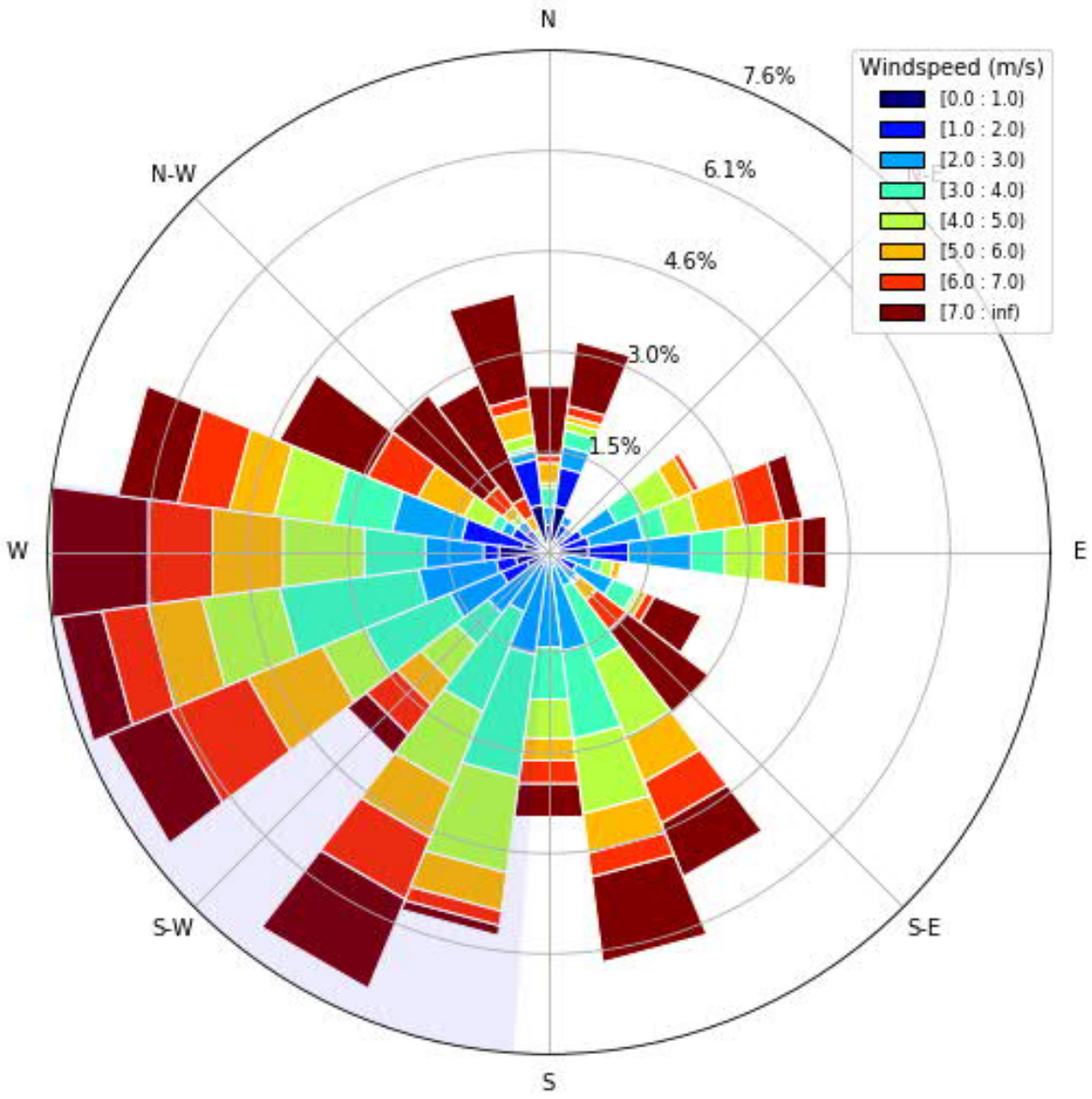
aercoustics

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix B
Wind Roses



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

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R165

Appendix B

Supplementary Wind Rose
based on All Data

aercoustics

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix C
Calibration Certificates

Calibration Certificates –

Details are disclosed in the table below regarding the calibration of the equipment used for the Phase 2 I-Audit campaign at monitor location R165. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
R165	Data Acquisition Card	NI 9234	1CAF718	2019-08-28
	Signal Conditioner	PCB 480E09	33659	2019-07-16
	Microphone	PCB 377B02	118497	2019-07-16
	Pre-Amplifier	PCB 426E01	037483	2019-07-16
	Weather Anemometer	Vaisala WXT 536	J3040014	2019-08-28

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	158023
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00033659	P. Order :	2019.07.09C
Asset # :	00209		

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 : 158023

Make	Model	Serial №	Asset	Cal by
PCB Piezotronics	480E09	00033659	00209	PO

Test	Setting	Input	Min	Reading	Max		In/Out

Excitation Voltage

• 1			25 Vdc	26.0 Vdc	29 Vdc		In

Constant Current Excitation

• 1			2.0 mA	2.98 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 # :	158016
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	118497	P. Order :	2019.07.09C
Asset # :	00183		

Cal. status : Received in spec's, no adjustment made.
Preamp System with Mic 377B02 s/n 150759

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 : 158016

Make			Model	Serial	Asset		
PCB Piezotronics			378B02	118497	00183		
PCB Piezotronics			426E01	037483	00183		
PCB Piezotronics			377B02	150759	00183		

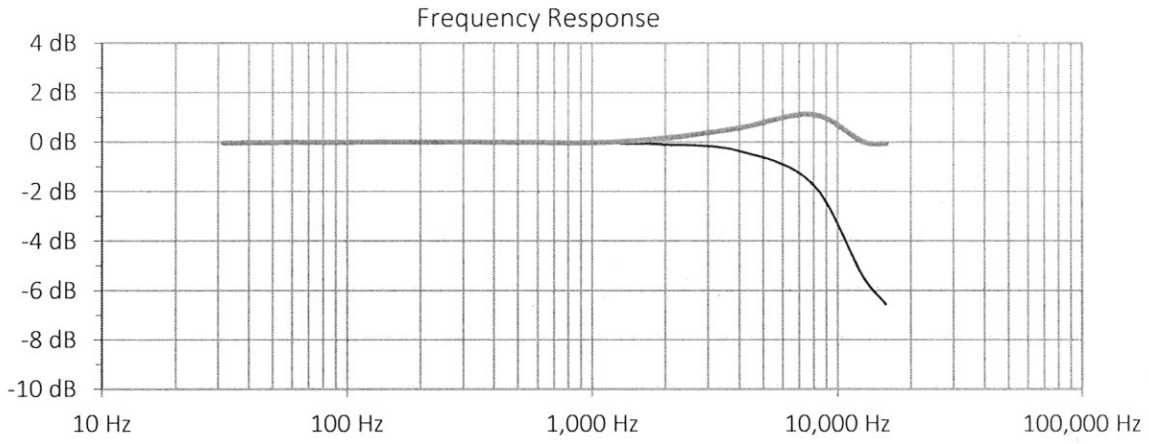
Sensitivity at 250 Hz

Specs Nom	Unit		Min	Reading	Max		In/Out
50	mV/Pa		39.72	47.34	62.94		In
-26.02	dB re 1V/Pa		-28.02	-26.49	-24.02		In
0	dB re 50mV/Pa		-2	-0.47	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	-0.05	-0.05	
63.1	-0.02	-0.02	
125.9	-0.01	-0.01	
251.3	**0.00**	**0.00**	ref
502.5	-0.01	-0.01	
1005.1	-0.05	-0.03	
1978.7	-0.10	0.15	
3957.5	-0.35	0.56	
7914.9	-1.69	1.12	
12663	-5.40	0.02	
15830	-6.56	-0.07	



SOH Wind Engineering LLC

141 Leroy Road · Williston, VT 05495 · USA

Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

Certificate number: 19.US2.07596 **Date of issue:** August 29, 2019

Type: Vaisala Weather Transmitter, WXT520 **Serial number:** J3040014

Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland

Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

Anemometer received: August 26, 2019 **Anemometer calibrated:** August 28, 2019

Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F

Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.01133 · U [m/s] + 0.06250

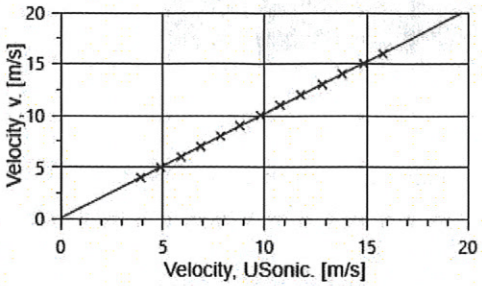
Standard uncertainty, slope: 0.00308 **Standard uncertainty, offset:** 0.52440

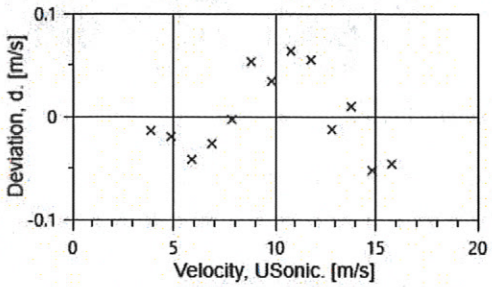
Covariance: -0.0000956 (m/s)²/m/s **Coefficient of correlation:** $\rho = 0.999948$

Absolute maximum deviation: 0.063 m/s at 11.023 m/s

Barometric pressure: 999.3 hPa **Relative humidity:** 42.6%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, U. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.20	25.8	31.3	3.985	3.8917	-0.014	0.023
4	14.39	25.8	31.3	4.985	4.8862	-0.019	0.026
6	20.82	25.8	31.3	5.995	5.9069	-0.042	0.030
8	28.39	25.8	31.3	7.001	6.8867	-0.026	0.034
10	37.21	25.8	31.3	8.015	7.8667	-0.003	0.038
12	47.11	25.8	31.3	9.019	8.8033	0.053	0.043
13-last	58.17	25.8	31.3	10.022	9.8138	0.034	0.047
11	70.37	25.8	31.3	11.023	10.7750	0.063	0.051
9	83.73	25.8	31.3	12.024	11.7733	0.055	0.056
7	98.20	25.8	31.3	13.022	12.8267	-0.013	0.060
5	113.85	25.8	31.3	14.022	13.7933	0.010	0.064
3	130.55	25.8	31.3	15.015	14.8367	-0.052	0.068
1-first	148.25	25.7	31.3	15.999	15.8033	-0.046	0.073





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.0035
13924	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
Njord2-PC	PC dedicated to data acquisition

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was positioned at 90° during the calibration.

Certificate number: 19.US2.07596

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

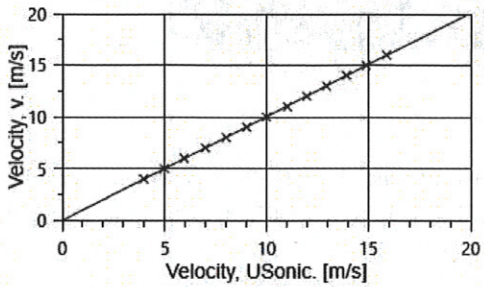
Certificate number: 19.US2.07595 **Date of issue:** August 29, 2019
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** J3040014
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

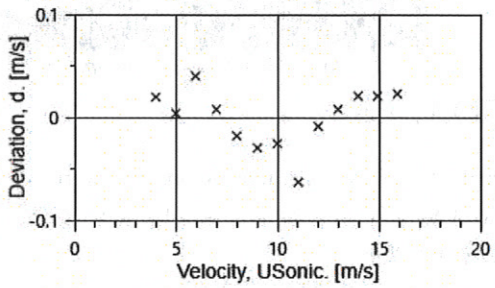
Anemometer received: August 26, 2019 **Anemometer calibrated:** August 28, 2019
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.00744 · U [m/s] + -0.03046

Standard uncertainty, slope: 0.00216 **Standard uncertainty, offset:** -0.76023
Covariance: -0.0000472 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999974
Absolute maximum deviation: -0.063 m/s at 11.015 m/s
Barometric pressure: 999.1 hPa **Relative humidity:** 42.6%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, U. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.25	25.9	31.3	3.995	3.9767	0.020	0.023
4	14.40	25.9	31.3	4.986	4.9759	0.004	0.026
6	20.80	25.9	31.3	5.994	5.9400	0.040	0.030
8	28.44	25.9	31.3	7.009	6.9800	0.008	0.034
10	37.15	25.9	31.3	8.011	8.0000	-0.018	0.038
12	47.10	25.9	31.3	9.020	9.0133	-0.030	0.043
13-last	58.02	25.9	31.3	10.012	9.9931	-0.025	0.047
11	70.23	25.9	31.3	11.015	11.0267	-0.063	0.051
9	83.81	25.9	31.3	12.033	11.9833	-0.009	0.056
7	98.22	25.9	31.3	13.027	12.9533	0.008	0.060
5	113.99	25.9	31.3	14.034	13.9400	0.021	0.064
3	130.25	25.9	31.3	15.001	14.9000	0.021	0.068
1-first	148.17	25.8	31.3	15.999	15.8879	0.023	0.073





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.0035
13924	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
Njord2-PC	PC dedicated to data acquisition

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was positioned at 0° during the calibration.

Certificate number: 19.US2.07595

Compliant Calibration Certificate

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1CAF718
DATE 28-AUG-2019
DUE 28-AUG-2020
ni.com/calibration

Certificate Number:	6128732.1	**OE Number:**	21742948
Date Printed:	28-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:	1CAF718		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	28-AUG-2019	**Issued Date:**	28-AUG-2019
Procedure Name:	NI 9234	**Recommended Calibration Due:**	28-AUG-2020
Procedure Version:	3.6.1.0	**Verification Results:**	As Found: Passed As Left: Passed
Lab Technician:	Rogelio Gaytan	**Calibration Executive Version:**	4.6.2.0
		Driver Info:	NI-DAQmx:17.6.0
Temperature:	23.0° C	**Humidity:**	41.2% RH

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

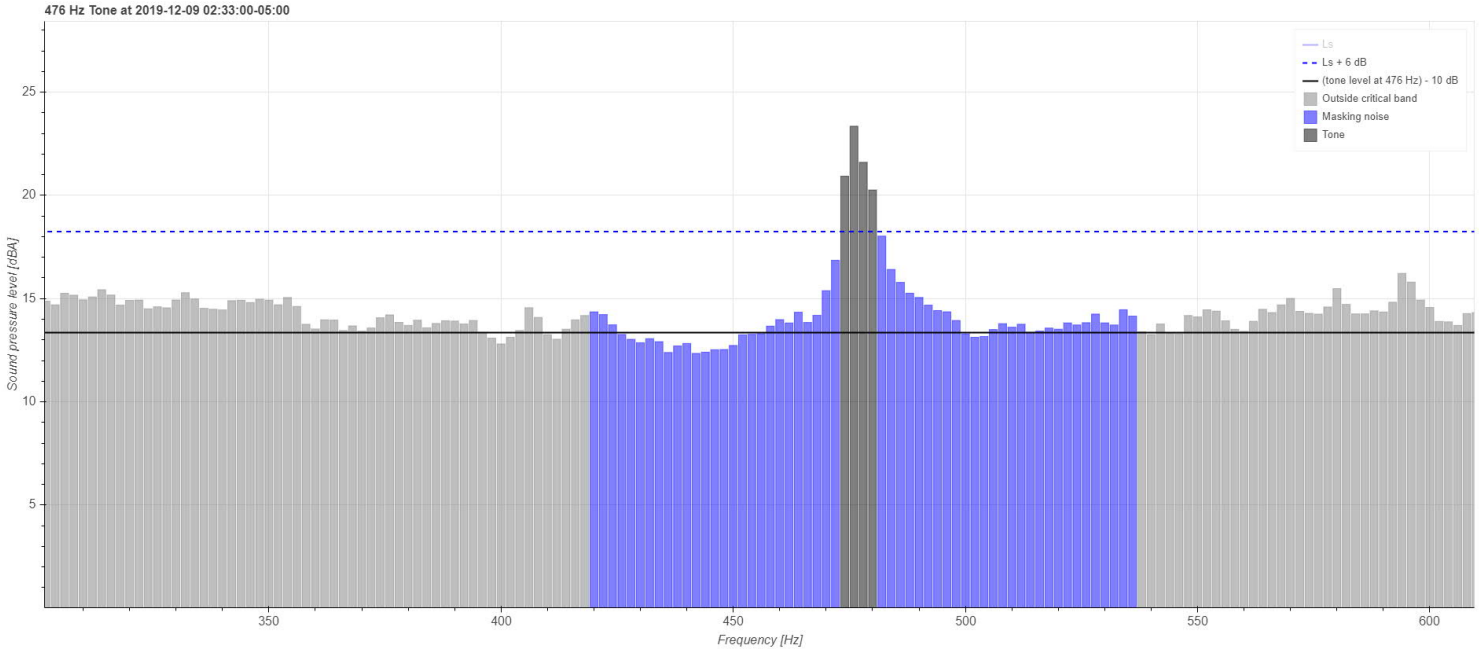
NATIONAL INSTRUMENTS™

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix D
Sample Tone Plot



Timestamp (America/Toronto)	Center Frequency (Hz)	Decisive Audibility (dB)	Level at Tone Line (dB)	Critical Bandwidth: Lower bound (Hz)	Critical Bandwidth: Upper bound (Hz)	Ls - Mean Masking Noise Level (dB)	LT - Tone Level (dB)	LG - Critical Band Masking Noise Level (dB)	Masking Index	Audibility (dB)
2019-12-09 02:33:00-05:00	476		23.4	420	536	12.2	26.0	29.9	-2.3	-1.6

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

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R165

Appendix D

Sample Tone Plot - R165 - Turbine ON 4m/s

aercoustics

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix E
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