

ASSESSMENT REPORT - Project: 17283.01

North Kent Wind 1 LP Phase 1 Acoustic Immission Audit - Part 3 of 5 R3214


Prepared for:

North Kent Wind 1 LP
2050 Derry Road West, 2nd Floor
Mississauga, Ontario
L5N 0B9

Prepared by:



Rachel Mandel, B.A.Sc



Addie Denison, B.A.Sc., P.Eng.



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

20 February 2020

Table of Contents

List of Tables	4
List of Figures	4
List of Appendices	4
1 Introduction	7
2 Facility Description	7
3 Audit Receptor Selection	7
3.1 Receptor Selection Criteria.....	7
3.1.1 Prevailing Wind Direction	8
3.1.2 Receptor Selection Table	10
4 Audit Measurement Locations	11
4.1 Existing Ambient Environment.....	11
4.1.1 Wind-Related Ambient Noise	11
4.1.2 Traffic Noise.....	11
4.2 Monitoring Location	11
5 Measurement Methodology	12
5.1 Test Equipment.....	12
5.2 Measurement Parameters	13
6 Assessment Methodology	14
6.1 Data Reduction and Filtering	14
6.2 Manual Exclusion of Data	14
6.3 Wind Gusting	14
6.4 Turbine Power & Wind Direction	15

6.5	Sample Size Requirements	16
6.6	Turbine Operating Conditions	16
6.7	Contribution from Adjacent Wind Facilities.....	16
7	Sound Level Limits	17
8	Audit Results	17
8.1	Weather Conditions.....	17
8.2	Wind Direction	18
8.3	Sound Levels	20
9	Discussion	21
9.1	Analysis Methodology.....	21
9.2	Effect of Filtering	21
10	Assessment of Compliance	21
10.1	Tonality Assessment.....	21
10.2	Assessment Tables	22
10.3	Assessment of Compliance	23
11	Conclusion	23
12	References	24

List of Tables

Table 1: I-Audit Receptor Selection Table	10
Table 2: Receptor and Monitor Locations	12
Table 3: Equipment Details	13
Table 4: MECP Sound Level Limits for Wind Turbines	17
Table 5: General Weather Conditions – Range of Measured Values.....	17
Table 6: Average Measured Sound Levels at R3214, RAM-I Analysis	20
Table 7: Effect of Data Filtering on Measurement Dataset	21
Table 10: R3214 Assessment Table – Cumulative Turbine-only Sound Impact	23

List of Figures

Figure 1 - Historical Wind Roses for NKWPP, filtered for hub-height wind speeds above 10 m/s	9
Figure 2: Measured wind rose for R3214 for the Phase 1 I-audit campaign	19
Figure 3: R3214 - Measured Sound Levels for Turbine ON and Background vs Wind Speed	20

List of Appendices

Appendix A – Location Details
Figure A.1 – Site Plan
Figure A.2 – Monitor and Receptor Location – R3214
Figure A.3 – Site Photo – R3214 to T23
Figure A.4 – Site Photo – R3214 to Receptor
Appendix B – Full Receptor Selection Table
Appendix C – R3214 Supplementary wind Roses based on Assessment Data
Appendix C.1 – Total Noise
Appendix C.2 – Background Noise
Appendix D – Statement from Operator
Appendix E – Summary of Tonality Assessment
Appendix F – Calibration Records
Appendix G – Power Thresholds for 90% Sound Power
Appendix H – I-Audit Checklist

Revision History

Version	Description	Author	Reviewed	Date
1	Initial Report	LP	MAD	June 27, 2019
2	Correction to Table 8	DEA	MAD	July 8, 2019
3	Monitor UTM Coordinates Corrected (Table 2)	KC	MAD	August 22, 2019
4	Correction to Appendix F Correction to Appendix H Correction to Tables 2, 3 Corrected list of parked turbines, Section 6.3 Updated operator statement, Appendix D	RAM	MAD	October 10, 2019
5	Clarifying information added to Appendix E based on MECP request	MAD	PA	February 20, 2020

Important Notice and Disclaimer

This report was prepared by Aercoustics Engineering Limited (Aercoustics) solely for the client identified above and is to be used exclusively for the purposes set out in the report. The material in this report reflects the judgment of Aercoustics based on information available to them at the time of preparation. Unless manifestly incorrect, Aercoustics assumes information provided by others is accurate. Changed conditions or information occurring or becoming known after the date of this report could affect the results and conclusions presented. Unless otherwise required by law or regulation, this report shall not be shared with any Third Party without the express written consent of Aercoustics. Aercoustics accepts no responsibility for damages, if any, suffered by any Third Party which makes use of the results and conclusions presented in this report.

Executive Summary

Aeroustics Engineering Limited (“Aeroustics”) has been retained by North Kent Wind 1 LP to complete the acoustic immission audit requirements outlined in the Renewable Energy Approval (“REA”) for the North Kent Wind Farm (“NKWPP”). NKWPP operates under REA #5272-A9FHRL, issued on June 29, 2016 [1].

As per the REA, five (5) measurement locations are required. Individual reports will be issued for each of the five measurement locations; This report summarises the results of Phase 1 of the I-audit testing at Receptor R3214.

The monitoring near receptor R3214 spanned the following dates:

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
R3214	February 28, 2019	April 30, 2019	8.5

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) [2].

Based on the results presented in Section 10.1 of this report, the cumulative sound impact calculated at R3214 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 North Kent Wind 1 L.P. to complete the immission audit (“I-audit”) requirement outlined in Section E of the Renewable Energy Approval (“REA”) for the North Kent 1 Wind Power Project (“NKWPP”). NKWPP operates under REA #5272-A9FHRL, issued on June 29, 2016 [1]. Measurements were conducted per the Compliance Protocol for Wind Turbine Noise (the “Protocol”) [2]. As per the REA, five (5) measurement locations are required. Individual reports will be issued for each of the five measurement locations; This report summarises the results of Phase 1 of the I-audit testing at Receptor R3214.

2 Facility Description

The North Kent 1 Wind Power Project is located in Chatham-Kent, Ontario. The site is bound by Corktown Line to the north, Pioneer Line to the south, Bear Line Rd to the west, and Centre Side Road to the east.

The NKWPP consists of 34 Siemens SWT-113 wind turbines for power generation, with a total nameplate capacity of 100 MW. Each turbine has a hub height of 99.5 meters, a rotor diameter of 113 meters and an individual nameplate capacity of either 2.772MW, 2.942MW, or 3.2MW. The facility operates 24 hours per day, 7 days per week. A Site Plan of the facility and the surrounding area are provided in Appendix A.1.

There are two wind facilities within 10 kilometres of the NKWPP: East Lake St. Clair Wind (“ELSC”) and Marsh Line Wind Farm (“Marsh Line”). With respect to the five audit measurement locations, the nearest ELSC turbine is Turbine T138, 2.6 km to the west of monitor R3214. The nearest Marsh Line turbine is Turbine T5, 4.8 km to the south west of monitor R3214.

3 Audit Receptor Selection

As per Section E.1(2) of the NKWPP REA, five receptor¹ locations were chosen to execute both phases of the I-audit: R3214, R3099, V6202, R3281 and R3408. Monitoring equipment was erected near each of these receptors. This report addresses the measurements conducted at R3214 between February 28, 2019 and April 30, 2019.

3.1 Receptor Selection Criteria

Receptor selection criteria are outlined in REA Section E1, and paraphrased below. “Predicted noise impact” refers to the predicted cumulative impact using the sound model

In this report, the term “receptor” refers to the Points of Reception outlined in the REA. The term “monitor” refers to the location of the measurement equipment used to assess the worst-case impact at the associated receptor.

outlined in the noise assessment report [3] (Dokouzian, 2016)², updated to only include the turbines that were constructed. “Primary Turbine” refers to the turbine having the highest predicted impact at a given receptor location. “Downwind” refers to the direction from monitor to primary turbine being within +/-45° of the direction of the prevailing winds.

- E1(3):
- Selected receptors should have the highest possible predicted noise impacts
 - Selected receptors should be in the direction of the prevailing winds

During the receptor selection process, North Kent Wind 1 consulted with the Ministry of the Environment, Conservation and Parks (“MECP”) District and Approvals branches regarding the inclusion of a complaint location in the I-Audit. It was agreed upon by the MECP that Receptor R3408 could be included as one of the 5 receptor locations, despite it not fulfilling the specific selection criteria in the REA. The MECP was also consulted regarding the specific location of the monitoring equipment for R3408. Approval regarding this measurement location was confirmed in an email from the MECP on December 6, 2018, which also stipulated that for this location both the Crosswind and Downwind conditions should be included in the final report.

In addition to the item above, the MECP was also consulted regarding the selection of the remaining four receptors in accordance with the methodology outlined in the REA and the Protocol. During this consultation, the MECP indicated that three of the locations initially selected were too close to each other and requested that R3281 be included in the place of the originally selected V6322. This specific guidance was received in an email from the MECP on January 30, 2019.

The receptors chosen for the NKWPP I-audit are R3214, R3099, V6202, R3281 and R3408. All receptors except R3408 are situated downwind with respect to the prevailing wind direction. Further details regarding the monitoring position are provided in Section 4.2.

3.1.1 Prevailing Wind Direction

The prevailing wind direction used for receptor selection was determined using historical weather data for the site. This data was filtered to isolate for the conditions during which the facility would generate over 85% power, to match the conditions required to fulfill the filtering requirements of the Protocol. A wind rose showing the historical wind direction at the site is included Figure 1. The predominant wind direction is southwest, specifically 235°.

² It is noted that the noise assessment report in [3] included 45 turbines, but only 34 turbines were constructed. As such, the receptor selections for the I-audit measurements in this report were conducted using the predicted sound impact of 34 turbines (as-built), modelled by DNV-GL.

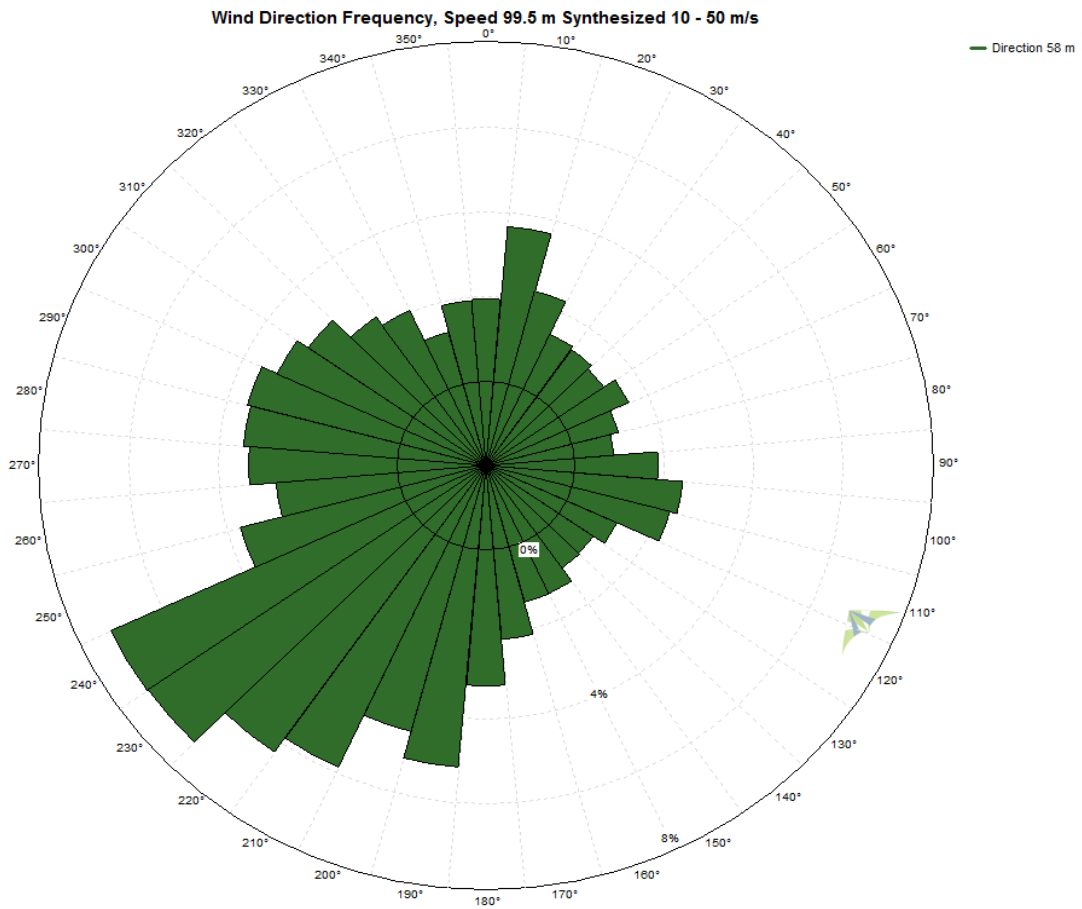


Figure 1 - Historical Wind Roses for NKWPP, filtered for hub-height wind speeds above 10 m/s

3.1.2 Receptor Selection Table

Receptors that are participants of NKWPP or that are not located in the predominant downwind direction from the closest turbine were automatically excluded during the receptor selection process, in accordance with the guidance in the NKWPP REA and the Protocol. Receptors excluded for other reasons are summarized in Table 1 below, along with the five locations that were selected. A full summary of the results of the receptor selection process is included in Appendix B. Details regarding the land access permission activities for this project are available upon request.

Table 1: I-Audit Receptor Selection Table

SPL Rank	Point of Reception ID	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA) ¹	Wind Direction ²	Notes
*	R3408	1.5	713	T3	36.7	CW	Selected – This receptor has been requested by the district office to be included in the audit
11	V6322	4.5	550	T19	39.6	DW	Excluded – Exclusion advised by the MECP, since two other proposed measurement locations are in close proximity to this location (cluster of receptors)
18	R3381	4.5	605	T30	39.5	DW	Excluded – Area surrounding receptor is heavily forested. Locations sufficiently set back from trees will place the monitor significantly closer to the turbine, or into a crosswind position.
31	R3159	4.5	605	T19	39.1	DW	Excluded – See comment for V6322
32	V6216	4.5	565	T7	39.1	DW	Denied Access – Resident was not interested in participating in the study
33	R3149	4.5	600	T19	39.1	DW	Excluded – See comment for V6322
36	R3099	4.5	554	T51	39.0	DW	Selected
45	V6381	4.5	621	T19	38.9	DW	Excluded – Located too close to receptor already selected (R3099)
54	R3214	4.5	751	T23	38.8	DW	Selected
57	V6202	4.5	620	T6	38.7	DW	Selected – Monitor erected in adjacent property due to land access restriction on resident's property.
62	V6313	4.5	659	T19	38.6	DW	Excluded – Located too close to receptor already selected (R3099)
71	R3170	4.5	690	T19	38.5	DW	Excluded – Located too close to receptor already selected (R3099)
79	R3398	1.5	566	T52	38.4	DW	Denied Access – Land owner indicated that he was no longer interested in allowing land access
83	R3281	7.5	632	T7	38.3	DW	Selected – was originally listed as Optional Alternative – MECP requested that this location be included

¹ Sound Pressure Level at the receptor location determined using an as-built sound model created by DNV-GL

² Relative to the prevailing wind direction, +/-45°

4 Audit Measurement Locations

The following section describes the measurement location used for R3214 and provides context to the ambient acoustic environment observed at the NKWPP.

4.1 Existing Ambient Environment

The ambient acoustical environment measured at R3214 was observed to be dominated by two factors: wind-related noise and traffic noise. These factors are described below.

4.1.1 Wind-Related Ambient Noise

Wind-related noise is comprised of two sources: self-noise and foliage noise. Self-noise results from wind blowing over objects associated with the monitoring equipment and is similar to what one might observe when wind blows over the ear on a windy day. Self-noise is present in all monitoring campaigns at high wind speeds. Conversely, foliage noise depends on the vegetation in the area surrounding the monitor. Measures to reduce the impact of wind-related noise were employed at the monitor location, as prescribed in the Protocol; a secondary wind screen was installed to reduce self-noise, and the monitoring equipment was located away from trees as much as practically possible.

4.1.2 Traffic Noise

St. Clair Road, located 200 meters east of R3214, was observed to be a significant ambient noise source at this location, both through observations during site visits and listening analysis of the measured data. It was noted that the contribution of the noise from St. Clair Road varied with the time of night. Most of this transient contamination was filtered out, either manually by listening analysis or automatically by the transient (LA_{eq-L90}) filter, described in Section 6.1. Additionally, a time-based filter was employed at this location to limit the data used in the analysis to 12 am to 5 am. This was done to isolate for periods with less traffic activity on St. Clair road, and therefore less ambient contamination. Assessing the wind farm noise impact during periods of (comparatively) minimal ambient impact represents a conservative approach. The effect of any residual traffic noise in this dataset is expected to be minimal.

4.2 Monitoring Location

Table 2 provides specific details of the receptor and monitoring equipment locations. The immediate surroundings of the monitor location are also described below. Photos of the surrounding area and measurement setup are included in Appendix A.3 and A.4.

Table 2: Receptor and Monitor Locations

Audit Receptor	Measurement Duration	Location	UTM Coordinates [m] (Zone 17T)	Distance to Primary Turbine [m]	Predicted Level (dBA) [†]
R3214	<i>February 28, 2019 – April 30, 2019</i>	<i>Receptor</i>	393,170 E 4,705,398 N	752	38.8
		<i>Monitor</i>	393,086 E 4,705,425 N	701	38.9

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

The closest turbine to Receptor R3214 is Turbine T23. Monitor R3214 was located roughly 200 meters west of St. Clair Road and 701 meters to the northeast of Turbine T23. The ground cover between the measurement location and Turbine T23 was predominantly an empty field, with no crop growth. The monitoring equipment was situated approximately 45 meters northwest of a large tree located on the property line of Receptor R3214. The noise monitor was located sufficiently far from the nearby foliage to minimize its impact on the ambient sound levels at the monitor location, however, measured data at higher windspeeds is expected to be impacted by this foliage noise in addition to wind self-noise.

5 Measurement Methodology

The acoustic audit was conducted at receptor R3214 and spanned from February 28, 2019 to April 30, 2019.

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

5.1 Test Equipment

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

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

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

Table 3: Equipment Details

Monitor	Equipment	Make/Model	Serial Number
R3214	Data Acquisition Card	NI 9234	1CAF70D
	Signal Conditioner	PCB 480E09	35339
	Microphone/ Pre-Amplifier Pair	PCB378B02	132222
	Microphone	PCB 377B02	132222
	Pre-Amplifier	PCB 426E01	051466
	Weather Anemometer	Vaisala WXT 520	M0410647

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

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

5.2 Measurement Parameters

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

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

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

³ L_{90} refers to the sound level that is exceeded for 90% of samples in the measurement interval.

6 Assessment Methodology

6.1 Data Reduction and Filtering

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

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

- The interval occurred between 12 am – 5 am
- No precipitation was detected within 60 minutes before or after the interval
- The ambient temperature was above -20°C
- The measured LA_{eq} was no more than 4 dB greater than the L_{90} value

Significant extraneous transient events are often detectable by comparing the LA_{eq} with the L_{90} level for the same interval. At this location, if the measured L_{90} differed from the LA_{eq} by more than 4 dB, the interval was automatically excluded. If necessary, listening tests are conducted to identify contaminated intervals not excluded by the filters listed above.

6.2 Manual Exclusion of Data

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

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

6.3 Wind Gusting

High levels of wind-related noise have been observed during intervals where the maximum measured 10-m AGL wind speed differed greatly from the average value for the same interval. An automatic filter has been applied to remove intervals of gusting at this monitor.

6.4 Turbine Power & Wind Direction

Intervals that pass the filtering criteria listed above are sorted into Total Noise⁴ or Background periods according to the conditions listed below. If neither Total Noise nor Background conditions are met, the data point is excluded.

- **Total Noise:** All facility turbines within 3 km must be rotating and generating power. For monitor R3214 these turbines were:
 - o T14, T15, T19, T23, T26, T44 and T51
- **Background:** Facility turbines must be parked and not generating power such that the predicted impact at the measurement location is less than 30 dBA. For monitor R3214 these turbines were:
 - o T3, T4, T6, T7, T14, T15, T19, T23, T30, T31, T41 and T51⁵

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

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

And

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

Based on the E-Audit test results at NKWPP, the project turbines reach 90% of their maximum measured sound power level at a power output significantly below that which corresponds to 85% of the turbine’s rated electrical power. Further to this, the power output corresponding to the *maximum* sound power level is also below that which corresponds to 85% of rated electrical power for all three turbine variants at NKWPP. For these reasons, using the 85% turbine power threshold alone will not effectively capture the worst-case impact at NKWPP, which was found to occur at an operating condition which corresponds to a lower power output.

For this reason, the 90% sound power condition has been selected to determine the power threshold corresponding to the worst-case impact from the turbine-type closest to R3214. In this case the closest turbine is T23, with a rated power of 3.2 MW. Based on the E-audit test conducted at T06 [6], the 90% sound power condition for this turbine type is reached at a power output of 1.923 MW. This is the power threshold that has been used for filtering this dataset. Details regarding

⁴ Total Noise refers to the measured sound level with the turbines running prior to the correction for Background sound (i.e. the total sound level of the turbines plus the ambient).

⁵ Turbines shutdown to satisfy Background criterion at all monitor locations

the measured sound power levels of the NKWPP turbines and the 90% sound power calculations are included in Appendix G.

6.5 Sample Size Requirements

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

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

Section E5.5(1)

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

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

Section E5.5(5)

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

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

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

6.6 Turbine Operating Conditions

Wind facility SCADA information was provided for the duration of the measurement campaign by the North Kent 1 Wind Power Project. This data was used to verify that the NKWPP wind turbines were operational for Total Noise intervals and parked for Background intervals. The turbine operating conditions were verified by the NKWPP for the duration of the campaign; see Appendix D.

6.7 Contribution from Adjacent Wind Facilities

The nearest wind facility to NKWPP is East Lake St. Clair Wind. The closest ELSC turbine to a monitoring location is Turbine T138, 2.6 km to the west of monitor R3214. At this distance, sound impact from ELSC is considered to be negligible and thus no contributions from adjacent wind facilities were considered in this study.

7 Sound Level Limits

Sound level limits are set by the MECP and vary based on the classification of the surrounding acoustic environment as well as the measured background sound level (if available). The area surrounding the facility has been deemed in the original Noise Assessment Report to be Class III, having exclusion limits based on 10-m AGL wind speed as noted in Table 4 below.

Table 4: MECP Sound Level Limits for Wind Turbines

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

Sections D3.5 and D6 of the Protocol state that in wind bins where the measured background sound levels are greater than the applicable exclusion limits, the sound level limit for that wind bin is the background sound level without extraneous noise sources. In effect, the exclusion limits outline the minimum sound level limit by wind bin, with increases in sound level limit permissible if it can be shown through measurements that the existing background sound level is higher than the exclusion limit. Any complete wind bins where the measured background sound level exceeded the exclusion limit are noted in Table 6.

8 Audit Results

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

8.1 Weather Conditions

General weather conditions observed in the assessment dataset during the Phase 1 I-audit are summarized in Table 5.

Table 5: General Weather Conditions – Range of Measured Values

		10-m AGL			Hub height	
		Atmospheric Pressure* [hPa]	Wind Speed [m/s]	Relative Humidity* [%]	Temperature* [°C]	Wind speed [m/s]
R3214	Minimum	971	0.1	38.9	-13.8	0.2
	Maximum	1008	13.7	94.5	21.9	24.3

*The anemometer at R3214 encountered periodic issues with the pressure, humidity and temperature sensors. For this reason, these parameters have been taken from the R3099 monitor located about 2 km to the south.

8.2 Wind Direction

A wind rose was created for R3214 using the yaw angle from the nearest wind turbine and the wind speeds from the 10-m AGL anemometer. As noted in Section 6.5 of this report, RAM-I methodology is being used, and thus all wind speeds from 1-7 m/s 10-m AGL can be used in the assessment.

The wind rose is provided in Figure 2. The distribution of wind directions observed during the measurement campaign roughly agrees with the historical wind rose (see Section 3.1.1), especially considering that the historical wind rose in Figure 1 is based on hub-height wind speeds, and is filtered for 10 m/s and greater. Supplementary wind roses for the specific valid Total Noise and Background datasets are included in Appendix E.

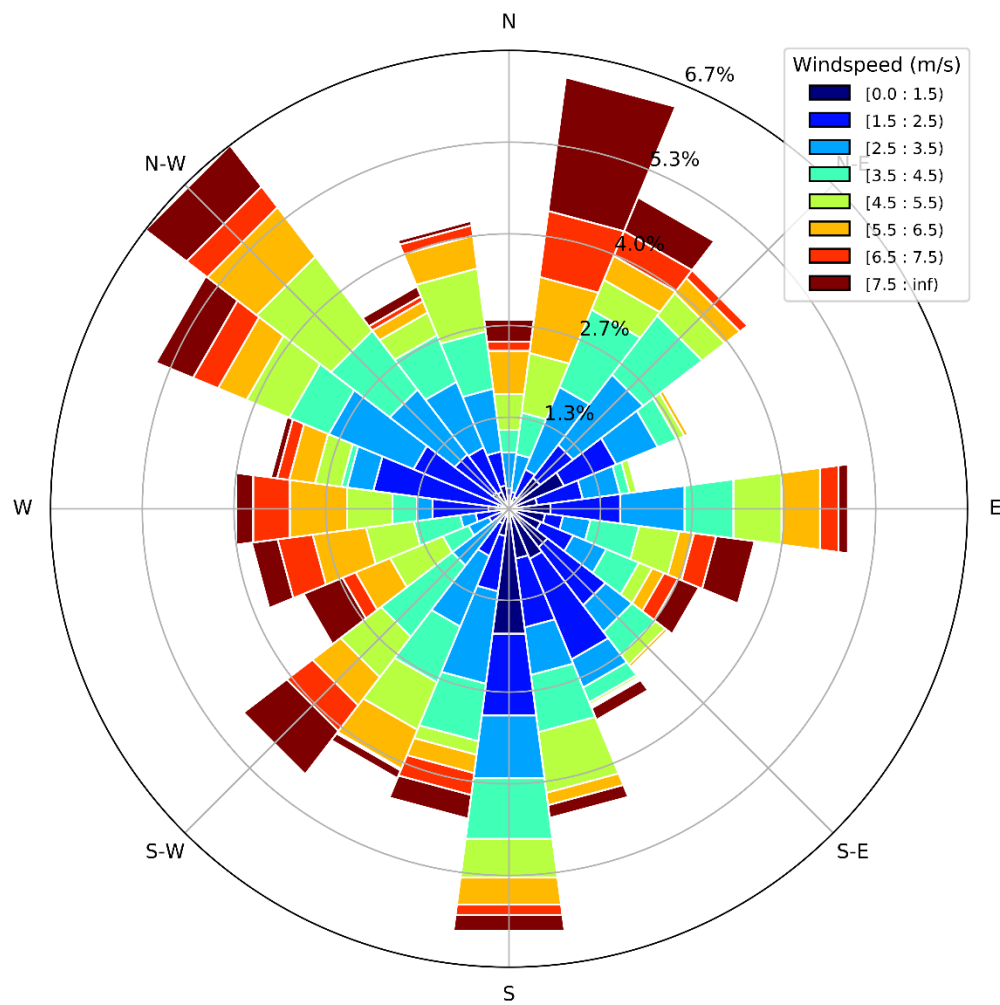


Figure 2: Measured wind rose for R3214 for the Phase 1 I-audit campaign⁶

⁶ The Wind Rose in this figure reflects all measured data across the entirety of the measurement campaign at R3214, as detailed in Table 2. The turbine from which the yaw angle information was taken is T23.

8.3 Sound Levels

Table 6 presents the average measured sound levels at monitor R3214. Results are separated by wind bin into Total Noise and Background periods.

Table 6: Average Measured Sound Levels at R3214, RAM-I Analysis

Receptor	Period	Measurement Parameter	I-audit Wind Bins (m/s)						
			1	2	3	4	5	6	7
R3214	<i>Total Noise</i>	Number of Samples	0	13	115	196	132	150	149
		Average LAeq [dBA]	-	-	39.0	39.7	40.7	42.2	44.5
		Standard Deviation [dB]	-	-	1.4	1.3	1.3	1.2	1.3
	<i>Background</i>	Number of Samples	108	9	0	50	117	41	3
		Average LAeq [dBA]	24.5	-	-	32.4	34.0	38.5	-
		Standard Deviation [dB]	1.9	-	-	1.8	2.1	2.7	-

- Significantly fewer than the minimum data counts outlined in Section 6.5 were attained in this wind bin.

A visualization of the assessment datasets for R3214 is presented in Figure 3 below.

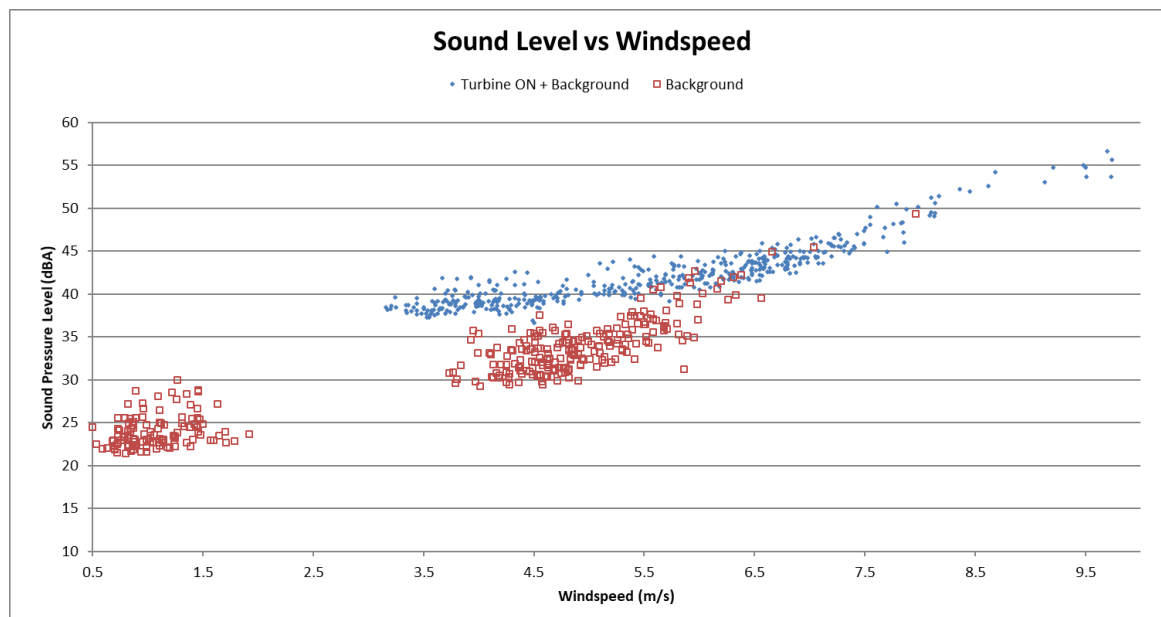


Figure 3: R3214 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

9 Discussion

9.1 Analysis Methodology

Interpretation and discussion of the measured sound levels are provided in this section.

9.2 Effect of Filtering

The measurement data was assessed according to Part D of the Protocol with the incorporation of the RAM-I data reduction methodology per Section E5.5 of the Protocol. The effect of each filter on the measurement datasets, as well as the total portion of measurement data excluded from the assessment data, are summarized in Table 7.

Table 7: Effect of Data Filtering on Measurement Dataset

Data Filter	% Data Excluded
	R3214
Turbine Power Threshold	75%
Wind Direction	73%
Rain	11%
Temperature	0%
Wind Gust	10%
Transient Contamination	55%
Excluded from Total Noise	97%

Table 7 illustrates the proportion of measurement time during the campaign that did not meet the criteria for worst-case noise impact at each receptor. Data not excluded by automatic or manual filters are used in the assessment of compliance. It is important to note that the data remaining after these filters are applied represents the times when the turbines were generating high power output in a downwind condition without significant transient contamination or inclement environmental conditions (such as rain or low temperature). In other words, this remaining data represents the portion of time that the immission impact from the facility is at its highest for the given monitor location.

10 Assessment of Compliance

The following section presents an assessment of compliance for the NKWPP based on the results of the Phase 1 Immission Audit.

10.1 Tonality Assessment

The tonality analysis results of the Emission audit measurements for T36 [4], T33 [5] and T06 [6] were used as a basis for tones at receptors which were likely to have been generated by the closest turbine rather than an external source.

Based on discussions with North Kent Wind 1 LP, it was determined that to be consistent with 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” {Section D5.1}

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 values greater than -3 dB at any of the assessed frequencies. Similar to the methodology in IEC 61400-11, a tone would have to be present in at least 20% of the valid measurement intervals to be classified 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 (L_{ta}) 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 0 dB 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.

A 78 Hz tone was observed at receptor R3214 but was not prevalent enough nor prominent enough for a tonal penalty to be applicable. A tonal assessment summary table is provided in Appendix E.

No tonal penalty was found to be applicable at R3214 based on detailed tonal audibility analysis.

10.2 Assessment Tables

Cumulative Turbine-Only sound levels at R3214 are presented in the table below. The cumulative noise impact in the table is calculated using the data presented in Table 6. Wind bins having insufficient data with which to determine the cumulative sound impact are marked with a “-“. The signal-to-noise for each complete wind bin is also presented. The *Cumulative Sound Impact* is the difference between the average Total Noise and Background sound levels from Table 6, unless otherwise noted.

Table 8: R3214 Assessment Table – Cumulative Turbine-only Sound Impact

Audited Receptor	Wind speed at 10-m AGL [m/s]	1	2	3	4	5	6	7
R3214	Cumulative Sound Impact - Receptor Location [dBA]	-	-	38 [†]	39	40	40	-
	Signal-to-noise [dB]	-	-	-	7.3	6.7	3.7	-
	Background Sound Level [dBA]	25	-	(30)	32	34	39	-
	MECP Exclusion Limit [dBA]	40	40	40	40	40	40	43
	Compliance? (Y/N)	-	-	Yes	Yes	Yes	Yes	-

- Significantly fewer than the minimum data counts outlined in Section 6.5 were attained in this wind bin.

† Per Table 6, no background data was collected in this wind bin. In accordance with Section E5.5(6b) of the Protocol, an assumed background level of 30 dBA has been used in the assessment of compliance in this wind bin.

10.3 Assessment of Compliance

Based on the results presented in Section 10.1, the cumulative sound impact calculated at R3214 complies with the MECP sound level limits at all wind bins having sufficient data for assessment.

11 Conclusion

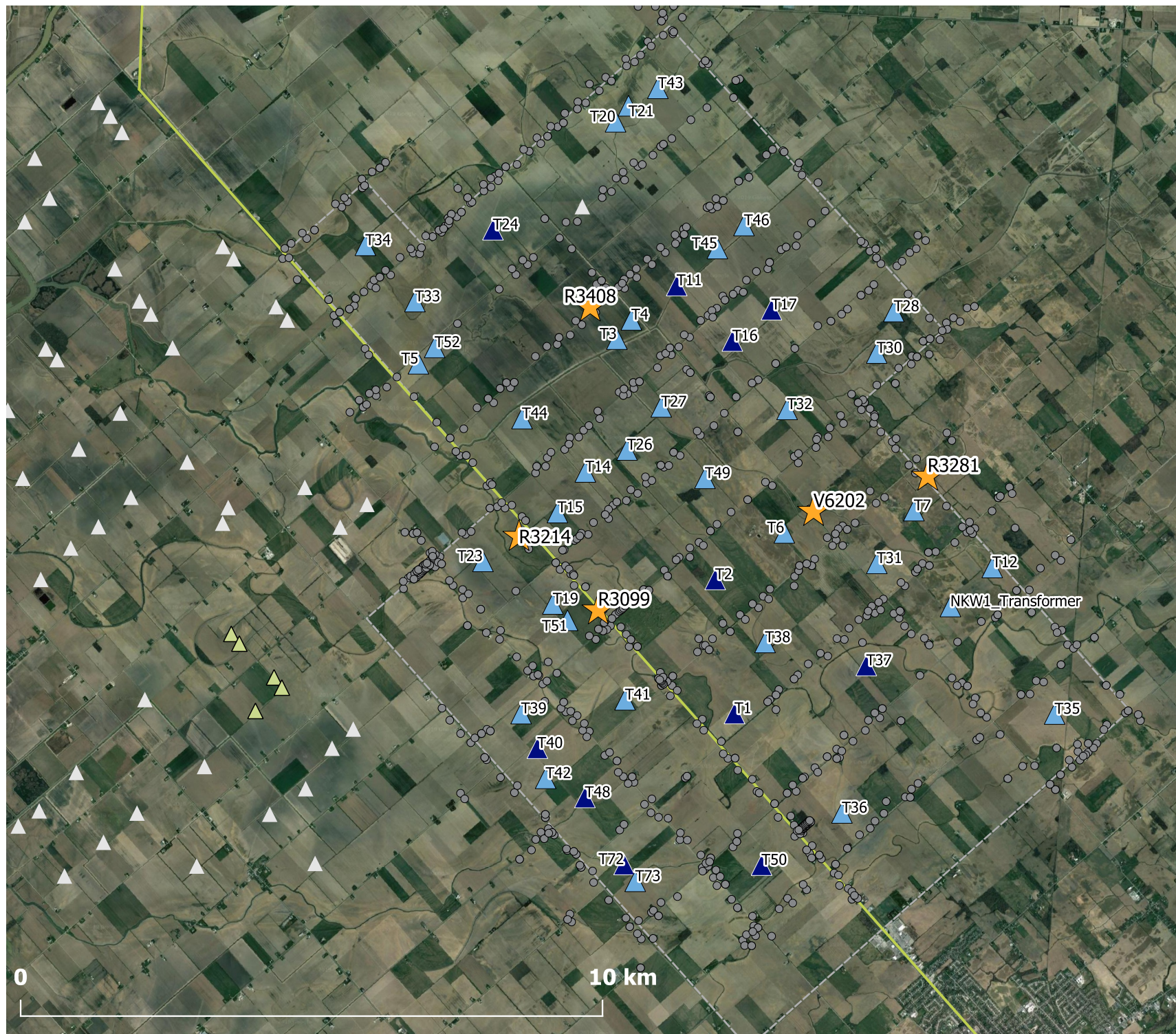
Aeroustics Engineering Limited has completed the Phase 1 immission audit outlined in Condition E the Renewable Energy Approval #5272-A9FHRL for the North Kent Wind Power Project. Testing was conducted in accordance with the methodology outlined in Part D and Part E of the MECP Compliance Protocol for Wind Turbine Noise. Compliance has been demonstrated at receptor R3214.

12 References

- [1] M. Keyvani, P.Eng., “Renewable Energy Approval #5272-A9FHRL”, Ontario Ministry of the Environment, Toronto, ON, June 29, 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] S. Dokouzian, A. Nercessian and A. Danaitis, “North Kent 1 Wind Project Renewable Energy Approval Application – Noise Impact Assessment” DNV-GL, Ottawa, ON, May 9, 2016.
- [4] P. Ashtiani, A. Denison and D.E.A. Villanueva, “North Kent Wind 1 LP – Turbine T36 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 20 March 2019.
- [5] P. Ashtiani, A. Denison and I. Khan, “North Kent Wind 1 LP – Turbine T33 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 22 March 2019.
- [6] A. Denison and D.E.A. Villanueva, “North Kent Wind 1 LP – Turbine T06 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 27 March 2019.

Appendix A

Location Details



Legend

- ★ Campaign Receptor
- Receptor
- St Clair Road
- North Kent Wind Project Boundary
- North Kent Turbines
 - ▲ Turbine - Not Built
 - ▲ Turbine - Built
- Other Turbines
 - ▲ ELSC Turbines
 - ▲ ML Turbines



Project ID: 17283.01
Drawn by: MJ
Reviewed by: AD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
 Phase 1 3214 I-Audit Report

Appendix A.1

Site Plan Overview



Legend

- Noise Monitors Phase 1
- ★ Campaign Receptor
- Receptor
- ▲ Turbine - Built
- St Clair Road
- Dover Centre Line



Project ID: 17283.01
Drawn by: MJ
Revised by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.2

Monitor and Receptor Location



Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.3

Site Photo - R3214 to T23



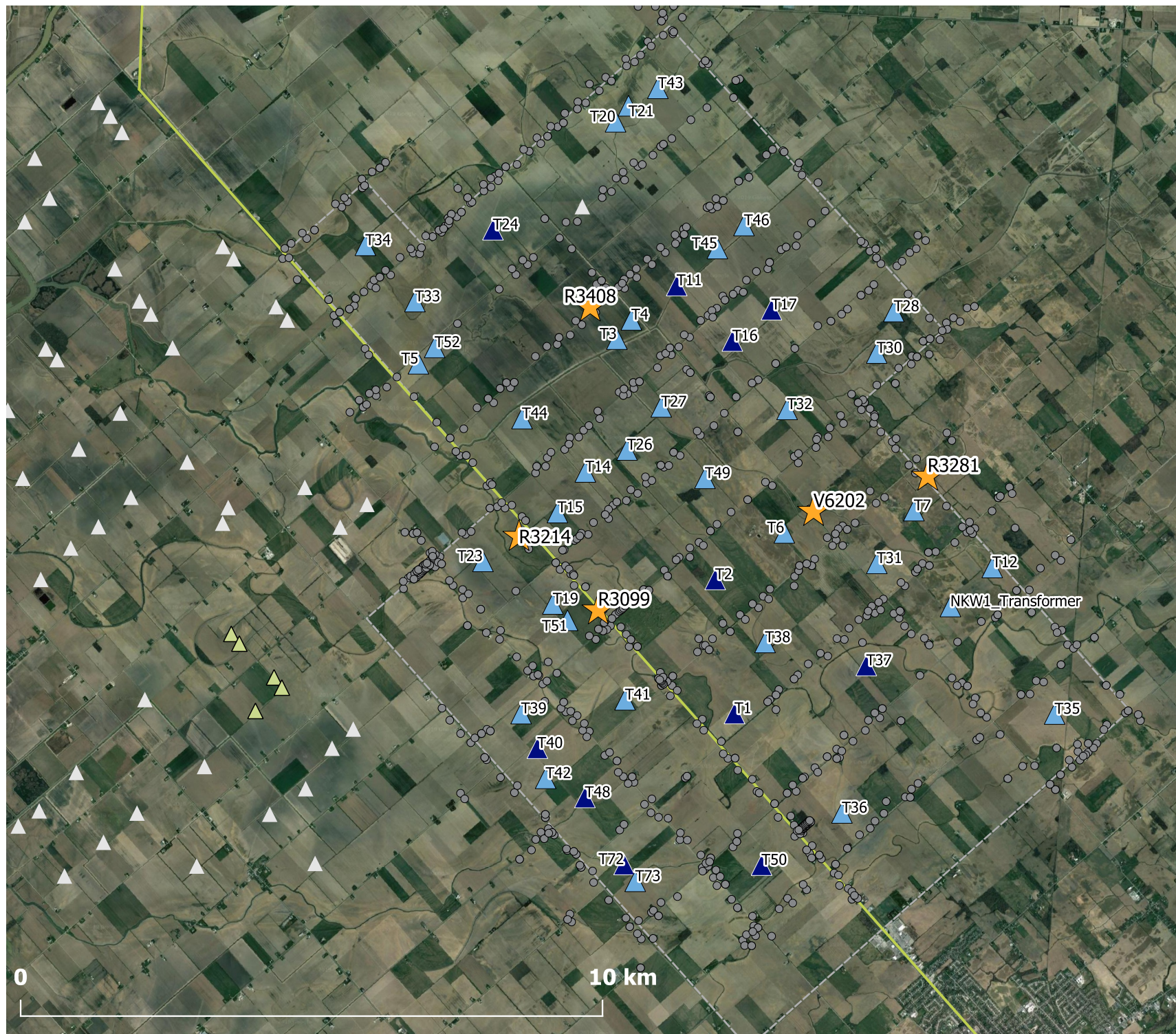
Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated









North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.4

Site Photo - R3214 to Receptor



Legend

-  Campaign Receptor
-  Receptor
-  St Clair Road
-  North Kent Wind Project Boundary
- North Kent Turbines
 -  Turbine - Not Built
 -  Turbine - Built
- Other Turbines
 -  ELSC Turbines
 -  ML Turbines



Project ID: 17283.01
Drawn by: MJ
Reviewed by: AD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
 Phase 1 3214 I-Audit Report

Appendix A.1

Site Plan Overview



Legend

- Noise Monitors Phase 1
- ★ Campaign Receptor
- Receptor
- ▲ Turbine - Built
- St Clair Road
- Dover Centre Line



Project ID: 17283.01
Drawn by: MJ
Revised by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.2

Monitor and Receptor Location



Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.3

Site Photo - R3214 to T23



Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 10, 2019
Revision: 1

Scale: As Indicated

North Kent Wind Project
Phase 1 R3214 I-Audit Report

Appendix A.4

Site Photo - R3214 to Receptor

Appendix B

Full Receptor Selection Table

North Kent Wind Power Project – Appendix B: Full Receptor Selection Table

Table 1: Receptors Sorted by Sound Level

SPL Rank	Point of Reception ID	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Wind Direction	Notes
*	R3408	1.5	713	T3	36.7	CW	Selected – This receptor has been requested by the district office to be included in the audit
1	V6306	4.5	385	T28	42.3	DW	Participating
2	R3375	4.5	458	T30	41.2	CW	Participating, Crosswind
3	R3372	4.5	436	T5	41.1	UW	Participating, Upwind
4	V6314	4.5	483	T19	40.6	DW	Participating
5	R3539	4.5	518	T21	40.4	CW	Participating, Crosswind
6	V6323	4.5	460	T51	40.1	CW	Participating, Crosswind
7	V6286	4.5	523	T14	39.9	CW	Participating, Crosswind
8	V6008	4.5	504	T4	39.8	CW	Participating, Crosswind
9	R3426	4.5	1312	T34	39.6	UW	Upwind
10	R2998	4.5	458	T39	39.6	DW	Participating
11	V6322	4.5	550	T19	39.6	DW	Excluded – Exclusion advised by the MECP, since two other proposed measurement locations are in close proximity to this location (cluster of receptors)
12	V6325	4.5	551	T23	39.6	CW	Participating, Crosswind
13	R3219	4.5	551	T23	39.5	CW	Crosswind
14	V6300	4.5	551	T30	39.5	CW	Crosswind
15	V6269	4.5	551	T7	39.5	CW	Crosswind
16	R3547	4.5	605	T43	39.5	CW	Crosswind
17	V6038	4.5	1837	T20	39.5	UW	Upwind
18	R3381	4.5	605	T30	39.5	DW	Excluded – Area surrounding receptor is heavily forested. Locations sufficiently set back from trees will place the monitor significantly closer to the turbine, or into a crosswind position.
19	R3544	4.5	660	T43	39.4	CW	Participating, Crosswind

North Kent Wind Power Project – Appendix B: Full Receptor Selection Table

SPL Rank	Point of Reception ID	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Wind Direction	Notes
20	R3352	7.5	573	T5	39.4	CW	Crosswind
21	V6065	4.5	551	T34	39.4	CW	Participating, Crosswind
22	V6289	4.5	566	T27	39.4	CW	Participating, Crosswind
23	V6136	4.5	562	T28	39.3	CW	Crosswind
24	V6061	4.5	618	T33	39.3	CW	Participating, Crosswind
25	V6007	4.5	583	T3	39.3	CW	Participating, Crosswind
26	R3535	1.5	565	T21	39.3	CW	Participating, Crosswind
27	V6321	4.5	673	T19	39.3	CW	Crosswind
28	V6282	4.5	609	T14	39.2	CW	Crosswind
29	V6277	4.5	579	T49	39.2	CW	Participating, Crosswind
30	V6465	4.5	560	T26	39.2	CW	Participating, Crosswind
31	R3159	4.5	605	T19	39.1	DW	Excluded – See comment for V6322
32	V6216	4.5	565	T7	39.1	DW	Denied Access – Resident was not interested in participating in study
33	R3149	4.5	600	T19	39.1	DW	Excluded – See comment for V6322
34	V6250	4.5	680	T14	39.1	CW	Participating, Crosswind
35	V6299	4.5	543	T15	39.0	CW	Participating, Crosswind
36	R3099	4.5	554	T51	39.0	DW	Selected
37	R3315	4.5	645	T14	39.0	CW	Crosswind
38	V6284	4.5	617	T27	39.0	CW	Crosswind
39	R3423	4.5	576	T28	39.0	CW	Crosswind
40	V6088	4.5	627	T21	38.9	CW	Crosswind
41	R3294	4.5	698	T14	38.9	CW	Crosswind

North Kent Wind Power Project – Appendix B: Full Receptor Selection Table

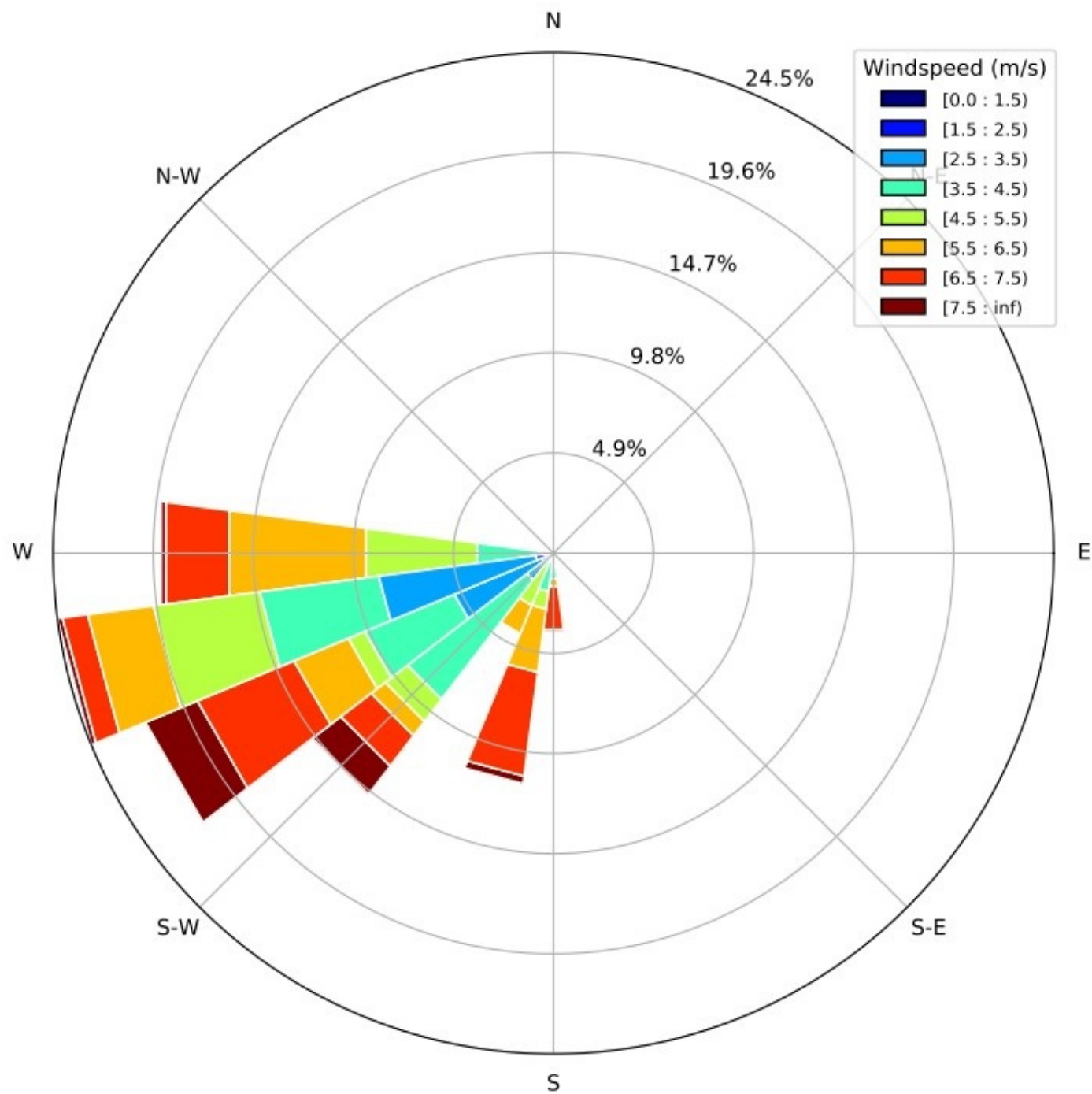
SPL Rank	Point of Reception ID	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Wind Direction	Notes
42	V6295	4.5	660	T49	38.9	CW	Crosswind
43	V6298	4.5	690	T14	38.9	UW	Upwind
44	R3529	4.5	607	T20	38.9	CW	Crosswind
45	V6381	4.5	621	T19	38.9	DW	Excluded – Located too close to receptor already selected (R3099)
46	R3550	7.5	644	T43	38.9	CW	Crosswind
47	V6447	4.5	624	T30	38.9	CW	Crosswind
48	R3289	4.5	700	T26	38.9	CW	Crosswind
49	V6003	4.5	559	T44	38.8	CW	Crosswind
50	V6195	4.5	520	T38	38.8	CW	Participating, Crosswind
51	V6153	4.5	543	T35	38.8	CW	Participating, Crosswind
52	V6057	4.5	560	T46	38.8	CW	Participating, Crosswind
53	R3125	4.5	598	T23	38.8	UW	Upwind
54	R3214	4.5	751	T23	38.8	DW	Selected
55	V6070	4.5	617	T34	38.8	CW	Crosswind
56	R3225	4.5	614	T23	38.7	CW	Crosswind
57	V6202	4.5	620	T6	38.7	DW	Selected – Monitor erected in adjacent property due to land access restriction on resident's property.
58	V6028	4.5	567	T44	38.7	CW	Crosswind
59	V6336	4.5	611	T23	38.7	UW	Upwind
60	R3321	4.5	717	T14	38.7	CW	Crosswind
61	R3201	4.5	798	T15	38.7	UW	Upwind
62	V6313	4.5	659	T19	38.6	DW	Excluded – Located too close to receptor already selected (R3099)
63	V6278	4.5	614	T15	38.6	UW	Upwind

North Kent Wind Power Project – Appendix B: Full Receptor Selection Table

SPL Rank	Point of Reception ID	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine	Calculated Sound Level (dBA)	Wind Direction	Notes
64	V6296	4.5	676	T27	38.6	CW	Crosswind
65	V6331	4.5	588	T51	38.6	CW	Crosswind
66	V6442	4.5	554	T4	38.6	CW	Crosswind
67	R3414	4.5	596	T4	38.5	CW	Crosswind
68	V6200	4.5	531	T31	38.5	CW	Participating, Crosswind
69	R3308	1.5	553	T14	38.5	CW	Crosswind
70	V6060	4.5	709	T33	38.5	CW	Crosswind
71	R3170	4.5	690	T19	38.5	DW	Excluded – Located too close to receptor already selected (R3099)
72	R5023	4.5	652	T15	38.5	CW	Crosswind
73	R4001	4.5	618	T46	38.5	CW	Crosswind
74	R3328	4.5	777	T26	38.4	CW	Crosswind
75	V6305	4.5	623	T28	38.4	CW	Crosswind
76	V6283	4.5	687	T26	38.4	CW	Crosswind
77	V6281	4.5	643	T15	38.4	CW	Crosswind
78	V6443	4.5	715	T26	38.4	CW	Crosswind
79	R3398	1.5	566	T52	38.4	DW	Denied Access – Land owner indicated that he was no longer interested in allowing land access
80	V6466	4.5	676	T26	38.4	CW	Crosswind
81	R3251	4.5	662	T7	38.3	CW	Crosswind
82	R3272	4.5	662	T26	38.3	CW	Crosswind
83	R3281	7.5	632	T7	38.3	DW	Selected – was originally listed as Optional Alternative – MECP requested that this location be included

Appendix C

Wind Roses

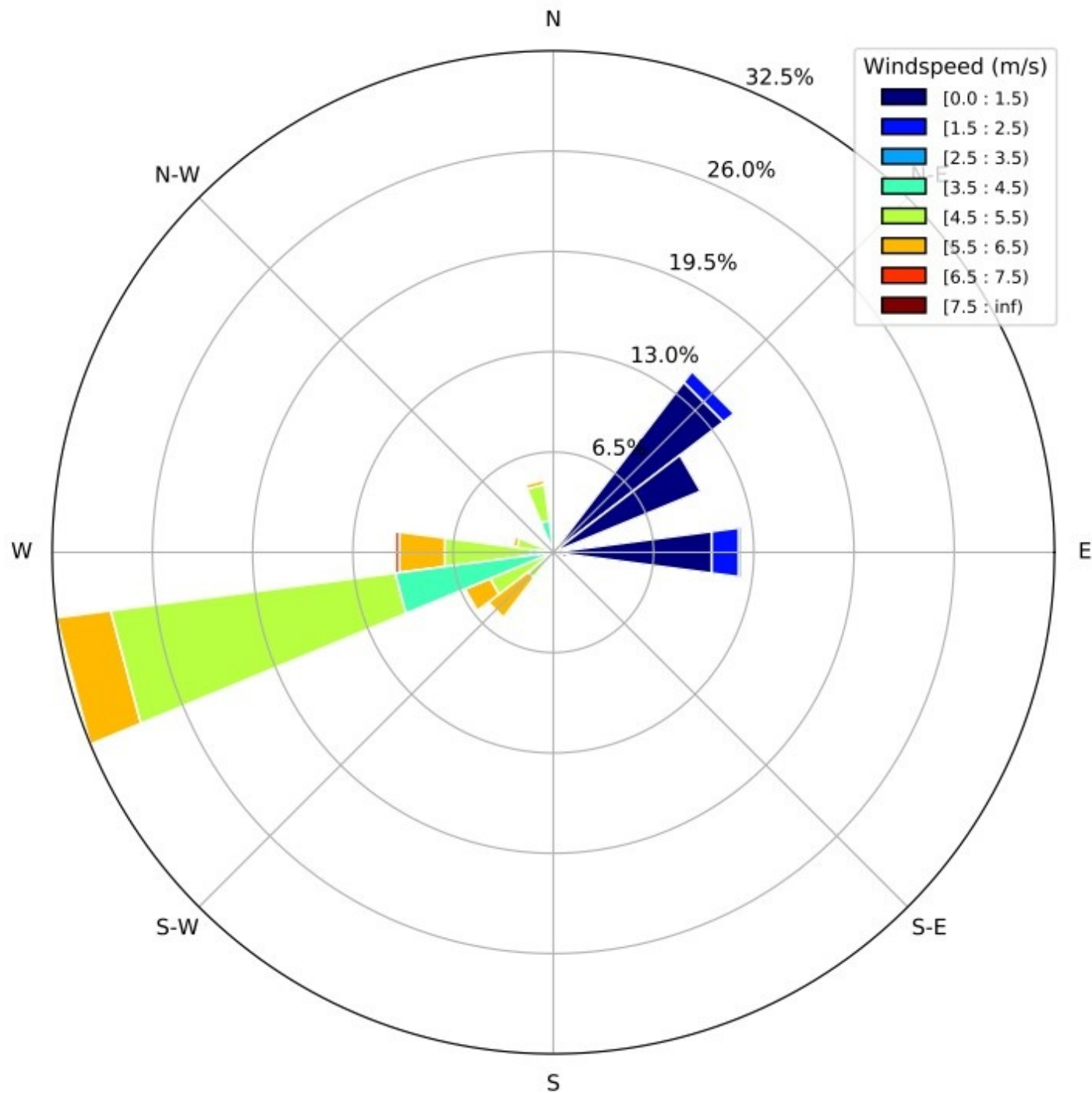


Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 26, 2019
Revision: 1

North Kent Wind Project
 Phase 1 R3214 I-Audit Report

Appendix C.1

Supplementary Wind Rose
 based on Assessment Data
 Total Noise

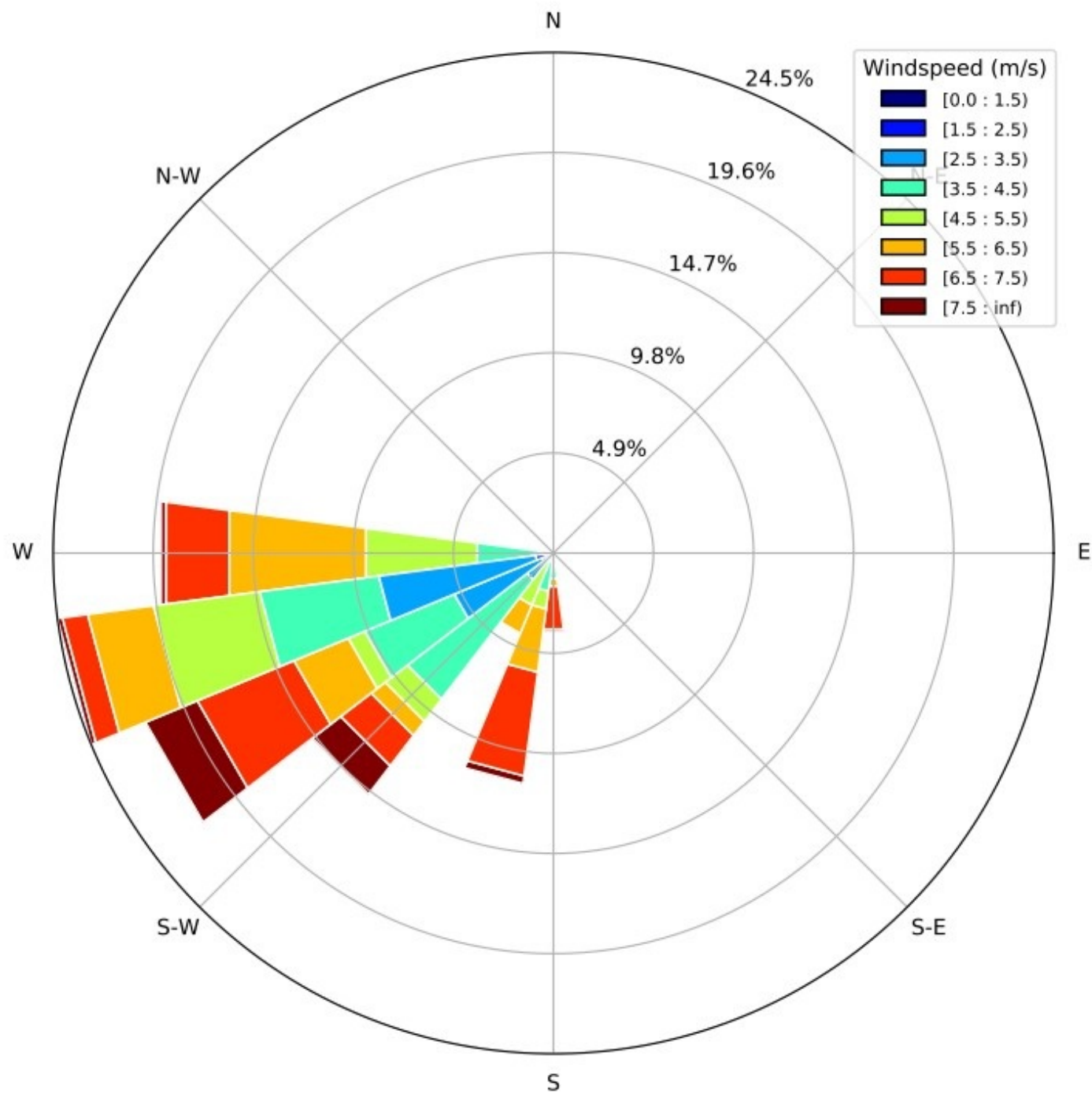


Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 26, 2019
Revision: 1

North Kent Wind Project
 Phase 1 R3214 I-Audit Report

Appendix C.2

Supplementary Wind Rose
 based on Assessment Data
 Background Noise

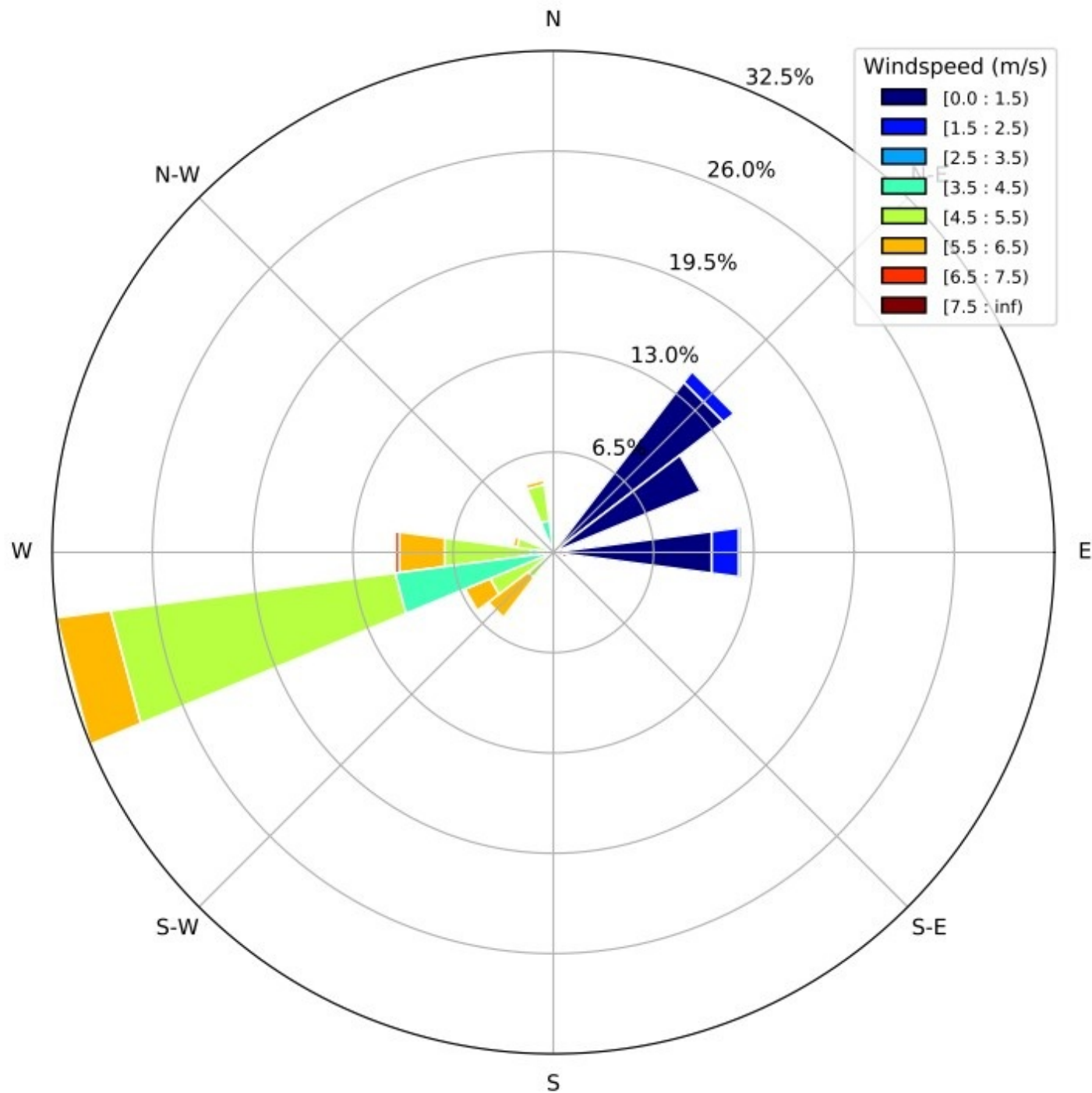


Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 26, 2019
Revision: 1

North Kent Wind Project
 Phase 1 R3214 I-Audit Report

Appendix C.1

Supplementary Wind Rose
 based on Assessment Data
 Total Noise



Project ID: 17283.01
Drawn by: MJ
Reveiwed by: MAD
Date: June 26, 2019
Revision: 1

North Kent Wind Project
 Phase 1 R3214 I-Audit Report

Appendix C.2

Supplementary Wind Rose
 based on Assessment Data
 Background Noise

Appendix D

Turbine Operational Statement from Operator



North Kent Wind 1 LP
2050 Derry Road West, 2nd Floor
Mississauga, Ontario L5N 0B9
www.northkentwind.ca

October 8, 2019

Director, Environmental Approvals Access and Service Integration Branch
Ministry of the Environment
2 St. Clair Avenue West, Floor 12A
Toronto ON M4V1L5

Subject: North Kent Wind 1 LP Renewable Energy Approval number 5272-A9FHRL Condition-Receptor "Phase 1 Receptor I- Audit".

Dear Director,

Please, accept this letter as confirmation that all turbines tested during the spring audit of 2019 acoustics measurement campaign conducted by Aercoustics LTD. From March 5, 2019 to June 17, 2019 were operating normally for the duration of the campaign, with the exception of specific time periods during which the turbines were placed in remote owner stop to facilitate ambient noise measurements.

The turbines placed in remote owner stop for ambient measurements were different depending on the receptor targeted, and were as follows:

- R3408: T03 and T04
- R3099: T15, T19, T23, T41 and T51
- R3214: T03, T04, T06, T07, T14, T15, T19, T23, T30, T31, T41 and T51.
- V6202: T03, T04, T06, T07, T14, T15, T19, T23, T30, T31, T41 and T51.
- R3281: T7, T30 and T31

The turbines verified for operational measurements across the five measurement locations were as follows:

- T03, T04, T06, T07, T12, T14, T15, T19, T23, T26, T27, T28, T30, T31, T32, T38, T39, T41, T42 T44, T45, T46, T49, T51 and T52.

Jonathan Miranda
Facility Manager Pattern Energy
North Kent Wind
C: (289) - 407-8387

Appendix E

Tonality Assessment

Appendix E - Tonality Assessment Summary

Project: North Kent Wind Power Project - 1st Acoustic Immission Audit R3214
Report ID: 17283.01

Page 1 of 1
Created on: 2020-02-20

R3214 78 Hz Tonality Summary ¹							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dBA)	MECP Sound Level Limit (dBA)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	**	**
1	0	0	**	**	40	**	**
2	13	4	31%	*	40	-1.2	0.0
3	115	12	10%	38	40	-2.1	0.0
4	196	22	11%	39	40	-1.4	0.0
5	132	20	15%	40	40	-1.9	0.0
6	150	5	3%	40	40	-1.4	0.0
7	149	2	1%	*	43	3.4	0.0

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

** No data points at wind speed

¹ Critical bandwidth used for assessment of 28 Hz - 128 Hz. Tones of same origin assessed between 53 Hz and 103 Hz

Appendix E – Tonality Assessment Summary Supporting Explanation

The calculation of Tonal Audibility in accordance with IEC 61400-11 Ed. 3.0 is defined in Section 9.5 of the standard. Here is an excerpt:

Tones of the same origin are defined as follows: Identified tones in different spectra are considered as tones of the same origin if they are within an interval $\pm 25\%$ of the critical band centered at the frequency. Tones of the same origin are treated and reported as one tone.

For each spectrum with identified tone, j , in each wind speed bin

- The sound pressure level of the tone $L_{pt,j,k}$ shall be determined.
- The sound pressure level of the masking noise $L_{pn,j,k}$ in the critical band around the tone shall be determined.
- The tonality $\Delta L_{tn,j,k}$, the difference between the sound pressure level of the tone and the masking noise level, shall be found.
- The tonal audibility $\Delta L_{a,j,k}$, the difference between the tonality and the audibility criterion of the tone, shall be found.

The overall tonal audibility, $\Delta L_{a,k}$, is determined in each wind speed bin for each of the identified tones of the same origin as the energy average of the individual $\Delta L_{a,j,k}$. Only spectra with identified tones are included.

Step 1) Identifying tones of the same origin to determine the sound pressure level of the tone ($L_{pt,j,k}$)

In accordance with the standard, we calculate the critical band with the following formula:

$$\text{Critical bandwidth} = 25 + 75 \cdot \left(1 + 1.4 \cdot \left[\frac{f_c}{1000} \right]^2 \right)^{0.69} \quad (30)$$

With the example of 78 Hz, this formula results in a critical bandwidth of 100 Hz.

Tones of the same origin are then identified using the guidance highlighted in yellow above, which stipulates that “tones in different spectra are considered tones of the same origin if they are within an interval of $\pm 25\%$ of the critical band centered at the frequency.”

With the example of 78 Hz, 25% of 100 Hz is 25 Hz. Therefore, tones of the same origin are identified between 78 Hz – 25 Hz and 78 Hz + 25 Hz, resulting in a range of 53 Hz and 103 Hz.

These are then used to calculate the sound pressure level of the tone ($L_{pt,j,k}$).

Step 2) Identify the sound pressure level of the masking noise ($L_{pn,j,k}$)

In accordance with the standard, masking noise is determined based on the critical band.

With the example of 78 Hz, masking noise is counted if it falls between 28 Hz and 128 Hz, since the critical band is 100 Hz.

Appendix F

Calibration Certificates

Calibration Certificates –

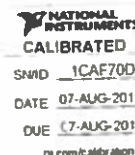
Details are disclosed in the table below regarding the calibration of the equipment used for the Phase 1 I-Audit campaign at monitor location R3214. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
R3214	Data Acquisition Card	NI 9234	1CAF70D	2018-08-07
	Signal Conditioner	PCB 480E09	35339	2018-07-25
	Microphone/ Pre-Amplifier Pair	PCB378B02	132222	2018-08-08
	Microphone	PCB 377B02	132222	2018-08-08
	Pre-Amplifier	PCB 426E01	051466	2018-08-08
	Weather Anemometer	Vaisala WXT 520	M0410647	2018-07-02

Compliant Calibration Certificate

Template Revision: Feb2018

Certificate Number:	5706515.1	OE Number:	21460701
Date Printed:	07-AUG-2018	Page:	1 of 14
Customer:	Aercooustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	Model:	NI 9234
Serial Number:	1CAF70D		
Part Number:	195551C-01L	Description:	MODULE ASSY, NI 9234, 4 AI CONFIGURABLE
Calibration Date:	07-AUG-2018	Recommended Calibration Due:	07-AUG-2019
Procedure Name:	NI 9234	Verification Results:	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	Calibration Executive Version:	4.5.0.0
Lab Technician:	Justin Rees	Driver Info:	NI-DAQmx:17.1.0
Temperature:	23.0° C	Humidity:	46.8% RH



The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments.
As Left The calibration data of the unit when returned from National Instruments.

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

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

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

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

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

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

Victor Peña
Technical Manager

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



Calibration Notes

Type	Note
Asset	Verification only was performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
Fluke	5700A/EP	Calibrator	3132	19-OCT-2018	
National Instruments	PXI-4461	Function generator	9383	25-APR-2019	
National Instruments	PXI-4071	Digital multimeter	8683	14-FEB-2019	
National Instruments	PXI-4132	SMU	9172	23-OCT-2018	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99981 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	-0.00003 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99984 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99989 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00001 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-3.99988 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99987 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00008 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00000 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	3.99990 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00002 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99991 V	-3.99520 V	Passed	

As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	

As Found

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.014 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.011 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	0.014 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.009 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.133 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.105 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	0.133 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.074 Degrees	0.490 Degrees	Passed	

As Found

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	75.639 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	74.216 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	75.538 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	74.949 dB	100.000 dB	Passed	

As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.092 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.072 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.071 mA	2.200 mA	Passed	

As Found

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.851 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.859 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.859 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.857 V	24.000 V	Passed	

As Left

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99981 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	-0.00003 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99984 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99989 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00001 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-3.99988 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99987 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00008 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00000 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	3.99990 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00002 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99991 V	-3.99520 V	Passed	

As Left

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	

As Left

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.014 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.011 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	0.014 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.009 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.133 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.105 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	0.133 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.074 Degrees	0.490 Degrees	Passed	

As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	75.639 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	74.216 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	75.538 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	74.949 dB	100.000 dB	Passed	

As Left

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.092 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.072 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.071 mA	2.200 mA	Passed	

As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.851 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.859 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.859 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.857 V	24.000 V	Passed	

CERTIFICATE of CALIBRATION

Make : PCB Piezotronics

Reference # : 153403

Model : 480E09

Customer : Aeroustics Engineering Ltd
Mississauga, ON

Descr. : Conditioning Amplifier

Serial # : 00035339

P. Order : 2018.07.18C

Asset # : 01213

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

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

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

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jul 25, 2018

By : 

Cal. Due : Jul 25, 2020

Petro Onasko

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

Standards used : J-255 J-367 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7

Phone : 905 565 1584

Fax: 905 565 8325

<http://www.navair.com>

e-Mail: service@navair.com

The copyright of this document is the property of Navair Technologies
Any reproduction other than in full requires written approval!

Form: 480E09	Approved by: JR	Jun-18	ver 1.2
--------------	-----------------	--------	---------

Calibration Report for Certificate :

153403

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00035339	01213

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

Gain accuracy at 1kHz

Gain Set	Input	V					
x1	1.000 V		0.9800	1.0000	1.0200		In
x10	0.100 V		0.9800	0.9998	1.0200		In
x100	0.010 V		0.9800	1.0006	1.0200		In

Gain Flatness

X1

I/P

%

10 Hz	1.000 V		-5.0	0.0	5.0		In
10 kHz	1.000 V		-5.0	0.0	5.0		In
50 kHz	1.000 V		-5.0	0.1	5.0		In
100 kHz	1.000 V		-5.0	0.4	5.0		In

X10

I/P

%

10 Hz	0.100 V		-5.0	0.0	5.0		In
10 kHz	0.100 V		-5.0	0.0	5.0		In
50 kHz	0.100 V		-5.0	0.2	5.0		In
100 kHz	0.100 V		-5.0	-0.9	5.0		In

X100

I/P

%

10 Hz	0.010 V		-5.0	0.0	5.0		In
10 kHz	0.010 V		-5.0	0.8	5.0		In
50 kHz	0.010 V		-5.0	1.2	5.0		In

CERTIFICATE of CALIBRATION

Make : PCB Piezotronics

Reference # : 153595

Model : 378B02

Customer : Aercoustics Engineering Ltd
Mississauga, ON

Descr. : Microphone System 1/2" Free Field

Serial # : 132222

P. Order : 2018.08.03C

Asset # : 01167

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

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

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

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Aug 08, 2018

By : 

Cal. Due : Aug 08, 2020

Petro Onasko

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

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

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7

Phone : 905 565 1584

Fax: 905 565 8325

<http://www.navair.com>

e-Mail: service@navair.com

The copyright of this document is the property of Navair Technologies

Any reproduction other than in full requires written approval!

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

Calibration Report for Certificate :

153595

Make			Model	Serial		Asset
PCB Piezotronics			378B02	132222		01167
PCB Piezotronics			377B02	177780		

Sensitivity at 250Hz

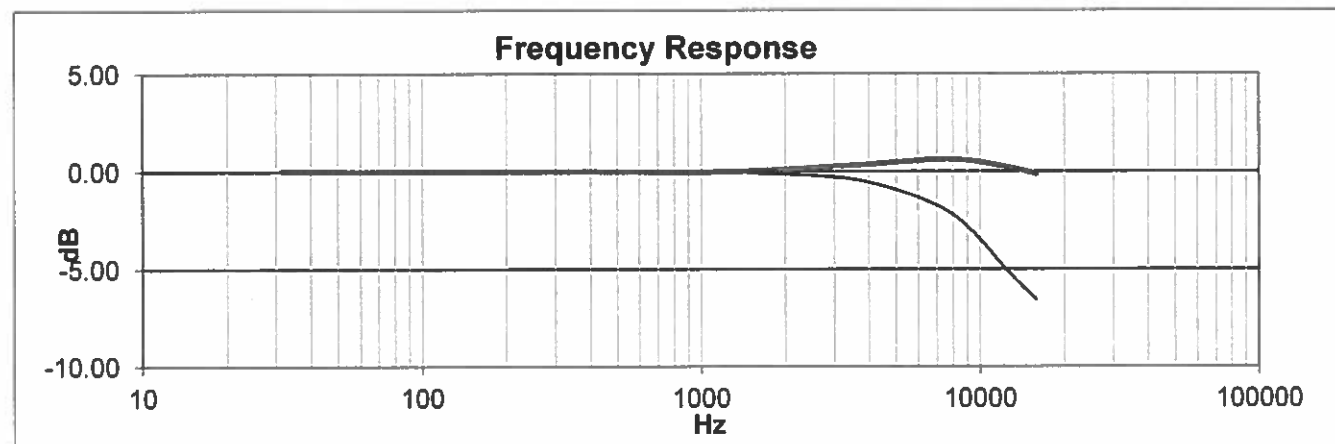
Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	44.62	62.94	In
-26.02	dB re 1V/Pa	-28.02	-27.01	-24.02	In
0	dB re 50mV/Pa	-2	-0.99	2	In

Ambient Conditions: Static Pressure 99.0 kPa
Temperature 23.5°C
Rel.Humidity 55.0%

Frequency response

	Lower	Upper
Freq	Pressure	Free Field
Hz	dB	dB
31.5	0.00	0.03
63.1	0.01	0.00
125.9	0.00	-0.01
251.3	0.00	0.00
502.5	-0.01	-0.02
1005.1	-0.05	-0.04
1978.7	-0.13	0.10
3957.5	-0.54	0.36
7914.9	-2.16	0.62
12663	-5.18	0.20
15830	-6.58	-0.14

ref





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: 18.US1.02880

Date of issue: July 02, 2018

Type: Vaisala Weather Transmitter, WXT520

Serial number: M0410647

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: June 29, 2018

Anemometer calibrated: June 29, 2018

Calibrated by: MEJ

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

Certificate prepared by: EJF

Approved by: Calibration engineer, EJF

Calibration equation obtained: $v \text{ [m/s]} = 1.00791 \cdot f \text{ [m/s]} + -0.05585$

Standard uncertainty, slope: 0.00217

Standard uncertainty, offset: -0.41559

Covariance: -0.0000476 (m/s)²/m/s

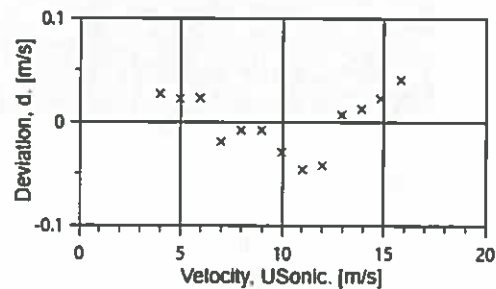
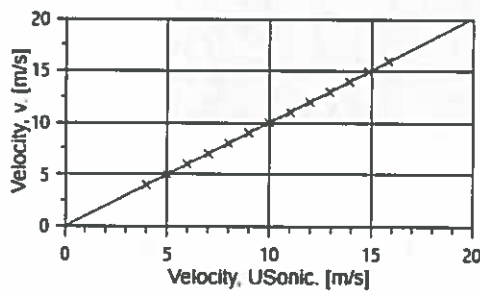
Coefficient of correlation: $\rho = 0.999974$

Absolute maximum deviation: -0.046 m/s at 10.995 m/s

Barometric pressure: 999.7 hPa

Relative humidity: 50.8%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.08	28.0	27.7	3.976	3.9733	0.027	0.021
4	14.27	28.0	27.7	4.985	4.9793	0.022	0.023
6	20.54	28.0	27.7	5.981	5.9667	0.023	0.026
8	27.97	28.0	27.7	6.980	7.0000	-0.019	0.029
10	36.64	28.0	27.7	7.989	7.9900	-0.008	0.033
12	46.54	28.0	27.7	9.004	8.9967	-0.008	0.037
13-last	57.22	28.0	27.7	9.983	9.9897	-0.030	0.041
11	69.40	28.0	27.7	10.995	11.0100	-0.046	0.045
9	82.24	28.0	27.7	11.970	11.9733	-0.042	0.049
7	96.79	28.0	27.7	12.987	12.9333	0.007	0.053
5	112.00	28.0	27.7	13.970	13.9033	0.012	0.057
3	128.00	28.0	27.7	14.934	14.8500	0.022	0.061
1-first	145.85	27.9	27.7	15.940	15.8300	0.040	0.065



AC-1746



EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

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

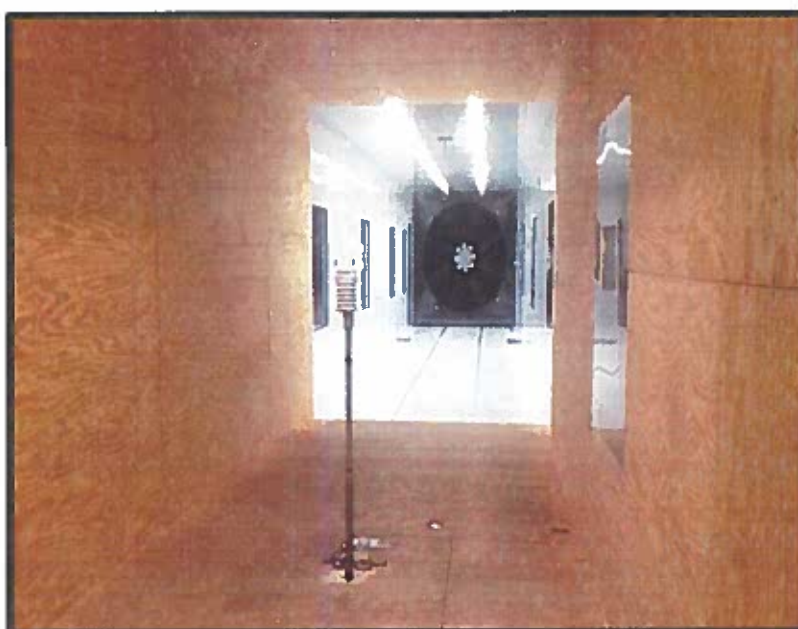


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

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

COMMENTS

This sensor was calibrated at 0°.

Certificate number: 18.US1.02880

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



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: 18.US1.02884

Date of issue: July 02, 2018

Type: Vaisala Weather Transmitter, WXT520

Serial number: M0410647

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

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

Anemometer received: June 29, 2018

Anemometer calibrated: June 29, 2018

Calibrated by: MEJ

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

Certificate prepared by: EJF

Approved by: Calibration engineer, EJF

Calibration equation obtained: $v [m/s] = 1.01025 \cdot f [m/s] + 0.08730$

Standard uncertainty, slope: 0.00243

Standard uncertainty, offset: 0.29473

Covariance: -0.0000591 (m/s)²/m/s

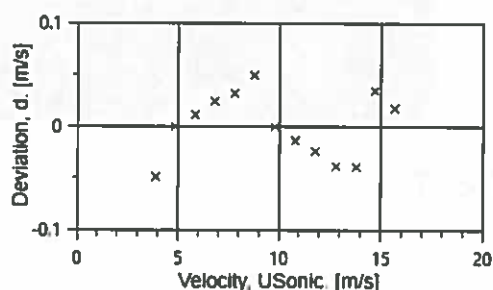
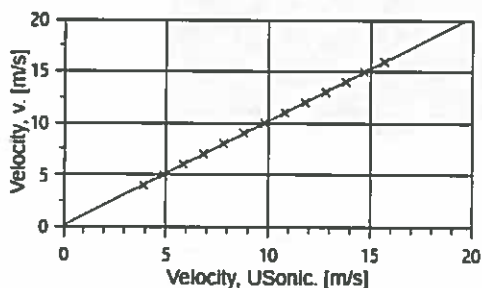
Coefficient of correlation: $\rho = 0.999967$

Absolute maximum deviation: -0.049 m/s at 3.971 m/s

Barometric pressure: 999.7 hPa

Relative humidity: 50.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.05	28.1	27.7	3.971	3.8933	-0.049	0.021
4	14.24	28.1	27.7	4.981	4.8448	-0.001	0.023
6	20.62	28.1	27.7	5.995	5.8367	0.011	0.026
8	28.10	28.1	27.7	6.998	6.8167	0.024	0.029
10	36.75	28.1	27.7	8.002	7.8033	0.032	0.033
12	46.55	28.1	27.7	9.006	8.7800	0.049	0.037
13-last	57.24	28.1	27.7	9.987	9.8000	-0.001	0.041
11	69.31	28.1	27.7	10.991	10.8067	-0.014	0.045
9	82.35	28.1	27.7	11.981	11.7967	-0.024	0.049
7	96.85	28.1	27.7	12.993	12.8133	-0.039	0.053
5	112.21	28.1	27.7	13.986	13.7967	-0.039	0.057
3	128.60	28.1	27.7	14.972	14.7000	0.034	0.061
1-first	145.83	28.0	27.7	15.942	15.6767	0.017	0.065



AC-1746



EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

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



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

UNCERTAINTIES

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

COMMENTS

This sensor was calibrated at 90°.

Certificate number: 18.US1.02884

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

Power Thresholds for 90% Sound Power

Appendix G - Power Thresholds for 90% Sound Power

Project: North Kent Wind Power Project - 1st Acoustic Immission Audit

Report ID: 17283.01

Page 1 of 1

Created on: 2019-06-26

*Wind bins for interpolation are highlighted in light blue

Table G.1: NKWPP 2.772 MW Turbine - Measured Power and Sound Power

T36 (2.772 MW) E-Audit Test Results Summary [4]												
IEC 61400-11 Test	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Power (kW)	1236	1481	1766	2051	2291	2530	2629	2727	2748	2768	2770	#N/A
SPL (dBA)	101.4	102.9	103.3	103.3	103.2	103.1	103.0	102.6	102.4	102.4	102.1	#N/A

Table G.2: NKWPP 2.942 MW Turbine - Measured Power and Sound Power

T33 (2.942 MW) E-Audit Test Results Summary [5]												
IEC 61400-11 Test	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Power (kW)	#N/A	1483	1774	2065	2328	2591	2728	2865	2900	2934	2938	2942
SPL (dBA)	#N/A	103.0	104.1	104.4	104.5	104.3	104.0	103.9	103.8	103.6	103.6	103.3

Table G.3: NKWPP 3.2 MW Turbine - Measured Power and Sound Power

T06 (3.2 MW) E-Audit Test Results Summary [6]												
IEC 61400-11 Test	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Power (kW)	#N/A	1485	1785	2085	2384	2683	2879	3074	3130	3186	3193	3199
SPL (dBA)	#N/A	103.9	105.3	106.1	106.1	105.6	105.5	105.6	105.5	105.5	105.2	105.4

Table G.4: Power Thresholds for 90% Sound Power

	maximum sound power level (dBA)	90% sound power level (dBA)	electrical power at 90% sound level (kW)	percentage of rated power
2.772 MW	103.3	102.9	1489	54%
2.942 MW	104.5	104.0	1749	59%
3.2 MW	106.1	105.7	1923	60%

Appendix H

I-Audit Checklist

Appendix H7: 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 $\pm 0.5\text{dB}$)? 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	✓	To ensure conservative results, 90% Sound Power filter was used in place of 85% Power filter: See Section 6.3 and Appendix G for justification.