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Vestas Australian Wind Technology Pty Ltd

3 May 2013

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Macarthur Wind Farm Commissioning Noise Monitoring

Monthly Summary Report - November 2012

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Prepared for

Vestas Australian Wind Technology Pty Ltd

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Quality Information

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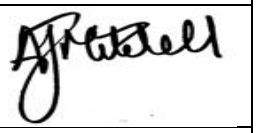
Prepared by Andrew Mitchell

Reviewed by David Peoples

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	3-Apr-2013	Initial Issue	Andrew Mitchell Principal Acoustics Engineer	
1	3-May-2013	Vestas comments incorporated	Andrew Mitchell Principal Acoustics Engineer	

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Executive Summary

AECOM was engaged by Vestas Australian Wind Technology Pty Ltd to perform noise monitoring at residential locations in the vicinity of the Macarthur Wind Farm, to assess the noise emissions from the wind farm during the commissioning phase.

Noise monitoring was performed at eight residential locations in the vicinity of the wind farm during the month of November 2012.

The noise monitoring, and analysis of the noise monitoring data, was performed in accordance with NZS 6808:1998[1], which is the standard referenced by the Planning Permit conditions for the wind farm.

At the beginning of the monitoring period on 1 November 2012 there were a total of 44 operational wind turbines at the wind farm. During the monitoring period wind turbines were progressively commissioned at the wind farm, and a total of 105 of the 140 wind turbines were operational at the end of the monitoring period on 30 November 2012.

At all locations, the noise level at each wind speed, ranging from the wind turbine cut-in wind speed to up to the wind speed where the turbines generate maximum noise emissions, was not greater than the respective noise limit. The noise monitoring results therefore indicate that the wind farm was compliant with the noise criteria prescribed by the Planning Permit during this period of commissioning noise monitoring.

[1] New Zealand Standard 6808:1998 – *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*

1.0 Introduction

AECOM was engaged by Vestas Australian Wind Technology Pty Ltd to perform noise monitoring at residential locations in the vicinity of the Macarthur Wind Farm, to assess the noise emissions from the wind farm.

This report summarises noise monitoring that was conducted during the period between 1 and 30 November 2012, as the wind farm was being commissioned.

A summary of the applicable noise criteria, the measurement methodology, and the measurement results are presented in the following sections.

Definitions of the acoustic nomenclature used in this report are presented in Appendix A.

2.0 Noise Criteria

The Planning Permit for Macarthur Wind Farm stipulates that noise from the operation of Macarthur Wind Farm must comply with noise limits determined in accordance with New Zealand Standard NZS6808:1998, titled '*Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*'.

In accordance with the New Zealand Standard, a noise limit is determined for each wind speed at which the wind turbines operate. The Standard stipulates that for each wind speed the wind farm noise shall not exceed 40 dB(A) or the background noise plus 5 dB(A), whichever is greater. The quantity 'dB(A)', or 'A-weighted decibels', means decibel level of the sound, adjusted depending on the pitch of the sound to replicate the response of the human ear.

Under the Planning Permit, separate limits apply for 'all-time' and 'night-time' periods (defined as 10pm to 7am).

Background noise levels at a number of the properties where commissioning noise monitoring has been undertaken were measured prior to construction of the wind farm between August 2010 and January 2011.

Where background noise levels were not measured prior to construction of the wind farm, the noise criteria have been determined based on either:

1) Background noise levels measured at the end of the construction period, between 19 September and 1 October 2012, when no wind turbines were operating;

   or

2) For locations where no background measurements were performed either prior to or following construction – a representative location in the same general area where background noise levels were measured.

It should be noted that the background noise monitoring that was conducted prior to construction of the wind farm was referenced to wind data from temporary meteorological masts, now decommissioned. Operational noise monitoring references the measured noise levels with wind data from the permanent meteorological masts at the wind farm.

To enable the background noise level versus wind speed curves, and thus the criteria, determined prior to construction to be directly compared to the operation noise level curves, both sets of data must be referenced to the same metrological masts. A conversion relating the wind speeds and directions from the temporary meteorological masts to the permanent ones has been provided by wind engineering consultant Garrad Hassan. The conversion is based on a correlation of the meteorological data gathered from the temporary and permanent met masts between July 2011 and August 2012 when both sets of masts were operating simultaneously. This conversion has been used to relate the pre-construction background noise measurements to the wind speeds at the permanent met masts.

The noise limits that have been determined to apply at each property are shown on the graphs presented in the measurement results section of this document (Section 6.0).

3.0 Noise Measurement Methodology

3.1 Procedure

A laboratory calibrated noise monitor was placed at each measurement location from 1 to 30 November 2012 to measure the noise emissions from the Wind Farm. The noise monitor was located on site in accordance with the requirements of New Zealand Standard NZS6808:1998.

A photograph of a typical noise monitoring installation at a measurement location is presented in Figure 1.

Figure 1 – Typical Noise Monitoring Setup

The noise monitor measured noise over 10-minute periods, in accordance with NZS6808:1998 and stored the measured noise level at the end of each 10-minute period. This process occurred continuously, 24 hours per day for the monitoring period.

The measured noise levels were correlated with wind speed data from meteorological masts at the wind farm to determine the “average” noise level at each wind speed, in accordance with the methodology prescribed by NZS 6808:1998.

The measured noise levels represent the combination of background noise and wind farm noise. As such, the measured noise levels would be higher than the noise levels due to the wind farm only.

It should be noted that NZS 6808:1998 allows for the measured noise levels to be adjusted to compensate for the influence of background noise when assessing the noise levels from the wind farm. Such an adjustment has not been applied to the measured levels presented in this report. The approach of comparing the combined background noise and wind farm noise to the assessment criteria (as used in this report), is therefore conservative.

3.2 Measurement Locations

Noise measurements were conducted at the following locations:

Table 1 Commissioning Noise Monitoring Locations

Location ID	Location Description
O17A	West of wind farm – nearest wind turbines approximately 1.7 km to the east
Q20A	West of wind farm – nearest wind turbines approximately 1.7 km to the east
R26B	South of wind farm – nearest wind turbines approximately 1.8 km to the north
S26A	South of wind farm – nearest wind turbines approximately 1.8 km to the north
W26A	South of wind farm – nearest wind turbines approximately 2.0 km to the north
Y16A	East of wind farm – nearest wind turbines approximately 2.7 km to the southwest
Y18A	East of wind farm – nearest wind turbines approximately 1.9 km to the west
Y21A	East of wind farm – nearest wind turbines approximately 2.6 km to the northwest

3.3 Instrumentation

The details of the instrumentation used to perform the noise measurements are presented in Table 2. All instrumentation held current certificates of laboratory calibration by a NATA accredited laboratory at the time of the monitoring. An example laboratory calibration certificate is presented in Appendix C.

The readings of the monitors were field-checked using a portable sound level calibrator at the beginning and end of the noise monitoring period, and at intermediate points when the noise monitors were stopped for downloading or battery change.

Table 2 Instrumentation Details

Location ID	Instrument Make / Model	Serial No.	Date of Last Laboratory Calibration*
O17A	Svan 957 Class 1 Environmental Noise Logger	23855	02/10/2011
Q20A	Svan 957 Class 1 Environmental Noise Logger	27554	11/04/2012
R26B	Svan 957 Class 1 Environmental Noise Logger *(1/11/2012 to 15/11/2012)* Rion NL-21 Class 2 Environmental Noise Logger *(15/11/2012 to 29/11/2012)* Rion NL-21 Class 2 Environmental Noise Logger *(29/11/2012 to 30/11/2012)*	27537 765701 409170	11/04/2012 22/11/2010** 24/08/2011
S26A	Rion NL-21 Class 2 Environmental Noise Logger	865769	11/07/2012
W26A	Svan 957 Class 1 Environmental Noise Logger	27542	11/04/2012
Y16A	Rion NL-21 Class 2 Environmental Noise Logger	465440	02/06/2012
Y18A	Rion NL-21 Class 2 Environmental Noise Logger	465445	01/06/2012
Y21A	Svan 957 Class 1 Environmental Noise Logger	27552	11/04/2012
All	Rion NC-74 Class 1 Portable Sound Level Calibrator	35084189	22/05/2012

* In accordance with NATA guidelines, laboratory calibration of Sound Level Meters should be performed once every two years, and laboratory calibration of Sound Level Calibrators should be performed annually.

** This noise monitor was removed from site for laboratory re-calibration on 29/11/2012, and was recertified as accurate by a NATA accredited testing laboratory on 4/12/2012.

4.0 Meteorological Data

There are six permanent meteorological masts (met masts) located at the wind farm (see site map presented in Appendix B). All of the met masts are located at positions where they may be affected by the wake from the wind turbines at certain times, depending on the wind direction. In order to avoid using wind data that is potentially wake-affected, the wind speed data used for the noise analysis was derived from a combination of the six met masts, and corrected for positional wind speed variation back to a reference met mast location, as recommended by the wind analyst, Garrad Hassan.

Wind speed and direction data used for the analysis is in terms of 10-minute averages at the wind turbine hub height of 84m. The measurement time intervals of the noise monitoring equipment were synchronised with the measurement intervals of the met masts.

5.0 Wind Farm Operations during Monitoring Period

At the beginning of the monitoring period on 1 November 2012 there were a total of 44 operational wind turbines at the wind farm. During the monitoring period wind turbines were progressively commissioned at the wind farm, and a total of 105 wind turbines were operational at the end of the monitoring period on 30 November 2012. A map showing the locations of the wind turbines that were operational at the start and the end of the monitoring period is presented in Appendix B.

6.0 Measurement Results

The graphs on the following pages compare the measured 'all-time' and 'night-time' noise levels with the noise criteria determined for each location. Each graph shows each 10-minute data point measured with the wind turbines operating during the monitoring period as black dots. The polynomial fit-line to this data (i.e. the "average" noise level determined in accordance with NZS 6808:1998) is shown on the graph as an orange line. The background noise levels measured without the wind turbines running are shown as light blue dots, for information.

The following additional points should be noted:

1) The wind turbines at Macarthur wind farm are set to operate in Noise Mode 0. Based on data from Vestas' General Specification for the turbines, the maximum wind turbine sound power levels in this operating mode occur at a wind speed of 10 m/s. Any increases in the measured noise levels with wind speed above 10 m/s would therefore be a function of increasing background noise levels.

2) The noise monitoring equipment at Location O17A was visited by AECOM staff on two occasions during November and on both occasions the microphone windscreen was found to be missing from the microphone and was replaced with a new one. The exact times at which the windscreens were removed are not evident from the monitoring data, and as such, it has not been possible in the analysis of the results to exclude the specific periods where there was no windscreen on the microphone. The effect of not having a windscreen on the microphone would be to falsely increase the noise levels measured by the noise monitor as a result of wind pressure fluctuations acting on the microphone. Analysis of the monitoring data including the periods where the wind screen was not present on the microphone therefore results in a conservative assessment of the wind farm noise.

6.1 O17A

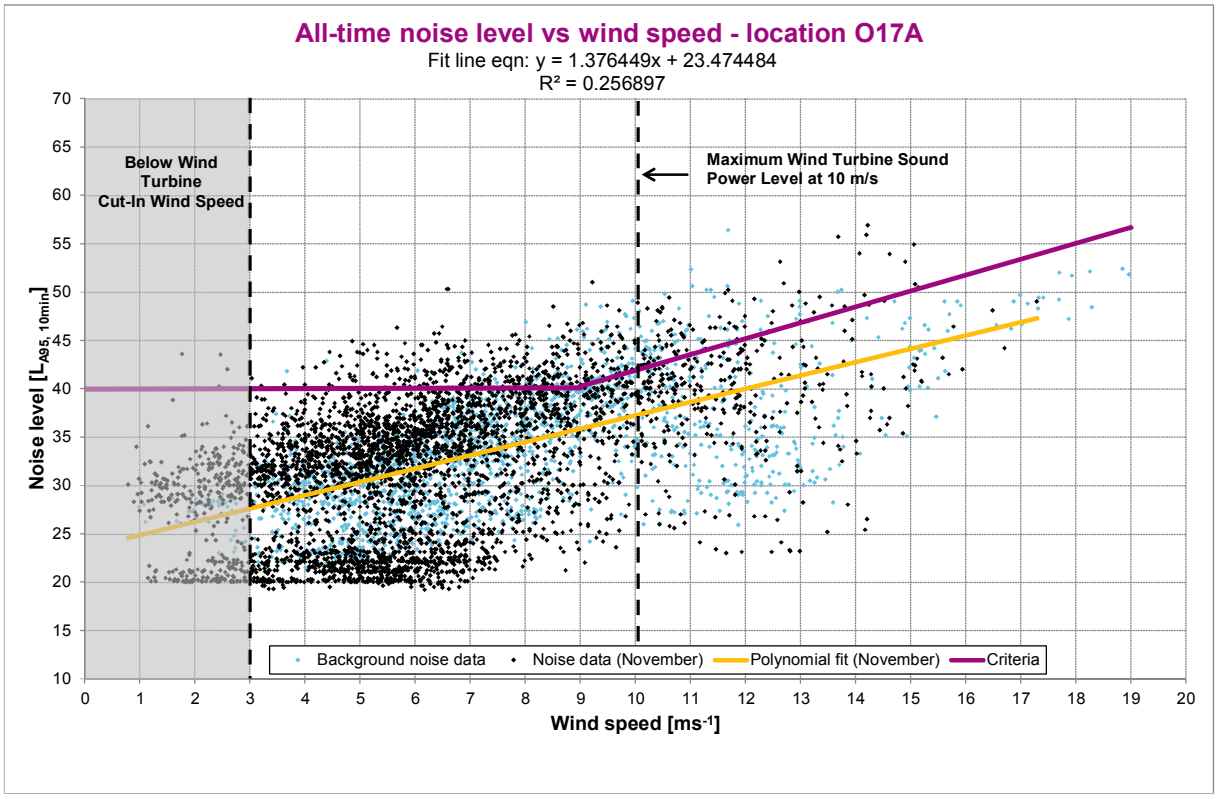


Figure 2 **All-Time Monitoring Results – O17A**

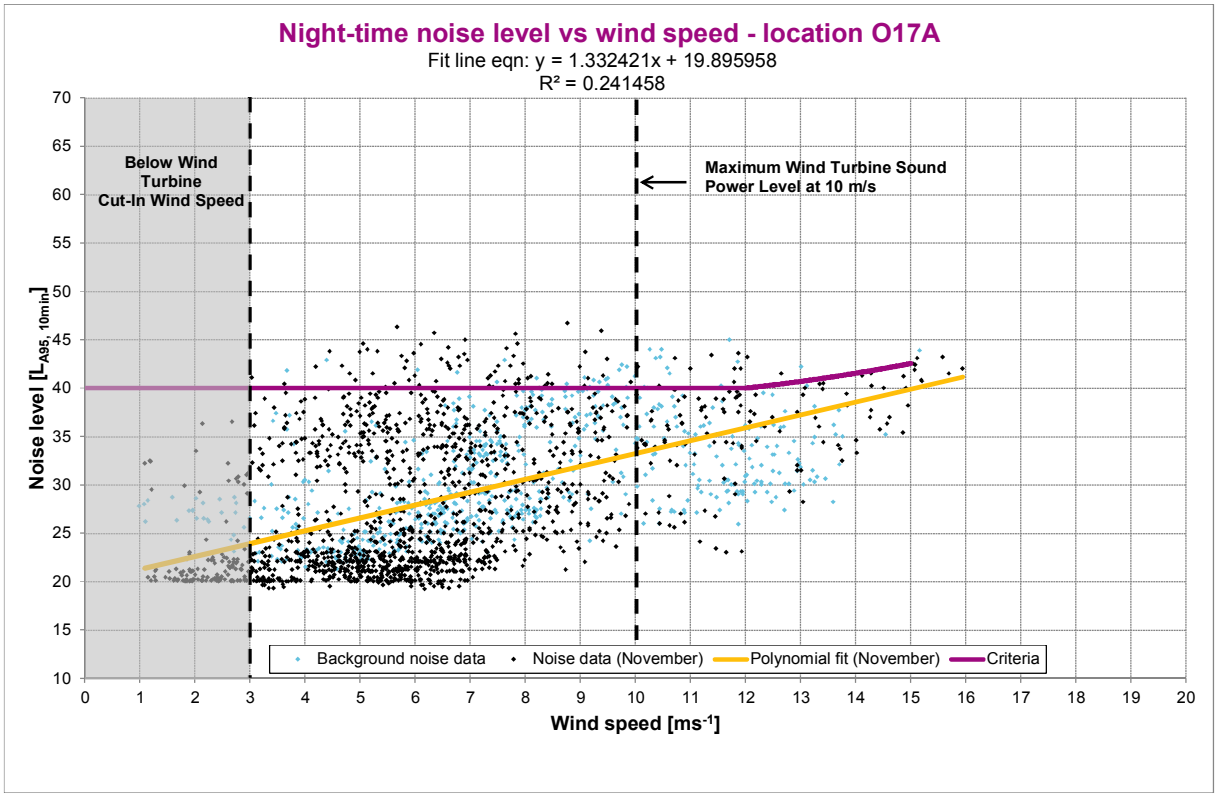


Figure 3 **Night-time Monitoring Results – O17A**

6.2 Q20A

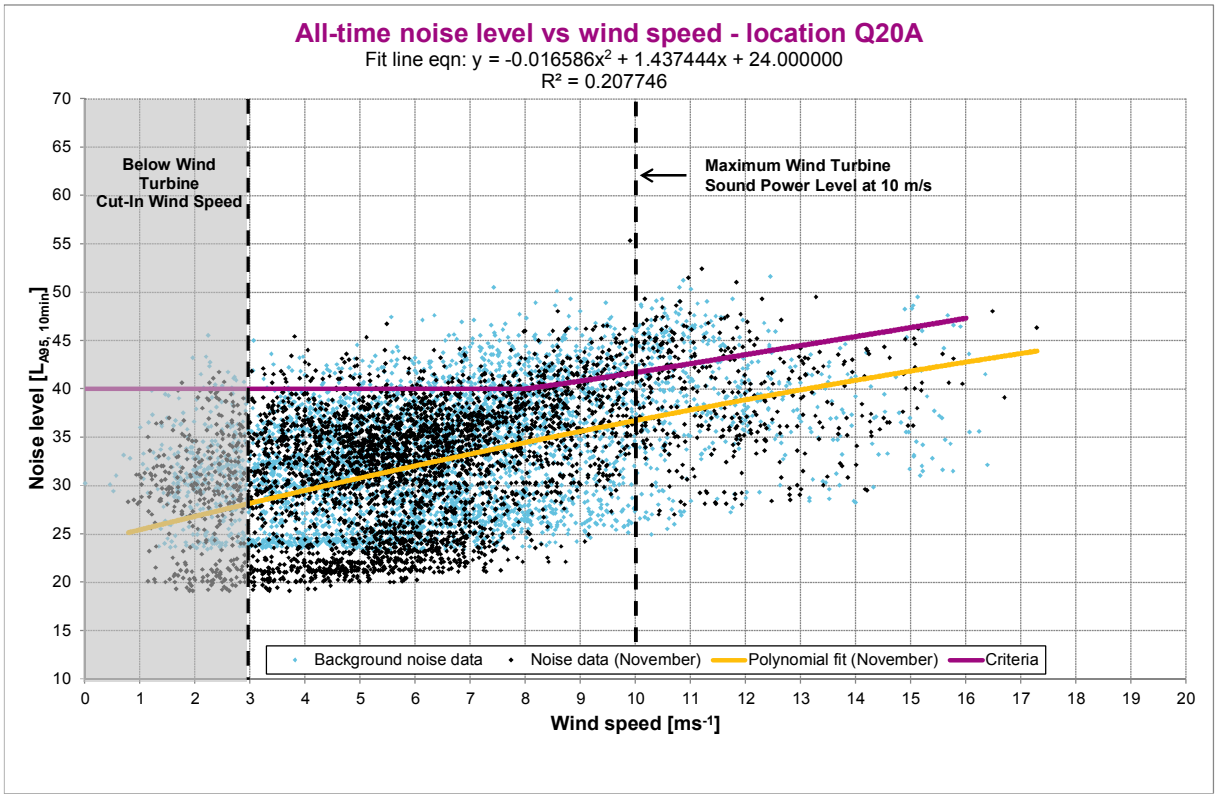


Figure 4 **All-Time Monitoring Results – Q20A**

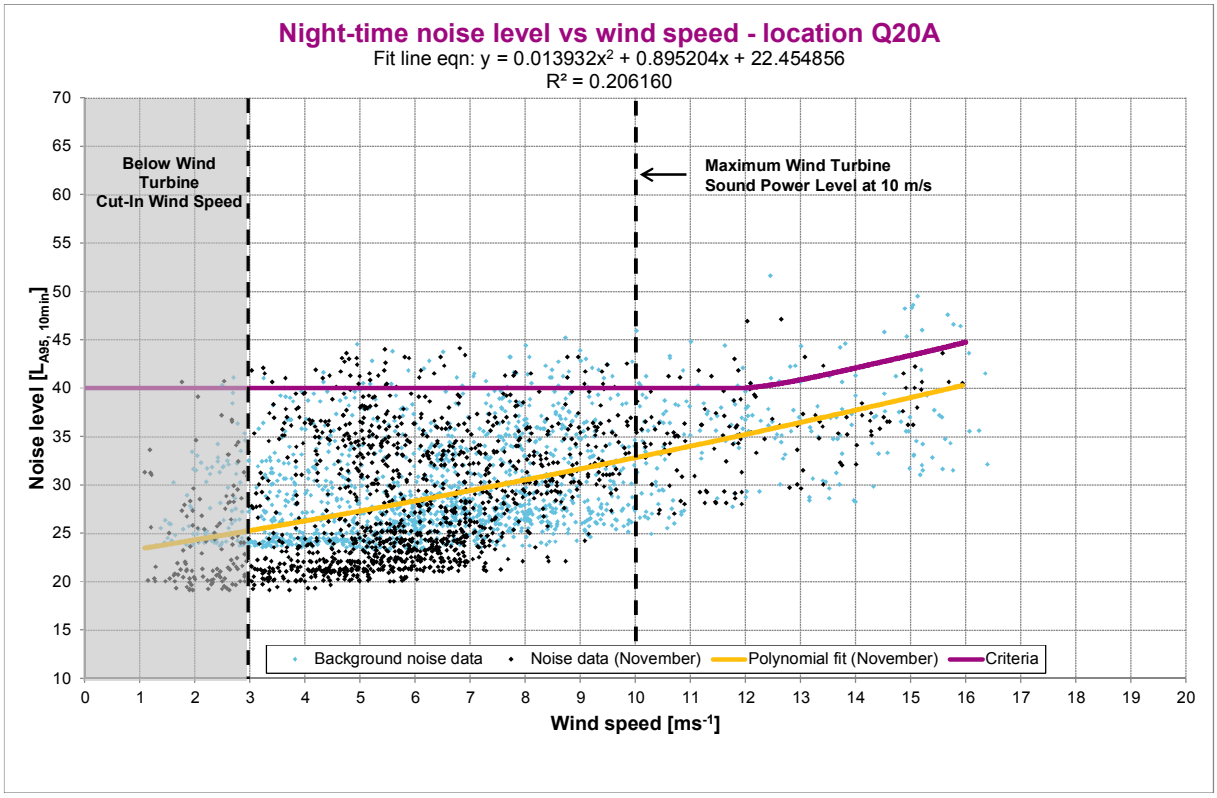


Figure 5 **Night-time Monitoring Results – Q20A**

6.3 R26B

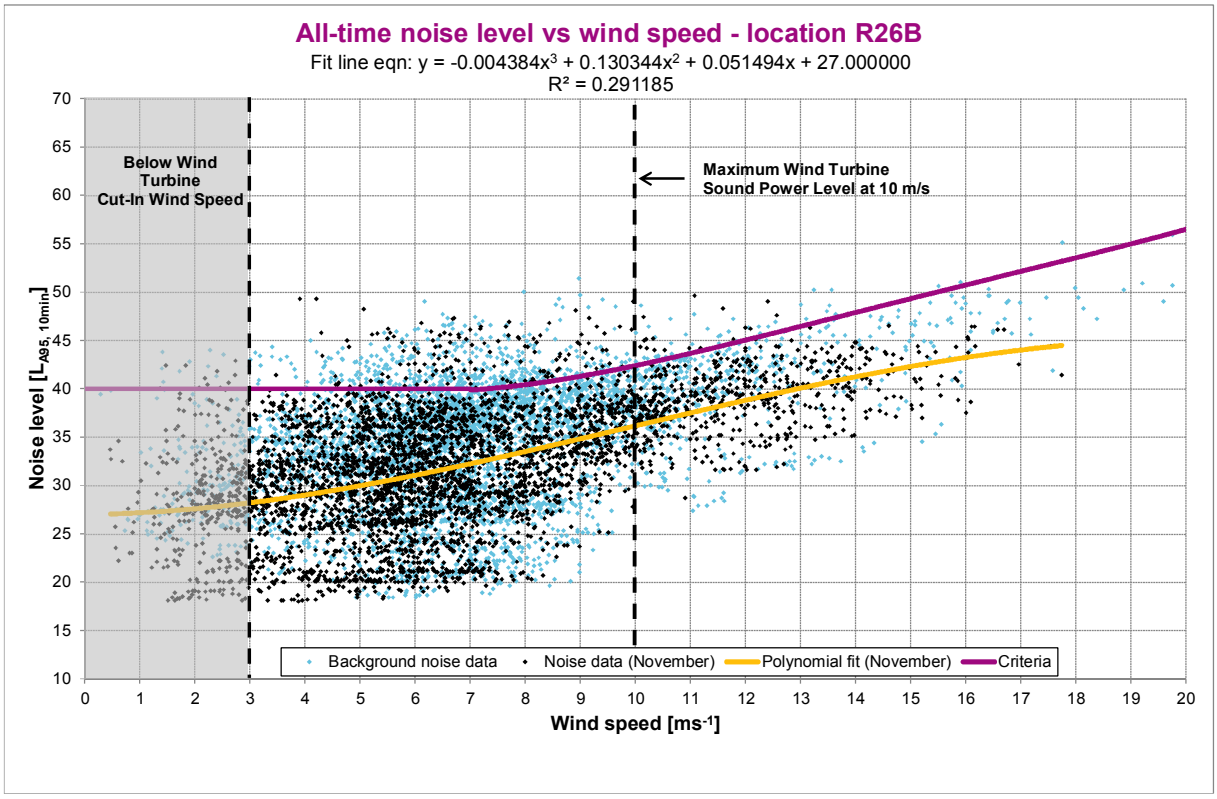


Figure 6 **All-Time Monitoring Results – R26B**

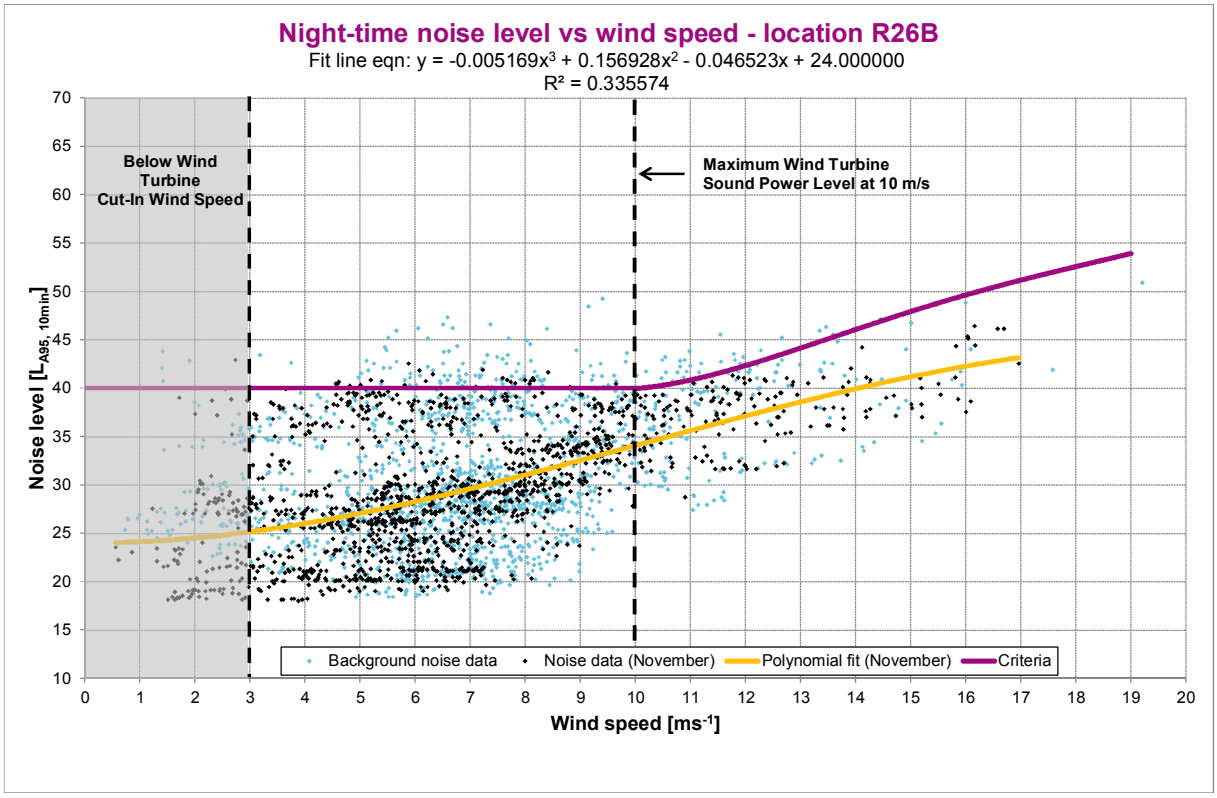


Figure 7 **Night-time Monitoring Results – R26B**

6.4 S26A

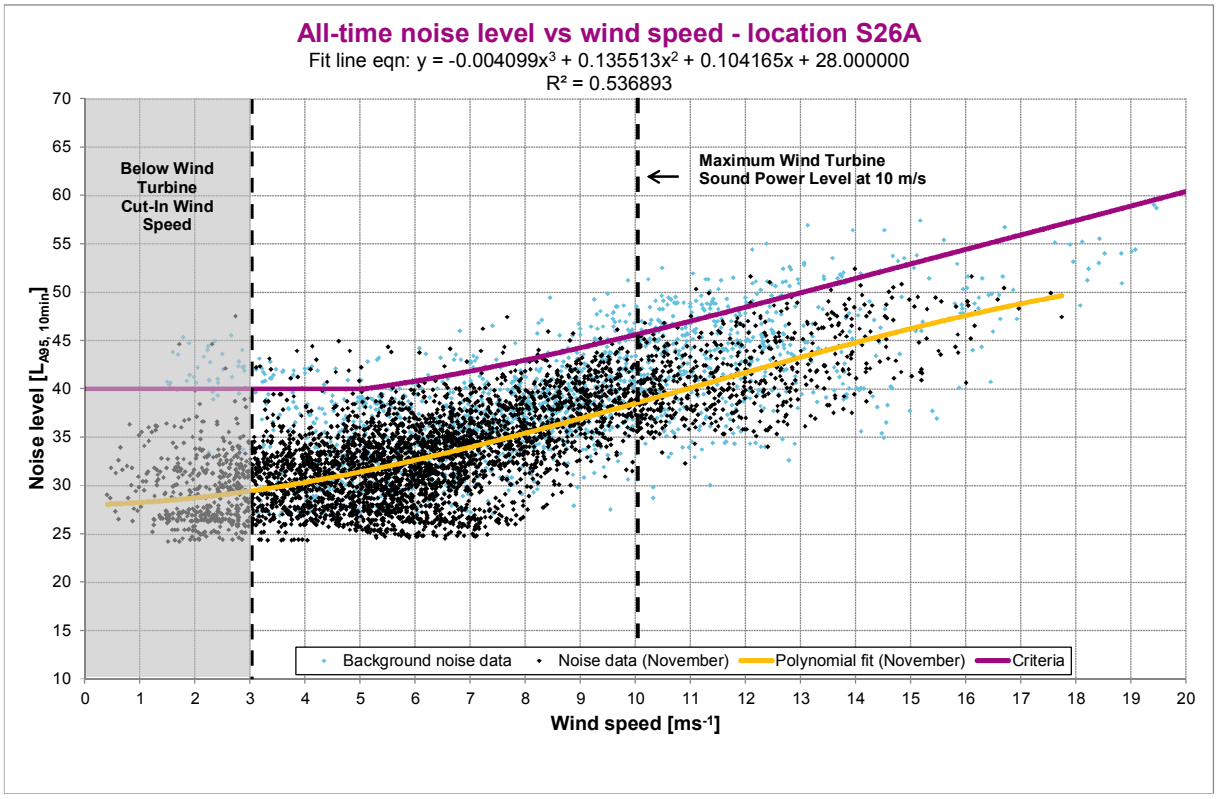


Figure 8 All-Time Monitoring Results – S26A

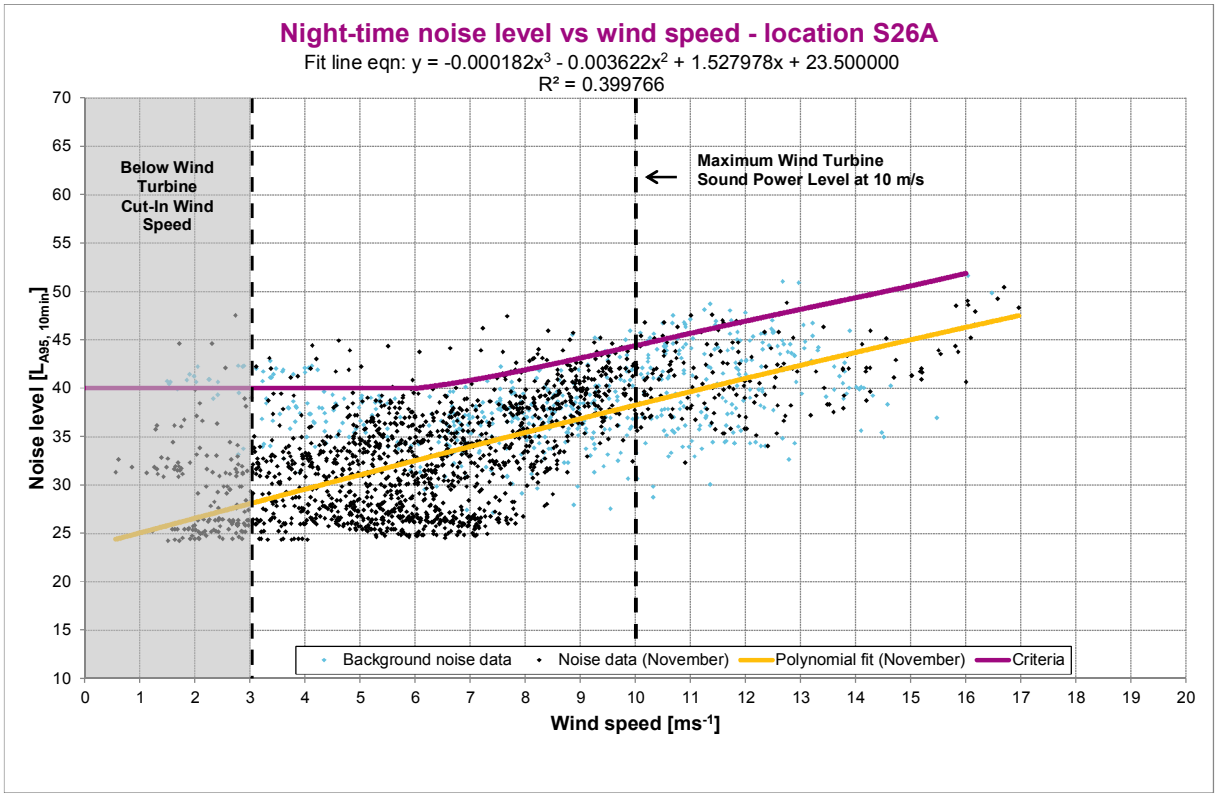


Figure 9 Night-time Monitoring Results – S26A

6.5 W26A

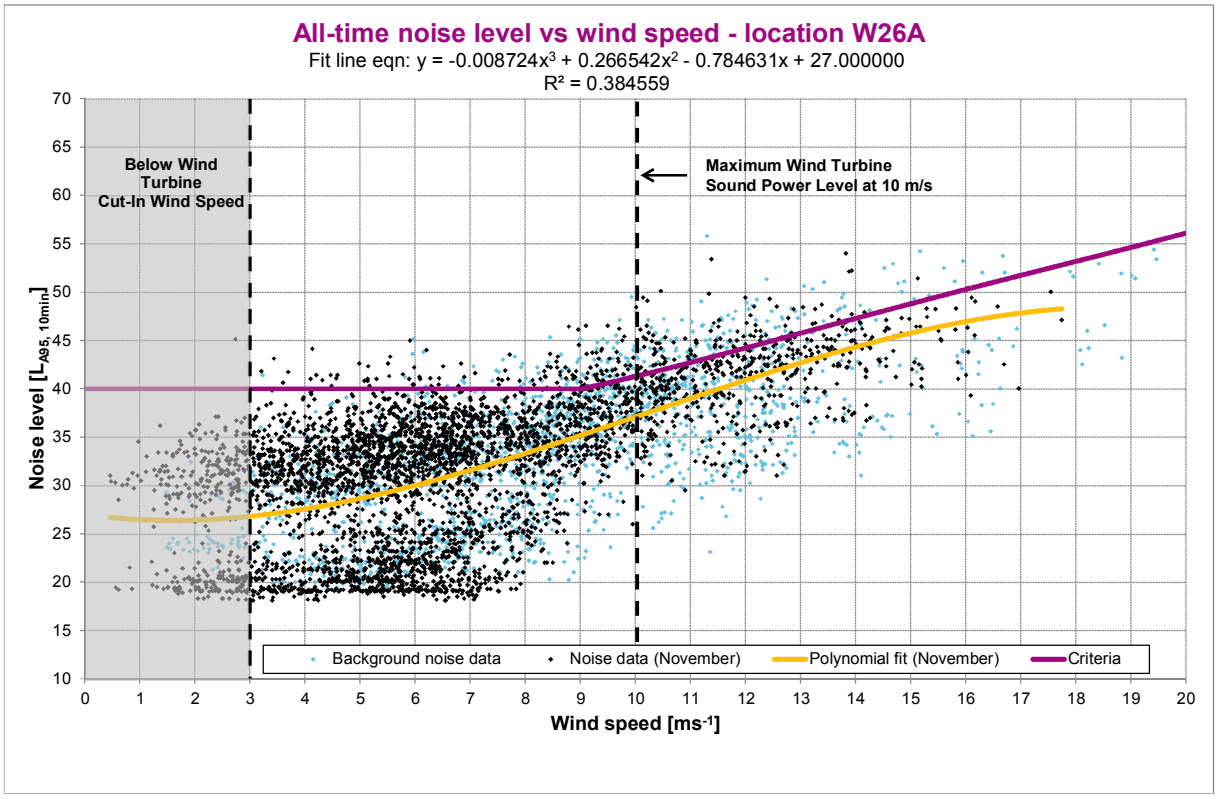


Figure 10 All-Time Monitoring Results – W26A

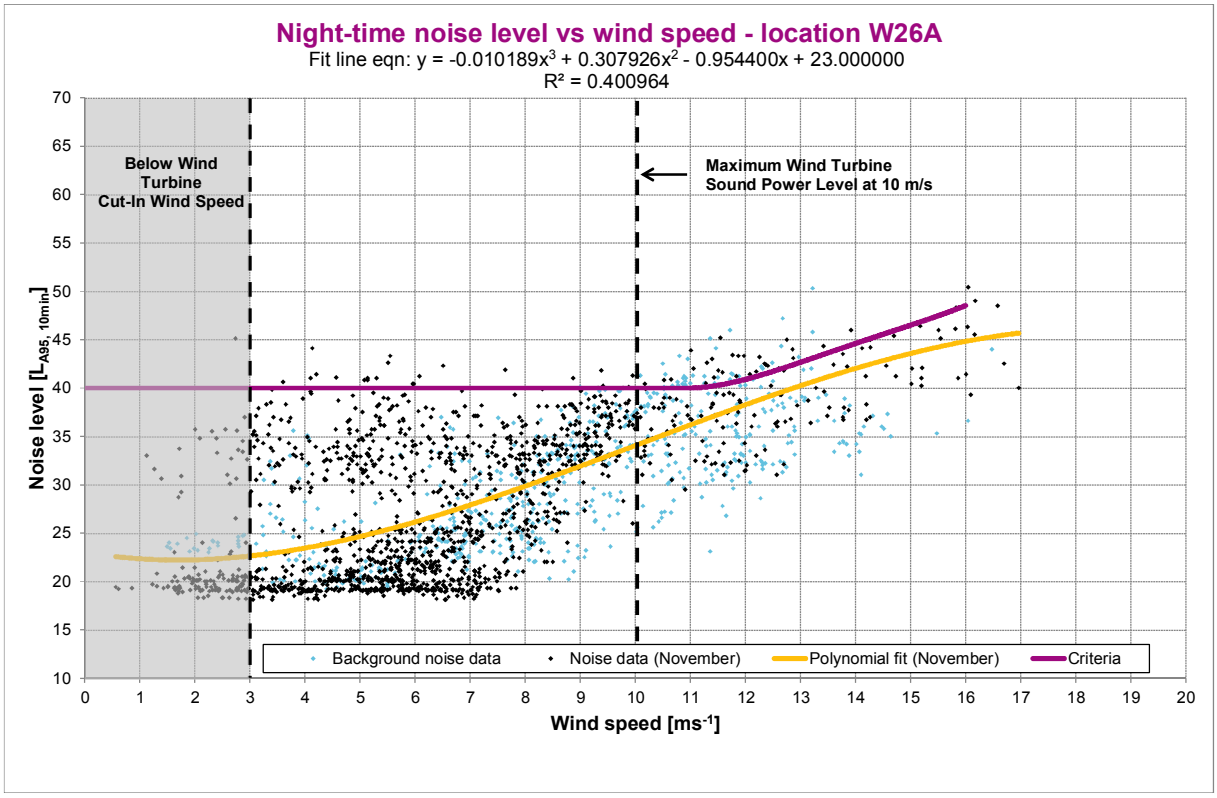


Figure 11 Night-time Monitoring Results – W26A

6.6 Y16A

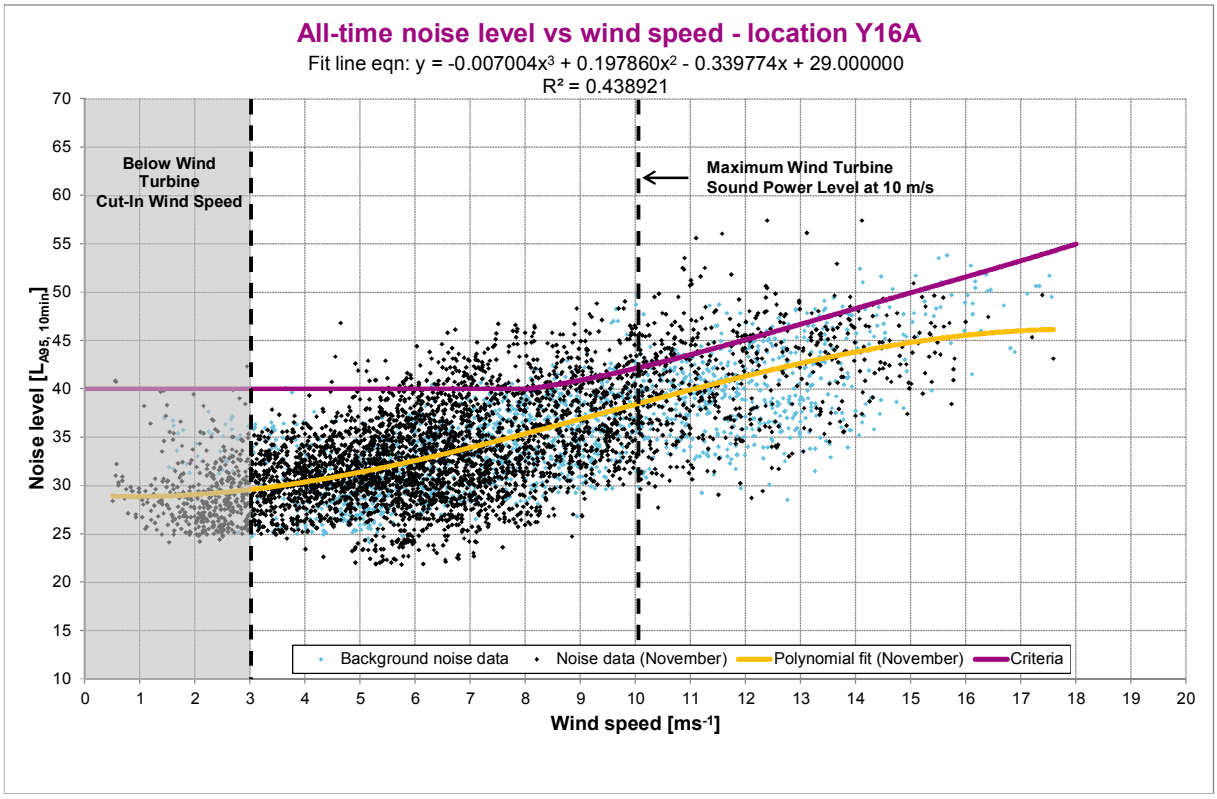


Figure 12 All-Time Monitoring Results – Y16A

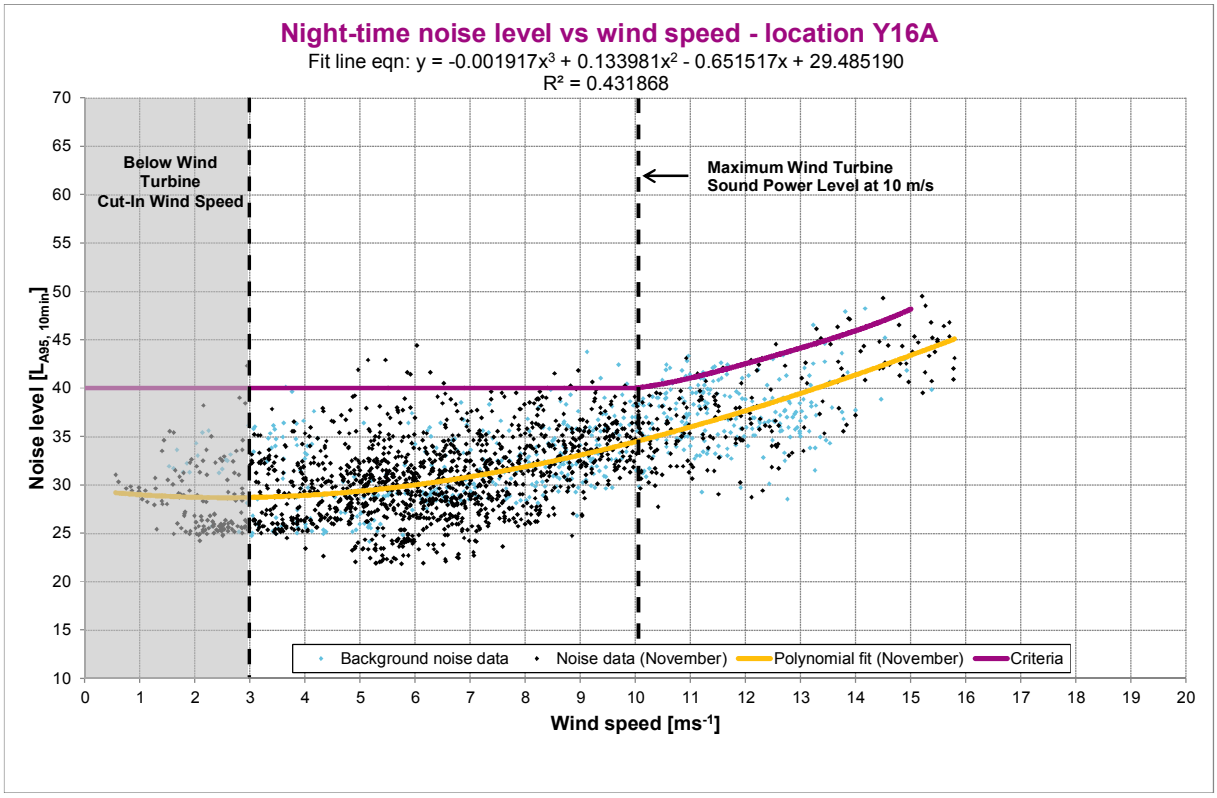


Figure 13 Night-time Monitoring Results – Y16A

6.7 Y18A

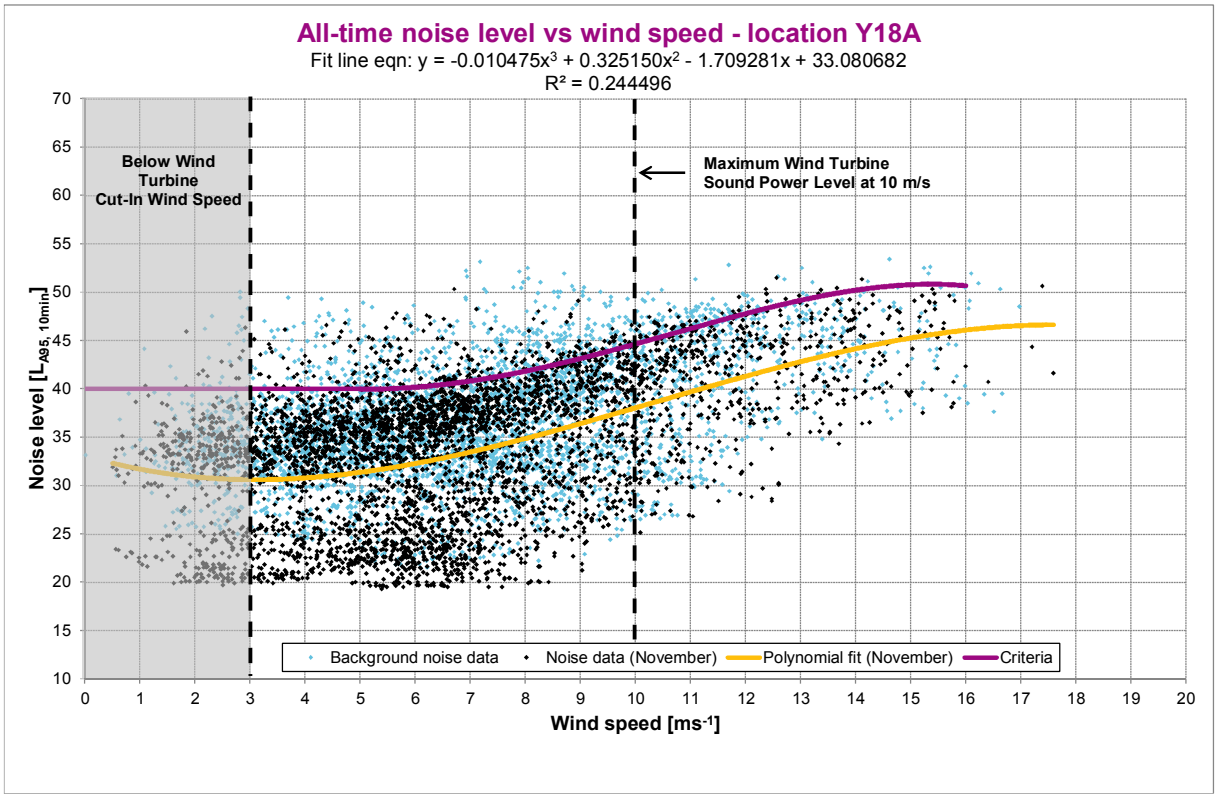


Figure 14 All-Time Monitoring Results – Y18A

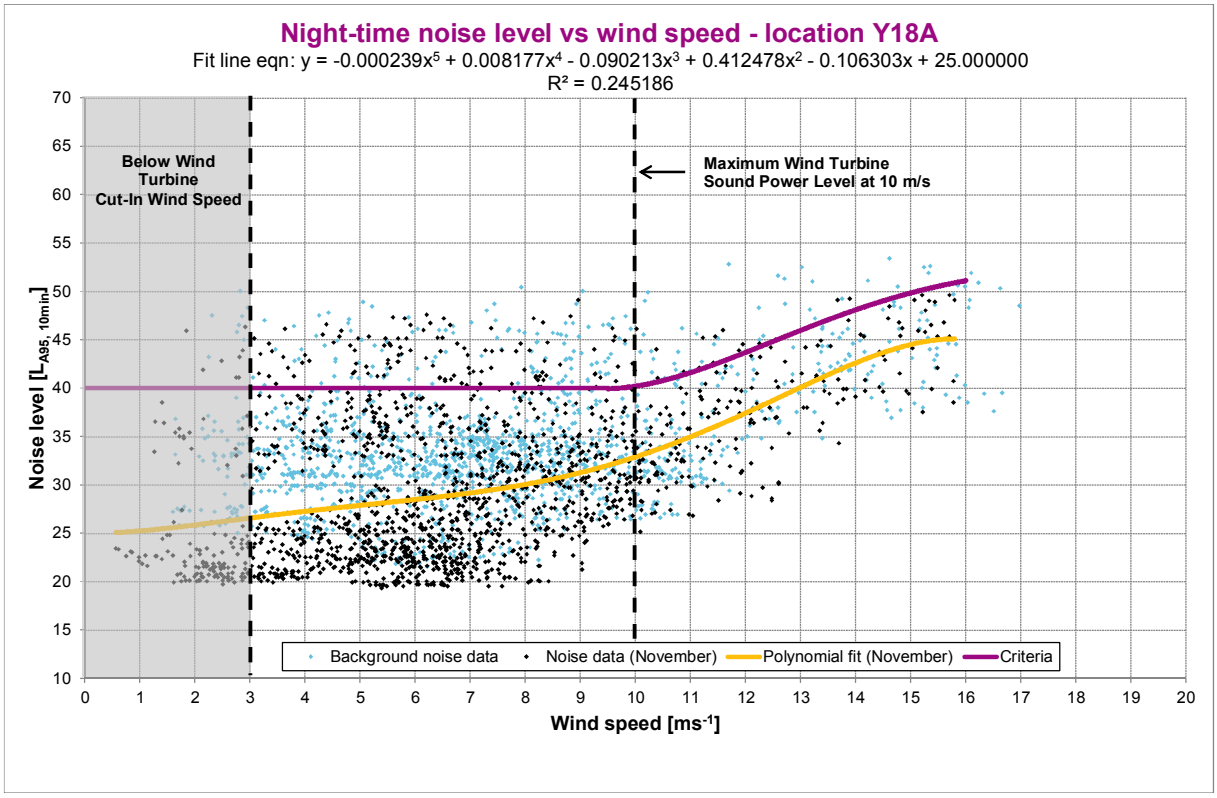


Figure 15 Night-time Monitoring Results – Y18A

6.8 Y21A

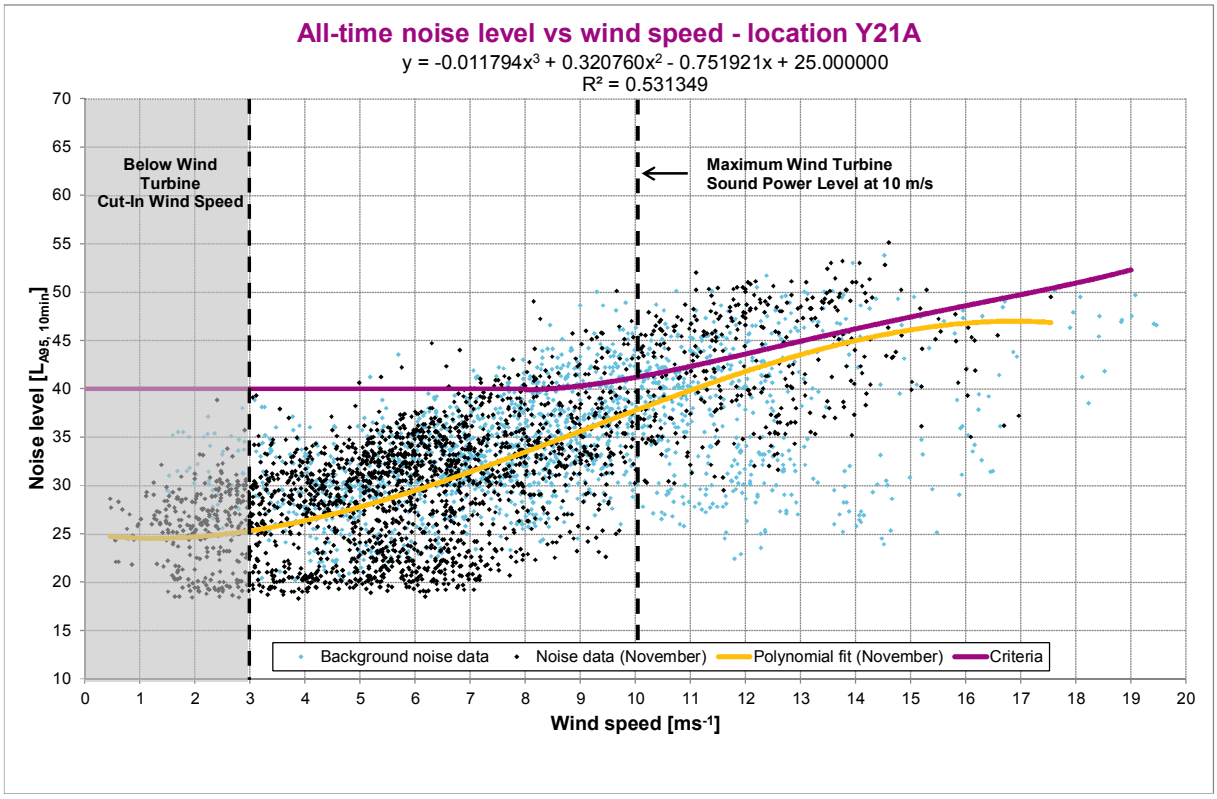


Figure 16 All-Time Monitoring Results – Y21A

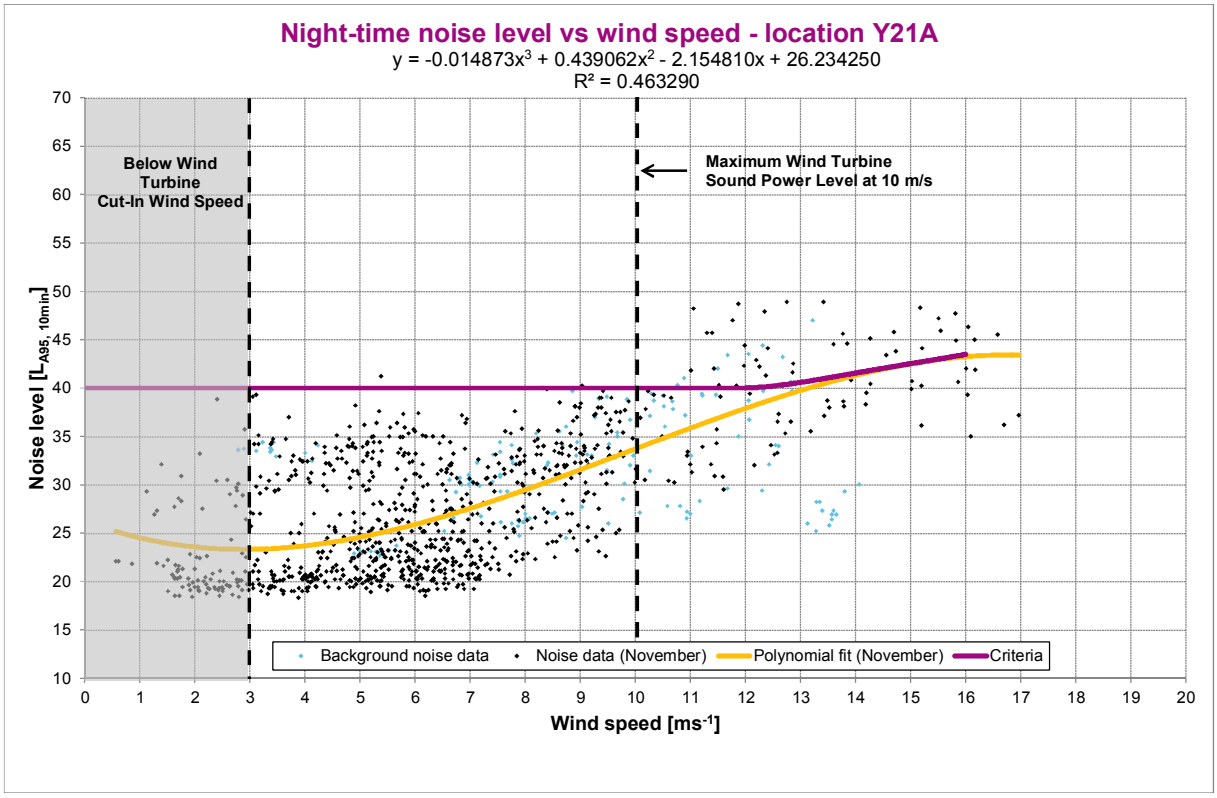


Figure 17 Night-time Monitoring Results – Y21A

7.0 Conclusion

At all locations, the measured noise levels during this monitoring period were not greater than the noise limits for each wind speed from wind turbine cut-in to the wind speed where maximum wind turbine noise emission occurs. Therefore, the noise monitoring results indicate that the wind farm was compliant with the noise criteria prescribed by the Planning Permit during this period of commissioning noise monitoring.

Appendix A

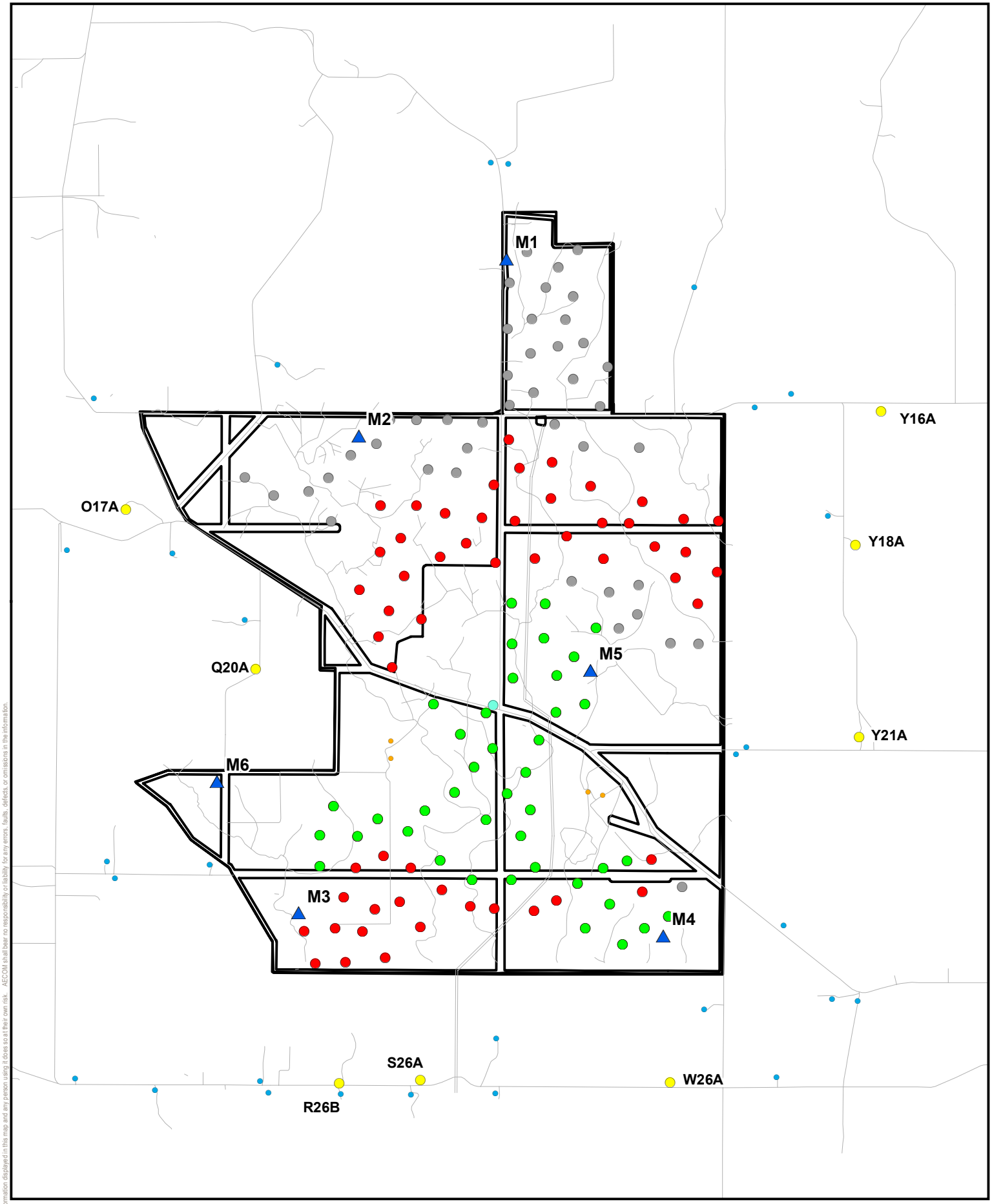
Acoustic Nomenclature

Appendix A Acoustic Nomenclature

A-weighting	The A-weighting scale is used to adjust the sound pressure levels measured in decibels to more accurately reflect the subjective response of the human ear to sound. The human ear is less sensitive to low frequency (pitch) sounds than sounds of middle to high frequency. That is, low frequency sounds of the same decibel level are not heard as loud as high frequency sounds. A sound level meter replicates the human response of the ear by using an electronic filter which is called the A-weighting filter. A sound level measured with this filter switched on is denoted as dB(A).
dB(A)	A-weighted decibels - the unit of A-weighted sound pressure level.
$L_{95,\ 10min}$	The A-weighted sound pressure level exceeded for 95% of a 10 minute measurement period. This descriptor is used to represent the background noise levels and the wind farm noise levels under NZS 6808:1998.
Sound Pressure Level	A measure of the magnitude of a sound wave. Mathematically, it is twenty times the logarithm to the base ten of the ratio of the root mean square sound pressure at a point in a sound field, to the reference sound pressure; where sound pressure is defined as the alternating component of the pressure (Pa) at the point, and the reference sound pressure is $2x10^{-5}$ Pa. [Unit: Decibels]

Appendix B

Site Map



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DATUM GDA 1994, PROJECTION MGA ZONE 55

0 500 1,000 2,000
metres

1:50,000 (when printed at A3)

LEGEND

- Monitoring Location
- Host Landowner Residence
- Other Residence
- Met Mast
- Wind farm Site Office
- Operational Turbine at 1 Nov 2012
- Turbine Commissioned During Nov 2012
- Non-Operational Turbine location
- Site Boundary

MACARTHUR WIND FARM COMMISSIONING NOISE MONITORING LOCATIONS - NOVEMBER 2012

PROJECT ID	60279731
CREATED BY	AJM
LAST MODIFIED	AJM - 3 April 2013
VERSION:	1

Map
3 Apr 13

A3 size

Filename: MACARTHUR WIND FARM - 26 MAY 2011 LAYOUT

Appendix C

Example Calibration Certificate

Appendix C Example Calibration Certificate

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 38900 & FILT 2720

Equipment Description: Sound Level Meter

Manufacturer: Svantek

Model No: Svan-957 **Serial No:** 27542

Microphone Type: 7052E **Serial No:** 50507

Filter Type: 1/3 Octave **Serial No:** 27542

Comments: All tests passed for type 1.

Owner: AECOM
540 Wickham Street
Fortitude Valley QLD 4006

Ambient Pressure: 1017 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 54 %RH ±5% R

Date of Calibration: 11/04/2012 **Issue Date:** 12/04/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: .AV. **AUTHORISED SIGNATORY:** .....
Jack Kiely

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Accredited for compliance with ISO/IEC 17025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

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Acoustic and Vibration Measurements

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