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ASSESSMENT REPORT - **Project: 16227.00**

Niagara Region Wind Farm Project
Acoustic Immission Audit – Phase 1

Prepared for:

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17 July 2018

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Executive Summary

Aercoustics Engineering Limited ("Aercoustics") has been retained by 1021702 B.C. Ltd as general partner for and on behalf of FWRN L.P. to complete the acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Niagara Region Wind Farm ("NRWF"). NRWF operates under REA #4353-9HMP2R, issued on November 6, 2014.

This report details the 1st measurement campaign of the NRWF immission audit. Monitoring near receptors O1153, V2705, O1602, O0616 and O0085 spanned the following dates:

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
M1153	February 26, 2018	May 8, 2018	10
M2705	February 26, 2018	May 8, 2018	10
M1602	February 26, 2018	June 6, 2018	14
M0616	March 1, 2018	June 6, 2018	14
M0085	February 26, 2018	April 30, 2018	9

The audit has been completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the "*MOECP 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 ("MOECP") sound level limits. The measured turbine-only levels were found to be in compliance with the applicable sound level limits at receptors O1153, V2705, M1602 and M0085 during the audit.

Insufficient data was collected at receptor O0616 despite an extended monitoring campaign. Measurements are expected to continue in the Fall for the second audit. As per Part E5.2 of the protocol the audit results of two measurement campaigns will be combined to fulfil the minimum required sample size at this location.

1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by 1021702 B.C. Ltd as general partner for and on behalf of FWRN L.P. to complete the acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Niagara Region Wind Farm ("NRWF"). NRWF operates under REA #4353-9HMP2R, issued on November 6, 2014 [1].

The audit was completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the MOECP guideline document for assessing noise from wind turbines that have already been built, "*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, Conservation and Parks ("MOECP") sound level limits.

2 Facility Description

The Niagara Region Wind Farm Project utilizes 77 Enercon turbines (Model E 101) wind turbines for power generation, each having a nameplate capacity ranging from of 2.9MW and 3.0MW respectively. Each turbine has a hub height of 124 meters and a rotor diameter of 101 meters. 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 O1153, V2705, O1602, O0616 and O0085[1]. Monitoring at M1153, M2705, M1602, M0616 and MO0085 spanned the following dates, summarized in Table 1.

Table 1: Monitoring Period for Each Receptor

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
M1153	February 26, 2018	May 8, 2018	10
M2705	February 26, 2018	May 8, 2018	10
M1602	February 26, 2018	June 6, 2018	14
M0616	March 1, 2018	June 6, 2018	14
M0085	February 26, 2018	April 30, 2018	9

[1] Receptor IDs taken from the Noise Assessment Report by K. Ganesh and K. Mallinen, dated April 08, 2016 [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 MOECP 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 MOECP 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
M1153	NI9234 Data Acquisition Card	1C009C6
	PCB 480E09 Signal Conditioner	34590
	PCB 377B02 Microphone	166109 (126059)
	PCB 426E01 Pre-Amplifier	044442
	Vaisala WXT 520	M4910199
M2705	NI9234 Data Acquisition Card	1C009D0
	PCB 480E09 Signal Conditioner	34591
	PCB 377B02 Microphone	155181 (122654)
	PCB 426E01 Pre-Amplifier	040835
	Vaisala WXT 520	M4910197
M1602	NI9234 Data Acquisition Card	19A4D6B
	PCB 480E09 Signal Conditioner	32445
	PCB 377B02 Microphone	166320 (125634)
	PCB 426E01 Pre-Amplifier	043992
	Vaisala WXT 520	M4910200
M0616	NI9234 Data Acquisition Card	1C0AFB2
	PCB 480E09 Signal Conditioner	34593
	PCB 377B02 Microphone	150759 (118497)
	PCB 426E01 Pre-Amplifier	037483
	Vaisala WXT 520	M4910198
M0085	NI9234 Data Acquisition Card	1C009CC
	PCB 480E09 Signal Conditioner	34594
	PCB 377B02 Microphone	155253 (120586)
	PCB 426E01 Pre-Amplifier	039195
	Vaisala WXT 520	M4910193

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 (All receptors were modeled using a height of 4.5m), 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 6 minutes after the interval
- The ambient temperature was above -10˚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 3.6.
- 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.

Contamination of the data due to the presence of insects and frogs (spring peepers) was noted in data collected after April 30th, 2018.The acoustic energy from frogs was present from above 1500Hz and insects were present from above 2000Hz, depending on the monitor location, and dominated the overall level for both Turbine ON and ambient measurements. The frequency ranges used for this filter was determined based on site-specific conditions to discount the effect of the contaminated insect and frog noise.

3.3 Measurement Location

Receptors O1153, V2705, O1602, O0616, and O0085 were chosen to be representative of the worst-case impact of the facility. These locations were chosen based on the MOECP selection requirements communicated in the NRWF REA. Please see Appendix F for an outline of the selection criteria and process. All five receptors are located in the predominant downwind direction of the facility. O1153, V2705, O1602, O0616, and O0085 have a predicted impact of 39.9 dBA, 39.7 dBA, 39.5 dBA, 39.7 dBA and 39.5 dBA respectively, as per level predicted from an "As Built" noise model based on the original CadnaA noise prediction model. The following describes the measurement locations in relation to the above listed receptors:

- M1153: Measurement equipment was placed on the open lawn on the property of and to the west of O1153, 428 m to the nearest turbine (T20), on the west side of Bird Road. The predicted level based on the acoustic model at M1153 is 41.6 dBA. Monitor M1153 was erected in a location that was closer to the wind project than their representative receptor due to site specific setup limitations (trees, pond and horse enclosure). The effect of the closer measurement location is a shorter source-to-receiver distance to the closest turbines and therefore a higher sound level from the turbines at the monitor location compared to the receptor location.

- M2705: Measurement equipment was placed on the vacant lot property of V2705, 603 m to the nearest turbine (T04), on the north side of Concession Road Four. The predicted level based on the acoustic model at M2705 is 39.7 dBA.

- M1602: Measurement equipment was placed in an open field on the property of and to the west of O1602, 539 m to the closest turbine (T28), on the west side of Comfort Road. The predicted level based on the acoustic model at M1602 is 39.7 dBA.

- M0616: Measurement equipment was placed in an open field on the property of and to west of O0616, 592 m to the closest turbine (T93), on the south side of Concession Road Four. The predicted level based on the acoustic model at M0616 is 39.8 dBA.

- M0085: Measurement equipment was placed in an open field on the property of and to the west of O0085, 540 m to the closest turbine (T08), on the south side of Concession Road Three. The predicted level based on the acoustic model at M0085 is 39.7 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	M1153 T20	M2705 T04	M1602 T28	M0616 T93	M0085 T08
Receptor	UTM Coordinates (X,Y)	17T 621067mE 4749725mN	17T 627870mE 4768233mN	17T 622682mE 4769629mN	17T 618600mE 4767679mN	17T 614752mE 4765425mN
	Distance to Nearest Turbine	584m	603m	558m	617m	554m
	Predicted Level dBA*	39.9	39.7	39.5	39.7	39.5
Monitor	UTM Coordinates (X,Y)	17T 620902mE 4749669mN	17T 627870mE 4768233mN	17T 622530mE 4769635mN	17T 618528mE 4767683mE	17T 614682mE 4765434mN
	Distance to Nearest Turbine	428m	603m	539m	592m	540m
	Predicted Level dBA**	41.6	39.7	39.7	39.8	39.7

* Predicted level from Sound Level Prediction Results, [Modified Model for As-built] 77 WTGs – Stantec [3]
** Predicted level from Aercoustics' acoustic model

3.4 Sample size Reporting Requirements

As per Section D3.8 of the MOECP 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 receptors O1153, V2705 and O1602 in wind speed bins between 1 and 7 m/s.

The RAM-I sample size requirement of 60 data points for Turbine ON and 30 data points for ambient measurements for 2 wind speed bins has been satisfied for receptor O0085 in wind speed bins between 1 and 4 m/s

Despite the extended duration (3 months) of the acoustic monitoring campaign the minimum reporting requirements (as per Part E5.5 of the protocol) has not been fulfilled at receptor measurement locations O_616. Acoustic measurements at this location has been more challenging due to less prevalent downwind conditions during the audit period and contamination from extraneous sources (animal activity, road traffic) during downwind conditions and high electrical power output.

3.5 Weather Conditions

Ambient conditions encountered over the measurement campaign were as follows:

- Ambient Humidity: 24% to 97%
- Ambient Temperature: -7˚C to 27˚C
- 10m Wind Speed: 0 m/s to 25 m/s

Historically, the predominant wind direction is from the southwest 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.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by NRWF. 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 T4, T5, T8 T20, T27, T28, T52, T53, T56, T58, T62, T63, T66, T85, T93, T94, T96, and T99.

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 MOECP allowable sound level limits. The MOECP 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: MOECP Sound Level Limits for Wind Turbines

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

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

5 Audit Results

The following tables detail the sound levels measured at all five 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 5, 6, 7, 8 and 9. 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.

Table 5: M1153 Sound levels measured for Turbine ON and OFF

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	17	*	*	26	*	*	*
1	51	*	*	209	27	2.7	*
2	51	*	*	621	30	3.1	*
3	94	42	0.5	834	30	2.8	40
4	266	42	0.7	568	32	2.5	40
5	147	43	0.5	412	35	2.2	40
6	34	*	*	217	41	2.4	*
7	2	*	*	84	46	2.3	*

*Insufficient amount of data points as per RAM-I protocol
**Turbine ONLY levels are given a distance correction (-1.7dB); Refer to Section 5.1 for more detail.

Table 6: M2705 Sound levels measured for Turbine ON and OFF

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	*	*	109	31	3.7	*
1	9	*	*	291	29	3.9	*
2	54	*	*	344	29	4.6	*
3	137	41	0.5	421	30	3.9	40
4	168	41	0.6	426	33	3.4	40
5	60	42	1.0	246	38	3.0	39
6	47	*	*	62	43	2.3	*
7	21	*	*	2	*	*	*

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

Table 7: M1602 Sound levels measured for Turbine ON and OFF

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	*	*	160	38	7.3	*
1	0	*	*	290	37	6.7	*
2	0	*	*	304	38	6.4	*
3	8	*	*	253	39	6.0	*
4	74	42	0.8	382	37	4.2	40
5	103	43	1.0	345	39	2.9	40
6	92	44	1.5	121	43	2.2	39‡
7	13	*	*	59	48	1.4	*

*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 8: M0085 Sound levels measured for Turbine ON and OFF

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	7	*	*	26	*	*	*
1	76	41	0.4	127	31	3.9	40
2	117	41	0.4	242	30	3.2	40
3	28	*	*	73	31	3.4	*
4	4	*	*	43	33	2.9	*
5	1	*	*	47	35	2.3	*
6	0	*	*	2	*	*	*
7	0	*	*	0	*	*	*

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

Table 9: M0616 Sound levels measured for Turbine ON and OFF

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	-	-	34	35	6.0	-
1	1	40	-	468	33	4.6	39
2	20	41	0.5	598	32	3.2	40
3	12	41	1.9	558	33	3.4	40
4	19	41	0.4	165	34	3.7	40
5	34	43	0.7	13	39	4.8	40
6	21	44	1.0	7	42	1.3	40
7	4	47	1.7	1	44	-	43

Note: Insufficient amount of data points as per RAM-I protocol in all wind bins

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at M1153, M2705, M1602, M0616 and M0085 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: M1153 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

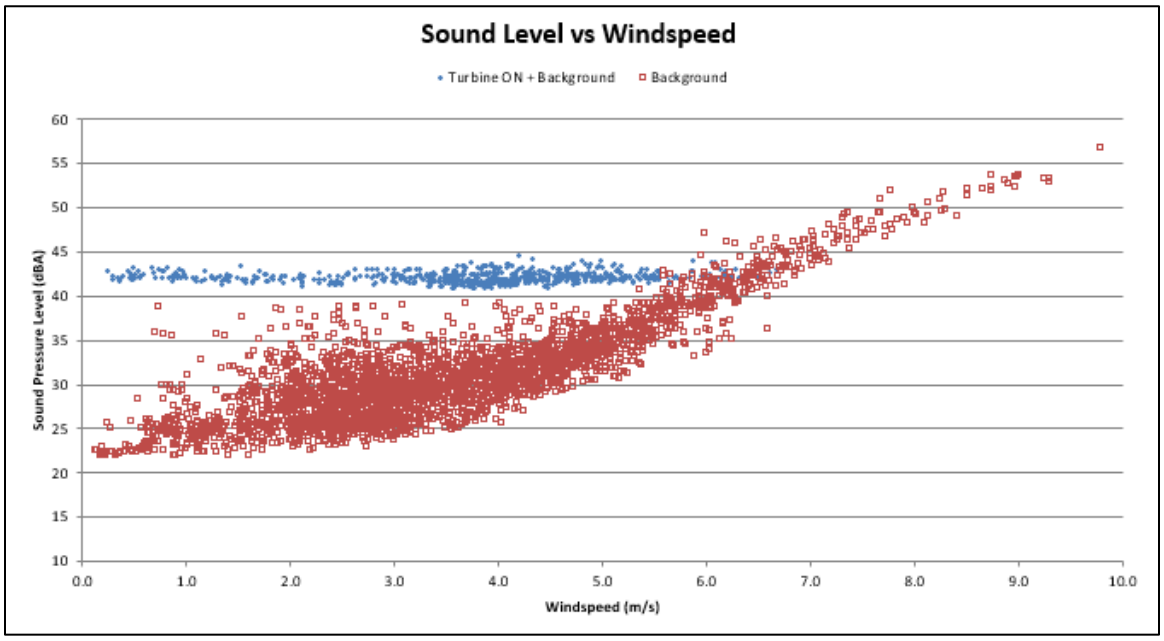


Figure 2: M2705 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

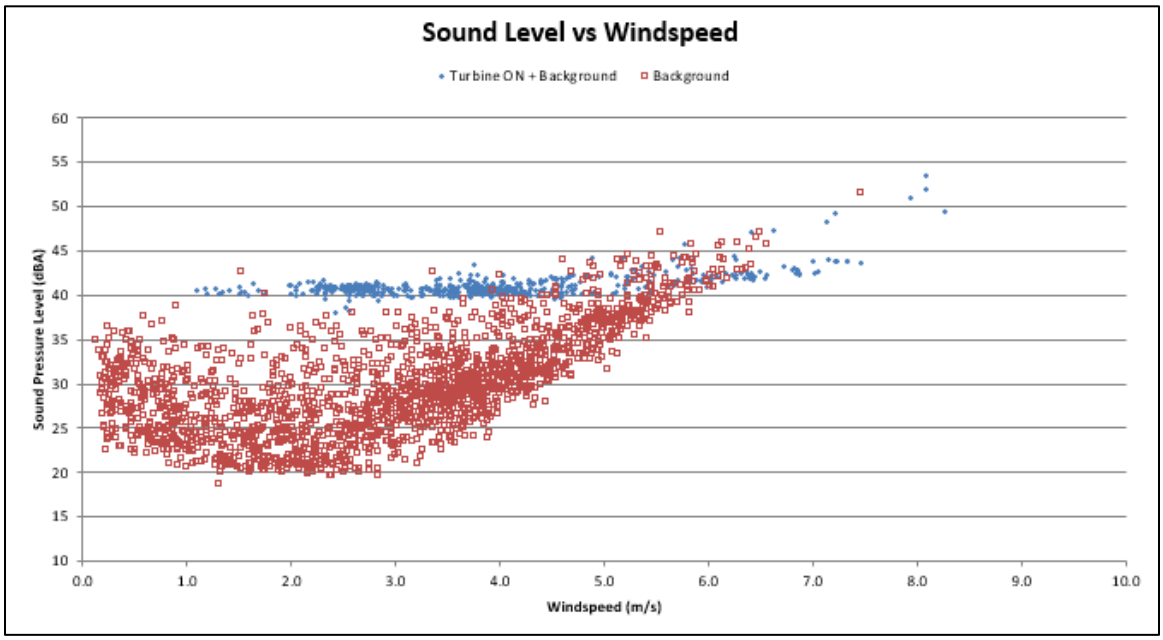


Figure 3: M1602 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

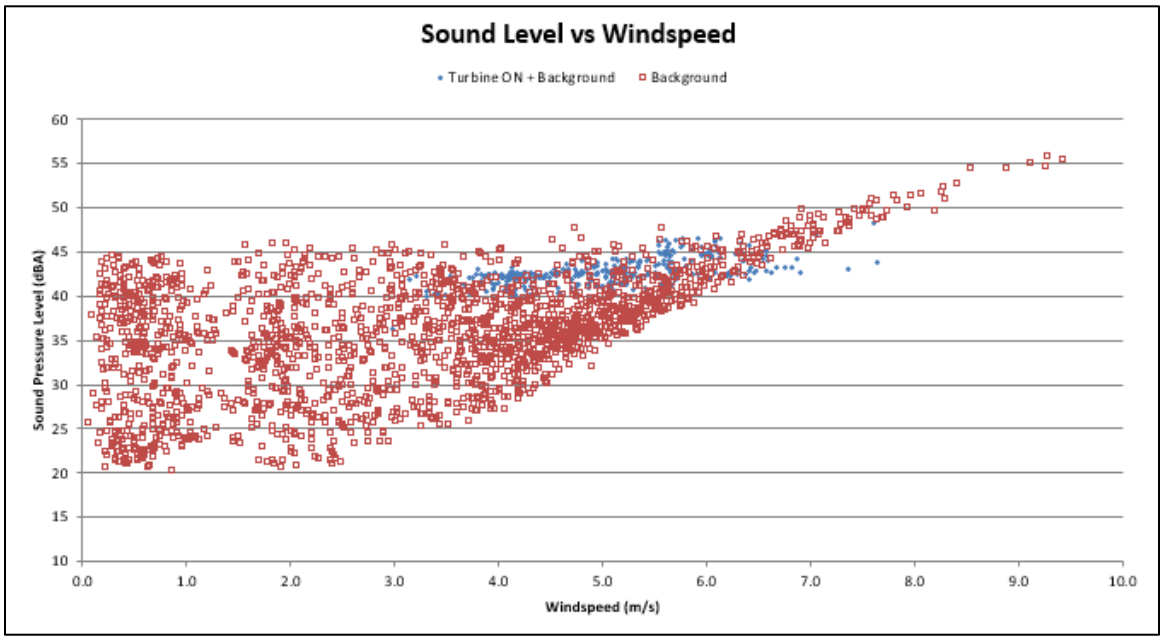


Figure 4: M0616 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

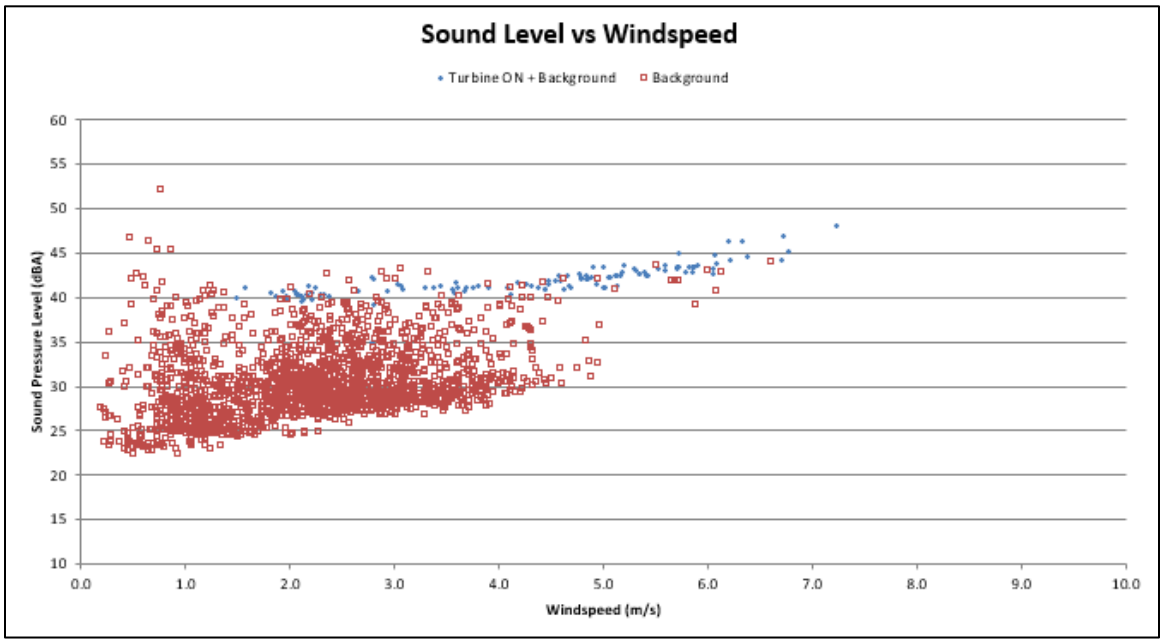
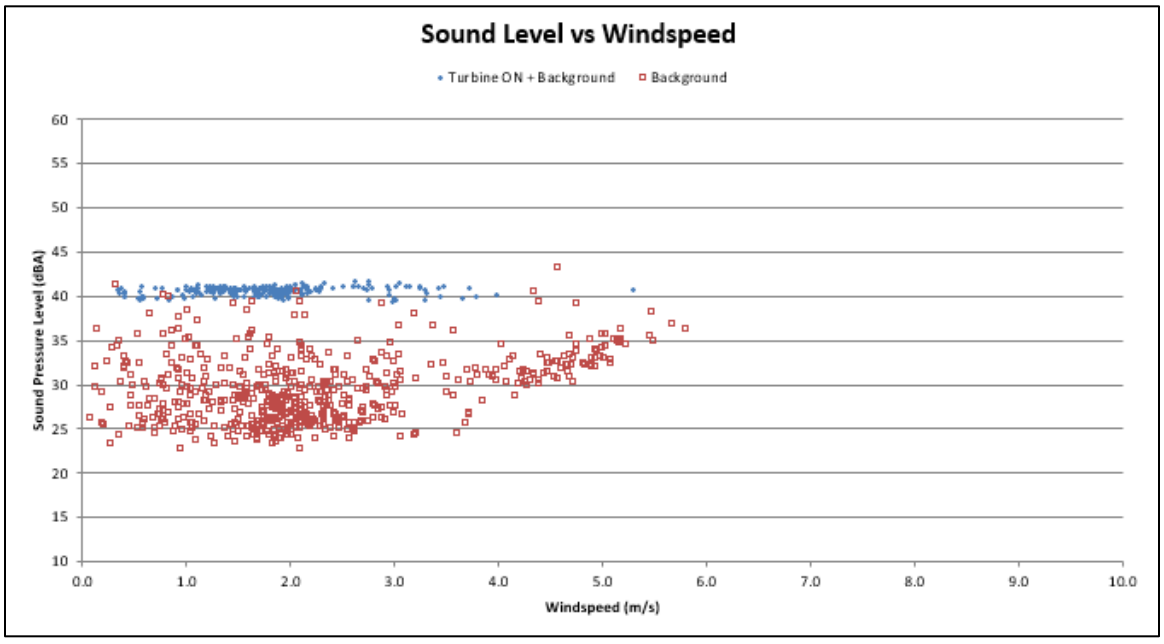


Figure 5: M0085 - Measured Sound Levels for Turbine ON and Background vs Wind Speed



6 Discussion

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 M2705, M1602, M0616 and M0085 are considered representative of the sound levels at Receptor M2705, M0616 and M0085 given the placement of the acoustic monitoring stations.

Monitor M1153 was erected in a location that was closer to the wind project than their representative receptor due to site specific setup limitations. The effect of the closer measurement location is a shorter source-to-receiver distance to the closest turbines and therefore a higher sound level from the turbines at the monitor location compared to the receptor location. To account for this difference in sound level, a correction has been applied based on the difference between the predicted level at the monitor location and the predicted level at the receptor location in the acoustic model. As a result, 1.7 dB was subtracted from the Turbine ONLY sound level for monitor O1153 and is presented in Table 10. See Appendix C for detailed calculation information.

Table 10 presents the Turbine ON, Turbine OFF and calculated Turbine ONLY sound pressure levels between 4-7 m/s. Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey.

Table 10: Assessment Table

Measurement Location	Wind speed at 10m height [m/s]	0	1	2	3	4	5	6	7
M1153	Turbine ON LAeq [dBA]	*	*	*	42	42	43	*	*
	Turbine OFF LAeq [dBA]	*	27	30	30	32	35	41	46
	Turbine ONLY LAeq [dBA]	*	*	*	40†	40†	40†	*	*
MOECP Limit		40	40	40	40	40	40	41**	46**
M2705	Turbine ON LAeq [dBA]	*	*	*	41	41	42	*	*
	Turbine OFF LAeq [dBA]	31	29	29	30	33	38	43	*
	Turbine ONLY LAeq [dBA]	*	*	*	40	40	39	38	*
MOECP Limit		40	40	40	40	40	40	43**	43
M1602	Turbine ON LAeq [dBA]	*	*	*	*	42	43	44	*
	Turbine OFF LAeq [dBA]	38	37	38	39	37	39	43	48
	Turbine ONLY LAeq [dBA]	*	*	*	*	40	40	39‡	*
MOECP Limit		40	40	40	40	40	40	43**	48**
M0085	Turbine ON LAeq [dBA]	*	41	41	*	*	*	*	*
	Turbine OFF LAeq [dBA]	*	31	30	31	33	35	*	*
	Turbine ONLY LAeq [dBA]	*	40	40	*	*	*	*	*
MOECP Limit		40	40	40	40	40	40	40	43

† Turbine ONLY levels are given a distance correction (-1.7dB) Refer to Section 5.1 for more detail.
‡ 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
*Insufficient amount of data points to calculate Turbine ONLY level as per RAM-I protocol
** 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 Figures 6 to 9.

Figure 6: M1153 Turbine Levels compared to MOECP Limits

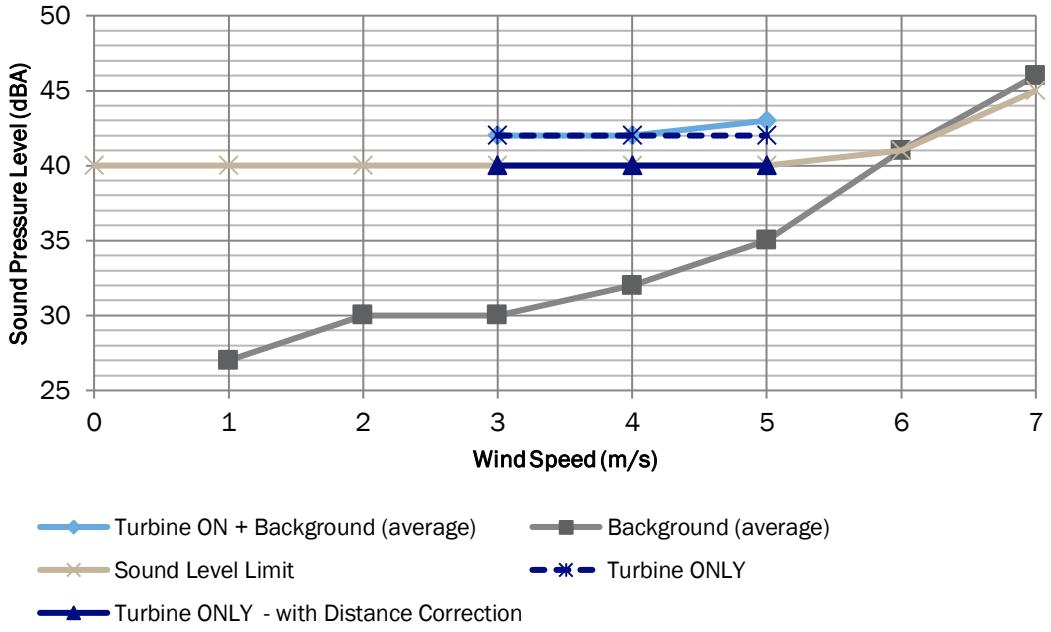


Figure 7: M2705 Turbine Levels compared to MOECP Limits

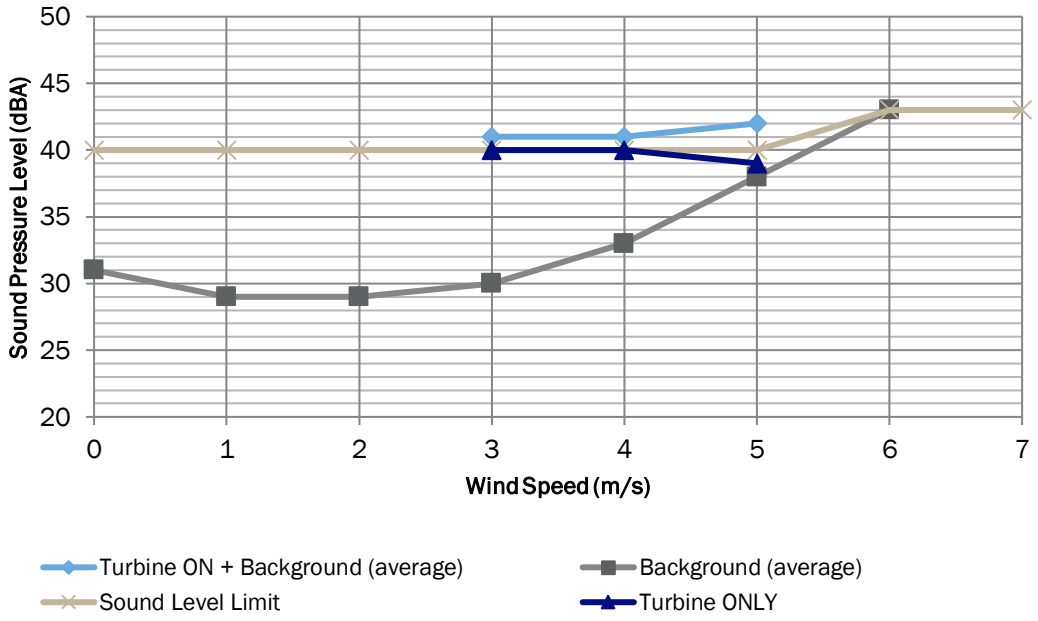


Figure 8: M1602 Turbine Levels compared to MOECP Limits

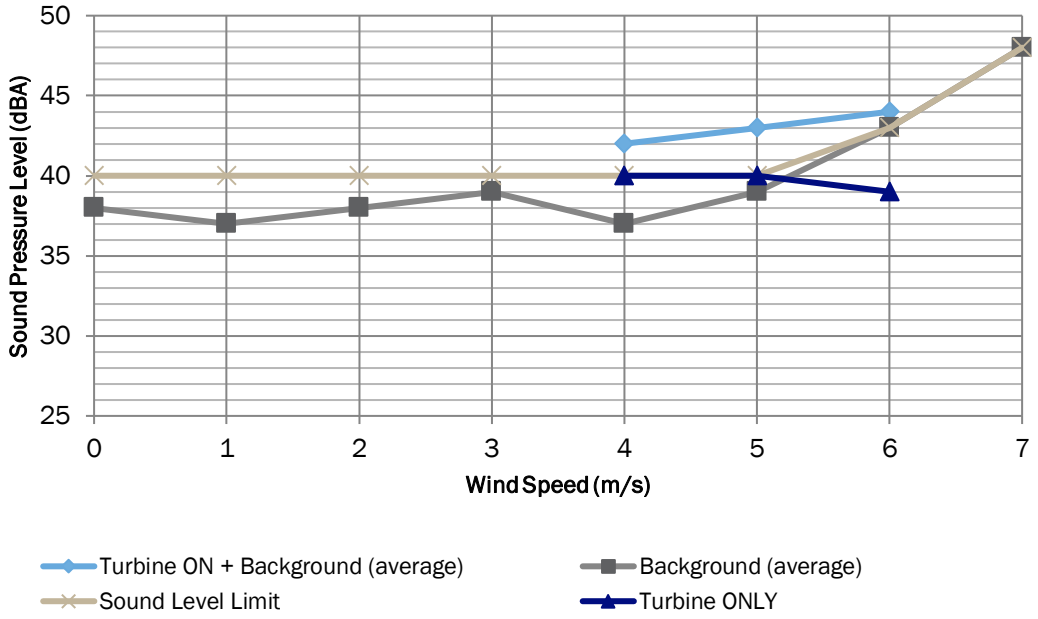
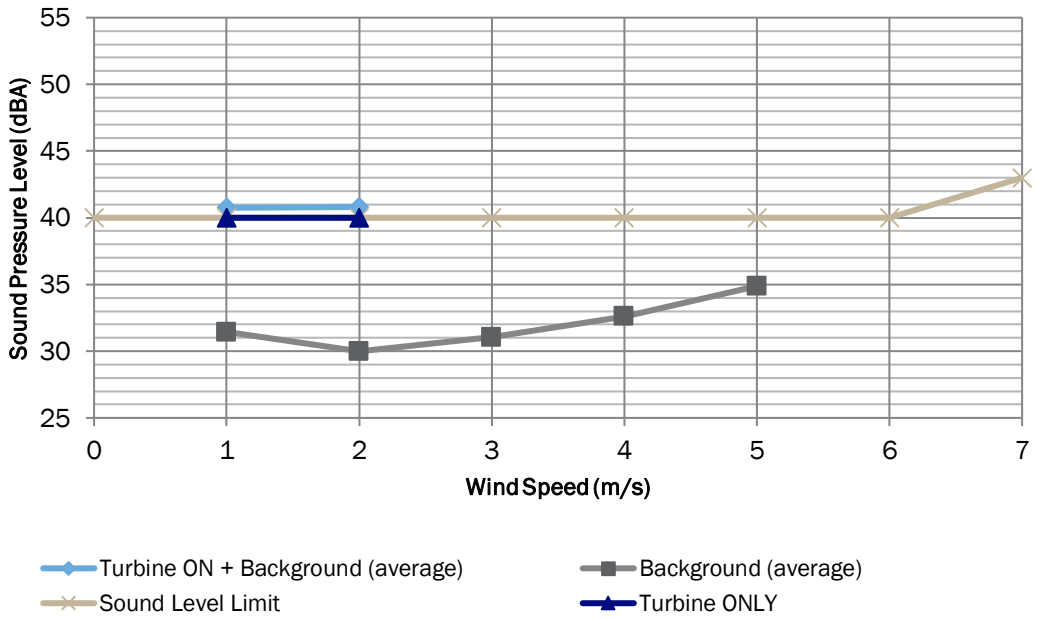


Figure 9: M0085 Turbine Levels compared to MOECP Limits



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.

The MOECP Compliance Protocol stipulates that additional tonality analysis must be carried out in situations where a noise test report on the wind turbine indicates an emitted tonal audibility greater than a value of 3dB. No such tones were assessed according to the IEC 61400-11 Edition 3.0 noise emission measurements carried out on turbines T46 [4] and T35 [5].

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 reduces 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 T35 (rated at 104.8 dBA) and T46 (rated at 102.9 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. A 116 Hz tone was observed at all receptors but was not prevalent enough nor prominent enough for a tonal penalty to be applicable. Tonal assessment summary tables are provided in Appendix D.

No tonal penalty was found to be applicable based on detailed tonal audibility analysis at audited receptors at the NRWF Wind Farm.

7 Assessment of Compliance

Based on the calculated turbine-only component indicated in Table 10 and Figures 6 to 9, the Niagara Region Wind Farm Project was found to be compliant with MOECP limits at receptors M1153, V2705, M1602 and M0085 during the audit.

Receptor O616 does not have sufficient data for assessment in accordance with the Protocol. However, the measured levels in Table 8 indicate compliance.

8 Conclusion

Aercoustics Engineering Limited has completed the Phase 1 acoustic immission audit outlined in the Renewable Energy Approval for the Niagara Region Wind Farm Project. The audit was completed as per the methodology outlined in Parts D and E of the "*MOECP Compliance Protocol for Wind Turbine Noise*."

The measured levels were compared to the MOECP limits, and the facility was determined to be in compliance at receptors O1153, V2705, O1602 and O0085 during the audit.

Insufficient data was collected at receptor O0616 despite an extended monitoring campaign. Measurements are expected to continue in the Fall for the second audit. As per Part E5.2 of the protocol the audit results of two measurement campaigns will be combined to fulfil the minimum required sample size at this location.

9 References

[1] V. Schroter, "Renewable Energy Approval #4353-9HMP2R", Ontario Ministry of the Environment, Toronto, ON, November 6, 2014 and further modified on November 23, 2015, May 6, 2016 and May 12, 2016.

[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] K. Ganesh and K. Mallinen, "Niagara Region Wind Farm Noise Assessment Report – REA Amendment", Stantec Consulting Ltd., Markham, ON, April 08, 2016.

[4] P. Ashtiani and A. Munro, "Niagara Region Wind Farm – Turbine T46 – IEC 61400-11 Edition 3.0 Measurement Report", Aercoustics Engineering Ltd., Mississauga, ON, 03 November 2017.

[5] P. Ashtiani and A. Munro, "Niagara Region Wind Farm – Turbine T35 – IEC 61400-11 Edition 3.0 Measurement Report", Aercoustics Engineering Ltd., Mississauga, ON, 03 November 2017.

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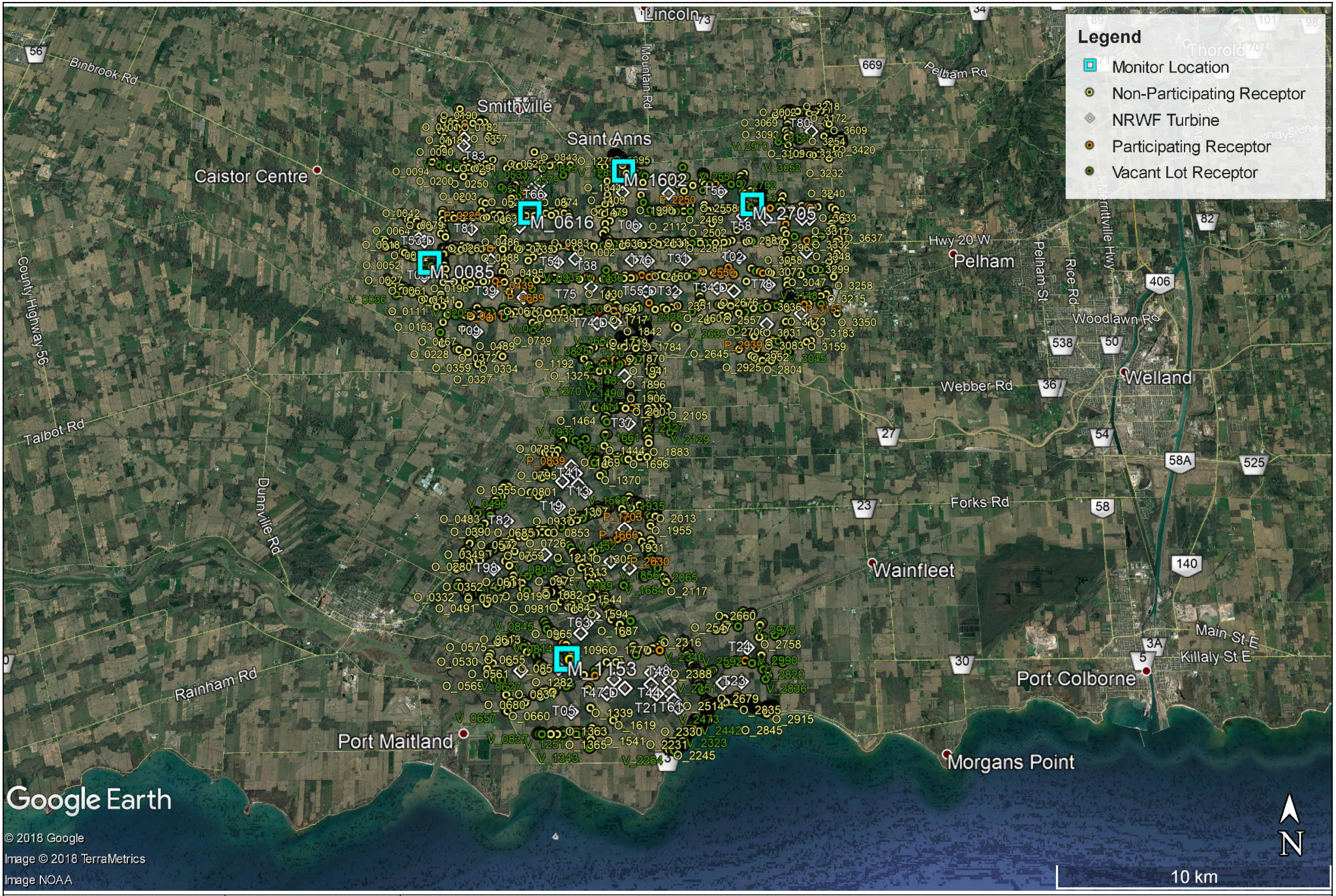
Appendix A
Location Details



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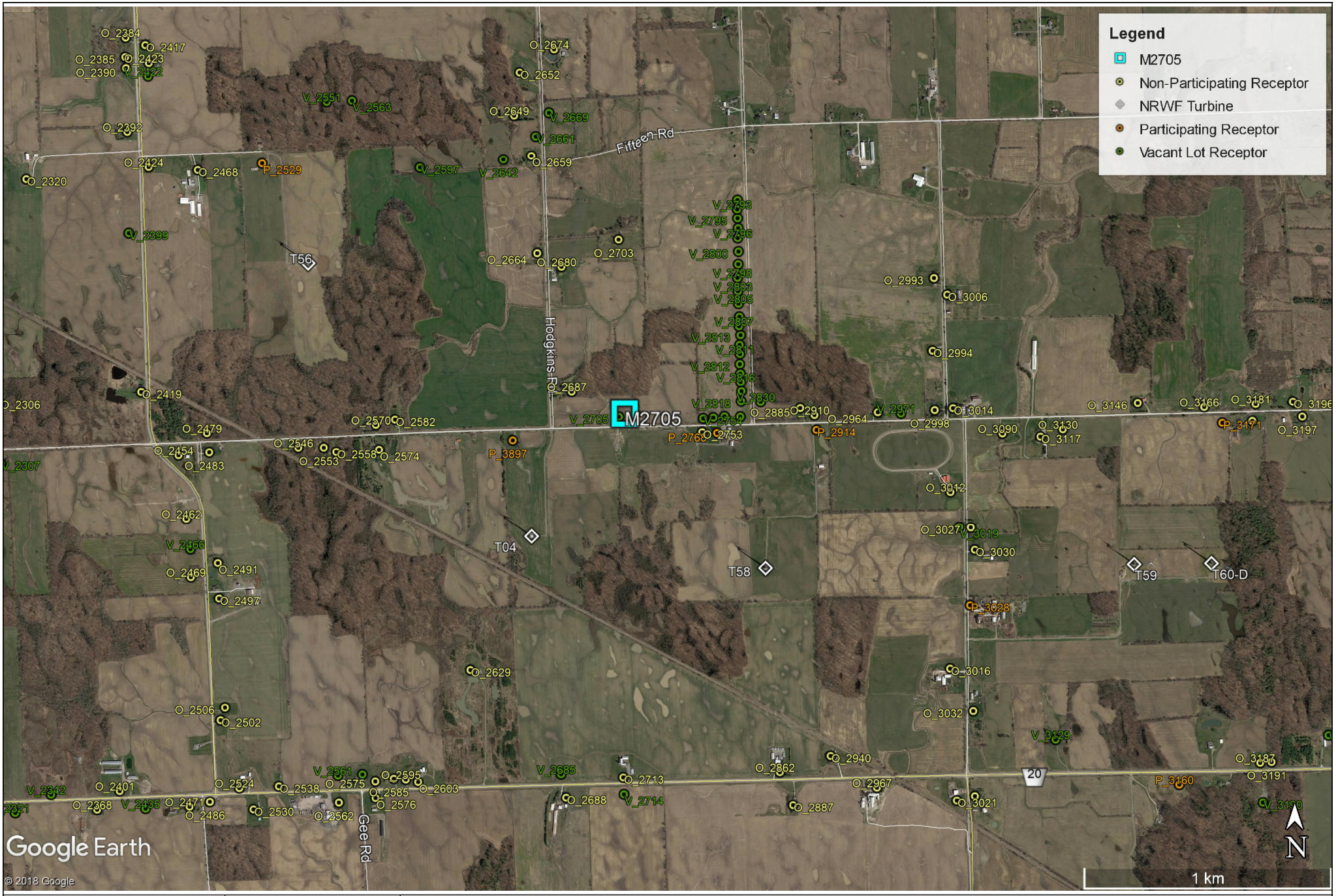
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
		Figure Title Site Plan
		Figure A.01

aercoustics	16227	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
		Figure Title M1153 - Monitor and Receptor Location Details
		Figure A.02



aercoustics	16227	**Project Name**
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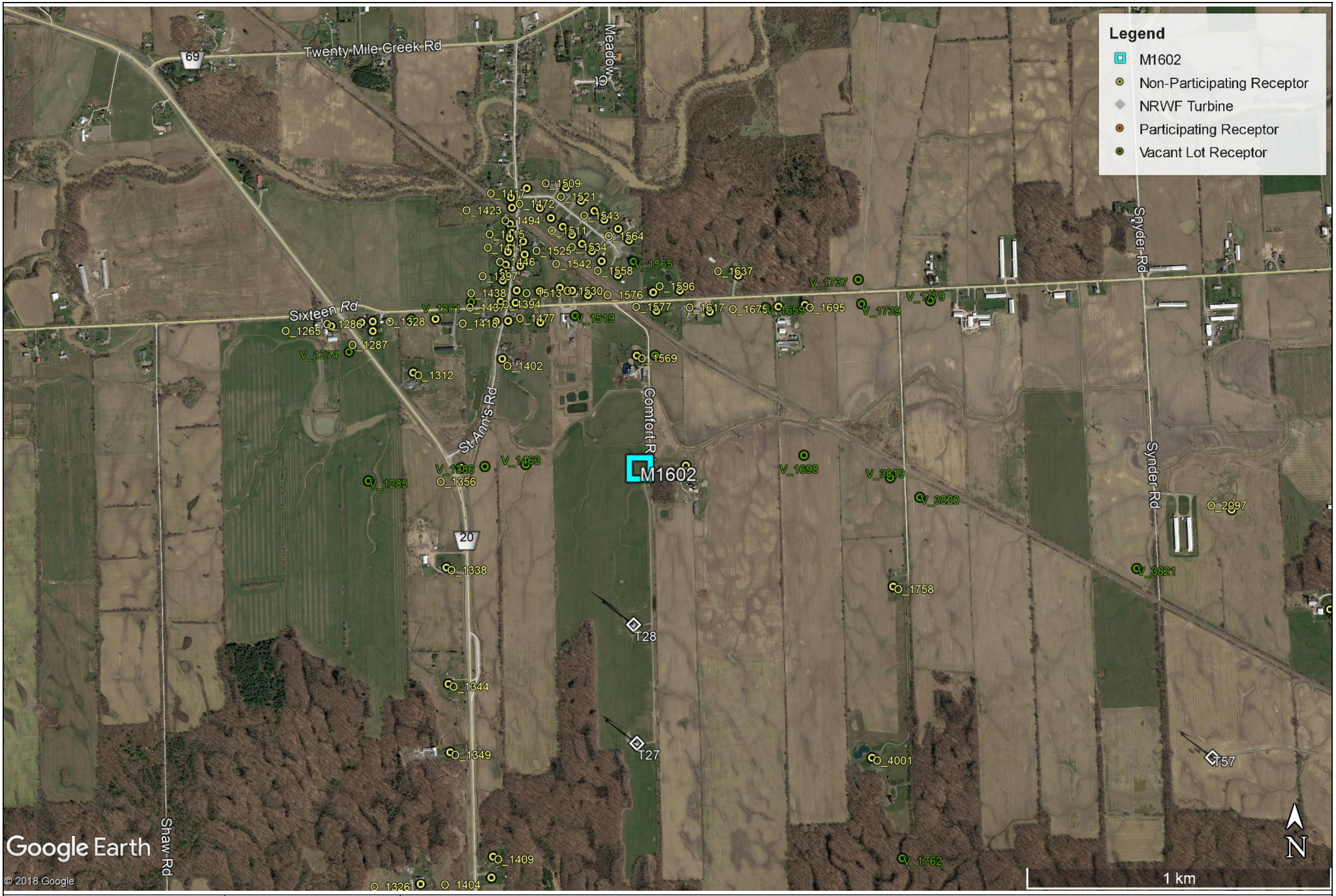
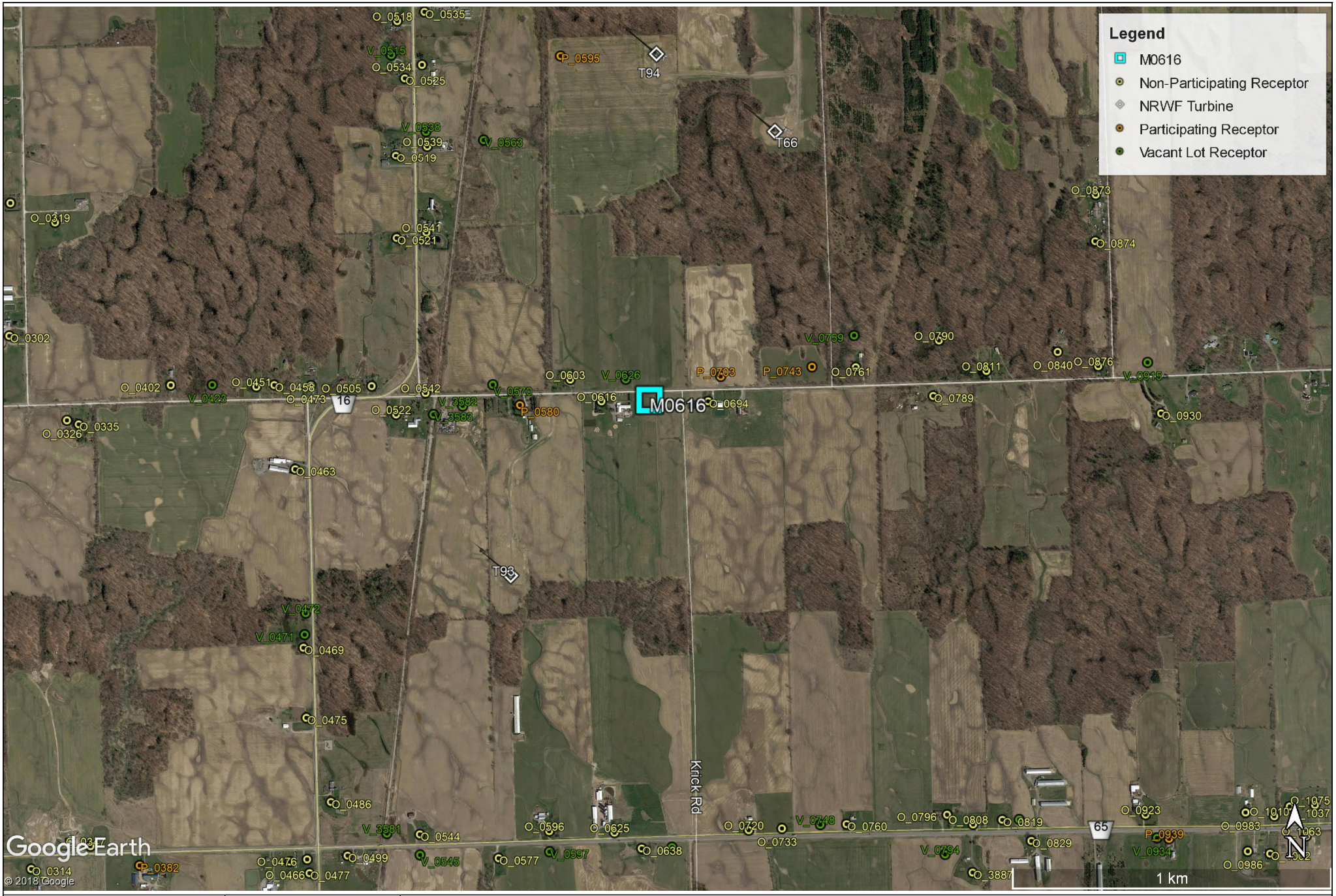
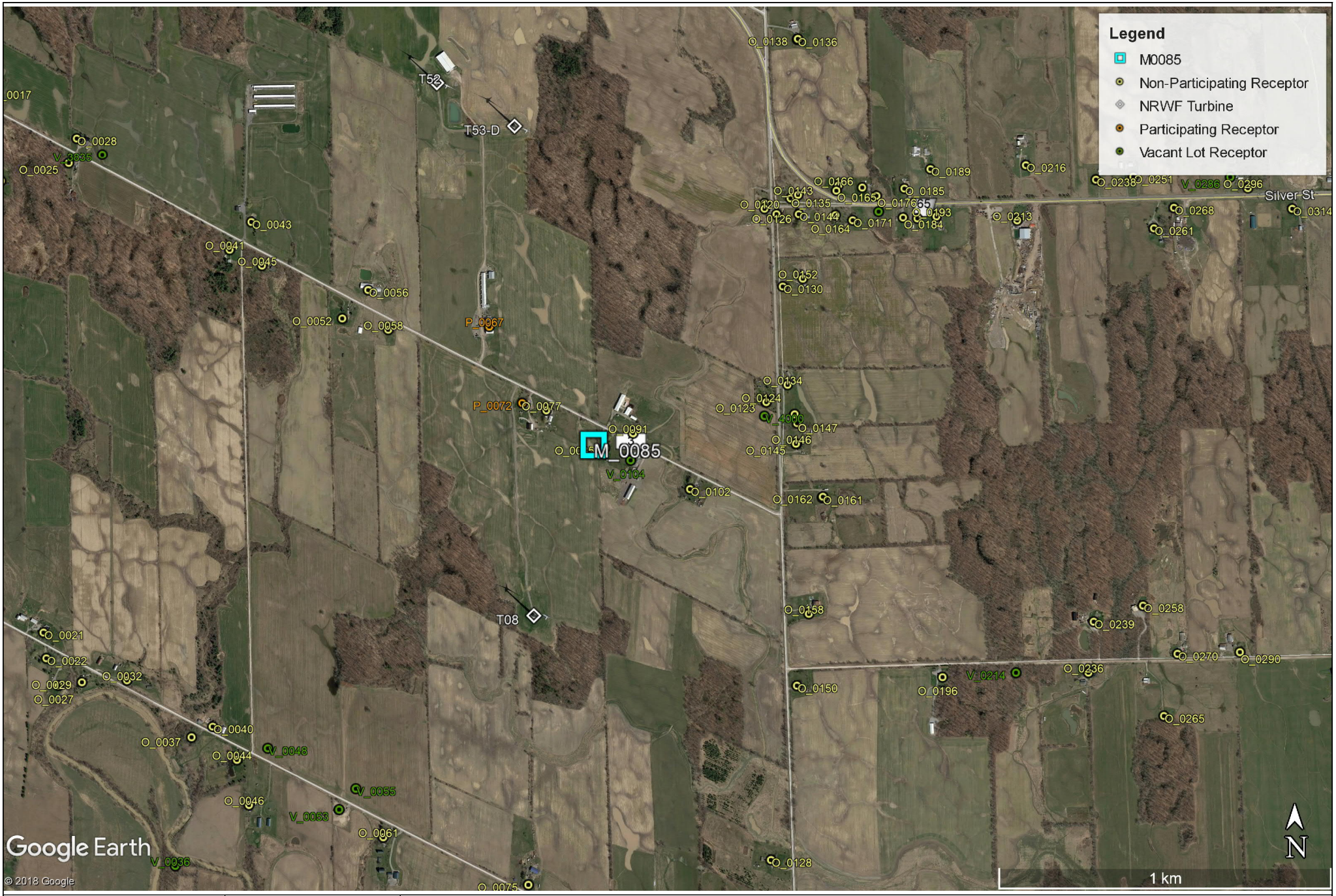
		Figure A.03



aercoustics	16227	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
		Figure Title M1602 - Monitor and Receptor Location Details
		Figure A.04



aercoustics	16227	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
		Figure Title M0616 - Monitor and Receptor Location Details
		Figure A.05



aercoustics	16227	**Project Name**
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
		Figure Title M0085 - Monitor and Receptor Location Details
		Figure A.06

aercoustics	16227	**Project Name**	
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit	
		Figure Title Site Photos - M1153	**Figure A.07**

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Revision: 1

Project Name

Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

Figure Title

Site Photos - M2705

Figure A.08

aercoustics	16227 Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 1st Acoustic Immission Audit	
		Figure Title Site Photos - M1602	**Figure A.09**

aercoustics	16227	**Project Name**	
	Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	Niagara Region Wind Farm Project - 1st Acoustic Immission Audit	
		Figure Title Site Photos - M0616	**Figure A.10**

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Drawn by: JM
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Date: Jul 10, 2018
Revision: 1

Project Name

Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

Figure Title

Site Photos - M0085

Figure A.11

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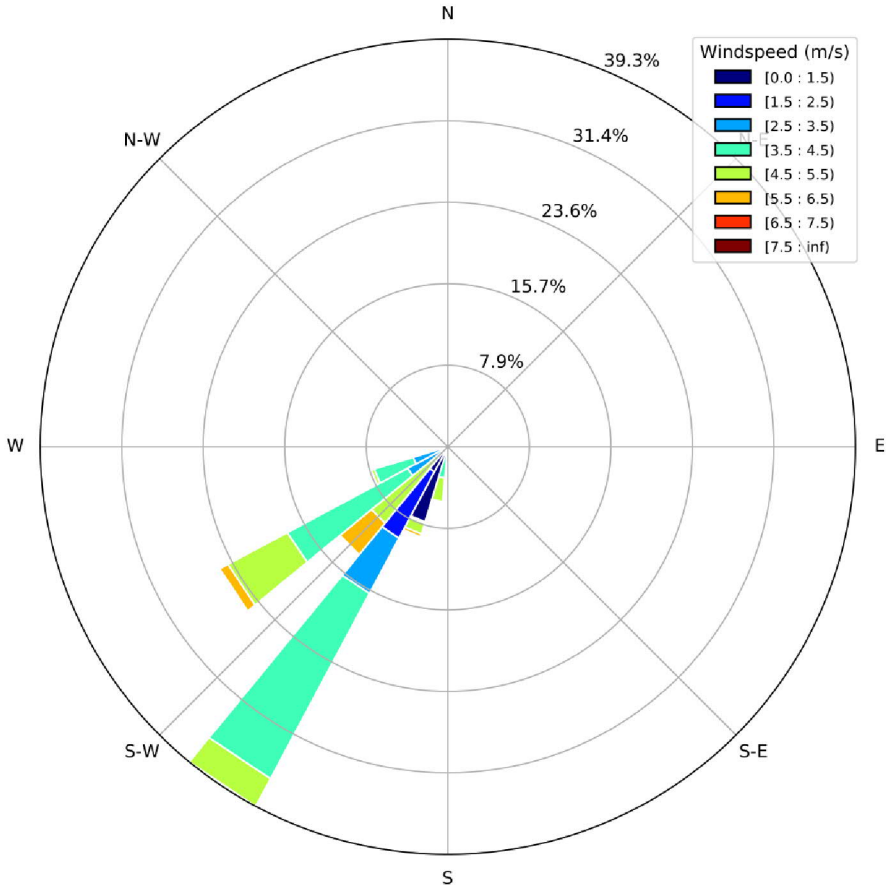
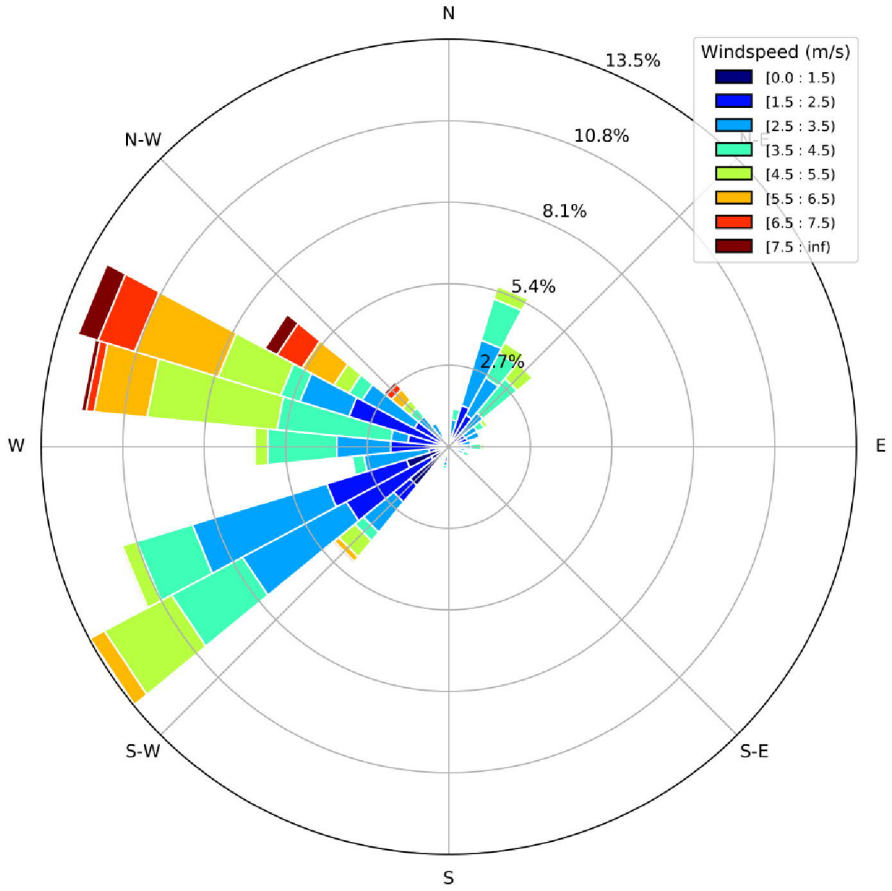
Appendix B
Wind Roses

M1153 TON



M1153 TOFF



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Scale: NTS
Drawn by: JM
Reviewed by: AM
Date: Jul 10, 2018
Revision: 1

Project Name

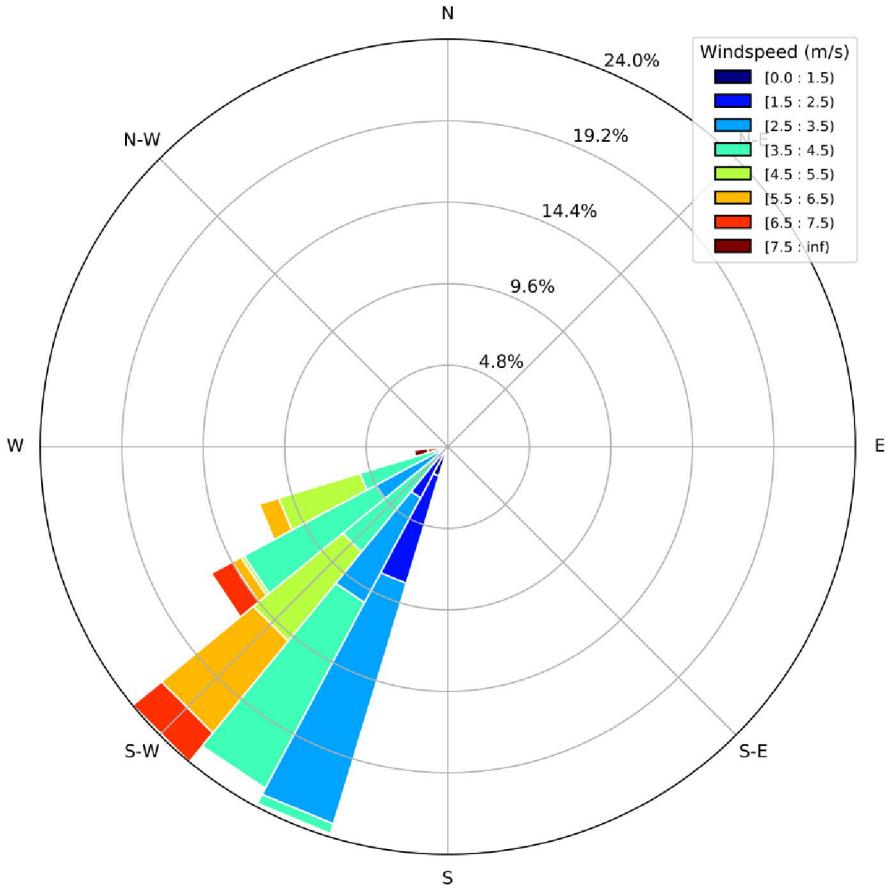
Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

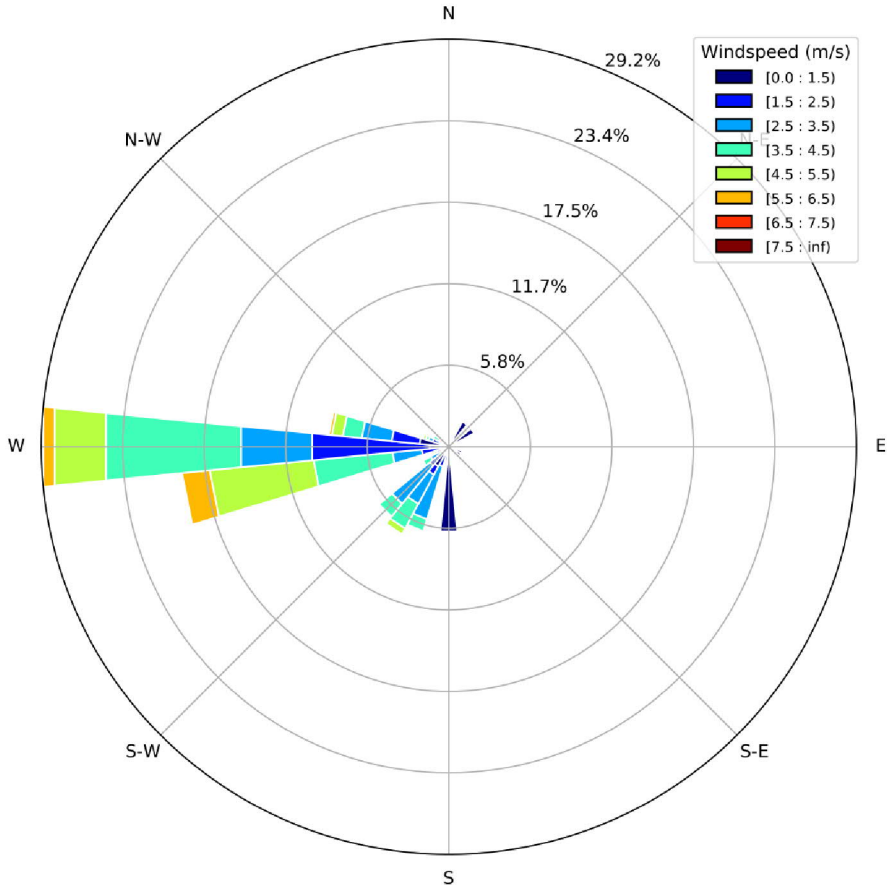
Figure Title

Wind Roses - M1153

Figure B.01

M2705 TON	M2705 TOFF





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Scale: NTS
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Date: Jul 10, 2018
Revision: 1

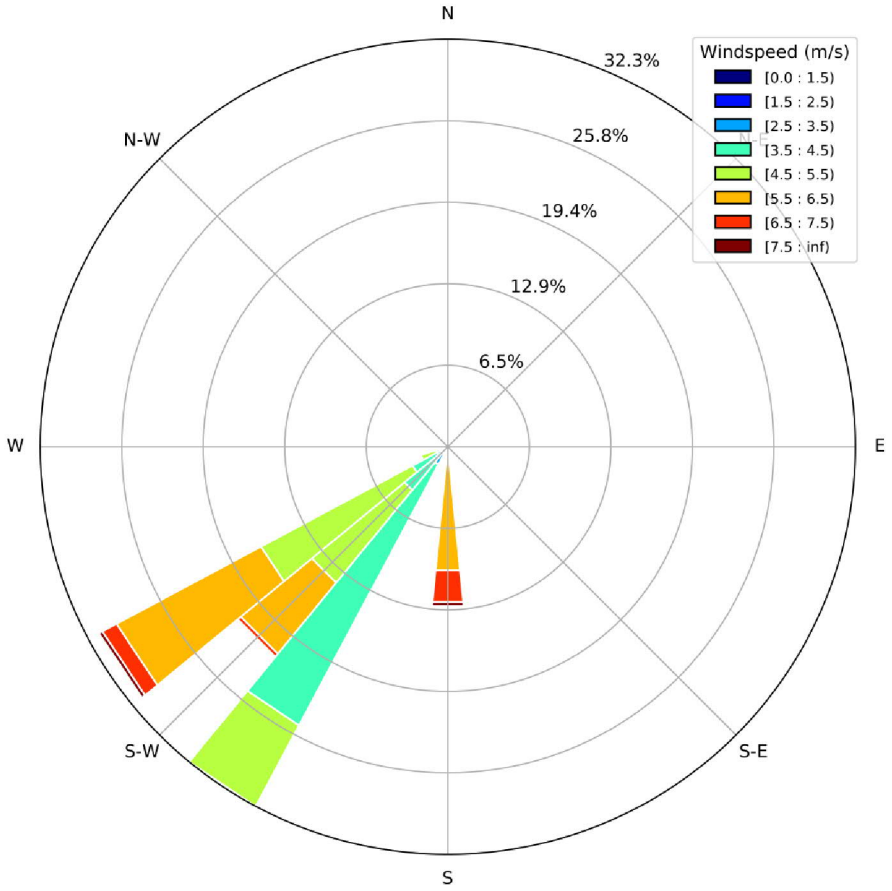
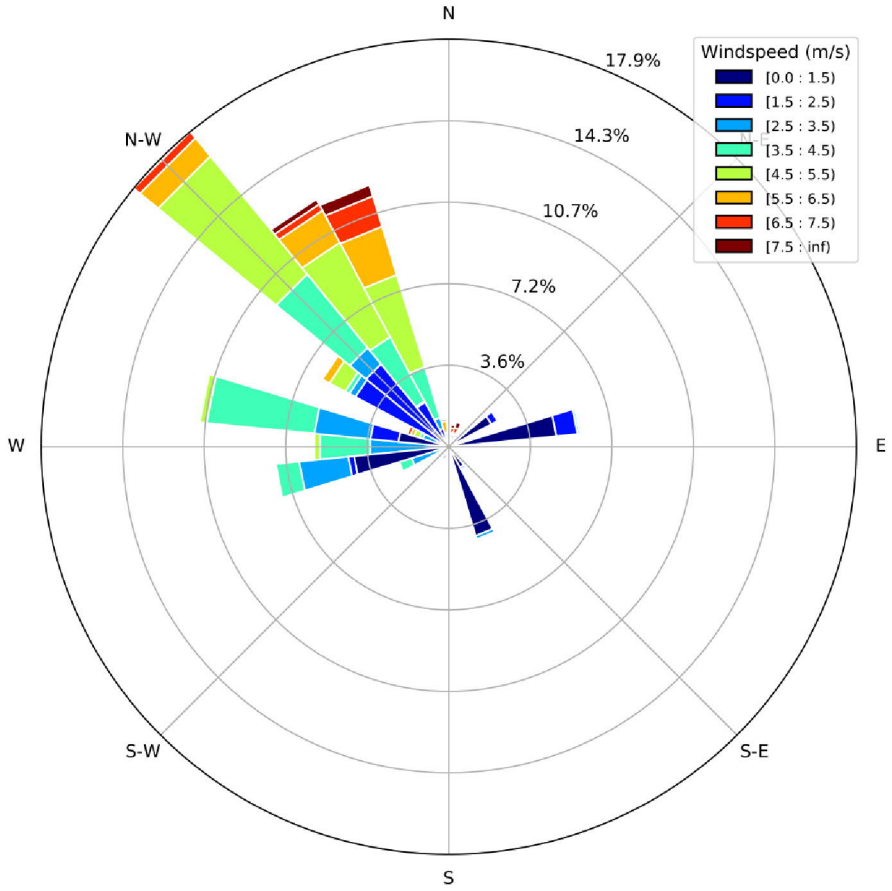
Project Name

Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

Figure Title

Wind Roses - M2705

Figure B.02

M1602 TON	M1602 TOFF
	

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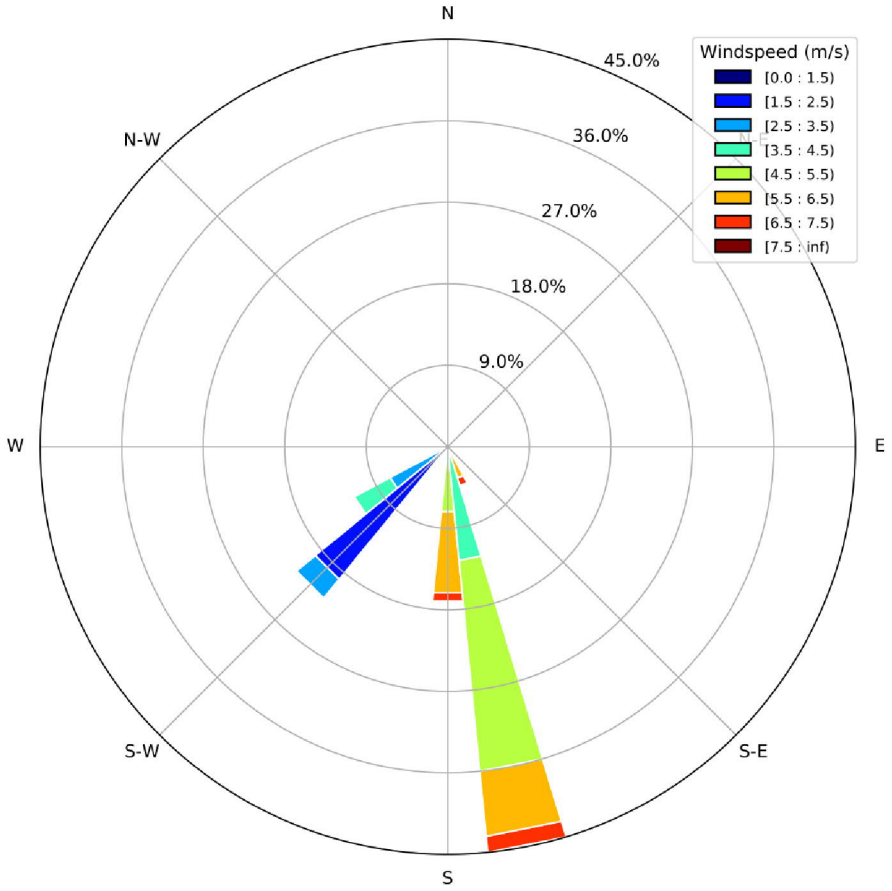
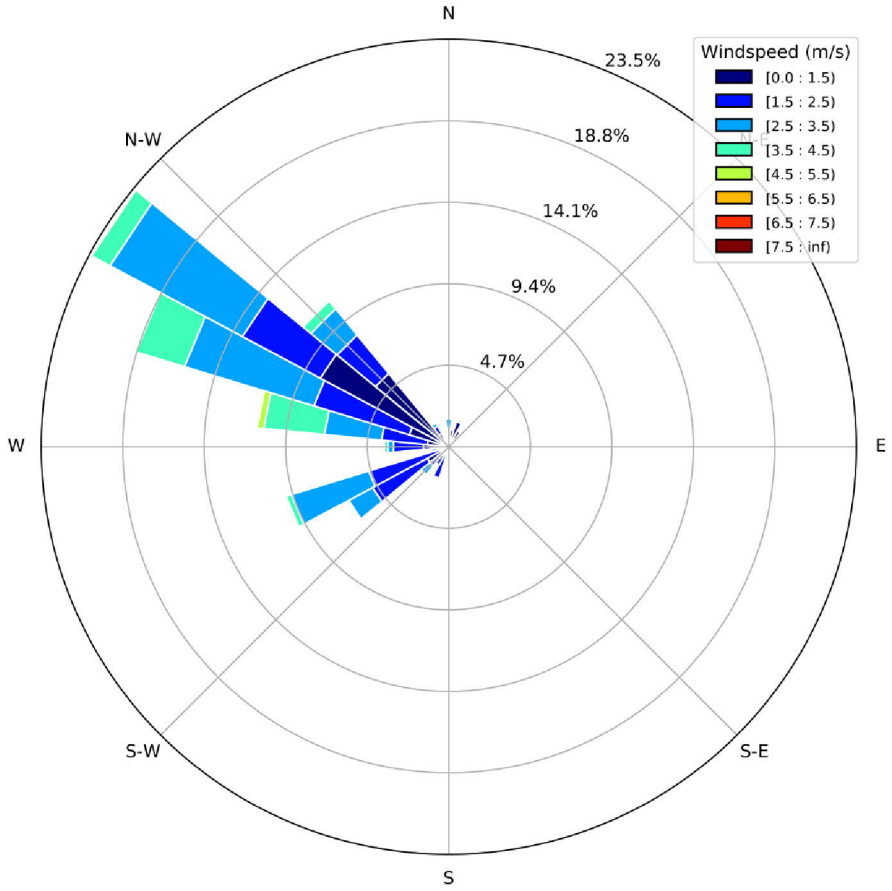
16227	
Scale: NTS Drawn by: JM Reviewed by: AM Date: Jul 10, 2018 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 1st Acoustic Immission Audit **Figure Title** Wind Roses - M1602

Figure B.03

M0616 TON	M0616 TOFF





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Revision: 1

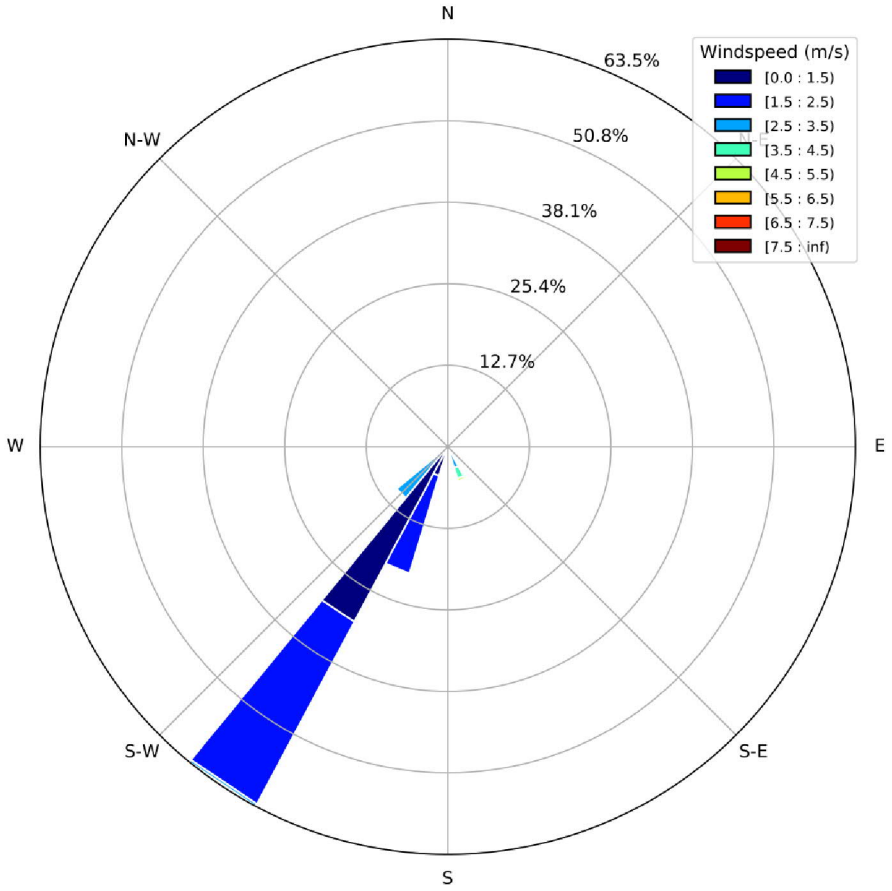
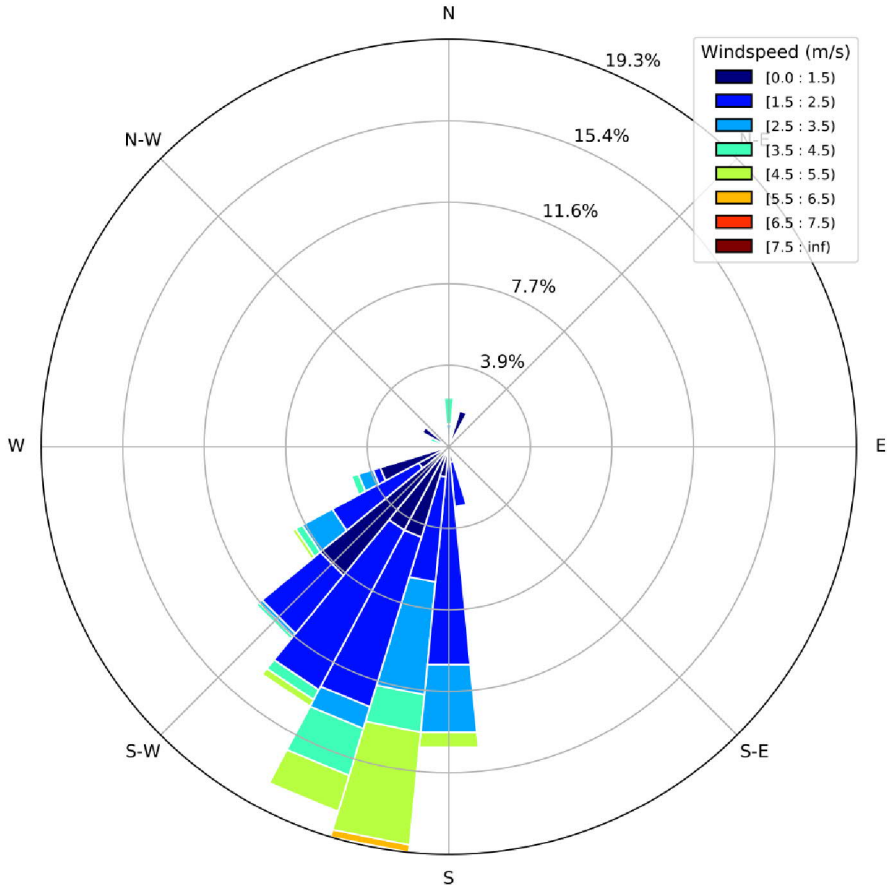
Project Name

Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

Figure Title

Wind Roses - M0616

Figure B.04

M0085 TON	M0085 TOFF
	

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Revision: 1

Project Name

Niagara Region Wind Farm Project - 1st Acoustic Immission Audit

Figure Title

Wind Roses - M0085

Figure B.05

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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: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 7/16/2018

M1153 49-99 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	17	0	0%	*	40	**	0
1	51	0	0%	*	40	**	0
2	51	0	0%	*	40	**	0
3	94	0	0%	40†	40	**	0
4	266	0	0%	40†	40	**	0
5	147	0	0%	40†	40	**	0
6	34	0	0%	*	40	**	0
7	2	0	0%	*	43	**	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed
† Turbine ONLY levels are given a distance correction (-1.7 dB)

M1153 91-141 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	17	17	100%	*	40	-0.9	0
1	51	50	98%	*	40	0.2	0
2	51	51	100%	*	40	1.0	0
3	94	94	100%	40†	40	3.1	0
4	266	266	100%	40†	40	2.6	0
5	147	147	100%	40†	40	2.6	0
6	34	34	100%	*	40	2.5	0
7	2	2	100%	*	43	2.5	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed
† Turbine ONLY levels are given a distance correction (-1.7 dB)

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 7/16/2018

M2705 49-99 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	9	0	0%	*	40	**	0
2	54	0	0%	*	40	**	0
3	137	0	0%	40	40	**	0
4	168	0	0%	40	40	**	0
5	60	0	0%	39	40	**	0
6	47	0	0%	*	40	**	0
7	21	0	0%	*	43	**	0

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

M2705 91-141 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	9	9	100%	*	40	-0.9	0
2	54	51	94%	*	40	-0.1	0
3	137	135	99%	40	40	0.3	0
4	168	166	99%	40	40	1.4	0
5	60	55	92%	39	40	1.8	0
6	47	24	51%	*	40	-1.5	0
7	21	10	48%	*	43	1.9	0

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

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 7/16/2018

M1602 49-99 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	0	0	**	**	40	**	0
3	8	1	13%	*	40	***	0
4	74	1	1%	40	40	***	0
5	103	0	0%	40	40	**	0
6	92	2	2%	39	40	***	0
7	13	0	0%	*	43	**	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed
*** Tone presence less than 20%

M1602 91-141 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	0	0	**	**	40	**	0
3	8	8	100%	*	40	2.3	0
4	74	73	99%	40	40	3.9	0
5	103	99	96%	40	40	2.1	0
6	92	50	54%	39	40	-0.2	0
7	13	5	38%	*	43	*	0

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

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 7/16/2018

M0616 49-99 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	1	0	0%	*	40	**	0
2	20	0	0%	*	40	**	0
3	12	2	17%	*	40	*	0
4	19	0	0%	*	40	**	0
5	34	0	0%	*	40	**	0
6	21	0	0%	*	40	**	0
7	4	0	0%	*	43	**	0

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

M0616 91-141 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	1	1	100%	*	40	*	0
2	20	15	75%	*	40	*	0
3	12	11	92%	*	40	*	0
4	19	16	84%	*	40	*	0
5	34	18	53%	*	40	*	0
6	21	17	81%	*	40	*	0
7	4	0	0%	*	43	**	0

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

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 7/16/2018

M0085 49-99 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	7	0	0%	*	40	*	0
1	76	0	0%	40	40	*	0
2	117	0	0%	40	40	*	0
3	28	0	0%	*	40	*	0
4	4	0	0%	*	40	*	0
5	1	0	0%	*	40	*	0
6	0	0	**	**	40	**	0
7	0	0	**	**	43	**	0

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

M0085 91-141 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	7	7	100%	*	40	*	0
1	76	75	99%	40	40	1.2	0
2	117	117	100%	40	40	2.1	0
3	28	27	96%	*	40	*	0
4	4	4	100%	*	40	*	0
5	1	1	100%	*	40	*	0
6	0	0	**	**	40	**	0
7	0	0	**	**	43	**	0

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

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Appendix E
Turbine Status during TON and TOFF

Niagara Region – Turbine Status Matrix for TON and TOFF

Turbine ID	Monitor Locations				
	M1153	M2705	M1602	M0616	M0085
T01					
T02					
T03					
T04		1			
T05	1				
T06					
T07					
T08					1
T09					
T10					
T11					
T12					
T13					
T14					
T16					
T18					
T19					
T20	1				
T21					
T22					
T23					
T24					
T27			1		
T28			1		
T29					
T31					
T32					
T33					
T34					
T35					
T36					
T37					
T38					
T39					
T41					
T42					
T43					
T44					
T45					
T46					
T47					
T48					
T49					
T51					
T52					1
T53					1
T54					

Turbine ID	Monitor Locations				
	M1153	M2705	M1602	M0616	M0085
T55					
T56		1			
T57					
T58		1			
T59					
T60					
T61					
T62	1				
T63	1				
T65					
T66				1	
T72					
T74					
T75					
T76					
T78					
T79					
T80					
T81					
T82					
T83					
T84					
T85				1	
T88					
T89					
T91					
T93				1	
T94				1	
T95					
T96	1				
T97					
T98					
T99	1				

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

aercoustics

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

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Fax 416-249-3613
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Appendix F
Receptor Selection Rationale

Appendix F - Receptor Selection Summary

Project: Niagara Region Wind Farm Project

Receptor ID	Description	Modelled Sound Level (dBA)	Receptor Height (m)	Distance to Closest Turbine (m)	Closest Turbine ID	Rationale
O_1097	Non-Participating Receptor	40.0	4.5	612	T75	Not in Prevailing Wind Direction
O_1344	Non-Participating Receptor	40.0	4.5	640	T28	Not in Prevailing Wind Direction
O_856	Non-Participating Receptor	40.0	4.5	556	T20	Not in Prevailing Wind Direction
V_2635	Non-Participating Vacant Lot	40.0	4.5	597	T24	Not in Prevailing Wind Direction
V_2719	Non-Participating Vacant Lot	40.0	4.5	552	T24	Not in Prevailing Wind Direction
V_563	Non-Participating Vacant Lot	40.0	4.5	601	T94	Not in Prevailing Wind Direction
O_368	Non-Participating Receptor	39.9	4.5	570	T39	Not in Prevailing Wind Direction
O_416	Non-Participating Receptor	39.9	4.5	610	T39	Not in Prevailing Wind Direction
O_1153	Non-Participating Receptor	39.9	4.5	584	T20	Selected Monitoring Location
O_1184	Non-Participating Receptor	39.9	4.5	718	T63	Not in Prevailing Wind Direction
O_1707	Non-Participating Receptor	39.9	4.5	734	T01	Not in Prevailing Wind Direction
V_2361	Non-Participating Vacant Lot	39.9	4.5	971	T43	Poor monitoring location; large tree lot to the South to block winds and corn stalks in field to cause high ambient noise
V_430	Non-Participating Vacant Lot	39.8	4.5	616	T39	Not in Prevailing Wind Direction
O_1349	Non-Participating Receptor	39.8	4.5	614	T27	Not in Prevailing Wind Direction
O_1734	Non-Participating Receptor	39.8	4.5	705	T06	Not in Prevailing Wind Direction
O_2160	Non-Participating Receptor	39.8	4.5	649	T32	Not in Prevailing Wind Direction
O_2550	Non-Participating Receptor	39.8	4.5	693	T34	Not in Prevailing Wind Direction
O_2593	Non-Participating Receptor	39.8	4.5	608	T49	Not in Prevailing Wind Direction
V_2180	Non-Participating Vacant Lot	39.8	4.5	653	T31	Not in Prevailing Wind Direction
V_3582	Non-Participating Vacant Lot	39.8	4.5	553	T93	Not in Prevailing Wind Direction
V_855	Non-Participating Vacant Lot	39.8	4.5	569	T20	Not in Prevailing Wind Direction
O_543	Non-Participating Receptor	39.7	4.5	663	T07	Not in Prevailing Wind Direction
O_1668	Non-Participating Receptor	39.7	4.5	651	T65	Not in Prevailing Wind Direction
O_1002	Non-Participating Receptor	39.7	4.5	555	T38	Not in Prevailing Wind Direction
O_1096	Non-Participating Receptor	39.7	4.5	657	T96	Not in Prevailing Wind Direction
O_1750	Non-Participating Receptor	39.7	4.5	697	T06	Not in Prevailing Wind Direction
O_1770	Non-Participating Receptor	39.7	4.5	776	T76	Not in Prevailing Wind Direction
O_2420	Non-Participating Receptor	39.7	4.5	900	T49	Not in Prevailing Wind Direction
O_2434	Non-Participating Receptor	39.7	4.5	856	T49	Not in Prevailing Wind Direction
O_2441	Non-Participating Receptor	39.7	4.5	833	T49	Not in Prevailing Wind Direction
O_2449	Non-Participating Receptor	39.7	4.5	799	T49	Not in Prevailing Wind Direction
O_2601	Non-Participating Receptor	39.7	4.5	626	T49	Not in Prevailing Wind Direction
O_2605	Non-Participating Receptor	39.7	4.5	635	T49	Not in Prevailing Wind Direction
O_2608	Non-Participating Receptor	39.7	4.5	645	T49	Not in Prevailing Wind Direction
O_2611	Non-Participating Receptor	39.7	4.5	650	T49	Not in Prevailing Wind Direction
O_2616	Non-Participating Receptor	39.7	4.5	662	T49	Not in Prevailing Wind Direction
O_2619	Non-Participating Receptor	39.7	4.5	676	T49	Not in Prevailing Wind Direction
O_2690	Non-Participating Receptor	39.7	4.5	728	T35	Permission not Granted
O_2753	Non-Participating Receptor	39.7	4.5	609	T58	Not in Prevailing Wind Direction
O_616	Non-Participating Receptor	39.7	4.5	617	T93	Selected Monitoring Location
O_986	Non-Participating Receptor	39.7	4.5	559	T38	Not in Prevailing Wind Direction
V_1122	Non-Participating Vacant Lot	39.7	4.5	628	T20	Permission not Granted
V_1995	Non-Participating Vacant Lot	39.7	4.5	705	T76	Not in Prevailing Wind Direction
V_2411	Non-Participating Vacant Lot	39.7	4.5	934	T49	Not in Prevailing Wind Direction
V_2437	Non-Participating Vacant Lot	39.7	4.5	847	T49	Not in Prevailing Wind Direction
V_2451	Non-Participating Vacant Lot	39.7	4.5	794	T49	Not in Prevailing Wind Direction
V_2705	Non-Participating Vacant Lot	39.7	4.5	603	T04	Selected Monitoring Location
O_1074	Non-Participating Receptor	39.6	4.5	632	T19	Not in Prevailing Wind Direction
O_1112	Non-Participating Receptor	39.6	4.5	673	T19	Not in Prevailing Wind Direction
O_937	Non-Participating Receptor	39.6	4.5	583	T19	Not in Prevailing Wind Direction
O_2589	Non-Participating Receptor	39.6	4.5	613	T49	Not in Prevailing Wind Direction
O_1409	Non-Participating Receptor	39.6	4.5	597	T27	Not in Prevailing Wind Direction
O_1546	Non-Participating Receptor	39.6	4.5	741	T65	Not in Prevailing Wind Direction
O_1662	Non-Participating Receptor	39.6	4.5	704	T06	Not in Prevailing Wind Direction
O_2280	Non-Participating Receptor	39.6	4.5	659	T31	Not in Prevailing Wind Direction
O_2440	Non-Participating Receptor	39.6	4.5	827	T49	Not in Prevailing Wind Direction
O_2580	Non-Participating Receptor	39.6	4.5	611	T49	Not in Prevailing Wind Direction
O_2598	Non-Participating Receptor	39.6	4.5	573	T35	Not in Prevailing Wind Direction
O_2627	Non-Participating Receptor	39.6	4.5	666	T23	Not in Prevailing Wind Direction
O_2629	Non-Participating Receptor	39.6	4.5	590	T04	Not in Prevailing Wind Direction
O_2633	Non-Participating Receptor	39.6	4.5	652	T23	Not in Prevailing Wind Direction
O_2710	Non-Participating Receptor	39.6	4.5	657	T02	Not in Prevailing Wind Direction
O_3030	Non-Participating Receptor	39.6	4.5	646	T59	Not in Prevailing Wind Direction
V_2404	Non-Participating Vacant Lot	39.6	4.5	965	T49	Not in Prevailing Wind Direction
V_3583	Non-Participating Vacant Lot	39.6	4.5	561	T93	Not in Prevailing Wind Direction
O_603	Non-Participating Receptor	39.5	4.5	643	T93	Receptor location 115m away from selected monitoring location M616
O_118	Non-Participating Receptor	39.5	4.5	636	T88	Not in Prevailing Wind Direction
O_1602	Non-Participating Receptor	39.5	4.5	558	T28	Selected Monitoring Location
O_1636	Non-Participating Receptor	39.5	4.5	724	T01	Not in Prevailing Wind Direction
O_1677	Non-Participating Receptor	39.5	4.5	700	T01	Not in Prevailing Wind Direction
O_2026	Non-Participating Receptor	39.5	4.5	759	T76	Not in Prevailing Wind Direction
O_2571	Non-Participating Receptor	39.5	4.5	618	T49	Not in Prevailing Wind Direction
O_2658	Non-Participating Receptor	39.5	4.5	603	T23	Not in Prevailing Wind Direction
O_85	Non-Participating Receptor	39.5	4.5	554	T08	Selected Monitoring Location

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Appendix G
Calibration Certificates

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONICS
Model No:	378B02
Serial No:	126059
Calibration Recall No:	28159

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.
The information supplied relates to the calibrated item listed above.
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

Calibration Date: 18-Oct-17

Felix Christopher (QA Mgr.)

Certificate No: 28159 - 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.

ISO/IEC 17025: 2005

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

ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

PCB Piezotronics Microphone Unit

Model No.: 378B02
Mic Model No.: 377B02
Preamp Model No.: 426E01

Serial No.: 126059
Serial No.: 166109
Serial No.: 044442
ID No.: XXXX

Company: Aercoustics Engineering Ltd

Calibration results:

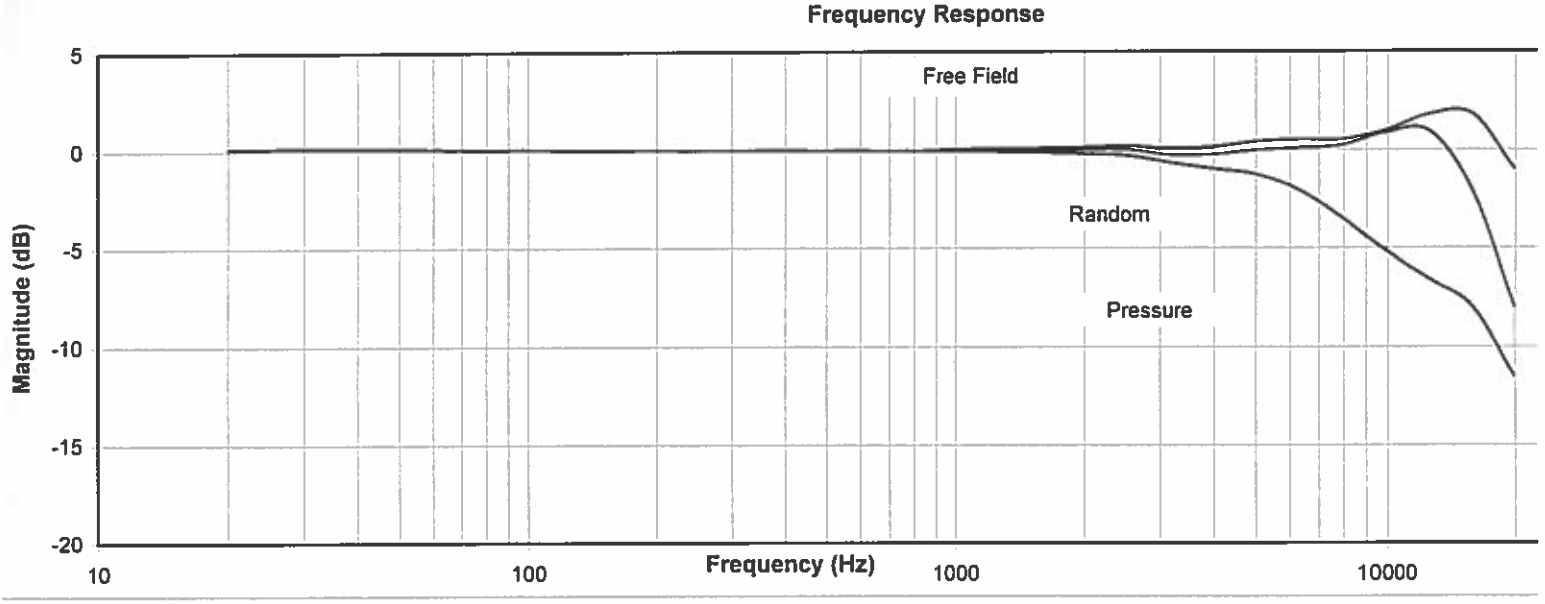
Before & after data same: ...X...

Combined Sensitivity @ 250 Hz and pressure of 100.21 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-26.01 dB re.1V/Pascal
50.08 mV/Pascal
0.01 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	20.5	°C
Ambient Humidity:	49.5	% RH
Ambient Pressure:	100.212	kPa
Calibration Date:	18-Oct-2017	
Calibration Due:	18-Oct-2018	
Report Number:	28159 -1	
Control Number:	28159	

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: .....
Kent Zeng

Calibrated on WCCL system type 9700

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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.: 126059**
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	0.15	0.15	0.15
31.62	0.15	0.15	0.15
39.81	0.13	0.13	0.13
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	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.01	0.01	0.01
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	-0.01	-0.01	-0.01
630.96	-0.02	-0.02	-0.02
794.33	-0.03	-0.03	-0.03
1000.00	-0.06	0.05	-0.06
1258.93	-0.07	0.09	-0.03
1584.89	-0.12	0.11	-0.04
1995.26	-0.19	0.14	0.01
2511.89	-0.28	0.20	0.03
3162.28	-0.64	0.08	-0.23
3981.07	-0.95	0.15	-0.22
5011.87	-1.25	0.43	-0.01
6309.57	-2.04	0.54	0.11
7943.28	-3.47	0.53	0.24
10000.00	-5.19	1.02	0.90
12589.25	-6.62	1.81	0.92
15848.93	-8.02	1.80	-2.14
19952.62	-11.49	-0.99	-7.99

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	11-Aug-2017	683/284413-14	11-Aug-2018
Brüel & Kjær	3560	S/N 2241893	11-Aug-2017	683/284413-14	11-Aug-2018
HP	33120A	S/N 36043716	11-Aug-2017	,287708	11-Aug-2018
HP	34401A	S/N 36064102	11-Aug-2017	,287708	11-Aug-2018

Cal. Date: 18-Oct-2017 **Tested by: Kent Zeng**

Calibrated on WCCL system type 9700

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VAISALA

Test report no. H31-16500011

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910199
Manufacturer	Vaisala Oyj, Finland
Test date	12 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	412	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.06	-1	1	hPa
Temperature difference	-0.72	-2	2	°C
Humidity difference	-0.63	-10	10	%RH
Heating current	0.75	0.6	0.8	A
Current (service port)	1.3	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	0.9	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 14.16 ±5 %RH, Temperature 22.19 ±1 °C, Pressure 1010.72 ±1 hPa.

Signature

Technician

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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. H31-16500012

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550054
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	1079.5	1079.5	0	± 0.4 hPa
Pressure	896.8	896.9	0.1	± 0.4 hPa
Pressure	796.6	796.6	0	± 0.4 hPa
Pressure	596.3	596.3	0	± 0.4 hPa
Temperature	59.6	59.6	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-32.3	-32.3	0	± 0.2 °C
Temperature	24.8	24.8	0	± 0.2 °C
Temperature	-52	-51.9	0.1	± 0.2 °C
Relative humidity	29.8	29.8	0	± 2 %RH
Relative humidity	58.4	58.4	0	± 2 %RH
Relative humidity	91.3	91.3	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

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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:	122654
Calibration Recall No:	27880

Submitted By:

Customer:

Company: Aercoustics Egineering 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: 25-Jul-17

Certificate No: 27880 - 5

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

uncompromised calibration West Caldwell Calibration Laboratories, Inc.
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

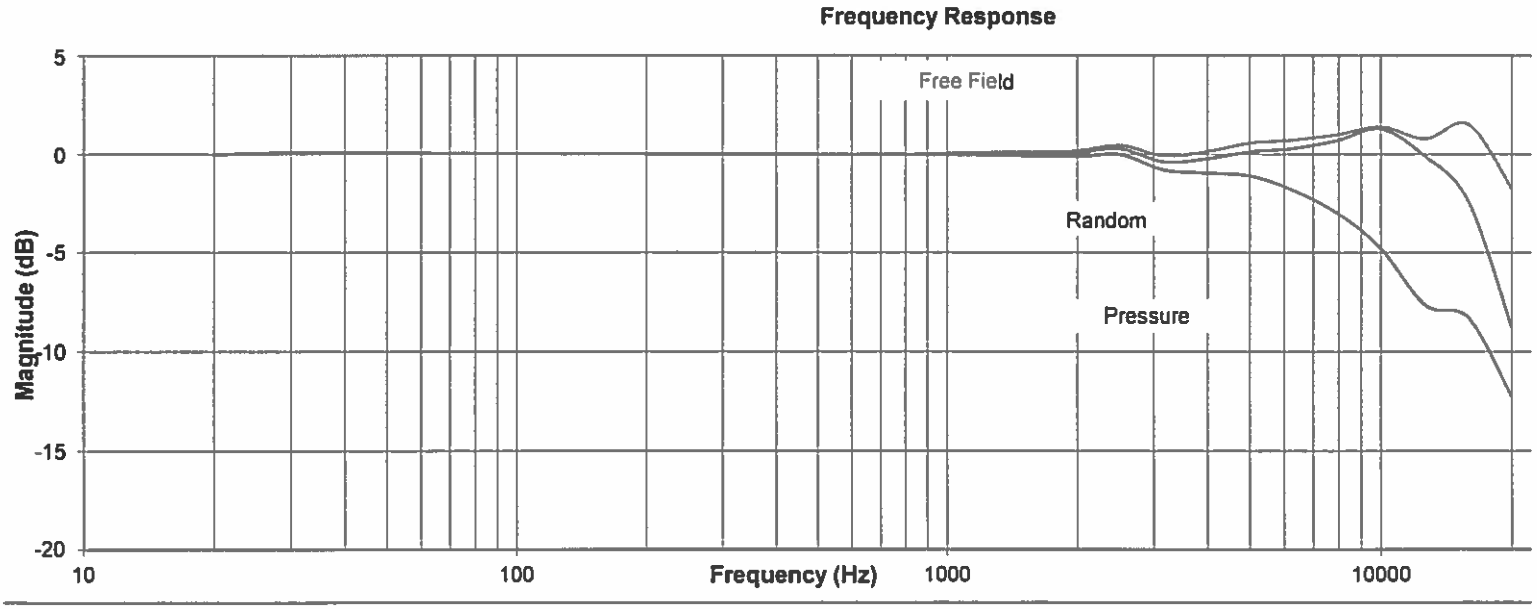
PCB Piezotronics Microphone Unit
Model No.: 378B02 Serial No.: 122654
Mic Model No.: 377B02 Serial No.: 155181
Preamp Model No.: 426E01 Serial No.: 040835
Company: Aercoustics Engineering LTD ID No.: XXXX

Calibration results:

Before & after data same: ...X...
Combined Sensitivity @ 250 Hz and pressure of 99.611 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-25.81 dB re.1V/Pascal
51.23 mV/Pascal
-0.19 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	22.6	°C
Ambient Humidity:	54.8	% RH
Ambient Pressure:	99.611	kPa
Calibration Date:	25-Jul-2017	
Calibration Due:	25-Jul-2019	
Report Number:	27880	-5
Control Number:	27880	

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

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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.: 122654**
Company: Aercoustics Engineering LTD **ID No.: XXXX**

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]	Random [dB]
19.95	-0.02	-0.02	-0.02
25.12	0.06	0.06	0.06
31.62	0.09	0.09	0.09
39.81	0.08	0.08	0.08
50.12	0.07	0.07	0.07
63.10	0.06	0.06	0.06
79.43	0.04	0.04	0.04
100.00	0.03	0.03	0.03
125.89	0.02	0.02	0.02
158.49	0.01	0.01	0.01
199.53	0.01	0.01	0.01
251.19	0.00	0.00	0.00
316.23	0.00	0.00	0.00
398.11	-0.01	-0.01	-0.01
501.19	-0.01	-0.01	-0.01
630.96	-0.02	-0.02	-0.02
794.33	-0.03	-0.03	-0.03
1000.00	-0.05	0.06	-0.05
1258.93	-0.06	0.10	-0.02
1584.89	-0.12	0.11	-0.04
1995.26	-0.14	0.19	0.06
2511.89	-0.03	0.45	0.28
3162.28	-0.81	-0.09	-0.40
3981.07	-0.96	0.14	-0.23
5011.87	-1.11	0.57	0.13
6309.57	-1.85	0.73	0.30
7943.28	-3.01	0.99	0.70
10000.00	-4.80	1.41	1.29
12589.25	-7.65	0.78	-0.11
15848.93	-8.30	1.52	-2.42
19952.62	-12.21	-1.71	-8.71

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: 25-Jul-2017 **Tested by: James Zhu**

Calibrated on WCCL system type 9700

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VAISALA

Test report no. H31-16490083

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910197
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	393	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.12	-1	1	hPa
Temperature difference	-0.43	-2	2	°C
Humidity difference	0.68	-10	10	%RH
Heating current	0.75	0.6	0.8	A
Current (service port)	1.37	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	0.99	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 26.27 ±5 %RH, Temperature 21.97 ±1 °C, Pressure 993.97 ±1 hPa.

Signature

Technician

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

VAISALA

Calibration sheet no. H31-16490084

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550066
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	1079	0	± 0.4 hPa
Pressure	899.3	899.3	0	± 0.4 hPa
Pressure	799.1	799.1	0	± 0.4 hPa
Pressure	598.9	598.9	0	± 0.4 hPa
Temperature	59.7	59.7	0	± 0.2 °C
Temperature	-6	-6	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

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPONE UNIT

Manufactured by:	PCB PIEZOTRONICS
Model No:	378B02
Serial No:	125634
Calibration Recall No:	28159

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.
The information supplied relates to the calibrated item listed above.
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

Calibration Date: 18-Oct-17

Felix Christopher (QA Mgr.)

Certificate No: 28159 - 2

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

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

ISO/IEC 17025: 2005

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration

ACCREDITED
Calibration Lab. Cert. # 1533.01

1575 State Route 96, Victor NY 14564

REPORT OF CALIBRATION

for

PCB Piezotronics Microphone Unit

Model No.: 378B02
Mic Model No.: 377B02
Preamp Model No.: 426E01

Serial No.: 125634
Serial No.: 166320
Serial No.: 043992
ID No.: XXXX

Company: Aercoustics Engineering Ltd

Calibration results:

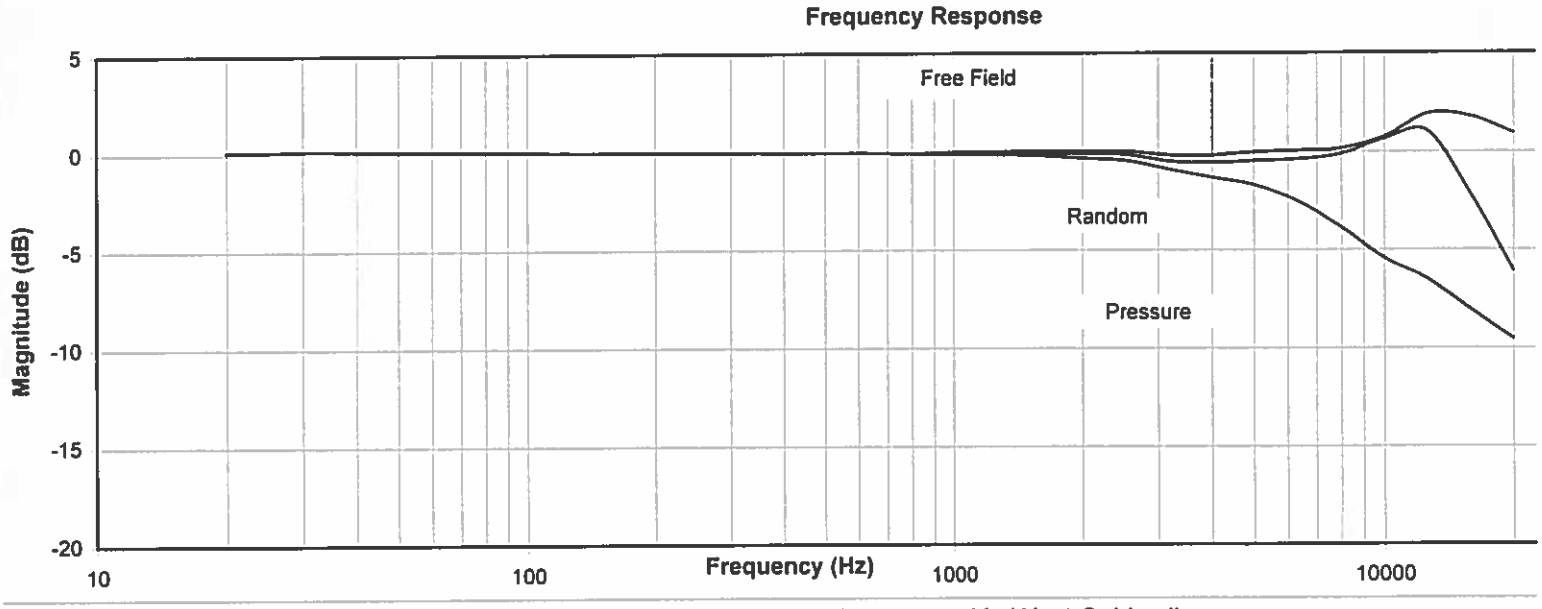
Before & after data same: ...X...

Combined Sensitivity @ 250 Hz and pressure of 100.21 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-26.05 dB re.1V/Pascal
49.82 mV/Pascal
0.05 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	20.5	°C
Ambient Humidity:	49.5	% RH
Ambient Pressure:	100.212	kPa
Calibration Date:	18-Oct-2017	
Calibration Due:	18-Oct-2018	
Report Number:	28159 -2	
Control Number:	28159	

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: .....
Kent Zeng

Calibrated on WCCL system type 9700

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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
Company: Aercoustics Engineering Ltd

Model No.: 378B02

Serial No.: 125634
ID No.: XXXX

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]	Random [dB]
19.95	0.12	0.12	0.12
25.12	0.14	0.14	0.14
31.62	0.15	0.15	0.15
39.81	0.13	0.13	0.13
50.12	0.13	0.13	0.13
63.10	0.10	0.10	0.10
79.43	0.07	0.07	0.07
100.00	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.01	0.01	0.01
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	-0.02	-0.02	-0.02
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	-0.08	0.03	-0.08
1258.93	-0.11	0.05	-0.07
1584.89	-0.18	0.05	-0.10
1995.26	-0.29	0.04	-0.09
2511.89	-0.44	0.04	-0.13
3162.28	-0.87	-0.15	-0.46
3981.07	-1.27	-0.17	-0.54
5011.87	-1.68	0.00	-0.44
6309.57	-2.51	0.07	-0.36
7943.28	-3.82	0.18	-0.11
10000.00	-5.45	0.76	0.64
12589.25	-6.51	1.92	1.03
15848.93	-8.06	1.76	-2.18
19952.62	-9.55	0.95	-6.05

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	11-Aug-2017	683/284413-14	11-Aug-2018
Brüel & Kjær	3560	S/N 2241893	11-Aug-2017	683/284413-14	11-Aug-2018
HP	33120A	S/N 36043716	11-Aug-2017	,287708	11-Aug-2018
HP	34401A	S/N 36064102	11-Aug-2017	,287708	11-Aug-2018

Cal. Date: 18-Oct-2017

Tested by: Kent Zeng

Calibrated on WCCL system type 9700

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VAISALA

Test report no. H31-16500013

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910200
Manufacturer	Vaisala Oyj, Finland
Test date	12 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	389	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.05	-1	1	hPa
Temperature difference	-0.59	-2	2	°C
Humidity difference	-0.86	-10	10	%RH
Heating current	0.74	0.6	0.8	A
Current (service port)	1.37	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	0.95	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 14.81 ±5 %RH, Temperature 22.23 ±1 °C, Pressure 1010.44 ±1 hPa.

Signature

Technician

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VAISALA

Calibration sheet no. H31-16500014

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550027
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	1078.9	1078.9	0	± 0.4 hPa
Pressure	896.4	896.5	0.1	± 0.4 hPa
Pressure	796.3	796.2	-0.1	± 0.4 hPa
Pressure	596.1	596.1	0	± 0.4 hPa
Temperature	59.6	59.6	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-32.5	-32.6	-0.1	± 0.2 °C
Temperature	24.8	24.8	0	± 0.2 °C
Temperature	-52.1	-52.1	0	± 0.2 °C
Relative humidity	29.7	29.7	0	± 2 %RH
Relative humidity	58.7	58.7	0	± 2 %RH
Relative humidity	91.7	91.7	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

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONICS
Model No:	378B02
Serial No:	118497
Calibration Recall No:	28159

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.
The information supplied relates to the calibrated item listed above.
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

Calibration Date: 18-Oct-17

Felix Christopher (QA Mgr.)

Certificate No: 28159 - 3

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

uncompromised calibration West Caldwell Calibration Laboratories, Inc.
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
Mic Model No.: 377B02
Preamp Model No.: 426E01

Serial No.: 118497
Serial No.: 150759
Serial No.: 037483
ID No.: XXXX

Company: Aercoustics Engineering Ltd

Calibration results:

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

Combined Sensitivity @ 250 Hz and pressure of 100.21 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):

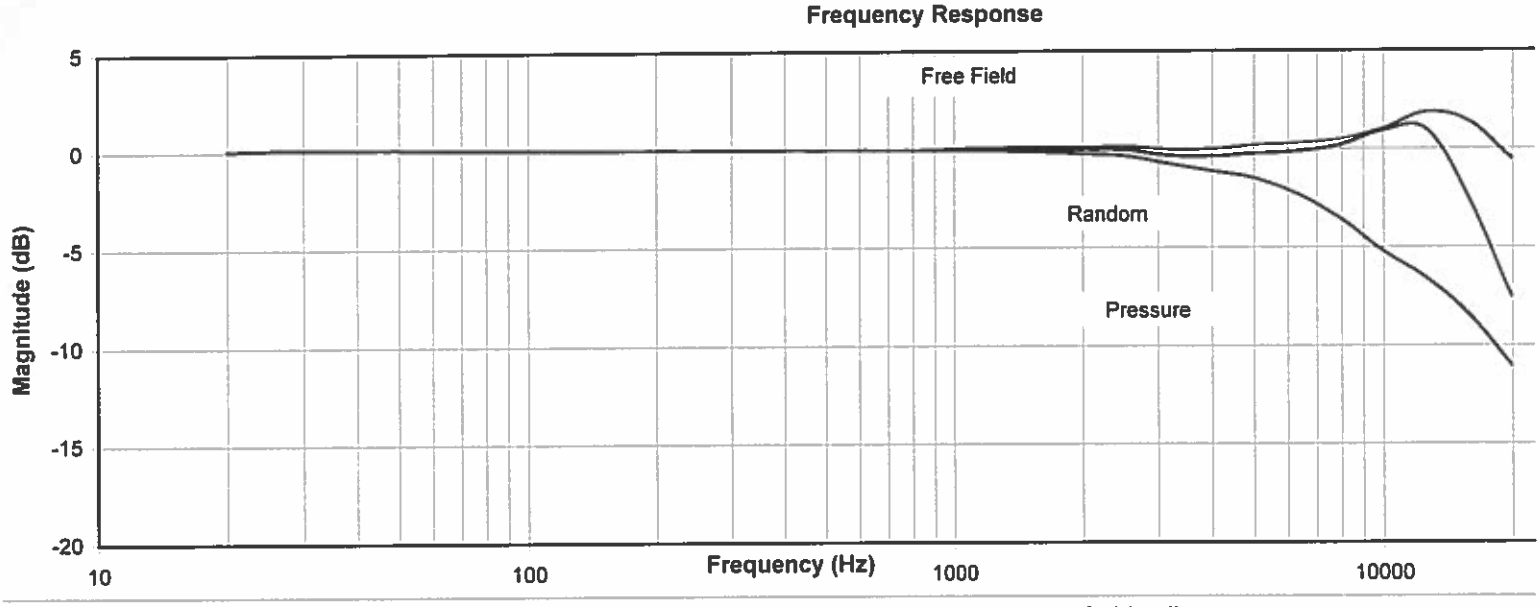
-25.50 dB re.1V/Pascal
53.11 mV/Pascal
-0.50 Ko (- dB re 50 mV/Pascal)

Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	20.5	°C
Ambient Humidity:	49.5	% RH
Ambient Pressure:	100.212	kPa
Calibration Date:	18-Oct-2017	
Calibration Due:	18-Oct-2018	
Report Number:	28159 -3	
Control Number:	28159	

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: .....
Kent Zeng

Calibrated on WCCL system type 9700

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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
Company: Aercoustics Engineering Ltd

Model No.: 378B02

Serial No.: 118497
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	0.15	0.15	0.15
31.62	0.15	0.15	0.15
39.81	0.13	0.13	0.13
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	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.01	0.01	0.01
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	-0.06	0.05	-0.06
1258.93	-0.07	0.09	-0.03
1584.89	-0.14	0.09	-0.06
1995.26	-0.24	0.09	-0.04
2511.89	-0.35	0.13	-0.04
3162.28	-0.73	-0.01	-0.32
3981.07	-1.11	-0.01	-0.38
5011.87	-1.48	0.20	-0.24
6309.57	-2.28	0.30	-0.13
7943.28	-3.54	0.46	0.17
10000.00	-5.19	1.02	0.90
12589.25	-6.58	1.85	0.96
15848.93	-8.46	1.36	-2.58
19952.62	-11.03	-0.53	-7.53

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	11-Aug-2017	683/284413-14	11-Aug-2018
Brüel & Kjær	3560	S/N 2241893	11-Aug-2017	683/284413-14	11-Aug-2018
HP	33120A	S/N 36043716	11-Aug-2017	,287708	11-Aug-2018
HP	34401A	S/N 36064102	11-Aug-2017	,287708	11-Aug-2018

Cal. Date: 18-Oct-2017

Tested by: Kent Zeng

Calibrated on WCCL system type 9700

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VAISALA

Test report no. H31-16500009

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910198
Manufacturer	Vaisala Oyj, Finland
Test date	12 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	413	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	-0.07	-1	1	hPa
Temperature difference	-0.45	-2	2	°C
Humidity difference	-1.16	-10	10	%RH
Heating current	0.75	0.6	0.8	A
Current (service port)	1.33	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	0.96	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 15.19 ±5 %RH, Temperature 22.17 ±1 °C, Pressure 1010.86 ±1 hPa.

Signature

Technician

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

VAISALA

Calibration sheet no. H31-16500010

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550060
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	1079.6	1079.6	0	± 0.4 hPa
Pressure	896.9	896.9	0	± 0.4 hPa
Pressure	796.6	796.7	0.1	± 0.4 hPa
Pressure	596.4	596.4	0	± 0.4 hPa
Temperature	59.7	59.7	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-32.2	-32.2	0	± 0.2 °C
Temperature	24.8	24.8	0	± 0.2 °C
Temperature	-51.9	-51.9	0	± 0.2 °C
Relative humidity	29.8	29.8	0	± 2 %RH
Relative humidity	58.5	58.5	0	± 2 %RH
Relative humidity	91.1	91.1	0	± 3 %RH

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

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

Signature

Technician

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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 PIEZOTRONICS
Model No:	378B02
Serial No:	120586
Calibration Recall No:	28159

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.
The information supplied relates to the calibrated item listed above.
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

Calibration Date: 18-Oct-17

Felix Christopher (QA Mgr.)

Certificate No: 28159 - 4

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

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

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1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
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REPORT OF CALIBRATION

for

PCB Piezotronics Microphone Unit
Model No.: 378B02
Mic Model No.: 377B02
Preamp Model No.: 426E01

Serial No.: 120586
Serial No.: 155523
Serial No.: 039195
ID No.: XXXX

Company: Aercoustics Engineering Ltd

Calibration results:

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

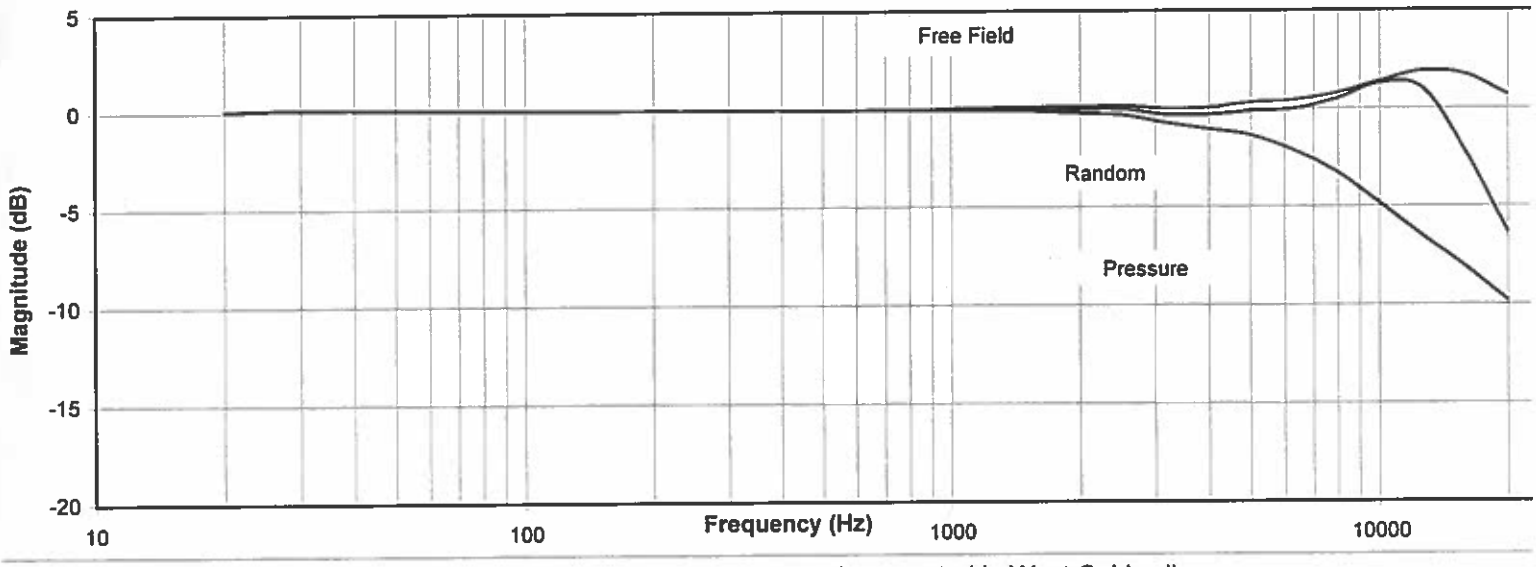
Combined Sensitivity @ 250 Hz and pressure of 100.21 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-26.67 dB re.1V/Pascal
46.37 mV/Pascal
0.67 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	20.5	°C
Ambient Humidity:	49.5	% RH
Ambient Pressure:	100.212	kPa
Calibration Date:	18-Oct-2017	
Calibration Due:	18-Oct-2018	
Report Number:	28159 -4	
Control Number:	28159	

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.

Frequency Response



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: .....
Kent Zeng

Calibrated on WCCL system type 9700

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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.: 120586**
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	0.13	0.13	0.13
31.62	0.15	0.15	0.15
39.81	0.13	0.13	0.13
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	0.05	0.05	0.05
125.89	0.03	0.03	0.03
158.49	0.01	0.01	0.01
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	-0.05	-0.05	-0.05
630.96	-0.02	-0.02	-0.02
794.33	-0.04	-0.04	-0.04
1000.00	-0.06	0.05	-0.06
1258.93	-0.07	0.09	-0.03
1584.89	-0.13	0.10	-0.05
1995.26	-0.22	0.11	-0.02
2511.89	-0.31	0.17	0.00
3162.28	-0.71	0.01	-0.30
3981.07	-1.04	0.06	-0.31
5011.87	-1.37	0.31	-0.13
6309.57	-2.15	0.43	0.00
7943.28	-3.23	0.77	0.48
10000.00	-4.83	1.38	1.26
12589.25	-6.53	1.90	1.01
15848.93	-8.12	1.70	-2.24
19952.62	-9.82	0.68	-6.32

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	11-Aug-2017	683/284413-14	11-Aug-2018
Brüel & Kjær	3560	S/N 2241893	11-Aug-2017	683/284413-14	11-Aug-2018
HP	33120A	S/N 36043716	11-Aug-2017	,287708	11-Aug-2018
HP	34401A	S/N 36064102	11-Aug-2017	,287708	11-Aug-2018

Cal. Date: 18-Oct-2017 — **Tested by: Kent Zeng**

Calibrated on WCCL system type 9700

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VAISALA

Test report no. H31-16490075

TEST REPORT

Product family	WXT530 series
Product type	WXT536
Order code	6B1B2A4D1B1B
Serial number	M4910193
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	404	345	575	mV
Zero wind speed	0	0	0.4	m/s
Pressure difference	0.01	-1	1	hPa
Temperature difference	-0.33	-2	2	°C
Humidity difference	0.52	-10	10	%RH
Heating current	0.74	0.6	0.8	A
Current (service port)	1.47	0.5	2	mA
Communication (service port)	pass	PASS	PASS	-
Current (main port)	1.14	0.5	2	mA
Communication (main port)	pass	PASS	PASS	-

Ambient conditions / Humidity 25.89 ±5 %RH, Temperature 21.86 ±1 °C, Pressure 993.72 ±1 hPa.

Signature

Technician

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

VAISALA

Calibration sheet no. H31-16490076

CALIBRATION SHEET

Instrument	WXTPTU
Serial number	M4550070
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	1079.2	1079.1	-0.1	± 0.4 hPa
Pressure	899.5	899.5	0	± 0.4 hPa
Pressure	799.3	799.3	0	± 0.4 hPa
Pressure	599	599	0	± 0.4 hPa
Temperature	59.6	59.6	0	± 0.2 °C
Temperature	-5.9	-5.9	0	± 0.2 °C
Temperature	-32.7	-32.7	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	92.2	92.2	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

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Doc218938-A

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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