

ASSESSMENT REPORT - Project: 16227.00

Niagara Region Wind Farm Project Acoustic Immission Audit – Phase 2 – O_0616

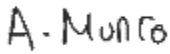
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Revision History

Version	Description	Author	Reviewed	Date
1	Initial Report	RAM	AM, PA	May 15, 2020

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Executive Summary

Aeroustics Engineering Limited (“Aeroustics”) 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 2nd measurement campaign of the NRWF immission audit at receptor O0616.

The monitoring near receptor O0616 spanned the following dates:

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
O0616	October 25 th , 2019	January 6 th , 2020	10.3

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

Based on the results presented in Section 6 of this report, the cumulative sound impact calculated at O0616 complies with the MECP sound level limits at all wind bins having sufficient data for assessment.

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 2nd 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, further modified on November 23, 2015, May 6, 2016 and May 12, 2016 [1].

The report has been prepared to facilitate submission to the MECP, in compliance with acoustic audit conditions outlined in the facility’s REA (#4353-9HMP2R) section E (Wind Turbine Acoustic Audit – Immission). The audit has been completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the Ontario Ministry of Environment, Conservation and Parks “*MECP Compliance Protocol for Wind Turbine Noise*” (Updated: April 21, 2017). This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the MECP sound level limits.

2 Facility Description

The Niagara Region Wind Farm Project utilizes 77 Enercon turbines (Model E 101) wind turbines for power generation, each having a nameplate capacity ranging from 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 receptor O0616¹. Monitoring at M0616 spanned the following dates, summarized in Table 1.

Table 1: Monitoring Period for Receptor

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
O0616	October 25 th , 2019	January 6 th , 2020	10.3

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

¹ Receptor IDs taken from the Noise Assessment Report by K. Ganesh and K. Mallinen, dated April 08, 2016 [3]

3.1 Test Equipment

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

- One (1) Type 1 sound level meter, with microphone and pre-amplifier that meet the MECP 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 MECP protocol.

The following table lists the specific model and serial numbers for the equipment used during the measurement campaign. Calibration records for equipment used during the measurement campaign are provided in Appendix F.

Table 2: Equipment Details

Location	Equipment	Serial Number
M0616	Microphone / Pre-Amplifier Pair	2250
	Microphone	4189
	Pre-Amplifier	ZC0032
	Vaisala	WXT 520

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 (L_{90}), and 1/3 octave band levels between 20 Hz and 10,000 Hz. The microphone was placed at a measurement height of 4.5 m above grade, at least 5 metres away from any large reflecting surfaces, in direct line of sight to the nearest turbines, and as far away as practically possible from trees or other foliage. The recorded weather data included average wind direction, wind speed, temperature, relative humidity, and atmospheric pressure. The maximum wind speed for each one-minute interval was also stored to filter the data for wind gusting.

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

A one-minute measurement interval was considered valid if:

- The interval occurred between 10pm – 5am
- No precipitation was detected 60 minutes before and 60 minutes after the interval
- The ambient temperature was above -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 closest wind turbine was producing approximately 85% or more of its rated power output
- The hub height wind speed was above 2 m/s

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. The downwind direction is determined using the closest turbine's yaw angle output, also known as nacelle position. 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.

Section D3.8.2 of the Protocol states that weather conditions should be similar between Background and Total Noise measurement intervals. By virtue of the minimum turbine power requirement, high hub-height wind speeds are present in all Total Noise Intervals. High hub-height wind speeds were found to produce increased wind-related noise, elevating the measured noise levels. Accordingly, a hub-height windspeed filter was applied to Background data at monitoring locations to better match the environmental conditions present in the Total Noise data. Lower hub-height wind speed thresholds for Background intervals have been used to increase the available data counts. These lower thresholds represent a conservative approach, as the Background sound level is expected to be lower during periods of low hub-height wind speed. Applying a lower hub-height wind speed threshold to the Background data therefore has the effect of over-estimating the calculated Turbine-Only sound levels.

3.3 Measurement Location

The monitoring location was chosen to be representative of the worst-case impact of the facility, follow the Phase 1 receptor locations. These locations were chosen based on the MECF selection requirements communicated in the NRWF REA. Appendix B details the receptor selection criteria and process.

O0616 is located in the predominant downwind direction of the facility, and has a predicted impact of 39.7 dBA. 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.

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	Location	UTM Coordinates [m] (Zone 17T)	Distance to Primary Turbine [m] (T93)	Predicted Level (dBA) [†]
O0616*	<i>Receptor</i>	618600 mE 4767679 mN	617m	39.7
M0616**	<i>Monitor</i>	618528 mE 4767683 mN	592m	39.8

* 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 MECF 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 sample size requirements of 120 data points for Turbine ON and 60 data points for the ambient measurements between 4-7 m/s integer wind speeds has been satisfied for this receptor.

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 ambient measurements for 3 wind speed bins has been satisfied for receptor O0616 in wind speed bins between 1 and 7m/s (inclusive).

3.5 Weather Conditions

The ambient conditions encountered at M0616 over the measurement campaign are summarized in Table 4:

Table 4: Range of ambient weather conditions

		10-m AGL			Hub height	
		Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]	Wind speed [m/s]
M0616	Minimum	973.5	0.0	45	-14.8	0.1
	Maximum	1012.3	19.4	89.7	13.3	25.0

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 C that show the measured direction based on closest turbine yaw angle compared to 10m height wind speeds at the receptor for valid Turbine ON. The wind rose for ambient measurement intervals show the measured 10m wind speed at the receptor compared to 10m height wind direction. 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 the 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 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 at M0616 were T66, T85, T93, and T94.

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 MECP allowable sound level limits. The MECP 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 5 below.

Table 5: MECP Sound Level Limits for Wind Turbines

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

As per section D6 of the MECP 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

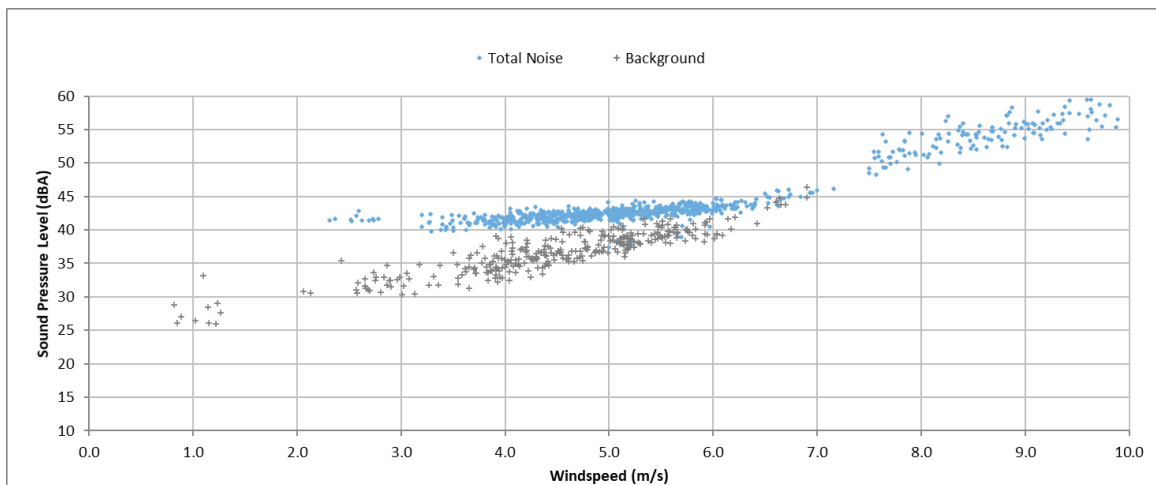
The following table details the measured sound levels when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey. The Turbine ON sound level presented was filtered such that 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 6 M0616 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
0	0	-	-	0	-	-
1	0	-	-	10	28.5	2.2
2	2	41.6	0.2	3	32.9	2.7
3	25	41.3	0.8	30	32.4	1.2
4	166	41.7	0.7	110	35.7	1.7
5	284	42.4	0.8	118	38.3	1.4
6	168	43.3	0.8	47	40.0	1.0
7	20	45.1	0.8	7	44.5	1.0

The following figure presents the scatter plot showing each valid 1-minute interval measured sound level at 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: M0616 - 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.

The audit at M0616 is considered representative of the sound levels at Receptor O0616 given the placement of the acoustic monitoring station.

Table 7 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. The data from Table 7 is plotted in Figure 2 below.

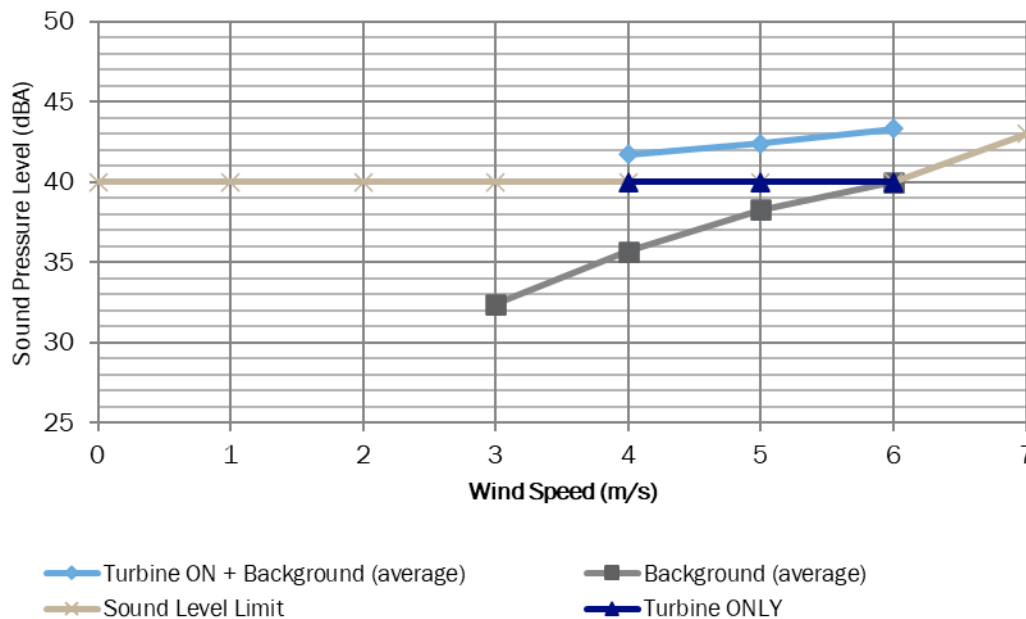
Table 7: Assessment Table

Measurement Location	Wind speed at 10m height [m/s]	0	1	2	3	4	5	6	7
O0616	Turbine ON LAeq [dBA]	-	-	*	*	42	42	43	*
	Turbine OFF LAeq [dBA]	-	*	*	32	36	38	40	*
	Turbine ONLY LAeq [dBA]	*	*	*	*	40	40	40	*
MECP Limit		40	40	40	40	40	40	40	43

- no data points recorded

*Insufficient data points to calculate Turbine ONLY level as per RAM-I protocol

Figure 2: M0616 Turbine Levels compared to MECP Limits



6.2 Tonality

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 on NRWF, respectively, which were likely to have been generated by the closest turbine rather than by an external source. No tones were reportable according to the IEC 61400-11 Edition 3.0 noise emission measurements carried out on turbines T46 [4] and T35 [5].

Based on discussions with 1021702 B.C. Ltd it was determined that to be consistent with the Phase 1 audit, and Sections 3.8.3 and Section 5.1 of the Compliance protocol, the tonal assessment should be completed using IEC 61400-11 Ed. 3.0 with modifications to adapt the method to immission measurements and the tonal penalty structure taken from ISO 1996-2:2007 Annex C. Namely, Section 5.1 of the compliance protocol states:

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

For the tonal assessment, 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 relevant. 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 $L_{ta} - 4 \text{ dB}$. i.e. a tonal audibility of 6.5 would incur a penalty of 2.5 dBA on the overall Turbine Only level.

A 116 Hz tone was observed but was not prevalent enough nor prominent enough for a tonal penalty to be applicable. Tonal assessment summary tables are provided in Appendix E.

No tonal penalty was found to be applicable based on detailed tonal audibility analysis at the audited receptor.

7 Assessment of Compliance

Based on the calculated turbine-only component indicated in Table 7 and Figure 2 and, the Niagara Region Wind Farm Project was found to be compliant with MECP limits at receptor O0616 during the audit.

8 Conclusion

Aeroustics Engineering Limited has completed the Phase 2 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 “MECP Compliance Protocol for Wind Turbine Noise.”

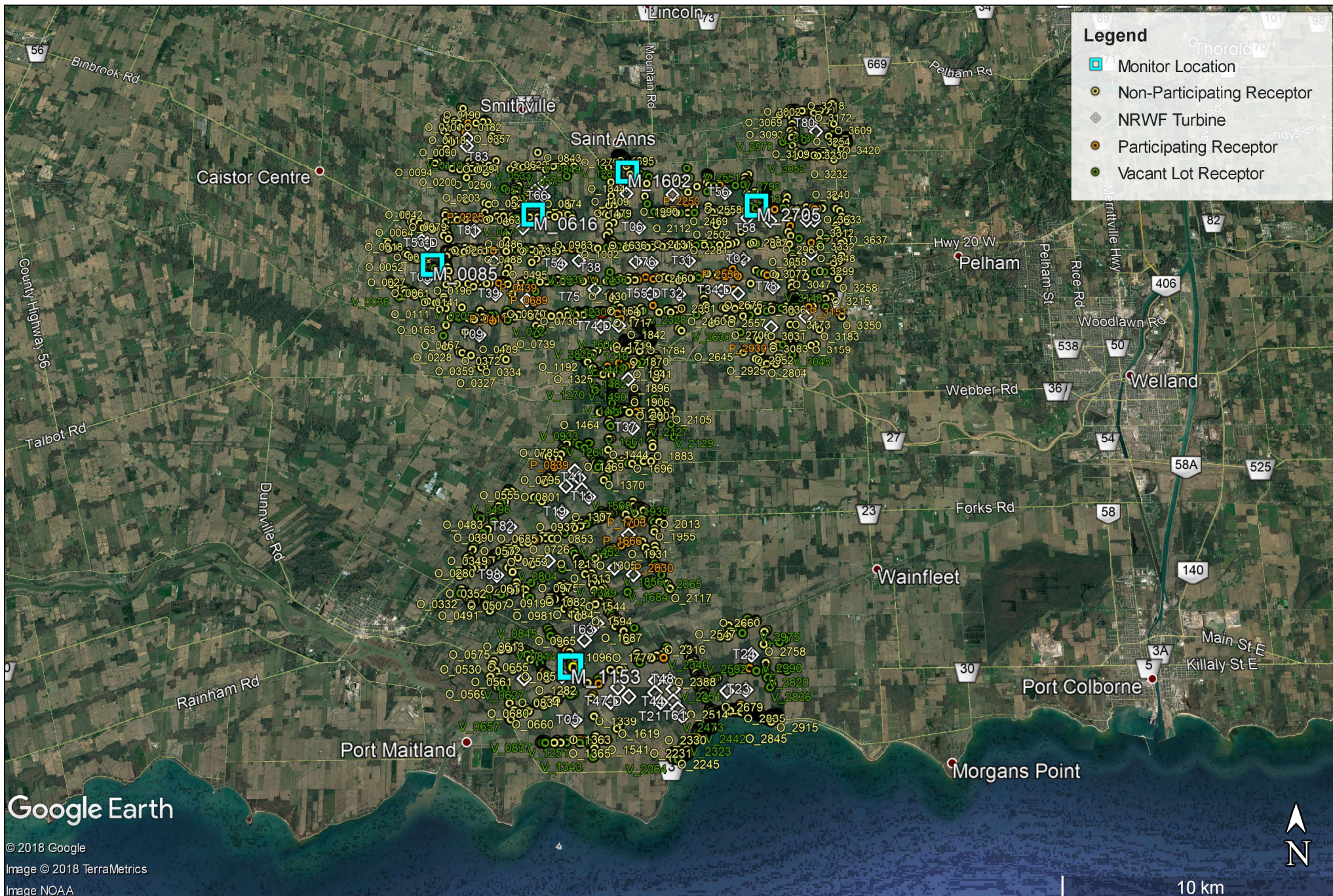
The measured levels were compared to the MECP limits, and the facility was determined to be in compliance at receptor O0616 during the audit.

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.

Appendix A

Location Details



	16227.00	Project Name	
	Scale: NTS	Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit	
	Drawn by: IK	Figure Title	
	Reviewed by: AM		
	Date: May 16, 2019	Site Plan	
	Revision: 1		
		Appendix A1	



Appendix B

Receptor Selection Rationale

Appendix B - Receptor Selection Summary

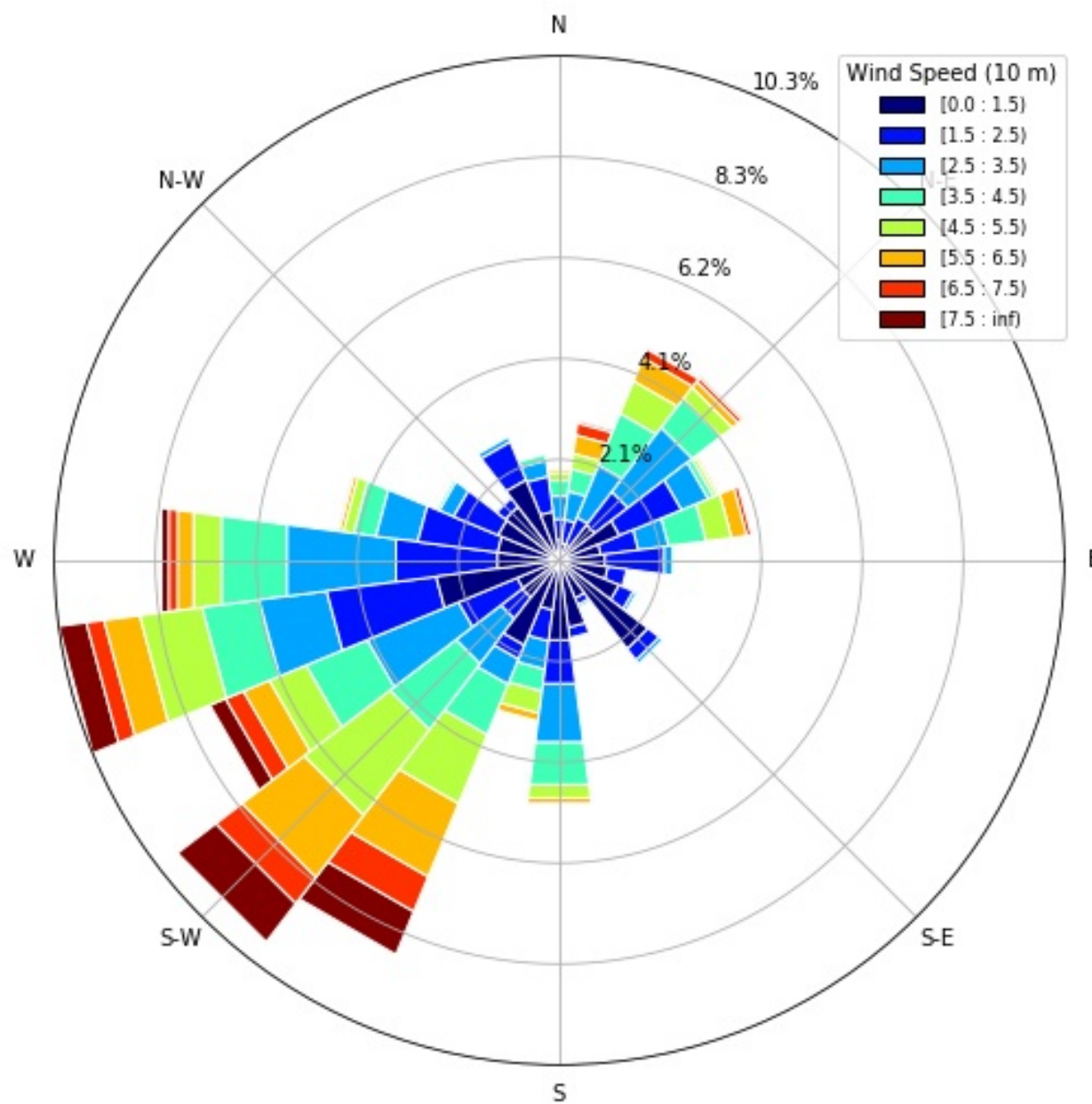
Project: Niagara Region Wind Farm Project

1 of 1

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

Appendix C

Wind Roses



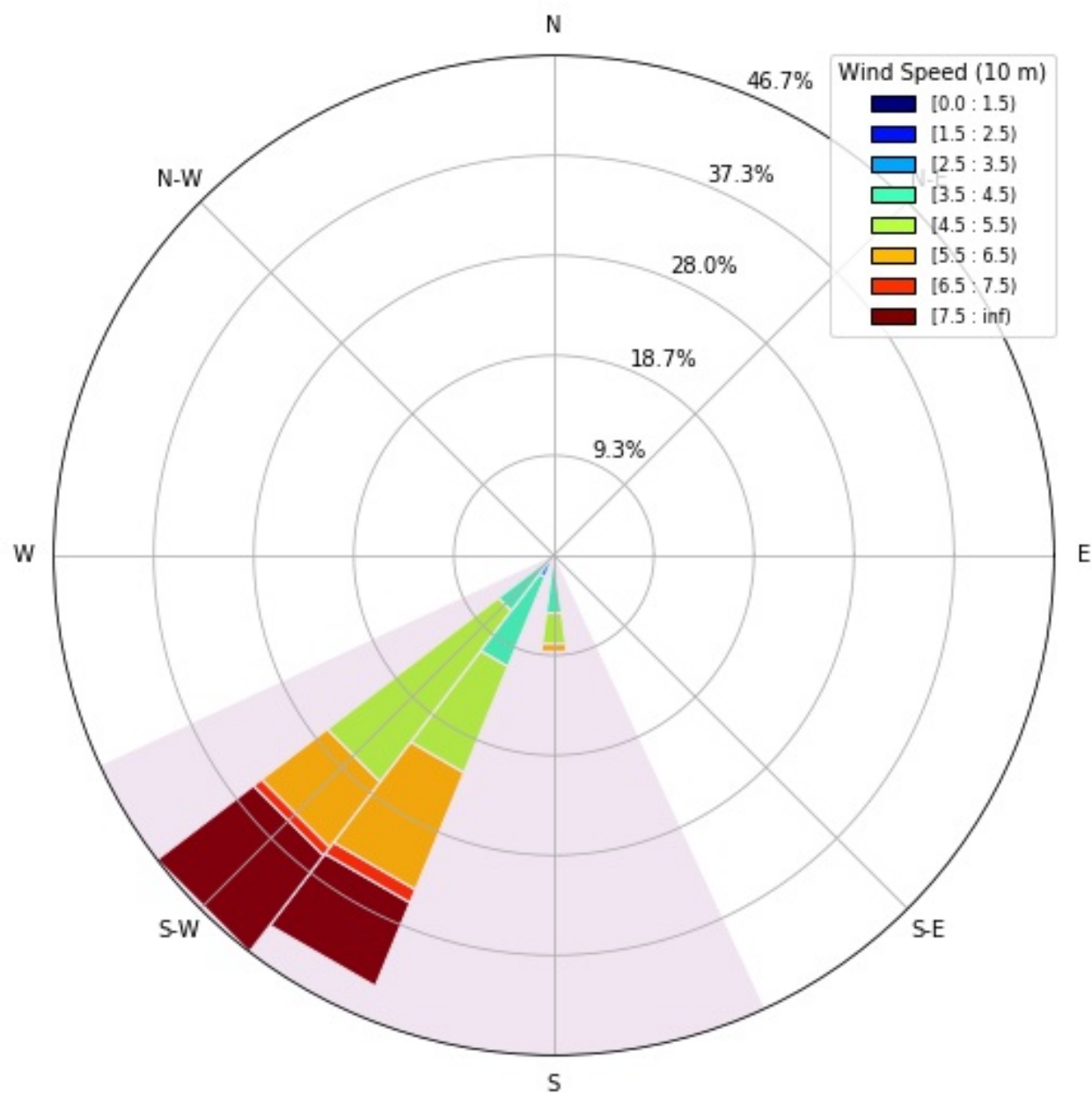
Project ID: 16227.00
Drawn by: RAM
Reviewed by: AM
Date: May 14, 2020
Revision: 1

Scale: As Indicated

Niagara Region Wind Farm
 Phase 2 00616 I-Audit Report

Appendix C.1

Supplementary Wind Rose
 based on All Data



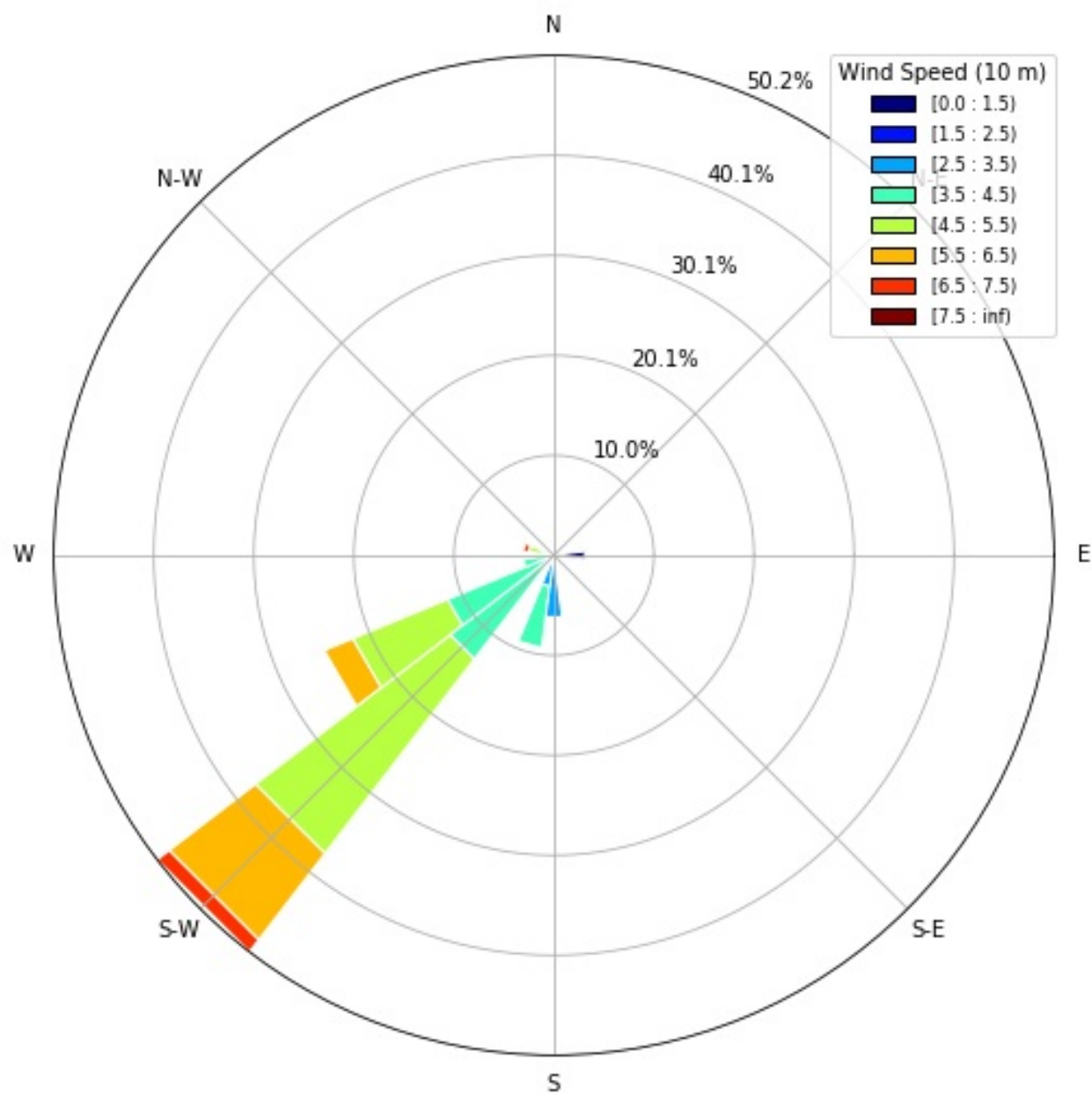
Project ID: 16627.00
Drawn by: RAM
Reviewed by: AM
Date: May 14, 2020
Revision: 1

Scale: As Indicated

Niagara Region Wind Farm
 Phase 2 00616 I-Audit Report

Appendix C.2

Supplementary Wind Rose
 based on Assessment Data
 Total Noise



Project ID: 16227.00
Drawn by: RAM
Reviewed by: AM
Date: May 14, 2020
Revision: 1

Scale: As Indicated

Niagara Region Wind Farm
Phase 2 00616 I-Audit Report

Appendix C.3

Supplementary Wind Rose
based on Assessment Data
Background

Appendix E

Tonality Assessment

Appendix E - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

Report ID: 16227

Page 1 of 1

Created on: 2020-05-14

M0616 116 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	0%	**	40	0.0	0
1	0	0	0%	**	40	0.0	0
2	2	2	100%	**	40	-4.7	0
3	25	21	84%	**	40	-1.3	0
4	166	144	87%	40	40	-2.1	0
5	284	256	90%	40	40	-1.2	0
6	168	152	90%	40	40	-2.3	0
7	20	16	80%	**	43	-3.1	0

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

** No data points at wind speed

Appendix F

Calibration Certificates

Calibration Certificates –

Details are disclosed in the table below regarding the calibration of the equipment used for the Phase 2 I-Audit campaign at monitor location O0616. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
O0616	Microphone/ Pre-Amplifier Pair	2250	3004506	2019-07-18
	Microphone	4189	3036522	2019-07-18
	Pre-Amplifier	ZC0032	24551	2019-07-18
	Weather Anemometer	Vaisala WXT 520	L0910579	2019-01-29

CERTIFICATE of CALIBRATION

Make : Bruel & Kjaer

Reference # : 158021

Model : 2250

Customer : Aeroustics Engineering Ltd
Mississauga, ON

Descr. : Sound Level Meter Type 1

Serial # : 3004506

P. Order : 2019.07.09C

Asset # : 00057

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

Cal with mike 4189 s# 3036522 and preamp ZC0032 s#24551.

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

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

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jul 18, 2019

By :



T. Beilin

Cal. Due : Jul 18, 2021

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

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7

Phone : 800-668-7440

Fax: 905 565 8325

<http://www.navair.com>

e-Mail: service@navair.com

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Form: BK2250	Approved by: JR	May-09	ver 1.0
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Calibration Report part of Certificate:

158021

Make	Model	Serial	Asset
Brüel & Kjær	2250	3004506	00057

With mike 4189 S# 3036522 & preamp ZC0032 S# 24551

TYPE 1 Specs

Test	Min	Reading	Max	In/Out
------	-----	---------	-----	--------

Freq.Response

Tested with dummy mike

IEC61672-1 limits

WTG Curve Check

		dBA		
31.5 Hz	72.6	74.5	76.6	In
63 Hz	86.3	87.8	89.3	In
125 Hz	96.4	97.8	99.4	In
250 Hz	103.9	105.3	106.8	In
500 Hz	109.4	110.7	112.2	In
1 kHz	112.9	114.0	115.1	In
2 kHz	113.6	115.2	116.8	In
4 kHz	113.4	115.0	116.6	In
8 kHz	109.8	112.8	115.0	In
12.5 kHz	103.7	109.3	112.7	In

		dBC		
31.5 Hz	109.0	111.0	113.0	In
63 Hz	111.7	113.2	114.7	In
125 Hz	112.3	113.8	115.3	In
250 Hz	112.5	114.0	115.4	In
500 Hz	112.6	114.0	115.4	In
1 kHz	112.9	114.0	115.1	In
2 kHz	112.2	113.8	115.4	In
4 kHz	111.6	113.2	114.8	In
8 kHz	107.9	110.9	113.1	In
12.5 kHz	101.8	107.4	110.8	In

Test	Min	Reading	Max	In/Out
		dBZ		
31.5 Hz	112.0	114.1	116.0	In
63 Hz	112.5	114.0	115.5	In
125 Hz	112.5	114.0	115.5	In
250 Hz	112.5	114.0	115.4	In
500 Hz	112.6	114.0	115.4	In
1 kHz	112.9	114.0	115.1	In
2 kHz	112.4	114.0	115.6	In
4 kHz	112.4	114.0	115.6	In
8 kHz	110.9	114.0	116.1	In
12.5 kHz	108.0	113.6	117.0	In

Scale Test with microphone

Scale

dBc @1kHz

I/P dB

20 - 140dB Range

114	113.5	114.0	114.5	In
104	103.5	104.0	104.5	In
94	93.5	94.0	94.5	In

Impulse Test Pass

Fast/Slow Pass

AC O/P Pass

Source operation Pass



SOH Wind Engineering LLC

141 Leroy Road - Williston, VT 05495 - USA

Tel 802.316.4368 - Fax 802.735.9106 - www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

Certificate number: 19.US2.01179

Date of issue: January 29, 2019

Type: Vaisala Weather Transmitter, WXT520

Serial number: L0910579

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

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

Anemometer received: January 24, 2019

Anemometer calibrated: January 29, 2019

Calibrated by: MEJ

Procedure: MEASNET, IEC 61400-12-1:2017 Annex F

Certificate prepared by: EJF

Approved by: Calibration engineer, EJF

Calibration equation obtained: $v \text{ [m/s]} = 1.01104 \cdot U \text{ [m/s]} + -0.10667$

Standard uncertainty, slope: 0.00158

Standard uncertainty, offset: -0.16044

Covariance: -0.0000257 (m/s)²/m/s

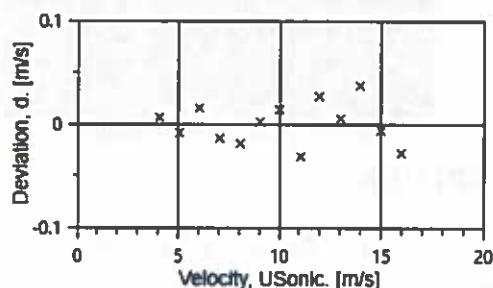
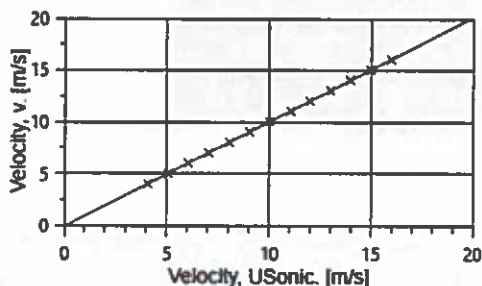
Coefficient of correlation: $\rho = 0.999986$

Absolute maximum deviation: 0.037 m/s at 14.051 m/s

Barometric pressure: 1000.5 hPa

Relative humidity: 7.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, U. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.45	22.4	26.8	4.005	4.0600	0.006	0.024
4	14.73	22.5	26.8	4.999	5.0586	-0.008	0.028
6	21.30	22.5	26.8	6.012	6.0367	0.015	0.032
8	28.89	22.5	26.8	7.002	7.0450	-0.014	0.037
10	37.89	22.5	26.9	8.020	8.0567	-0.019	0.042
12	47.99	22.5	26.9	9.025	9.0300	0.002	0.046
13-last	59.20	22.5	26.9	10.025	10.0069	0.014	0.051
11	71.80	22.5	26.9	11.041	11.0567	-0.032	0.056
9	85.19	22.5	26.9	12.026	11.9733	0.027	0.061
7	100.19	22.5	26.8	13.042	13.0000	0.005	0.065
5	116.30	22.5	26.8	14.051	13.9667	0.037	0.070
3	133.28	22.4	26.8	15.042	14.9900	-0.007	0.075
1-first	151.32	22.3	26.8	16.025	15.9833	-0.028	0.079



AC-1746



EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.0035
13924	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	Setra Model 278, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
66GSPS1	PC dedicated to data acquisition

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

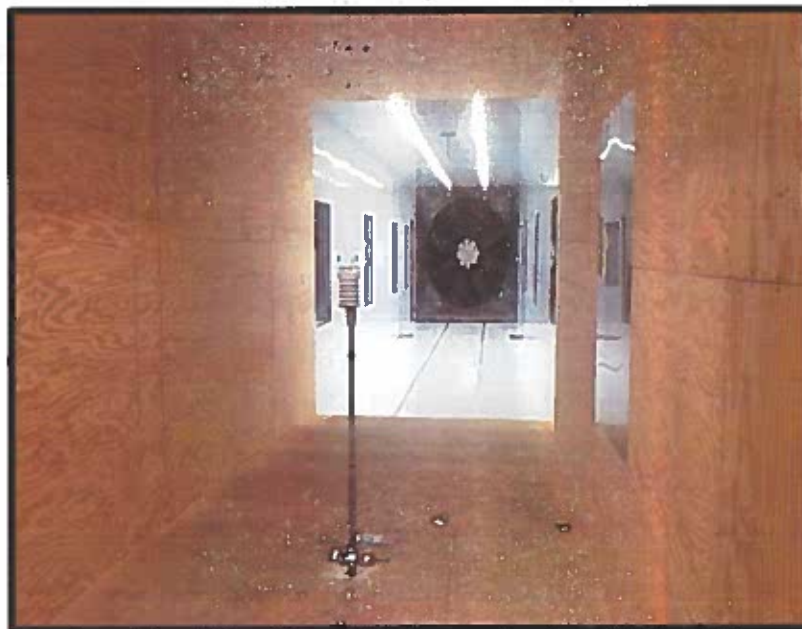


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

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

COMMENTS

This sensor was calibrated at the 0° position.

Certificate number: 19.US2.01179

All calibrations are done in the "As Left" condition unless otherwise noted.

This certificate must not be reproduced, except in full, without the approval of SOH Wind Engineering LLC

Appendix G

Turbine Status during TON and TOFF

Niagara Region – Turbine Status Matrix for TON and TOFF

Turbine ID	Monitor ID	
	O0616	O0085
T01		
T02		
T03		
T04		
T05		
T06		
T07		
T08		1
T09		
T10		
T11		
T12		
T13		
T14		
T16		
T18		
T19		
T20		
T21		
T22		
T23		
T24		
T27		
T28		
T29		
T31		
T32		
T33		
T34		
T35		
T36		
T37		
T38		
T39		
T41		
T42		
T43		
T44		
T45		
T46		
T47		
T48		

Turbine ID	Monitor ID	
	O0616	O0085
T49		
T51		
T52		1
T53		1
T54		
T55		
T56		
T57		
T58		
T59		
T60		
T61		
T62		
T63		
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		
T97		
T98		
T99		

1 - Turbine ON/OFF

Turbines turned off such that predicted impact at monitor/receptor location is 30 dBA or less

Appendix H

I-Audit Checklist

Appendix H: 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?	✓	
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