

ASSESSMENT REPORT - Project: 14284.00

Grand Renewable Wind Farm – 2nd Immission Audit Receptor Measurements

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Prepared for:

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18 April 2016

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Executive Summary

Aercoustics Engineering Limited (“Aercoustics”) has been retained by Grand Renewable Wind L.P. to complete the acoustic audit outlined in the Renewable Energy Approval (“REA”) for the Grand Renewable Wind Farm (“GRWF”). GRWF operates under REA #0300-8UQPKR, issued on June 15, 2012.

This report details the second measurement campaign of the GRWF immission audit. Monitoring at R2885, R2956, and V3276 spanned from the following dates, respectively: January 21, 2016 to March 21, 2016; January 20, 2016 to March 21, 2016; and January 20, 2016 to March 18, 2016. Acoustic and weather data was logged simultaneously for the duration of the measurement campaign.

The audit has been completed as per the methodology outlined in Part D of the “*MOE Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement.*”

The turbine-only noise contribution was compared to the Ministry of Environment and Climate Change sound level limits and the facility was found to be in compliance.

1 Introduction

Aeroustics Engineering Limited (“Aeroustics”) has been retained by Grand Renewable Wind L.P. to complete the required acoustic audit outlined in the Renewable Energy Approval (“REA”) for the Grand Renewable Wind Farm (“GRWF”) [1]. GRWF operates under REA #0300-8UQPKR, issued on June 15, 2012.

The audit was completed as per the methodology outlined in Part D of the “*MOE Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement*”, [2] to fulfil Section E, “*Acoustic Audit – Immission*” of the REA. This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the Ontario Ministry of Environment and Climate Change (“MOECC”) sound level limits.

2 Facility Description

The GRWF utilizes 67 Siemens SWT-101 wind turbines for power generation, each having a nameplate capacity of either 2.221MW or 2.126MW. Each turbine has a hub height of 99.5 meters and a rotor diameter of 101 meters.

The facility operates 24 hours per day, 7 days per week.

3 Audit Details

The acoustic audit was conducted at receptors R2885, R2956, and V3276¹. Monitoring at R2885, R2956, and V3276 spanned from the following dates, respectively: January 21, 2016 to March 21, 2016; January 20, 2016 to March 21, 2016; and January 20, 2016 to March 18, 2016.

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

3.1 Test Equipment

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

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

¹ Receptor IDs taken from the Noise Assessment Report by Zephyr North, dated May 29, 2012 [3]

- One (1) primary and one (1) secondary windscreen for the microphone. The 1/3 Octave band insertion loss of the secondary windscreen has been tested, and was accounted for in the data analysis.
- One (1) anemometer programmed to sample weather data every 0.5 seconds. The anemometer was located 10m above grade, as defined by Section D3.4. Performance specifications comply with Part D, Section D.2.2 of the MOECC protocol.

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

Table 1 Equipment Details

Location	Equipment	Serial Number
GRWF R2885	B&K 2250 Sound Level Meter	3006579
	B&K 4189 Microphone	2919502
	B&K ZC 0032 Pre-amplifier	21158
	Vaisala WXT 520	J4830029
GRWF R2956	B&K 2250 Sound Level Meter	3004461
	B&K 4189 Microphone	2888697
	B&K ZC 0032 Pre-amplifier	20327
	Vaisala WXT 520	K0550007
GRWF V3276	B&K 2250 Sound Level Meter	2630243
	B&K 4189 Microphone	2237528
	B&K ZC 0032 Pre-amplifier	21913
	Vaisala WXT 520	K0630016

The sound level meter, microphone, and pre-amplifier were calibrated successfully before and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator with serial number 2513130.

3.2 Measurement Methodology

For the duration of the measurement campaign, acoustic and anemometer data was logged simultaneously in one-minute intervals. The measurement equipment was setup to log one minute equivalent sound levels (L_{eq}) in broadband and 1/3 octave bands between 20-20,000 Hz. The microphone was placed at a measurement height of 4.5m above grade, at least 5 meters 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. Measurement data was filtered into integer wind bins from 3 to 10 m/s. Each bin ranged from 0.5m/s below to 0.5m/s above each respective wind bin (i.e. 5 m/s data represents data between 4.5m/s and 5.5m/s).

A one-minute measurement interval was considered valid if:

- The interval occurred between 10pm – 5am
- No precipitation was detected within an hour before the interval
- The maximum measured wind speed at 10m was no more than 2m/s higher than the recorded average for that interval
- The temperature was above -10°C
- Either all nearby turbines were on (for turbine ON measurements), or all nearby turbines were off (for ambient measurements). The list of turbines parked for ambient measurements is provided in Section 3.6.
- The measured L_{eq} was no more than 6 dB greater than the L90 value

These filters were designed to obtain measurement data of the wind farm when it is fully operational, as well as reduce the amount of contamination from transient ambient noise sources such as vehicle passbys and dog barks. These filters also are based on equipment operating limitations, and the filters prescribed in the Part D of the Protocol to eliminate noise from precipitation, as well as noise on the microphone from gusty periods where the reliability of the data is reduced.

It should be noted that although the MOECC Protocol calls for data points to be excluded if the minimum wind speed at 10m is more than 2m/s less than the recorded average, this limitation was not employed on this data-set. The effect on the dataset of removing the minimum wind speed filter has been assessed at a number of locations and found to be insignificant; this study is provided in Appendix D.

3.3 Sample size requirements

In order to account for the dependence on wind speed of wind turbine noise and ambient noise, the measurement data is sorted into integer wind speed bins according to the measured wind speed. As per Section D3.8 of the MOECC protocol, at least 120 data points in each wind bin are required for Turbine ON measurements, and 60 data points for the ambient measurements.

3.4 Measurement Location

Receptors R2885, R2956, and V3276 were chosen to be representative of the worst-case impact from the facility. The receptors are located downwind from the predominant wind direction of the farm. R2885, R2956, and V3276 have a predicted impact of 39.9dBA, 39.8dBA, and 39.9dBA respectively, as per data provided in the Acoustic Assessment Report [3]. The following describes the measurement locations in relation to the above listed receptors:

- R2885: Measurement equipment was placed in an open field north west of R2885, 523m to the nearest turbine, on the west side of Port Maitland Road.
- R2956: Measurement equipment was placed in an open field directly west of R2956, 729m to the nearest turbine and 40 m south of a nearby stand of trees.
- V3276: Measurement equipment was placed in the open field on the property of V3276, 576m to the nearest turbine on the northwest corner of Kohler Road and Haldimand Road 20.

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

Table 2 Receptor Measurement Locations

Audit Receptor ID Nearest Turbine ID		R2885 T60	R2956 T54	V3276 T20
Receptor	UTM Coordinates (X,Y)	17T 615610mE 4747398mN	17T 608109mE 4746658mN	17T 593143mE 4749588mN
	Distance to Nearest Turbine	640 m	783 m	584 m
	Predicted Level dBA*	39.9	39.8	39.9
Monitor	UTM Coordinates (X,Y)	17T 615497mE 4747476mN	17T 608065mE 4746620mN	17T 593130mE 4749587mN
	Distance to Nearest Turbine	523 m	729 m	576 m

* Predicted level from Noise Assessment Report – Zephyr North [3]

3.5 Weather Conditions

Ambient conditions encountered over the measurement campaign were as follows:

- Ambient Humidity: 43% to 94%
- Ambient Temperature: -15°C to 9°C
- 10m Wind Speed: 0 m/s to 16 m/s

Historically, the predominant wind direction is from the south-west for this site. The wind direction varied over the course of the audit campaign. Wind roses have been provided in Appendix B that show the measured 10m wind direction at each receptor averaged for all Turbine ON measurements. 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 GRWF. Measurement data at each receptor was filtered to include only intervals when all turbines in the immediate vicinity were operational, or, in the case of the ambient noise measurements, were not operational. The turbines included in this study were chosen such that when they are turned off, the partial impact of the remaining turbines was less

than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were T01, T03, T07, T08, T10, T16, T20, T24, T48, T54, T60, T61, T62, T63, T64 and T69.

4 Sound Level Limits

The purpose of the sound measurements was to confirm whether the sound emitted by the wind facility is in compliance with the MOECC allowable sound level limits. The MOECC sound level limits for wind turbines vary with wind speed defined at a 10m height. The details of the sound level limits are presented in Table 3 below.

Table 3 MOECC Sound Level Limits for Wind turbines

Wind speed at 10m height [m/s]	MOECC Sound level limit [dBA]
≤ 4	40
5	40
6	40
7	43
8	45
9	49

5 Audit Results

The following tables detail the sound levels measured at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF).

Table 4 R2885 Sound levels measured for Turbine ON and OFF

Wind speed at 10m height [m/s]		4	5	6	7
Turbine ON	Number of Samples	657	443	252	131
	LAeq [dBA]	40	42	45	47
	Std Dev [dBA]	2.7	2.0	1.6	1.5
Turbine OFF	Number of Samples	281	287	176	77
	LAeq [dBA]	37	40	43	47
	Std Dev [dBA]	2.7	2.2	1.6	1.6
Turbine ONLY		37	37	40	37

Table 5 R2956 Sound levels measured for Turbine ON and OFF

Wind speed at 10m height [m/s]		4	5	6	7
Turbine ON	Number of Samples	688	483	320	131
	LAeq [dBA]	41	45	48	52
	Std Dev [dBA]	3.6	3.3	2.0	2.5
Turbine OFF	Number of Samples	93	89	97	133
	LAeq [dBA]	42	44	49	53
	Std Dev [dBA]	2.5	1.8	1.8	1.6
Turbine ONLY		*	36	*	*

*measured Turbine OFF level exceeds Turbine ON level, no Turbine ONLY level could be determined

Table 6 V3276 Sound levels measured for Turbine ON and OFF

Wind speed at 10m height [m/s]		4	5	6	7
Turbine ON	Number of Samples	520	252	267	276
	LAeq [dBA]	39	42	44	46
	Std Dev [dBA]	4.8	3.4	1.6	1.5
Turbine OFF	Number of Samples	52**	67	149	147
	LAeq [dBA]	31	37	41	45
	Std Dev [dBA]	3.1	2.6	1.8	2.4
Turbine ONLY		38	40	40	37

**No. of samples deficient by 8 samples

Fifty-two (52) data points were collected at 4 m/s at V3276. This deviation from the protocol's requirements is considered minor and does not affect the conclusion of the report. Further, the measured Turbine ON level at this location and wind speed is compliant with the MOECC limits without a background correction.

The following figures are the plots of the measured sound levels at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Note that all plots include the 95% confidence interval as a dashed line above and below the average value.

Figure 1 R2885 Measured Turbine ON levels

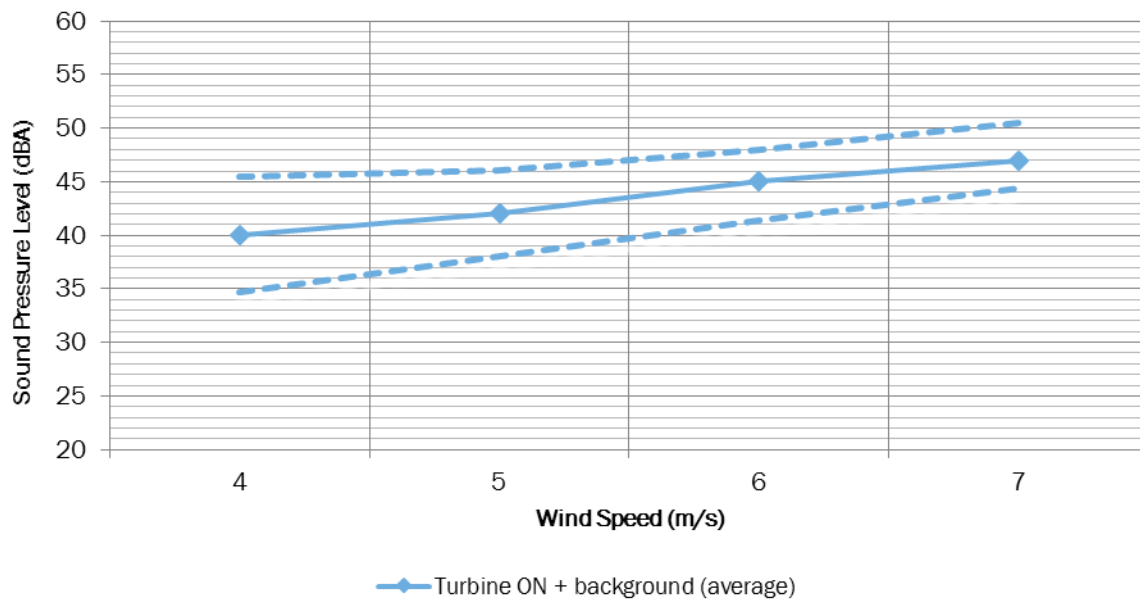


Figure 2 R2885 Measured Turbine OFF (Background) levels

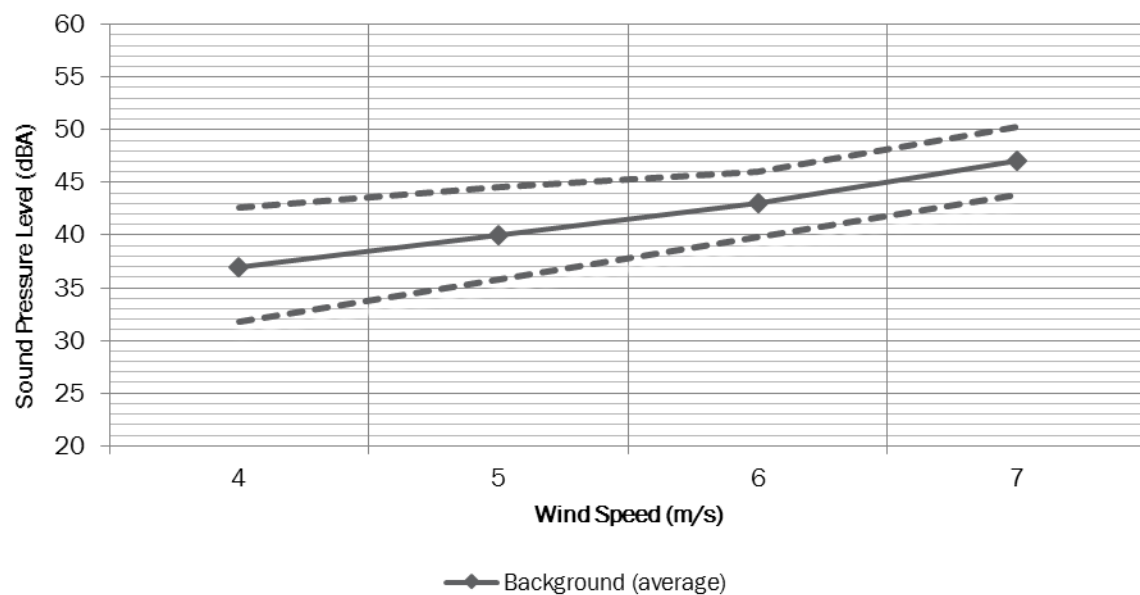


Figure 3 R2956 Measured Turbine ON levels

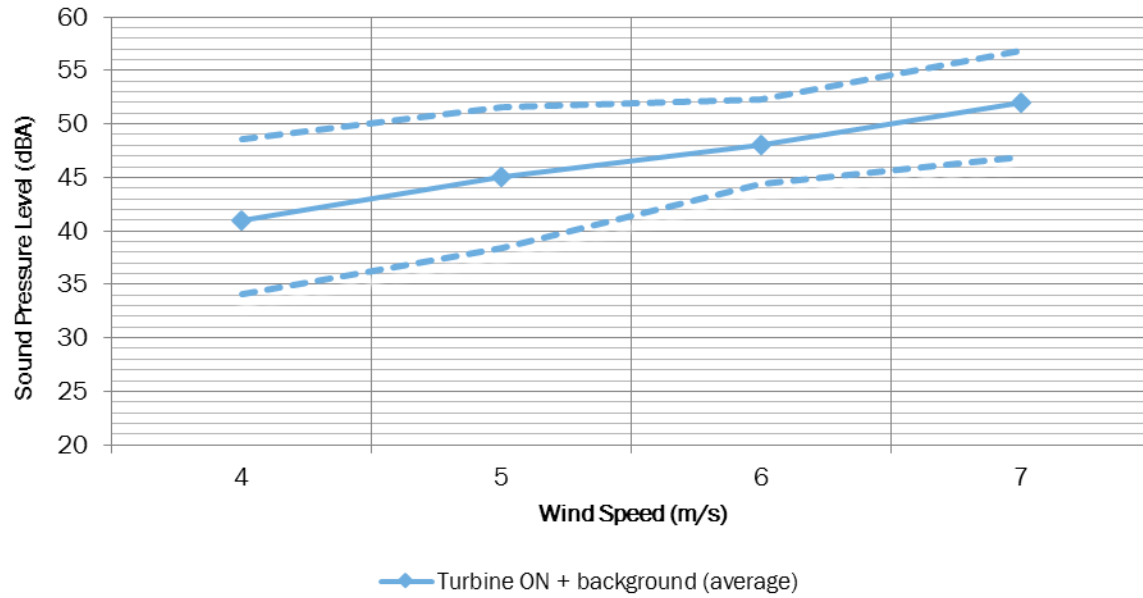


Figure 4 R2956 Measured Turbine OFF (Background) levels

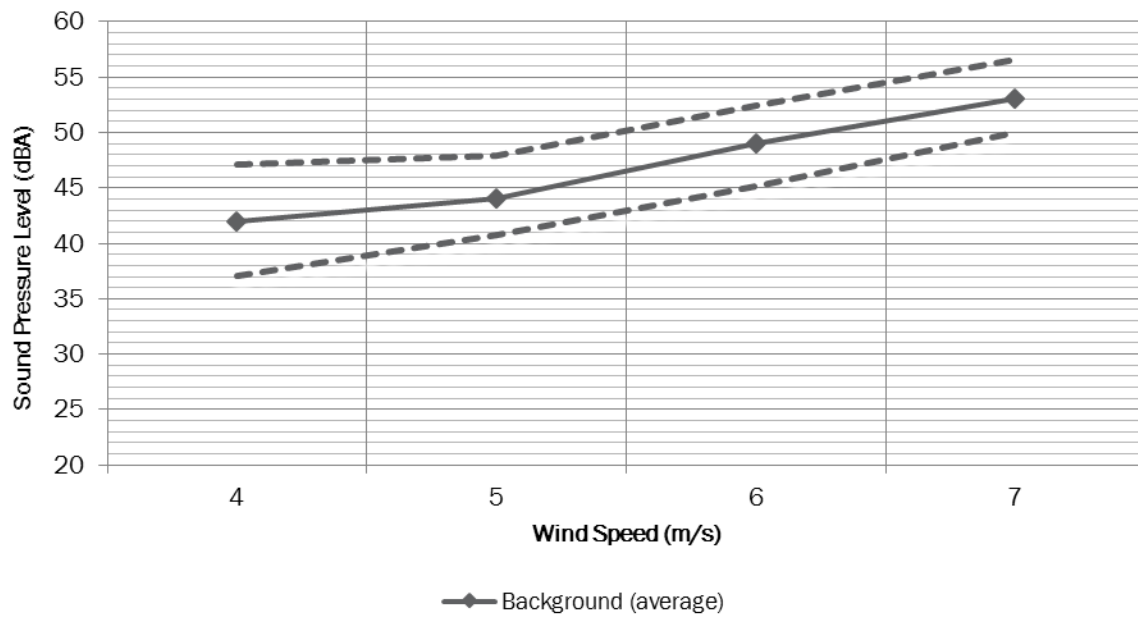


Figure 5 V3276 Measured Turbine ON levels

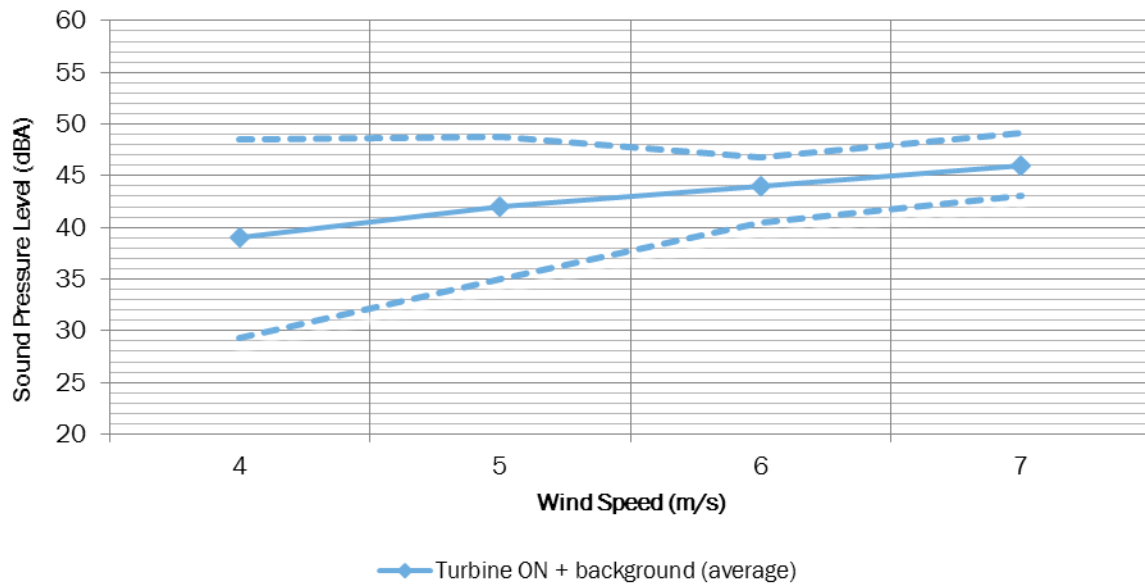
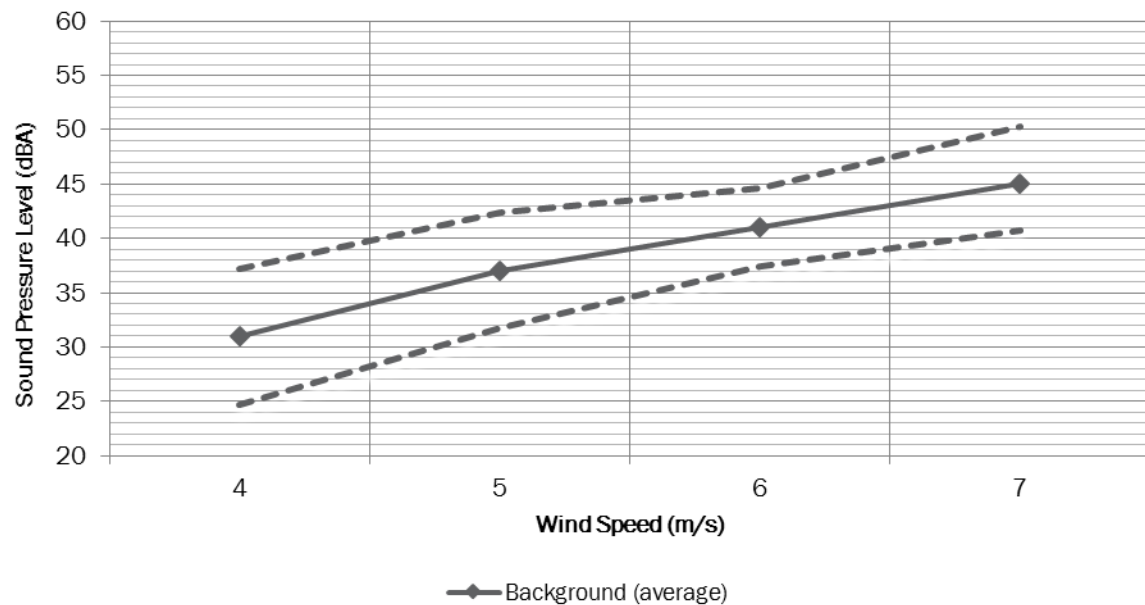


Figure 6 V3276 Measured Turbine OFF (Background) levels



6 Discussion

6.1 Overall Sound Level

The turbine-only component of the sound level was derived from a logarithmic subtraction of the ambient noise from that of the sound level measured with the turbines operating. The resulting sound level can be attributed to the turbines. It should be noted that all values in Table 7 have been rounded to the nearest integer. Calculated Turbine ONLY levels listed were calculated based on unrounded Turbine ON and Turbine OFF values.

To ensure conservative results and improved signal to noise, all monitors were erected in locations that were closer to the wind farm than their corresponding receptors. The effect of the closer measurement locations was higher sound levels from the turbines than would have been measured at the receptor location itself. Although all monitor locations show compliance without any distance correction, a correction has been applied to R2885 to be consistent with the audit completed in the fall of 2015.

The distance correction applied to R2885 was based on the difference in the predicted sound level between the receptor and monitor locations. This difference was determined using the CadnaA model used for the Noise Assessment Report [3]. As a result 1.5 dB was subtracted from the Turbine ONLY sound level at the R2885 receptor location.

Insufficient data was collected at 4 m/s at V3276. In this case, however, the measured Turbine ON value indicates compliance with the MOECC limits without any background correction. For this reason, the discrepancy does not affect the conclusion of the report.

Table 7 Assessment Table

Measurement Location	Wind speed at 10m height [m/s]	4	5	6	7
R2885	Turbine ON LAeq [dBA]	40	42	45	47
	Turbine OFF LAeq [dBA]	37	40	43	47
	Calculated Turbine ONLY LAeq [dBA]	37	37	40	37 [†]
	Calculated level at R2885	35	36	39	36
R2956	Turbine ON LAeq [dBA]	41	45	48	52
	Turbine OFF LAeq [dBA]	42	44 [†]	49	53
	Calculated Turbine ONLY LAeq [dBA]	*	36	*	*
V3276	Turbine ON LAeq [dBA]	39	42	44	46
	Turbine OFF LAeq [dBA]	31 ^{**}	37	41	45
	Calculated Turbine ONLY LAeq [dBA]	38	40	40	37 [†]
MOECC Limit		40	40	40	43

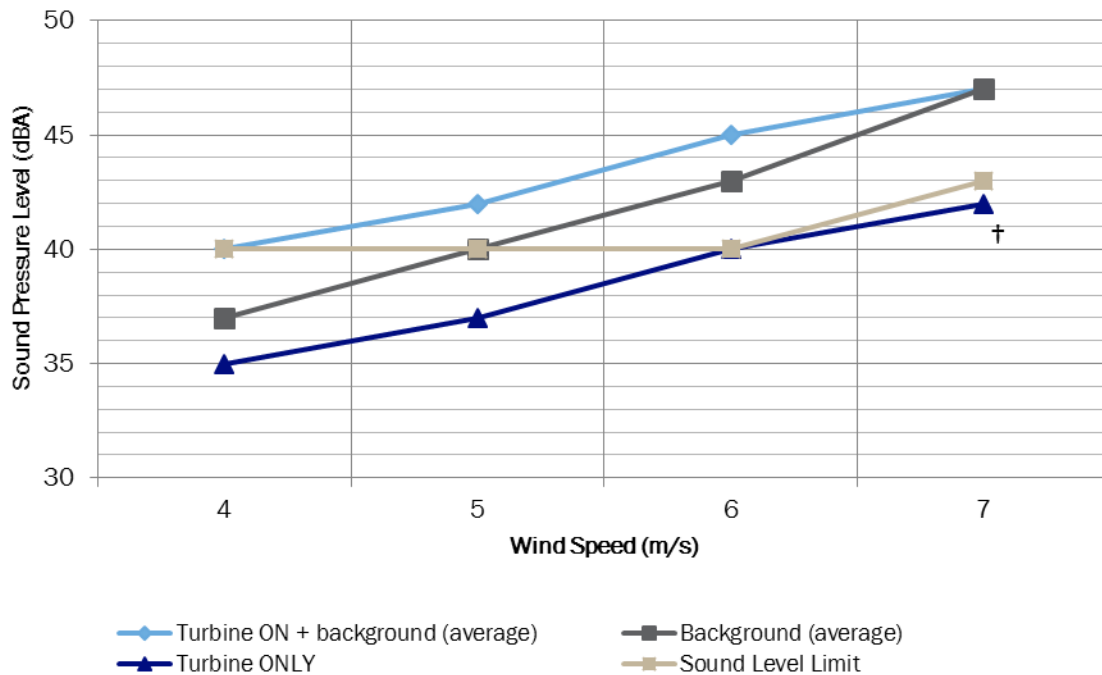
[†] Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB the measured Turbine ON level.

* Measured Turbine OFF level exceeds Turbine ON level, Turbine ONLY level in determinant

**No. of samples deficient by 8 sample

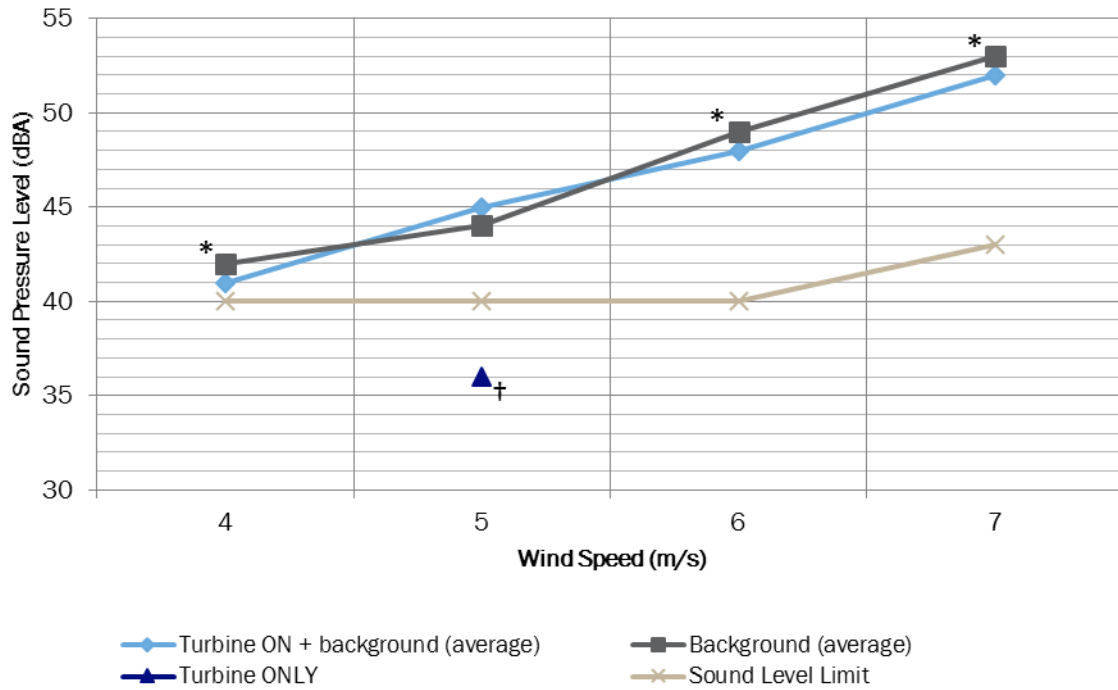
The data from Table 7 is plotted in Figures 7, 8 and 9.

Figure 7 R2885 Turbine Levels compared to MOECC Limits



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

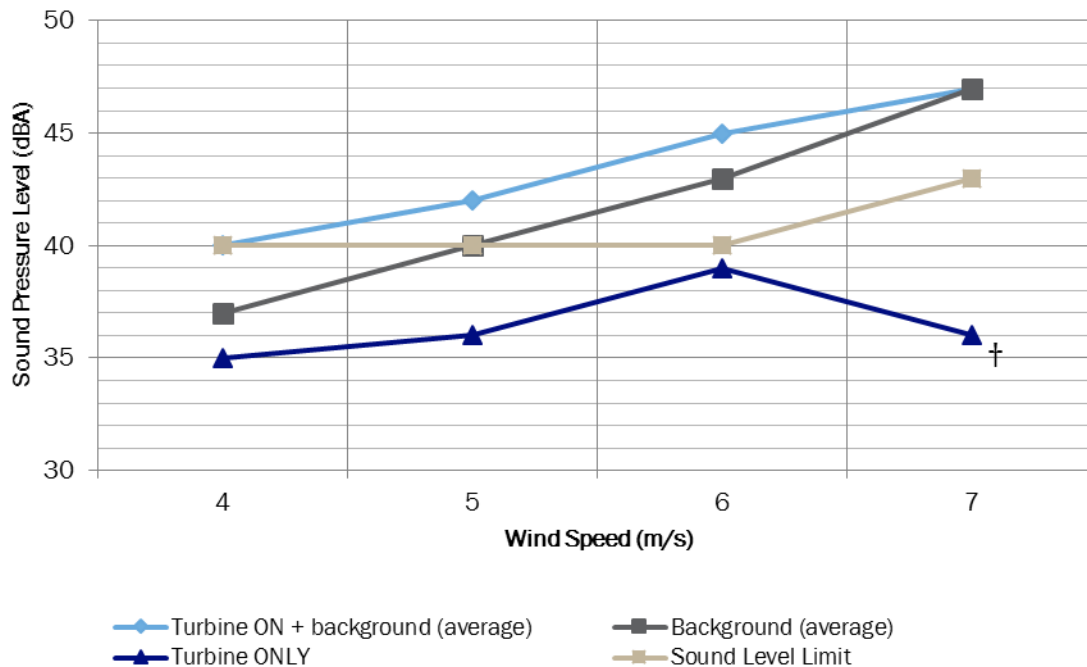
Figure 8 R2956 Turbine Levels compared to MOECC Limits



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

* Measured Turbine OFF level exceeds Turbine ON level, no Turbine ONLY level could be determined

Figure 9 V3276 Turbine Levels compared to MOECC Limits



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

6.2 Tonality

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

7 Assessment of Compliance

Based on the calculated turbine-only component indicated in To ensure conservative results and improved signal to noise, all monitors were erected in locations that were closer to the wind farm than their corresponding receptors. The effect of the closer measurement locations was higher sound levels from the turbines than would have been measured at the receptor location itself. Although all monitor locations show compliance without any distance correction, a correction has been applied to R2885 to be consistent with the audit completed in the fall of 2015.

The distance correction applied to R2885 was based on the difference in the predicted sound level between the receptor and monitor locations. This difference was determined using the CadnaA model used for the Noise Assessment Report [3]. As a result 1.5 dB was subtracted from the Turbine ONLY sound level at the R2885 receptor location.

Insufficient data was collected at 4 m/s at V3276. In this case, however, the measured Turbine ON value indicates compliance with the MOECC limits without any background correction. For this reason, the discrepancy does not affect the conclusion of the report.

Table 7 and Figures 7-9, the Grand Renewable Wind Farm is compliant with MOECC limits at all receptors.

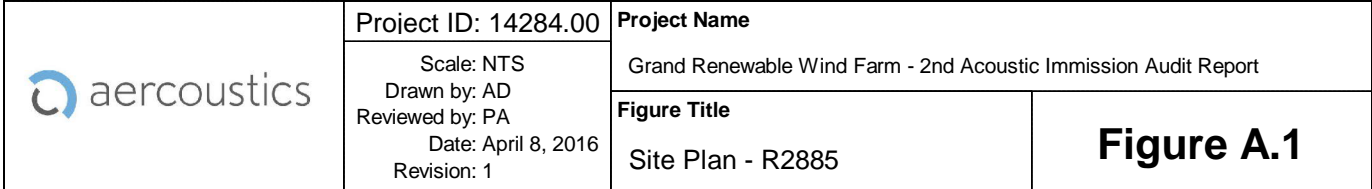
8 Conclusion

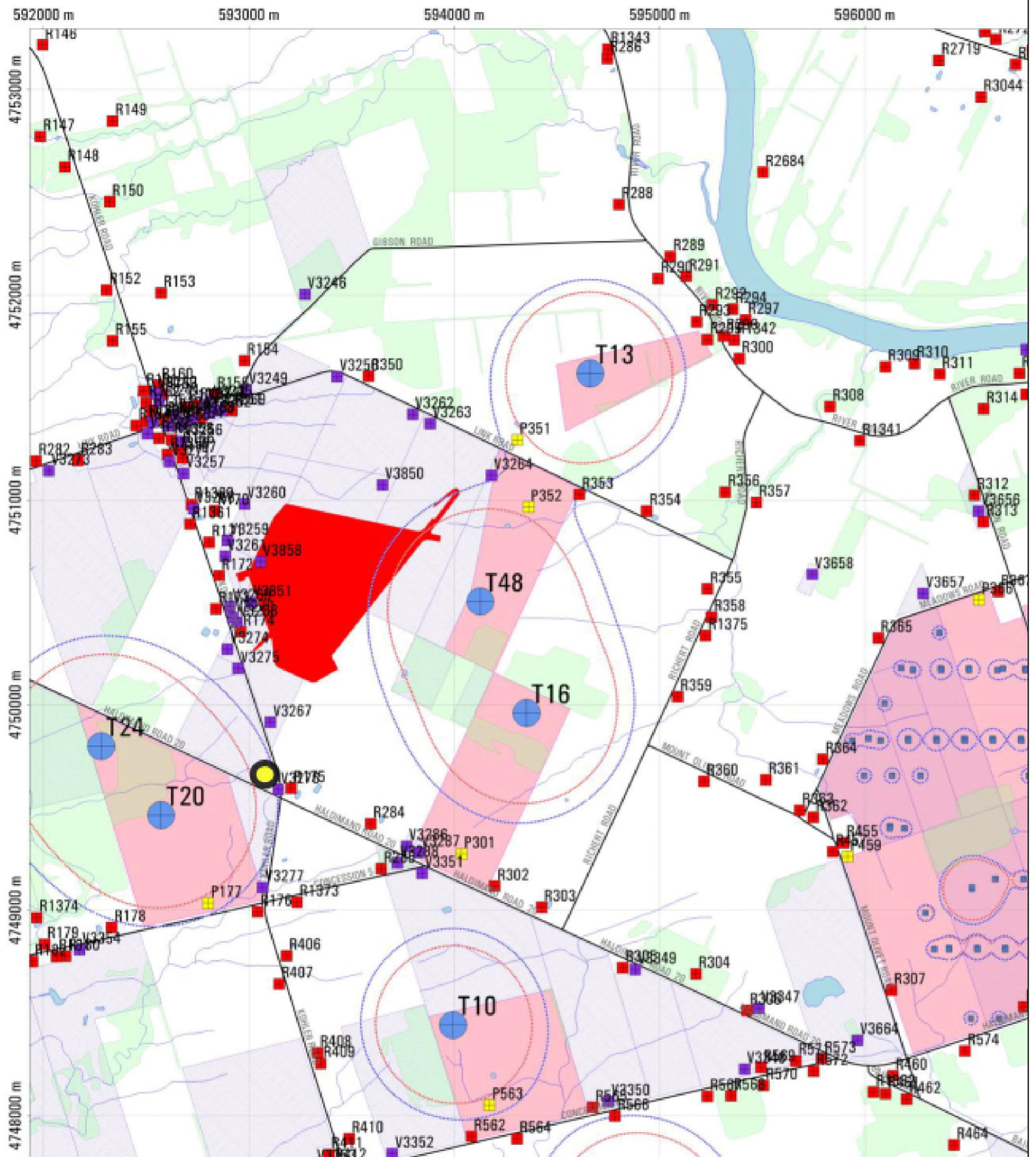
Aeroustics Engineering Limited has completed the acoustic audit outlined in the Renewable Energy Approval for the Grand Renewable Wind Farm. The audit was completed as per the methodology outlined in Part D of the “*MOE Compliance Protocol for Wind Turbine Noise*.” The measured levels were compared to the MOECC limits, and the facility was determined to be in compliance at all receptors.

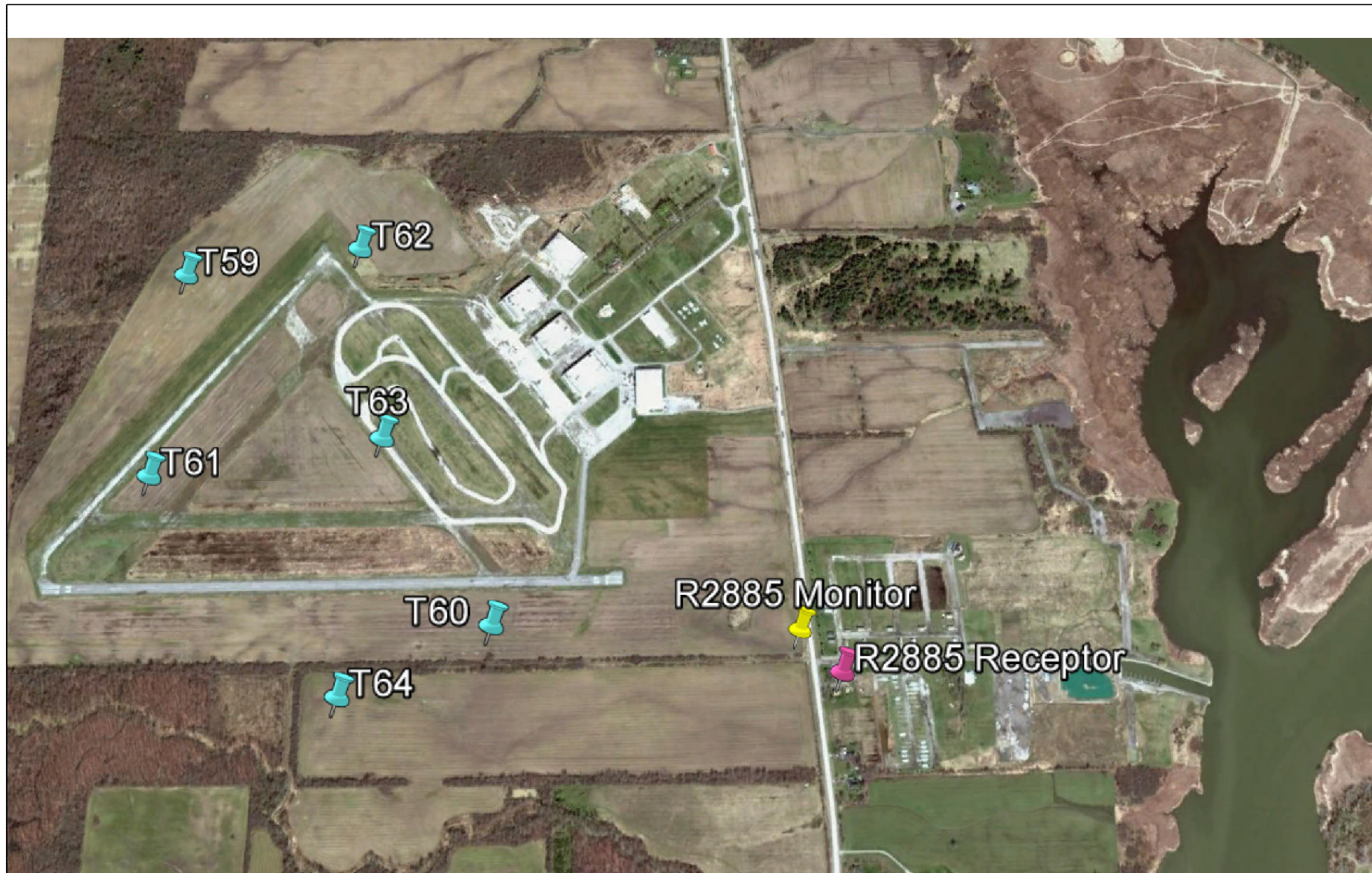
9 References


- [1] V. Schroter, “Renewable Energy Approval #0300-8UQPKR”, Ontario Ministry of the Environment, Toronto, ON, June 15, 2012
- [2] Ministry of the Environment, “Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement”, Ontario Ministry of the Environment, Toronto, ON.
- [3] C.F. Brothers, J.R. Salmon and S.J. Corby., “Grand Renewable Energy Park Noise Assessment Report” Zephyr North, Burlington, ON, Rev. 2, May 29, 2012.

APPENDIX A – LOCATION DETAILS




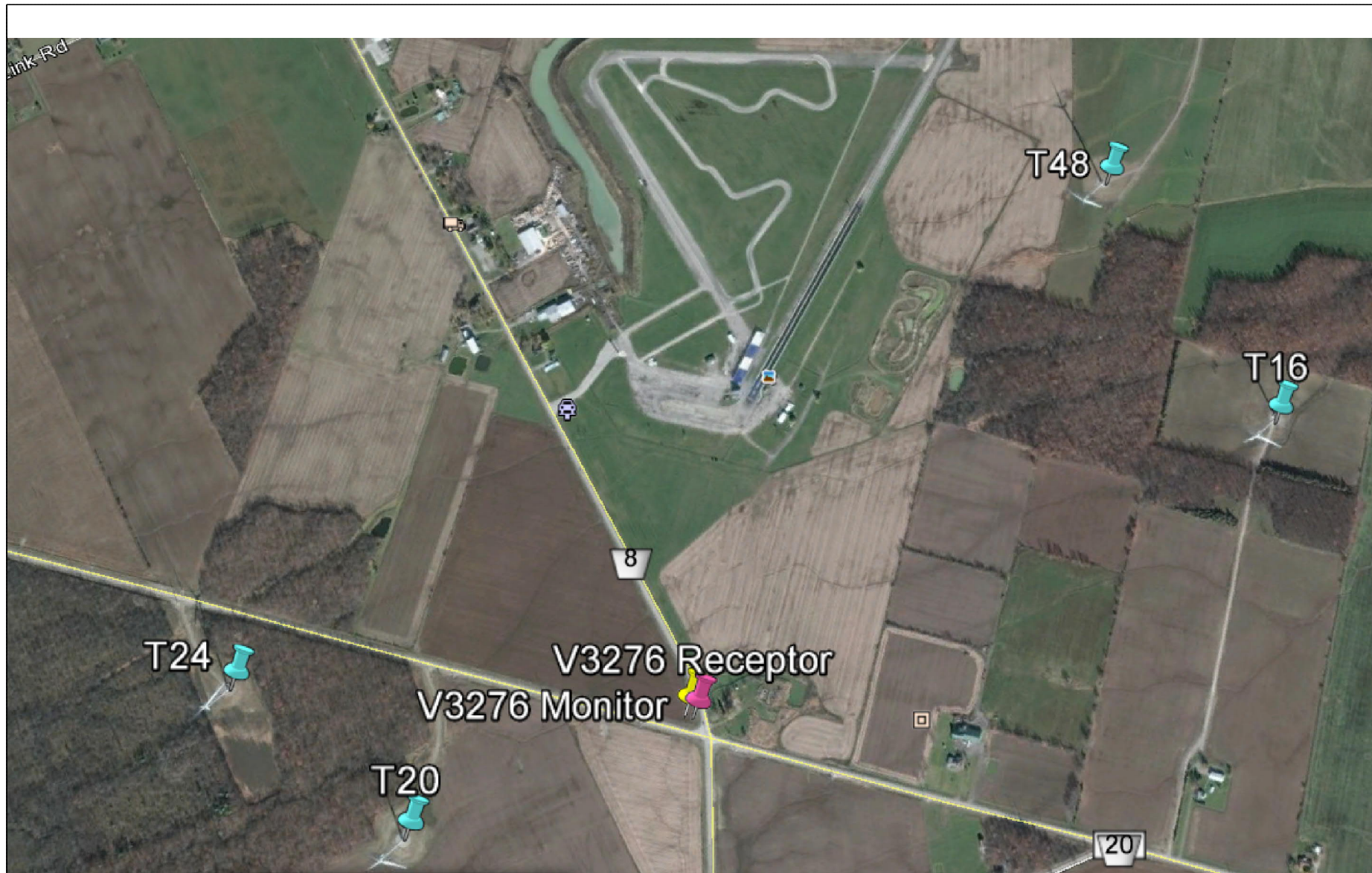





	Project ID: 14284.00	Project Name	Figure A.4
	Scale: NTS Drawn by: AD Reviewed by: PA Date: April 8, 2016 Revision: 1	Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report	
		Figure Title Measurement Location - R2885	



	Project ID: 14284.00	Project Name	
	Scale: NTS Drawn by: AD Reviewed by: PA Date: April 8, 2016 Revision: 1	Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report	
		Figure Title	
		Measurement Location - R2956	Figure A.5



	Project ID: 14284.00	Project Name	Figure A.6
	Scale: NTS Drawn by: AD Reviewed by: PA Date: April 8, 2016 Revision: 1	Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report Figure Title Measurement Location - V3276	



Project ID: 14284.00

Scale: NTS
Drawn by: AD
Reviewed by: PA
Date: April 8, 2016
Revision: 1

Project Name


Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report

Figure Title

Site Photo - R2885

Figure A.7



	Project ID: 14284.00	Project Name	
	Scale: NTS Drawn by: AD Reviewed by: PA Date: April 8, 2016 Revision: 1	Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report	
		Figure Title	
		Site Photo - R2956	Figure A.8



Project ID: 14284.00

Scale: NTS
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 Date: April 8, 2016
 Revision: 1

Project Name

Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report

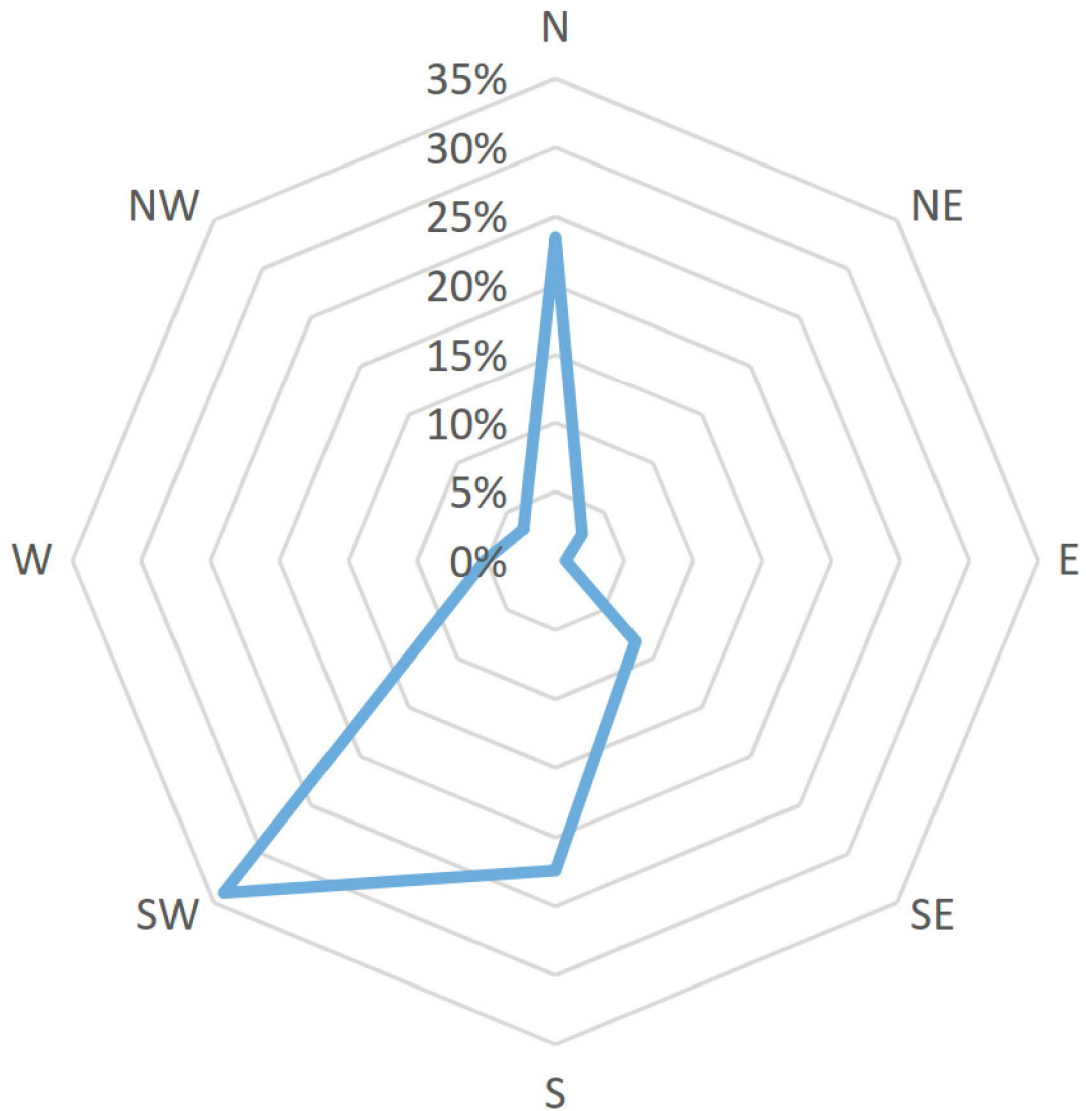
Figure Title

Site Photo - V3276

Figure A.9

APPENDIX B – WIND ROSES

R2885 - TON



Project ID: 14284.00

Scale: NTS
 Drawn by: AD
 Reviewed by: PA
 Date: April 8, 2016
 Revision: 1

Project Name

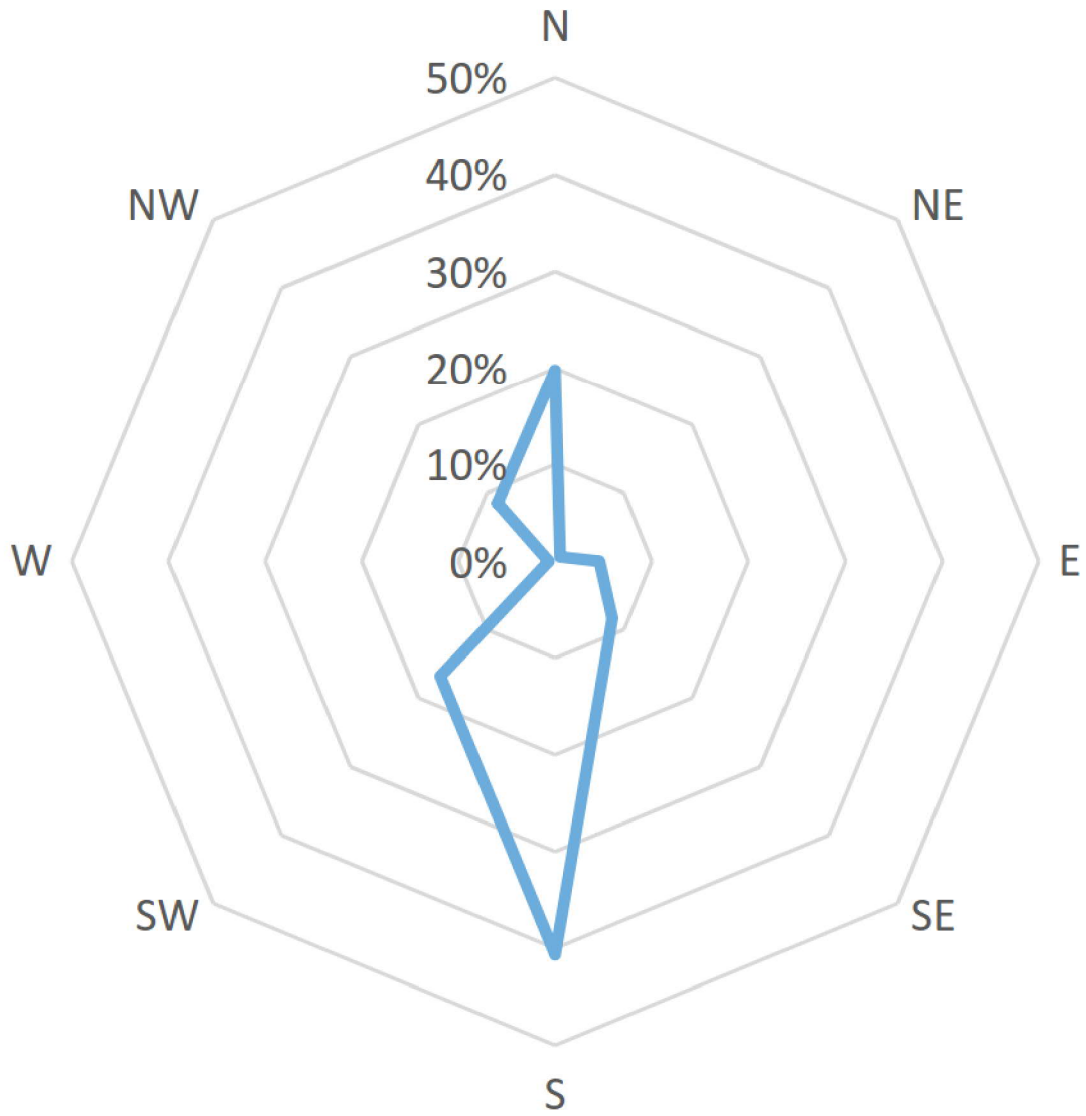
Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report

Figure Title

Wind Rose R2885

Figure B.1

R2956 - TON



Project ID: 14284.00

Scale: NTS
 Drawn by: AD
 Reviewed by: PA
 Date: April 8, 2016
 Revision: 1

Project Name

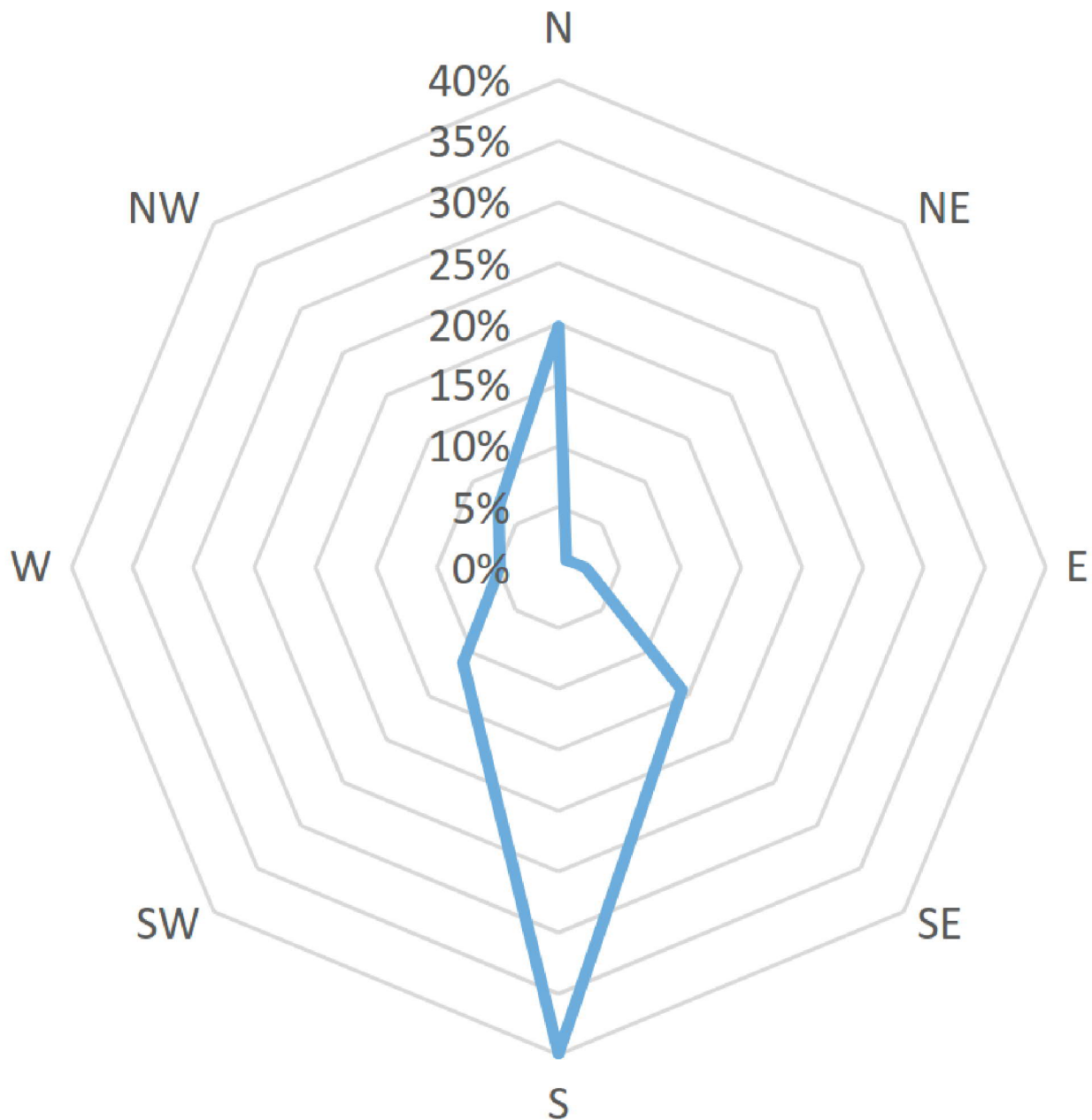
Grand Renewable Wind Farm - 2nd Acoustic Immission Audit Report

Figure Title

Wind Rose R2956

Figure B.2

V3276 - TON



**APPENDIX C – TURBINE OPERATIONAL DATA STATEMENT
FROM OPERATOR**



Grand Renewable Wind LP
2050 Derry Rd. West 2nd Floor
Mississauga, Ontario
L5N 0B9
<http://www.grandrenewablewind.com>

April 18th, 2016.

District Manager, MOE Hamilton
12th floor, 119 King street W
Hamilton ON L8P 4Y7

Subject:

**Grand Renewable Wind LP Renewable Energy Approval number 0300-8UQPKR
Condition- Receptor audit immission part 2 of 2**

To whom it may concern

Please accept this letter as confirmation that all turbines tested during the spring audit of 2016 acoustics measurement campaign conducted by Aercoustics Ltd. From January 20th through March 21st, 2016 were operating normal for the duration of the campaign.

Sincerely,

Jonathan Miranda
Facility Manager
Grand Renewable Wind

2788 Haldimand Rd. 20
Haldimand, ON
N0A 1E0

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C:289-407-8387
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APPENDIX D – WIND GUSTING ANALYSIS

Wind Gusting Analysis Summary

The purpose of this document is to provide supporting information for wind turbine receptor audits in which the wind speed gusting filter deviates from that prescribed by the Ministry of the Environment and Climate Change (MOECC). The Compliance Protocol for Wind Turbine Noise requires that the maximum and minimum wind speeds be within 2 m/s of the average wind speed in a measurement interval (1-minute average). Any intervals that do not meet this requirement would be excluded from the analysis. Aercoustics examined the possibility of changing this filtering to only exclude intervals where the maximum wind speed is more than 2 m/s above the average without filtering based on minimum wind speed.

Aercoustics reviewed 11 different data sets representing measurements from 3 different wind farms and 10 different receptor locations. Each data set was filtered using both the prescribed and the modified methods for wind speed gusting. The resulting sound pressure levels for Turbine On and Background measurements were computed for each wind bin. The change in number of valid data points and the change in measured sound pressure level were calculated. The increase in number of data points and change in sound pressure from the prescribed filtering method to the proposed method were averaged across the 11 data sets. The mean values by wind speed are presented in Table 1 below.

Table 1: Results

Wind Bins	Turbine ON		Background	
	Difference (pts)	Difference (dB)	Difference (pts)	Difference (dB)
3	2%	0.0	3%	0.0
4	6%	0.1	7%	0.0
5	10%	0.1	9%	0.1
6	11%	0.1	13%	0.1
7	21%	0.1	25%	0.1

These results clearly show that the proposed modification of the wind speed gusting filter increases the number of data points in all wind bins, with a more pronounced effect at high wind speeds. The over 20% increase in data points in the 7 m/s wind bins is significant as these wind speeds are typically the most difficult to measure and can considerably increase the time required to complete an audit. There are negligible increases in the measured sound levels, which occur during both Turbine On and Background measurements.