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ASSESSMENT REPORT - **Project: 14355.00**

Port Ryerse Wind Power Project
1st Acoustic Immission Audit

Port Ryerse Road to the west, Woolley Road to the north,
Blue Line Road to the east and Lake Erie to the south
County of Norfolk, Ontario

Prepared for:

8437084 Canada Inc.
operating as Port Ryerse Wind Farm Limited Partnership
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Executive Summary

Aercoustics Engineering Limited ("Aercoustics") has been retained by 8437084 Canada Inc. operating as Port Ryerse Wind Farm Limited Partnership to complete the acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Port Ryerse Wind Power Project ("PRWPP"). PRWPP operates under REA #6498-9HKHN3, issued on August 20, 2014.

This report details the 1st measurement campaign of the PRWPP immission audit. Monitoring near receptors R151, R310, M364, P323 and R411 spanned the following dates: December 14, 2017 to April 5, 2018 for receptor R151; December 13, 2017 to April 5, 2018 for receptors P305, VM364 and P323; and January 16, 2018 to April 2, 2018 for receptor P411. Acoustic and weather data was logged simultaneously for the duration of the measurement campaign.

The audit has been completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the "*MOECC Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The measured turbine-only noise impact at the audit locations was compared to the Ministry of Environment and Climate Change ("MOECC") sound level limits. The measured turbine-only levels were found to be in compliance with the applicable sound level limits.

1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by 8437084 Canada Inc. operating as Port Ryerse Wind Farm Limited Partnership to complete the acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Port Ryerse Wind Power Project ("PRWPP"). PRWPP operates under REA #6498-9HKHN3, issued on August 20, 2014 [1].

The MOECC's letter dated July 11, 2017 provided direction to conduct the I-Audits as per the 2017 Wind Turbine Noise Compliance Protocol and a submission deadline of October 2018.

The audit was completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the MOECC guideline document for assessing noise from wind turbines that have already been built, "*MOECC Compliance Protocol for Wind Turbine Noise*" [2] to fulfil Section E, "*Acoustic Audit – Immission*" of the REA. This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the Ontario Ministry of Environment and Climate Change ("MOECC") sound level limits.

2 Facility Description

The Port Ryerse Wind Power Project utilizes 4 Siemens (Model SWT 3.2-113) wind turbines for power generation, each having a nameplate of 2.5 MW. Each turbine has a hub height of 99.5 metres and a rotor diameter of 113 metres. The facility operates 24 hours per day, 7 days per week.

An overall site plan is provided in Figure A.01.

3 Audit Details

The acoustic audit was conducted at receptors R151, R310, M364, P323 and P411[1]. Monitoring at M151, M310, M364, M323 and M411 spanned the following dates, summarized in Table 1.

Table 1: Monitoring Period for Each Receptor

Location	Monitoring Start Date	Monitoring End Date
M151	December 14, 2017	April 5, 2018
M310	December 13, 2017	April 5, 2018
M364	December 13, 2017	April 5, 2018
M323	December 13, 2017	April 5, 2018
M411	January 16, 2018	April 2, 2018

[1] Receptor IDs taken from the Noise Assessment Report by J. R. Salmon and S. J. Stewart, dated July 15, 2014 [3]

The following sections detail the test equipment, measurement methodology, measurement locations, and environmental conditions during the audit.

3.1 Test Equipment

The equipment, both acoustic and non-acoustic, used at each audit location for the measurement campaign is as follows.

- One (1) Type 1 sound level meter, with microphone and pre-amplifier that meet the MOECC protocol specifications outlined in Part D, Section D2.1 - Acoustic Instrumentation.

- 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 programmed to sample weather data every 0.5 seconds. The anemometer was located 10m above grade, as defined by Section D3.4. Performance specifications comply with Part D, Section D.2.2 of the MOECC protocol.

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

Table 2: Equipment Details

Location	Equipment	Serial Number
M151	NI9234 Data Acquisition Card	1CAF758
	PCB 480E09 Signal Conditioner	33370
	PCB 377B02 Microphone	129386
	PCB 378B02 Pre-Amplifier	047775
	Vaisala WXT 520	M2130088
M310	NI9234 Data Acquisition Card	1ADD8EC
	PCB 480E09 Signal Conditioner	33658
	PCB 377B02 Microphone	126954
	PCB 378B02 Pre-Amplifier	044925
	Vaisala WXT 520	K0550007
M364	NI9234 Data Acquisition Card	1854438
	PCB 480E09 Signal Conditioner	35331
	PCB 377B02 Microphone	123030
	PCB 378B02 Pre-Amplifier	041166
	Vaisala WXT 520	M0410644
M323	NI9234 Data Acquisition Card	1AA38AE
	PCB 480E09 Signal Conditioner	35341
	PCB 377B02 Microphone	132189
	PCB 378B02 Pre-Amplifier	043997
	Vaisala WXT 536	M4910195
M411	NI9234 Data Acquisition Card	1AE4581
	PCB 480E09 Signal Conditioner	33662
	PCB 377B02 Microphone	124690
	PCB 378B02 Pre-Amplifier	043047
	Vaisala WXT 520	J3040014

The sound level meter, microphone, and pre-amplifier were 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 (LA_{eq}), percentile statistical levels (L90), and 1/3 octave band levels between 20 Hz and 20,000 Hz. The microphone was placed at a measurement height of 4.5 m above grade (this is considered the worst-case assessment location for a second-storey residence), at least 5 metres away from any large reflecting surfaces, in

direct line of sight to the nearest turbines, and as far away as practically possible from trees or other foliage. 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 filter the data for wind gusting.

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).

A one-minute measurement interval was considered valid if:

- The interval occurred between 10pm – 5am
- No precipitation was detected 60 minutes before and 60 minutes after the interval
- The ambient temperature was above -20˚C
- Either all nearby turbines were on (for Turbine ON measurements), or all nearby turbines were off (for ambient measurements). The list of turbines parked for ambient measurements is provided in Section 3.7.
- The measured LA_{eq} was no more than 10 dB greater than the L90 value
- The closest wind turbine was producing approximately 85% or more of its rated power output
- The measurement location was downwind (+/- 45 degrees from the line of sight between the turbine and measurement location) from the wind turbine during the measurement interval

These filters are based on the requirements outlined in Part D of the Protocol as well as the measurement equipment specifications. The intention is to exclude measurement intervals where the data reliability is reduced due to transient noise intrusions (such as vehicle pass-bys), environmental conditions, or equipment operating outside of its specifications.

3.3 Measurement Location

The Port Ryerse Wind Project has a total of four (4) turbines. Due to the relatively small number of turbines at the Facility and the fact that most of the receptors are not located in the predominant downwind direction, it is not possible to select five (5) receptors located in the predominant downwind direction.

An alternate approach to receptor selection has been used in consultation with the MOECC. The alternative approach evaluates receptors with the highest predicted sound level in each general direction around the facility.

Please see Appendix F for a memo entitled "Port Ryerse Wind Power Project Acoustic Audit – Immission – Monitoring Location Selection" dated March 28, 2017 prepared for the MOECC detailing the receptor selection rationale. The following describes the measurement locations:

- M151: Measurement equipment was placed on the open lawn on the property of and to the east of R151, 526 m to the nearest turbine (T1), on the east side of Port Ryerse Road. The predicted level based on the Aercoustics acoustic model at M151 is 38.2 dBA.

- M310: Measurement equipment was placed in an open field on the property of and to the south of R310, 6109 m to the nearest turbine (T2), on the south side of Woolley Road. The predicted level based on the Aercoustics acoustic model at M310 is 39.4 dBA.

- M364: Measurement equipment was placed on the vacant lot R364, 607 m to the closest turbine (T3), on the northwest side of Avalon Lane. The predicted level based on the Aercoustics acoustic model at M364 is 39.0 dBA.

- M323: Measurement equipment was placed in an open field on the property of and to south of P323, 563 m to the closest turbine (T4), on the south side of Woolley Road. The predicted level based on the Aercoustics acoustic model at M323 is 39.7 dBA.

- M411: Measurement equipment was placed on the open lawn on the property of and to the east of R411, 818 m to the closest turbine (T2), on the east side of Port Ryerse Road. The predicted level based on the Aercoustics acoustic model at M411 is 35.6 dBA.

The following table provides a summary of the receptor locations. Detailed site plans showing the receptor and audit locations are attached in Appendix A.

Table 3: Receptor Measurement Locations

	Audit Receptor ID Nearest Turbine ID	R151 T1	R310 T2	R364 T3	P323 T4	R411 T2
Receptor	UTM Coordinates (X,Y)	17T 560585mE 4734533mN	17T 561414mE 4768233mN	17T 562011mE 4734738mN	17T 561613mE 4735881mN	17T 560632mE 4735336mN
	Distance to Nearest Turbine	569m	649m	612m	601m	859m
	Predicted Level dBA*	37.6	38.8	38.9	39.0	33.4
Monitor	UTM Coordinates (X,Y)	17T 560624mE 4734553mN	17T 561425mE 4735825mN	17T 562016mE 4734748mN	17T 561606mE 4735826mE	17T 560404mE 4735344mN
	Distance to Nearest Turbine	526m	609m	607m	563m	818m
	Predicted Level dBA*	38.2	39.4	39.0	39.7	35.6

* Predicted level from Aercoustics' acoustic model

3.4 Sample Size Reporting Requirements

As per Section D3.8 of the MOECC protocol, at least 120 data points in each wind bin are required for Turbine ON measurements, and 60 data points for the ambient measurements between 4-7 m/s integer wind speeds inclusively (10m height).

The Revised Assessment Methodology for I-Audits (RAM-I) may allow for a lower amount of data points to be used in the analysis, provided that the quality of data remains high. RAM-I analysis was conducted as per Section 5.5 of the Protocol. This methodology is employed in cases where insufficient data is collected despite sound monitoring lasting longer than 6-weeks.

3.4.1 RAM-I Sample Size Requirements

The RAM-I assessment methodology reduces the sample size requirements, the Protocol states:

> "*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)" {Section E 5.5 (5)}*
>
> The threshold of 60 data points for Turbine ON measurements and 30 data points for Turbine OFF measurements is used in this assessment.

The range of wind bins which may be used to assess compliance is expanded to include a minimum of one of the following conditions as outlined in Section E 5.5(1):

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)"*

The RAM-I sample size requirement of 60 data points for Turbine ON and 30 data points for the ambient measurements for 3 wind speed bins has been satisfied for receptor R151

in wind speed bins 5, 6 and 7 m/s, receptors R310 and R411 in wind speed bins 4, 5 and 6 m/s, receptor M364 in wind speed bins 1, 2 and 3 m/s, and receptor P323 in wind speed bins 2, 3 and 4 m/s.

3.5 Wind Direction Reporting Requirements

3.5.1 RAM-I Downwind and Crosswind Requirements

The MOECC has required that collected measurement data is filtered for the downwind condition for all receptors.

In addition, the MOECC has required that collected measurement data is filtered for the crosswind condition for receptors R411, R151 and R364.

3.5.2 Aggregate Downwind Angle for M310, M364, M323, M411

For monitors M310, M364, M323 and M411 there are two turbines that have sound pressure levels at the measurement location within 2 dB of the turbine with the highest predicted impact. As a result, the aggregate downwind angle was used for the analysis such that the measurement location was considered downwind if the downwind condition (+/- 45 degrees from the line of site between the turbine and measurement location) was satisfied for the turbines listed as per Appendix F11 of the Protocol.

3.6 Weather Conditions

Ambient conditions encountered over the measurement campaign were as follows:

- Ambient Humidity: 13% to 96%
- Ambient Temperature: -20˚C to 18˚C
- 10m Wind Speed: 0 m/s to 14 m/s

Historically, the predominant wind direction is from the South-West for this site. The wind direction varied over the course of the audit campaign. Wind roses have been provided in Appendix B that show the measured 10 m height wind directions and wind speeds at each receptor for valid Turbine ON and Ambient measurement intervals. Wind directions shown on the wind roses indicate the direction the wind is coming from.

3.7 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by PRWPP. Measurement data at each 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 turbines was less than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were T1, T2, T3 and T4.

4 Sound Level Limits

The purpose of the sound measurements was to confirm whether the sound emitted by the wind facility is in compliance with the MOECC allowable sound level limits. The MOECC sound level limits for wind turbines vary with wind speed defined at a 10 m height. The details of the sound level limits are presented in Table 4 below.

Table 4: MOECC Sound Level Limits for Wind Turbines

Wind speed at 10m height [m/s]	MOECC Sound level limit [dBA]
≤ 4	40
5	40
6	40
7	43

As per section D6 of the MOECC Protocol, if the background sound levels are greater than the applicable exclusion limits then the applicable limits are now the background sound levels without extraneous noise sources.

5 Audit Results - Downwind

The following tables detail the sound levels measured at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey in Table 5 to Table 9.

Table 5: M151 Sound levels measured for Turbine ON and OFF – Downwind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	54	27	2.2	-
1	0	-	-	501	28	2.8	-
2	1	*	*	299	31	3.3	*
3	10	*	*	338	32	2.7	*
4	18	*	*	359	35	2.9	*
5	88	43	1.5	209	39	2.3	40
6	150	45	1.6	150	45	2.5	36†
7	118	48	1.8	61	49	2.7	**

* Insufficient amount of data points as per RAM-I protocol

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

† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

Table 6: M310 Sound levels measured for Turbine ON and OFF – Downwind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	60	26	2.8	-
1	0	-	-	272	28	4.0	-
2	4	*	*	94	35	3.7	*
3	33	*	*	235	35	4.2	*
4	115	42	1.8	241	38	3.9	40
5	288	44	1.4	148	43	3.9	39
6	594	46	1.4	30	46	2.9	23†
7	613	49	1.6	6	*	*	*

*Insufficient amount of data points as per RAM-I protocol
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

Table 7: M364 Sound levels measured for Turbine ON and OFF – Downwind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	13	*	*	79	28	2.3	*
1	309	40	1.6	663	30	4.1	40
2	479	41	1.6	403	38	5.0	38
3	217	45	3.4	208	44	4.8	39
4	37	*	*	64	49	3.1	*
5	8	*	*	5	*	*	*
6	0	-	-	0	-	-	-
7	0	-	-	0	-	-	-

*Insufficient amount of data points as per RAM-I protocol

Table 8: M323 Sound levels measured for Turbine ON and OFF – Downwind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	372	26	3.0	-
1	0	-	-	345	32	5.2	-
2	61	41	0.7	306	34	4.4	40
3	191	41	0.7	205	34	4.1	40
4	175	41	1.1	53	36	3.1	40
5	280	44	1.4	14	*	*	*
6	261	47	1.5	7	*	*	*
7	166	50	1.6	2	*	*	*

*Insufficient amount of data points as per RAM-I protocol
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

Table 9: M411 Sound levels measured for Turbine ON and OFF – Downwind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	51	26	2.3	-
1	0	-	-	409	27	3.1	-
2	1	*	-	258	30	3.8	*
3	11	*	*	134	36	2.6	*
4	64	41	1.0	195	38	1.9	39
5	129	43	1.5	117	42	2.3	37†
6	120	46	1.5	30	46	1.7	**
7	39	*	*	7	*	*	*

*Insufficient amount of data points as per RAM-I protocol
** Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at M151, M310, M364, M323 and M411 when all the nearby turbines were ON (Turbine ON + Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON sound level presented was filtered such that only data when the closest turbine was generating 85% power or greater and the receptor was in a downwind condition from the closest turbine was included. It should be noted that the turbine ON sound level includes all sounds measured during the interval.

Figure 1: M151 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Downwind

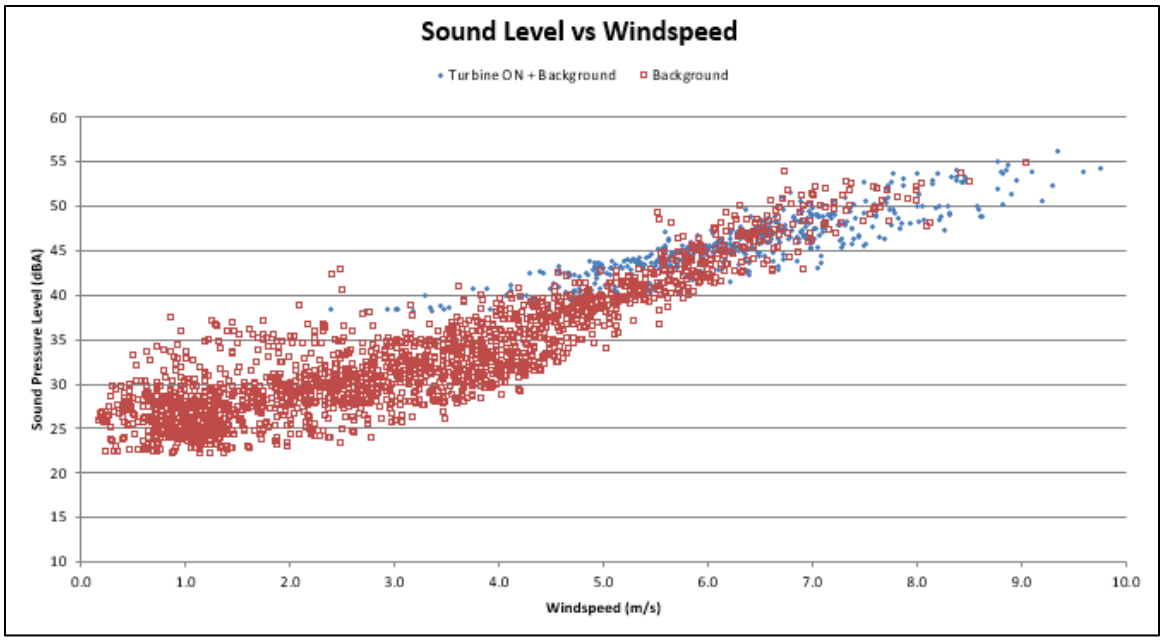


Figure 2: M310 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Downwind

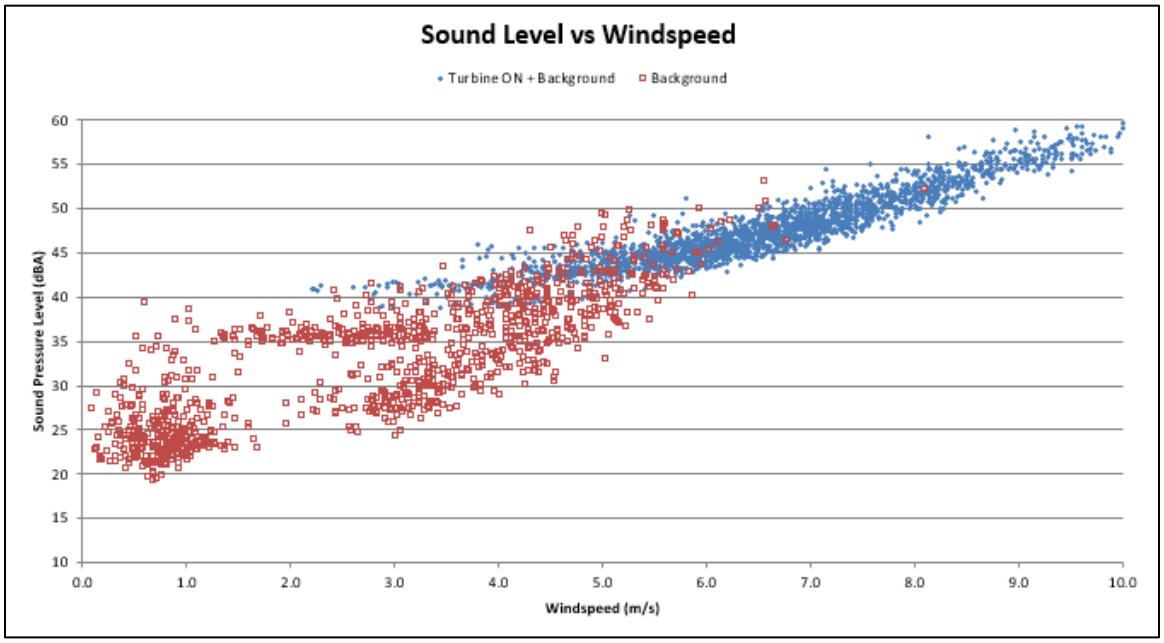


Figure 3: M364 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Downwind

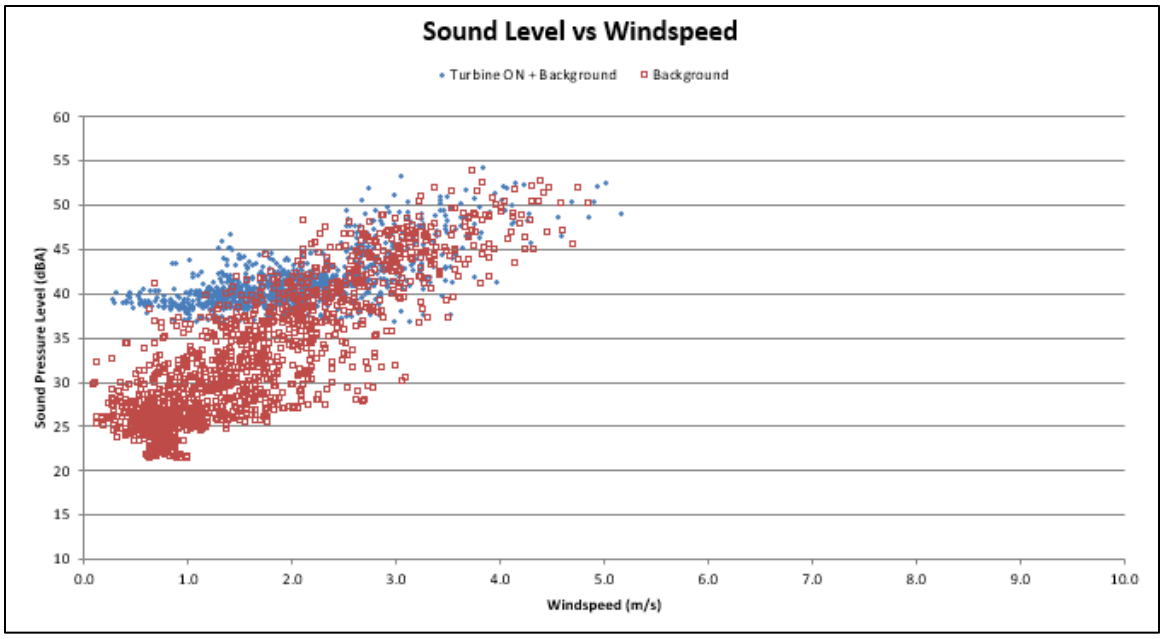


Figure 4: M323 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Downwind

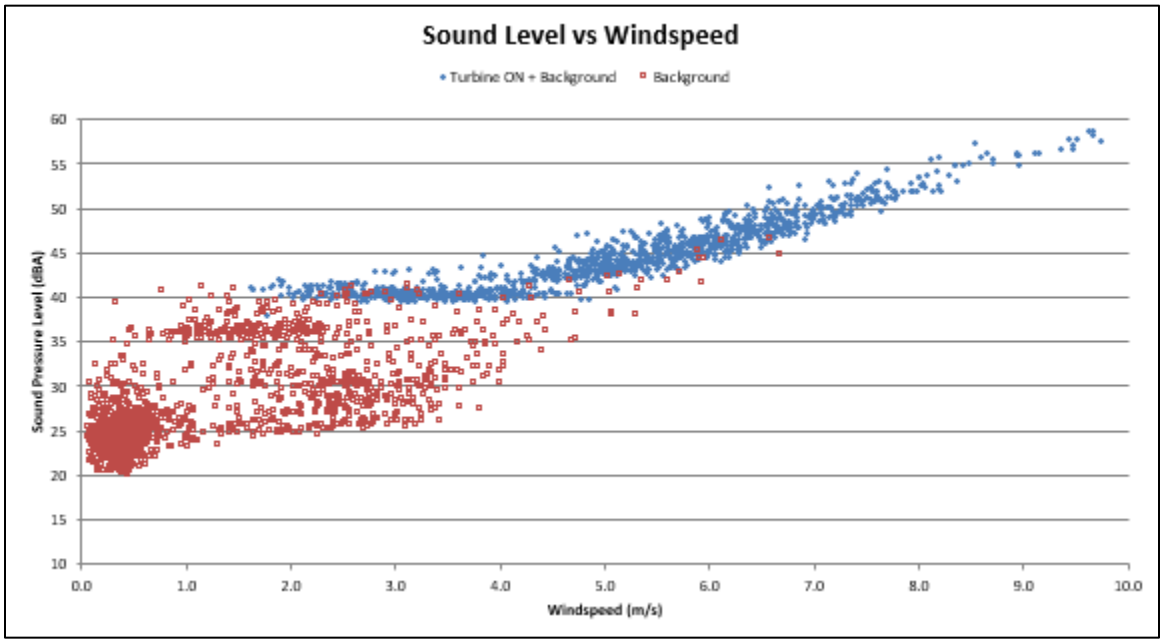
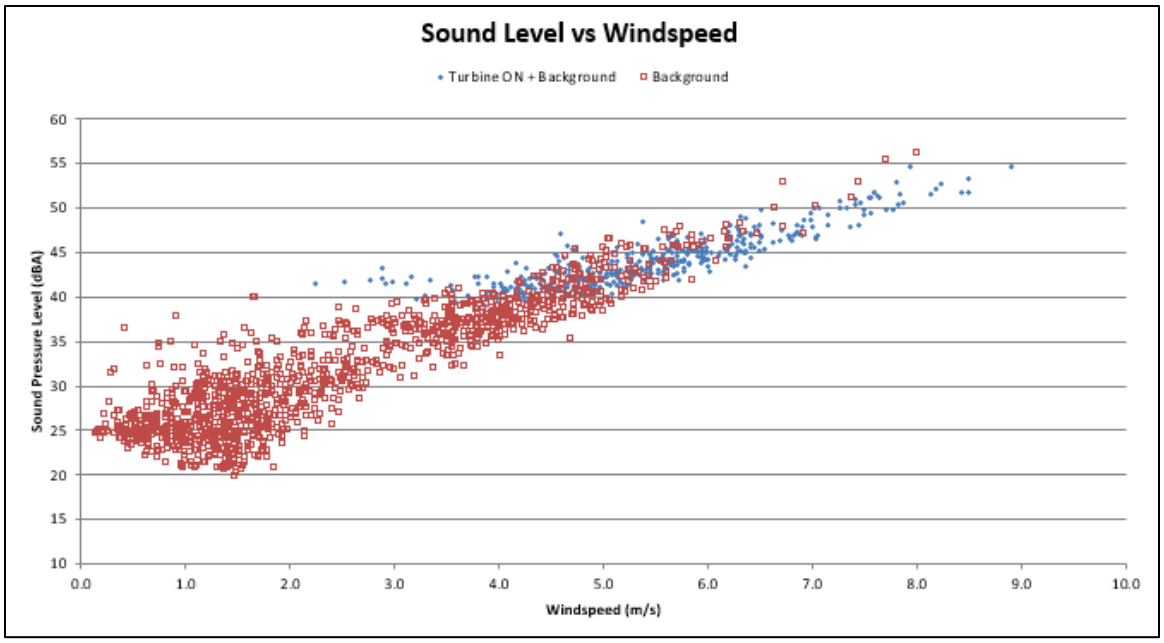


Figure 5: M411 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Downwind



6 Discussion - Downwind

6.1 Overall Sound Level

The turbine-only component of the sound level was derived from a logarithmic subtraction of the ambient noise from that of the sound level measured with the turbines operating. The resulting sound level can be attributed to the turbines. It should be noted that all values in Tables 5 to 9 have been rounded to the nearest integer. Calculated Turbine ONLY levels listed were calculated based on unrounded Turbine ON and Turbine OFF values.

The audit at all 5 monitoring locations are considered to be a conservative representative of the sound levels at their respective receptors given the placement of the acoustic monitoring stations and the predicted levels at the monitoring locations.

Table 10 presents the Turbine ON, Turbine OFF and calculated Turbine ONLY sound pressure levels between 0-7 m/s for the downwind condition. Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey.

Table 10: Assessment Table – Downwind

Measurement Location	Wind speed at 10m height [m/s]	0	1	2	3	4	5	6	7
M151	Turbine ON LAeq [dBA]	-	-	*	*	*	43	45	48
	Turbine OFF LAeq [dBA]	27	28	31	32	35	39	45	49
	Calculated Turbine ONLY LAeq [dBA]	-	-	*	*	*	40	36†	**
MOECC Limit		40	40	40	40	40	40	45‡	49‡
M310	Turbine ON LAeq [dBA]	-	-	*	*	42	44	46	49
	Turbine OFF LAeq [dBA]	26	28	35	35	38	43	46	*
	Calculated Turbine ONLY LAeq [dBA]	-	-	*	*	40	39	23†	*
MOECC Limit		40	40	40	40	40	43‡	46‡	43
M364	Turbine ON LAeq [dBA]	*	40	41	45	*	*	-	-
	Turbine OFF LAeq [dBA]	28	30	38	44	49	*	-	-
	Calculated Turbine ONLY LAeq [dBA]	*	40	38	39	*	*	-	-
MOECC Limit		40	40	40	44‡	49‡	40	40	43
M323	Turbine ON LAeq [dBA]	-	-	41	41	41	44	47	50
	Turbine OFF LAeq [dBA]	26	32	34	34	36	*	*	*
	Calculated Turbine ONLY LAeq [dBA]	-	-	40	40	40	*	*	*
MOECC Limit		40	40	40	40	40	40	40	43
M411	Turbine ON LAeq [dBA]	-	-	*	*	41	43	46	*
	Turbine OFF LAeq [dBA]	26	27	30	36	38	42	46	*
	Calculated Turbine ONLY LAeq [dBA]	-	-	*	*	39	37†	**	*
MOECC Limit		40	40	40	40	40	42‡	46‡	43

*Insufficient amount of data points as per RAM-I protocol
** Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level
‡ Background sound level is greater than the applicable exclusion limit, the applicable limit is the background sound level

The data from Table 10 is plotted in Figure 6 to Figure 10.

Figure 6: M151 Turbine Levels compared to MOECC Limits – Downwind

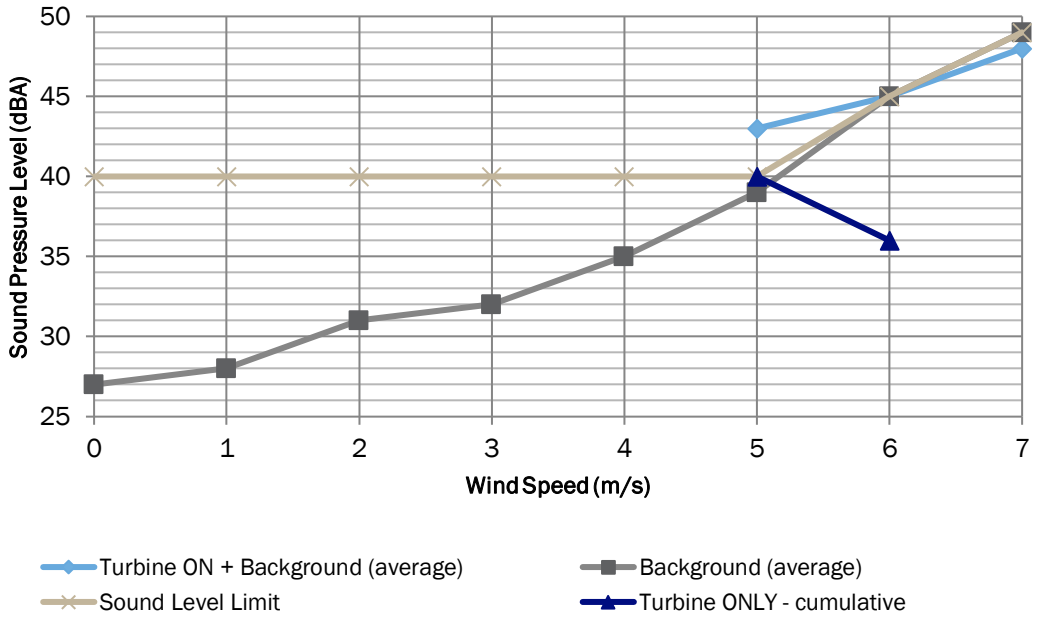


Figure 7: M310 Turbine Levels compared to MOECC Limits – Downwind

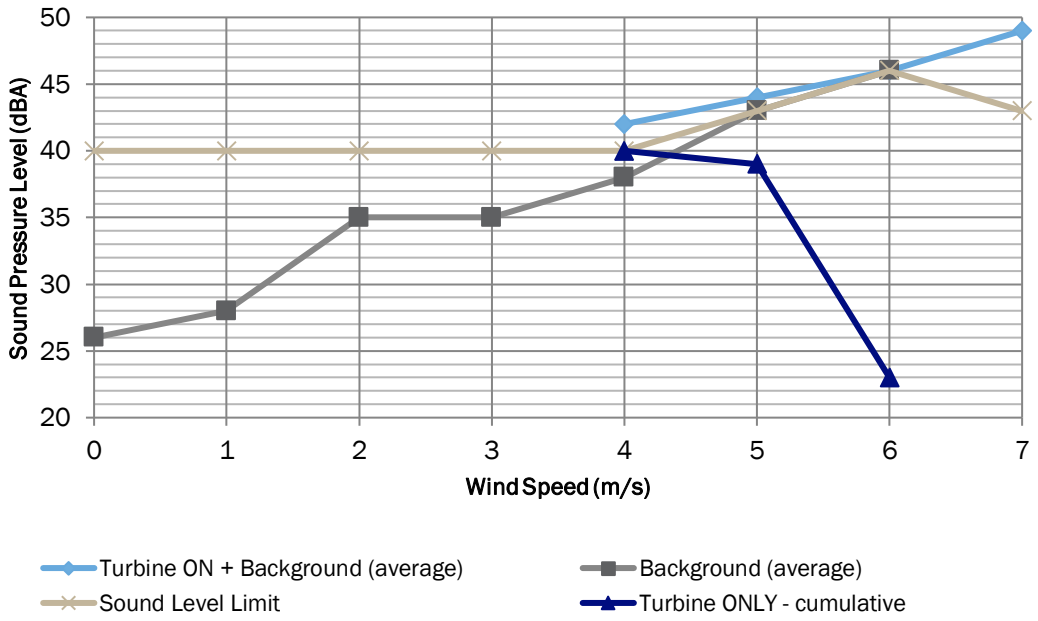


Figure 8: M364 Turbine Levels compared to MOECC Limits – Downwind

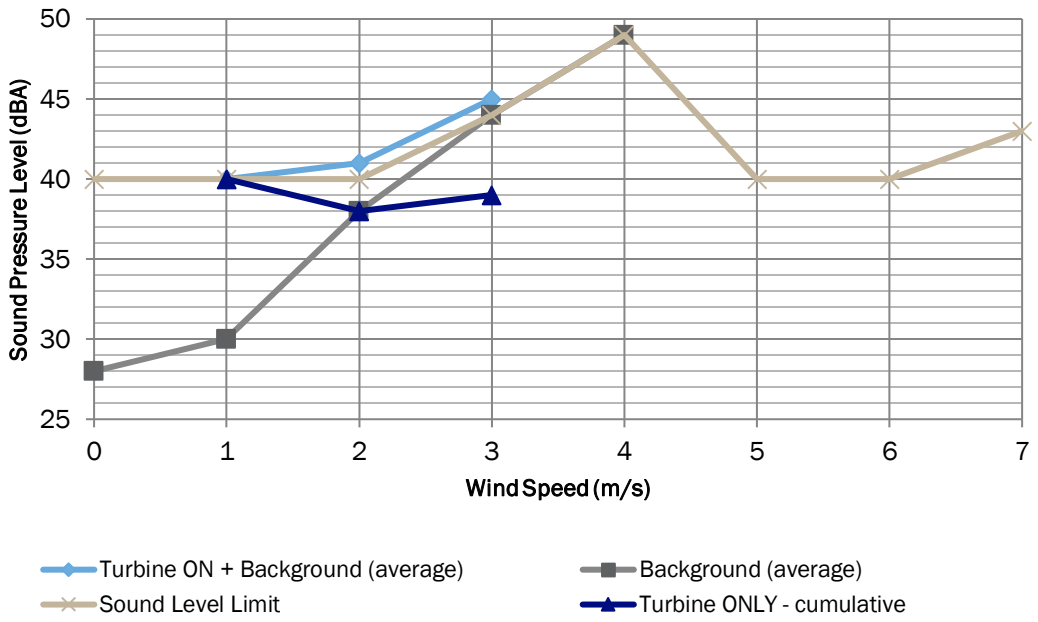


Figure 9: M323 Turbine Levels compared to MOECC Limits – Downwind

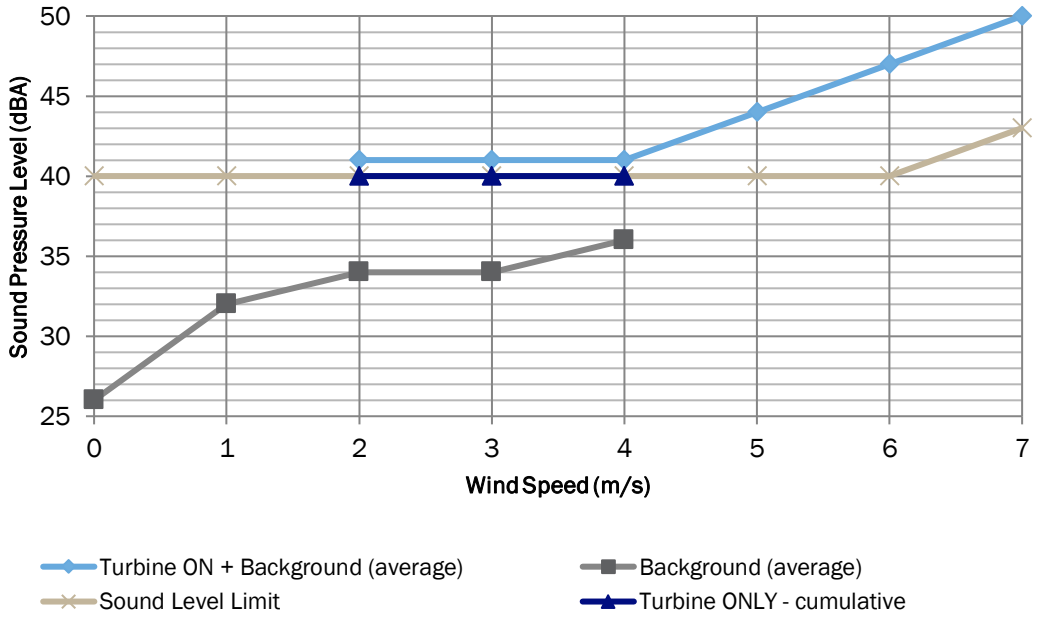
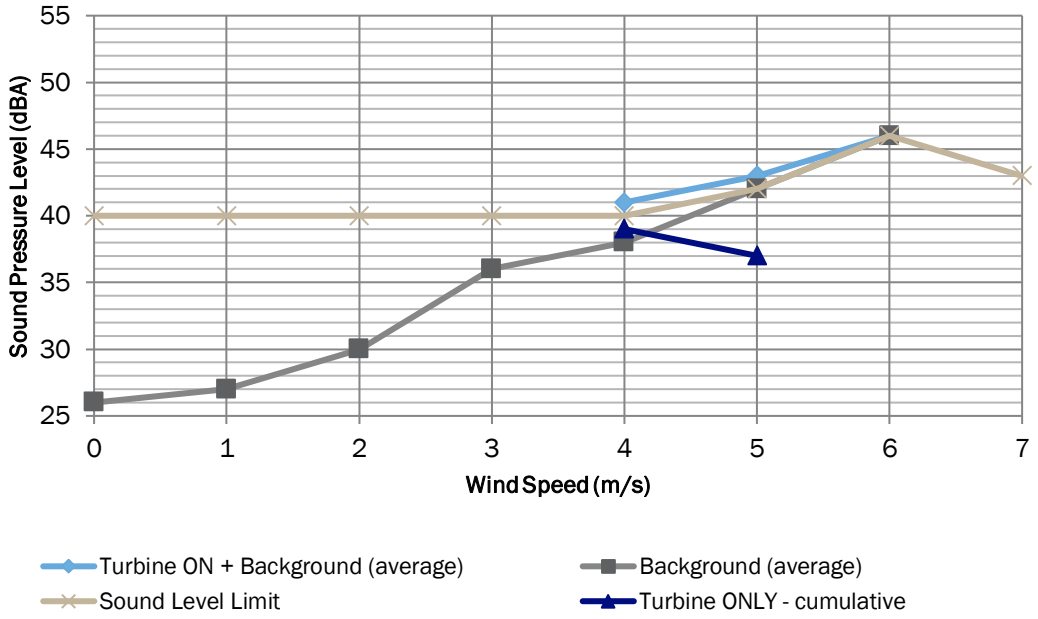


Figure 10: M411 Turbine Levels compared to MOECC Limits – Downwind



6.2 **Tonality**

Our site observations qualitatively indicate no presence of distinctly audible tones at the measurement locations. The noise from the wind turbines was subjectively assessed not to be tonal.

Objective and in-depth tonality analysis was also completed based on 1-minute narrow band spectra, ranging from 20 Hz to 3000 Hz. The methodology followed that of IEC 1400-11 Ed. 3.0 with modifications to adapt the method to immission measurements. Specifically, narrowband data was acquired and calculated for each 1-minute interval used in the immission analysis and binned by wind speed. Each minute was analysed in order to detect any tones with tonal audibility greater than -3 dB at any of the measured frequencies. Similar to the methodology in IEC 61400-11, a tone would have to be present in at least 20% of the sample to be deemed as existing. This removes the possibility of intermittent tones related to either the unsteady operation of the turbines, or from other contaminating sources, being attributed to the steady state operation of the turbines. The tonal audibility for the most prominent tones in each wind bin were then evaluated to determine if a tonal penalty would be applicable. The penalty structure was taken from ISO1996-2 Annex C: namely that the tonal penalty would be a positive number between 0dB and 6 dB based on the degree of tonal audibility of the worst-case tone. A tonal penalty is calculated as L_{ta} - 4 dB. i.e. a tonal audibility of 6.5 would incur a penalty of 2.5 dBA on the overall Turbine Only level.

The tonality analysis results of the Emission audit measurements for turbines T02 (rated at 102.5 dBA) and T04 (rated at 102.5 dBA) were used as a basis for tones at all receptors, respectively, which were likely to have been generated by the closest turbine rather than by an external source. It should be noted that tonality analysis results of the Emission audit measurements for turbines T02 and T04 showed no reportable tones detected. Tonal assessment summary tables are provided in Appendix D.

Tones at 58Hz and 239Hz were detected at receptors R151, R310, R364 and P323. It is unclear if the detected tones are from the facility or from external sources at the receptor locations. Regardless, the average tonal audibility for the detected tones was less than 4dB in all wind bins at all receptors.

As such, no tonal penalty was found to be applicable based on detailed tonal audibility analysis at audited receptors at the PRWF Wind Power Project.

7 Audit Results – Crosswind

The following tables detail the sound levels measured at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey in Tables 11, 12 and 13. The Turbine ON sound level presented was filtered such that only data when the closest turbine was generating 85% power or greater and the receptor was in a crosswind condition from the closest turbine was included. It should be noted that the turbine ON sound level includes all sounds measured during the interval.

Table 11: M151 Sound levels measured for Turbine ON and OFF – Crosswind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	54	27	2.2	-
1	12	*	*	501	28	2.8	*
2	181	40	0.9	299	31	3.3	39
3	137	40	0.9	338	32	2.7	39
4	314	41	1.8	359	35	2.9	40
5	390	43	1.8	209	39	2.3	40
6	354	46	1.9	150	45	2.5	40†
7	225	50	2.1	61	49	2.7	39†

* Insufficient amount of data points as per RAM-I protocol
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

Table 12: M364 Sound levels measured for Turbine ON and OFF – Crosswind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	79	28	2.3	-
1	111	39	1.0	663	30	4.1	38
2	432	40	2.0	403	38	5.0	36
3	1115	44	2.8	208	44	4.8	**
4	1560	48	3.1	64	49	3.1	**
5	792	51	2.7	5	*	*	*
6	248	53	2.4	0	-	-	-
7	36	*	*	0	-	-	-

* Insufficient amount of data points as per RAM-I protocol
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level
** Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

Table 13: M411 Sound levels measured for Turbine ON and OFF – Crosswind

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	24	*	*	51	27	2.3	*
1	313	37	1.9	409	28	3.1	36
2	204	39	2.7	258	31	3.8	38
3	136	41	2.1	134	36	2.6	39
4	98	42	1.9	195	38	1.9	39
5	87	44	1.5	117	42	2.3	39
6	76	47	2.0	30	46	1.7	39†
7	28	*	*	7	*	*	**

* Insufficient amount of data points as per RAM-I protocol
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level
** Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at M151, M364, and M411 when all the nearby turbines were ON (Turbine ON + Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON sound level presented was filtered such that only data when the closest turbine was generating 85% power or greater and the receptor was in a crosswind condition from the closest turbine was included. It should be noted that the turbine ON sound level includes all sounds measured during the interval.

Figure 11: M151 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Crosswind

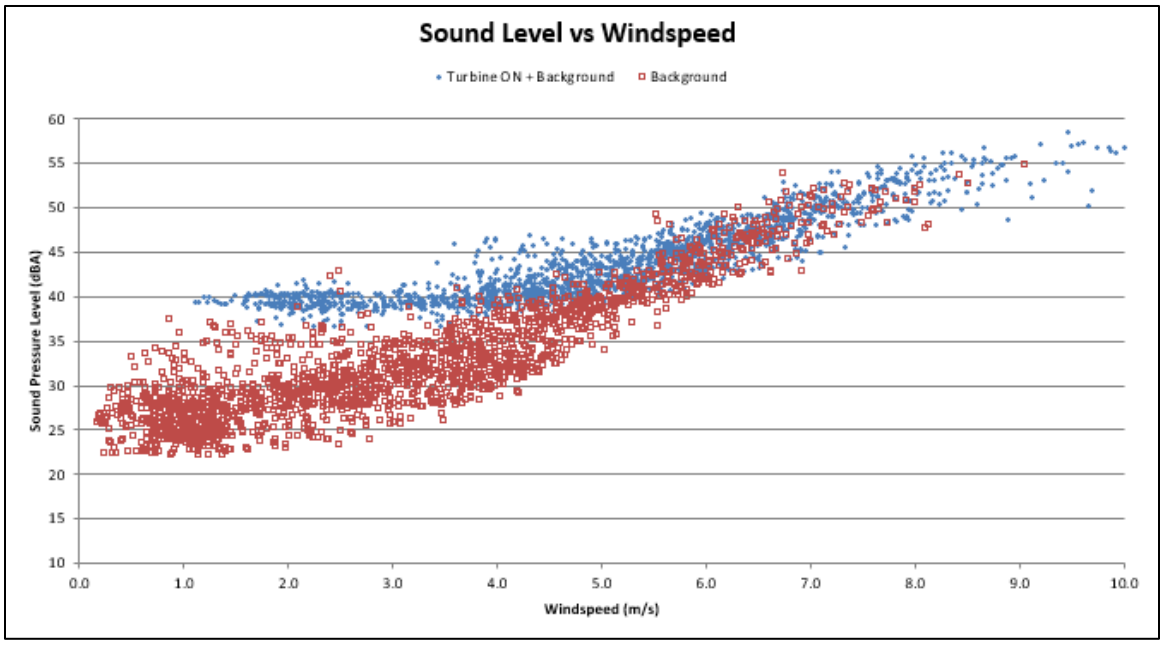


Figure 12: M364 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Crosswind

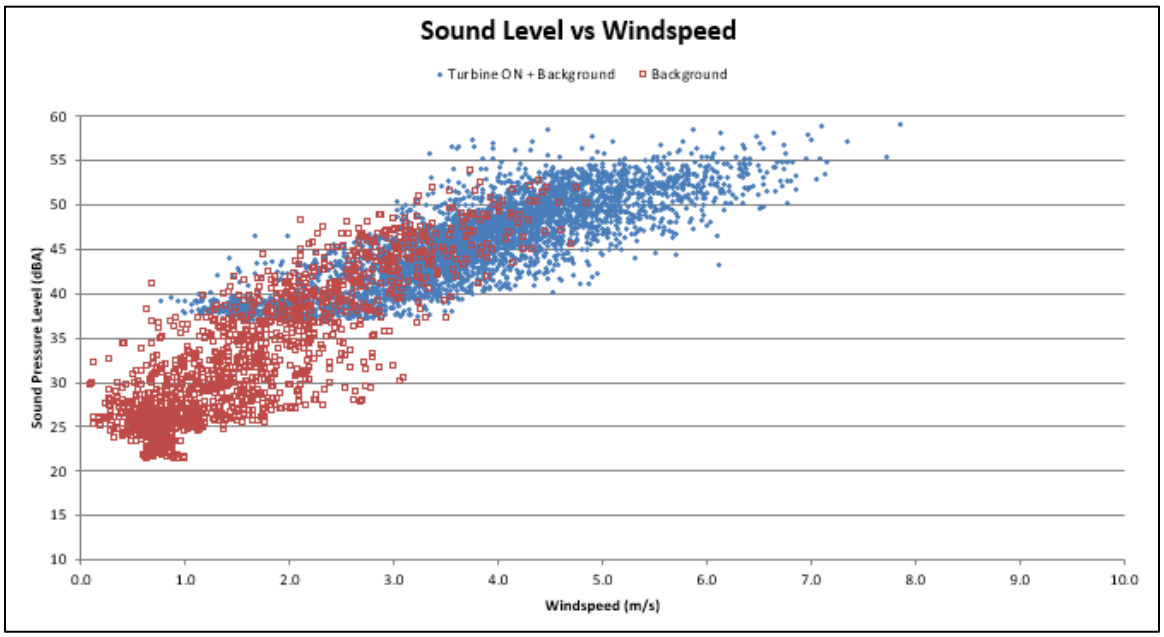
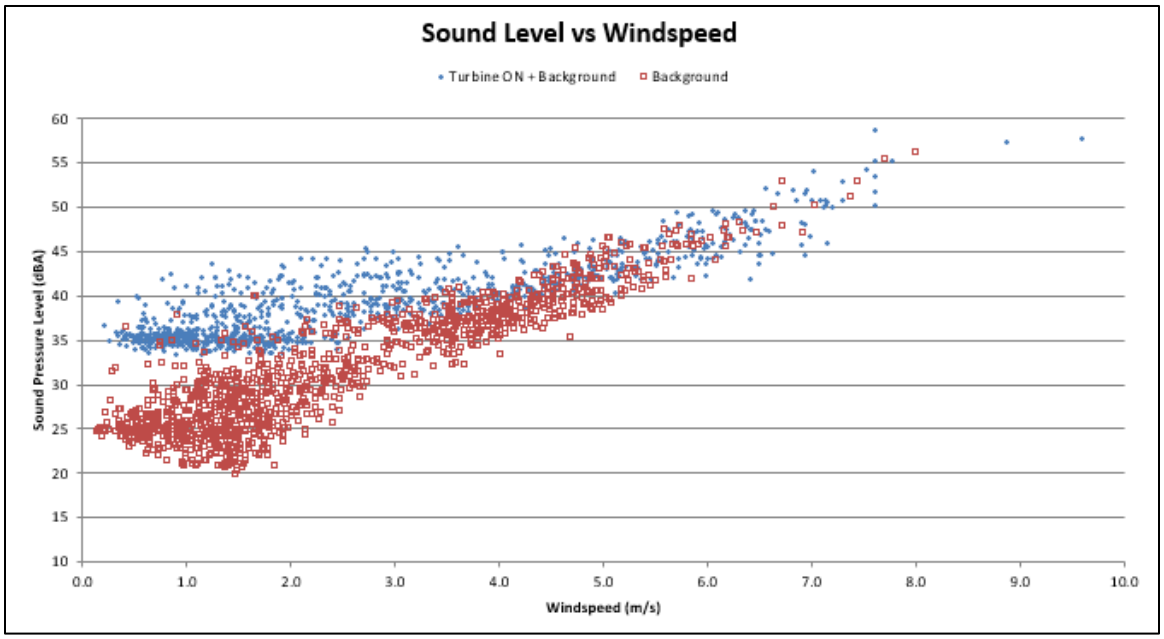


Figure 13: M411 - Measured Sound Levels for Turbine ON and Background vs Wind Speed – Crosswind



8 Discussion - Crosswind

8.1 Overall Sound Level

The turbine-only component of the sound level was derived from a logarithmic subtraction of the ambient noise from that of the sound level measured with the turbines operating. The resulting sound level can be attributed to the turbines. It should be noted that all values in Tables 11 to 13 have been rounded to the nearest integer. Calculated Turbine ONLY levels listed were calculated based on unrounded Turbine ON and Turbine OFF values.

The audit at all 5 monitoring locations are considered to be conservatively representative of the sound levels at their respective receptors given the placement of the acoustic monitoring stations and the predicted levels at the monitoring locations.

Table 14 presents the Turbine ON, Turbine OFF and calculated Turbine ONLY sound pressure levels between 0-7 m/s for the crosswind condition. Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey.

Table 14: Assessment Table – Crosswind

Measurement Location	Wind speed at 10m height [m/s]	0	1	2	3	4	5	6	7
M151	Turbine ON LAeq [dBA]	-	*	40	40	41	43	46	50
	Turbine OFF LAeq [dBA]	27	28	31	32	35	39	45	49
	Calculated Turbine ONLY LAeq [dBA]	-	*	39	39	40	40	40†	39†
MOECC Limit		40	40	40	40	40	40	45‡	49‡
M364	Turbine ON LAeq [dBA]	-	39	40	44	48	51	53	*
	Turbine OFF LAeq [dBA]	28	30	38	44	49	*	-	-
	Calculated Turbine ONLY LAeq [dBA]	-	38	36	**	**	*	-	-
MOECC Limit		40	40	40	44‡	49‡	40	40	43
M411	Turbine ON LAeq [dBA]	*	37	39	41	42	44	47	*
	Turbine OFF LAeq [dBA]	27	28	31	36	38	42	46	*
	Calculated Turbine ONLY LAeq [dBA]	*	36	38	39	39	39	39†	*
MOECC Limit		40	40	40	40	40	42‡	46‡	43

* Insufficient amount of data points as per RAM-I protocol
** Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined
† Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level
‡ Background sound level is greater than the applicable exclusion limit, the applicable limit is the background sound level

The data from Table 14 is plotted in Figures 14 to 16.

Figure 14: M151 Turbine Levels compared to MOECC Limits – Crosswind

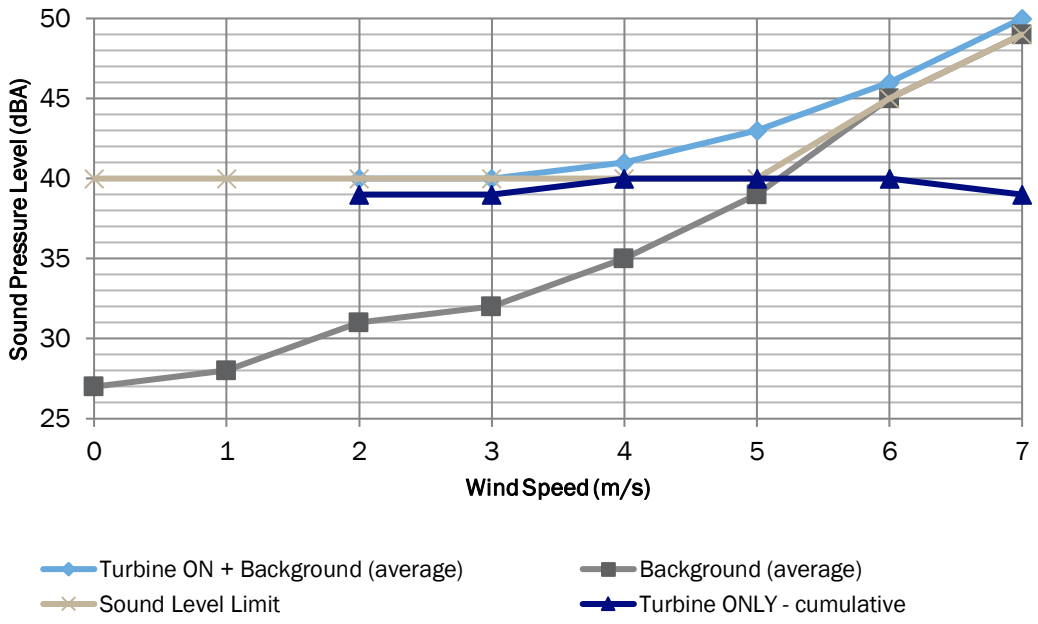


Figure 15: M364 Turbine Levels compared to MOECC Limits – Crosswind

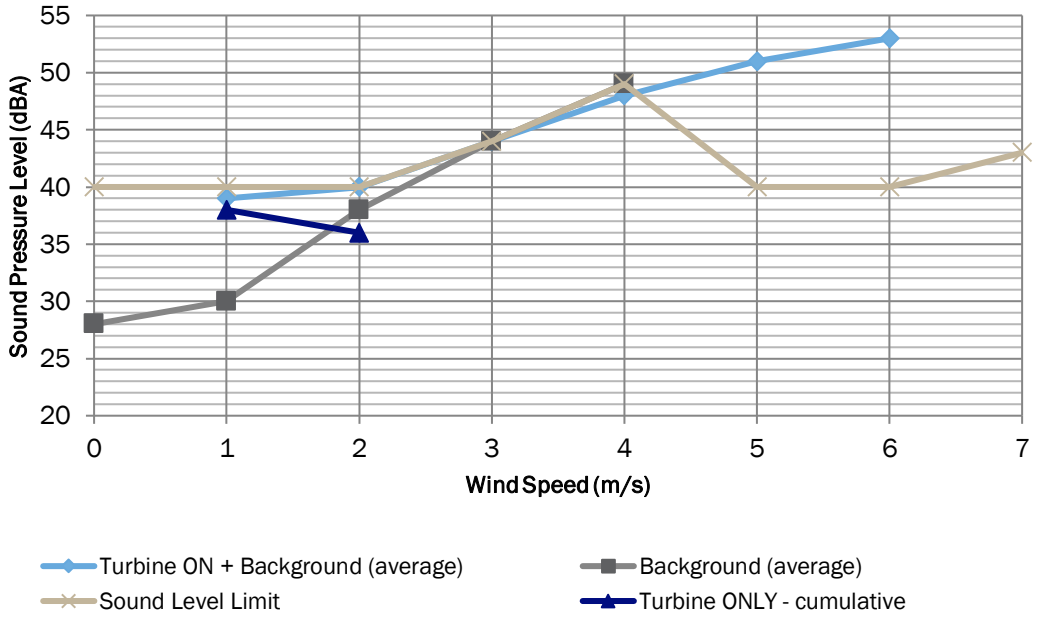
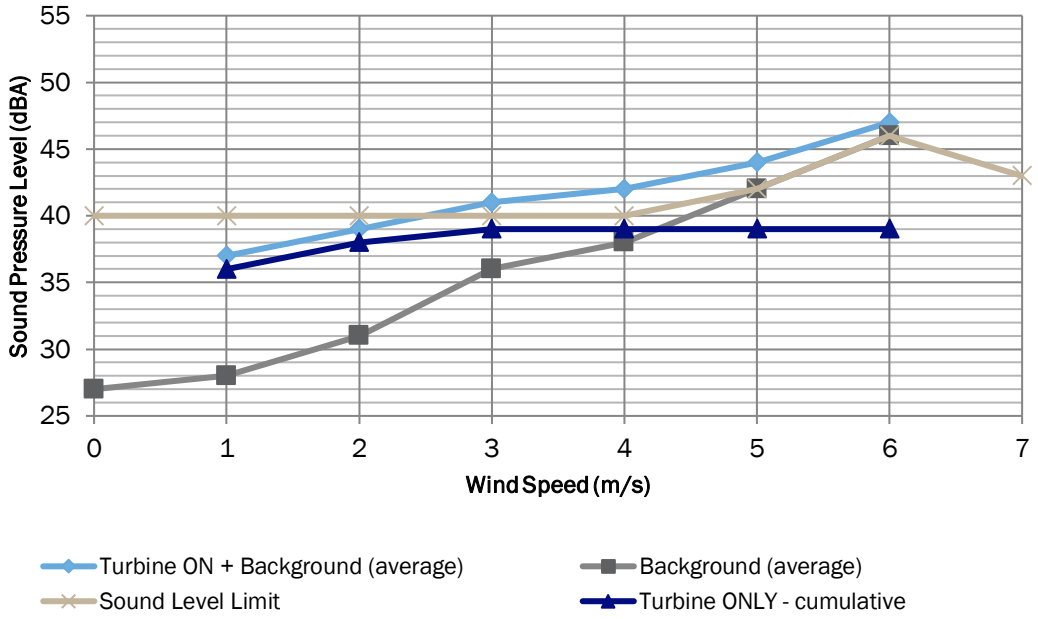


Figure 16: M411 Turbine Levels compared to MOECC Limits – Crosswind



9 Assessment of Compliance

Based on the calculated turbine-only component for downwind conditions indicated in Table 10 and Figures 6 to 9, and crosswind conditions indicated in Table 14 and Figures 14 to 16 the Port Ryerse Wind Power Project was found to be compliant with MOECC limits at receptors R151, R310 R364, P323 and R411.

10 Conclusion

Aercoustics Engineering Limited has completed the acoustic audit outlined in the Renewable Energy Approval for the Port Ryerse Wind Power Project. The audit was completed as per the methodology outlined in Parts D and E of the "*MOECC Compliance Protocol for Wind Turbine Noise*." The measured levels were compared to the MOECC limits, and the facility was determined to be compliant at receptors R151, R310, R364, P323 and R411.

11 References

[1] V. Schroter, “Renewable Energy Approval #6498-9HKHN3”, Ontario Ministry of the Environment, Toronto, ON, August 20, 2014.

[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] J.R. Salmon and S. J. Stewart, “Port Ryerse Wind Power Project – Noise Assessment Report”, Zephyr North Ltd., Burlington, ON, July 15, 2014.

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Appendix A
Location Details

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title Site Plan
		Figure A.01

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title M151 - Monitor and Receptor Location Details
		Figure A.02

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title M310 - Monitor and Receptor Location Details
		Figure A.03

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title M364 - Monitor and Receptor Location Details
		Figure A.06

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title M323 - Monitor and Receptor Location Details
		Figure A.05

aercoustics	14355	**Project Name**
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		Figure Title M411 - Monitor and Receptor Location Details
		Figure A.06

aercoustics	14355 Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit	
		Figure Title M151 - Site Photos	**Figure A.07**

aercoustics	14355 Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** M310 - Site Photos

Figure A.08

aercoustics

14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	
Project Name Port Ryerse Wind Power Project - 1st Acoustic Immission Audit	
Figure Title M364 - Site Photos	**Figure A.09**

aercoustics	14355	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
		Figure Title M323 - Site Photos
		Figure A.10

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14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
	Figure Title M411 - Site Photos

Figure A.11

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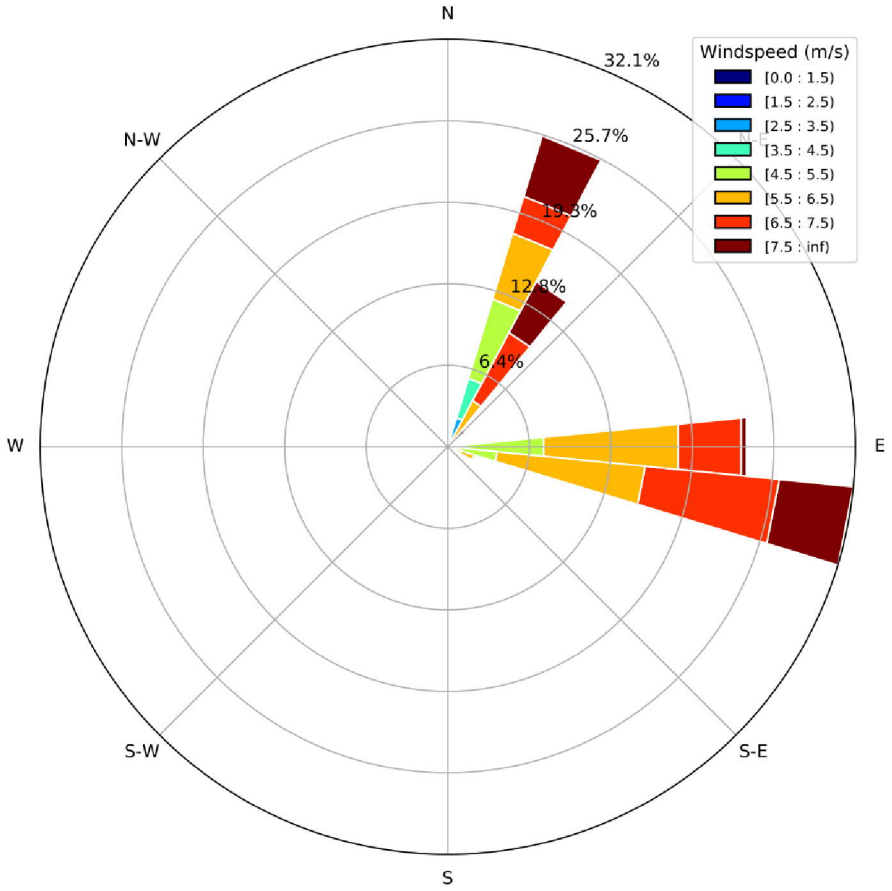
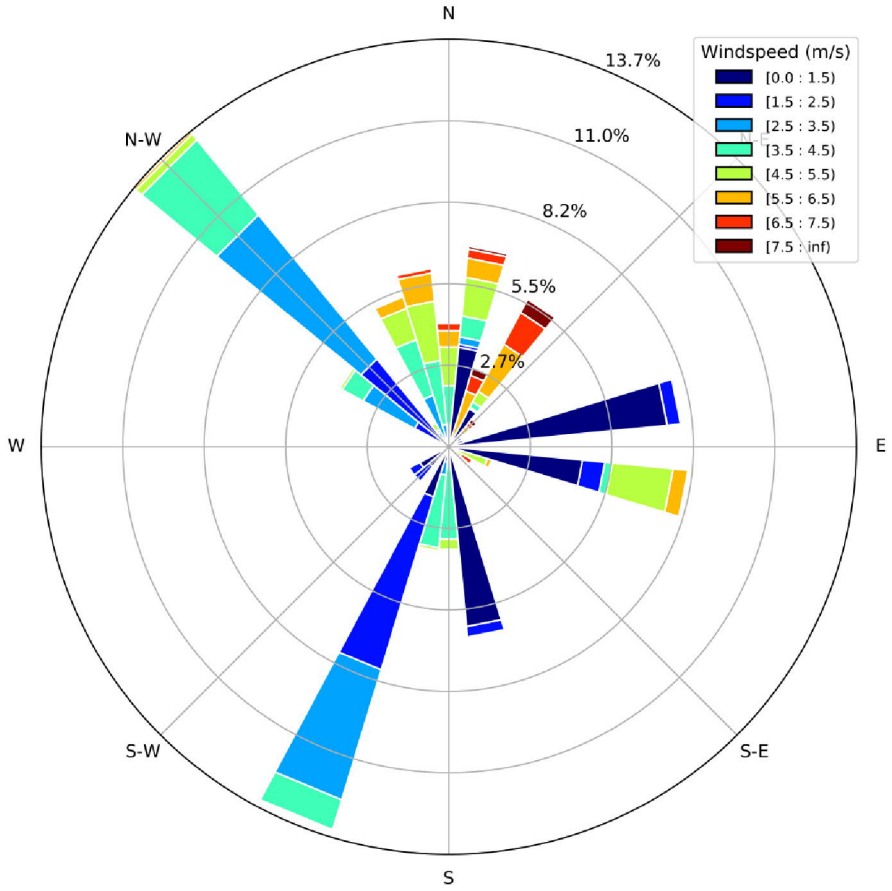
Appendix B
Wind Roses

M151 TON	M151 TOFF





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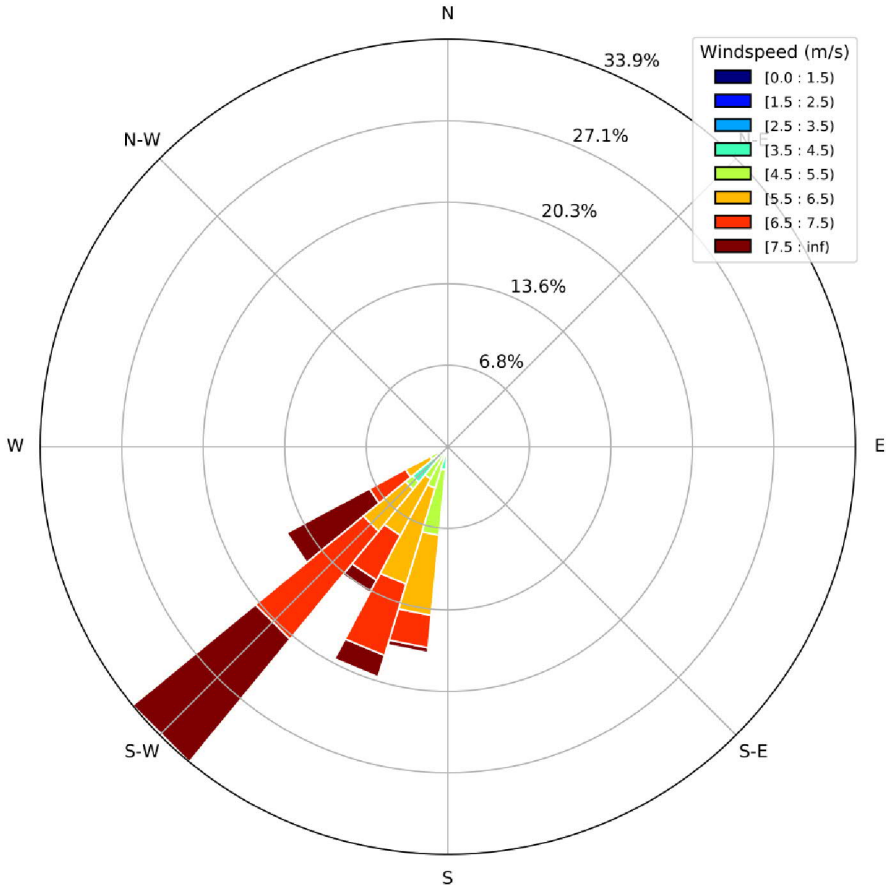
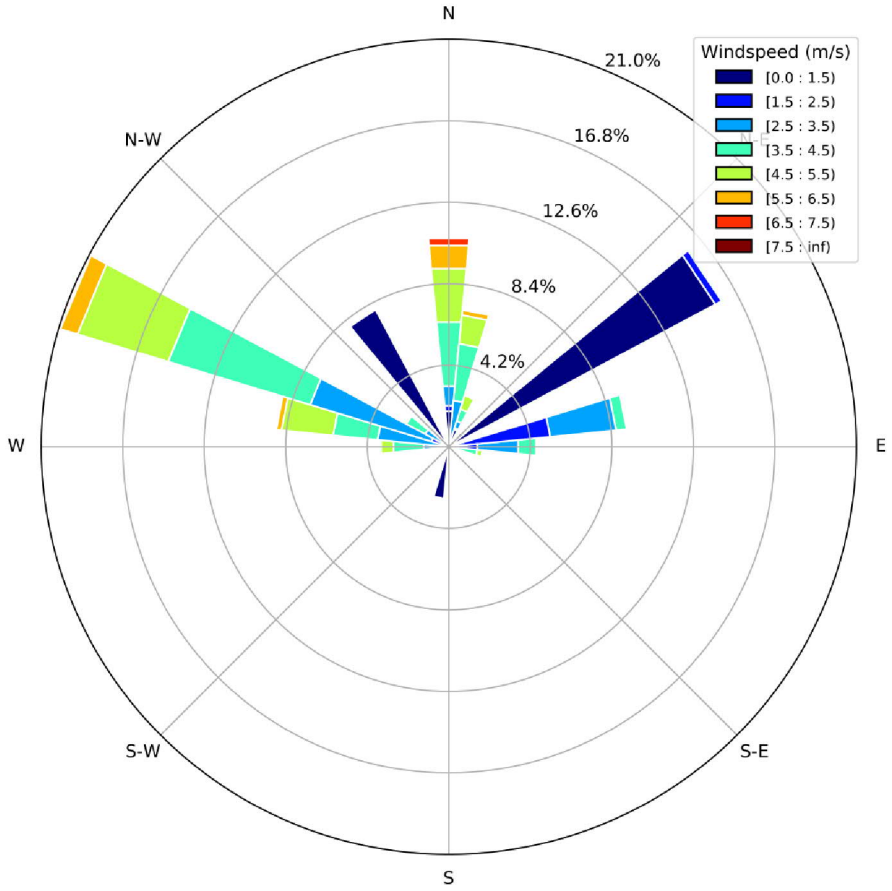
14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M151 Downwind

Figure B.01

M310 TON	M310 TOFF
	

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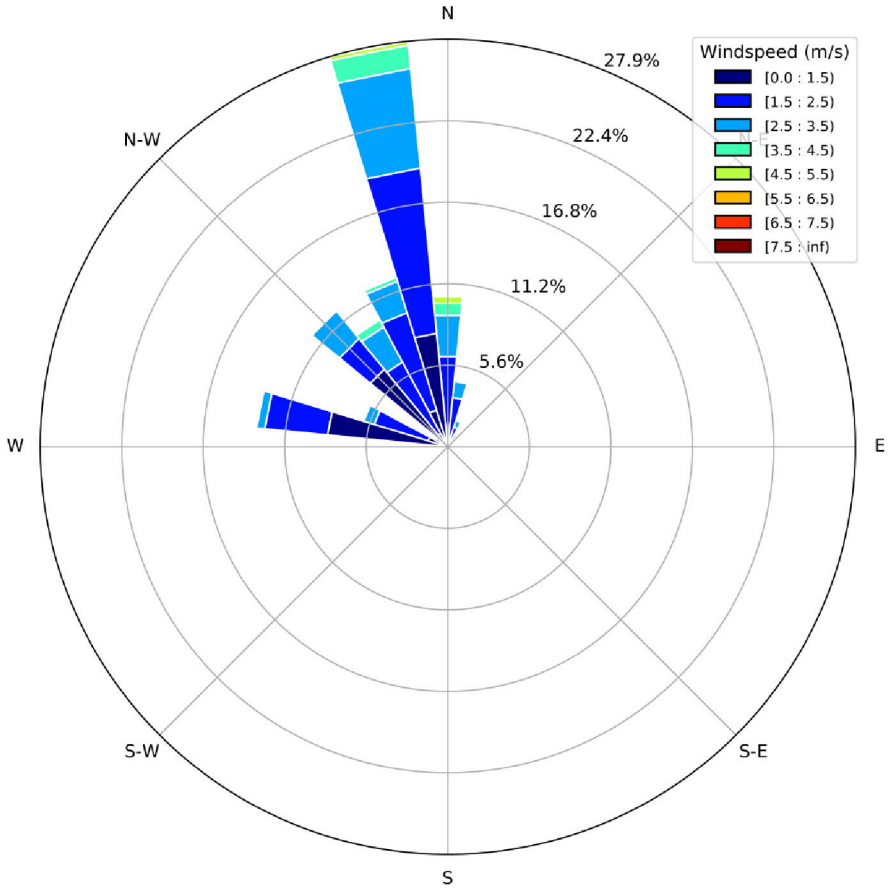
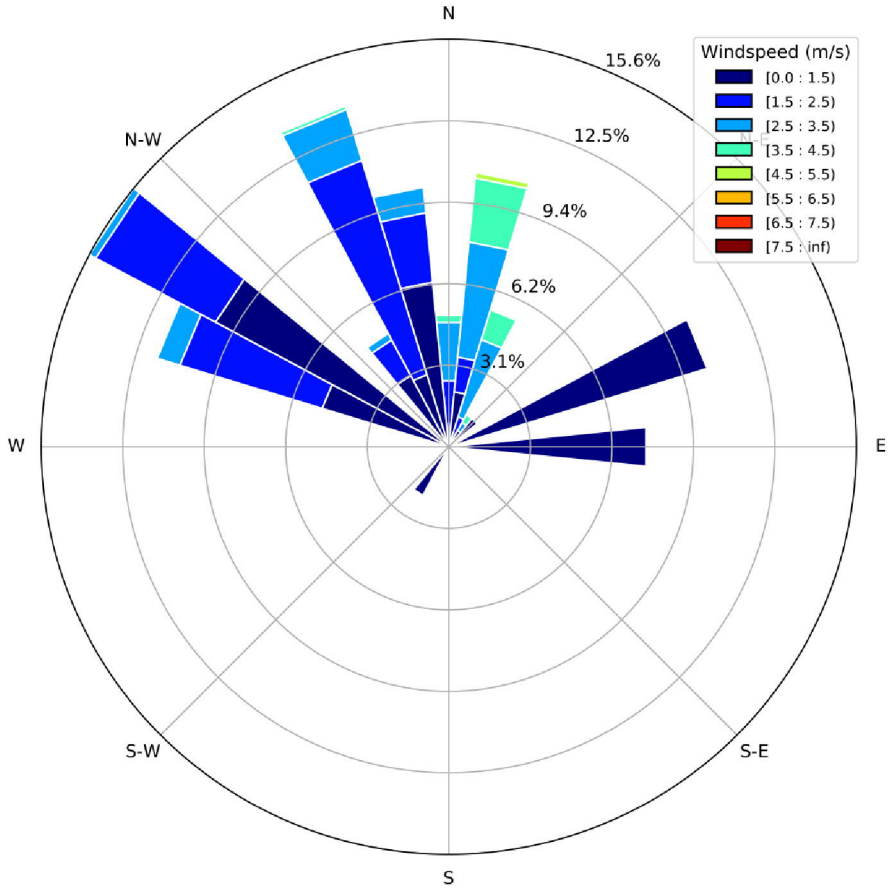
14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M310 Downwind

Figure B.02

M364 TON	M364 TOFF



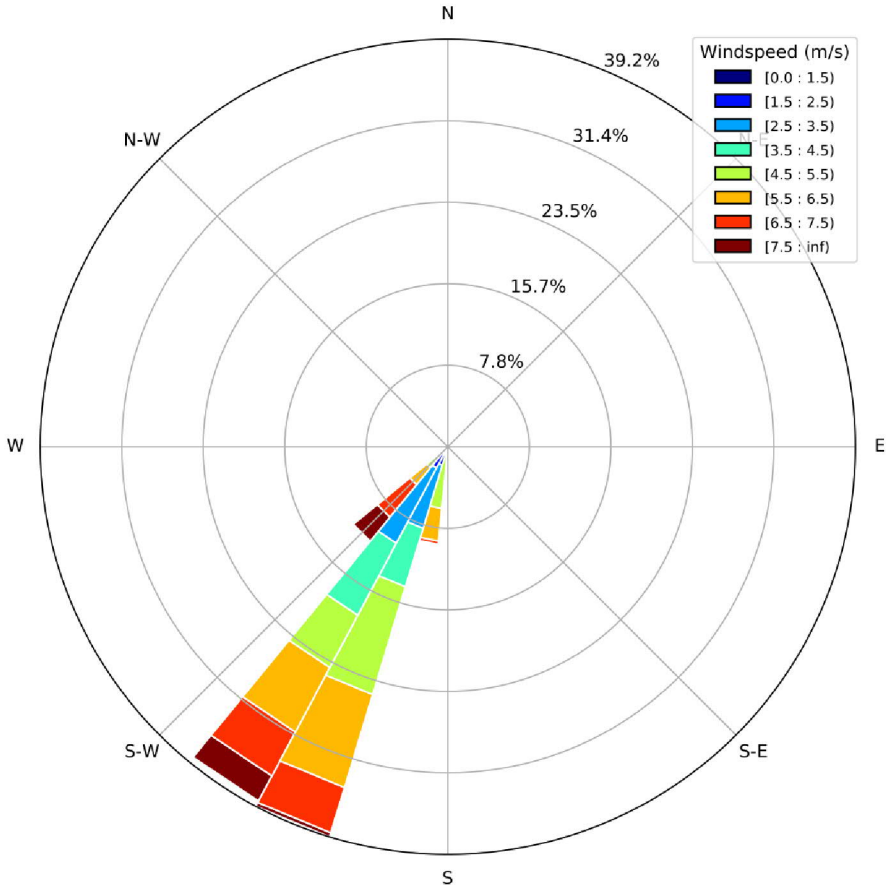


aercoustics

14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M364 Downwind

Figure B.03

M323 TON	M323 TOFF



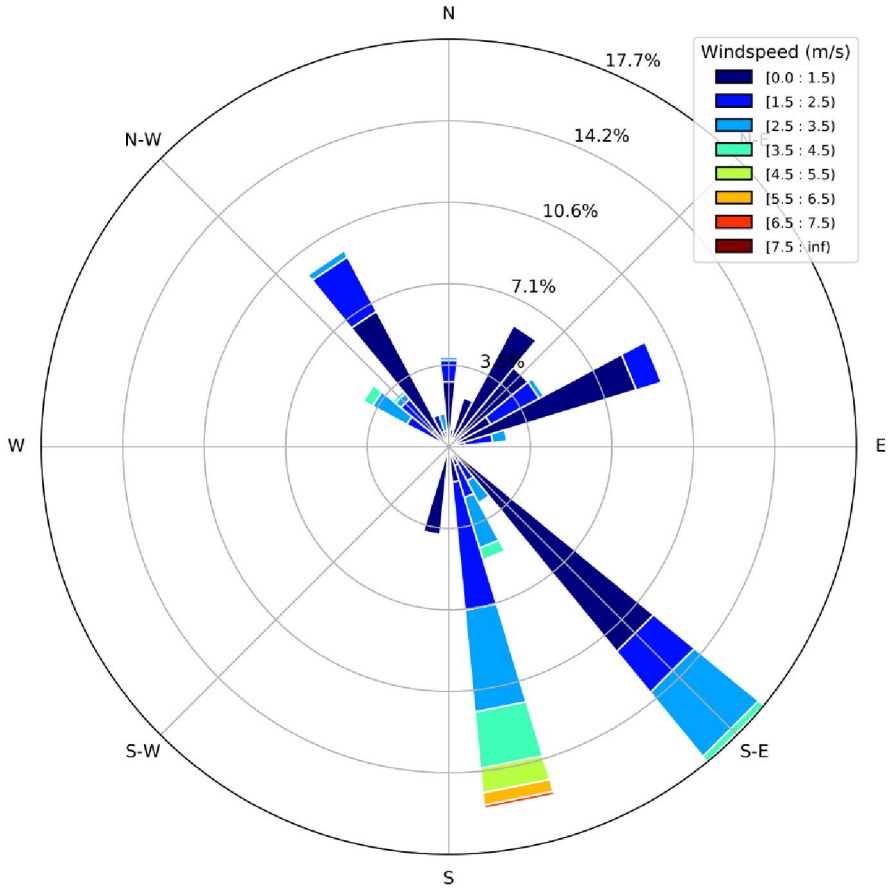


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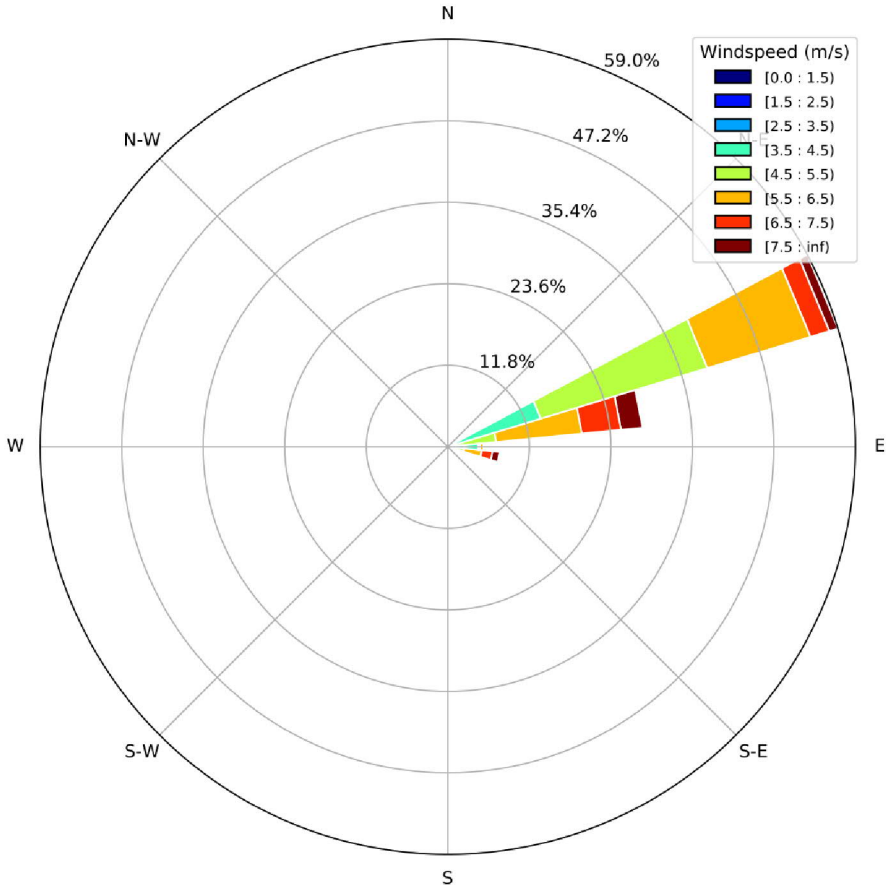
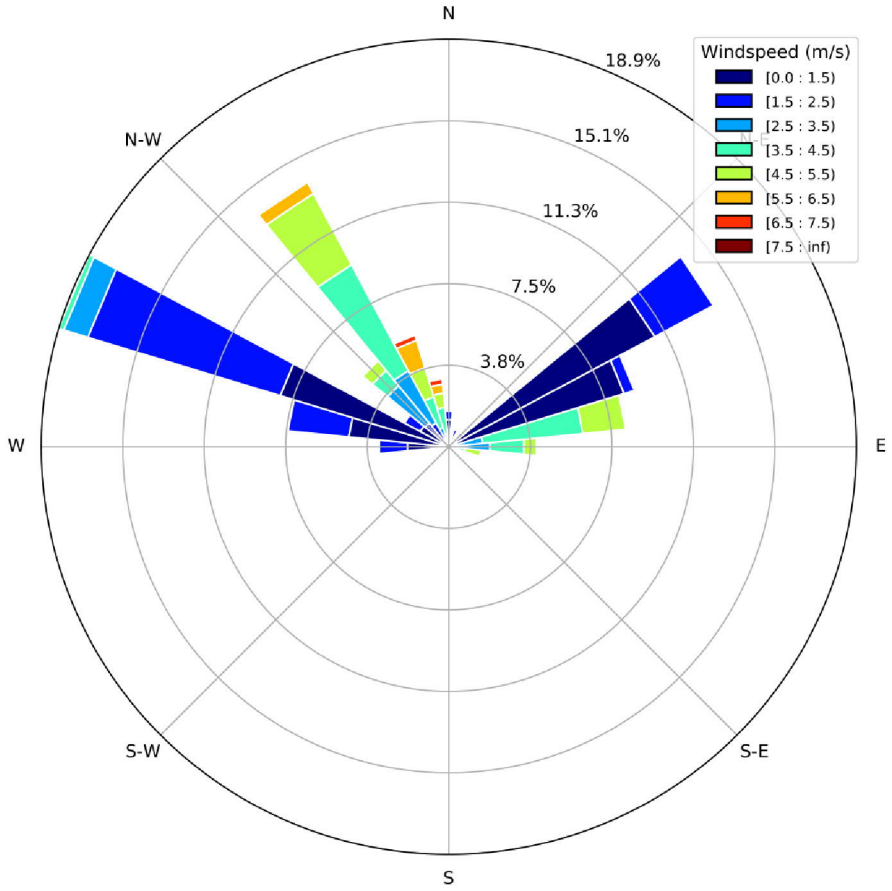
Figure B.04

M411 TON	M411 TOFF





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14355	
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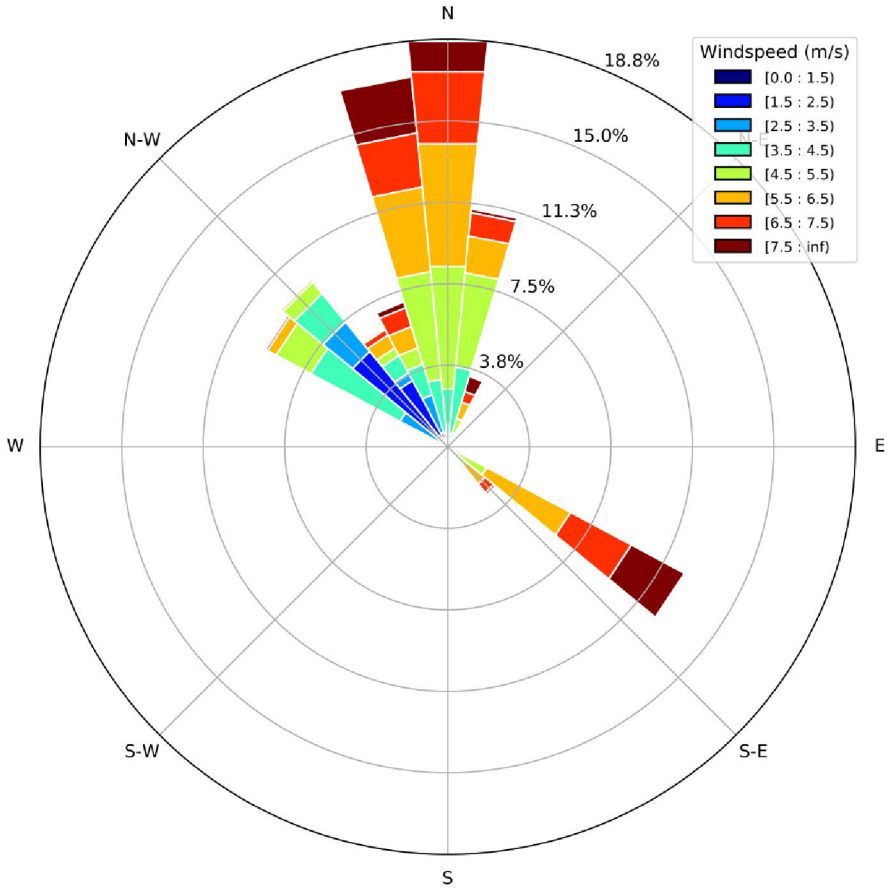
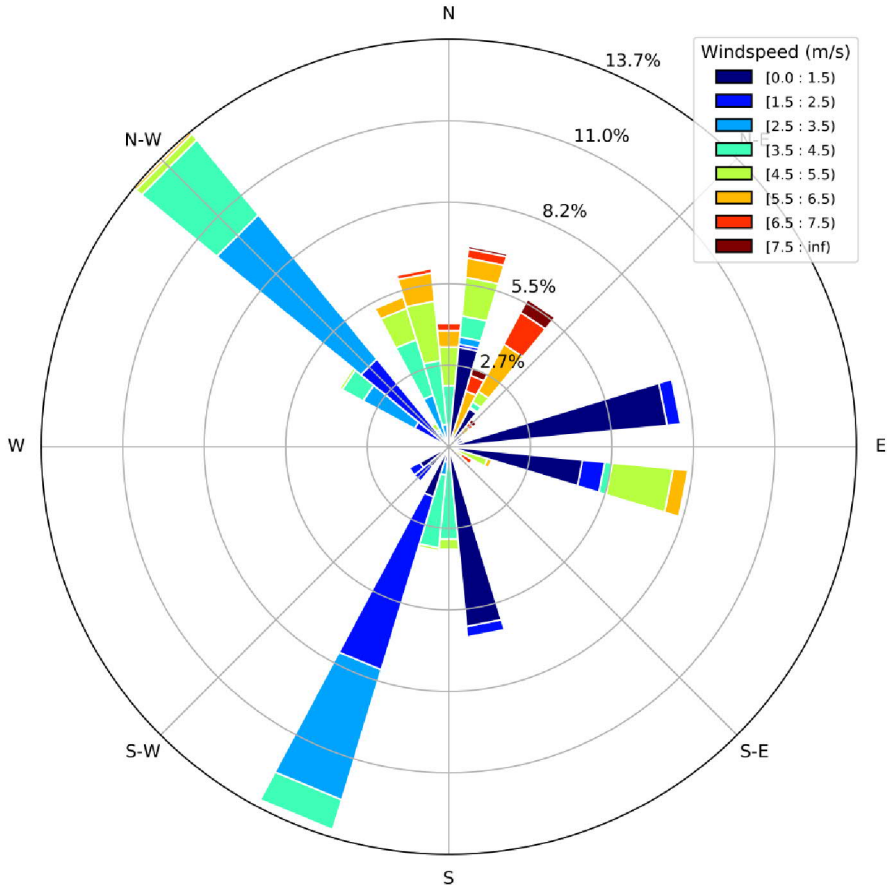
Figure B.05

M151 TON	M151 TOFF
	

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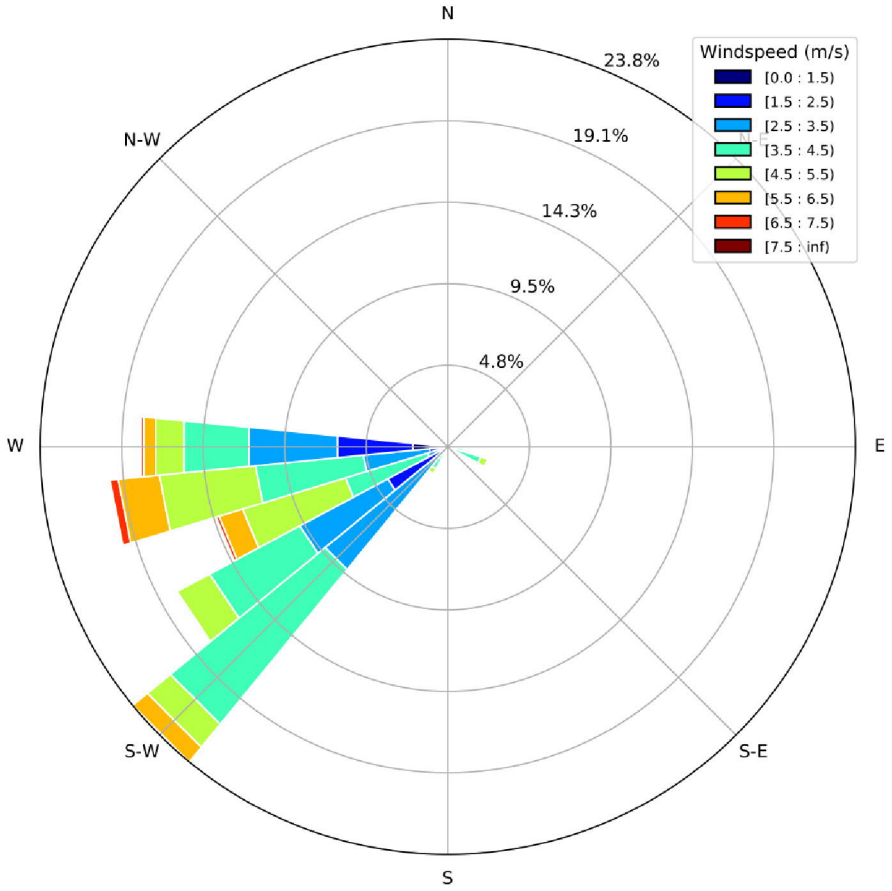
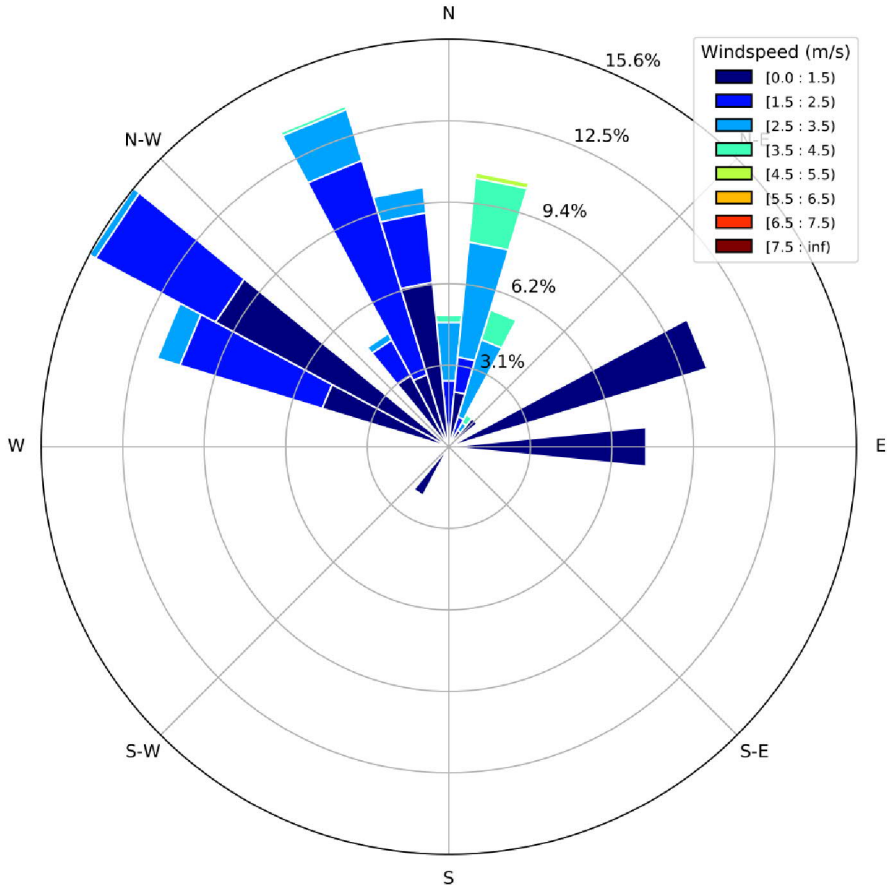
14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M151 Crosswind

Figure B.06

M364 TON	M364 TOFF
	

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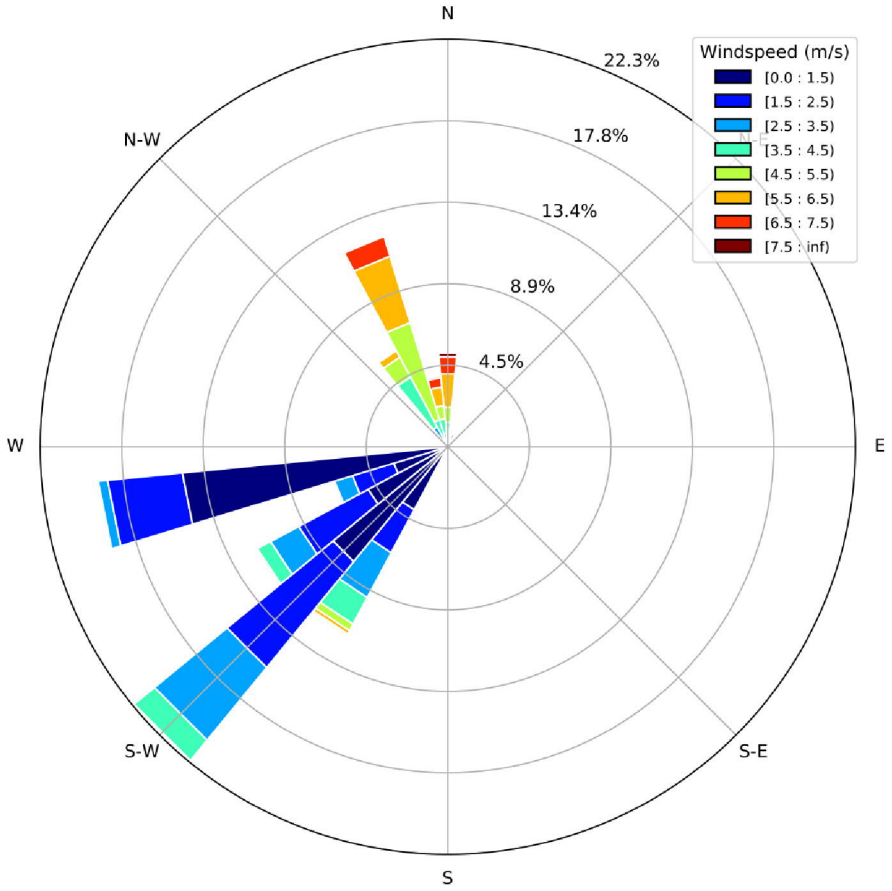
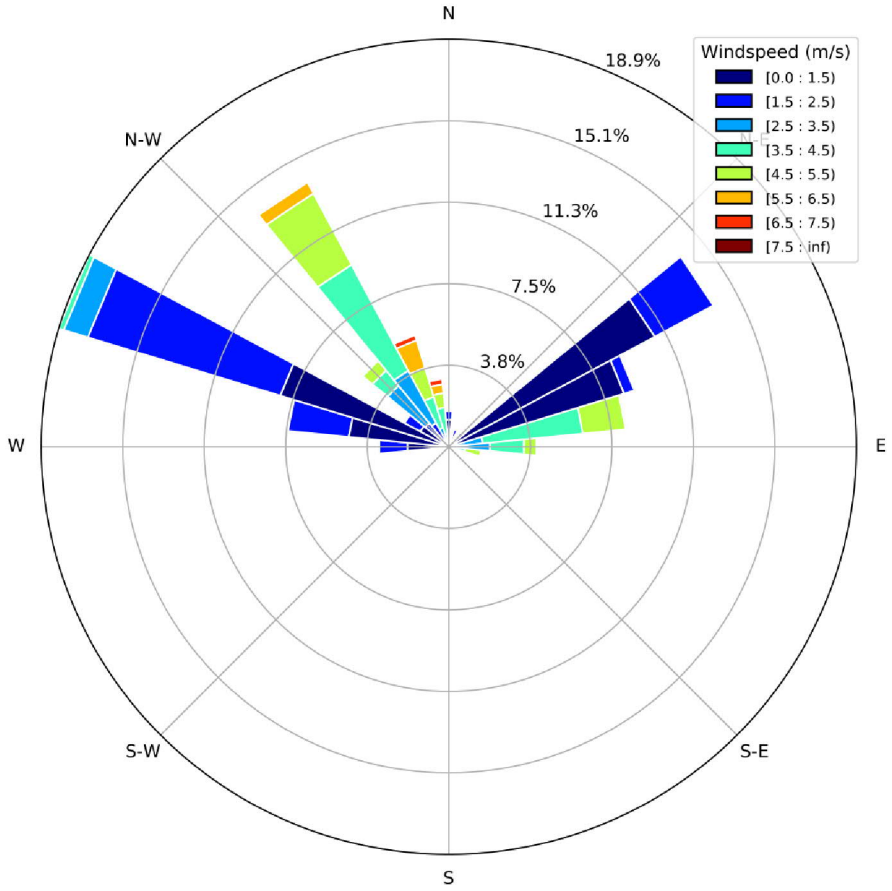
14355	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jun 07, 2018 Revision: 1	**Project Name** Port Ryerse Wind Power Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M364 Crosswind

Figure B.07

M411 TON	M411 TOFF





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Drawn by: JM
Reviewed by: AM
Date: Jun 07, 2018
Revision: 1

Project Name

Port Ryerse Wind Power Project - 1st Acoustic Immission Audit

Figure Title

Wind Roses - M411 Crosswind

Figure B.08

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Appendix C
Turbine Operational Statement from Operator

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Appendix D
Tonality Assessment

Appendix D - Tonality Assessment Summary

Project: Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
Report ID: 14355

Created on: 6/13/2018

M151 33-83 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	1	1	100%	**	40	**	0
3	10	8	80%	**	40	**	0
4	18	1	6%	**	40	**	0
5	88	0	0%	40	40	*	0
6	150	0	0%	37	40	*	0
7	118	1	1%	+	43	3.6	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol
+ Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

M151 213-265 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	1	1	100%	**	40	**	0
3	10	3	30%	**	40	**	0
4	18	0	0%	**	40	**	0
5	88	2	2%	40	40	-1.4	0
6	150	0	0%	37	40	*	0
7	118	0	0%	+	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol
+ Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

Appendix D - Tonality Assessment Summary

Project: Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
Report ID: 14355

Created on: 6/13/2018

M310 33-83 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	4	4	100%	**	40	**	0
3	33	11	33%	**	40	**	0
4	115	16	14%	40	40	0.9	0
5	288	75	26%	40	40	0.3	0
6	594	55	9%	35	40	-0.8	0
7	613	2	0%	**	43	-2.0	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

M310 213-265 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	4	0	0%	**	40	*	0
3	33	0	0%	**	40	*	0
4	115	2	2%	40	40	2.1	0
5	288	0	0%	40	40	*	0
6	594	0	0%	35	40	*	0
7	613	0	0%	**	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

Appendix D - Tonality Assessment Summary

Project: Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
Report ID: 14355

Created on: 6/13/2018

M323 33-83 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	61	61	100%	40	40	3.1	0
3	191	109	57%	40	40	3.2	0
4	175	63	36%	40	40	2.3	0
5	280	49	18%	**	40	-0.8	0
6	261	5	2%	**	40	-2.0	0
7	166	0	0%	**	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

M323 213-265 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	61	0	0%	40	40	*	0
3	191	0	0%	40	40	*	0
4	175	1	1%	40	40	-0.9	0
5	280	0	0%	**	40	*	0
6	261	0	0%	**	40	*	0
7	166	0	0%	**	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

Appendix D - Tonality Assessment Summary

Project: Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
Report ID: 14355

Created on: 6/13/2018

M364 33-83 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	13	13	100%	**	40	**	0
1	309	143	46%	40	40	3.2	0
2	479	46	10%	39	40	1.5	0
3	217	6	3%	39	40	1.6	0
4	37	1	3%	**	40	**	0
5	8	0	0%	**	40	**	0
6	0	0	*	*	40	*	0
7	0	0	*	*	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

M364 213-265 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	13	0	0%	**	40	*	0
1	309	9	3%	40	40	-0.6	0
2	479	9	2%	39	40	0.5	0
3	217	0	0%	39	40	*	0
4	37	0	0%	**	40	**	0
5	8	0	0%	**	40	**	0
6	0	0	*	*	40	*	0
7	0	0	*	*	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol

Appendix D - Tonality Assessment Summary

Project: Port Ryerse Wind Power Project - 1st Acoustic Immission Audit
Report ID: 14355

Created on: 6/13/2018

M411 33-83 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	1	0	0%	**	40	*	0
3	11	0	0%	**	40	*	0
4	64	0	0%	39	40	*	0
5	129	0	0%	37	40	*	0
6	120	0	0%	+	40	*	0
7	39	0	0%	**	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol
+ Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

M411 213-265 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	*	*	40	*	0
1	0	0	*	*	40	*	0
2	1	0	0%	**	40	*	0
3	11	0	0%	**	40	*	0
4	64	0	0%	39	40	*	0
5	129	0	0%	37	40	*	0
6	120	0	0%	+	40	*	0
7	39	0	0%	**	43	*	0

* No data points at wind speed
** Insufficient amount of data points as per RAM-I protocol
+ Measured Turbine OFF level is equal to or greater than Turbine ON, no Turbine ONLY level could be determined

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Appendix E
Turbine Status during TON and TOFF

Port Ryerse – Turbine Status Matrix for TON and TOFF

Turbine ID	Monitor Locations				
	M151	M310	M365	M323	M411
T01	1	1	1	1	1
T02	1	1	1	1	1
T03	1	1	1	1	1
T04	1	1	1	1	1

1 - Turbine ON/OFF
Turbines turned off such that predicted impact at monitor/receptor location is 30 dBA or less

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Appendix F
Receptor Selection Rationale

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Subject: Port Ryerse Wind Power Project
Acoustic Audit – Immission – Monitoring Location Selection
REA# 6498-9HKHN3

Date: March 28, 2017

Aercoustics Engineering Limited ("Aercoustics") has been retained by Boralex to complete the acoustic audit outlined in the Renewable Energy Approval (REA) for the Port Ryerse Wind Project (PRWF). PRWF operates under REA #6498-9HKHN3, originally issued on August 20, 2014.

In order to facilitate consultation with the Ministry of Environment and Climate Change (MOECC) regarding the PRWF acoustic audit, Aercoustics has prepared this letter to outline the proposed measurement locations.

Aercoustics has updated this letter to include detailed wind direction statistical analysis as justification for the deviation from the 2017 MOECC Compliance Protocol for Wind Turbine Noise and REA requirement for non-downwind monitoring locations at the MOECC's request in a meeting on March 24, 2017.

REA Requirements

The REA states that the acoustic audit measurements shall be performed by an Independent Acoustical Consultant at two (2) separate occasions at five (5) different Points of Receptions.

The Points of Reception should be located in the direction of prevailing winds from the Facility.

Receptor Audit Locations

A total of 45 non-participating receptors were identified with the greatest predicted noise impact (based on predicted levels of 37dBA or above from the PRWF). Please see table 2 for the list of receptors sorted by predicted sound level.

The predominant downwind direction is from the West-South-West. As per the 2017 MOECC Compliance Protocol for Wind Turbine Noise 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.

A total of 2 non-participating receptor locations were identified with the greatest predicted noise impact (based on predicted levels of 37 dBA or above from the PRWF) and in a downwind condition from the closest turbine. Both identified non-participating receptor locations are very close to each other and this group is considered a cluster. As both receptor locations are in the same cluster only one location from this cluster will be considered for monitoring and the other as an alternate should permission be denied at the other. Figure 1 shows the site plan of the Port Ryerse wind turbines and downwind receptors. Please see table 3 for the list of receptors sorted by predicted sound level and downwind direction.

The Port Ryerse Wind Project has a total of four (4) turbines. Due to the relatively small number of turbines at the Facility and the fact that most of the receptors are not located in the predominant downwind direction, it is not possible to select five (5) downwind receptors.

As it is not possible to select five (5) downwind receptors. An alternative approach has been proposed and discussed with the MOECC in a meeting on March 24, 2017. The alternative approach proposed intends to evaluate receptors with the highest predicted sound level in each general direction around the Facility. Where possible receptors with complaint locations nearby were identified, and given priority. Alternative receptor locations are also identified as backup locations should the primary receptor decline permission for acoustic monitoring.

Table 1 below presents the proposed monitoring locations.

Table 1 Proposed Monitoring Locations

Receptor ID	Alternates	Direction from PRWF	Predicted Level (dBA)	Comments
R310	R312, R316	North	38.4	Downwind location
R380		East	36.7	Downwind location, predicted level <37 dBA
R412	R150	West	37.5	
R151	R168	South-West	37.0	R151 - close to complaint location CL4 R168 - close to complaint location CL5
R364	V366	South-East	38.5	R364 - close to complaint location CL2

A site plan showing the locations of the proposed receptors is shown in Figures 1-5.

Receptor Locations – Deviation from Protocol and Justifications

In a meeting with Aercoustics and Boralex on Friday 24th March 2017 the MOECC approvals branch has indicated that it is open to the proposed approach in this specific instance as the Port Ryerse Wind Project is a special case.

Detailed wind direction statistical analysis has been provided as justification for the deviation from the 2017 MOECC Compliance Protocol for Wind Turbine Noise and REA requirement that the points of reception should be located in the direction of prevailing winds from the Facility at the MOECC's request.

As previously mentioned it is not possible to select more than two (2) unique downwind receptor locations. As such potentially three out of five (3/5) of the proposed locations will not satisfy the criteria that the points of reception should be located in the direction of prevailing winds from the Facility prescribed in the REA.

It is a possibility that the minimum sample size requirement may not be met if a downwind filter is required on the dataset at locations that are not located in the direction of prevailing winds from the Facility and a deviation from the 2017 MOECC Compliance Protocol for Wind Turbine Noise may be necessary to access compliance for these locations.

All other requirements as per the 2017 MOECC Compliance Protocol for Wind Turbine Noise are expected to be satisfied; i.e. 85% power filter and minimum sample size requirements without a downwind filter.

The table below presents the relative frequency of wind speeds greater than 9 m/s (Hub height) from the different wind directions and shows which wind directions would have a low probability of occurrence on a per-month basis. At wind speeds, greater than 9 m/s (Hub height) the Port Ryerse Wind Project turbines would have a power output of 85% or greater. The longest data set available was used to minimize effects due to short term weather patterns. The data represents hub height (99.5m) wind speeds and directions at an on-site meteorological tower. The period of data represented is for five (5) years.

The presented monthly wind roses confirm that the predominant wind direction is from the West-South-West except for the month of May when winds from the North-West are comparable to the annual predominant wind direction. The presented monthly wind roses also confirm that hub height winds (>9m/s) in the direction towards the receptors located to the North, West and South are statistically much less frequent.

Although hub height winds (>9m/s) in the direction towards the receptors located to the North, West and South do occur and may be captured during an acoustic audit, their frequency is relatively low. Considering the added requirements for data quality which would involve excluding data for times between 7am -10pm, times of precipitation, extraneous events and gusty intervals, the probability of fulfilling the MOECC downwind criteria ***and*** minimum sample size requirements for the receptors not located in the prevailing downwind locations may not be possible in a practical time frame.

It is Aercoustics opinion that in the case of receptors located in non-downwind orientations a measurement campaign that represents a very similar wind direction regime as the historic wind expectations is a good representation of the long-term wind profile and associated sound exposures from the wind facility. As such in this special case, a downwind filter is not practical for the proposed non-downwind monitoring locations at the Port Ryerse Wind Project, and our recommendation is to allow for other wind directions to also be included in the data analysis.

It should be noted that the three non-downwind proposed receptors presented are complaint locations. During the Community Liaison Committee (CLC) meeting for the Port Ryerse wind farm, some of the complainants also mentioned that the cross-wind condition is what they found most objectionable. It is Aercoustics opinion that as a downwind condition is not expected to be satisfied for three (3) out of the five (5) locations as described in the REA, that complaint locations should be addressed in lieu, without the requirement for downwind conditions.

Aercoustics would like to proceed with the 1st acoustic audit measurement campaign at the earliest opportunity to capitalise on the spring time higher wind speeds and before the lower wind speed summer time lull and would appreciate prompt feedback on the proposed approach.

Port Ryerse Wind Farm

Wind Direction Distribution

3/27/2017

Source : Five years of on-site measurement for wind speed extrapolated at 99.5m higher than 9.0m/s.

Sector	Frequency [%]											
Midpoint	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0°	1.5	2.4	6.3	5.3	3.7	8.1	7.6	7.1	4.8	1.8	1.3	0.8
30°	2.5	7.1	15.4	14.1	12.2	4.7	6.9	5.1	1.6	10.1	2.9	1.0
60°	1.9	4.6	4.1	7.2	7.0	6.3	2.0	1.5	3.6	5.7	4.2	5.0
90°	1.0	2.6	8.9	6.3	7.2	4.3	2.8	0.0	3.8	2.6	3.1	6.2
120°	1.3	2.7	3.0	0.5	0.8	5.0	0.2	1.0	1.0	0.6	1.1	1.9
150°	1.2	0.5	0.7	0.6	0.4	0.7	0.1	1.6	1.2	1.2	3.9	1.9
180°	3.6	1.6	3.2	1.3	3.2	0.9	2.0	4.4	3.5	3.5	4.7	5.3
210°	16.2	14.3	7.6	9.8	15.9	7.2	15.9	13.5	23.2	16.4	22.6	16.5
240°	32.8	28.5	17.3	18.9	14.7	19.5	23.4	30.9	21.5	27.3	28.9	25.9
270°	21.6	18.0	15.9	13.9	10.0	19.0	23.3	12.0	21.9	12.4	19.2	17.5
300°	12.3	13.3	9.4	15.0	17.3	14.5	8.6	9.3	7.2	15.1	5.6	9.7
330°	4.1	4.3	8.1	7.0	7.7	9.9	7.1	13.6	6.6	3.5	2.3	8.3
Occurrences [nb]	*5498*	*5086*	*4844*	*5950*	*3366*	*1741*	*1008*	*1241*	*2183*	*4099*	*4975*	*4646*

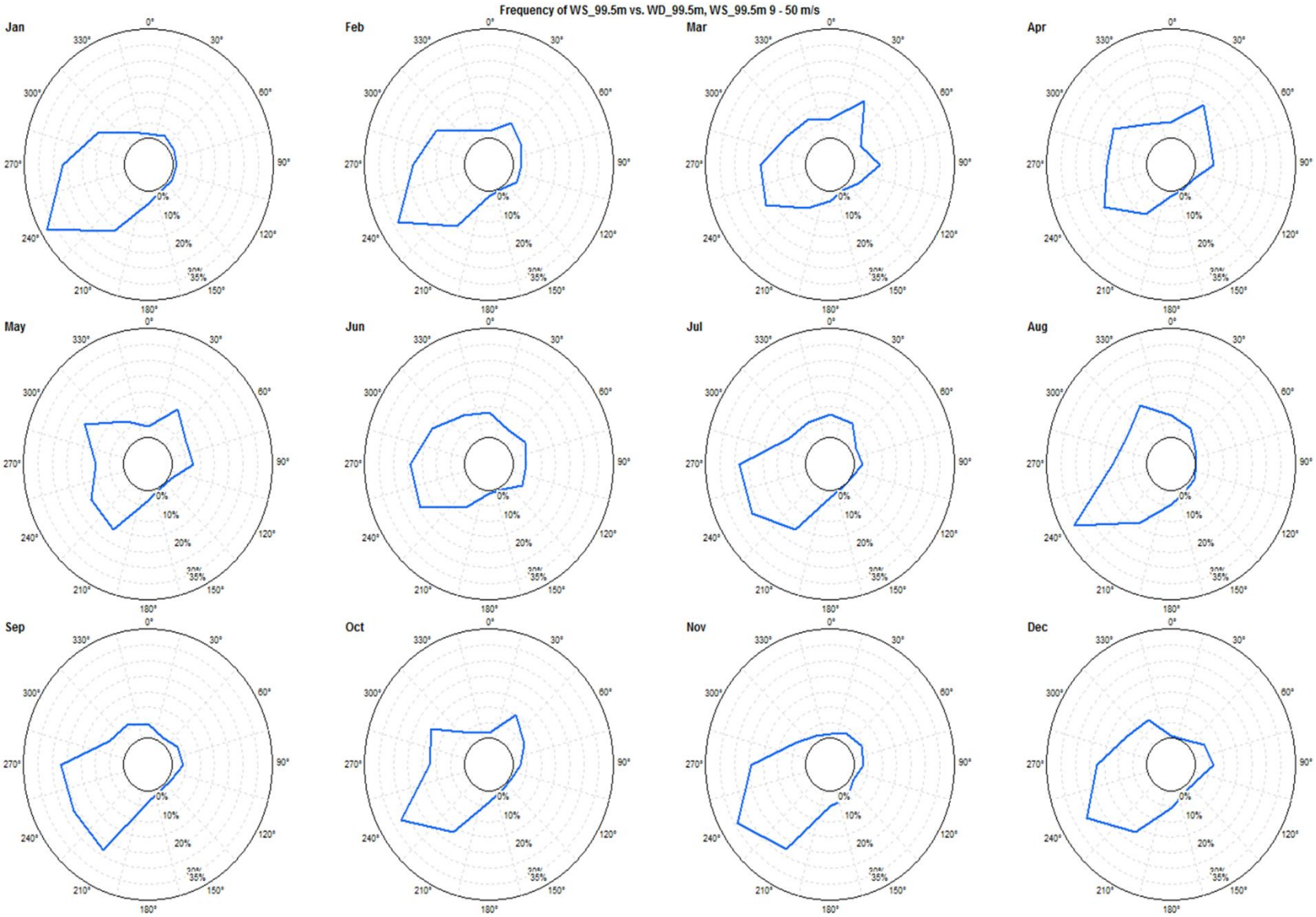

Frequency of WS_99.5m vs. WD_99.5m, WS_99.5m 9 - 50 m/s
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0%
10%
20%
35%

Table 2 Receptors Sorted by Sound Level

#	Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Sound Level Limit (dBA)
1	R316	Residence	4.5	663	T4	38.6	40
2	R343	Residence	4.5	618	T3	38.6	40
3	R301	Residence	4.5	577	T2	38.5	40
4	R307	Residence	4.5	613	T2	38.5	40
5	R353	Residence	4.5	616	T3	38.5	40
6	R362	Residence	4.5	609	T3	38.5	40
7	R364	Residence*	4.5	613	T3	38.5	40
8	R370	Residence	4.5	625	T3	38.5	40
9	V365	VLSR	4.5	612	T3	38.5	40
10	V366	VLSR	4.5	616	T3	38.5	40
11	R310	Residence	4.5	649	T2	38.4	40
12	V339	VLSR	4.5	651	T3	38.4	40
13	V344	VLSR	4.5	655	T3	38.2	40
14	R150	Residence	4.5	558	T1	38.1	40
15	R374	Residence	4.5	626	T4	38	40
16	R661	Residence	4.5	683	T3	38	40
17	V410	VLSR	4.5	661	T3	38	40
18	V372	VLSR	4.5	666	T3	37.9	40
19	R312	Residence	4.5	721	T2	37.7	40
20	R345	Residence	1.5	616	T3	37.7	40
21	R349	Residence	1.5	613	T3	37.7	40
22	R347	Residence	1.5	619	T3	37.6	40
23	R351	Residence	1.5	617	T3	37.6	40
24	R355	Residence	1.5	609	T3	37.6	40
25	R358	Residence	1.5	614	T3	37.6	40
26	R360	Residence	1.5	609	T3	37.6	40
27	R368	Residence	1.5	619	T3	37.6	40
28	R371	Residence	1.5	627	T3	37.6	40
29	R412	Residence	1.5	593	T1	37.5	40
30	R142	Residence	4.5	564	T1	37.3	40

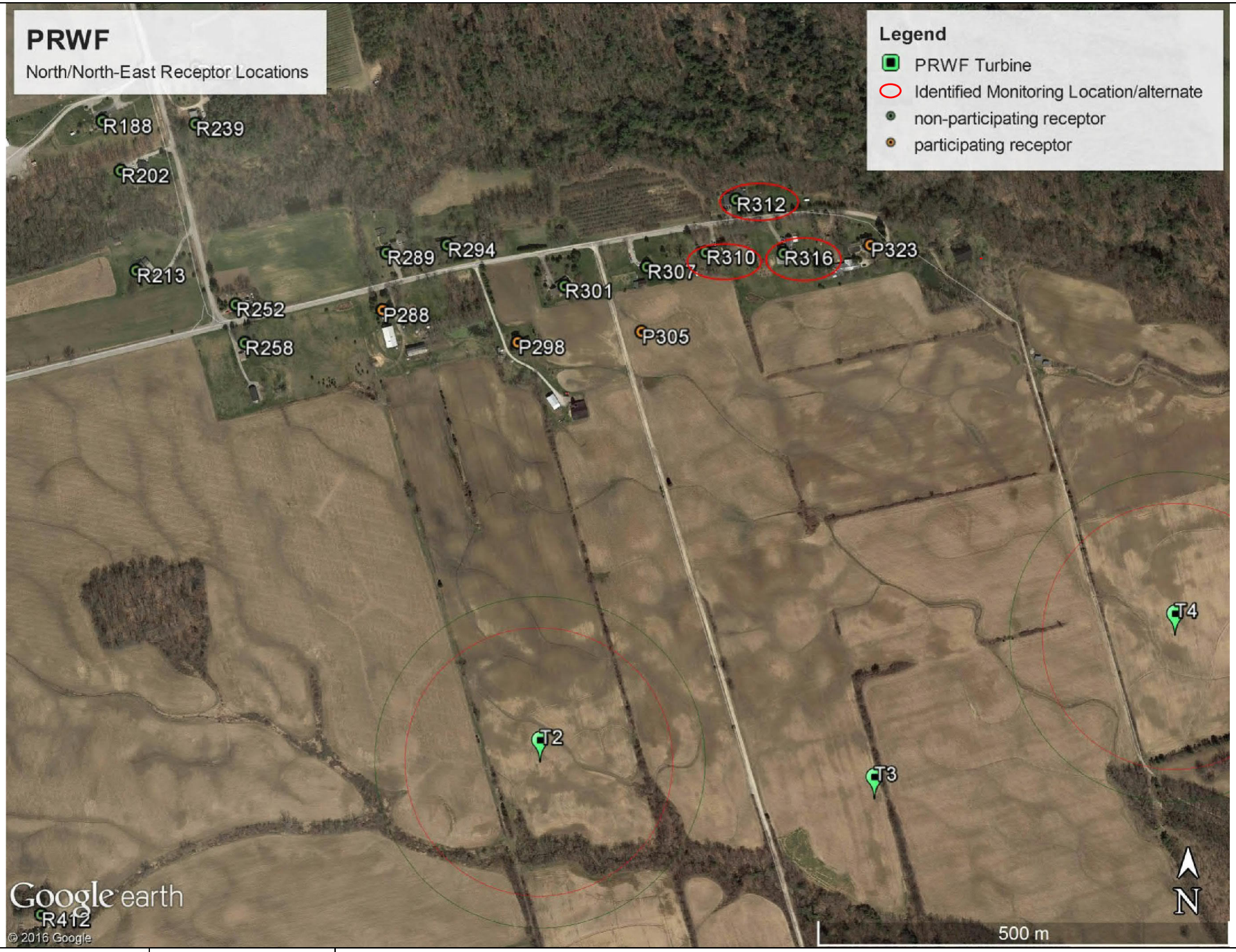
#	Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Sound Level Limit (dBA)
31	R294	Residence	4.5	635	T2	37.3	40
32	R144	Residence	4.5	562	T1	37.2	40
33	R342	Residence	1.5	659	T3	37.2	40
34	R147	Residence	4.5	564	T1	37.1	40
35	R258	Residence	4.5	619	T2	37.1	40
36	R289	Residence	4.5	643	T2	37.1	40
37	R346	Residence	1.5	668	T3	37.1	40
38	R348	Residence	1.5	658	T3	37.1	40
39	R350	Residence	1.5	659	T3	37.1	40
40	R352	Residence	1.5	655	T3	37.1	40
41	R354	Residence	1.5	657	T3	37.1	40
42	R151	Residence*	4.5	569	T1	37	40
43	R356	Residence	1.5	657	T3	37	40
44	R359	Residence	1.5	660	T3	37	40
45	R361	Residence	1.5	657	T3	37	40
-	-	-	-	-	-	-	-
52	R168	Residence*	4.5	663	T2	36.5	40
-	-	-	-	-	-	-	-
80	R642	Residence*	4.5	669	T1	35.3	40
-	-	-	-	-	-	-	-
182	R195	Residence*	4.5	877	T1	33.2	40

*- Complaint Location
VLSR – Vacant Lot Receptor
yellow – Complaint Location with predicted sound level greater than or equal to 37 dBA
white – Complaint Location with predicted sound level less than 37 dBA

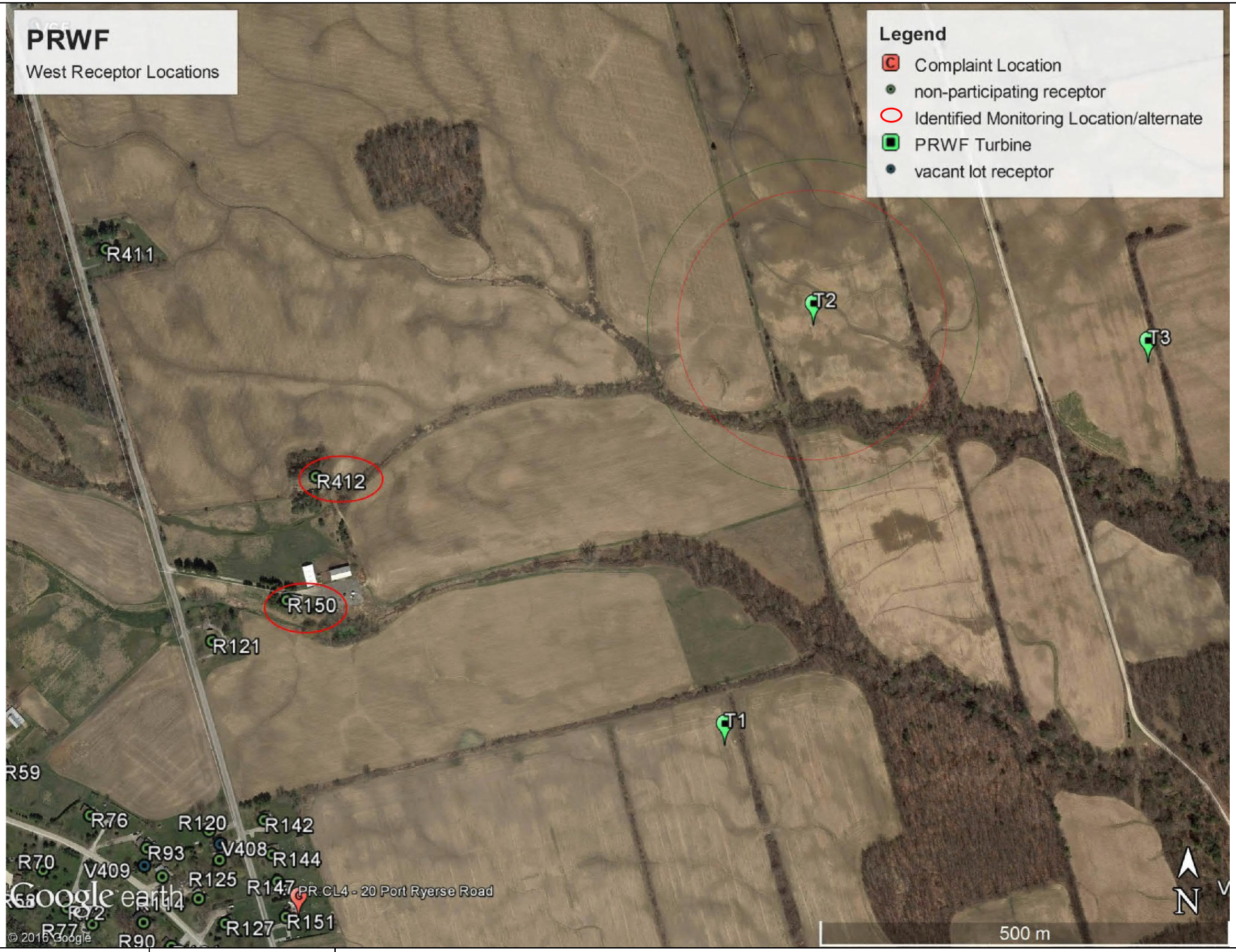
Table 3 Receptors Sorted by Sound Level and Downwind Direction

#	Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Sound Level Limit (dBA)
1	R310*	Residence	4.5	649	T2	38.4	40
2	R312*	Residence	4.5	721	T2	37.7	40
3	R380	Residence	4.5	586	T4	36.7	40
4	R388	Residence	4.5	939	T4	32.8	40
5	R614	Residence	4.5	1074	T4	31.6	40
6	V386	VLSR	4.5	1139	T4	31.2	40
7	R387	Residence	4.5	1186	T4	30.9	40
8	R379	Residence	4.5	1256	T4	30.6	40
9	R613	Residence	4.5	1234	T4	30.4	40
10	R385	Residence	4.5	1287	T4	30.2	40
11	R390	Residence	4.5	1292	T4	30	40
12	R612	Residence	4.5	1287	T4	30	40
13	R611	Residence	4.5	1309	T4	29.9	40
14	R610	Residence	4.5	1334	T4	29.7	40
15	R383	Residence	4.5	1393	T4	29.6	40
16	R384	Residence	4.5	1422	T4	29.4	40
17	R393	Residence	4.5	1409	T4	29.2	40
18	R394	Residence	4.5	1418	T4	29.2	40
19	R609	Residence	4.5	1437	T4	29.1	40
20	R389	Residence	4.5	1473	T4	29	40
21	R395	Residence	4.5	1464	T4	28.9	40

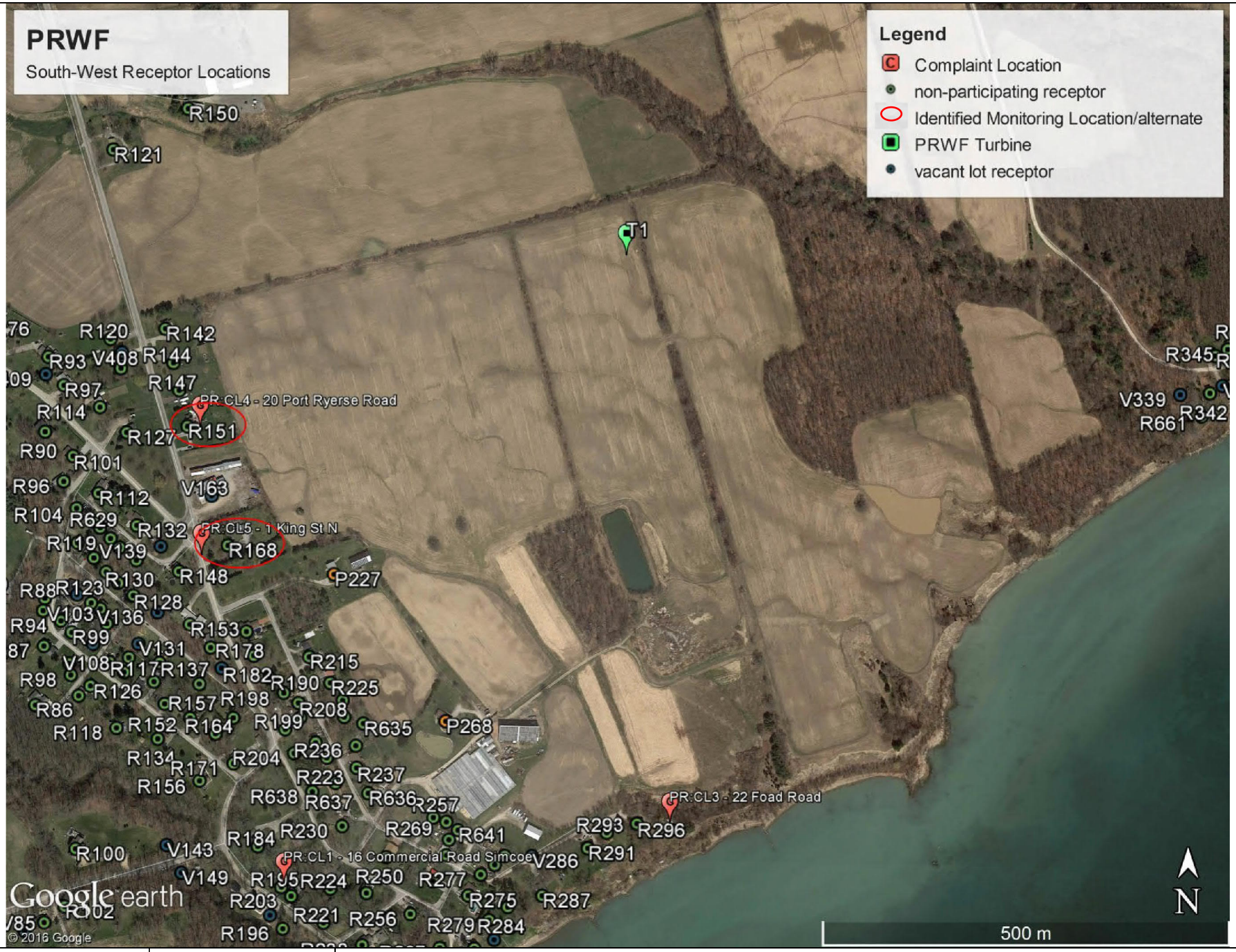
*- Downwind Receptors in cluster, 1 will be selected
grey- Downwind Receptors with predicted level less than 37 dBA



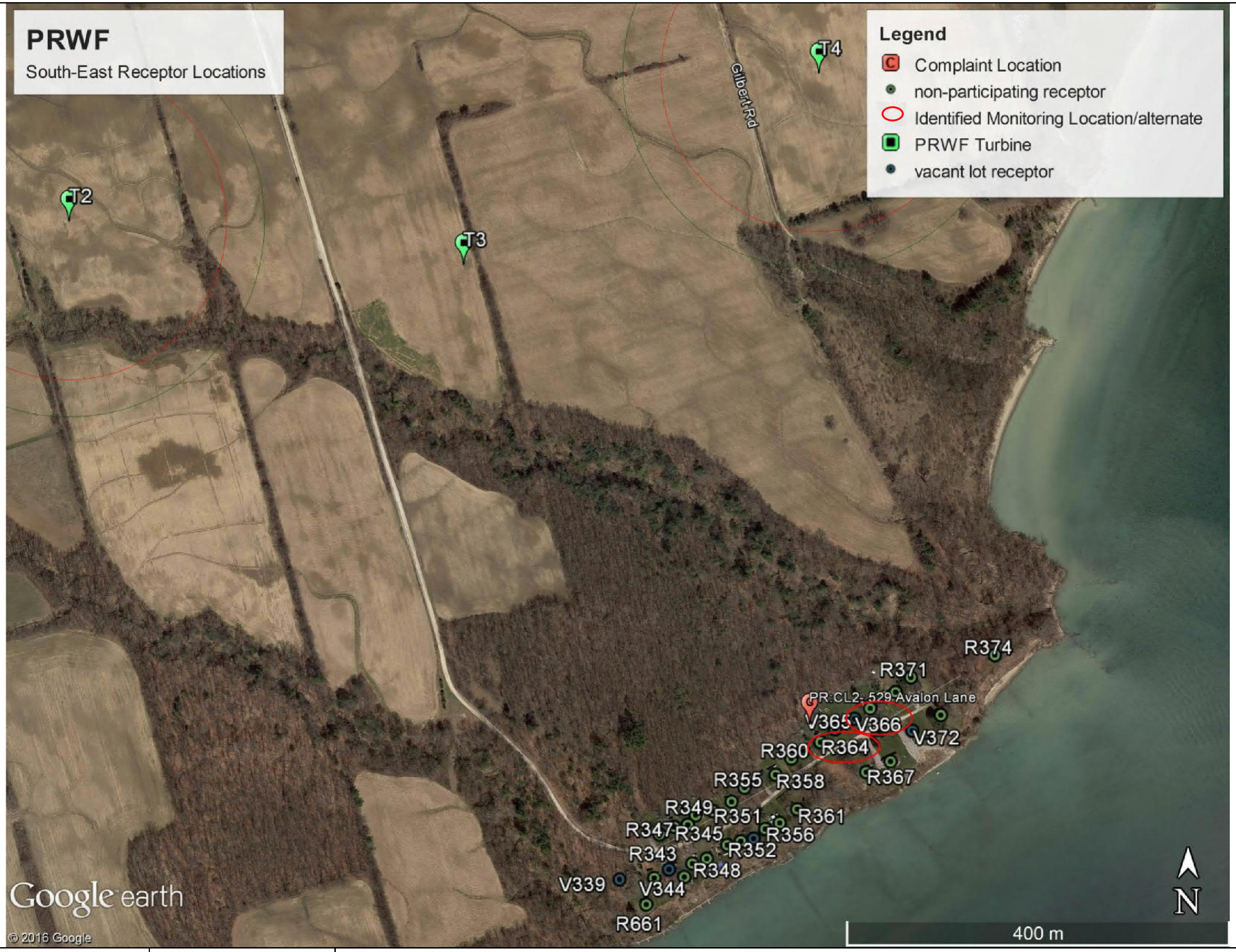
aercoustics	14335.00	**Project Name**
	Scale: As Shown Drawn by: AM Reviewed by: PA Date: Mar 28, 2017 Revision: 1	Port Ryerse Wind Project
		Figure Title Site Plan - North/North-East Receptor Locations
		Figure 1



aercoustics	14335.00	**Project Name**
	Scale: As Shown Drawn by: AM Reviewed by: PA Date: Mar 28, 2017 Revision: 1	Port Ryerse Wind Project
		Figure Title Site Plan - West Receptor Locations
		Figure 2



aercoustics	14335.00	**Project Name**
	Scale: As Shown Drawn by: AM Reviewed by: PA Date: Mar 28, 2017 Revision: 1	Port Ryerse Wind Project
		Figure Title Site Plan - South-West Receptor Locations
		Figure 3



aercoustics	14335.00	**Project Name**
	Scale: As Shown Drawn by: AM Reviewed by: PA Date: Mar 28, 2017 Revision: 1	Port Ryerse Wind Project
		Figure Title Site Plan - South-East Receptor Locations
		Figure 4

aercoustics	14335.00	**Project Name**
	Scale: As Shown Drawn by: AM Reviewed by: PA Date: Mar 28, 2017 Revision: 1	Port Ryerse Wind Project
		Figure Title Site Plan - East Receptor Locations
		Figure 5

Appendix F - Receptor Selection Summary

Project: Port Ryerse Wind Power Project

Direction From Facility	Receptor ID	Description	Modelled Sound Level* (dBA)	Receptor Height (m)	Distance to Closest Turbine (m)	Closest Turbine ID	Rationale
North	R310	Non-Participating Receptor	38.4	4.5	649	T2	Selected Monitoring Location
	R312	Non-Participating Receptor	37.7	4.5	721	T2	
	R316	Non-Participating Receptor	38.6	4.5	556	T4	
East/North East	R380	Non-Participating Receptor	36.7	4.5	597	T4	Permission not granted
	P323	Participating Receptor	38.7	4.5	601	T4	Selected Monitoring Location
West	R412	Non-Participating Receptor	37.5	4.5	593	T1	Permission not granted
	R150	Non-Participating Receptor	38.1	4.5	558	T1	Permission not granted
	R411	Non-Participating Receptor	33.7	1.5	859	T2	Selected Monitoring Location
South-West	R151	Non-Participating Receptor	37.0	4.5	569	T1	Selected Monitoring Location
	R168	Non-Participating Receptor	36.5	4.5	596	T1	
South-East	R364	Non-Participating Receptor	38.5	4.5	613	T3	Selected Monitoring Location
	V366	Non-Participating Vacant Lot	38.5	4.5	616	T3	

* Predicted sound level taken from the Noise Assessment Report by J.R. Salmon and S. J. Stewart, dated July 15, 2014

aercoustics

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

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

Appendix G
Calibration Certificates

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	152543
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	129386	P. Order :	2018.04.27C
Asset # :	01087		

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 calibration system complies with the requirements of ISO-9001-2008 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 : Apr 30, 2018 By : Petro Onasko

Cal. Due : Apr 30, 2019

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

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

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com

Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

#1087

NT NAVAIR TECHNOLOGIES

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

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

Calibration Report for Certificate : **152543**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	129386		01087
PCB Piezotronics			377B02	172971		01087

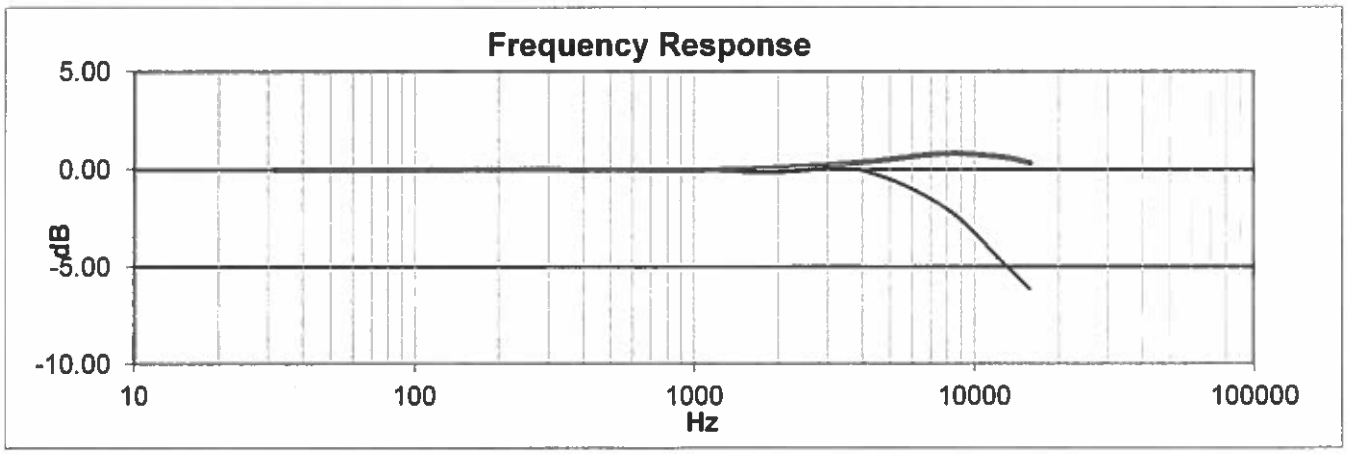
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	45.08	62.94	In
-26.02	dB re 1V/Pa	-28.02	-26.92	-24.02	In
0	dB re 50mV/Pa	-2	-0.90	2	In

Ambient Conditions: Static Pressure 100.2 kPa
Temperature 23.5°C
Rel.Humidity 28.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.00	0.00	
63.1	-0.01	-0.01	
125.9	0.00	0.00	
251.3	0.00	0.00	ref
502.5	-0.01	-0.01	
1005.1	-0.06	-0.03	
1978.7	-0.15	0.09	
3957.5	-0.05	0.37	
7914.9	-1.97	0.82	
12663	-4.79	0.63	
15830	-6.18	0.33	



VAISALA

Test report no. H31-16210020

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A5D1B1B
Serial number	M2130088
Manufacturer	Vaisala Oyj, Finland
Test date	25 May 2016

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	385	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.08	-1	1	hPa
Temperature difference	-0.45	-2	2	°C
Humidity difference	0.2	-10	10	%RH
Heating current	0.73	0.6	0.8	A
Current (service port)	1.39	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	1.04	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 33.95 ±5 %RH, Temperature 22.47 ±1 °C, Pressure 1006.39 ±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. H31-16210021

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M1710017
Manufacturer	Vaisala Oyj, Finland
Test date	26 April 2016

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	1077.9	1077.9	0	± 0.4 hPa
Pressure	901.5	901.5	0	± 0.4 hPa
Pressure	796.8	796.7	-0.1	± 0.4 hPa
Pressure	598.8	598.8	0	± 0.4 hPa
Temperature	59.8	59.8	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-33.2	-33.2	0	± 0.2 °C
Temperature	24.9	24.9	0	± 0.2 °C
Temperature	-52	-52	0	± 0.2 °C
Relative humidity	29.7	29.7	0	± 2 %RH
Relative humidity	61.4	61.4	0	± 2 %RH
Relative humidity	91.6	91.6	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

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

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONCS
Model No:	378B02
Serial No:	126954
Calibration Recall No:	27798

Submitted By:

Customer:

Company: Aercoustics Engineering LTD

Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 378B02 PCB P

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

Note: With this Certificate, Report of Calibration is included.

Approved by: FC

Felix Christopher (QA Mgr.)

Calibration Date: 12-Jul-17

Certificate No: 27798 - 3

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

PCB Piezotronics Microphone Unit
Model No.: 378B02 Serial No.: 126954
Mic Model No.: 377B02 Serial No.: 167996
Preamp Model No.: 426E01 Serial No.: 044925
Company: Aercoustics Engineering LTD ID No.: XXXX

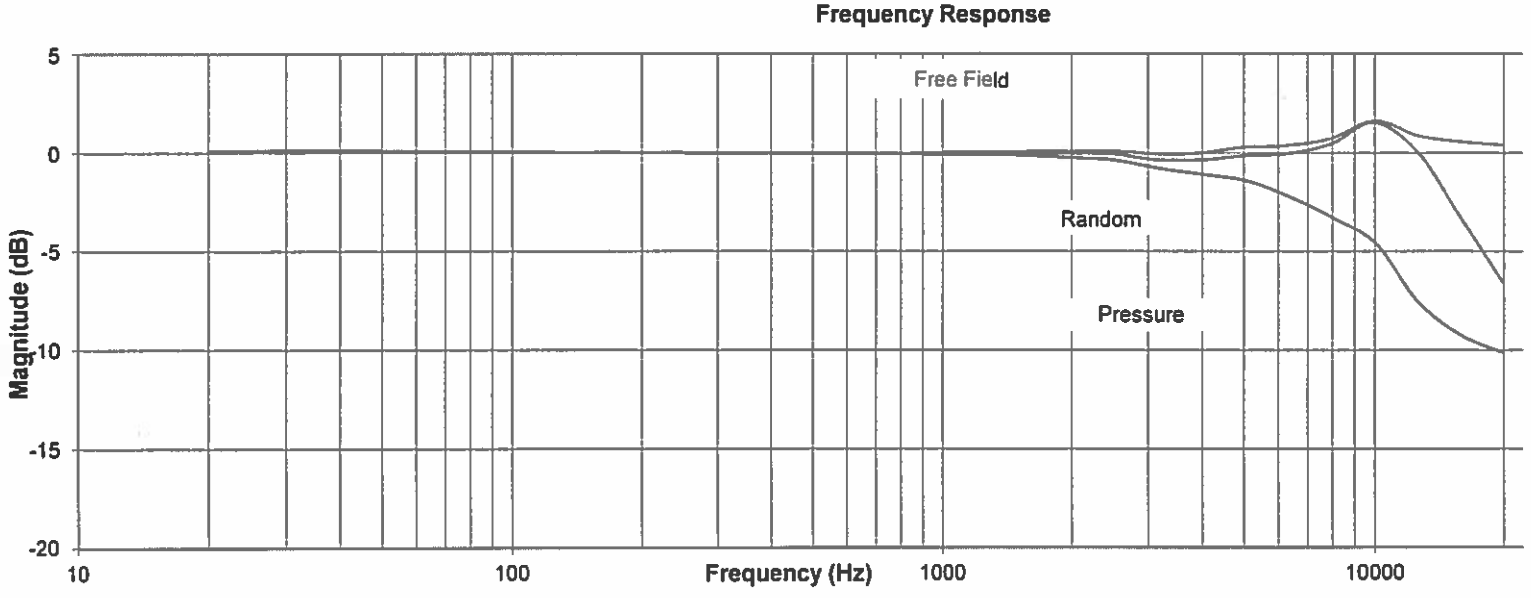
Calibration results:

Before & after data same: ...X...

Combined Sensitivity @ 250 Hz and pressure of 99.23 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-25.81 dB re.1V/Pascal
51.25 mV/Pascal
-0.19 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	23.6	°C
Ambient Humidity:	53.7	% RH
Ambient Pressure:	99.230	kPa
Calibration Date:	12-Jul-2017	
Calibration Due:	12-Jul-2019	
Report Number:	27798 -3	
Control Number:	27798	

The above listed instrument meets or exceeds the tested manufacturer's specifications.
The IEC 651:type 1 and ANSI S1.4 1983 specification passed.
This Calibration is traceable through NIST test numbers: 683/284413-14
The expanded uncertainty of calibration: 0.079dB at 95% confidence level with a coverage factor of k=2.
The pressure response recorded with electroacoustic method.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P378B02PCB**
Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Measurements performed by: .....
James Zhu

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.
1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

PCB Piezotronics Microphone Unit **Model No.: 378B02** **Serial No.: 126954**
Company: Aercoustics Engineering LTD **ID No.: XXXX**

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]	Random [dB]
19.95	0.09	0.09	0.09
25.12	0.12	0.12	0.12
31.62	0.14	0.14	0.14
39.81	0.11	0.11	0.11
50.12	0.11	0.11	0.11
63.10	0.09	0.09	0.09
79.43	0.06	0.06	0.06
100.00	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.02	0.02	0.02
199.53	0.01	0.01	0.01
251.19	0.00	0.00	0.00
316.23	-0.01	-0.01	-0.01
398.11	-0.01	-0.01	-0.01
501.19	-0.02	-0.02	-0.02
630.96	-0.03	-0.03	-0.03
794.33	-0.04	-0.04	-0.04
1000.00	-0.07	0.04	-0.07
1258.93	-0.09	0.07	-0.05
1584.89	-0.14	0.09	-0.06
1995.26	-0.24	0.09	-0.04
2511.89	-0.37	0.11	-0.06
3162.28	-0.78	-0.06	-0.37
3981.07	-1.08	0.02	-0.35
5011.87	-1.39	0.29	-0.15
6309.57	-2.18	0.40	-0.03
7943.28	-3.25	0.75	0.46
10000.00	-4.56	1.65	1.53
12589.25	-7.55	0.88	-0.01
15848.93	-9.24	0.58	-3.36
19952.62	-10.11	0.39	-6.61

Freq. response: Expanded Uncertainty (dB) with coverage factor K = 2
20 to 63Hz 0.1dB, 63 to 12.5kHz 0.094dB, 12.5k to 16kHz 0.10dB, 16k to 20kHz 0.5dB.

Instruments used for calibration:			Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær	4226	S/N 1445428	3-Nov-2016	683/284413-14	3-Nov-2017
Brüel & Kjær	3560	S/N 2202374	3-Nov-2016	683/284413-14	3-Nov-2017
HP	33120A	S/N 36043716	1-Oct-2016	,287708	1-Oct-2017
HP	34401A	S/N 36064102	1-Oct-2016	,287708	1-Oct-2017

Cal. Date: 12-Jul-2017 **Tested by: James Zhu**

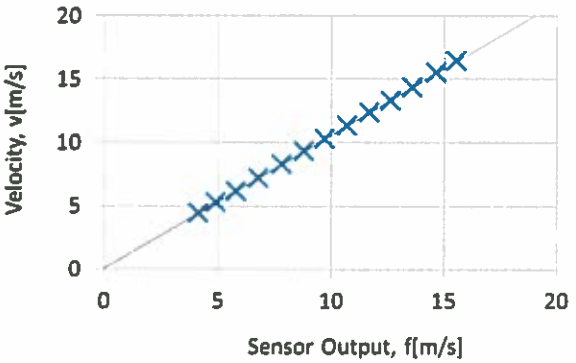
Calibrated on WCCL system type 9700

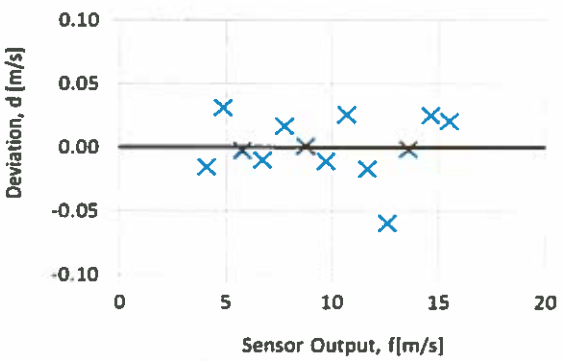
SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

Certificate number: 16.US1.10500 **Date of issue:** September 28, 2016
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** KD550007.90deg
Manufacturer: VAISALA Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 50 Ronson Dr, Suite 165, Toronto, ON M9W 1B3, Canada
Anemometer received: September 27, 2016 **Anemometer calibrated:** 09:54 September 28, 2016
Calibrated by: mej **Procedure:** MEASNET, IEC 61400-12-1:2005(E) Annex F
Certificate prepared by: Software Revision 7 **Approved by:** Calibration engineer, rds
Calibration equation obtained: v [m/s] = 1.04997· f [m/s] + 0.06827
Standard uncertainty, slope: 0.00186 **Standard uncertainty, offset:** 0.28685
Covariance: -0.0000371 (m/s)²/ m/s **Coefficient of correlation:** ρ = 0.999981
Absolute maximum deviation: 0.059 m/s at 13.293 m/s
Barometric pressure: 1009.6 hPa **Relative humidity:** 36.3%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.65	26.7	27.4	4.404	4.1448	-0.016	0.024
4	15.11	26.8	27.4	5.247	4.9034	0.031	0.025
6	20.79	26.8	27.4	6.155	5.8000	-0.003	0.027
8	28.23	26.8	27.4	7.173	6.7759	-0.010	0.030
10	37.66	26.7	27.4	8.285	7.8103	0.016	0.033
12	47.37	26.7	27.4	9.291	8.7828	0.001	0.036
13-last	58.25	26.7	27.3	10.303	9.7586	-0.011	0.039
11	70.73	26.7	27.4	11.353	10.7241	0.025	0.042
9	83.59	26.7	27.4	12.343	11.7069	-0.017	0.045
7	96.94	26.7	27.4	13.293	12.6517	-0.059	0.048
5	112.89	26.7	27.4	14.346	13.6000	-0.002	0.052
3	131.14	26.7	27.4	15.462	14.6379	0.025	0.055
1-first	147.27	26.7	27.4	16.385	15.5207	0.020	0.058





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.004
2254	Control cup anemometer
-	Mounting tube, D = 30 mm
TT004	Summit RT-AUI, wind tunnel
TP001	Summit RT-AUI, differential pressure box
DP006	Setra Model 239 pressure transducer
HY001	Dwyer Instruments RHP-2D20 humidity transmitter
BP002	Setra Model 278 barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

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

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.

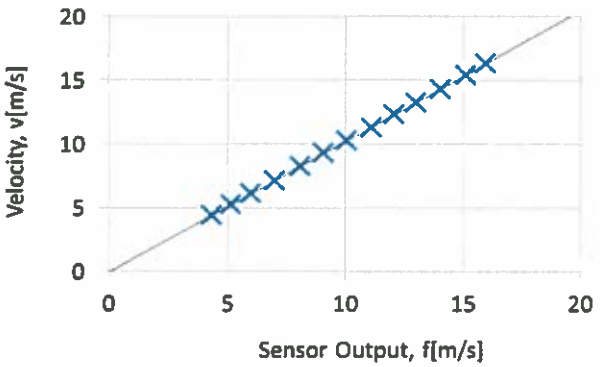
Certificate number: 16.US1.10500

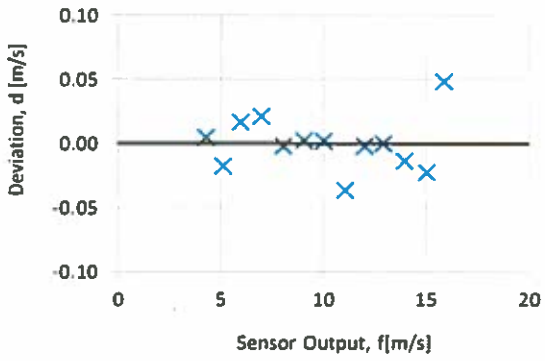
SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

Certificate number: 16.US1.10499 **Date of issue:** September 28, 2016
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** KD550007.0deg
Manufacturer: VAISALA Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 50 Ronson Dr, Suite 165, Toronto, ON M9W 1B3, Canada
Anemometer received: September 27, 2016 **Anemometer calibrated:** 09:34 September 28, 2016
Calibrated by: mej **Procedure:** MEASNET, IEC 61400-12-1:2005(E) Annex F
Certificate prepared by: Software Revision 7 **Approved by:** Calibration engineer, rds
Calibration equation obtained: v [m/s] = 1.02722· f [m/s] + -0.01865
Standard uncertainty, slope: 0.00162 **Standard uncertainty, offset:** -0.92374
Covariance: -0.0000279 (m/s)²/ m/s **Coefficient of correlation:** ρ = 0.999986
Absolute maximum deviation: 0.048 m/s at 16.380 m/s
Barometric pressure: 1009.6 hPa **Relative humidity:** 36.4%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.66	26.6	27.3	4.407	4.3034	0.005	0.024
4	15.12	26.7	27.3	5.249	5.1448	-0.018	0.025
6	20.72	26.7	27.3	6.144	5.9828	0.017	0.027
8	28.26	26.6	27.3	7.175	6.9828	0.021	0.030
10	37.62	26.6	27.3	8.278	8.0793	-0.002	0.033
12	47.51	26.6	27.4	9.303	9.0724	0.002	0.036
13-last	58.25	26.6	27.4	10.301	10.0448	0.002	0.039
11	70.67	26.6	27.4	11.347	11.1000	-0.036	0.042
9	83.73	26.6	27.3	12.352	12.0448	-0.002	0.045
7	96.96	26.6	27.3	13.293	12.9586	0.000	0.048
5	112.92	26.6	27.3	14.345	13.9966	-0.013	0.052
3	131.01	26.6	27.3	15.452	15.0828	-0.023	0.055
1-first	147.23	26.6	27.4	16.380	15.9172	0.048	0.058





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.004
2254	Control cup anemometer
-	Mounting tube, D = 30 mm
TT004	Summit RT-AUI, wind tunnel
TP001	Summit RT-AUI, differential pressure box
DP006	Setra Model 239 pressure transducer
HY001	Dwyer Instruments RHP-2D20 humidity transmitter
BP002	Setra Model 278 barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

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

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.

Certificate number: 16.US1.10499

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONCS
Model No:	378B02
Serial No:	123030
Calibration Recall No:	27798

Submitted By:

Customer:

Company: Aercoustics Engineering LTD

Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 378B02 PCB P

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

Note: With this Certificate, Report of Calibration is included.

Approved by: FC

Felix Christopher (QA Mgr.)

Calibration Date: 12-Jul-17

Certificate No: 27798 - 1

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

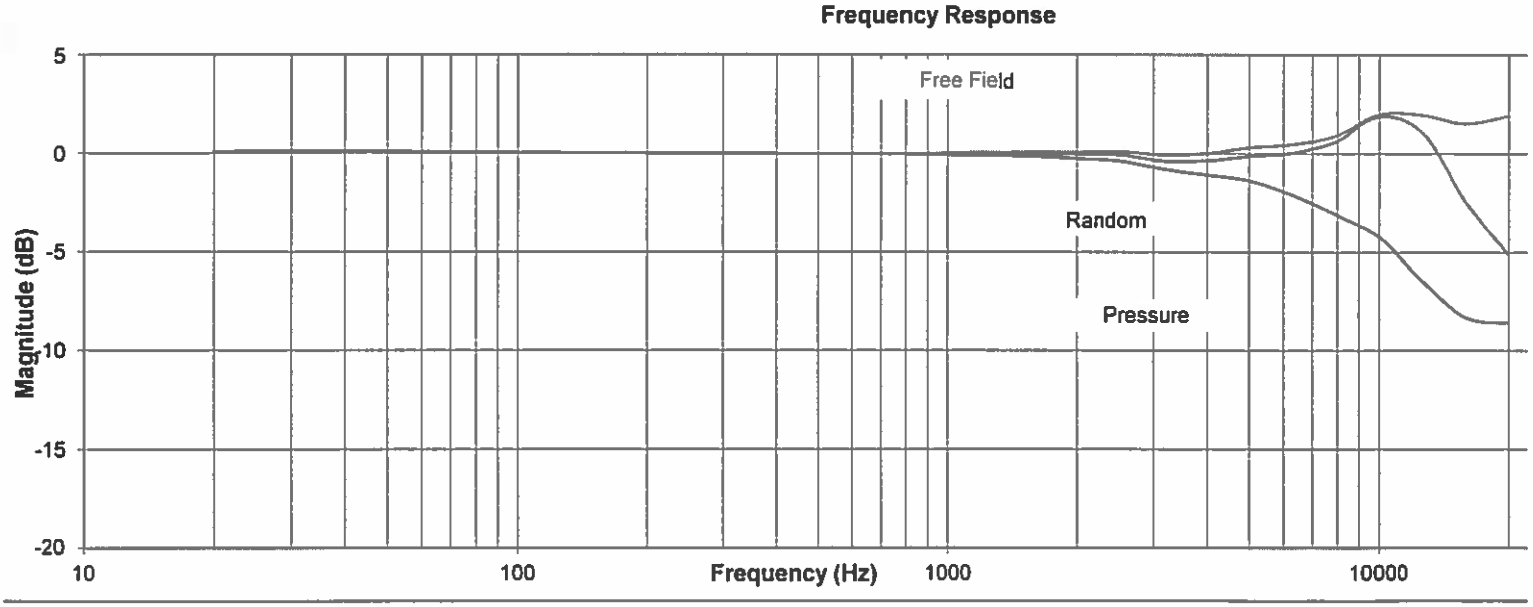
PCB Piezotronics Microphone Unit
Model No.: 378B02 Serial No.: 123030
Mic Model No.: 377B02 Serial No.: 148047
Preamp Model No.: 426E01 Serial No.: 123030
Company: Aercoustics Engineering LTD ID No.: XXXX

Calibration results:

Before & after data same: ...X...
Combined Sensitivity @ 250 Hz and pressure of 99.23 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-26.51 dB re.1V/Pascal
47.23 mV/Pascal
0.51 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature: 23.6 °C
Ambient Humidity: 53.7 % RH
Ambient Pressure: 99.230 kPa
Calibration Date: 12-Jul-2017
Calibration Due: 12-Jul-2019
Report Number: 27798 -1
Control Number: 27798

The above listed instrument meets or exceeds the tested manufacturer's specifications.
The IEC 651:type 1 and ANSI S1.4 1983 specification passed.
This Calibration is traceable through NIST test numbers: 683/284413-14
The expanded uncertainty of calibration: 0.079dB at 95% confidence level with a coverage factor of k=2.
The pressure response recorded with electroacoustic method.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P378B02PCB**
Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Measurements performed by: .....
James Zhu

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.
1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

PCB Piezotronics Microphone Unit **Model No.: 378B02** **Serial No.: 123030**
Company: Aercoustics Engineering LTD **ID No.: XXXX**

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]	Random [dB]
19.95	0.09	0.09	0.09
25.12	0.12	0.12	0.12
31.62	0.13	0.13	0.13
39.81	0.12	0.12	0.12
50.12	0.11	0.11	0.11
63.10	0.08	0.08	0.08
79.43	0.06	0.06	0.06
100.00	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.02	0.02	0.02
199.53	0.01	0.01	0.01
251.19	0.00	0.00	0.00
316.23	-0.01	-0.01	-0.01
398.11	-0.01	-0.01	-0.01
501.19	-0.02	-0.02	-0.02
630.96	-0.02	-0.02	-0.02
794.33	-0.04	-0.04	-0.04
1000.00	-0.07	0.04	-0.07
1258.93	-0.09	0.07	-0.05
1584.89	-0.15	0.08	-0.07
1995.26	-0.25	0.08	-0.05
2511.89	-0.38	0.10	-0.07
3162.28	-0.79	-0.07	-0.38
3981.07	-1.08	0.02	-0.35
5011.87	-1.37	0.31	-0.13
6309.57	-2.10	0.48	0.05
7943.28	-3.09	0.91	0.62
10000.00	-4.22	1.99	1.87
12589.25	-6.48	1.95	1.06
15848.93	-8.31	1.51	-2.43
19952.62	-8.58	1.92	-5.08

Freq. response: Expanded Uncertainty (dB) with coverage factor K = 2
20 to 63Hz 0.1dB, 63 to 12.5kHz 0.094dB, 12.5k to 16kHz 0.10dB, 16k to 20kHz 0.5dB.

Instruments used for calibration:			Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær	4226	S/N 1445428	3-Nov-2016	683/284413-14	3-Nov-2017
Brüel & Kjær	3560	S/N 2202374	3-Nov-2016	683/284413-14	3-Nov-2017
HP	33120A	S/N 36043716	1-Oct-2016	,287708	1-Oct-2017
HP	34401A	S/N 36064102	1-Oct-2016	,287708	1-Oct-2017

Cal. Date: 12-Jul-2017 **Tested by: James Zhu**

Calibrated on WCCL system type 9700

VAISALA

Test report no. B01-17070011

TEST REPORT

Instrument	WXT520
Serial number	M0410644
Manufacturer	Vaisala Oyj, Finland
Test date	15th February 2017
Test procedure	**Doc211850-C**

This instrument has been tested and found to meet its published specifications.

Test results

Test	Result	Passed
Current consumption	1.05 mA	OK
Zero wind speed	0.00 m/s	OK
Pressure	996.8 hPa	OK
Temperature	22.5 °C	OK
Humidity	23.7 %RH	OK

Paul Joyce

doc219022-b

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Email us-technicalsupport@vaisala.com | www.vaisala.com

VAISALA

Calibration sheet no. H31-16190051

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M1620086
Manufacturer	Vaisala Oyj, Finland
Test date	11th May 2016

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	Error*	Uncertainty**
Pressure	1078.6 hPa	1078.6 hPa	0.0 hPa	± 0.4 hPa
Pressure	895.7 hPa	895.7 hPa	0.0 hPa	± 0.4 hPa
Pressure	795.6 hPa	795.6 hPa	0.0 hPa	± 0.4 hPa
Pressure	599.4 hPa	599.5 hPa	0.1 hPa	± 0.4 hPa
Temperature	59.7 °C	59.7 °C	0.0 °C	± 0.2 °C
Temperature	24.9 °C	24.9 °C	0.0 °C	± 0.2 °C
Temperature	-5.8 °C	-5.8 °C	0.0 °C	± 0.2 °C
Temperature	-32.9 °C	-32.9 °C	0.0 °C	± 0.2 °C
Temperature	-52.0 °C	-52.0 °C	0.0 °C	± 0.2 °C
Relative humidity	29.6 %RH	29.6 %RH	0.0 %RH	± 2 %RH
Relative humidity	58.7 %RH	58.7 %RH	0.0 %RH	± 2 %RH
Relative humidity	91.8 %RH	91.8 %RH	0.0 %RH	± 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

~ Certificate of Calibration and Compliance ~

Model: 378B02	Serial Number: 132189	
Microphone Model: 377B02	Serial Number: 177358	Manufacturer: PCB
Preamplifier Model: 426E01	Serial Number: 051458	Manufacturer: PCB

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Reference Equipment

Manufacturer	Model #	Serial #	PCB Control #	Cal Date	Due Date
National Instruments	PCIe-6351	1896F08	CA1918	10/25/16	10/25/17
Larson Davis	PRM915	146	CA2115	2/15/17	2/15/18
Larson Davis	PRM902	4186	CA1083	1/13/17	1/12/18
Larson Davis	PRM916	104	LD015	2/15/17	2/15/18
Larson Davis	CAL250	5374	CA2068	2/7/17	2/7/18
Larson Davis	2201	140	CA890	5/3/17	5/3/18
Bruel & Kjaer	4192	2764626	CA1636	8/7/17	8/7/18
Larson Davis	GPRM902	5337	CA2153	1/13/17	1/12/18
Newport	iTHX-SD/N	1080002	CA1511	2/14/17	2/14/18
Larson Davis	PRA951-4	241	CA1449	10/11/16	10/11/17
Larson Davis	PRM915	122	CA865	11/18/16	11/17/17
0	0	0	0	not required	not required
0	0	0	0	not required	not required
0	0	0	0	not required	not required
0	0	0	0	not required	not required

Frequency sweep performed with B&K UA0033 electrostatic actuator.

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration of reference equipment is traceable to one or more of the following National Labs; NIST, PTB or DFM.
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 9001, ISO 10012-1, ANSI/NCSL Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. System Sensitivity is measured following procedure AT603-5.
6. Measurement uncertainty (95% confidence level with coverage factor of 2) for sensitivity is +/-0.20 dB.
7. Unit calibrated per ACS-63.

Technician: Leonard Lukasik

Date: September 25, 2017

ilac-MRA ACCREDITED

CALIBRATION CERT #1662.01

PCB PIEZOTRONICS VIBRATION DIVISION

3425 Walden Avenue, Depew, New York, 14043

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

~ Calibration Report ~

Model: 378B02 Serial Number: 132189
Microphone Model: 377B02 Serial Number: 177358
Preamplifier Model: 426E01 Serial Number: 051458

Description: 1/2" Free-Field Microphone and Preamplifier

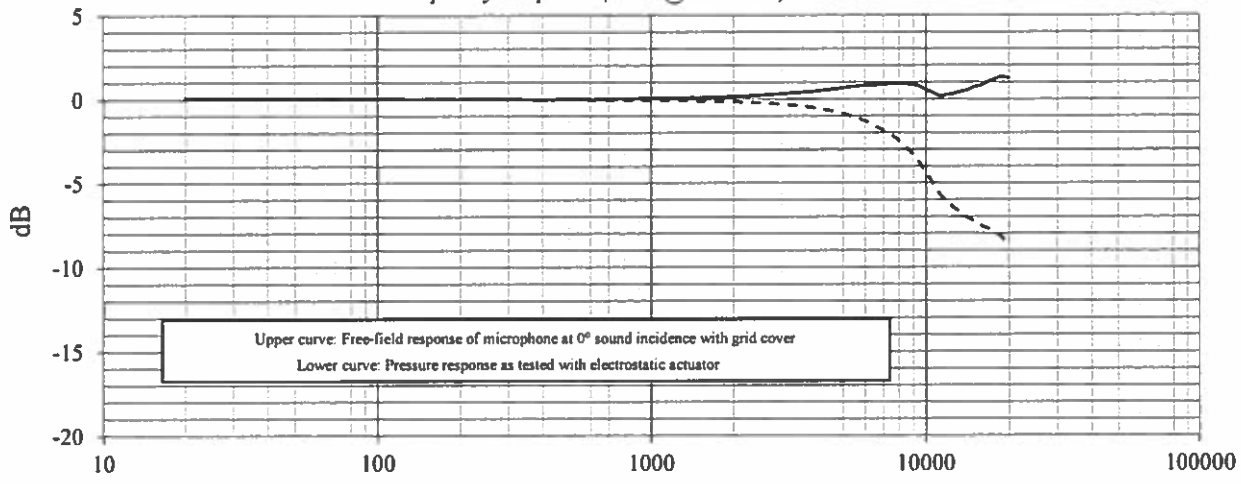
Calibration Data

System Sensitivity @ 251.2 Hz: 49.08 mV/Pa
-26.18 dB re 1V/Pa

Polarization Voltage, External: 0 V

Temperature: 69 °F (21°C) Ambient Pressure: 994 mbar Relative Humidity: 47 %

Frequency Response (0 dB @ 251.2 Hz)



Freq (Hz)	Lower (dB)	Upper (dB)	Freq (Hz)	Lower (dB)	Upper (dB)	Freq (Hz)	Lower (dB)	Upper (dB)	Freq (Hz)	Lower (dB)	Upper (dB)
20.0	0.11	0.11	1679	-0.13	0.10	7499	-2.15	0.93	-	-	-
25.1	0.11	0.11	1778	-0.14	0.11	7943	-2.44	0.95	-	-	-
31.6	0.08	0.08	1884	-0.15	0.13	8414	-2.84	0.89	-	-	-
39.8	0.09	0.09	1995	-0.16	0.15	8913	-3.25	0.86	-	-	-
50.1	0.08	0.08	2114	-0.17	0.17	9441	-3.75	0.77	-	-	-
63.1	0.06	0.06	2239	-0.19	0.18	10000	-4.41	0.54	-	-	-
79.4	0.04	0.04	2371	-0.21	0.20	10593	-5.02	0.38	-	-	-
100.0	0.03	0.03	2512	-0.23	0.23	11220	-5.68	0.18	-	-	-
125.9	0.02	0.02	2661	-0.25	0.26	11885	-6.08	0.24	-	-	-
158.5	0.01	0.01	2818	-0.27	0.29	12589	-6.46	0.31	-	-	-
199.5	0.01	0.01	2985	-0.31	0.31	13335	-6.75	0.44	-	-	-
251.2	0.00	0.00	3162	-0.34	0.34	14125	-7.07	0.52	-	-	-
316.2	-0.01	0.00	3350	-0.38	0.36	14962	-7.26	0.71	-	-	-
398.1	-0.02	-0.02	3548	-0.43	0.40	15849	-7.54	0.81	-	-	-
501.2	-0.03	0.01	3758	-0.46	0.44	16788	-7.71	1.01	-	-	-
631.0	-0.04	0.00	3981	-0.54	0.46	17783	-7.93	1.18	-	-	-
794.3	-0.06	0.03	4217	-0.60	0.51	18837	-8.19	1.32	-	-	-
1000.0	-0.07	0.05	4467	-0.68	0.55	19953	-8.69	1.24	-	-	-
1059.3	-0.08	0.05	4732	-0.77	0.60	-	-	-	-	-	-
1122.0	-0.08	0.06	5012	-0.87	0.66	-	-	-	-	-	-
1188.5	-0.09	0.06	5309	-0.99	0.71	-	-	-	-	-	-
1258.9	-0.09	0.07	5623	-1.12	0.76	-	-	-	-	-	-
1333.5	-0.09	0.09	5957	-1.26	0.81	-	-	-	-	-	-
1412.5	-0.11	0.09	6310	-1.45	0.84	-	-	-	-	-	-
1496.2	-0.11	0.09	6683	-1.68	0.84	-	-	-	-	-	-
1584.9	-0.12	0.09	7080	-1.91	0.87	-	-	-	-	-	-

Technician: Leonard Lukasik Date: September 25, 2017

ilac-MRA ACCREDITED
CALIBRATION CERT #1662.01

PCB PIEZOTRONICS
VIBRATION DIVISION

3425 Walden Avenue, Depew, New York, 14043
TEL: 888-684-0013 FAX: 716-685-3886 www.pcb.com

ID:CAL112-3589185534 861+0

VAISALA

Test report no. H31-16490079

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910195
Manufacturer	Vaisala Oyj, Finland
Test date	9 December 2016

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	394	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.04	-1	1	hPa
Temperature difference	-0.15	-2	2	°C
Humidity difference	0.11	-10	10	%RH
Heating current	0.75	0.6	0.8	A
Current (service port)	1.38	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	1.03	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 26.31 ±5 %RH, Temperature 21.95 ±1 °C, Pressure 993.86 ±1 hPa.

Signature

Technician

 DOC233154-A.doc

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Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

VAISALA

Calibration sheet no. H31-16490080

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550068
Manufacturer	Vaisala Oyj, Finland
Test date	13 November 2016

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	1079.1	1079.1	0	± 0.4 hPa
Pressure	899.4	899.4	0	± 0.4 hPa
Pressure	799.2	799.3	0.1	± 0.4 hPa
Pressure	599	598.9	-0.1	± 0.4 hPa
Temperature	59.6	59.6	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-32.8	-32.8	0	± 0.2 °C
Temperature	24.9	24.9	0	± 0.2 °C
Temperature	-52.3	-52.3	0	± 0.2 °C
Relative humidity	29.9	29.9	0	± 2 %RH
Relative humidity	58.4	58.4	0	± 2 %RH
Relative humidity	92.3	92.3	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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Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONCS
Model No:	378B02
Serial No:	124690
Calibration Recall No:	27798

Submitted By:

Customer:

Company: Aercoustics Engineering LTD

Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 378B02 PCB P

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

Note: With this Certificate, Report of Calibration is included.

Approved by: FC

Felix Christopher (QA Mgr.)

Calibration Date: 12-Jul-17

Certificate No: 27798 - 2

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

PCB Piezotronics Microphone Unit
Model No.: 378B02 Serial No.: 124690
Mic Model No.: 377B02 Serial No.: 163103
Preamp Model No.: 426E01 Serial No.: 043047
Company: Aercoustics Engineering LTD ID No.: XXXX

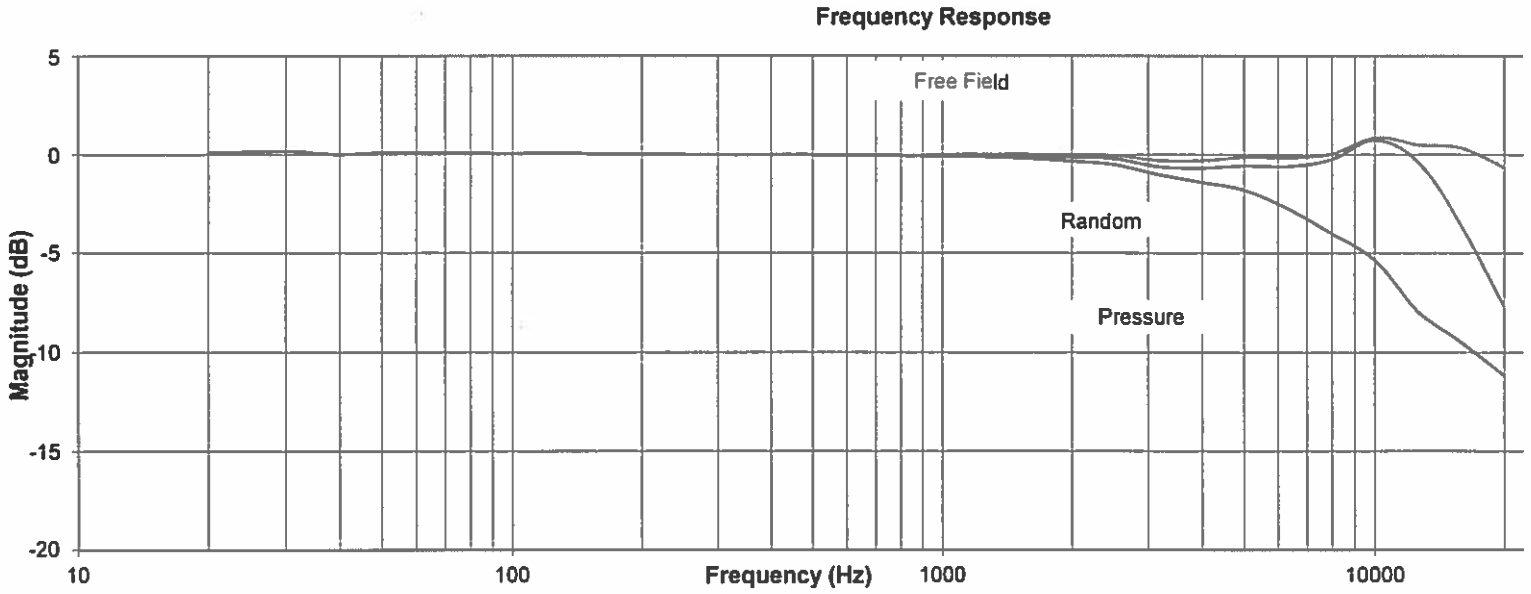
Calibration results:

Before & after data same: ...X...
Combined Sensitivity @ 250 Hz and pressure of 99.23 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-26.60 dB re.1V/Pascal
46.75 mV/Pascal
0.60 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature: 23.6 °C
Ambient Humidity: 53.7 % RH
Ambient Pressure: 99.230 kPa
Calibration Date: 12-Jul-2017
Calibration Due: 12-Jul-2019
Report Number: 27798 -2
Control Number: 27798

The above listed instrument meets or exceeds the tested manufacturer's specifications.
The IEC 651:type 1 and ANSI S1.4 1983 specification passed.
This Calibration is traceable through NIST test numbers: 683/284413-14
The expanded uncertainty of calibration: 0.079dB at 95% confidence level with a coverage factor of k=2.

The pressure response recorded with electroacoustic method.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P378B02PCB

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Measurements performed by: .....
James Zhu

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.
1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

PCB Piezotronics Microphone Unit **Model No.: 378B02** **Serial No.: 124690**
Company: Aercoustics Engineering LTD **ID No.: XXXX**

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]	Random [dB]
19.95	0.10	0.10	0.10
25.12	0.14	0.14	0.14
31.62	0.16	0.16	0.16
39.81	0.00	0.00	0.00
50.12	0.12	0.12	0.12
63.10	0.10	0.10	0.10
79.43	0.07	0.07	0.07
100.00	0.06	0.06	0.06
125.89	0.10	0.10	0.10
158.49	0.02	0.02	0.02
199.53	0.02	0.02	0.02
251.19	0.00	0.00	0.00
316.23	-0.01	-0.01	-0.01
398.11	-0.01	-0.01	-0.01
501.19	-0.02	-0.02	-0.02
630.96	-0.03	-0.03	-0.03
794.33	-0.05	-0.05	-0.05
1000.00	-0.09	0.02	-0.09
1258.93	-0.13	0.03	-0.09
1584.89	-0.21	0.02	-0.13
1995.26	-0.34	-0.01	-0.14
2511.89	-0.52	-0.04	-0.21
3162.28	-1.02	-0.30	-0.61
3981.07	-1.41	-0.31	-0.68
5011.87	-1.80	-0.12	-0.56
6309.57	-2.73	-0.15	-0.58
7943.28	-3.97	0.03	-0.26
10000.00	-5.35	0.86	0.74
12589.25	-7.93	0.50	-0.39
15848.93	-9.48	0.34	-3.60
19952.62	-11.14	-0.64	-7.64

Freq. response: Expanded Uncertainty (dB) with coverage factor K = 2
20 to 63Hz 0.1dB, 63 to 12.5kHz 0.094dB, 12.5k to 16kHz 0.10dB, 16k to 20kHz 0.5dB.

Instruments used for calibration:			Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær	4226	S/N 1445428	3-Nov-2016	683/284413-14	3-Nov-2017
Brüel & Kjær	3560	S/N 2202374	3-Nov-2016	683/284413-14	3-Nov-2017
HP	33120A	S/N 36043716	1-Oct-2016	,287708	1-Oct-2017
HP	34401A	S/N 36064102	1-Oct-2016	,287708	1-Oct-2017

Cal. Date: 12-Jul-2017 **Tested by: James Zhu**

Calibrated on WCCL system type 9700

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

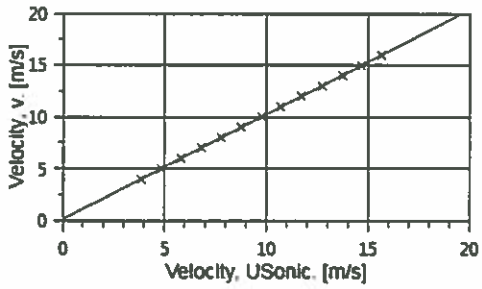
Certificate number: 17.US1.08481 **Date of issue:** September 21, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** J3040014
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

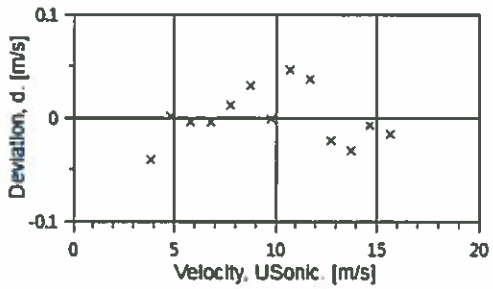
Anemometer received: September 14, 2017 **Anemometer calibrated:** September 18, 2017
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: $v\,[m/s] = 1.01271 \cdot f\,[m/s] + 0.11416$

Standard uncertainty, slope: 0.00202 **Standard uncertainty, offset:** 0.18665
Covariance: -0.0000407 $(m/s)^2/m/s$ **Coefficient of correlation:** $\rho = 0.999978$
Absolute maximum deviation: 0.046 m/s at 10.996 m/s
Barometric pressure: 1007.5 hPa **Relative humidity:** 56.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.15	25.6	28.5	3.959	3.8367	-0.040	0.024
4	14.55	25.7	28.5	4.994	4.8172	0.001	0.025
6	20.96	25.7	28.5	5.994	5.8100	-0.004	0.027
8	28.66	25.7	28.5	7.009	6.8133	-0.005	0.030
10	37.35	25.7	28.5	8.002	7.7767	0.012	0.032
12	47.42	25.7	28.5	9.016	8.7600	0.031	0.035
13-last	58.40	25.7	28.5	10.006	9.7690	-0.001	0.038
11	70.52	25.7	28.5	10.996	10.7000	0.046	0.041
9	84.19	25.7	28.5	12.015	11.7150	0.037	0.044
7	98.46	25.7	28.5	12.994	12.7400	-0.022	0.047
5	114.36	25.7	28.5	14.004	13.7467	-0.032	0.051
3	130.58	25.6	28.5	14.963	14.6700	-0.007	0.054
1-first	148.66	25.6	28.5	15.964	15.6667	-0.016	0.057





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	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.
DP004	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	Setra Model 278, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

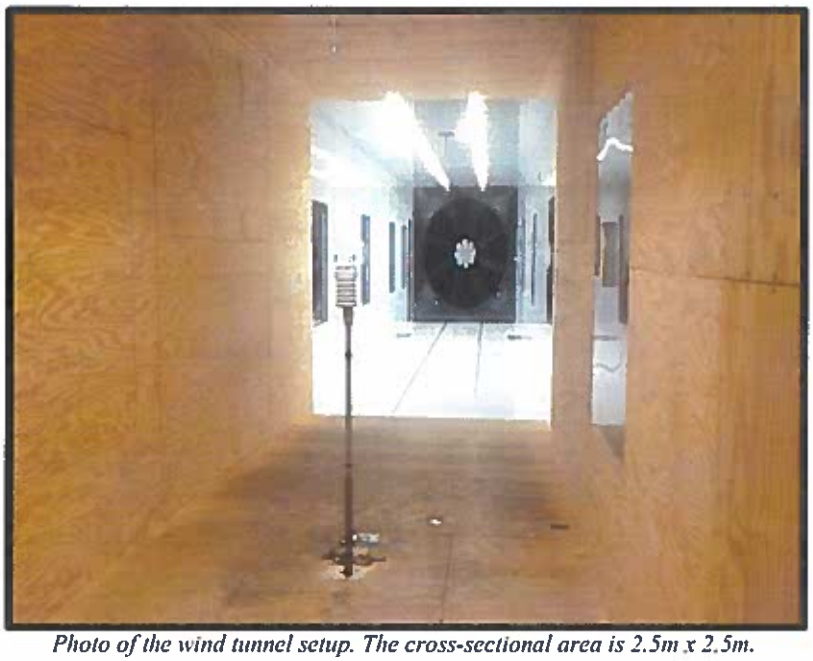


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

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

The sensor was positioned at 90° during calibration.

Certificate number: 17.US1.08481

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CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

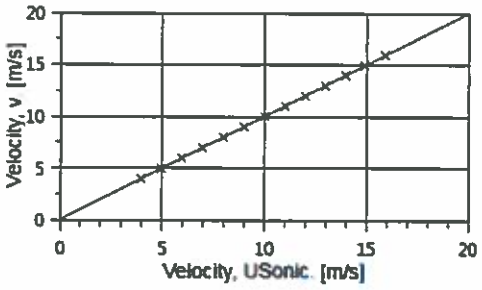
Certificate number: 17.US1.08478 **Date of issue:** September 21, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** J3040014
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

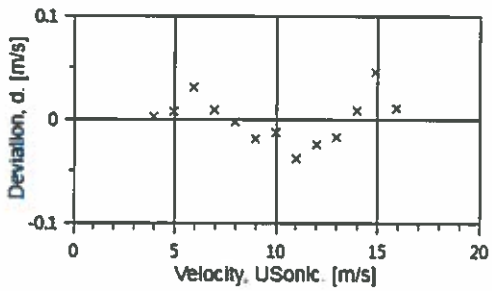
Anemometer received: September 14, 2017 **Anemometer calibrated:** September 18, 2017
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.99933 · f [m/s] + 0.03185

Standard uncertainty, slope: 0.00177 **Standard uncertainty, offset:** 0.59104
Covariance: -0.0000312 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999983
Absolute maximum deviation: 0.046 m/s at 14.971 m/s
Barometric pressure: 1007.7 hPa **Relative humidity:** 56.8%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.32	25.5	28.5	3.995	3.9633	0.002	0.024
4	14.55	25.5	28.5	4.991	4.9552	0.007	0.025
6	21.00	25.5	28.5	5.997	5.9383	0.031	0.027
8	28.55	25.5	28.5	6.993	6.9567	0.009	0.030
10	37.33	25.5	28.5	7.997	7.9733	-0.003	0.032
12	47.28	25.5	28.5	9.000	8.9933	-0.019	0.035
13-last	58.51	25.5	28.5	10.012	10.0000	-0.013	0.038
11	70.58	25.5	28.5	10.996	11.0100	-0.038	0.041
9	84.04	25.5	28.5	11.999	12.0000	-0.024	0.044
7	98.43	25.5	28.5	12.986	12.9800	-0.017	0.047
5	114.46	25.5	28.5	14.004	13.9733	0.008	0.051
3	130.81	25.5	28.5	14.971	14.9033	0.046	0.054
1-first	148.42	25.4	28.5	15.945	15.9133	0.011	0.057





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
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-	Mounting tube, D = 19 mm
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TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
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HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	Setra Model 278, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Esseo Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

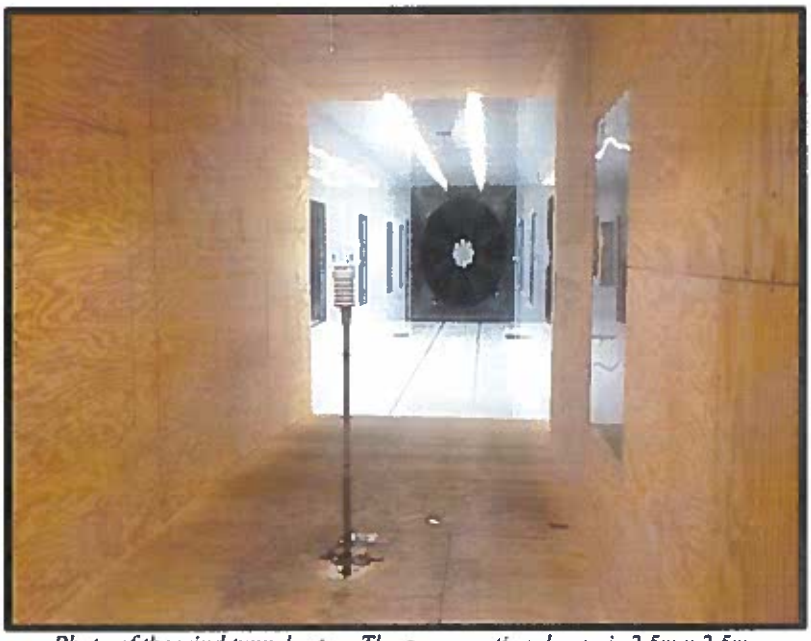

Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

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

The sensor was positioned at 0° during calibration.

Certificate number: 17.US1.08478

aercoustics

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Appendix H
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