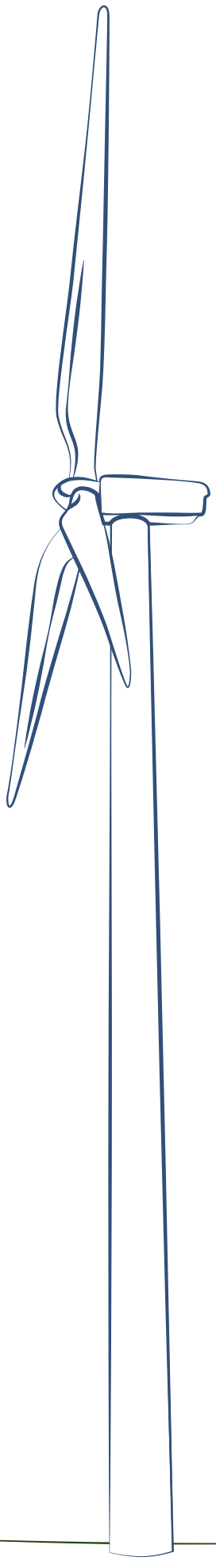

Attachment J

Environmental Noise Assessment

SONUS

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BODANGORA WIND FARM

ENVIRONMENTAL NOISE ASSESSMENT

S3627C8

May 2012

EXECUTIVE SUMMARY

The proposed Bodangora Wind Farm comprises 35 wind turbine generators and is located to the north east of Bodangora NSW.

The Bodangora Wind Farm has been assessed against the Director General's requirements (DGRs) for operational noise and construction noise and vibration.

The operational noise has been assessed against the stringent *South Australian Environmental Noise Wind Farm Guidelines 2003 (the SA Guidelines)*. The SA Guidelines require the predicted noise levels from the wind farm to be compared against criteria developed from the measured background noise levels in the area.

The assessment has been based on the Vestas V112 3MW wind turbine generators. The V112 turbines are predicted to achieve the SA Guidelines at all dwellings for the proposed layout.

Based on the above, for any turbine with a sound power level and hub height that is equal to or less than that assessed for the V112 turbines, the proposed layout can achieve the stringent requirements of the SA Guidelines.

A construction noise and vibration framework has also been developed in this assessment to achieve the relevant Director General's requirements for general construction activity, transport and potential blasting activity.

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INTRODUCTION

Sonus Pty Ltd has been engaged by Infigen Energy to conduct an environmental noise assessment of the proposed Bodangora Wind Farm, located near Bodangora, New South Wales.

The Director-General's Requirements (DGRs) dated 12th of November, 2010, specify that the assessment must be conducted in accordance with the following guidelines:

- Wind Turbines – the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines* (2003);
- Substation - *NSW Industrial Noise Policy* (EPA 2000);
- Site Establishment and Construction - *Interim Construction Noise Guideline* (DECC 2009)
- Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999)
- Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006); and,
- Blasting – *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC 1990).

Noise from the proposed wind farm has been predicted to residences in the vicinity based on the ISO 9613[1] noise propagation model and sound power level data provided by the proposed wind turbine generator manufacturer. The applicable environmental noise criteria were determined based on the relevant guidelines and background noise monitoring conducted at five residences in the vicinity of the wind farm. The locations of the turbines and relevant receivers are provided in appendices A and B respectively.

[1] ISO 9613-2:1996 "Acoustics – Attenuation of sound during propagation outdoors"

DIRECTOR GENERALS REQUIREMENTS

The Director-General's Requirements (DGRs) dated 12th of November, 2010, specify the relevant guidelines for which each aspect of wind farm noise is to be assessed against. A copy of the relevant DGRs is provided in Appendix C.

Wind Farms - Environmental Noise Guidelines (2003)

In accordance with the DGRs, wind turbine noise is to be assessed against the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines 2003* (the SA Guidelines).

Criteria

The SA Guidelines state:

> *The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:*
>
> - *35 dB(A), or*
> - *The background noise level ($L_{A90,10}$) by more than 5 dB(A)*
>
> *Whichever is the greater, at all relevant receivers for each integer wind speed[2] from cut-in to rated power of the WTG.*

It is noted that if the wind farm noise contains tonal characteristics a 5 dB(A) penalty is to be applied. In addition the SA Guidelines note that:

> *The criteria have been developed to minimise the impact on the amenity of premises that do not have an agreement with the wind farm developers.*

[2] Where wind speed is referenced in this report, it is taken to be the wind speed measured 10m above the ground in accordance with the SA Guidelines, unless specifically noted otherwise

Landowners with Commercial Agreements

The landowners of a number of residences have entered into commercial agreements with the developers of the wind farm. These landowners are listed in appendix B.

As each of these landowners has an agreement with the wind farm developer, suitable noise criteria for each residence will be agreed between the developer and the landowner. However, to protect landholders with an agreement in this project from unreasonable interference to amenity, reference is also made to the WHO Guidelines[3]. The WHO Guidelines recommend an indoor level of 30 dB(A) is achieved to protect against sleep disturbance. The indoor limit of 30 dB(A) equates to an outdoor noise level of 45 dB(A) with windows open or 52 dB(A) with windows closed.

It is proposed that the noise at residences of landholders with an agreement will achieve the recommendations of the WHO Guidelines.

Background Noise Monitoring

To determine the background noise level at various wind speeds, background noise levels were measured at 5 locations in the vicinity of the proposed wind farm between the 16th of February and the 9th of March, 2011. The measurements were conducted in accordance with the SA Guidelines.

The 5 monitoring locations (R12, R13, R14, R16, and R17) were selected based on initial predictions of the wind farm noise, where preference was given to houses with the highest predicted noise levels and without commercial agreements.

[3] "WHO Guidelines for Community Noise" World Health Organisation, 1999

The background noise was measured with Rion NL21 type 2 sound level meters, calibrated at the beginning and end of the measurement period with a Rion NC74 Calibrator. All microphones were fitted with 90mm weather proof windshelds, with the microphone approximately 1500mm above ground level. Each noise logger was positioned at an equivalent distance from the facade of the dwelling as any significant trees at that location whilst minimising the influence of fixed noise sources such as pumps. The background noise level was measured in 10 minute intervals at each of the monitoring locations. Photographs of the noise monitoring equipment at each location are provided in Appendix D.

During the background noise monitoring campaign Infigen Energy measured the wind speed with locally positioned wind masts in 10 minute intervals at a height of 10m above ground, in accordance with the SA Guidelines. Details of the wind masts are provided below in Table 1.

Table 1: Wind Mast Details

Mast ID	Measurement Heights (m)	Position (WGS84 – Zone55)	
		Easting	Northing
Bodangora 1	82, 60, 40, 10	693989	6414345
Bodangora 2	80, 65, 40, 10	699512	6411983

During the background noise measurement periods, rainfall and wind speed at the microphone height (approximately 1.5m above ground level) were also measured at Residence R14, using a HOBO Micro Station Logger H21-002. The rainfall and wind speed data collected were used to determine the periods when weather directly on the microphone may have affected the background noise measurement. This noise data was discarded before further analysis. The discarded data is for periods where rainfall was measured and/or where the measured wind speed exceeded 5 m/s at the microphone for more than 90% of the measurement period. Table 2 summarises the number of useable data points at each monitoring location, following the removal of wind data below the typical cut-in wind speed of a wind turbine generator and the influence of weather. It is noted that the Guidelines require a minimum of 2,000 data points.

Table 2: Useable Data Points

Residence ID	Representative Weather Mast	Number of Useable Data Points
R12	Bodangora 2	2516
R13	Bodangora 2	2514
R14	Bodangora 2	2518
R16	Bodangora 1	2774
R17	Bodangora 2	2513

The resultant background noise data collected at the monitoring locations were correlated with the wind speed measured by the wind mast, and a least squares regression analysis of the data was undertaken to determine the line of best fit for the correlations in accordance with the SA Guidelines. The data and the regression curves are shown in Appendix E. Based on this regression analysis, the background noise level ($L_{A90,10}$) at a range of wind speeds within the operating range of the turbines is shown in Table 3 below.

Table 3: Background Noise Levels – 24hr (dB(A))

Wind Speed 10m AGL (m/s)	3	4	5	6	7	8	9	10	11	12
R12	30	29	29	31	33	35	38	41	44	46
R13	35	35	36	37	38	39	41	43	45	48
R14	28	28	29	30	33	35	38	41	44	46
R16	32	32	32	32	33	34	35	37	39	41
R17	30	31	31	32	33	34	36	37	39	40

The Director General's Requirements include consideration of any difference in the background noise level during the day and night time periods. The approach of the Guidelines is to consider noise over a 24 hour period. Therefore, to satisfy the Director General's Requirements, correlations have also been made for each of the dwellings during the day (7am to 10pm) and night (10pm to 7am) periods. The correlations for the day and night periods are presented in Appendices F and G respectively, and the resultant background noise levels are listed in Tables 4 and 5 below.

Table 4: Background Noise Levels – Day (dB(A))

Wind Speed 10m AGL (m/s)	3	4	5	6	7	8	9	10	11	12
R12	30	30	30	32	34	37	40	42	45	47
R13	35	35	36	37	38	40	42	44	46	49
R14	29	29	30	31	34	36	39	42	45	47
R16	33	33	34	36	38	40	43	46	48	50
R17	33	33	34	35	36	37	38	40	41	42

Table 5: Background Noise Levels – Night (dB(A))

Wind Speed 10m AGL (m/s)	3	4	5	6	7	8	9	10	11	12
R12	29	28	28	29	30	33	35	38	41	44
R13	34	35	36	36	37	38	40	41	44	46
R14	27	27	27	29	31	34	37	40	43	45
R16	29	29	30	32	36	39	42	44	45	44
R17	27	27	27	27	28	29	30	32	34	36

From the above, the assessment criteria at each residential location have been determined for both associated (with an agreement) and non-associated (without an agreement) land holders, summarised in Appendix H. In order to account for the difference between the measured day and night background noise levels, the criteria have been developed based on the generally lower night time background noise levels. This is conservative (more stringent) when compared to the requirements of the SA guidelines. In addition, where background noise monitoring has not occurred at a dwelling, the lowest measured background level at any of the 5 locations has been used to derive the criteria, also a conservative (more stringent) approach.

Substation Noise

To assess substation noise in accordance with the DGRs, the New South Wales Environment Protection Authority's *Industrial Noise Policy 2000* (the INP), is referenced.

The INP establishes objective criteria based on the existing ambient noise environment and the envisaged amenity of the area. The most stringent criteria provided by the two methods are selected. If the noise levels are exceeded, then all reasonable and practicable noise reduction measures should be implemented.

In accordance with the INP, the Rating Background Level (RBL) is used to characterise the existing ambient noise environment for each of the day, evening and night periods. The RBL is determined from the lower tenth percentile of the L_{A90} noise level in the environment and effectively represents the "lulls". That is, the RBL effectively "selects" the quietest periods at the monitoring locations. Where the RBL is measured to be below 30 dB(A), then it is set to 30 dB(A).

The ambient noise environment was monitored at five residences in the vicinity of the wind farm, as described for the SA Guidelines. The RBL for each monitoring location and for each time period is provided in Table 6 below.

Table 6: RBL at Background Monitoring Locations

RBL	R12	R13	R14	R16	R17
Day	30	30	30	31	30
Evening	30	30	30	31	30
Night	30	30	30	30	30

The INP requires that noise from industrial sources should not exceed the measured RBL by more than 5 dB(A). Therefore the most stringent criterion in accordance with the INP's ambient noise method is 35 dB(A).

The INP also provides criteria based on the envisaged amenity of an area. Table 7 lists the recommended noise levels from industrial noise sources in order to protect the "noise amenity" of dwellings in a rural environment.

Table 7: Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
	Acceptable	Recommended Maximum
Day	50	55
Evening	45	50
Night	40	45

Based on the above, the INP requires that noise from the proposed substation is no greater than 40 dB(A) at dwellings in the vicinity of the substation.

The INP applies the most stringent of the ambient and amenity based criteria, which in this case is 35 dB(A). In addition, if the noise is found to have a character that has the potential to be more annoying, such as tonality, modulation or dominant low-frequency content, a modifying correction factor is to be applied to the measured level. A substation has the potential to exhibit tonality, however, based on the predicted noise levels such a characteristic is unlikely to be audible at the nearest residential locations. Notwithstanding, it is recommended that a conservative approach is adopted, and a 5 dB(A) correction is applied to the relevant criteria to allow for the presence of an annoying characteristic.

Therefore, in order to achieve the criteria provided by the INP, it is recommended that noise from the proposed substation achieves a level of 30 dB(A) at all residential locations.

Construction Noise

The construction of a wind farm comprises activities such as road construction, civil works, excavation and foundation construction, electrical infrastructure works and turbine erection requiring processes such as heavy vehicle movements, crushing and screening, concrete batching, loaders, excavators, generators, cranes and, subject to local conditions, possibly blasting.

To assess construction noise in accordance with the DGRs, the Department of Environment & Climate Change, *Interim Construction Noise Guideline 2009* (the ICN Guideline), is referenced.

The ICN Guideline provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria. However, the ICN Guideline does establish a quantitative approach, whereby "management levels" are defined based on the existing RBL. The management levels as defined by the ICN Guideline are provided below in Table 8.

Table 8: Interim Construction Noise Guideline – Management Levels

Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Traffic Noise

In accordance with the DGRs, traffic noise associated with the construction of the wind farm is to be assessed against the NSW Environment Protection Authority, *Environmental Criteria for Road Traffic Noise* (ECRTN).

Traffic noise criteria are provided for a range of scenarios. The most appropriate classification for the Bodangora Wind Farm construction site and its associated traffic is considered to be "land use developments with the potential to create additional traffic on local roads". However, it should be noted that this criteria applies to an ongoing operation, as distinct to a temporary construction process and as such provides a conservative (more stringent) approach.

The criteria are equivalent ($L_{Aeq,\ 1hour}$) noise levels of no greater than 55 dB(A) during the daytime (7am to 10pm) and 50 dB(A) during the night (10pm to 7am). This noise level is to be achieved outside, at a distance of 1.5m from the facade of a dwelling.

Blasting

The DGRs specify that blasting should be assessed against the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration,* ANZECC 1990, (the Blasting Guidelines).

The Blasting Guidelines provide the following recommended criteria:

- Peak sound pressure level of 115 dBL for 95% of blasts over a 12 month period, and a maximum level of 120 dBL.
- Peak particle velocity of 5mm/s for 95% of blasts over a 12month period, and a maximum velocity of 10mm/s
- Blasting should generally only be permitted during the hours of 9am to 5pm Monday to Saturday. Blasting should not take place on Sundays or Public Holidays.

Construction Vibration

To assess construction vibration levels in accordance with the DGRs, the DECC document "Assessing Vibration: A Technical Guideline", February 2006 (the Technical Guideline) is referenced.

The Technical Guideline provides an emphasis on construction activity implementing feasible and practicable vibration reduction measures and does not set mandatory standards or objective criteria.

The Technical Guideline does establish a quantitative approach, whereby goal vibrations levels are established based on human response to continuous, intermittent and impulsive vibration. Continuous vibration is uninterrupted for an extended period of time. Intermittent vibration is an interrupted form of continuous vibration, and impulsive vibration is a sudden event or events.

For construction activity occurring during the day time, the Technical Guideline can be interpreted to provide the following vibration criteria at the dwellings, based on the core document used as the technical basis for the Guideline, the British Standard BS 6472-1992 "Evaluation of human exposure to vibration in buildings (1-80Hz)":

Table 9: Vibration Criteria

Continuous mm/s^2 Vertical (rms)	Impulsive mm/s^2 Vertical (rms)	Intermittent $m/s^{1.75}$ Vibration Dose Value
10-20	30-60	0.2-0.4

Continuous and impulsive vibration criteria are provided as "rms" values for acceleration. The term "rms" relates to a mathematical process that is regularly performed on varying noise and vibration signals to assist in their expression, quantification and comparison. The "rms" value for acceleration is expressed in millimetres per second squared (mm/s^2). The intermittent vibration criterion is derived from a prescribed mathematical process performed on the results and therefore its quantity and units ($m/s^{1.75}$) differ from those for continuous and intermittent vibration.

ASSESSMENT

Wind Farm Noise

Noise from the wind farm has been predicted based on the use of Vestas V112 3MW model turbines. The proposed wind farm consists of 35 turbines with the coordinates of each given in Appendix A.

The predictions of the turbine noise have been based on manufacturers warranted sound power level data. Vestas have also provided octave band sound power levels for low wind speeds, where low background noise levels result in the most stringent criteria. Table 10 contains the sound power levels for the Vestas V112 turbines.

Table 10: Vestas V112 Sound Power Levels (dB(A))

Octave Band Centre Frequency (Hz)	Wind Speed (m/s)						
	4	**5**	**6**	**7**	**8**	**9**	**10**
31.5	69.6	72.7	76.7	77.6	77.2	76.0	76.6
63	79.7	83.1	87.4	89.9	89.9	89.0	89.6
125	86.6	90.4	93.9	95.7	95.4	94.6	95.8
250	89.5	93.6	96.2	97.8	96.0	94.4	94.8
500	91.8	96.1	99.2	100.1	98.5	96.8	96.8
1000	93.7	97.8	101.4	101.9	101.3	100.3	100.7
2000	92.6	97.3	98.3	98.8	99.2	98.9	99.7
4000	87.0	91.4	92.5	92.1	94.3	94.0	95.6
8000	71.0	75.9	80.9	80.7	84.1	84.6	87.3
Warranted Total	**98.8**	**103.1**	**105.8**	**106.6**	**106.0**	**105.1**	**105.8**

It is not expected that the proposed turbines will contain tonal characteristics as this is required to be reported on as part of the sound power level testing procedure conducted in accordance with the relevant international standard[4]. To provide certainty, the developer may seek the manufacturer to guarantee the turbines do not result in tonal characteristics at the location of the dwellings. The predictions have been performed without a penalty for the presence of tonal characteristics.

[4] IEC 61400-11 *Wind turbine systems – Part 11: Acoustic noise measurement techniques*

As well as separately considering noise from the substation against the INP, noise from the substation has been included in the wind turbine noise predictions. It is proposed that a 100-120MVA transformer (33-132kV) is to be located in the position listed in Appendix A. The sound power levels of the transformers have been derived from the Australian Standard AS2374.6-1994[5]. Table 11 lists the octave band sound power levels of the transformers.

Table 11: 100-120MVA (33-132kV) Transformer, Sound Power Levels (dB(A))

Octave Band Centre Frequency (HZ)	63	125	250	500	1000	2000	4000	8000	Total
SWL (dB(A))	82.0	90.1	97.6	100.0	92.2	89.4	82.2	78.1	102.9

ISO 9613-2:1996

Noise predictions were conducted using the propagation model, ISO 9613-2:1996 “Acoustics – Attenuation of sound during propagation outdoors” (ISO 9613). This noise propagation model is widely accepted as an appropriate model for the assessment of wind farms when appropriate inputs are used. The ISO 9613 model has the ability to take into account the distance between the source and receiver, topography, hardness of the ground and atmospheric absorption at different frequencies in either temperature inversion or downwind conditions (conditions conducive to noise propagation).

The assessment has been based on the following inputs, agreed upon by UK experts[6] in a joint paper:

- Warranted sound power levels
- 10°C temperature
- 70% relative humidity
- 50% acoustically hard ground and 50% acoustically soft ground
- Barrier attenuation of no greater than 2 dB(A)
- 4m receiver height

[5] Australian Standard AS2374.6-1994, *Power Transformers Part 6: Determination of transformer and reactor sound levels.*
[6] Institute of Acoustics Vol 34 No2 March/April 2009, “Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects”

The noise modeling is conducted for an atmospheric stability class that is the most conducive to noise propagation. This conservative approach is taken to provide a worst case (highest noise level) scenario with respect to the predicted noise levels. For any other atmospheric stability class, the predicted noise levels from the wind farm will be lower than those presented in this report.

Predicted Turbine Noise Levels

The predicted noise from the wind farm has been assessed against the relevant criteria according to the SA Guidelines. Appendix H lists the predicted noise from the turbines and the criteria for each residence at each relevant wind speed. Based on the predicted noise levels shown in Appendix H, the turbines are predicted to comply with the relevant criteria at all residences (both with and without an agreement) for all wind speeds. The criteria are easily achieved for all residences without an agreement.

To supplement the assessment summary in Appendix H, a noise contour map has been included as Appendix I. The contour map has been generated for the wind speed associated with the highest sound power level of the Vestas V112 model turbine (7m/s).

Substation

Noise from the substation has been included into the wind farm predictions. At the worst case residence (closest to the proposed substation location) the predicted substation noise is 26 dB(A). This level easily achieves the conservative criteria of 30 dB(A) developed under the INP, and as such will not adversely impact on the amenity of residences in the locality of the wind farm.

Cumulative Impacts

The SA Guidelines have been widely described as one of the most stringent assessment approaches of any jurisdiction in the World. The baseline criterion of 35 dB(A) is set at least 5 dB(A) less than the New Zealand Standard 1998 baseline used in Victoria and 10 dB(A) less than the World Health Organisation's (WHO) recommendation for the prevention of sleep disturbance effects.

Due to their stringency, the SA Guidelines explicitly account for the cumulative effect of other wind farms. The baseline criterion specified by the SA Guidelines accounts for cumulative impacts according to the following:

> *The base noise level is typically 5 dB(A) lower than the level considered to reflect the amenity of the receiving environment. Designing new developments at a lower level accounts for the cumulative effect of noise from other similar development and for the increased sensitivity of receivers to a new noise source.*

Section 2.5 of the SA Guidelines is titled "Cumulative Development", this section is repeated below:

> *Separate wind farm developments in close proximity to each other may impact on the same relevant receiver.*
>
> *Therefore, as for staged development, any additional wind farm that may impact on the same relevant receiver as an existing wind farm should meet the criteria using the background noise levels as they existed before the original wind farm site development. The noise generated by existing WTGs from another wind farm should not be considered as part of the background noise in determining criteria for subsequent development.*

Notwithstanding the above, there are currently no known wind farms within the vicinity of the proposed Bodangora Wind Farm.

Modulation

Amplitude modulation, or "swish", is an inherent noise character associated with wind farms. The SA Guidelines explicitly account for "swish" as a fundamental characteristic of noise from a wind farm regardless of its depth, provided that it is generated by a properly maintained and operated wind turbine or wind farm.

The ability to hear "swish" depends on a range of factors. It will be most prevalent when there is a stable environment (temperature inversion) at the wind farm and the background noise level at the listening location is low. In addition, "swish" is greater when located cross wind from a wind turbine. It is noted that whilst the amplitude modulation is greater at a cross wind location, the actual noise level from the wind farm will be lower than at a corresponding downwind location (the predicted noise levels conservatively assume that each residence is located downwind of all turbines).

The conditions noted above are most likely to occur when wind speeds at the wind farm are low under a clear night sky. The Van Den Berg effect is an increase of the modulation depth from a wind farm under very specific meteorological and operational conditions which include those conditions described above.

The Van Den Berg effect was observed on a flat site in Europe under specific conditions and in the two matters before the NSW Land and Environment Court (Gullen Range wind farm NSW LEC 41288 of 2008 and Taralga wind farm NSW LEC 11216 of 2007), it has been determined by the relevant meteorological experts that the required meteorological conditions to trigger the effect were not a feature of the environment. In Gullen Range (NSW LEC 41288 of 2008), the meteorological analysis prepared by Dr Chris Purton concluded that suitable conditions for this effect were not a feature because of the elevated ridgeline location of the wind farm (Purton, evidence NSW LEC 41288 of 2008).

If suitable conditions did exist to regularly generate high levels of swish, then there is no scientific research to indicate that the stringent SA Guidelines do not adequately account for it. Indeed, given the conditions are more likely to occur at night, then sleep disturbance would be the main issue to address, and the noise standards applied by the SA Guidelines to wind farms are significantly more stringent than limits established for the potential onset of sleep disturbance.

In addition, the SA Guidelines inherently account for "swish" and compliance with the SA Guidelines will provide an adequate level of protection for the amenity of the surrounding area due to their stringency. The Bodangora wind farm assessment provides for a more stringent approach than that required by the SA Guidelines by considering background noise levels during the night time period only.

Low Frequency Noise

Noise sources that produce low frequency content, such as a freight train locomotive or diesel engine; have dominant noise content in the frequency range between 20 and 200 Hz. Low frequency noise is often described as a "rumble".

Aerodynamic noise from a wind turbine is not dominant in the low frequency range. The main content of aerodynamic noise generated by a wind turbine is often in the area known generically as the mid-frequencies, being between 200 and 1000Hz.

Noise reduces over distance due to a range of factors including atmospheric absorption. The mid and high frequencies are subject to a greater rate of atmospheric absorption compared to the low frequencies and therefore over large distances, whilst the absolute level of noise in all frequencies reduces, the relative level of low frequency noise compared to the mid and high frequency content increases. For example, when standing alongside a road corridor, the mid and high frequency noise from the tyre and road interaction is dominant, particularly if the road surface is wet. However, at large distances from a road corridor in a rural environment, the remaining audible content is the low frequency noise of the engine and exhaust.

In addition to this effect, wind farms are located in an environment that includes masking noise in the mid and high frequencies, such as that produced by wind in nearby trees.

At a distance from a wind farm, in an ambient environment where wind in the trees is present, it is therefore possible that only low frequencies remain audible and detectable, albeit at very low levels.

Low frequency sound produced by wind farms is not unique in overall level or content. Low frequency sound can be easily measured and heard at a range of locations at levels well in excess than in the vicinity of a wind farm. Compliance with the SA Guidelines will therefore inherently provide an adequate level of protection of amenity in the surrounding area from low frequency noise impacts.

Notwithstanding, predictions of the C-weighted noise level (the C-weighting is used to indicate low frequency content) at residences have been made based on the warranted sound power level spectral data for the V112 turbines down to 31.5Hz, and an estimate of the sound power level of the V112 turbines in the 16 Hz octave band, based on measured levels in the vicinity of an operating wind turbine.

Based on the above, at the closest non-associated residence it is predicted that low frequency noise will be less than 48 dB(C) at any wind speed. This predicted level is significantly below that required to prompt a detailed analysis in accordance with the *Draft NSW Planning Guidelines for Wind Farms*, which sets threshold levels of 65 dB(C) during the day and 60 dB(C) during the night.

Infrasound

Infrasound is generally defined as noise at frequencies less than 20 Hz. The generation of infrasound was detected on early turbine designs, which incorporated the blades 'downwind' of the tower structure. The mechanism for the generation was that the blade passed through the wake caused by the presence of the tower.

Modern turbines locate the blades upwind of the tower and it is found that turbines of contemporary design produce much lower levels of infrasound.

Infrasound is often described as inaudible, however, sound below 20 Hz remains audible provided that the sound level is sufficiently high. The thresholds of hearing for infrasound have been determined in a range of studies. Non-audible perception of infrasound through felt vibrations in various parts of the body only occurs at levels well above the threshold of hearing.

Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. The A-weighting network is used by the SA Guidelines. The G-weighting network has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range.

A common audibility threshold from the range of studies is an infrasound noise level of 85 dB(G) or greater. This is used by the Queensland Department of Environment and Resource Management's (DERM's) draft Guideline for the assessment of low frequency noise as the acceptable level of infrasound in the environment from a noise source to protect against the potential onset of annoyance and is consistent with other approaches, including the UK Department for Environment, Food and Rural Affairs (DEFRA).

Whilst the aerodynamic noise from a rotating turbine blade produces energy in the infrasound range, a large range of measurements of infrasound noise emissions from modern upwind turbines indicates that at distances of 200 metres, infrasound is in the order of 25 dB below the recognised perception threshold of 85 dB(G). A 25 dB difference is significant and represents at least a 100 fold difference in energy content. Infrasound also reduces in level when moving away from the source, and separation distances between wind farms and dwellings are well in excess of 200m.

Notwithstanding the above, there are natural sources of infrasound including wind and breaking waves, and a wide range of man-made sources such as industrial processes, vehicles and air conditioning and ventilation systems that make infrasound prevalent in the natural and urban environment at a similar or greater level than that regularly measured within 200m of a modern wind turbine.

Contingency Strategy

The DGR's require that a contingency strategy exists in the event of commissioned turbine noise exceeding the noise predictions. It is noted that the Vestas V112 have several operating modes which produce lower noise levels than that of the mode used in this assessment (the highest noise generating mode).

Therefore, in the event of commissioned turbine noise exceeding the predicted noise, opportunities exist to reduce the noise of the turbines using lower noise modes that can be implemented under certain operating conditions. Notwithstanding, the predictions are based on conservative (higher noise level) modelling assumptions as a means of reducing the potential for commissioned turbine noise levels to exceed the predictions.

Construction Noise

The equipment and activities on site will vary throughout the project, depending on various stages of construction. The predicted noise from construction activity is presented as a worst case (highest noise level) scenario, where it is assumed all equipment is present and operating simultaneously on site for each stage of construction.

The weather conditions used for the predictions are the most conducive for the propagation of noise, comprising of an overcast day with a breeze from the construction activity to the receiver. Other weather conditions would result in lower noise levels than those predicted for daytime construction.

The separation distance is approximately that of the closest non-associated dwelling to a proposed WTG. Greater distances than 1200m will result in lower noise levels than that presented below in Table 12.

Table 12: Predicted Construction Noise Levels at 1200m

Phase	Main Plant and Equipment	Predicted Noise Level
Site Set-Up and Civil Works	Generators Transport trucks Excavators Low Loaders	41 dB(A) at 1200m
Road and Hard Stand Construction	Mobile crushing and screening plant Dozers Rollers Low loaders Tipper trucks Excavators Scrapers Transport trucks	48 dB(A) at 1200m
Excavation and foundation construction	Concrete batching plant Mobile crushing and screening plant Truck-mounted concrete pumps Concrete mixer trucks Excavators Front End Loaders Mobile Crane Transport trucks Tipper trucks	47 dB(A) at 1200m
Earthing	Percussion drilling rig	46 dB(A) at 1200m
Electrical Installation	Concrete trucks Low loaders Tipper trucks Mobile Crane Rock trenchers	46 dB(A) at 1200m
Turbine Delivery and Erection	Extendable trailer trucks Low loaders Mobile crane	41 dB(A) at 1200m

Based on the predicted noise levels, it is expected that construction noise will be greater than 10 dB(A) above the RBL and less than 75 dB(L_{Aeq}) at a distance of 1200m. In accordance with the ICN Guideline it is expected that a dwelling 1200m from construction activity may be "noise affected" but not "highly noise affected". Therefore, the developer *should apply all feasible and reasonable work practices to meet the noise affected level*, and should inform any impacted residents of the proposed construction work.

"Feasible and reasonable" noise control strategies to minimise noise during construction may include engineering measures such as the construction of temporary acoustic barriers, the use of proprietary enclosures around machines, the use of silencers, the substitution of alternative construction processes and the fitting of broadband reversing signals. It may also include administrative measures such as inspections, scheduling and providing training to establish a noise minimisation culture for the works.

The following mitigation measures are recommended to be implemented for the construction works:

<u>Scheduling</u>

Construction works, including heavy vehicle movements into and out of the site, restricted to between 7am and 6pm Monday to Friday, and between 8am and 1pm on Saturdays. Works carried out outside of the hours will only entail:

- works that do not cause noise emissions to be audible at any nearby residences not located on the site; or
- the delivery of materials as requested by Police or other authorities for safety reasons; or
- emergency work to avoid the loss of lives, property, and/or to prevent environmental harm.

If any other works are required outside of the specified hours, they will only be carried out with the prior consent of the New South Wales Department of Environment and Climate Change and Water.

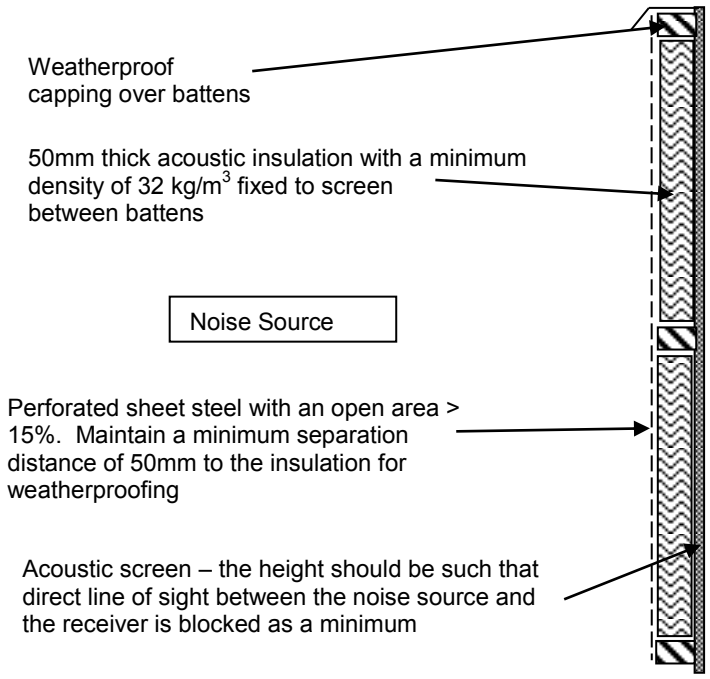
Location of Fixed Noise Sources

Locate fixed noise sources such as crushing and screening plant, concrete batching plant, percussion drilling rigs and generators and compressors at the maximum practicable distance to the nearest dwellings, and where possible, use existing landforms to block line of sight between the equipment and the dwelling.

Provide Acoustic Screens Around Fixed Noise Sources

Provide acoustic screens or mounding for fixed crushing and screening plant, concrete batching plant and percussion drilling rigs wherever these noise sources are located within 1200m of a non-associated dwelling and do not have direct line of sight blocked to that dwelling, in accordance with the following requirements:

- Locate as close as practicable to the noise source;
- Construct from mounding using excavated soil from the site, or a material with a minimum surface density of 10 kg/m^2, such as 1.2mm thick sheet steel or 9mm thick compressed fibre cement sheeting;
- Construct to a minimum height that blocks direct line of sight between the noise source and any receiver within the 1200m limit;
- Construct such that there are no air gaps or openings at joints;
- Extend such that the length is at least 5 times greater than its height or so that it is bent around the noise source;
- If barriers (rather than mounding from excavated soil) are constructed, then include acoustic insulation facing into the noise source in accordance with the following detail.



In addition, the site topography, and other shielding features (e.g. large stationary machines, mounds of topsoil and piles of materials) should be used to an advantage in terms of increased shielding when locating fixed noise sources within the 1200m distance.

Enclose Generators and Compressors

Provide proprietary acoustic enclosures for site compressors and generators.

Alternative Processes

Investigate and implement alternative processes where feasible and practicable, such as hydraulic or chemical splitters as an alternative to impact rock breaking, or the use of broadband reversing alarms in lieu of the high pitched devices. A broadband reversing alarm emits a unique sound which addresses the annoyance from the high pitched devices. The fitting of a broadband alarm should be subject to an appropriate risk assessment, with the construction team being responsible for ensuring the alarms are installed and operated in accordance with all relevant occupational, health and safety legislative requirements.

Site Management

- Select and locate centralised site activities and material stores as far from noise-sensitive receivers as possible;
- Care should be taken not to drop materials such as rock, to cause peak noise events, including materials from a height into a truck. Site personnel should be directed as part of an off-site training regime to place material rather than drop it;
- Plant known to emit noise strongly in one direction, such as the exhaust outlet of an attenuated generator set, shall be orientated so that the noise is directed away from noise sensitive areas if practicable;
- Machines that are used intermittently shall be shut down in the intervening periods between works or throttled down to a minimum;
- Implement worksite induction training, educating staff.

Equipment and Vehicle Management

- Ensure equipment has Original Equipment Manufacturer (OEM) mufflers installed;
- Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the OEM design specifications. This inspection should be part of a monitoring regime;
- Ensure silencers and enclosures are intact, rotating parts are balanced, loose bolts are tightened, frictional noise is reduced through lubrication and cutting noise reduced by keeping equipment sharp. These items should be part of a monitoring regime;
- Use only necessary power to complete the task;
- Inspect, as part of a monitoring regime, plant and equipment to determine if it is noisier than other similar machines, and replace or rectify as required.

Community Consultation

The developer should implement the following noise and vibration elements into the overall community consultation process. The aim of the consultation is to ensure adequate community awareness and notice of expected construction noise.
The minimum elements should include:

- Regular Community Information newsletters, providing details of the construction plan and duration of the construction phases;
- A site notice board in a community location providing copies of the newsletters, updated construction program details, and contact details of relevant project team members and an ability to register for email updates of the newsletter;
- A feedback mechanism for the community to submit questions to the construction team, and for the construction team to respond;
- Regular updates on the construction activities to local authorities to assist in complaint management if necessary;
- Contact details of the project manager and / or site “Environmental Representative”.

In addition, prior to any blasting activity, or construction activity occurring within 1000m of a non-associated dwelling, or significant construction traffic periods or impacts on local road conditions:

- Contact the local community potentially affected by the proposed works and inform them by letter of the proposed work, the location of the work, the day(s) and date(s) of the work and the hours involved[7]
- This contact shall be made a reasonable time before the proposed commencement of the work; and
- The letter should provide the contact details of the project manager and / or site "Environmental Representative".

Project Mitigation Measures in Context

It is unlikely that the above measures will result in meeting the construction noise goals at all times due to the stringency of these goals, and the variable nature of construction activity. However, they will serve to reduce the impacts and represent the extent of feasible and practicable noise reduction measures in accordance with the ICN Guidelines.

The above measures should be incorporated and implemented through a Construction Noise Management Plan for the site. The Plan should include the following additional elements and associated control provisions:

Construction Traffic

Construction activity will incorporate passenger vehicle and heavy vehicle movements to and from the site along local roads in the vicinity of the wind farm. These vehicles will include semi-trailers, low loaders, haulage trucks, mobile cranes, water tankers, four-wheel-drive vehicles and passenger vehicles.

[7] It is preferable to overestimate the hours of work, rather than extending the work hours for longer than anticipated.

The daytime criterion provided by the ECRTN is an equivalent ($L_{Aeq,\ 1hour}$) noise level of 55 dB(A) during any given hour. It is predicted that a distance of 10m from the road side the criterion can be achieved for 10 passenger vehicle movements and 3 heavy vehicle movements in one hour. The number of vehicle movements can double for every doubling of distance from the roadside and continue to achieve the 55 dB(A) criterion. That is, 20 passenger vehicles and 6 heavy vehicle movements could be accommodated in an hour at a dwelling that is 20m from the roadside. It is noted that care should be taken to avoid the acceleration of trucks and the use of truck engine brakes in close proximity to dwellings.

In accordance with the general principles of dealing with temporary construction noise impacts as compared to permanent operational noise, where the ECRTN is exceeded, the following mitigation measures should be employed to reduce construction traffic noise:

- Communicate with the affected community in accordance with the provisions above;
- Establish and maintain a route into the site so that heavy vehicles do not enter noise sensitive areas for access where practicable;
- Incorporate information regarding the route to all drivers prior to accessing the site and the need to minimise impacts through driver operation at certain locations;
- Schedule construction traffic deliveries such that it is as evenly dispersed as practicable;
- Restrict construction to the daytime operating hours for the construction site, subject to the scheduling caveats in the Construction Noise Management Plan.

Blasting

It is understood that minimal blasting is likely to occur during construction of the Bodangora Wind Farm. Notwithstanding, the separation distances between the potential blasting activity and the nearest dwellings are of the order of magnitude for which ground vibration and airblast levels have been adequately controlled at other sites.

Given the range of factors associated with both the generation and control of blasting, it is recommended that in the event of blasting occurring, a monitoring regime is implemented to ensure compliance with the Blasting Guidelines. Monitoring is a common control measure around sites where blasting occurs.

Construction Vibration

It is expected that the main sources of vibration will be the drilling rigs where required, rock trenching equipment and roller operation during the road and hard stand construction. The level of vibration at a distance will be subject to the energy input of the equipment and the local ground conditions. Typically, the distances required to achieve the construction vibration criteria provided in the Technical Guidelines are in the order of 20m to 100m. The 100m distance is a conservative estimate, with vibration from these activities unlikely to be detectable to humans at such a distance.

Based on the separation distances between the construction activities and the nearest dwellings being well in excess of the conservative distance of 100m, vibration levels are expected to easily achieve the criteria.

If construction activities do occur within 100m of a dwelling, as might occur with some limited areas of new road construction, it is recommended that a monitoring regime is implemented during these times to ensure compliance with the Technical Guidelines.

CONCLUSION

An environmental noise and vibration assessment of the construction and operation of the Bodangora Wind Farm, comprising up to 35 turbines, has been made.

The assessment considered the Director General's requirements (DGRs) for noise and vibration and compared the proposal against the following:

- Wind Turbines – the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines* (2003);
- Substation - *NSW Industrial Noise Policy* (EPA 2000);
- Site Establishment and Construction - *Interim Construction Noise Guideline* (DECC 2009)
- Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999)
- Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006); and,
- Blasting – *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC 1990).

Construction activity is addressed through the establishment of a construction noise and vibration framework, developed to achieve the relevant DGRs for the adequate control of noise and vibration from general construction activity, transport and potential blasting activity.

The operation of the wind farm has been considered against the stringent SA EPA Guidelines (the SA Guidelines) for Vestas V112 3MW turbines. It is predicted that the wind farm will achieve the Guidelines at all dwellings for the proposed layout.

Based on the above, for any turbine with a sound power level and hub height that is equal to or less than that assessed for the V112 turbines, the proposed layout can achieve the stringent requirements of the SA Guidelines.

In addition, through compliance with the SA Guidelines, the cumulative impacts of other wind farms in the vicinity and impacts from special characteristics such as "swish" and low frequency noise will be adequately addressed, as detailed in this report.

Based on the above, with the implementation of a construction noise and vibration management plan and for the proposed 37 turbine layout as considered in this assessment, the construction and operation of the proposed Bodangora Wind Farm achieves the Director General's requirements.

APPENDICES

Appendix A: Location of Operational Noise Sources

Turbine ID	Easting	Northing	Turbine ID	Easting	Northing
WTG-10	690990	6411498	WTG-31	694025	6414477
WTG-12	698211	6412679	WTG-32	693448	6416362
WTG-13	698831	6413115	WTG-33	693423	6415324
WTG-15	695291	6414133	WTG-34	693346	6411867
WTG-16	697255	6411811	WTG-35	693193	6411552
WTG-17	699713	6412565	WTG-36	692829	6414961
WTG-18	699560	6411787	WTG-37	692599	6411960
WTG-19	699518	6412163	WTG-38	692599	6416740
WTG-20	696649	6412773	WTG-39	691963	6415040
WTG-21	696262	6413204	WTG-40	691692	6416642
WTG-22	696260	6412508	WTG-41	691672	6415899
WTG-23	696086	6411834	WTG-42	690833	6413029
WTG-24	695086	6412384	WTG-43	690466	6410294
WTG-25	694977	6415650	WTG-44	689673	6412056
WTG-26	694944	6414839	WTG-45	689646	6412574
WTG-27	694935	6415159	WTG-46	689376	6413614
WTG-28	694526	6411184			
WTG-29	694275	6414144	**Substation**		
WTG-30	694083	6411772	-	704385	6408570

Appendix B: Residence Locations

Residence ID	Associated	Easting	Northing	Closest Turbine
R1	Yes	692341	6411582	WTG-37, 458(m)
R2	Yes	691864	6412319	WTG-37, 818(m)
R3	Yes	692800	6413328	WTG-37, 1383(m)
R4	Yes	695042	6416317	WTG-25, 670(m)
R5	Yes	696724	6414191	WTG-21, 1090(m)
R6	Yes	699834	6410724	WTG-18, 1098(m)
R7	Yes	703624	6409796	WTG-18, 4526(m)
R8	Yes	703348	6409983	WTG-18, 4196(m)
R9	Yes	703601	6409630	WTG-18, 4581(m)
R10	Yes	692861	6417565	WTG-38, 866(m)
R11	No	690273	6417460	WTG-40, 1638(m)
R12	No	698586	6415818	WTG-13, 2714(m)
R13	No	696905	6409427	WTG-16, 2410(m)
R13B	No	696738	6409602	WTG-16, 2269(m)
R14	No	703405	6413792	WTG-17, 3891(m)
R15	No	703349	6411856	WTG-17, 3704(m)
R16	No	691947	6407949	WTG-43, 2774(m)
R17	No	704000	6407217	WTG-18, 6372(m)
R18	No	705567	6412186	WTG-17, 5866(m)
R19	Yes	689454	6410083	WTG-43, 1034(m)
R20	No	689021	6405103	WTG-43, 5388(m)
R21	No	691607	6405283	WTG-43, 5139(m)
R22	No	701314	6406657	WTG-18, 5422(m)
R23	No	687573	6409950	WTG-43, 2913(m)
R24	No	684782	6414788	WTG-46, 4742(m)
R25	No	685541	6415477	WTG-46, 4264(m)

Appendix C: Director General's Requirements

Director-General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Project	Construction and operation of a wind farm with between 25 and 40 turbines and a generating capacity of between 60 and 110 Megawatts. Associated infrastructure includes access tracks, local road infrastructure upgrades, electrical connections between the turbines (both underground cable and aboveground power lines), up to three temporary and three permanent meteorological masts, gravel pit, a temporary concrete batching plant, an operations and maintenance facility, temporary lay-down areas and a construction site office. Grid connection would be either through a possible new switchyard to the existing 132 kV transmission line between the Wellington substation and Beryl, or directly into the existing Wellington substation.
Site	Approximately 2 kilometres north-east of the rural settlement of Bodangora, 15 kilometres north-east of Wellington and 40 kilometres south-east of Dubbo in the Wellington local government area. The project area is approximately 20 kilometres across (west to east) and 10 kilometres in length (north to south).
Proponent	Infigen Energy Development Pty Ltd
Date of Issue	12 November 2010
Date of Expiration	12 November 2012
General Requirements	The Environmental Assessment (EA) must include: • an **executive summary**; • a **detailed description** of the project for both the wind farm and transmission line including: → construction, operation and decommissioning details; → the location and dimensions of all project components including the wind turbines (including map coordinates and AHD heights), underground and above ground cabling between turbines, electrical substation and transmission line linking the wind farm to the grid (including easement width and height), on-site control room and equipment storage, temporary concrete batching plant(s), construction compounds, access roads/road upgrades (including access tracks), any obstacle lighting, relation to Crown roads, and any subdivision proposals; → a timeline identifying the proposed construction and operation of the project components, their envisaged lifespan and arrangements for decommissioning and staging; → supporting maps/plans clearly identifying existing environmental features (e.g. watercourses, vegetation), infrastructure and land use (including nearby residences and approved residential developments or subdivisions) and the location/siting of the project (including associated infrastructure) in the context of the existing environment; and → resourcing requirements (including, but not limited to, water supply and gravel). • consideration of any **relevant statutory provisions** including the consistency of the project with the objects of the *Environmental Planning and Assessment Act 1979* and any relevant development control plans. Consideration should be given to the Central West Catchment Action Plan; • an **assessment of the key issues** outlined below, during construction, operation and decommissioning (as relevant). The Environmental Assessment must assess the worst case as well as representative impact for all key issues; • a **draft Statement of Commitments** detailing measures for environmental mitigation, management and monitoring for the project; • a **conclusion justifying the project** taking into consideration the environmental,

	social and economic impacts of the project; the suitability of the site; and the public interest; and • **certification by the author** of the EA that the information contained in the Assessment is neither false nor misleading. The EA should present, with respect to each relevant transmission line impact, a considered overview of potential impacts along the length of the line, to identify areas of potentially significant impact for further, more detailed assessment. In addition to detailed assessment of areas of potentially significant impact, other areas along the length of the line should be assessed in a more general manner, with a particular focus on the development of frameworks for the mitigation, management and monitoring of more minor and generic environmental issues.
Key Assessment Requirements	The EA must include assessment of the following key issues for both the wind farm and transmission line: • **Strategic Justification** - the EA must: → include a strategic assessment of the need, scale, scope and location for the project in relation to predicted electricity demand, predicted transmission constraints and the strategic direction of the region and the State in relation to electricity supply, demand and electricity generation technologies, and its role within the Commonwealth's Renewable Energy Target Scheme. The EA must clearly demonstrate that the existing transmission infrastructure has sufficient capacity to accommodate the project; → include a clear demonstration of quantified and substantiated greenhouse gas benefits, taking into consideration sources of electricity that could realistically be replaced and the extent of their replacement. Reference should be made to *Estimating Greenhouse Gas Emissions Abatement from Wind Farms in NSW*, McLennan Magasanik Associates, July 2010, Report to the Department of Environment, Climate Change and Water (DECCW) and the associated *NSW Wind Farm Greenhouse Gas Savings Tool* developed by DECCW; → include an analysis of the suitability of the project with respect to potential land use conflicts with existing and future surrounding land uses (including rural residential development, building entitlement and subdivision potential, land of significant scenic or visual value, land of high agricultural value, other water users, mineral reserves, forestry and conservation areas) taking into account local and strategic land use objectives; and → describe the alternatives considered (location and/or design) for all project components, and provide justification for the preferred project demonstrating its benefits including community benefits (for example community enhancement programmes) on a local and strategic scale and how it achieves stated objectives. • **Visual Impacts** - the EA must: → provide a comprehensive assessment of the landscape character and values and any scenic or significant vistas of the area potentially affected by the project, including both the wind farm and the transmission line. This should describe community and stakeholder values of the local and regional visual amenity and quality, and perceptions of the project based on surveys and consultation; → assess the impact of shadow "flicker", blade "glint" and night lighting from the wind farm; → identify the zone of visual influence of the wind farm (no less than 10 kilometres) and assess the visual impact of all project components on this landscape; → include an assessment of the visual impacts associated with the transmission line, including impacts on local and regional views. Alternative pole designs should be presented and assessed and the potential for undergrounding in sensitive locations should also be assessed; → include photomontages of the project taken from potentially affected residences (including approved but not yet developed dwellings or

subdivisions with residential rights), settlements and significant public view points, and provide a clear description of proposed visual amenity mitigation and management measures for both the wind farm and the transmission line;

→ provide an assessment of the feasibility, effectiveness and reliability of proposed mitigation measures and any residual impacts after these measures have been implemented.

- **Noise Impacts** – the EA must:
  - → include a comprehensive noise assessment of all phases and components of the project including, but not limited to, turbine operation, the operation of the electrical substation, corona and/or aeolian noise from the transmission line, construction noise (focusing on high noise-generating activities and any works proposed outside of standard construction hours), traffic noise during construction and operation, and vibration generating activities (including blasting) during construction and/ or operation. The assessment must identify noise/vibration sensitive locations (including approved but not yet developed dwellings), baseline conditions based on monitoring results, the levels and character of noise (eg. tonality, impulsiveness etc.) generated by noise sources, noise/vibration criteria, modelling assumptions and worst case and representative noise/vibration impacts;
  - → in relation to wind turbine operation, determine the noise impacts under operating meteorological conditions (i.e. wind speeds from cut in to rated power), including impacts under meteorological conditions that exacerbate impacts (including varying atmospheric stability classes and the van den Berg effect for wind turbines). The probability of such occurrences must be quantified;
  - → include monitoring to ensure that there is adequate wind speed/profile data and ambient background noise data that is representative for all sensitive receptors;
  - → provide justification for the nominated average background noise level used in the assessment process, considering any significant difference between daytime and night time background noise levels;
  - → identify any risks with respect to low frequency or infra-noise;
  - → if any noise agreements with residents are proposed for areas where noise criteria cannot be met, provide sufficient information to enable a clear understanding of what has been agreed and what criteria have been used to frame any such agreements;
  - → clearly outline the noise mitigation, monitoring and management measures that would be applied to the project. This must include an assessment of the feasibility, effectiveness and reliability of proposed measures and any residual impacts after these measures have been incorporated; and
  - → include a contingency strategy that provides for additional noise attenuation should higher noise levels than those predicted result following commissioning and/or noise agreements with landowners not eventuate.

  The assessment must be undertaken consistent with the following guidelines:
  - → Wind Turbines - the South Australian Environment Protection Authority's *Wind Farms - Environmental Noise Guidelines* (2003);
  - → Substation – *NSW Industrial Noise Policy* (EPA, 2000);
  - → Site Establishment and Construction – *Interim Construction Noise Guidelines* (DECC, 2009);
  - → Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999);
  - → Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006); and
  - → Blasting – *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC 1990).

- **Flora and Fauna** – the EA must:
  - → include an assessment of all project components on flora and fauna (both terrestrial and aquatic, as relevant) and their habitat consistent with the *Draft*

Appendix D: Photographs of Logger Locations

R12

R13

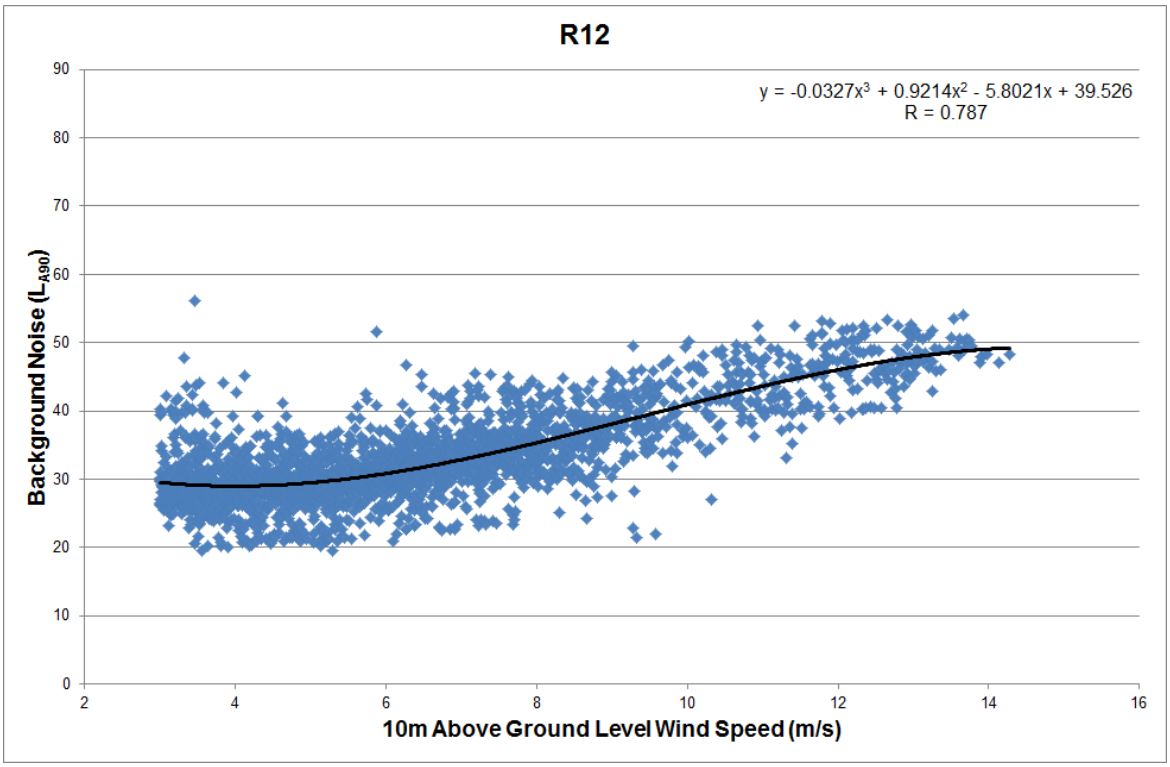
R14

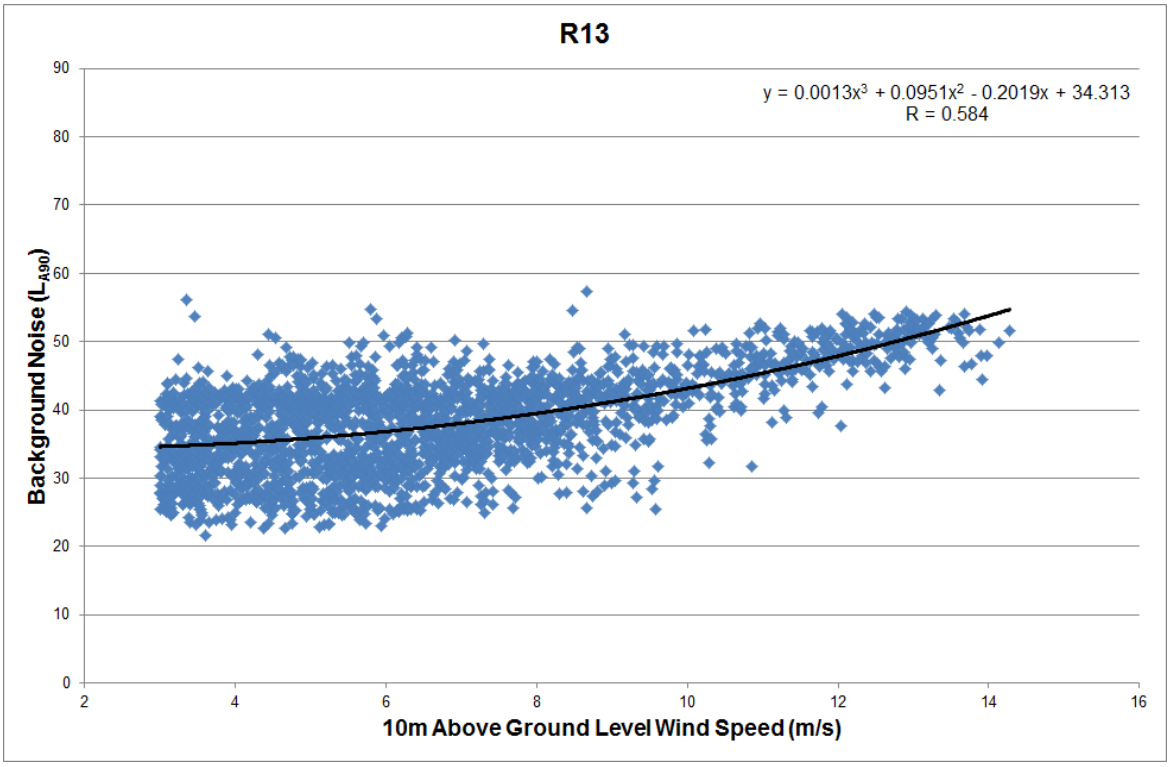
Weather Logger at R14

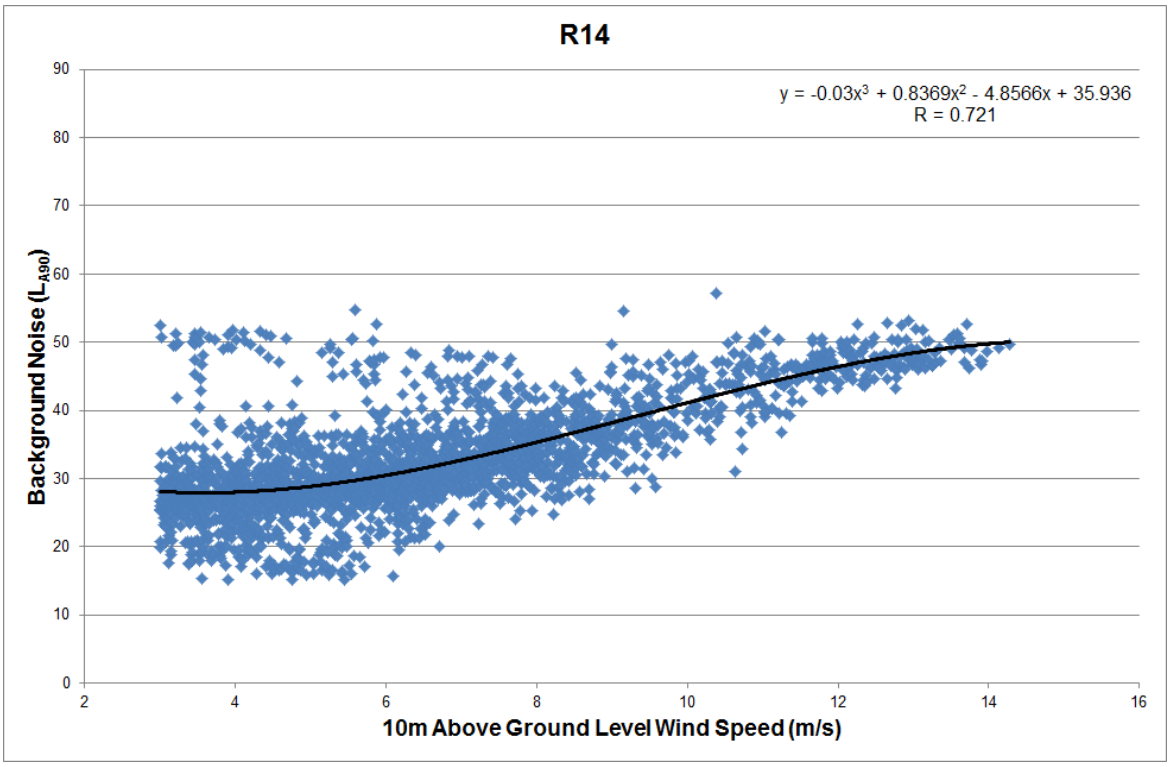
R16

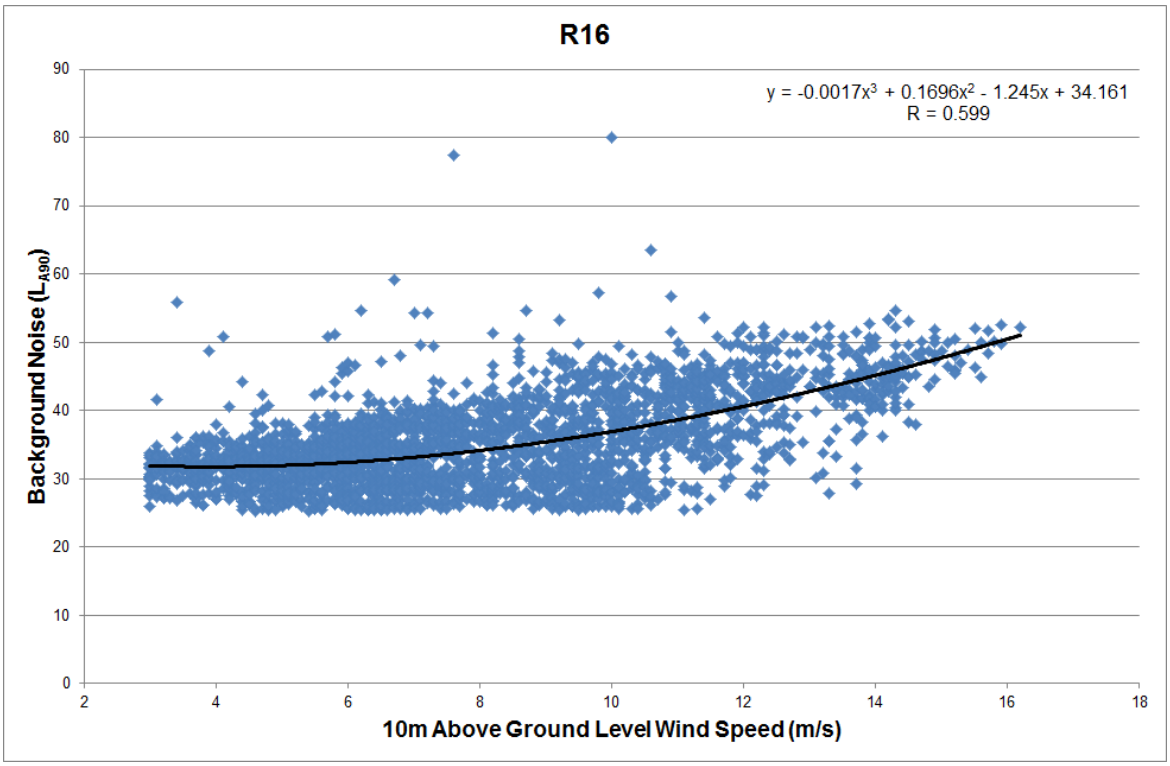
R17

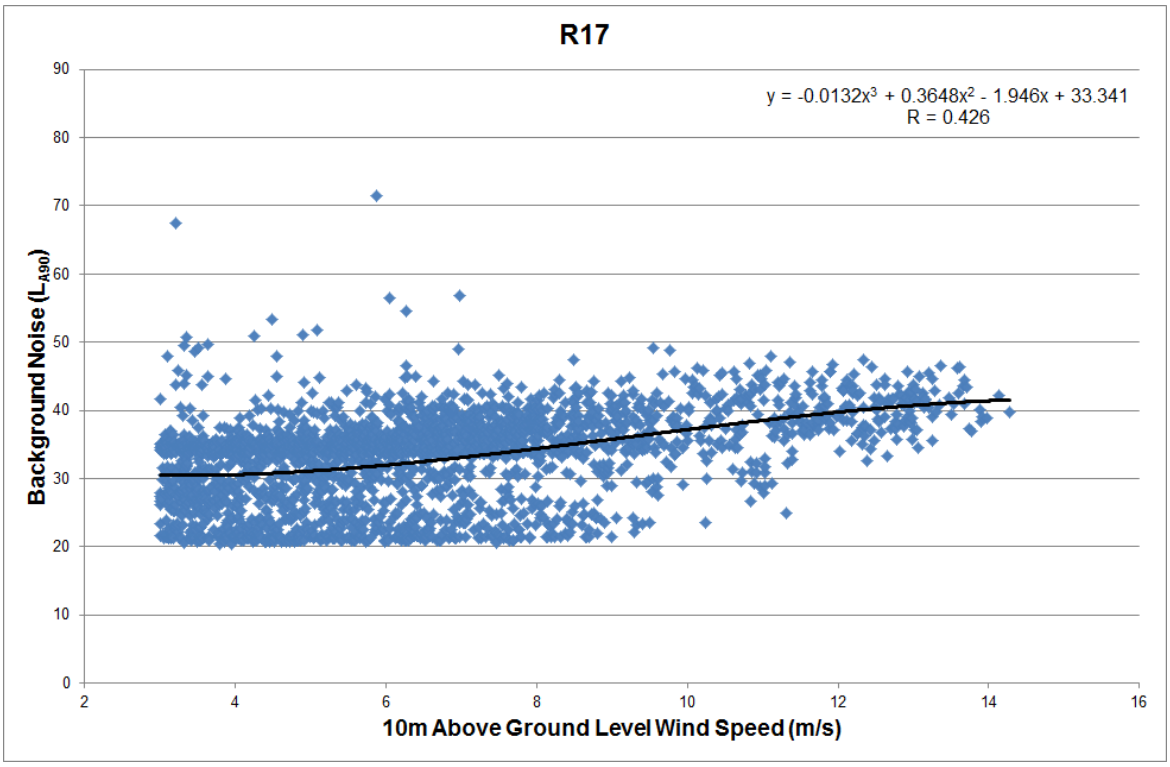
Appendix E: Noise Correlations (24 Hour)



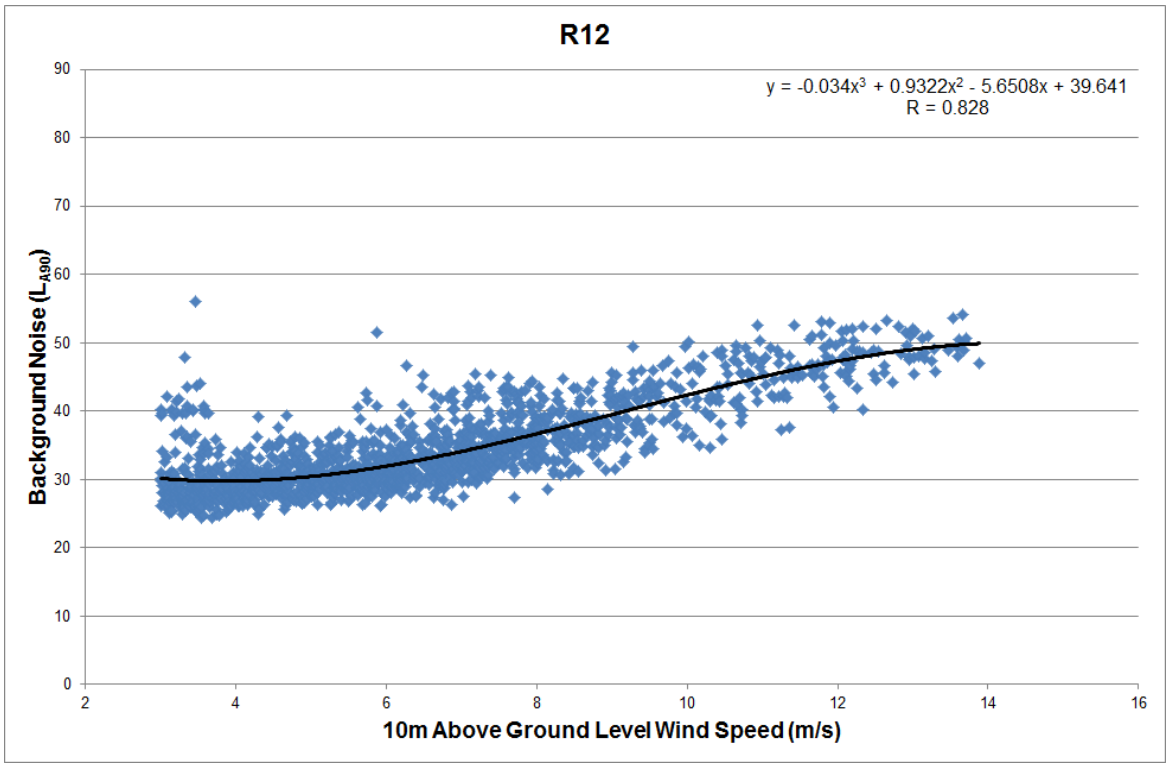


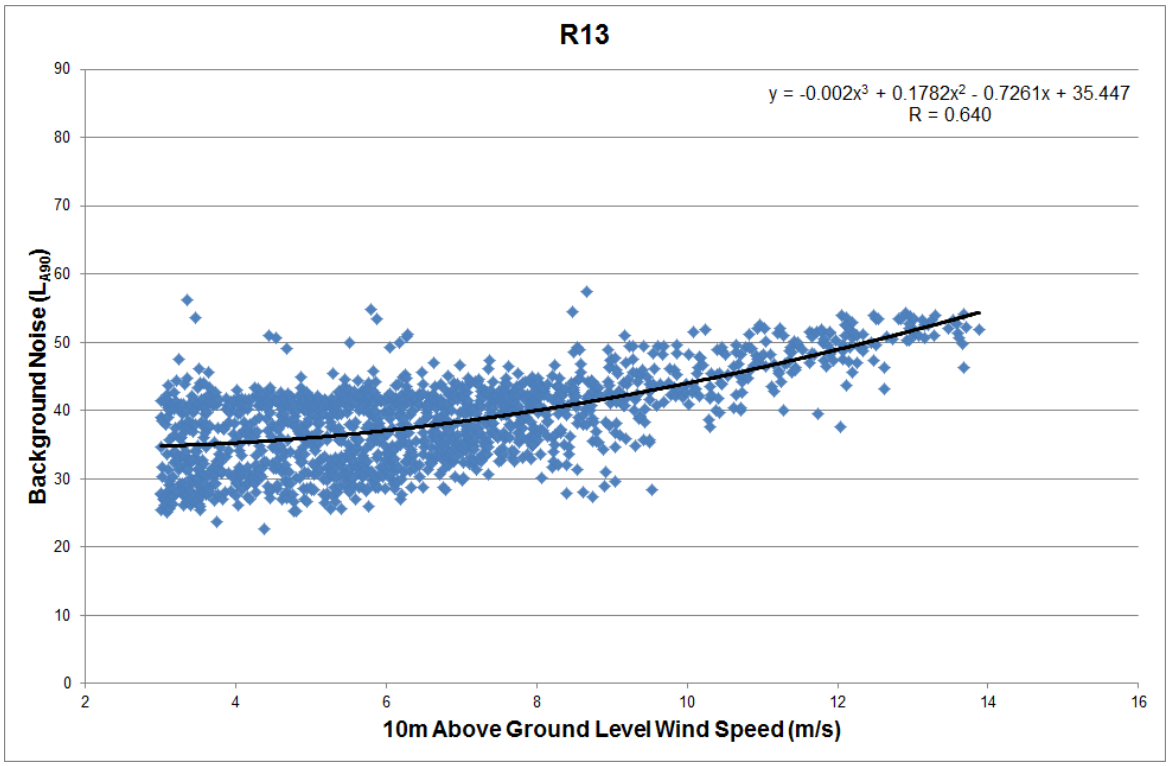

R14
y = -0.03x³ + 0.8369x² - 4.8566x + 35.936
R = 0.721
Background Noise (L$_{A90}$)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16

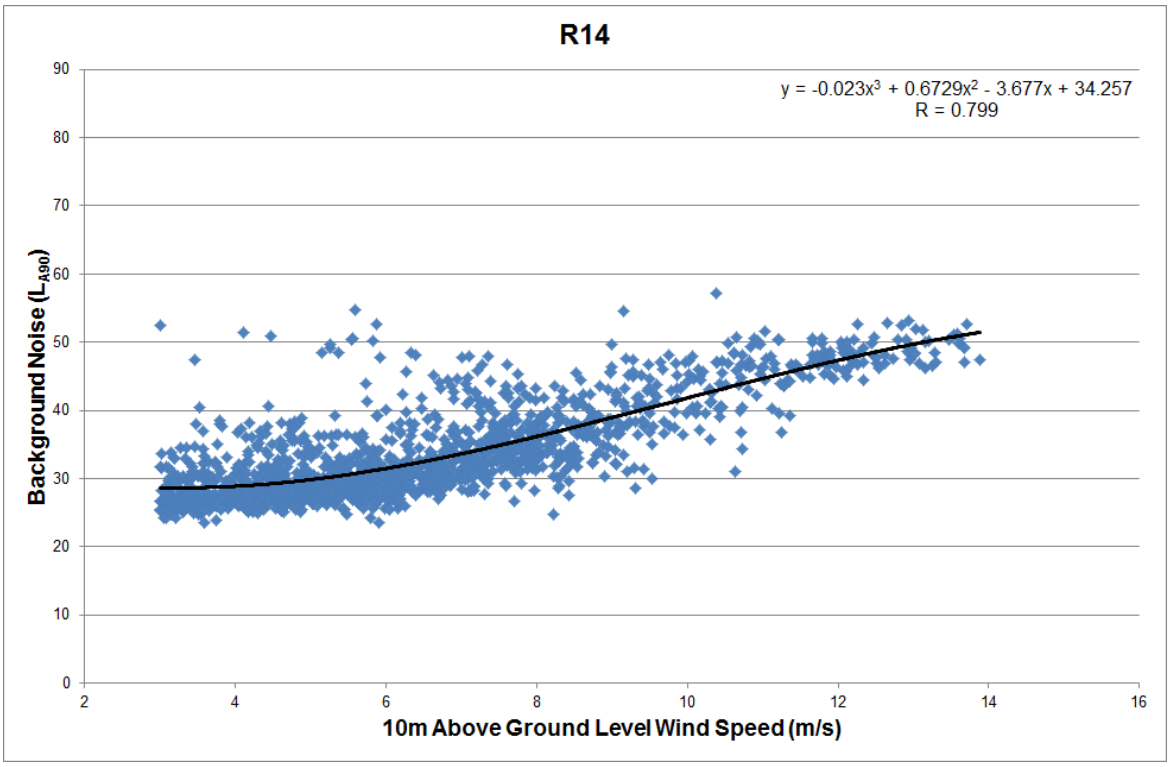

R16
y = -0.0017x³ + 0.1696x² - 1.245x + 34.161
R = 0.599
Background Noise (L$_{A90}$)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16
18

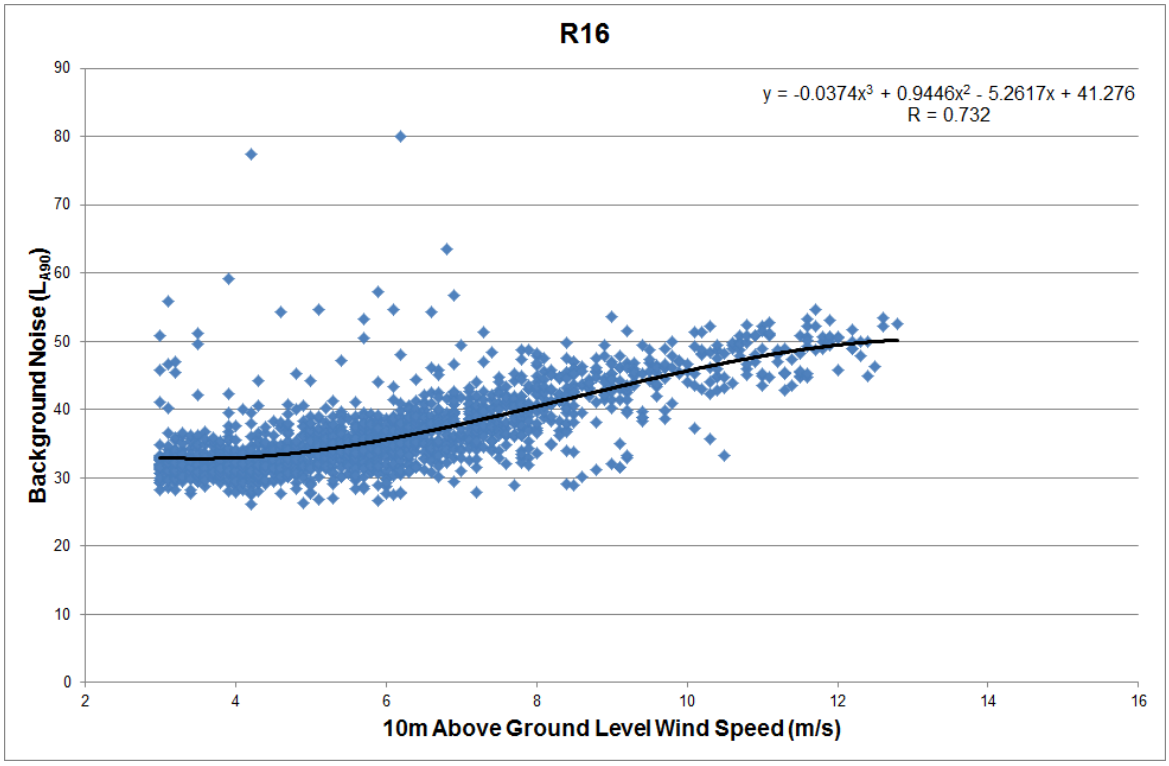

R17
y = -0.0132x³ + 0.3648x² - 1.946x + 33.341
R = 0.426
Background Noise (L-A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16

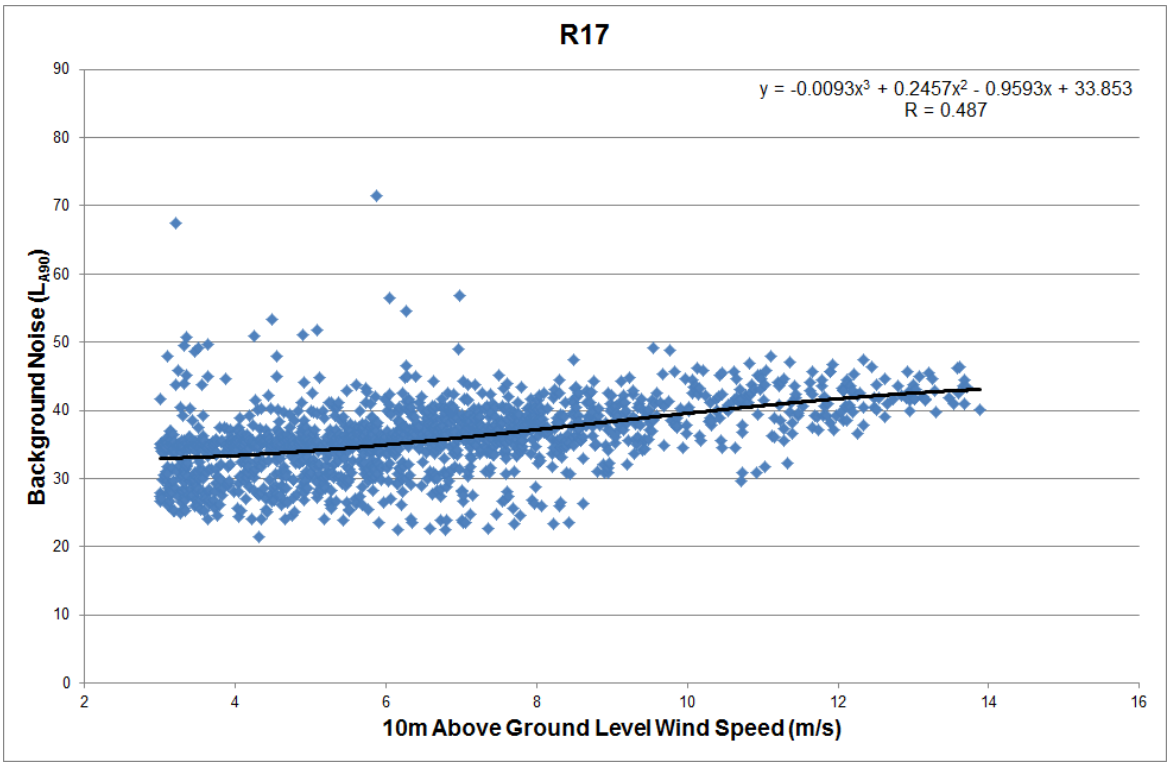
Appendix F: Noise Correlations (Day)



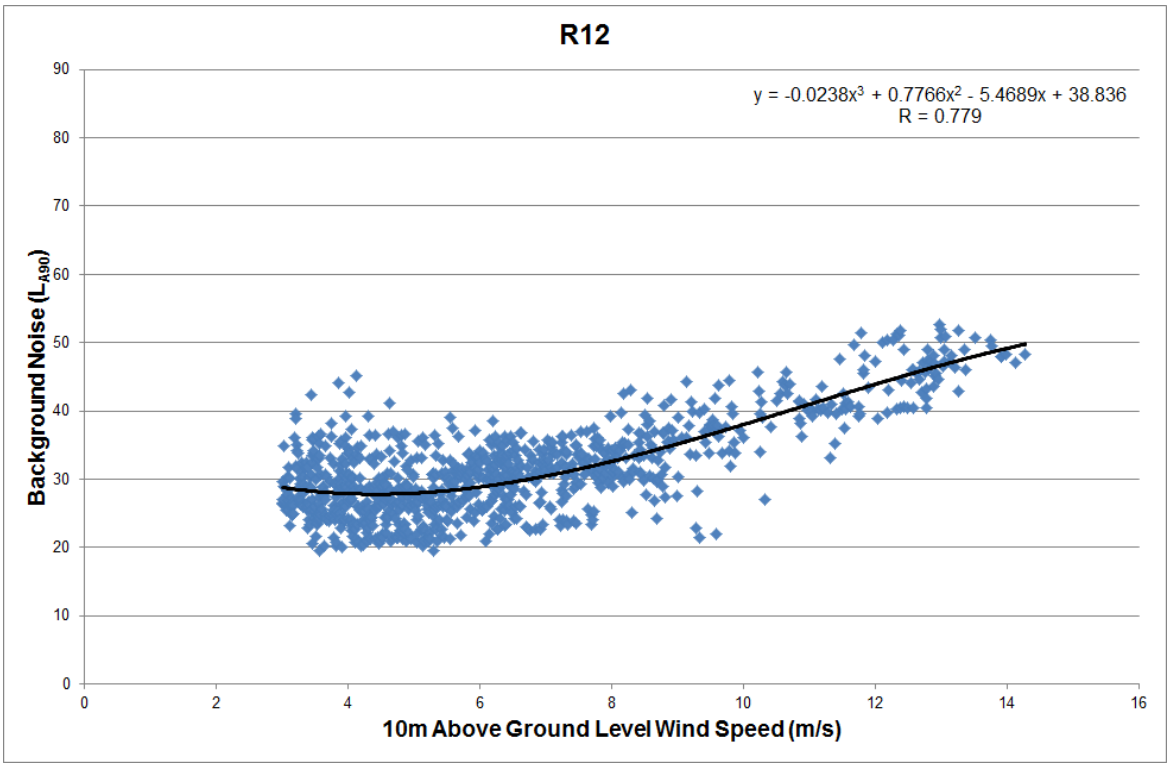


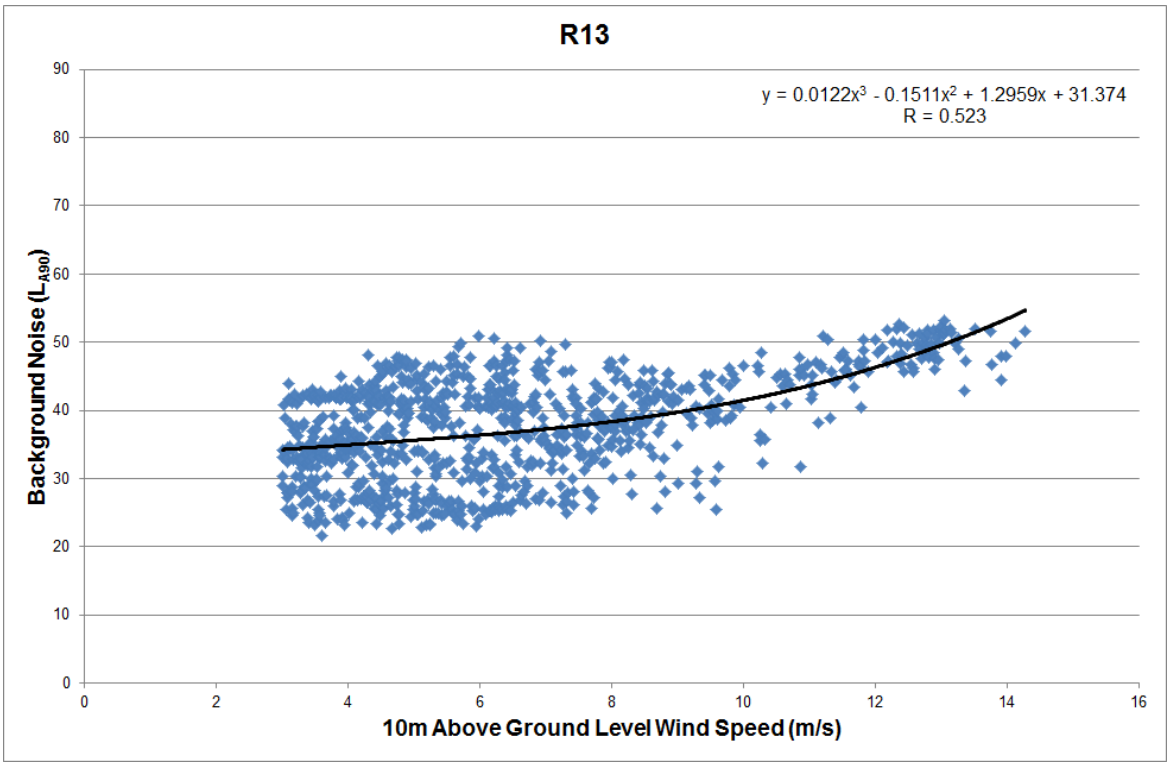

R14
y = -0.023x³ + 0.6729x² - 3.677x + 34.257
R = 0.799
Background Noise (L_A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16

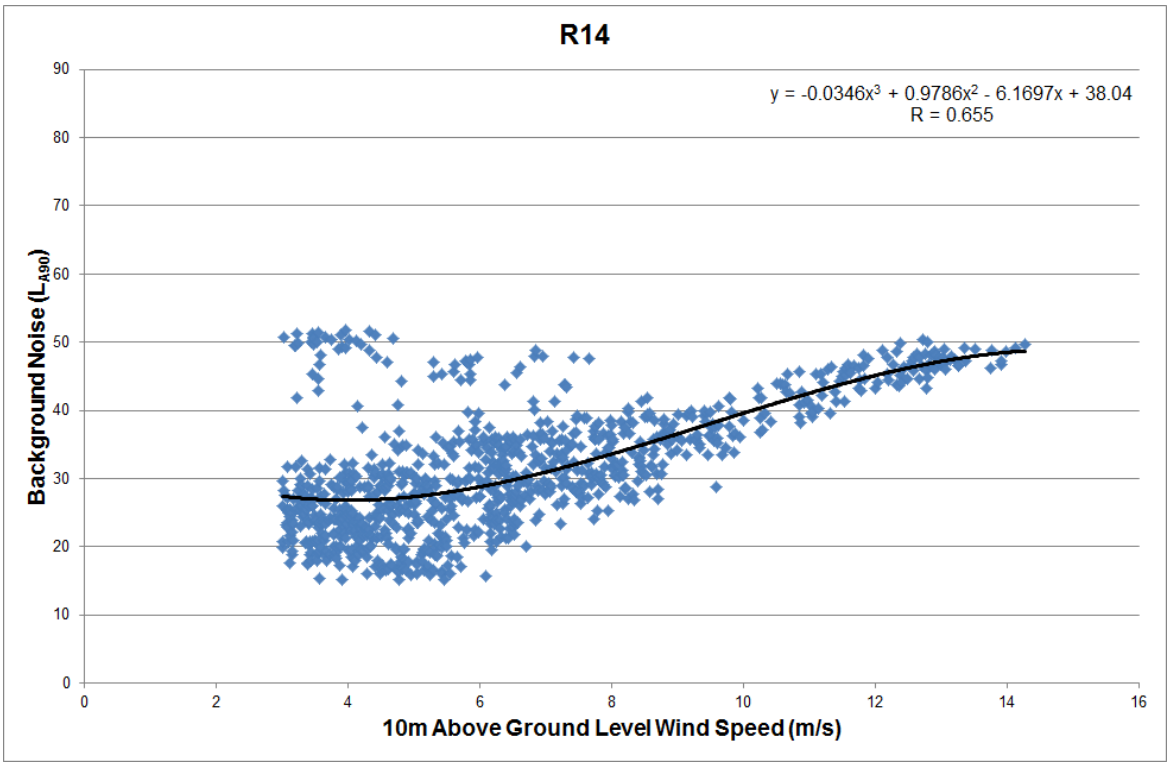

R16
y = -0.0374x³ + 0.9446x² - 5.2617x + 41.276
R = 0.732
Background Noise (L_A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16

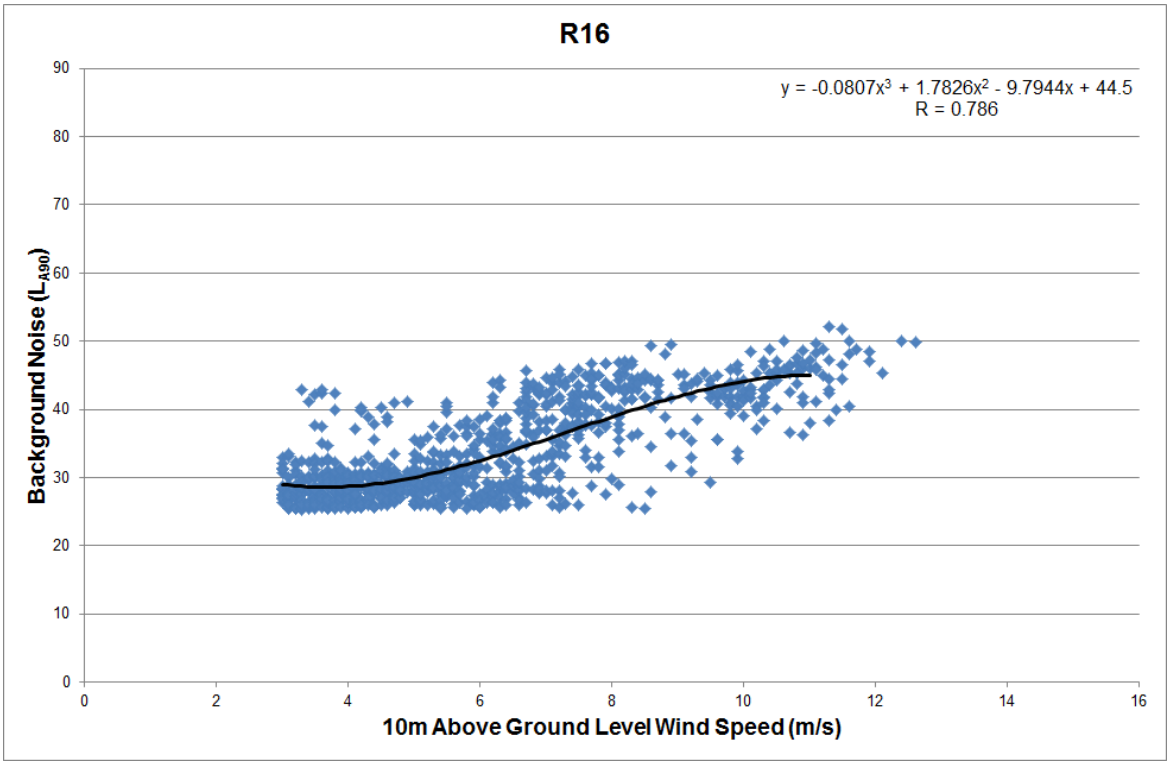

R17
y = -0.0093x³ + 0.2457x² - 0.9593x + 33.853
R = 0.487
Background Noise (L-A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
2
4
6
8
10
12
14
16

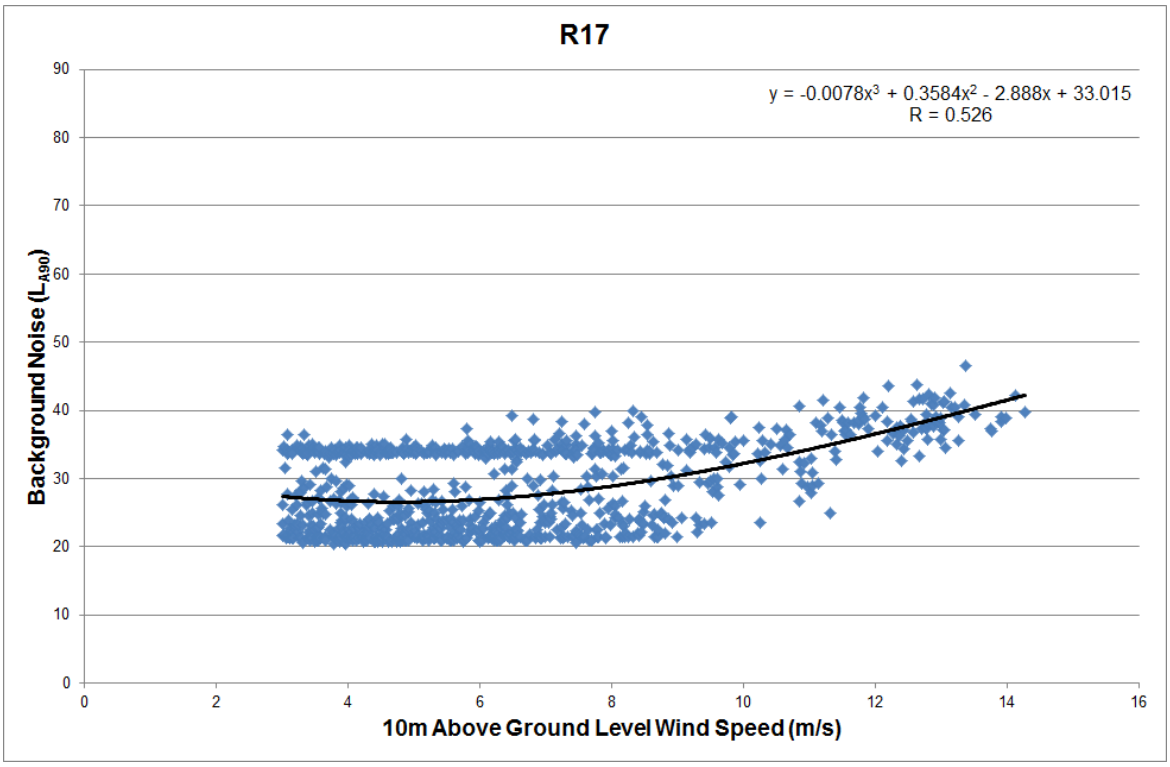
Appendix G: Noise Correlations (Night)






R14
y = -0.0346x³ + 0.9786x² - 6.1697x + 38.04
R = 0.655
Background Noise (L-A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16


R16
y = -0.0807x³ + 1.7826x² - 9.7944x + 44.5
R = 0.786
Background Noise (L-A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16


R17
y = -0.0078x³ + 0.3584x² - 2.888x + 33.015
R = 0.526
Background Noise (L-A90)
10m Above Ground Level Wind Speed (m/s)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16

Appendix H: Predicted Wind Farm Noise and Relevant Criteria

	Criteria (dB(A))							Predicted Noise Level (dB(A))						
Wind Speed (m/s)	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
R1	45	45	45	45	45	45	45	36	40	43	44	43	42	42
R2	45	45	45	45	45	45	45	32	36	39	40	39	38	39
R3	45	45	45	45	45	45	45	30	35	38	39	38	37	37
R4	45	45	45	45	45	45	45	32	36	40	41	40	39	39
R5	45	45	45	45	45	45	45	30	34	38	39	38	36	37
R6	45	45	45	45	45	45	45	28	32	35	36	35	34	34
R7	45	45	45	45	45	45	45	26	26	26	27	27	26	27
R8	45	45	45	45	45	45	45	24	24	25	26	25	25	25
R9	45	45	45	45	45	45	45	27	27	27	28	27	27	27
R10	45	45	45	45	45	45	45	30	34	37	39	38	36	37
R11	35	35	35	35	35	35	37	24	28	32	33	32	31	31
R12	35	35	35	35	38	40	43	21	25	29	30	29	28	29
R13	40	41	41	42	43	45	46	23	27	30	32	31	30	30
R13B	35	35	35	35	35	35	37	22	26	30	31	30	29	29
R14	35	35	35	36	39	42	45	15	19	22	23	23	22	22
R15	35	35	35	35	35	35	37	18	20	23	24	24	23	23
R16	35	35	37	41	44	47	49	20	24	27	29	28	27	28
R17	35	35	35	35	35	35	37	26	26	26	26	26	26	26
R18	35	35	35	35	35	35	37	15	16	18	20	19	18	19
R19	45	45	45	45	45	45	45	27	31	34	35	34	33	34
R20	35	35	35	35	35	35	37	10	14	17	19	18	17	18
R21	35	35	35	35	35	35	37	14	18	21	23	22	21	22
R22	35	35	35	35	35	35	37	16	18	20	21	21	20	21
R23	35	35	35	35	35	35	37	19	23	26	27	27	25	26
R24	35	35	35	35	35	35	37	14	17	21	23	22	21	22
R25	35	35	35	35	35	35	37	14	18	21	23	22	21	22

Appendix I: Noise Contour