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Rye Park Wind Farm

Noise Impact Assessment

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Rye Park Wind Farm Pty Ltd

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Noise Impact Assessment

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Executive Summary

SLR Consulting Australia Pty Ltd (SLR Consulting) has completed a noise impact assessment of Rye Park Wind Farm. The methodology and criteria used in the assessment are supported by the South Australian Environmental Protection Authority (SA EPA) *Environment Noise Guidelines for Wind Farms (February 2003)*, World Health Organization (WHO) limits, construction noise guidelines (DECC Interim Construction Noise Guideline 2009) and blasting impact.

Noise monitoring was conducted by Epuron in the period 8 June 2012 through to 22 August 2012 at twenty locations to determine baseline conditions and establish indicative criteria for surrounding residential receivers.

Noise predictions were made for receptors within a 2 km of a proposed WTG. WTG noise for a layout of 126 Vestas V112 WTG's of hub height 80m has been predicted and assessed against relevant criteria prescribed by the SA EPA Guideline and World Health Organisation (WHO) goals where appropriate. The model was then mitigated using Sound Management Mode for some turbines. The predicted noise levels of the mitigated layout were determined to meet the relevant criteria at all receptor locations.

The project is yet to select and finalise the WTG make and model. Upon finalising the WTG model a revised noise prediction and assessment will be completed in which the noise impact mitigation techniques listed in **Section 7.5** will be investigated thoroughly to produce a fully compliant layout.

WTG vibration levels have been evaluated and based upon overseas research available were found to be acceptable.

Construction noise has been predicted to all receivers; a number of these are deemed 'noise affected' under the NSW Construction Noise Guidelines. In order to ensure all appropriate measures are being taken to manage construction noise, a more detailed construction management plan should be developed by the proponent. This document will provide detailed guidance on various noise mitigation strategies for the construction stage.

Blasting impact has been assessed and found to be acceptable. With a maximum instantaneous charge (MIC) of up to 80 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear for all existing residences. Similarly, vibration levels are anticipated to be well below the acceptable criteria.

Construction traffic noise impact has been assessed and the 'worst case' maximum construction traffic generated scenario would comply to the NSW RNP requirements, due to the typically large setback of dwellings from the road network. Night-time deliveries are unlikely to cause sleep disturbance based on predicted maximum noise levels.

Table of Contents

Table of Contents

Table of Contents

Table of Contents

TABLES

FIGURES

Table of Contents

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting), has been engaged by Rye Park Wind Farm Pty Ltd (RPWF) as the acoustical consultants for the proposed Rye Park Wind Farm.

This report describes the methodology and findings of the Noise Impact Study (NIS) for the proposed Rye Park Wind Farm forming part of the Environmental Impact Assessment for the proposed project.

Detailed in this report are the main aspects of the proposed wind farm project, the acoustic criteria, the background noise measurements and the predicted noise levels at all potentially impacted receivers from the operation of the proposed wind farm. It also addresses the acoustic impact of the wind farm during the construction phase, including blasting and transportation noise.

1.1 Wind Farm Assessment Methodology

1.1.1 Acceptability Limit Criteria

The methodology and acceptability limit criteria that have been applied to this study are based upon the *South Australia Environment Protection Authority (SA EPA) Noise Guidelines for Wind Farms (February 2003)* (SA EPA Guidelines). The principal acceptability limit criteria is that the wind farm $L_{eq,(10\ min)}$ noise should not exceed the greater of an amenity limit of 35 dBA or the pre-existing background noise, $L_{90,(10\ min)}$ by more than 5 dBA (for any given wind speed).

The project requirements and wind farm acceptability limit criteria are discussed in more detail in **Section 6**.

1.1.2 Wind Farm Noise Level Prediction

The noise emission model used in this study to predict wind farm noise levels at sensitive receptors is based on ISO 9613-2:1996 as implemented in the SoundPLAN computer noise model. The model predicts noise levels through spherical spreading and includes the effect of air absorption (as per ISO 9613), ground attenuation and shielding.

Predicted L_{Aeq} noise levels were calculated based upon sound power levels determined in accordance to the recognised standard IEC-61400-11:2002 *(Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques)*, where available, for the wind range 3 to 12 m/s.

The noise character of Wind Turbine Generator (WTG) noise emissions is also assessed for any special audible characteristics, such as tonality or low frequency content, which would be deemed more annoying or offensive. If sufficient characteristics such as tonality are identified then the predicted noise level would be penalised by the addition of 5 dBA. It should be noted that the characteristic noise level modulation of WTGs, commonly referred to as ‘swish’, is considered to be a fundamental part of wind farm noise and is taken into account by the SA EPA Guideline assessment procedure.

1.1.3 Ambient Noise Monitoring

In order to establish the intrusive noise limit, background noise monitoring is required to establish the pre-existing ambient noise environment as a function of wind speed. As wind speed increases the ambient noise level at most receivers generally also increases as natural sources such as wind in trees begin to dominate. The variation of background noise with wind speed is usually quite site specific and related to various physical characteristics such as topographic shielding and the extent and height of exposed vegetation.

Noise monitoring is completed for a period of approximately 2 weeks and correlated to synchronous wind speed and direction data measured at the wind farm monitoring mast. The captured data is screened for validity, with data monitored during periods of rain or where the average wind speed at the microphone position likely exceeded 15 m/s (10 m AGL) being discarded from the data set. Other data that was obviously affected by external noise sources (eg pond pumps, grass mowing, birds at dawn, frogs etc) was also removed from the data set. A regression analysis of all valid data is used to determine a line of 'best fit' from which the noise limit is established.

1.1.4 Assessment Procedure

In general, the assessment procedure contains the following steps:

1. Predict and plot the L_{Aeq} 35 dBA noise level contour from the wind farm under reference conditions. Receivers outside the contour are considered to be within acceptable wind farm noise levels.
2. Establish the pre-existing background noise level at each of the relevant assessment receivers within the L_{Aeq} 35 dBA noise level contour through background noise monitoring.
3. Predict wind farm noise levels at all relevant assessment receivers for the wind range from cut-in of the WTG to approximately 10 m/s (at hub height).
4. Assess the acceptability of wind farm noise at each relevant assessment receiver to the established limits.

In addition, where the assessment of a receiver has predicted unacceptable wind farm noise levels, a process of noise mitigation and alternative wind farm layouts is considered and Steps 3 and 4 are repeated until an acceptable arrangement is developed.

A brief explanation and description of the acoustic terminology used in this report is included in **Appendix D.**

2 ENVIRONMENTAL NOISE CRITERIA

2.1 Introduction

The New South Wales (NSW) Government Department of Planning and Infrastructure (DOPI) has issued information on the required inputs into the Environmental Assessment (EA). The environmental assessment requirements issued by the Director-General (DGRs) in relation to noise impacts are:

→ Include a comprehensive noise assessment of all phases and components of the project including turbine operation, the operation of the electrical substation, corona and / or Aeolian noise from the transmission line, construction noise (focusing on high noise generating construction scenarios and works 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 (e.g. tonality, impulsiveness, low frequency etc) generated by noise sources, noise vibration criteria, modelling assumptions and worst case and representative noise/vibration impacts;

→ In related 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 day time and night time background noise levels higher than 30 dB(A)

→ Identify any risks with respect to low frequency or infra-noise;

→ 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 the proposed measures and any residual impacts after these measures have been incorporated;

→ 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;

→ 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.

2.2 Applicable Noise Policies and Guidelines

The assessment must be undertaken consistent with the following guidelines for each aspect of the project.

→ *Wind Turbines - the South Australian Environment Protection Authority's Wind Farms - Environmental Noise Guidelines (2003);*
→ *Electrical 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); and*
→ *Vibration – Assessing Vibration: A Technical Guideline (DECC, 2006).*

2.3 SA EPA Wind Farm Noise Guidelines

The South Australia EPA Noise Guidelines for Wind Farms, 2003 (SA EPA Guidelines) recommends the following noise criteria for new wind farms,

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

These guidelines also provide information on measuring the background noise levels, locations and requirements on the number of valid data points to be obtained and the methodology for excluding invalid data points. It also outlines the process for determining lines of best fit for the background data, and determination of the noise limit.

The Guideline explicitly states that the "swish" or normal modulation noise from wind turbines is a fundamental characteristic of such turbines; however, it specifies that tonal or annoying characteristics of turbine noise should be penalised.

A 5 dBA penalty should be applied to the measured noise level if an "authorised" officer determines that tonality is an issue and that tonality should be assessed in a way acceptable to the EPA.

The Guideline does not provide an assessment for the potential of low frequency noise or infrasound, but it does state that recent turbine designs do not appear to generate significant levels of infrasound, as the earlier turbine models did.

The Guideline accepts that wind farm developers commonly enter into agreements with private landowners in which they are provided compensation. The guideline is intended to be applied to premises that do not have an agreement with the wind farm developers. This does not absolve the obligations of the wind farm developer entirely as appropriate action can be taken under the *Environmental Protection Act* if a development 'unreasonably interferes' with the amenity of an area. The guideline lists that there is unlikely to be unreasonable interference if:

- a formal agreement is documented between the parties
- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect on the landowner's amenity
- the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance)

The proponent RPWF has discussed the possible noise implications of the various proposed turbine layouts with the involved residents whose property the turbines would be located on and will enter into agreements with these parties. The full noise assessment will be made available to all residents as part of the exhibited Environmental Assessment on the EPA website.

These agreements would specify that:

(a) RPWF would ensure that the properties met the World Health Organisation noise guidelines (see **Section 2.5**); and,

(b) RPWF would implement an adaptive management approach which could include the use of building treatments and turbine operation / management strategies if operational noise causes significant impact to the amenity of involved residents.

This noise agreement would only be required under those turbine configurations where the SA EPA Guidelines would be exceeded for that particular property.

2.4 NSW Industrial Noise Policy (INP)

The NSW Industrial Noise Policy (INP) requirements include site selection for background measurements, description of the site, the equipment used, graphing of results and amenity noise criteria during each of the three periods (Day, Evening and Night).

The proposed site for the Rye Park Wind Farm is in a rural area and therefore the Amenity Criteria for rural residential receivers, as detailed in Table 2.1 in the NSW INP, is applicable.

The criteria vary as a function of time of day. The Day, Evening and Night Periods are defined as:

Day Period	7:00 am - 6:00 pm 8:00 am - 6:00 pm (Sundays and Public Holidays)
Evening Period	6:00 pm - 10:00 pm
Night Period	10:00 pm - 7:00 am 10:00 pm - 8:00 am (Sundays and Public Holidays)

The Amenity Criteria (L_{Aeq} level) for the residential noise sensitive locations for the Rye Park Wind Farm project are,

Day Period	50 dBA
Evening Period	45 dBA
Night Period	40 dBA

The Intrusiveness Criterion in the INP is based on the rating background level (RBL), where the Criterion is,

$$L_{Aeq,\ 15\ min} \leq \text{RBL} + 5\ \text{dBA}$$

This is almost identical to the SA EPA Guidelines (**Section 2.3**), the difference being the measurement interval (15 and 10 minute) and the determination of the background noise level (rating level, based on the 10^{th} percentile of measured background levels, or using a line of best fit through the data points).

The INP states where the measured RBL is less than 30 dBA, then the RBL is considered to be 30 dBA.

In summary it is evident that the non project related residential receivers assessed under the *SA EPA Wind Farm Guideline* will generally comply to INP amenity criteria. Furthermore, intrusiveness is covered by the *SA EPA Wind Farm Guideline.*

2.5 World Health Organisation (WHO) Guidelines

The WHO publication '*Guidelines for Community Noise'* identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

The appropriate guideline limits are listed in **Table 1** below**.**

Table 1 WHO Guideline values for environmental noise in specific environments

Specific Environment	Critical Health Effect(s)	L_{eq} (dBA)	Time base (hours)	L_{Max} (dBA, Fast)
Outdoor living area	Serious Annoyance, daytime & evening	55	16	-
	Moderate annoyance, daytime & evening	50	16	-
Dwelling indoors	Speech Intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance – window open, night-time	45	8	60

Where noise levels at project-involved residences do not comply with the SA EPA Guidelines, the proponent intends to enter into agreements with the owners of those residences to achieve noise criteria in accordance with World Health Organisation (WHO) Guidelines. The proponent will apply those guidelines as necessary to ensure that the project does not result in an 'unreasonable interference' with the amenity or cause any adverse health effects at those residences. (See **Section 2.3**)

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

2.6 Construction Noise Guidelines

The Department of Environment, Climate Change and Water (DECCW) issued the "*Interim Construction Noise Guideline"* in July 2009. The main objectives of the guideline are stated in Section 1.3, a portion of which is presented below:

- promote a clear understanding of ways to identify and minimise noise from construction works.
- focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts.
- encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.

The guideline sets out Noise Management Levels (NMLs) at residences, and how they are to be applied, as presented in **Table 2**. This approach intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

Table 2 Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq(15minute)}$[1]	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to	Noise affected RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. 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.

Time of Day	Management Level $L_{Aeq(15minute)}$[1]	How to Apply
1.00 pm No work on Sundays or public holidays	Highly noise affected 75 dBA	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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dBA	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 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

2.7 Vibration Guidelines

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

The DECCW's *Assessing Vibration: A Technical Guideline* provides acceptable values for continuous and impulsive vibration based upon guidelines contained in BS 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz)*.

Both preferred and maximum vibration limits are defined for various locations and are shown in **Table 3**, with the preferred night-time PPV criteria of 0.2 mm/s being the most relevant to the project.

Table 3 Preferred and maximum values for continuous and impulsive vibration

Location	**Assessment period**[1]	**Preferred values** RMS acceleration m/s^2		**Maximum values** RMS acceleration m/s^2		**Peak Velocity PPV mm/s**	
		z-axis	x- and y-axes	z-axis	x- and y-axes	Preferred	Maximum
Continuous vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.010	0.0071	0.020	0.014	0.28	0.56
	night-time	0.007	0.005	0.014	0.010	0.20	0.40
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028	0.56	1.1
Workshops	Day- or night-time	0.04	0.029	0.080	0.058	1.1	2.2
Impulsive vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.30	0.21	0.60	0.42	8.6	17.0
	night-time	0.010	0.0071	0.020	0.014	2.8	5.6
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0
Workshops	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472–1992

These limits relate to a long-term (16 hours for daytime), continuous exposure to vibration sources. Where vibration is intermittent, a higher level of vibration is typically acceptable.

2.7.1 Building Damage

In regard to potential building damage, the German Standard DIN4150 recommends a limit of 10 mm/s PPV within any building and the British Standard BS7385: Part 2 - 1993 sets a limit within buildings which depends upon the vibration frequency, but is as low as 7.5 mm/s PPV (at 4.5Hz). For the purposes of ensuring a reasonable factor of safety a conservative limit of approximately 5 mm/s PPV has been applied for this project.

2.8 Blasting Criteria

The ground vibration and airblast levels which cause concern or discomfort to residents are generally lower than the relevant building damage limits.

The DECCW advocates the use of the Australian and New Zealand Environment Conservation Council (ANZECC) guideline *"Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration"* for assessing potential residential disturbance arising from blast emissions. The ANZECC guidelines for control of blasting impact at residences are as follows:

→ The recommended maximum level for airblast is 115 dB Linear. The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dB Linear at any time.

→ The recommended maximum for ground vibration is 5 mm/s, Peak Vector Sum (PVS) vibration velocity. It is recommended however, that 2 mm/s (PVS) be considered as the long term regulatory goal for the control of ground vibration. The PVS level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.

→ Blasting should generally only be permitted during the hours of 9:00 am to 5:00 pm Monday to Saturday. Blasting should not take place on Sundays and public holidays.

→ Blasting should generally take place no more than once per day.

The Australian Standard 2187.2-1993 "*Explosives - Storage, Transport and Use. Part 2: Use of Explosives*" does not present human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying "a limit of 120 dB for human comfort is commonly used". This is consistent with the ANZECC guidelines.

AS 2187.2-1993 nominates building damage assessment criteria as presented in **Table 4**.

Table 4 Blast Emission Building Damage Assessment Criteria (AS 2187)

Building Type	Vibration Level	Airblast Level (dB re 20 μPa)
Sensitive (and Heritage)	PVS 5 mm/s	133 dB(Linear) Peak
Residential	PVS 10 mm/s	133 dB(Linear) Peak
Commercial/Industrial	PVS 25 mm/s	133 dB(Linear) Peak

2.9 Traffic Noise

The NSW *Environmental Criteria for Road Traffic Noise* (ECRTN May 1999) as required by the Director General Requirements presents guidelines for the assessment of road traffic noise arising from new or redeveloped roads.

Subsequent to the issuing of the DGR's the Department of Environment, Climate Change and Water NSW (DECCW) superseded ECRTN with the publication of NSW Road Noise Policy (RNP) in March 2011. The document provides road traffic noise guidelines for a range of road or residential developments, as well as guidelines that apply for other nominated sensitive land uses.

The road traffic guidelines recommended are based on the functional categories of the subject roads, as applied by the Roads Traffic Authority (RTA).

The functional categories are as follows:

→ Arterial roads (including freeways) carrying predominantly through-traffic from one region to another, forming principal avenues of communication for urban traffic movements.

→ Sub-arterial roads connecting the arterial roads to areas of development and carrying traffic from one part of a region to another. They may also relieve traffic on arterial roads in some circumstances.

→ Local roads, which are the subdivisional roads within a particular developed area. These are used solely as local access roads

For this project, traffic associated with the construction stage has the potential to increase noise levels on existing arterial and local roads during the day (no night period construction proposed). As such, the relevant traffic noise criteria, as provided in Table 3 of the NSW RNP, are provided in **Table 5** below.

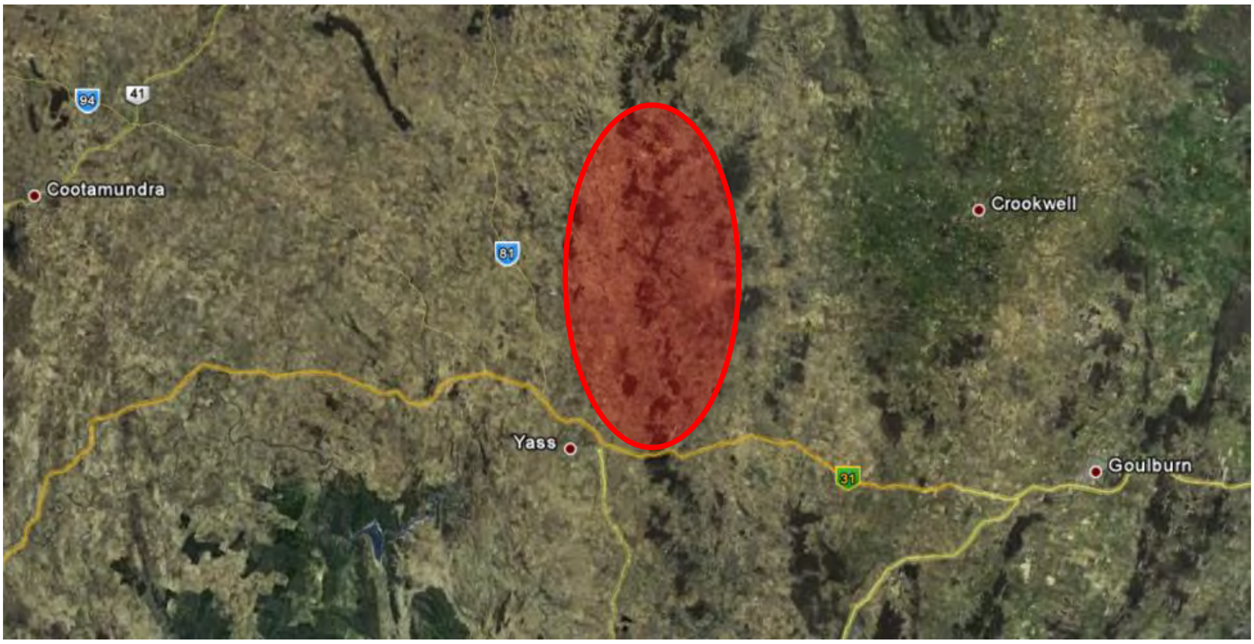
Table 5 Road Traffic Noise Criteria

Type of Development	**Criteria**	
	Day 7am - 10pm (dBA)	**Where Criteria are Already Exceeded**
Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.
Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.

3 GENERAL SITE DESCRIPTION

The proposed Rye Park Wind Farm site is located on the edge of the Southern Tablelands and the South West Slopes in the vicinity of the township of Rye Park, approximately 12 km north east of Yass and 42 km west of Crookwell, in NSW. An aerial view of Rye Park Wind Farm is shown in **Figure 1** below.

Figure 1 Location of proposed Rye Park Wind Farm



3.1 Characteristics of the site

The proposed project site incorporates up to 36 landowners. A numerical noise assessment has been carried out for all dwellings within 2 km of a turbine using the noise limit set in SA EPA Guidelines. Dwellings further than this distance are deemed to comply if dwellings closer to the wind farm comply with the SA EPA noise limit.

Topographically, the proposed site runs along a series of ridgelines running north-to-south. The ridges are approximately 700m above sea level, with the majority of the receptor locations either on the slopes of the ridges, or on flat terrain either side of the ridgelines approximately 550 to 650 m above sea level.

The surrounding district is primarily used for agricultural (grazing) purposes with several densely vegetated areas scattered around and within the proposed wind farm allotment. The township of Rye Park lies approximately 3 kilometres to the east of the proposed wind farm.

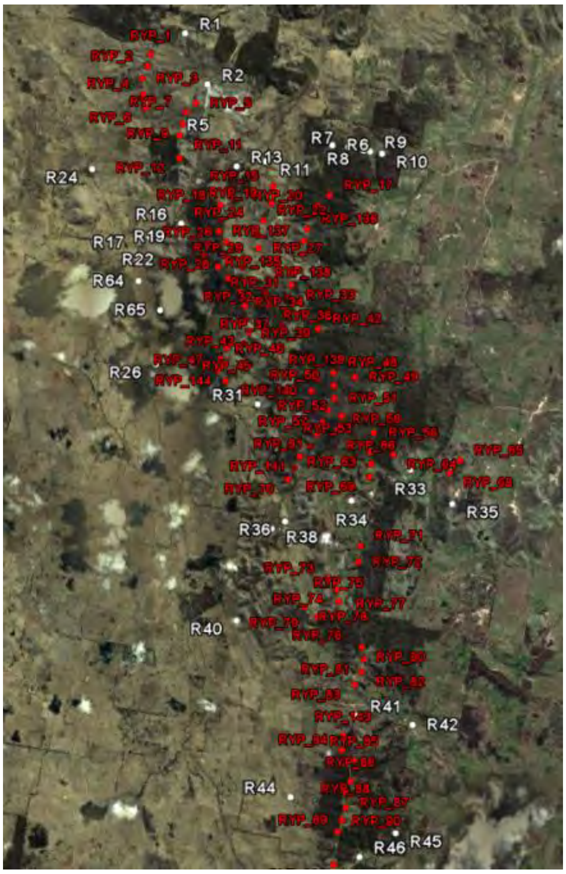
All properties surrounding the proposed wind farm site have an ambient background noise environment that is determined by pre-dominantly natural sources which are largely wind-influenced.

Prevailing winds are easterlies and westerlies. The district receives approximately 600 mm – 700 mm of rainfall annually.

3.2 Dwelling Locations

Figure 2 shows all locations assessed (shown in white) and the turbine positions for the layout considered (show in red).

Figure 2 Dwelling Locations and WTG Layouts



North End

South End

Table 6 lists all 51 receiver locations, their positions and identifies those that are project involved. Other dwellings located beyond 6 km of a proposed WTG are not considered within this assessment, primarily as WTG noise is unlikely to be audible at these distances and compliance to noise criteria more critical at closer receivers.

Table 6 Surrounding Receivers

Location	Easting (m)	Northing (m)
R1	677514	6187097
R2*	678095	6185733
R6	681484	6184020
R7	681917	6183967
R8	682339	6183864
R9	682517	6183838
R10	682842	6183767

Location	East (m)	North (m)
R36*	679988	6173811
R38	679623	6173620
R40	678605	6171136
R41*	681802	6168516
R42*	683370	6168206
R44*	679986	6166322
R45	682847	6165279

Location	Easting (m)	Northing (m)
R11*	679650	6183618
R24	678848	6183498
R13*	677807	6183115
R14*	677297	6181991
R16*	676127	6181740
R17	676412	6181665
R19	676130	6181544
R20	676095	6181037
R22	674877	6183534
R25*	677075	6178323
R26*	676523	6178178
R29	676434	6177903
R30*	682495	6177218
R31*	679304	6177019
R32*	680416	6176683
R33*	683440	6175148
R34*	681817	6174338
R35*	684554	6174195

Location	East (m)	North (m)
R46*	681835	6164679
R47	680155	6162689
R48	679834	6162662
R49*	680667	6162540
R50	680701	6161784
R51*	680970	6161588
R52*	684135	6161246
R53	680877	6160875
R54*	683514	6155819
R56	686567	6153140
R58	686872	6151613
R59*	684670	6149654
R60*	684244	6149529
R61*	684489	6149335
R62	683916	6149096
R63	683875	6148991
R64*	676089	6180459
R65	676668	6179644

Note: * Denotes the location is involved with the project

The distances between the surrounding receivers and WTG's are compiled in **Appendix C.**

4 PROPOSED WIND FARM LAYOUT

4.1 WTG Type and Details

The WTG manufacturer and model has not yet been finalised, and accordingly it is necessary to evaluate the wind farm based on a typical turbine model that may comprise a layout. The base layout presented in this report is a 126 WTG layout, the considered WTG model is the Vestas V112 3.0MW.

The WTG considered is three bladed, upwind, pitch regulated and active yaw. A comprehensive tabulated listing of WTG coordinates for the layout is included in **Appendix E.** Should an alternative selection or turbine type or layout be finalised them a revised noise impact assessment prediction will be completed.

Table 7 and **Table 8** summarise the relevant turbine input data used for noise level prediction.

Table 7 WTG Manufacturers Data

Make, model, power	Vestas V112 3.0MW
Rotor diameter	112 m
Hub height	84 m
Cut-in wind speed	3 m/s
Rated wind speed	12 m/s
Rotor speed	4.4 – 17.7 rpm
'Standard Mode' Sound Power Level, $L_{WA,ref\ 8m/s}$	106.5 dBA
'Sound Management Mode' Sound Power, $L_{WA,ref\ 8m/s}$ (Mode 2)	104.5 dBA

Table 8 Vestas V112 Sound Power Curves

Wind Turbine Model	Wind speed Vs (10m AGL) (m/s)									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Standard Mode (Mode 0)	94.5	97.4	100.9	104.3	106.0	106.5	106.5	106.5	106.5	106.5
Sound Management Mode (Mode 2)	94.5	97.3	100.9	104.5	104.5	104.5	104.5	104.5	104.5	104.5

Noise emissions for the proposed WTG have been provided by the manufacturer and have either been independently tested according to International Standard IEC 61400-11 or are warranted noise levels calculated in accordance with the International Standard. Copies of the certification test or manufacturers documentation that give the sound power level variation with wind speed, frequency spectra and tonality assessment have been provided by RPWF and will be made available on request**.**

4.2 Assessment of Tonality and Infrasound

WTG manufacturers are obliged to conduct independent tests in accordance with IEC 61400-11. A part of this assessment is to conduct a tonal audibility test. The tonal audibility $\Delta L_{t,a}$ is assessed using the methodology outlined in *Joint Nordic Method Version 2 – Objective Method for Assessing the Audibility of Tones in Noise*.

The tonal audibility data $\Delta L_{A,k}$ values have been supplied by the WTG manufacturers as follows:

Table 9 Audible tonality assessment to IEC 61400-11

Wind Turbine Model	Wind speed Vs (10m AGL) (m/s)									
	3	4	5	6	7	8	9	10	11	12
Standard Mode - Mode 0				-1.97	-3.04	-13.27	-11.88	-9.19		

No tonality has been provided for Mode 2 operation of the turbine. The manufacturer should provide any tonality data on this mode upon finalisation of the turbine model for the wind farm.

A more detailed assessment of tonality has been undertaken for the V112 model. This analysis is presented in **Section 7.3**.

Infrasound is not tested as an obligatory part of IEC 61400-11. It is noted that, in general, modern WTG's do not exhibit significant infrasound emissions. Refer to **Section 7.1** for a more detailed discussion.

5 OPERATIONAL NOISE LEVELS

5.1 Introduction

As discussed in **Section 1.1.2**, a three-dimensional computer noise model was used to predict L_{Aeq} noise levels from all WTG's at all surrounding residential dwellings.

The ISO 9613 noise model incorporates a 'hard ground' assumption and includes one-third octave band calculated effects for air absorption, ground attenuation and topographic shielding. It is noted that ISO 9613 equations predict for average downwind propagation conditions and also hold for average propagation under a well-developed moderate ground-based temperature inversion.

The estimated accuracy of the prediction model is approximately ±3 dBA.

5.2 Wind Turbine Noise

For indicative purposes the WTG noise levels from the proposed WTG layout was calculated for the reference wind condition of 8 m/s at 10m AGL and listed in **Table 10.** The predicted noise contour plot is presented in **Figure 3.**

Table 10 Predicted Wind Turbine Noise Level (dBA) – Base Layout

Location	Predicted Noise Level, L_{eq} dBA	Location	Predicted Noise Level, L_{eq} dBA
R1	37.1	R36*	37.2
R2*	41.7	R38	36
R6	34.2	R40	27.9
R7	32.9	R41*	43.1
R8	31.4	R42*	34.1
R9	30.8	R44*	37.2
R10	30.8	R45	36.2
R11*	41	R46*	42.7
R13*	41.2	R47	35.5
R14*	42.3	R48	34.3
R16*	42.7	R49*	37.4
R17	35.1	R50	35.4
R19	36.8	R51*	36.5
R20	35.2	R52*	32.3
R22	34.6	R53	33.4
R24	31.4	R54*	33.6
R25*	37.4	R56	39.8
R26*	33.6	R58	29.1
R29	33.7	R59*	34.2
R30*	43	R60*	33
R31*	39.9	R61*	32.1
R32*	45.7	R62	32.4
R33*	41.4	R63	31.9

Location	Predicted Noise Level, Leq dBA	Location	Predicted Noise Level, Leq dBA
R34*	41.4	R64*	34
R35*	37.8	R65	33.9

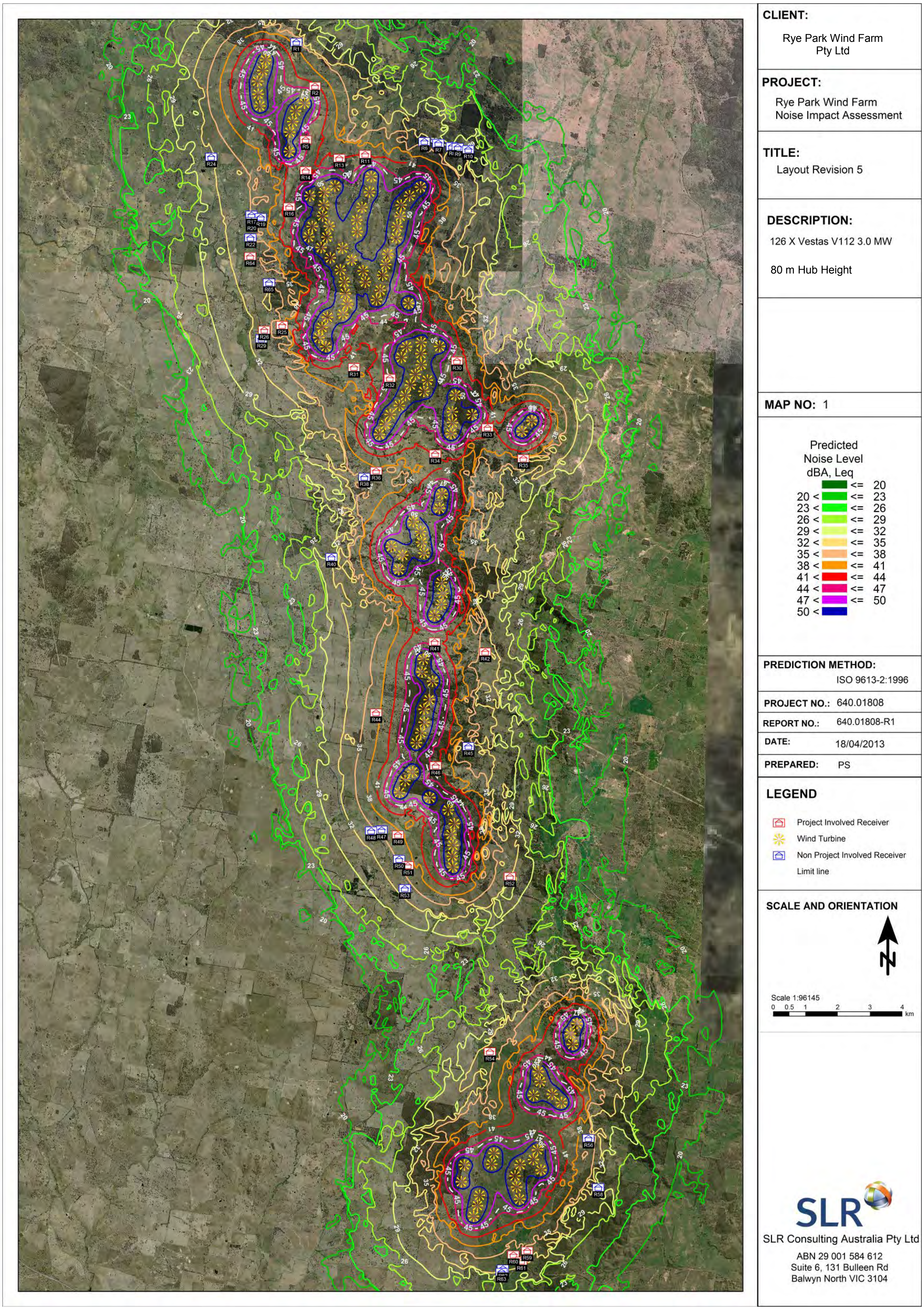
Note that '*' denotes a project involved location

Furthermore, noise levels from the proposed wind farm were calculated for all integer wind speeds in the range of 3 m/s to 12 m/s (at 10m AGL) at all surrounding assessment receivers within 6 km of a WTG. Whilst the rated wind speed of the WTG's is typically 13 m/s to 14 m/s, published manufacturers sound power level test data (IEC 61400-11) has only been generated as high as 12 m/s. It should be noted that noise produced by WTG's begins to 'plateau off' at higher wind speeds and because of the higher masking background noise level at higher wind speeds, noise impacts and compliance are not critical at these speeds. The assessed wind range sufficiently covers the most noise critical operational conditions.

To compare predicted noise levels with the assessment criteria, the wind speed data measured at several heights above ground level was extrapolated to a hub height of 80 m using the logarithmic profile law[1] by RPWF (Refer to **Section 6**). The assessment graphs of WTG operational noise levels were prepared and are depicted in **Appendix A1.**

[1] (Section 8 Data reduction procedures, page 20, International Standard IEC61400-11 ©IEC:2002+A1:2006 (E) *'Wind Turbine Generator Systems – Part 11: Acoustic noise measurement techniques'*).

Figure 3 Predicted Noise Levels Contour Map, L_{Aeq}, v_{ref}=8m/s



6 BACKGROUND LEVELS AND NOISE LIMITS

6.1 Measurement Locations

The locations for the background noise measurements were selected by SLR Consulting on the basis of preliminary predicted WTG noise levels as well as proximity and similarity to other receptors.

Monitoring equipment was deployed by RPWF and photos taken at each location. The SA EPA Guidelines recommend that the measurement locations should be located at least 5 metres from a reflecting surface (other than the ground) and within 20 metres of a residence.

The relative proximity of some receiver locations to one another and their similar wind exposure and surrounding environment meant that background noise monitoring could be conducted at one representative location and be considered indicative of other similar locations.

Monitoring was conducted at 20 locations around the proposed wind farm site. The background noise monitoring locations, along with locations allocated as being indicative to that site, are listed in **Table 11**.

Table 11 Measurement Locations

Location	Indicative of	Notes / Similar Characteristic for wind induced noise
R2*	R1, R2	Geographic proximity, similar region, exposure to wind
R6	R6, R7, R8, R9, R10	Geographic proximity, similar region, exposure to wind
R13*	R11, R13	Geographic proximity, similar region, exposure to wind
R14*	R14, R16	Geographic proximity, similar region, exposure to wind
R19	R17, R19, R20, R22	Geographic proximity, similar region, exposure to wind
R24	R24	Geographic proximity, similar region, exposure to wind
R25*	R25, R26, R29	Geographic proximity, similar region, exposure to wind
R30*	R30, R33	Geographic proximity, similar region, exposure to wind
R32*	R31, R32	Geographic proximity, similar region, exposure to wind
R34*	R34, R35	Geographic proximity, similar region, exposure to wind
R36*	R36, R38, R64	Geographic proximity, similar region, exposure to wind
R41*	R41, R42	Geographic proximity, similar region, exposure to wind
R44*	R40, R44, R65	Geographic proximity, similar region, exposure to wind
R46*	R45, R46	Project involved, close to WTGs, sheltered from the West, indicative of R45 (possibly R42 & R43) due to exposure & trees
R49*	R47, R48, R49	Geographic proximity, similar region, exposure to wind
R51*	R51, R53	Geographic proximity, similar region, exposure to wind
R52*	R52	Project involved, closest to WTGS, on top of small hill, maybe exposed to wind
R54*	R54	Project involved, closest to WTGS, relatively sheltered
R56	R56, R58	Potentially higher WTG noise, project involved, more sheltered from wind
R60*	R59, R60, R61, R62, R63	Most representative of others near creek, lowest in gully and therefore potentially shielded, similar level of vegetation of others in area

Note that '*' denotes a project involved location

At each location noise monitoring equipment was placed in the vicinity of the residence and the position of the monitoring equipment was documented with photographs.

A single weather station was deployed by RPWF near the monitoring sites. The station was relocated to areas where the noise monitoring was concentrated throughout the monitoring campaign. The weather data was used to identify and exclude any data collected during rain periods, which may have affected the background noise levels. The measured data for rain confirmed that the monitoring period was generally dry and as a result only a small number of data points were rejected due to rain.

Any periods of data that were clearly affected by extraneous noise sources (eg pumps, insects, birds, frogs etc) were removed from the analysis data set. If after exclusion there were not sufficient valid data points, the loggers were typically re-deployed to obtain a more complete data set.

The SA EPA Guidelines require measurements to be conducted in 10 minute intervals, while the NSW INP request 15 minute interval data. Given that almost all wind data, including the wind farm site monitored data, is in 10 minute intervals, this period was used for all measurements.

Simultaneous noise monitoring and wind monitoring was conducted during the period 1 June 2012 to 21 September 2012. Wind speed was monitored at 4 wind masts throughout the proposed site. Wind speed for a given background monitoring location was allocated to the wind mast nearest to that location. Where the receptor was approximately equidistant to two wind masts, the background noise was correlated to the wind mast with the highest correlation coefficient (R^2 value).

Table 12 Wind mast details

Wind Mast	Easting	Northing	Nearest Background Locations
RYP_2	676503	6186530	R2, R6, R13, R14, R19, R24
RYP_3	682046	6170278	R25, R30, R32, R34, R36, R41, R44
RYP_4	682325	6162517	R46, R49, R51, R52
YJ	684969	6152742	R54, R56, R60

Wind speed at a height of 80 metres AGL was provided by RPWF. Local noise data was then correlated to the 80 m AGL wind speed.

6.2 Measurement Details

The measurement location, monitoring period, and serial number of the Type 2 RION NL42 noise loggers used by RPWF for all testing are summarised in **Table 13**, along with the number of valid data points for each location.

The SA EPA Guideline recommends a set of approximately 2,000 valid data points. Any data points adversely affected by extraneous noise were excluded.

The measured background noise levels (L_{A90}) are then plotted against the 80 metre wind speed to obtain a background versus wind speed characteristic for each location.

The line of best fit for the data set is then determined, as required by the SA EPA Guideline, using a linear, second order (quadratic) or third order (cubic) polynomial. The Guideline requires that the correlation coefficient (R^2 value) for each line type be reported and the line of best fit with the highest correlation coefficient used. At each location the cubic polynomial gave the highest correlation and was therefore used for the line of best fit.

Table 13 Measurement Details for each Location

Measurement Location	Measurement Period	Noise Logger Model # Serial number	Total No. of monitoring intervals	No. of valid data points		Correlation Coefficient (R^2)		
				All	Night	Linear	Quad.	Cubic
R2*	8/6/12 to 15/6/12 and 6/7/12 to 18/7/12	RION NL42 S/N 810839	2679	2296	777	0.3064	0.3491	0.3494
R6	8/6/12 to 15/6/12 (sporadic) and 15/6/12 to 27/6/12	RION NL42 S/N 810849	2522	2345	718	0.3033	0.3282	0.3306
R13*	15/6/12 to 6/7/12 and 24/8/12 to 31/8/12	RION NL42 S/N 410151	4037	2479	1037	0.3997	0.4424	0.4428
R14*	1/6/12 to 8/6/12, 15/6/12 to 23/6/12, 6/7/12 to 12/7/12, and 24/7/12 to 31/7/12	RION NL42 S/N 221356	4023	2453	1216	0.3719	0.4111	0.4113
R19	1/6/12 to 8/6/12 and 15/6/12 to 28/6/12	RION NL42 S/N 810840	2903	2778	1041	0.1764	0.2111	0.2135
R24	1/6/12 to 8/6/12 15/6/12 to 18/6/12 and 6/7/12 to 23/7/12	RION NL42 S/N 810850	3692	3307	811	0.2594	0.3074	0.3074
R25*	18/7/12 to 7/8/12	RION NL42 S/N 810712	2869	2647	906	0.2035	0.2688	0.2758
R30*	31/7/12 to 14/8/12 and 31/8/12 to 4/9/12	RION NL42 S/N 410151 & 810839	2531	2244	956	0.2482	0.2778	0.2781
R32*	15/6/12 to 3/7/12	RION NL42 S/N 410151	2589	2504	399	0.2258	0.2493	0.2495
R34*±	4/9/12 to 21/9/12	RION NL42 S/N 0021356	2440	1531	832	0.7945	0.7957	0.8039
R36*	31/7/12 to 12/8/12 and 31/8/12 to 4/9/12	RION NL42 S/N 221356	2309	2178	1288	0.2366	0.3348	0.3351
R41*	6/7/12 to 18/7/12 and 26/7/12 to 8/8/12	RION NL42 S/N 810840	3670	3454	841	0.4482	0.4665	0.4736
R44*	8/8/12 to 20/8/12 and 4/9/12 to 10/9/12	RION NL42 S/N 810840	2634	2259	1114	0.4842	0.522	0.5243
R46*	10/7/12 to 31/7/12	RION NL42 S/N 410152	3001	2817	1017	0.2541	0.3129	0.3131
R49*	31/7/12 to 20/8/12	RION NL42 S/N 410152	2956	2720	1053	0.3806	0.4025	0.4038
R51*	6/7/12 to 21/7/12 and 26/7/12 to 7/8/12	RION NL42 S/N 810852 & 221356	3966	2913	1146	0.1862	0.2528	0.258
R52*	26/7/12 to 17/8/12	RION NL42 S/N 410151	3164	3012	902	0. 126	0.2631	0.2632
R54*	10/7/12 to 31/7/12	RION NL42	2973	2303	905	0.1766	0.2733	0.2735

Measurement Location	Measurement Period	Noise Logger Model # Serial number	Total No. of monitoring intervals	No. of valid data points		Correlation Coefficient (R^2)		
				All	Night	Linear	Quad.	Cubic
		S/N 810713						
R56	31/7/12 to 4/8/12 and 4/9/12 to 21/9/12	RION NL42 S/N 810713	3116	2475	890	0.2647	0.3004	0.305
R60*	8/8/12 to 22/8/12 and 4/9/12 to 10/9/12	RION NL42 S/N 810852	2811	2337	941	0.3019	0.311	0.3369

Note that '±' denotes a location with fewer than 2000 monitoring intervals

Note that '*' denotes a project involved location

The number of valid data points at location R34 fell short of the recommended 2000 intervals due to data exclusion of local, extraneous noise sources. However, as more than 50% of the data had been collected and the correlation coefficient was relatively good (greater than 80%) the result for the full period was deemed as still statistically relevant.

6.3 Night Period Analysis

A reduced data set was created for the night period (10:00 pm to 7:00 am). The resulting data sets typically included 400 to 900 data points and were fitted with a cubic polynomial regression line of best fit.

The regression line for night-only data is generally lower than that for all data by between 1 dB to 5 dB and varies considerably from location to location. Lower night data is attributed to two main factors. Firstly that extraneous noise sources (animals, traffic etc) are lower during the night period and secondly that the wind shear for the night period is usually greater compared to the day period which results in lower ground level wind speeds for a given hub height reference wind speed and hence lower wind related background noise levels.

The resulting effect on project involved receptors' criteria with consideration to only the lower night period background data is generally minimal with the criteria being exactly the same (criteria is a constant 45 dBA as background noise regression lines are always less than 40 dBA) or marginally higher at high wind speeds where compliance is more easily achieved.

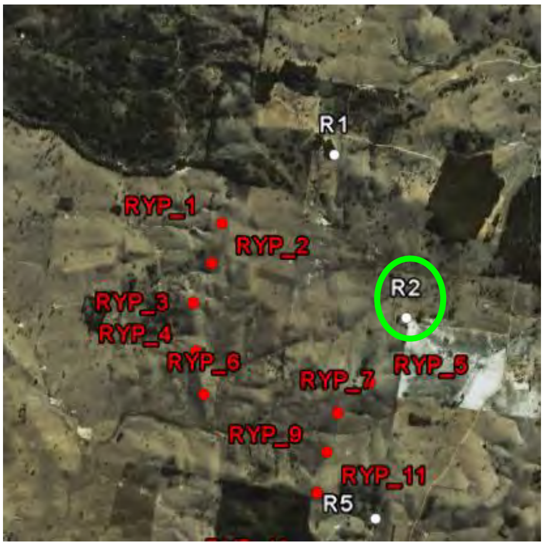
The criteria for project uninvolved receptors with consideration to only the night period background data is generally marginally lower at higher wind speeds. As this is typically not the most critical wind range for compliance the net effect of night data based criteria is negligible with regards to compliance.

6.4 Location R2

Location R2 is located to the north of the proposed wind farm allotment, below the ridge for RYP_1, RYP_2 etc. The nearest proposed turbine to this location is approximately 600 m away.

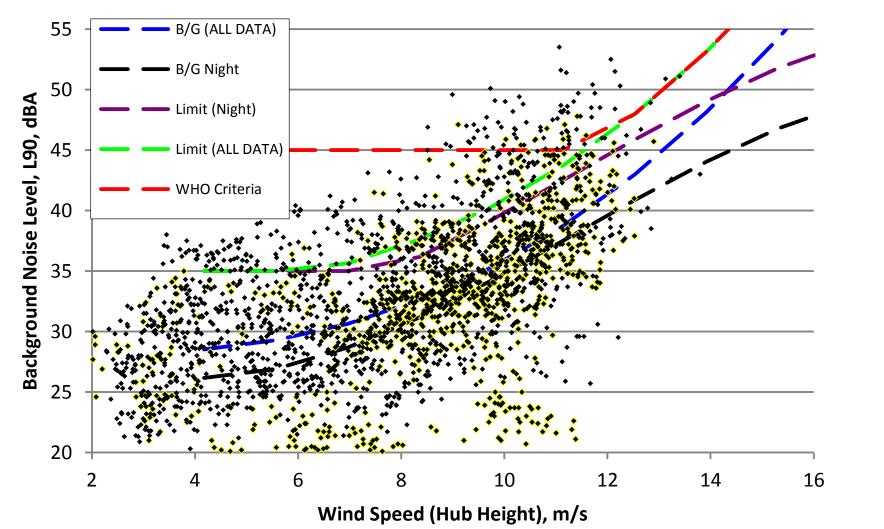
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 4 Photo and Map of Location R2



The results of the background noise monitoring taken from 8/6/12 to 15/6/12 and 6/7/12 to 18/7/12, showing the data points, line of best fit and criteria curve for that group are shown in **Figure 5.**

Figure 5 Background Noise Measurements and Noise Criteria Curve – Location R2

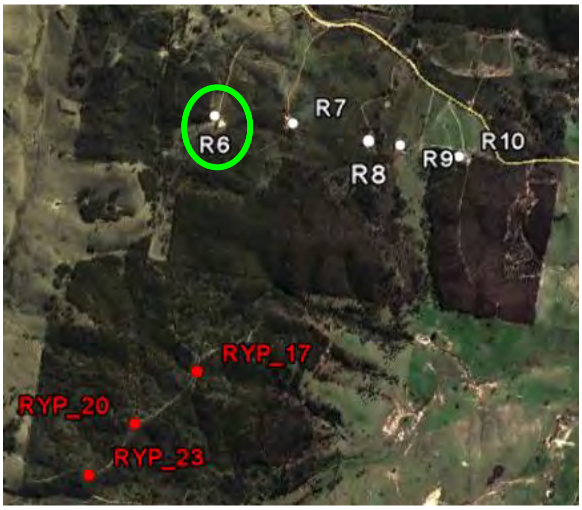


Order	Equation	R^2
Linear	$y = 1.2608x + 23.164$	0.3064
Quadratic	$y = 0.1614x^2 - 1.0029x + 29.789$	0.3491
Cubic	$y = 0.0039x^3 + 0.0826x^2 - 0.533x + 29.031$	0.3494
Order Used:	**Cubic**	

6.5 Location R6

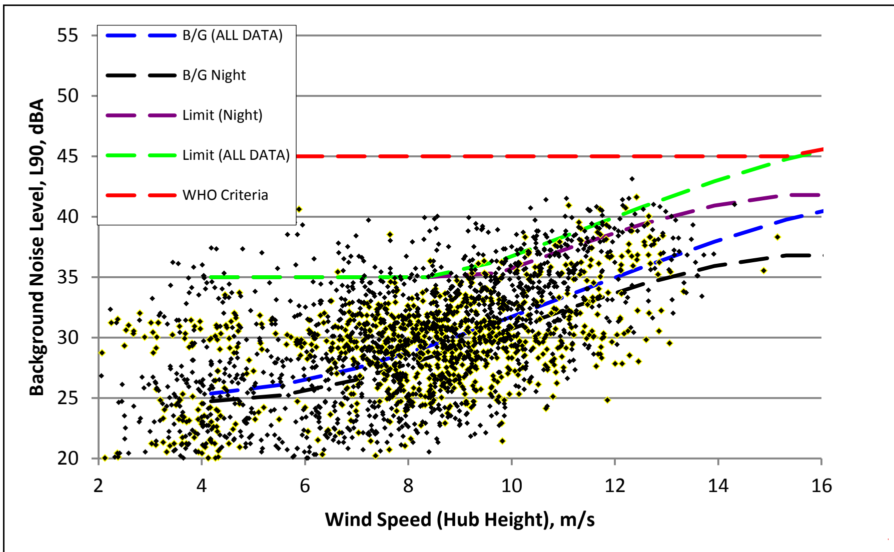
Location R6 is located north east of the proposed wind farm allotment, on the north side of the ridge line for RYP_117, RYP_20 RYP_23 etc. The residence is set back approximately 750 m from the main road. The nearest proposed turbine to this location is approximately 1.3 km away.

Figure 6 Photo and Map of Location R6



The results of the background noise monitoring taken from 8/6/12 to 15/6/12 and 15/6/12 to 27/6/12, showing the data points, line of best fit and criteria curve for that group are shown in **Figure 7**.

Figure 7 Background Noise Measurements and Noise Criteria Curve – Location R6



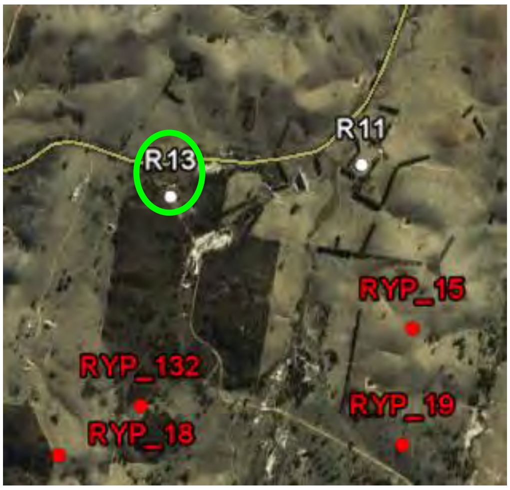
Order	Equation	R^2
Linear	$y = 1.1107x + 20.511$	0.3033
Quadratic	$y = 0.0998x^2 - 0.3932x + 25.48$	0.3282
Cubic	$y = -0.0091x^3 + 0.3063x^2 - 1.804x + 28.225$	0.3306
Order Used:	**Cubic**	

6.6 Location R13

Location R13 is located within the northern end of proposed wind farm allotment. The residence is set back approximately 130 m from Rye Park-Rugby Rd. The nearest proposed turbine to this location is approximately 800 m away.

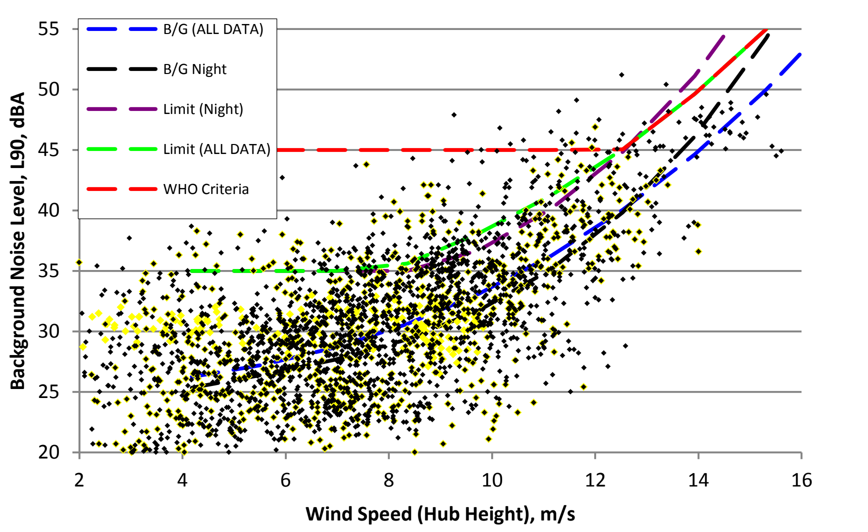
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 8 Photo and Map of Location R13



The results of the background noise monitoring taken from 15/6/12 to 6/7/12 and 24/8/12 to 31/8/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 9**.

Figure 9 Background Noise Measurements and Noise Criteria Curve – Location R13



Order	Equation	R^2
Linear	y = 1.4727x + 19.294	0.3997
Quadratic	y = $0.139x^2$ - 0.6753x + 26.562	0.4424
Cubic	y = $0.0038x^3$ + $0.0503x^2$ - 0.0495x + 25.298	0.4428
Order Used:	Cubic	

6.7 Location R14

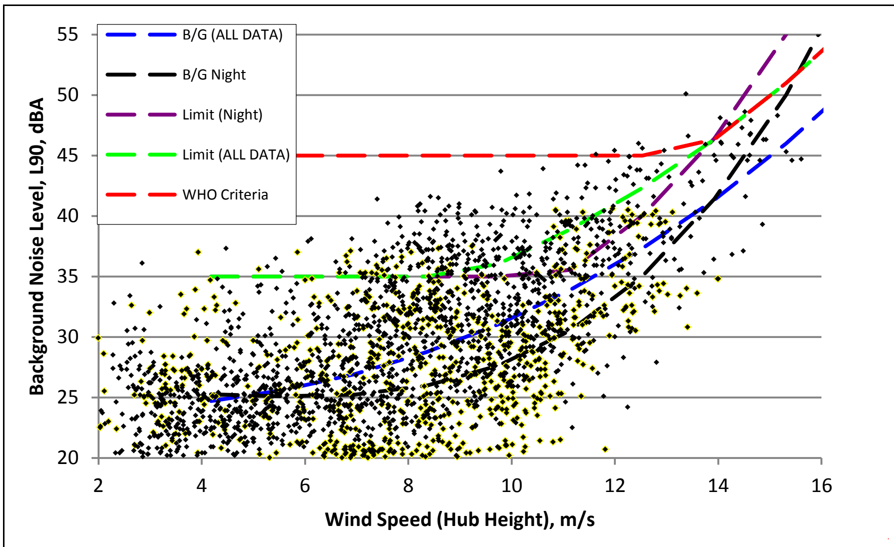
Location R14 is located within the proposed wind farm allotment in a valley between two ridgelines. The residence is set back approximately 200 m from Rye Park-Rugby Rd. The nearest proposed turbine to this location is approximately 620 m away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 10 Photo and Map of Location R14

The results of the background noise monitoring taken from 1/6/12 to 8/6/12, 15/6/12 to 23/6/12, 6/7/12 to 12/7/12, and 24/7/12 to 31/7/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 11**.

Figure 11 Background Noise Measurements and Noise Criteria Curve – Location R14



Order	Equation	R^2
Linear	y = 1.3269x + 18.647	0.3719
Quadratic	y = 0.1266x² - 0.6017x + 24.946	0.4111
Cubic	y = 0.0021x³ + 0.0772x² - 0.2551x + 24.263	0.4113
Order Used:	**Cubic**	

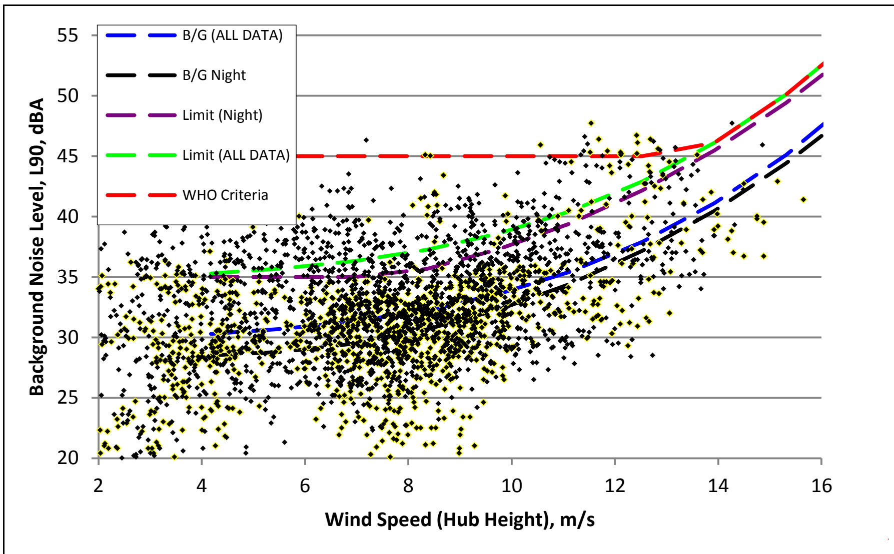
6.8 Location R19

Location R19 is located to the east of the proposed wind farm allotment. The residence is set back approximately 80 m from Rye Park-Rugby Rd. The nearest proposed turbine to this location is approximately 1.6 km away.

Figure 12 Photo and Map of Location R19

The results of the background noise monitoring taken from 1/6/12 to 8/6/12 and 15/6/12 to 28/6/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 13**.

Figure 13 Background Noise Measurements and Noise Criteria Curve – Location R19



Order	Equation	R^2
Linear	y = 0.7268x + 26.883	0.1764
Quadratic	y = 0.0892x² - 0.5752x + 30.908	0.2111
Cubic	y = 0.0063x³ - 0.0518x² + 0.3486x + 29.281	0.2135
Order Used:	**Cubic**	

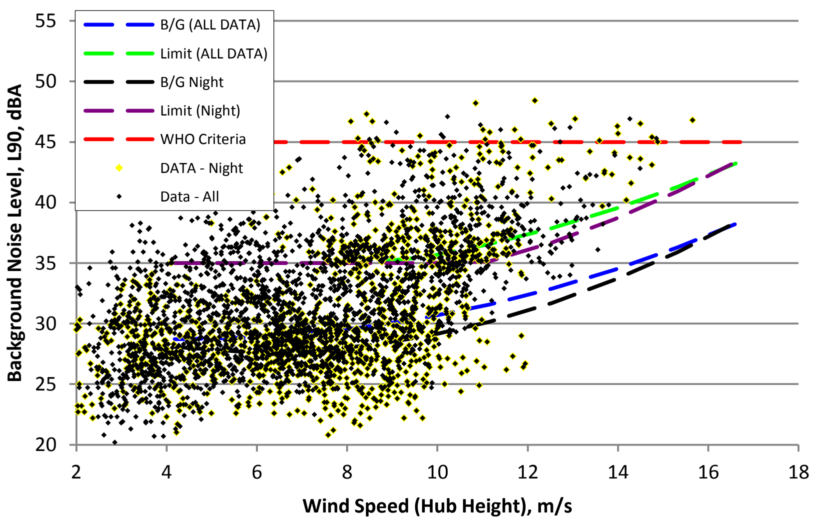
6.9 Location R24

Location R24 is located east of the proposed wind farm allotment. The residence is set back approximately 200 m from the main road. The nearest proposed turbine to this location is approximately 2.4 km away.

Figure 14 Photo and Map of Location R24

The results of the background noise monitoring taken from 1/6/12 to 8/6/12, 15/6/12 to 18/6/12 and 6/7/12 to 23/7/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 15**.

Figure 15 Background Noise Measurements and Noise Criteria Curve – Location R24



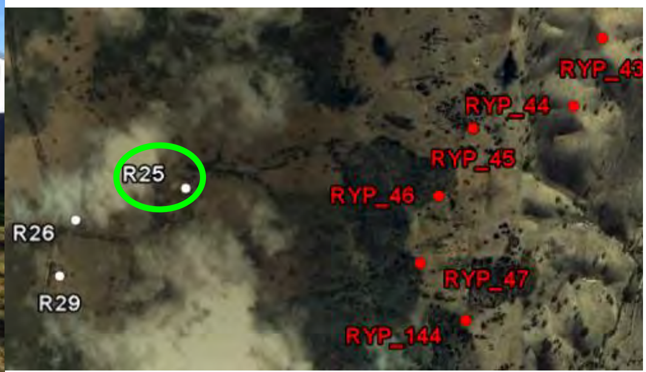
Order	Equation	R^2
Linear	y = 0.9615x + 24.702	0.2594
Quadratic	y = $0.1249x^2$ - 0.8028x + 30.001	0.3074
Cubic	y = $0.0006x^3$ +$0.1121x^2$ - 0.721x + 29.856	0.3074
Order Used:	**Cubic**	

6.10 Location R25

Location R25 is located east of the proposed wind farm allotment, at the base of the ridgeline for R47, R46 etc. The residence is approximately 2 km from the township of Rye Park. The nearest proposed turbine to this location is approximately 1.2 km away.

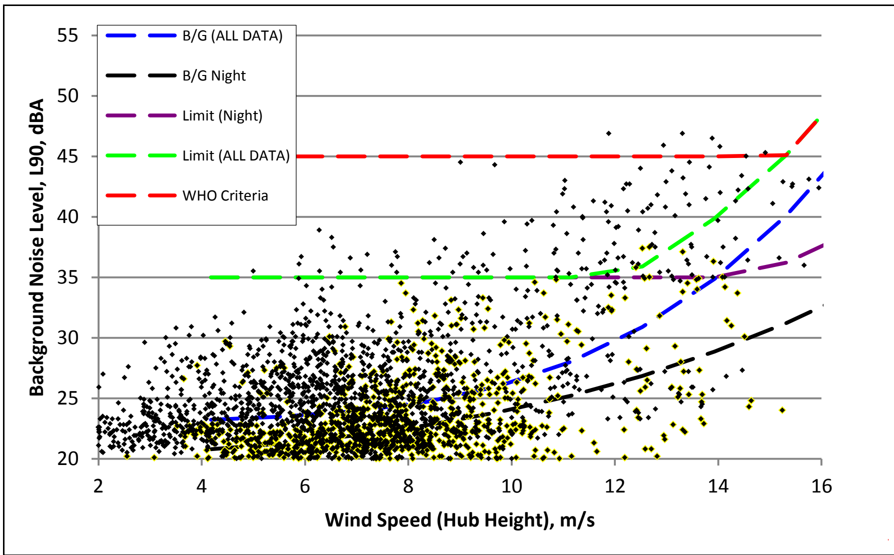
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 16 Photo and Map of Location R25



The results of the background noise monitoring taken from 18/7/12 to 7/8/12 showing the data points, line of best fit and criteria curve for that group is shown in **Figure 17**.

Figure 17 Background Noise Measurements and Noise Criteria Curve – Location R25



Order	Equation	R^2
Linear	$y = 0.8211x + 18.903$	0.2035
Quadratic	$y = 0.1234x^2 - 1.0889x + 25.394$	0.2688
Cubic	$y = 0.0114x^3 - 0.1507x^2 + 0.8519x + 21.455$	0.2758
Order Used:	**Cubic**	

6.11 Location R30

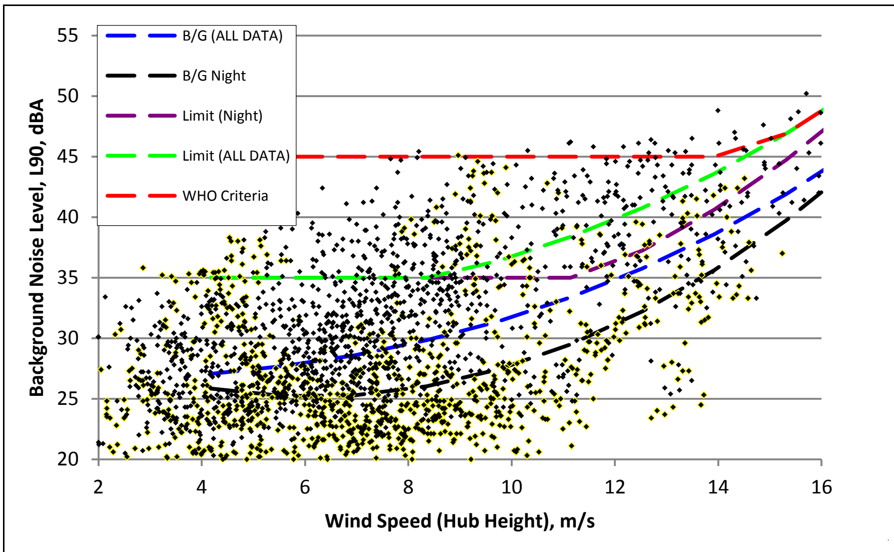
Location R30 is located within the proposed wind farm allotment on the east side, in a sheltered part between ridges. The nearest proposed turbine to this location is approximately 600 m away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered ‘project involved’.

Figure 18 Photo and Map of Location R30

The results of the background noise monitoring taken from 31/7/12 to 14/8/12 and 31/8/12 to 4/9/12 showing the data points, line of best fit and criteria curve for that group is shown in **Figure 19**.

Figure 19 Background Noise Measurements and Noise Criteria Curve – Location R30



Order	Equation	R^2
Linear	y = 1.0391x + 22.086	0.2482
Quadratic	y = 0.0915x² - 0.4771x + 27.439	0.2778
Cubic	y = 0.0021x³ +0.0379x² - 0.071x + 26.561	0.2781
Order Used:	**Cubic**	

6.12 Location R32

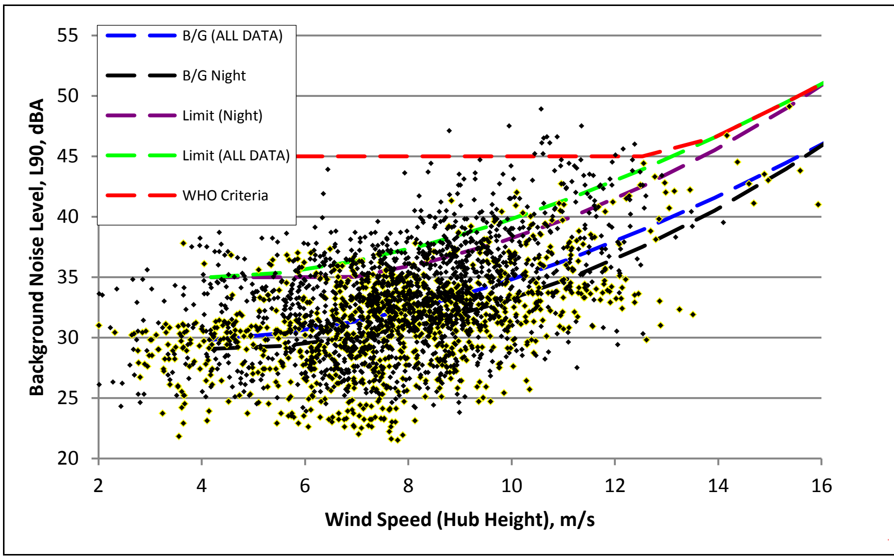
Location R32 is located within the proposed wind farm allotment, on the west side of the ridgeline for RYP_53, RYP_57, RYP_61 etc. The nearest proposed turbine to this location is approximately 700 m away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered ‘project involved’.

Figure 20 Photo and Map of Location R32

The results of the background noise monitoring taken from 15/6/12 to 3/7/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 21**.

Figure 21 Background Noise Measurements and Noise Criteria Curve – Location R32



Order	Equation	R^2
Linear	$y = 0.9756x + 24.958$	0.2258
Quadratic	$y = 0.0974x^2 - 0.5356x + 30.361$	0.2493
Cubic	$y = -0.002x^3 + 0.1453x^2 - 0.8862x + 31.129$	0.2495
Order Used:	**Cubic**	

6.13 Location R34

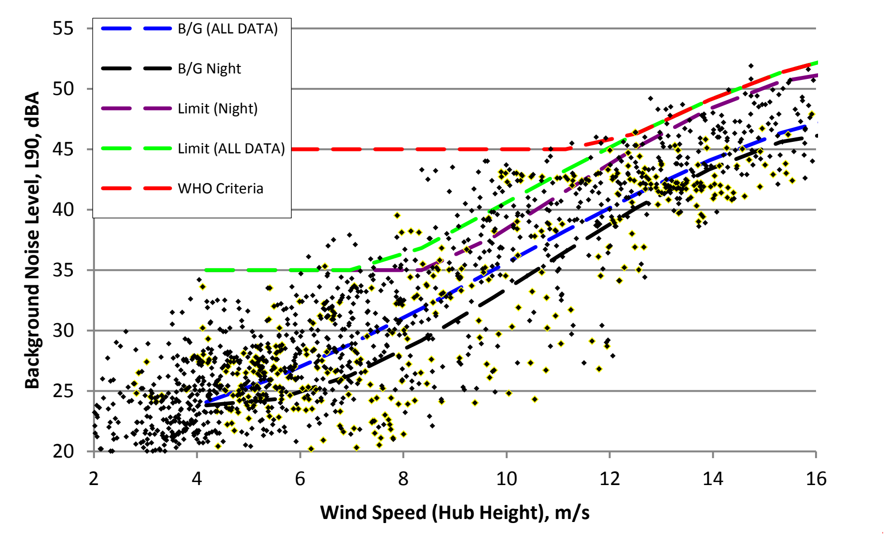
Location R34 is located within the proposed wind farm allotment, to the south of the ridge for RYP_69, RYP_66 etc. The residence is surrounded by trees, particularly to the south-west. The nearest proposed turbine to this location is approximately 800 m away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 22 Photo and Map of Location R34

The results of the background noise monitoring taken from 4/9/12 to 21/9/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 23**.

Figure 23 Background Noise Measurements and Noise Criteria Curve – Location R34



Order	Equation	R^2
Linear	y = 1.9581x + 16.053	0.7945
Quadratic	y = $0.0194x^2$ + 1.6087x + 17.286	0.7957
Cubic	y = - $0.0104x^3$ +$0.3096x^2$ - 0.7489x + 22.545	0.8039
Order Used:	**Cubic**	

Note that this monitoring location fell below the 2000 points required by the standard, due to data exclusion of local noise sources. However, as more than 50% of the data had been collected and the correlation coefficient was relatively good (greater than 80%) the result for the full period was deemed as still statistically relevant.

6.14 Location R36

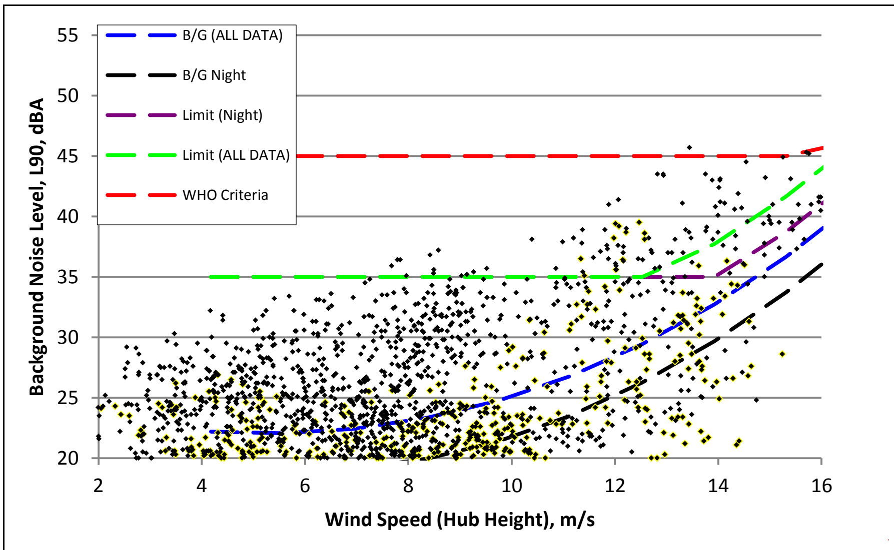
Location R36 is located within the proposed wind farm allotment. The residence sits within a small valley, with ridgelines to the north and south. The nearest proposed turbine to this location is approximately 1.1 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 24 Photo and Map of Location R36

The results of the background noise monitoring taken from 31/7/12 to 12/8/12 and 31/8/12 to 4/9/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 25**.

Figure 25 Background Noise Measurements and Noise Criteria Curve – Location R36



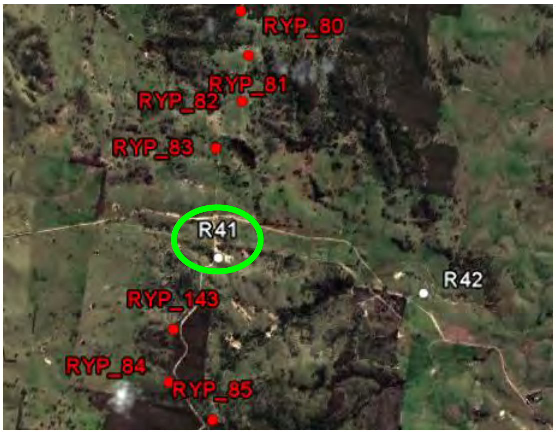
Order	Equation	R^2
Linear	y = 0.9196x + 17.125	0.2366
Quadratic	y = $0.1453x^2$ - 1.5406x + 26.053	0.3348
Cubic	y = $0.0018x^3$ +$0.0976x^2$ - 1.1709x + 25.238	0.3351
Order Used:	**Cubic**	

6.15 Location R41

Location R41 is located within the proposed wind farm allotment. The residence is on the north side of the ridge for RYP_143, RYP_83 etc. The nearest proposed turbine to this location is approximately 620 m away.

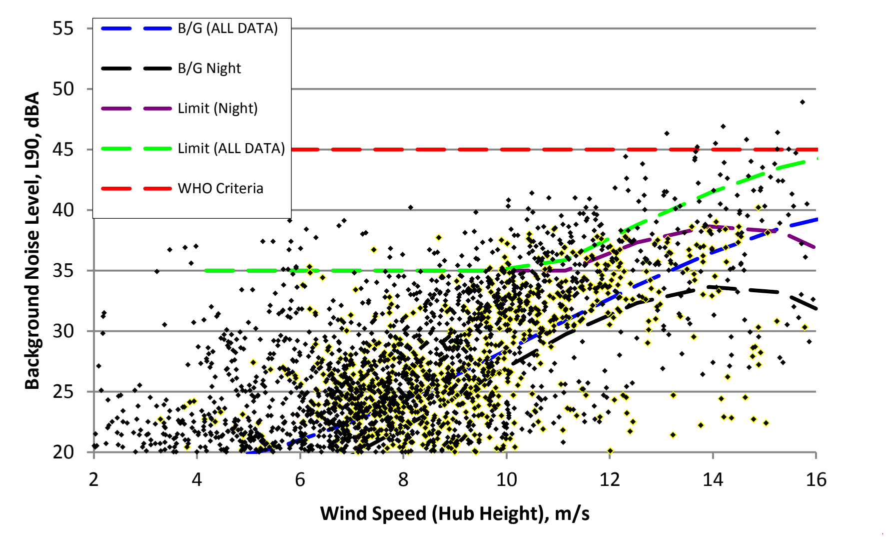
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered ‘project involved’.

Figure 26 Photo and Map of Location R41



The results of the background noise monitoring taken from 6/7/12 to 18/7/12 and 26/7/12 to 8/8/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 27**.

Figure 27 Background Noise Measurements and Noise Criteria Curve – Location R41



Order	Equation	R^2
Linear	$y = 1.6131x + 12.156$	0.4482
Quadratic	$y = 0.0812x^2 + 0.2983x + 16.76$	0.4665
Cubic	$y = -0.0129x^3 + 0.408x^2 - 2.1358x + 21.869$	0.4736
Order Used:	**Cubic**	

6.16 Location R44

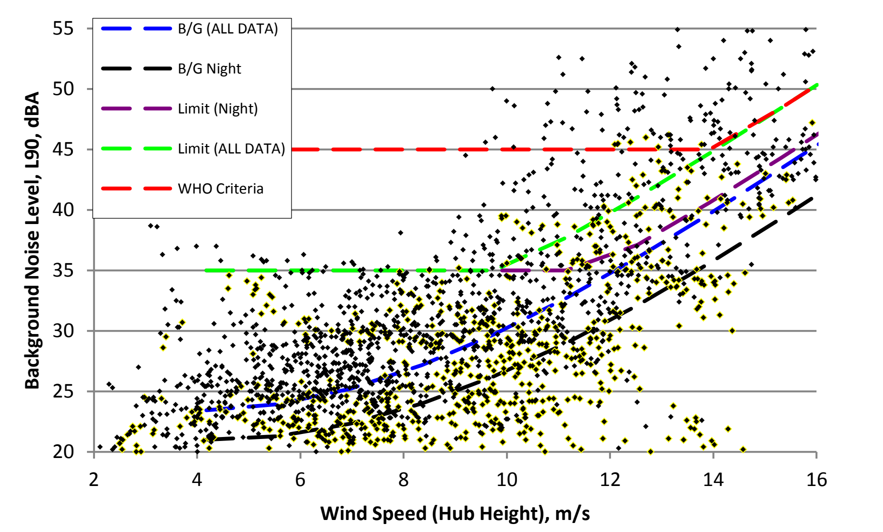
Locaiton R44 is located to the west of the ridge for RYP_143, RYP_84 etc. The residence is set back approximately 2 km from Rye Park-Dalton Rd. The nearest proposed turbine to this location is approximately 1.5 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 28 Photo and Map of Location R44

The results of the background noise monitoring taken from 8/8/12 to 20/8/12 and 4/9/12 to 10/9/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 29**.

Figure 29 Background Noise Measurements and Noise Criteria Curve – Location R44



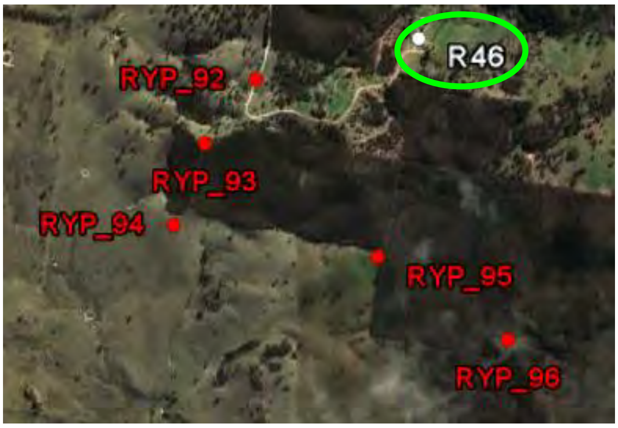
Order	Equation	R^2
Linear	y = 1.7537x + 13.973	0.4842
Quadratic	y = 0.1189x² - 0.5102x + 23.329	0.522
Cubic	y = -0.0064x³ + 0.3077x² - 2.1782x + 27.62	0.5243
Order Used:	**Cubic**	

6.17 Location R46

Location R46 is located on the south of the ridge for RYP_143, RYP_88. The nearest proposed turbine to this location is approximately 740 m away.

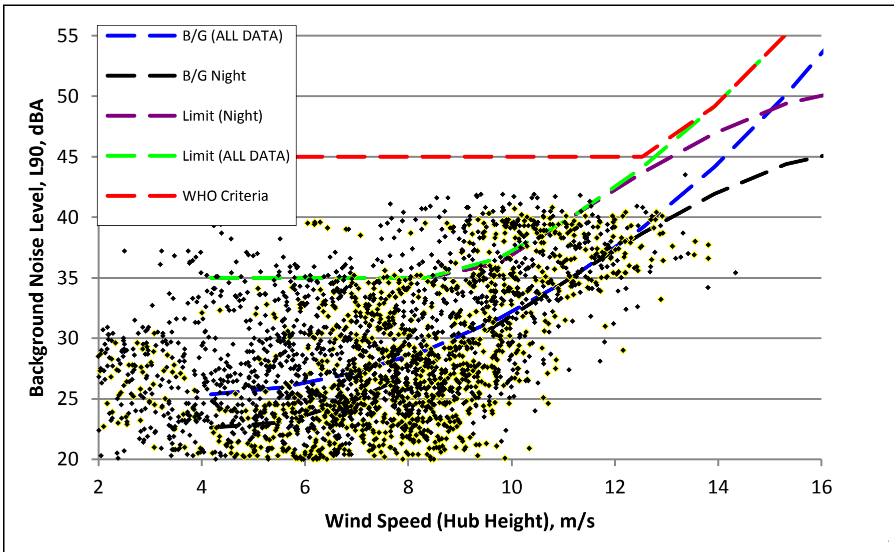
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 30 Photo and Map of Location R46



The results of the background noise monitoring taken from 10/7/12 to 31/7/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 31**.

Figure 31 Background Noise Measurements and Noise Criteria Curve – Location R46



Order	Equation	R^2
Linear	y = 1.1486x + 20.313	0.2541
Quadratic	y = 0.1697x² - 1.2075x + 27.338	0.3129
Cubic	y = 0.0034x³ + 0.0984x² - 0.7685x + 26.6	0.3131
Order Used:	**Cubic**	

6.18 Location R49

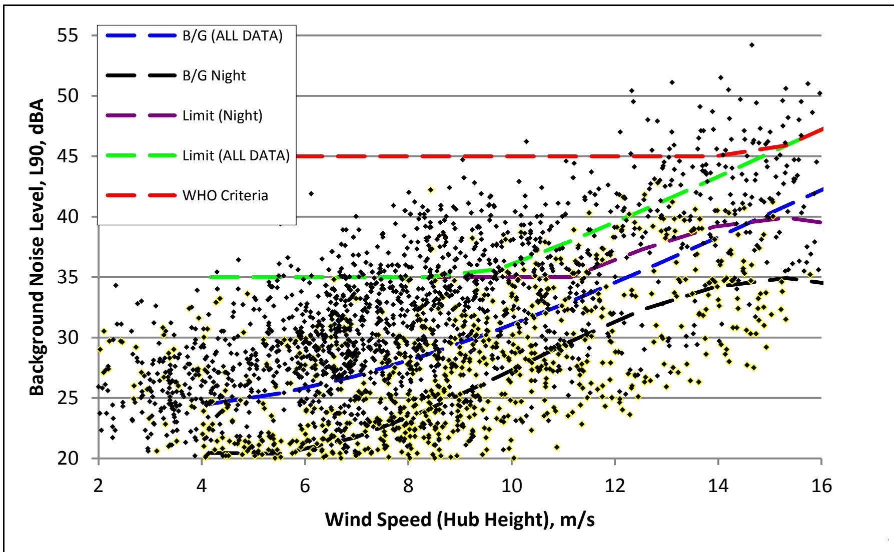
Location R49 is located to the west of the ridge for RYP_95, RYP_96 etc. The residence is set back approximately 550 m from Rye Park-Dalton Rd. The nearest proposed turbine to this location is approximately 1.3 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 32 Photo and Map of Location R49

The results of the background noise monitoring taken from 31/7/12 to 20/8/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 33**.

Figure 33 Background Noise Measurements and Noise Criteria Curve – Location R49



Order	Equation	R^2
Linear	$y = 1.3591x + 18.098$	0.3806
Quadratic	$y = 0.0756x^2 + 0.0132x + 23.223$	0.4025
Cubic	$y = -0.0042x^3 + 0.1889x^2 - 0.8856x + 25.226$	0.4038
Order Used:	Cubic	

6.19 Location R51

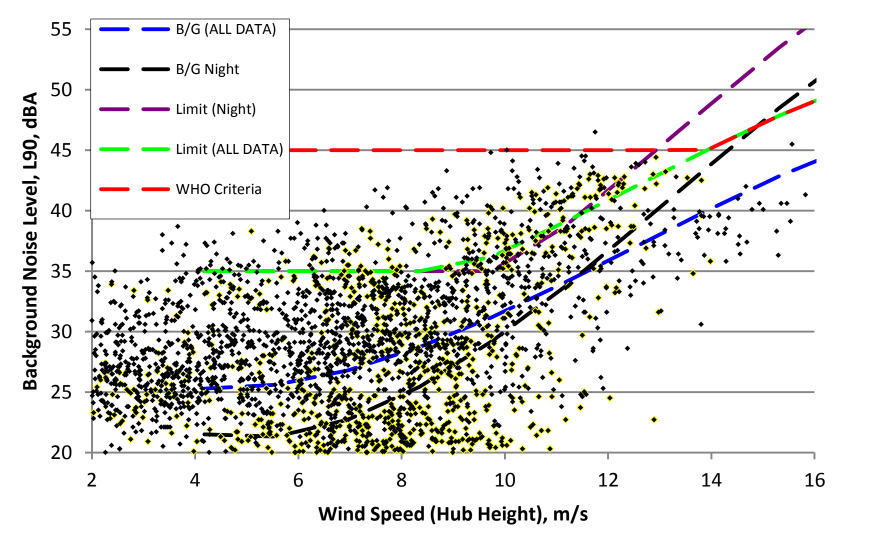
Location R51 is located to the west of the ridge for RYP_95, RYP_96 etc, south east of Location R49 The residence is set back approximately 200 m from Rye Park-Dalton Rd. The nearest proposed turbine to this location is approximately 1.3 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 34 Photo and Map of Location R51

The results of the background noise monitoring taken from 6/7/12 to 21/7/12 and 26/7/12 to 7/8/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 35**.

Figure 35 Background Noise Measurements and Noise Criteria Curve – Location R51



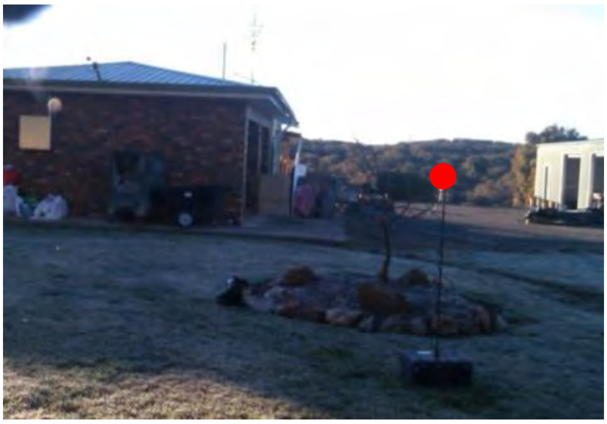
Order	Equation	R^2
Linear	y = 0.973x + 21.464	0.1862
Quadratic	y = 0.1609x² - 1.3322x + 28.404	0.2528
Cubic	y = -0.0112x³ +0.4204x² - 3.0804x + 31.643	0.258
Order Used:	Cubic	

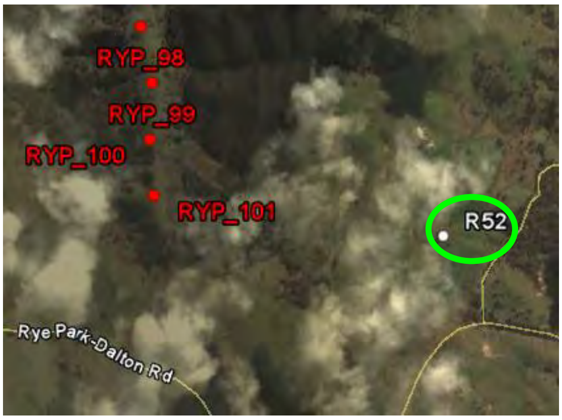
6.20 Location R52

Location R52 is located east of the ridge for RYP_95, RYP_96 etc.. The residence is set back approximately 350 m from Blakney Creek North Rd. The nearest proposed turbine to this location is approximately 1.8 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

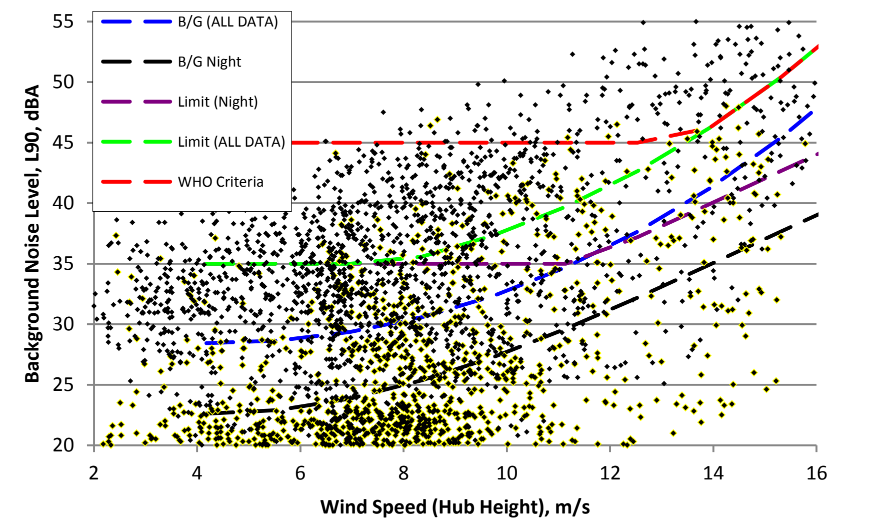
Figure 36 Photo and Map of Location R52





The results of the background noise monitoring taken from 26/7/12 to 17/8/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 37**.

Figure 37 Background Noise Measurements and Noise Criteria Curve – Location R52



Order	Equation	R^2
Linear	y = 1.2769x + 21.31	0.2126
Quadratic	y = $0.1438x^2$ - 1.2949x + 31.326	0.2631
Cubic	y = $0.0016x^3$ $+0.1009x^2$ - 0.9471x + 30.519	0.2632
Order Used:	**Cubic**	

6.21 Location R54

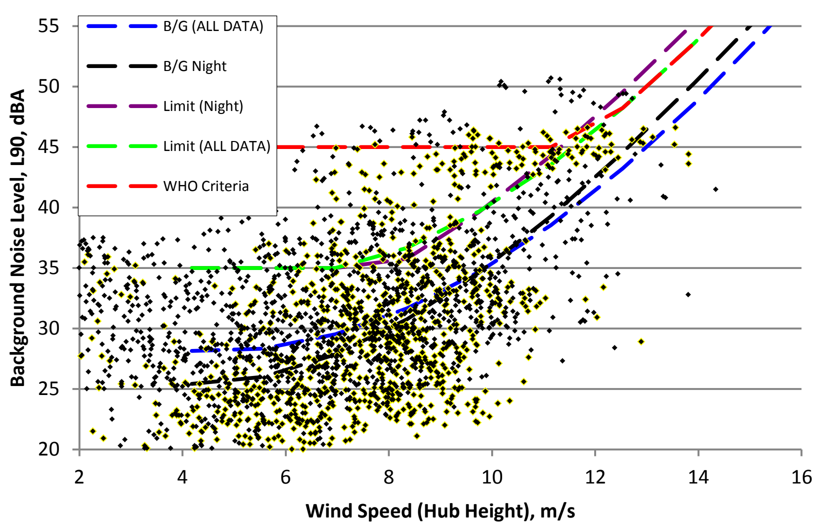
Location R54 is located north west of the ridge for RYP_106, RYP_107 etc. The residence is set back approximately 1.2 km from Blakney Creek South Rd. The nearest proposed turbine to this location is approximately 1.7 km away.

This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered 'project involved'.

Figure 38 Photo and Map of Location R54

The results of the background noise monitoring taken from 10/7/12 to 31/7/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 39**.

Figure 39 Background Noise Measurements and Noise Criteria Curve – Location R54

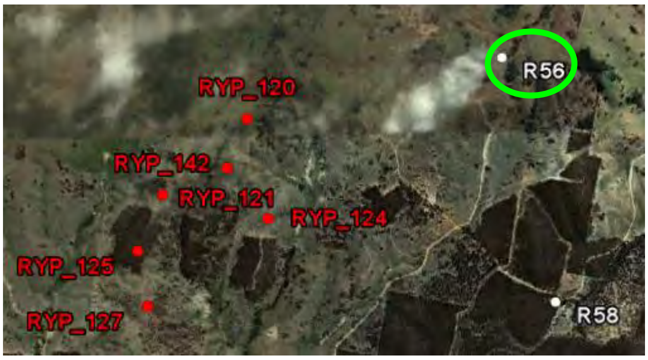


Order	Equation	R^2
Linear	y = 1.0758x + 23.644	0.1766
Quadratic	y = 0.2449x² - 2.2678x + 33.447	0.2733
Cubic	y = -0.0033x³ +0.3137x² - 2.6897x + 34.152	0.2735
Order Used:	**Cubic**	

6.22 Location R56

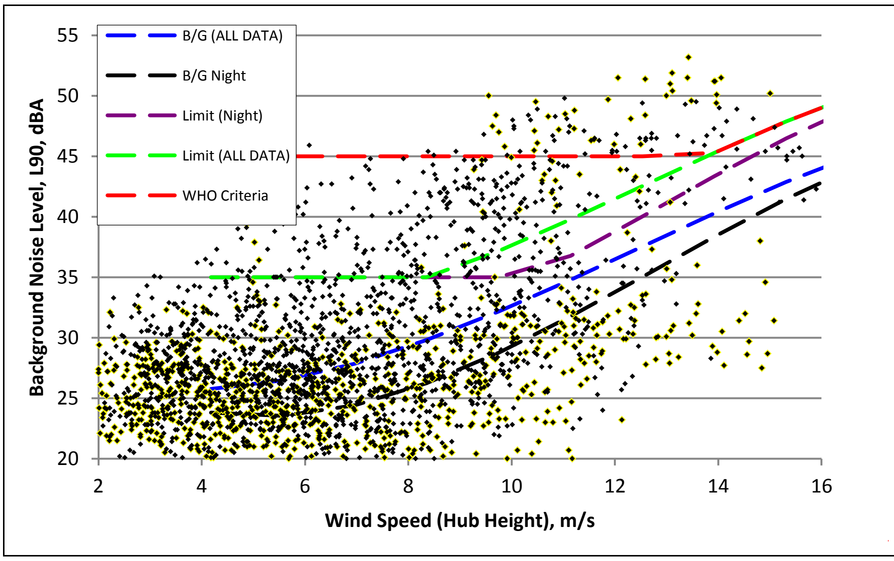
Location R56 is located south east of the ridge for RYP_106, RYP_ 107 etc. west-north-west from RYP_120, RYP_121 etc. The residence is approximately 1.5 km from location R58. The nearest proposed turbine to this location is approximately 1.4 km away.

Figure 40 Photo and Map of Location R56



The results of the background noise monitoring taken from 31/7/12 to 4/8/12 and 4/9/12 to 21/9/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 41**.

Figure 41 Background Noise Measurements and Noise Criteria Curve – Location R56



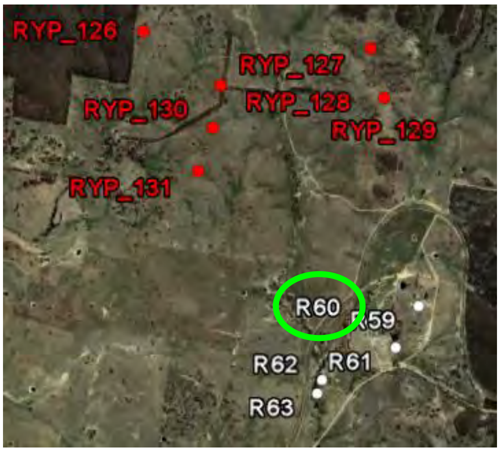
Order	Equation	R^2
Linear	y = 1.1825x + 20.865	0.2647
Quadratic	y = 0.1089x² - 0.4822x + 26.145	0.3004
Cubic	y = -0.0086x³ + 0.321x² - 2.0034x + 29.155	0.305
Order Used:	**Cubic**	

6.23 Location R60

Location R60 is located south of the proposed wind farm allotment. The residence is set back approximately 420 m from Coolalie Rd. The nearest proposed turbine to this location is approximately 1.7 km away.

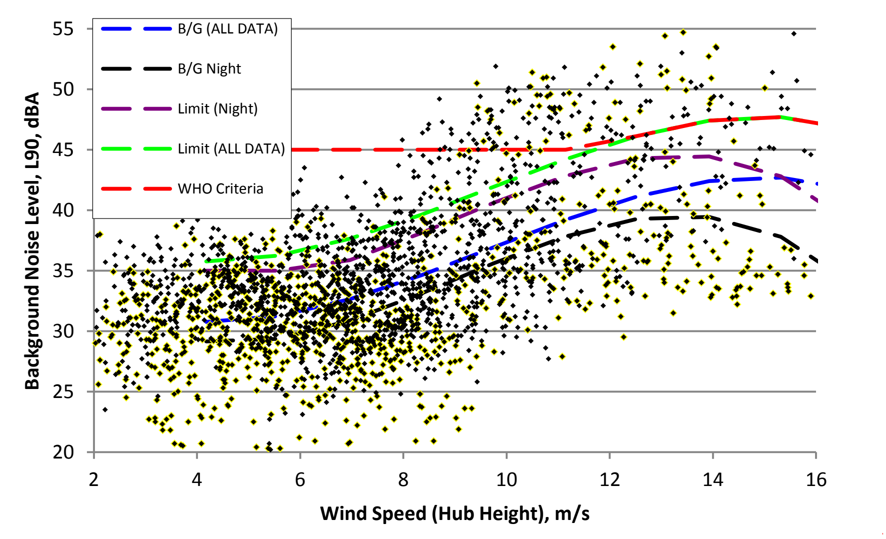
This residence is occupied by one of the landowners that make up part of the proposed Rye Park Wind Farm site and is therefore considered ‘project involved’.

Figure 42 Photo and Map of Location R60



The results of the background noise monitoring taken from 8/8/12 to 22/8/12 and 4/9/12 to 10/9/12, showing the data points, line of best fit and criteria curve for that group is shown in **Figure 43**.

Figure 43 Background Noise Measurements and Noise Criteria Curve – Location R60



Order	Equation	R^2
Linear	y = 1.0835x + 26.081	0.3019
Quadratic	y = 0.0465x^2 + 0.2969x + 28.926	0.311
Cubic	y = -0.0195x^3 +0.5635x^2 - 3.7504x + 38.008	0.3369
Order Used:	**Cubic**	

7 ACOUSTIC ASSESSMENT OF PROPOSED WIND FARM

7.1 Initial Layout - Unmitigated

An assessment of the acceptability of wind farm noise levels at all assessment receivers located within 2 km of a turbine using the noise limit set in SA EPA Guidelines has been completed. Dwellings further than this distance are deemed to comply if dwellings closer to turbines comply with the SA EPA noise limit. The pre-existing background noise level regression analysis used to set the background + 5 dBA limit curve is detailed in **Section 6**.

The proponent RPWF intends to enter into noise agreements with some project involved residences prior to construction. Under the SA EPA Guidelines these residences are not required to comply to the 35 dBA or ‘background + 5 dBA’ limits. However, it is necessary to ensure that the project does not result in an ‘unreasonable interference’ with the amenity of these areas or cause any adverse health effects. Therefore for the assessment of project involved residences the adopted external criteria of 45 dBA (as per the WHO guidelines) or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher. (See **Section 2.5** for details)

Predicted external noise levels will be further mitigated by shielding effects of the building, with the anticipated internal noise levels similarly reduced by the façade of the dwelling.

It should be further noted that all predicted noise levels are considered to be conservative with the model assuming ‘hard ground’ and average downwind propagation from all WTG’s to each receiver or a well-developed moderate ground based temperature inversion.

Predicted noise levels for a reference wind speed of 8 m/s are shown in **Table 10** (See **Section 5.2**), based on the sound power levels provided by the manufacturer at this wind speed.

The assessment figures contained in **Appendix A1** depict the predicted WTG noise level curves for the proposed WTG layout, superimposed over SA EPA Guideline Criteria and WHO based noise limits.

Table 14 below shows the predicted exceedances for all locations. Project involved locations are denoted with an asterisk.

Table 14 Noise Criteria Exceedances

		Exceedance at Wind speed (m/s, 10m AGL) dBA									
Receiver	**BG Location**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Max**
R32*	R32*				0.2	0.7	0.7	0.7			0.7
R38	R36				0.5	1.0	0.7				1.0
R56	R56			2.4	1.6						2.4

Note that ‘*’ denotes a project involved location

For comparative purposes, predicted wind farm noise levels were compared to the SA EPA limits based on the night-time background noise regression curve. The exceedances of the night-time criteria are shown in **Table 15.**

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Table 15 Noise Criteria Exceedances – Night-time Limits

Receiver	BG Location	Exceedance at Wind speed (m/s, 10m AGL) dBA									
		4	5	6	7	8	9	10	11	12	Max
R32*	R32*				0.2	0.7	0.7				0.7
R56	R56			2.6	4.3	2.3					4.3
R38	R36				0.5	1.0	1.0	0.2			1.0
R47	R49					0.1					0.1

Note that '*' denotes a project involved location

7.2 Mitigated Layout – Sound Management Mode

As some exceedances were predicted additional analysis was conducted to determine if full compliance can be achieved using the Sound Management Mode on some turbines. The contribution of each turbine to the receiver locations listed above was calculated. Those turbines that contributed most to the overall noise level were remodelled in Sound Management Mode (Mode 2).

A total of 12 turbines were set to Sound Management Mode. A detailed tabulation of the mitigated turbine layout is shown in **Appendix E.** The mitigated scenario was then remodelled in SoundPLAN software and compared to the noise limit curve for all wind speeds. **Table 16** shows the predicted noise levels for the mitigated layout at the reference wind speed 8 m/s (10 m AGL). The assessment curves for the mitigated scenario are shown in **Appendix A2.**

Table 16 Predicted Wind Turbine Noise Level (dBA) – Mitigated Layout

Location	Predicted Noise Level, Leq dBA	Location	Predicted Noise Level, Leq dBA
R1	37.1	R36*	36.0
R2*	41.7	R38	35.0
R6	34.2	R40	27.7
R7	32.9	R41*	43.1
R8	31.4	R42*	34.0
R9	30.7	R44*	36.7
R10	30.8	R45	35.6
R11*	41.0	R46*	42.4
R13*	41.2	R47	35.4
R14*	42.3	R48	34.1
R16*	42.7	R49*	37.2
R17	35.1	R50	34.9
R19	36.8	R51*	35.7
R20	35.2	R52*	31.5
R22	34.6	R53	32.5
R24	31.4	R54*	33.2
R25*	37.4	R56	35.0
R26*	33.6	R58	27.9
R29	33.6	R59*	34.1
R30*	42.9	R60*	32.9
R31*	39.5	R61*	32.0

Location	Predicted Noise Level, Leq dBA
R32*	44.7
R33*	41.4
R34*	41.2
R35*	37.8
R62	32.3
R63	31.8
R64*	34.0
R65	33.9

Note that '*' denotes a project involved location

The predicted noise levels from this scenario were determined to comply for all receivers for all wind speeds. This mitigation process demonstrates that full compliance is achievable for the wind farm. As the final turbine model is still to be decided, a final noise assessment will be needed to ensure compliance will be achieved on the wind farm as constructed.

7.3 Vestas V112 Detailed Tonality assessment

IEC 61400-11:2002 is the measurement standard used for determining the sound power in one-third octave bands for wind turbines, as measured in the near field. In addition, the standard uses narrow band analysis to quantify tones in the measured sound power spectrum. The result of this test is the tonal audibility criterion $\Delta L_{A,k.}$ In general, $\Delta L_{A,k}$ values greater than -3 should be reported as per the standard.

The origin of the $\Delta L_{A,k}$ test can be found in the *Objective Method for Assessing the Audibility of Tones in Noise, Joint Nordic Method* developed by DELTA. While not fully explained in the IEC 61400-11 standard, the tonality penalty is determined according to the following formula.[2]

$$for\ \Delta L_{ta} < 4dB: k = 0\ dB$$

$$for\ 4 \leq \Delta L_{ta} \leq 10dB: k = \Delta L_{ta} - 4$$

$$for\ \Delta L_{ta} > 10dB: k = 6dB$$

Note: k is not restricted to integer values

Examining the Vestas V112 data provided by the manufacturer[3], $\Delta L_{A,k}$ is less than 4 dB at all wind speeds and therefore does not attract a penalty under the Joint Nordic Method.

In addition to this test a one-third octave band test was completed using the noise levels as predicted by the SoundPLAN model. Levels were assessed against the description of tonality as defined in the NSW Industrial Noise Policy. The policy states that the presence of excessive tonality is defined as when the level of one-third octave band measured in the equivalent noise level L_{eq}(10 minute) exceeds the level of the adjacent bands on both sides by:

→ **5 dB or more** if the centre frequency of the band containing the tone is above 400Hz

→ **8 dB or more** if the centre frequency of the band containing the tone is 160 to 400Hz inclusive

→ **15 dB or more** if the centre frequency of the band containing the tone is below 160Hz

The predicted noise level in one third octave bands did not meet the descriptions as stated above and would therefore be deemed 'non tonal' in the field.

[2] Source: Equation 4 from Objective Method for Assessing the Audibility of Tones in Noise. Joint Nordic Method – Version 2. AV 1952/99 14 April 2000, pg 5.

[3] Source: Garad Hassan report, GLGH-4286 12 09255 258-A-00001-B dated 20 August 2012

7.4 Van den Berg Effect

The phenomena commonly referred to as the 'van den Berg effect' actually includes several effects. They are:

- Increased WTG Sound Power Level due to higher wind shear across the blade of the turbine
- Enhanced propagation of noise due to higher wind shear
- Lower ground level background masking noise for a given operational wind speed due to higher wind shear
- Increased modulation character of the turbine due to higher wind shear

These effects all occur as a result of high wind shear (stable atmosphere) conditions. Atmospheric stability is discussed in the following sections, including a quantification of wind shear on site based on one year's worth of wind monitoring data.

7.4.1 Atmospheric stability and wind profile

The wind velocity at a location can be represented by a vertical profile (gradient) that generally is at a minimum at ground level and increases with altitude. The wind velocity profile is primarily determined by physical factors such as surface roughness and topographic (relief) effects, which are reasonably constant over time, however can also be affected by more variable local atmospheric conditions including atmospheric stability and turbulence.

Atmospheric stability is determined by the total heat flux to the ground, primarily being the sum of incoming solar and outgoing thermal radiation and heat exchanged with the air. During clear summer days (incoming radiation dominates) air is heated from below and rises, causing significant thermal mixing, vertical air movements and turbulence. This process limits large variations in the vertical wind velocity profile.

During clear nights when outgoing radiation dominates, air is cooled from below, air density is greatest closer to the ground and minimal thermal mixing occurs. This leads to a stable atmosphere where horizontal layers of air are largely decoupled and allows for a higher wind velocity gradient.

The noise assessment methodology outlined in the SA EPA Guidelines, as in many other similar wind farm noise assessment methodologies, by necessity rely on the independently verified reference sound power data available for specific wind turbines measured at a manufacturer's test site. The measurement procedure has been standardised (IEC 61400-11) to require sound power data to be measured coincidentally with reference wind speed measurements at an altitude of 10 metres.

As discussed in **Section 5.2** the SA EPA Guideline methodology has been adapted to the alternative reference wind speed at a height of 80 metres AGL which is more representative of hub height wind speed. Accordingly the turbine sound power level data has been amended to the appropriate 80 m AGL wind speed. This approach goes some way to alleviating the variability that changing wind profiles has with respect to a 10 metre reference height.

While the proposed layout meets the requirements of the SA EPA Guidelines, some uncertainty remains as to the likely noise conditions that will result under specific atmospheric conditions over time. The SA EPA Guidelines noise limits are generally set within the requirements of the WHO Guidelines that relate to health impacts, and it is highly unlikely that the remaining uncertainty could lead to health impacts. Some additional analysis into the prevalence of stable atmospheres (ie high wind shear) has been undertaken and is discussed in **Section 7.4.3.**

An adaptive management approach (See **Section 7.5**) could be implemented if undue noise impacts are identified during WTG operation that are related to elevated WTG noise levels during stable atmosphere conditions.

7.4.2 Temperature Inversions

Temperature inversion is an atmospheric condition in which temperature increases with height above ground. Such conditions may increase noise levels by focussing sound wave propagation paths at a single point. Temperature inversions occurring within the lowest 50m to 100m of atmosphere can affect noise levels measured on the ground. Temperature inversions are most commonly caused by radiative cooling of the ground at night leading to cooling of the air in contact with the ground. Such conditions are especially prevalent on cloudless nights with little wind.

The SA EPA Guidelines do not require or suggest temperature inversions be included during wind farm noise assessments. The NSW INP states that temperature inversions be included in an assessment if they are deemed to be a prevalent feature of the environment, which generally requires they occur for greater than 30% of the total night-time during winter (approximately two nights per week between 6:00 pm and 7:00 am). Currently there is insufficient data available to accurately determine the prevalence of temperature inversions; however, given that temperature inversions require atmospheric conditions to be stable, the analysis into wind shear values for the site (See **Section 7.4.3)** may provide some additional context.

Conventional approaches to assessing noise propagation under temperature inversion conditions require knowledge of the temperature gradient and assume that the noise source is located below the temperature inversion, typically near to the ground. The effect of temperature inversions on noise propagation from highly elevated noise sources, such as WTG's is therefore not typical of other sources.

WTG's for the Rye Park Wind Farm project are located on top of elevated ridges. The hub height (assumed acoustic centre of the WTG) is typically located 150 m to 200 m higher than receiver locations on the surrounding area. It is therefore unlikely that conventional temperature inversion conditions, in the lower 200m of the atmosphere, would significantly affect noise propagation from such an elevated source.

A further consideration must be that temperature inversions require little to no wind in order to minimise atmospheric mixing and hence develop. During calm conditions the WTGs are unlikely to operate, as their cut-in speed is typically 3m/s.

Notwithstanding the above, an adaptive management approach (See **Section 7.5**) could be implemented if undue noise impacts are identified during WTG operation that are related to temperature inversion effects.

7.4.3 Likelihood of Enhanced Noise Generation and Propagation Conditions

The probability of meteorological effects that may exacerbate the impacts of noise is an area of interest amongst the research community. Several hypotheses exist to explain why stable atmospheric conditions may cause such phenomena but as yet there is no standardised way of determining a direct, numerical relationship between meteorological conditions and the resulting effect on WTG noise levels.

The IEC61400 testing method does not include any requirement to report the change in output Sound Power Level under differing wind shear values, nor would such information necessarily relate to a particular wind farm site. The local terrain and topographical features of any project site can vary considerably and have a large influence on near-ground-level air flow and, by extension, the wind shear characteristics of the site.

Nonetheless, a brief evaluation of various wind shear values at the site using a simplified model has been undertaken for Rye Park Wind Farm. This may better direct decisions regarding the potential for increased noise impact under different atmospheric conditions once further research findings improves the general understanding of these phenomena.

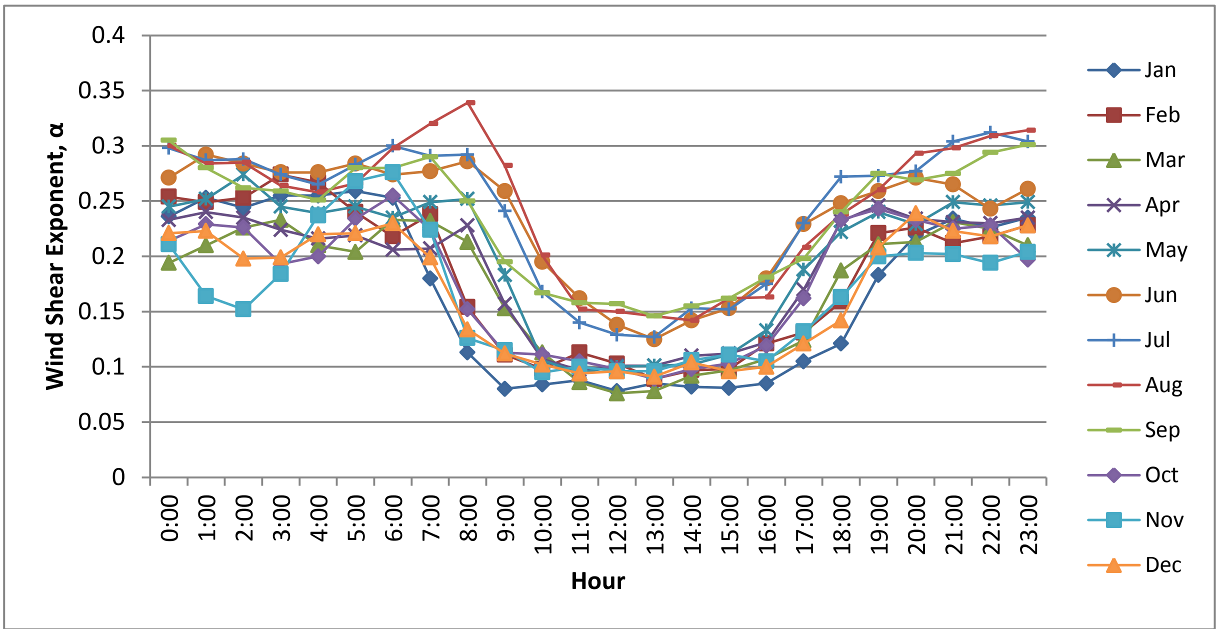
The relationship between wind speeds at differing heights above the ground can be approximated to:

$$V_{@h} = V_{@g}\left(\frac{h}{h_g}\right)^{\alpha} \ where$$
$$V_h = Velocity\ at\ height\ h$$
$$V_g = Velocity\ at\ ground\ level$$
$$\alpha = Wind\ Shear\ Exponent$$

A high value of α indicates a stable atmosphere, which may increase the prevalence of conditions that increase noise generation and propagation.

The proponent has provided SLR Consulting measurement data from a wind mast on site which was analysed to give the wind shear exponent values at different times of day. The data provided was for a full year in the period April 2009 to April 2010. **Figure 44** below shows the average values provided by the proponent, grouped by month.

Figure 44 Variability of Wind Shear by Month & Hour (Average)



Several values of wind shear exponent value (α) have been proposed as defining a stable atmosphere. A wind shear value of greater than 0.55 has been suggested as a 'highly stable' atmosphere for rural environments;[4] van den Berg[5] suggests that a wind shear exponent of 0.41 is appropriate.

To further examine the prevalence of high wind shear values, detailed analysis of wind shear was conducted, with the percentage likelihood of wind shear exponent for each season and time period (Day/Evening/Night). **Table 17** shows the results for two values of α presented in research papers discussed.

[4] Source: Table 2 from *'Sources of Wind Turbine Noise and Sound Propagation'* - Renzo Tonin and Associates - Acoustics Australia Vol. 40 No. 1 pg 24

[5] Source: Table 1 from '*Effects of the wind profile at night on wind turbine sound'* - GP van den Berg - Journal of Sound and Vibration

Table 17 Likelihood of High Wind Shear Exponent

	α > 0.41			α > 0.55		
Season	**Day**	**Evening**	**Night**	**Day**	**Evening**	**Night**
Summer	2.1%	7.2%	13.9%	0.5%	0.7%	1.9%
Autumn	4.5%	6.1%	10.4%	1.4%	0.6%	2.6%
Winter	9.8%	14.7%	18.9%	2.1%	2.2%	3.8%
Spring	4.9%	7.9%	14.6%	1.4%	0.7%	2.3%

The values presented show that high wind shear does not occur for more than 30% of any time period in any season. The NSW INP deems this as being sufficiently occurring to define it as a prevailing meteorological feature for a site.

While the data shows that stable atmosphere conditions may exist for short periods of time, the results of the analysis undertaken indicate that stable atmospheres do not to occur at this site on a long term basis and are not deemed a feature of the site under NSW INP.

7.5 Adaptive Management

If undue WTG noise impacts are identified during operations due to temperature inversion, atmospheric stability or other reasons, then an 'adaptive management' approach could be implemented to mitigate or remove the impact. This process could include;

→ Receiving and documenting noise impact complaint through 'hotline' or other means.

→ Investigating the nature of the reported impact.

→ Identifying exactly what conditions or times lead to undue impacts.

→ Operating WTG's in a reduced 'noise optimised' mode during identified times and conditions (sector management).

→ Turning off WTG's that are identified as causing the undue impact.

→ Providing acoustic upgrades (glazing, façade, masking noise etc) to affected dwellings.

The type of mitigation required would depend on the conditions which occur when the noise is shown to have an impact as well as site-specific details at the location where the impact is demonstrated. Any noise impact would need to be appropriately investigated by a qualified acoustics consultant to understand which mitigation strategy is most appropriate. Nominating an appropriate management technique is the responsibility of the wind farm operator and would depend on the nature and times of the impact. Specific details of the steps to mitigate potential adverse noise impacts would form a part of a Noise Management Plan for the project which would be completed following approval of the wind farm.

7.6 Wind Turbine Vibration

Vibration or more specifically the oscillatory movement of receptor structures could potentially propagate from a source (in this case a wind farm) through either a ground path (ground borne vibration) or an airborne path as sound which could couple with lightweight structures and produce a movement in the structure.

7.6.1 Ground borne vibration

Ground borne vibration levels attenuate with distance with varying amounts dependant upon such variables as frequency and geotechnical parameters. There are a few documented research reports with regards to wind farm generated ground vibration.

The Snow Report (*Low Frequency Noise & Vibration Measurements at a Modern Wind Farm*, ETSU W/13/01392/REP, D J Snow, 1997) describes measurements taken at a wind farm consisting of eleven 450 kW WTG's, where noise and vibration measurements were taken at increasingly distant points up to 1 kilometre. Low frequency vibration was determined down to 0.1 Hz with varying wind speeds and on/off operation. The research found that the absolute level of vibration signals measured at any frequency at 100 metres from the nearest WTG were significantly below the most stringent criteria given by BS 6472:1992 *Evaluation of human exposure to vibration in buildings (1Hz to 80Hz).* Furthermore vibration in the 0.5Hz to 1Hz range remained at similar levels when the wind farm was not operating, suggesting that the vibration measured may have been due to other (ambient) sources.

Detailed *Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Wind Farms* were undertaken by the Applied and Environmental Geophysics Group of Keele University as part of a comprehensive report giving '*Recommendations on The Siting of Wind Farm in the Vicinity the Eskdalemuir, Scotland*'. The Eskadelmuir Seismic Array (EKA) is in the southern uplands of Scotland and is sited on a very quiet magnetic and seismic environment with twin 9 km long lines of seismometer instrumentation which are sensitive enough to pick up nuclear explosions from up to 15,000 km away. It should be noted that the objective of the study was to measure vibration levels many orders of magnitude lower than project criteria detailed in **Section 2.7**

The Eskdalemuir report details results taken from St Breock Downs Wind Farm (possibly the same measurements taken in the Snow Report). From the documented seismic vibration measurements taken at 25 metres from a single WTG a peak particle velocity (PPV) of approximately $8x10^{-5}$ mm/s has been calculated. This is approximately 2500 orders of magnitude lower than project criteria. Whilst we note that turbines proposed for Rye Park Wind Farm are larger than those measured above we are confident that ground vibration will be completely imperceptible at surrounding receptors. Furthermore, our own experience and observations at other operating wind farms has not indicated perceptible ground vibration at any distance from turbines.

7.6.2 Air borne vibration / Infrasound

A good deal of misunderstanding and attention has been given in recent times to low frequency noise and infrasound generated by wind farms. Infrasound at sufficient levels has the potential to be perceived as vibration or alternatively cause the movement of lightweight structures which then in turn are perceived as vibration. It should be noted that the sometimes audible cyclical modulation of aerodynamic noise, the '*swish swish'* of blades, is often mistakenly identified as low frequency noise, where it actually is the low frequency modulation of audible noise.

The subject of infrasound is most complex, dealing with frequencies that are sub audible, requiring alternative frequency weighting scales, specialist measurement equipment and techniques, and evaluating the variance of hearing sensitivity in a population at low frequency. Furthermore, infrasound levels depend on many variables including turbine type and size, wind conditions (including turbulence), propagation distance, building structure and materials, room sizing and positioning within room.

Comprehensive review, measurement testing and evaluation are offered in numerous technical reports investigating infrasound and low frequency noise from wind farms including;

- *A Review of Published Research on Low Frequency Noise and its Effects* - Report for Defra by Dr Geoff Leventhall assisted by Dr Peter Pelmear and Dr Stephen Benton - 2002 (refer to http://www.defra.gov.uk/environment/quality/noise/research/lowfrequency/documents/lowfreqnoise.pdf)
- *The Measurement of Low Frequency Noise at Three UK Wind Farms* - report for DTI by Hayes McKenzie Partnership – 2006 (refer to http://www.berr.gov.uk/files/file31270.pdf)
- *Wind turbines & Infrasound 2006* - Report for Canadian Wind Energy Association (CanWEA) by Howe Gastmeier Chapnik Limited (HGC Engineering) - 2006
(refer to http://www.canwea.ca/images/uploads/File/CanWEA_Infrasound_Study_Final.pdf)

- *Wind Farms Technical Paper – Environmental Noise* – report for Clean Energy Council Australia by Sonus Pty Ltd – 2010 (refer to http://www.cleanenergycouncil.org.au/cec/mediaevents/media-releases/November2010/sonus-report.html)

The consensus drawn by all investigations is that infrasound noise emissions from modern WTG's are significantly below the recognised threshold of perception for acoustic energy within this range.

7.7 Substation Transformer Noise Levels

The appropriate noise criteria for Substation Noise are provided in *NSW INP* (See **Section 2.2** and **2.4**). Noise from the substation will be assessed separately from the wind farm and will be subject to a separate approval.

Australian Standard AS 60076 Part 10 2009: *"Power Transformers – Determination of sound levels"* indicates that the 200 MVA transformer facility may produce sound power levels up to 98 dBA and a 450 MVA transformer may produce sound power levels up to 103A dB. The dominant frequency of such transformers is 100 Hz.

Noise predictions for transformer substations have been made using CONCAWE algorithms assuming an absolute 'worst case' meteorology enhancement condition of downwind 3 m/s and Pasquill Stability Class F temperature inversion. The results are presented in **Table 18** for the nearest receptor locations, along with the appropriate NSW INP limit (See **Section 7.8** for RBL derivation).

Table 18 Predicted 'worst case' 200 MVA switching substation noise

		NSW Industrial Noise Policy Criteria		
Location	**Predicted Noise Level, Leq dB(A)**	**RBL (Night)**	**Noise Limit (Intrusive Criteria)**	**Complies?**
R41	30.6	20	35	Yes
R59	29	31	35	Yes
R61	27.3	31	35	Yes
R62	27	31	35	Yes
R63	26.5	31	35	Yes
R60	22.5	31	35	Yes

7.8 Transmission Line Noise (Corona Noise)

Corona noise is caused by the partial breakdown of the insulation properties of air surrounding the conducting wires. It generally only occurs in humid conditions, as provided by fog or rain. A minimum line potential of 70 kV or higher is required to generate corona noise depending on the electrical design. Corona noise does not occur on domestic distribution lines.

Corona noise has two major components, a low frequency tone associated with the frequency of the AC supply (100 Hz for 50 Hz source) and broadband noise. The tonal component of the noise is related to the point along the electric waveform at which the air begins to conduct. This varies with each cycle and consequently the frequency of the emitted tone is subject to great fluctuations. Corona noise can be characterised as broadband 'crackling' or 'buzzing' and is generally only a feature during foggy or raining conditions.

We have previously measured corona noise (reference GEHA Report 045-109/2 dated 9 November 2004) at a site near Officer in outer Melbourne, Victoria. We found it possible to measure corona noise at close distances, at high frequencies only, as other noise sources, namely traffic and birds, caused some interference at times. A 500 kV line was measured during damp foggy conditions.

At a distance of 30m along the ground from the line an L_{eq} noise level of approximately 44 dBA was measured. At a distance of 100m the corona noise was calculated to be approximately 39 dBA.

Assuming a minimum RBL value of 30 dBA, the minimum intrusive criteria as determined by the NSW Industrial Noise Policy (INP) would be 35 dBA. We therefore conservatively estimate that the minimum criteria level of 35 dBA would be complied with at a distance of 240 metres. The developer has advised that the proposed transmission route is further than this distance from any receptor and hence any occasional corona noise will comply with the NSW INP minimum limit at all residential receivers.

9 NSW DRAFT WIND FARM GUIDELINES

In December 2011 the NSW Department of Planning and Infrastructure released the *Draft NSW Planning Guidelines Wind Farms – Appendix B: NSW Wind Farm Noise Guidelines.*

Whilst the guidelines are yet to be finalised it has been requested by the Director General that during the interim period due consideration should be given to a number of the additional requirements of the proposed draft guideline. These are presented below.

9.1 Daytime vs. Night-time Background Noise

The background noise data was reprocessed to define background noise curves for the daytime period (7.00 am to 10.00 pm) and night-time period (10.00 pm to 7.00 am) as defined by the draft guideline. The corresponding 3rd order regression curve and correlation coefficient are presented in **Table 19** below.

Table 19 Background Noise Regression Curves and Correlation Coefficient

Location	Daytime	Daytime R^2	Night-time	Night-time R^2
R2	$0.004x^3 + 0.0675x^2 - 0.2107x + 28.332$	0.3494	$-0.0146x^3 + 0.5005x^2 - 3.2897x + 32.238$	0.3445
R6	$-0.0047x^3 + 0.1943x^2 - 0.8391x + 26.145$	0.3306	$-0.0145x^3 + 0.4377x^2 - 2.8665x + 30.122$	0.3009
R13	$-0.0041x^3 + 0.252x^2 - 1.683x + 29.857$	0.4428	$0.0176x^3 - 0.2545x^2 + 1.994x + 20.174$	0.3872
R14	$-0.0049x^3 + 0.2106x^2 - 0.7195x + 24.259$	0.4113	$0.02x^3 - 0.2626x^2 + 1.0216x + 24.109$	0.252
R19	$0.0066x^3 - 0.0775x^2 + 0.6283x + 29.502$	0.2135	$0.0022x^3 + 0.0703x^2 - 0.6383x + 29.799$	0.3118
R24	$-0.0055x^3 + 0.1967x^2 - 0.8652x + 29.768$	0.3074	$-0.0012x^3 + 0.2153x^2 - 1.8413x + 31.706$	0.3458
R25	$0.0115x^3 - 0.1688x^2 + 1.3235x + 20.633$	0.2758	$0.0022x^3 + 0.0046x^2 + 0.1516x + 19.907$	0.2382
R30	$-0.0013x^3 + 0.0643x^2 + 0.5145x + 24.623$	0.2781	$8E-05x^3 + 0.1703x^2 - 2.0978x + 31.624$	0.2094
R32	$0.0066x^3 - 0.0399x^2 + 0.3799x + 29.191$	0.2495	$-0.0001x^3 + 0.121x^2 - 0.9889x + 31.088$	0.3105
R34	$-0.0082x^3 + 0.2317x^2 + 0.0968x + 20.66$	0.8039	$-0.0233x^3 + 0.7447x^2 - 5.1951x + 34.199$	0.7439
R36	$-0.0016x^3 + 0.1622x^2 - 1.3908x + 26.761$	0.3351	$-6E-05x^3 + 0.1693x^2 - 2.0032x + 24.906$	0.4326
R41	$-0.0076x^3 + 0.2461x^2 - 0.6705x + 19.441$	0.4736	$-0.0324x^3 + 0.894x^2 - 5.6692x + 26.728$	0.5152
R44	$-0.0104x^3 + 0.3862x^2 - 2.3486x + 28.104$	0.5243	$-0.0051x^3 + 0.2755x^2 - 2.1163x + 25.414$	0.4665
R46	$0.0075x^3 - 0.0479x^2 + 0.5806x + 24.267$	0.3131	$-0.0223x^3 + 0.7267x^2 - 5.1643x + 33.143$	0.4345
R49	$-0.0018x^3 + 0.0804x^2 + 0.4197x + 23.562$	0.4038	$-0.0258x^3 + 0.7838x^2 - 5.8263x + 32.991$	0.4853
R51	$-0.0037x^3 + 0.1526x^2 - 0.5917x + 27.473$	0.258	$-0.018x^3 + 0.7135x^2 - 5.7973x + 34.583$	0.3686
R52	$-0.0003x^3 + 0.1141x^2 - 0.6748x + 32.126$	0.2632	$-0.0062x^3 + 0.2728x^2 - 2.0066x + 26.692$	0.2743
R54	$-0.0055x^3 + 0.3039x^2 - 2.3277x + 33.946$	0.2735	$-0.0094x^3 + 0.4771x^2 - 3.5489x + 32.598$	0.3768

Location	Daytime	Daytime R^2	Night-time	Night-time R^2
R56	$-0.0085x^3 + 0.2961x^2 - 1.513x + 28.567$	0.305	$-0.0136x^3 + 0.5228x^2 - 4.3054x + 33.647$	0.3299
R60	$-0.013x^3 + 0.4374x^2 - 3.0842x + 38.204$	0.3369	$-0.0316x^3 + 0.8557x^2 - 5.917x + 41.243$	0.3271

Daytime regression curves were typically 0.5 to 1dB higher than the regression curve based on the full data set. Night-time regression curves were typically 2 to 4 dB lower than the regression curves based on the full data set. Correlations for daytime regression curves were generally close to correlation for the full data set. Correlations for night-time regression curves were usually higher, although in some cases were significantly lower. This is most likely due to high data scatter at lower wind speeds.

The new background noise curves were used to update the noise limit curves for all receptors and all predicted results were assessed against these criteria. There were no exceedances of the daytime only criteria for any receiver.

Table 20 below shows the exceedances for all project uninvolved locations for the night-time criteria.

Table 20 NSW Draft Wind Farm Guidelines Exceedances – Night-time Criteria

		Exceedance at Wind speed (m/s, 10m AGL) dBA										
Receiver	**BG Location**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Max**
R47	R49*						0.4					0.4

Note that '*' denotes a project involved location

The predicted exceedance is below 0.5 dBA. This is a relatively minor exceedance which would be difficult to measure in the field.

9.2 Special Audible Characteristics

The Draft NSW Guidelines have been developed with the fundamental characteristics of wind turbine noise taken into consideration including reasonable levels of swish, modulation, discrete tones and low frequency noise.

The Draft NSW Guidelines introduce recommendations for procedures to assess excessive levels of special audible character and these procedures (if adopted) are to be used to evaluate noise character from an operational wind farm. Notwithstanding the above, the proposed procedures have been adapted to evaluate the predicted likelihood of excessive levels of special audible character.

9.2.1 Low Frequency Noise

An assessment of the potential for low frequency noise was completed with C-weighted noise levels predicted for the proposed layout.

A criteria of 65 dBC daytime and 60 dBC night-time as proposed by the Draft NSW Guidelines was used to determine if further investigation into low frequency noise was warranted.

The results of the SoundPLAN predicted levels showed that no receiver location exceeded 60 dBC.

9.2.2 Tonality

The simplified 1/3 octave band method for assessing tonality as proposed by the Draft NSW Guidelines was completed for the proposed layouts using the same method evaluated in **Section 7.3.**

The tonality tests showed no presence of tonality in the predicted results. A full set of results for this analysis is shown in **Appendix F.**

9.2.3 Amplitude Modulation

Amplitude modulation (AM) refers to the cyclical modulation of audible aerodynamic noise from WTGs. The modulation typically occurs at rate corresponding to blade passing frequency which is approximately once per second (i.e. ~1 Hz). This is not to be confused with infrasound, that is, sound waves at frequencies below the range of human hearing; rather it refers to the fluctuation of noise level in the audible range.

Noise from a wind turbine typically includes an inherent level of amplitude modulation, often referred to as 'swish' and the criteria in the Draft NSW Guidelines have been determined with the inherent characteristics of wind turbine noise – including reasonable levels of amplitude modulation – taken into consideration. The Draft NSW Guidelines propose an excessive level of modulation is taken to be a variation of greater than 4 dBA at the blade passing.

The issue of AM of WTG noise is now the subject of considerable research and investigation and whilst 'normal' amplitude modulation (swish) is generally well characterised and the source mechanism better understood, the hypothesised potential causes of excessive (Other) AM are somewhat more complex and not well understood.

Research into AM undertaken by Salford University in 2007, found that out of the total number of operational wind farms investigated (133) in the UK approximately 20% at some point had registered a noise complaint(s); but AM was considered to be a factor in noise complaints at only 3% of the sites and a possible factor at 6% of the sites. Furthermore, the periods when AM complaints were registered at four wind farms determined that the necessary conditions were relatively infrequent. From this it appears that whatever the actual number of occurrences of potential excessive AM, it only occurs at a minority of wind farm sites for a small amount of the time.

There currently is no means to predict the eventuality, severity or frequency of occurrence of excessive AM and the proposed Draft NSW Guideline methodology is limited to the assessment of operational wind farms. Research evidence would suggest that excessive AM has only been confirmed at a small number of wind farm sites and when it occurs it is relatively infrequent.

Nevertheless, should excessive AM be found to be a problem with the wind farm, it would be possible to limit the impact on the residents through adaptive management techniques (See also **Section 7.5**).

10 ASSESSMENT OF CONSTRUCTION NOISE & VIBRATION LEVELS

10.1 Project Construction Noise

The appropriate criteria for construction noise are provided in the Interim Construction Noise Guidelines (DECCW, 2009) (See **Sections 2.2** and **2.6**).

Proposed construction activities associated with the wind farm include;

→ construction of access roads,

→ establishment of turbine tower foundations and electrical substation,

→ digging of trenches to accommodate underground power cables,

→ erection of turbine towers and assembly of WTG's.

The equipment required to complete the above tasks will typically include;

→ excavator/grader, bulldozer, dump trucks, vibratory roller

→ bucket loader, rock breaker, drill rig, excavator/grader, bulldozer, dump truck, flat bed truck, concrete truck

→ cranes, fork lift, and various 4WD and service vehicles.

The anticipated construction period is anticipated to be less than 24 months, with civil works expected to span approximately 12 to 15 months, however, due to the large area of the wind farm site, intensive works will be located within close proximity to individual residential receivers for only very short and intermittent periods of time.

It is anticipated that most construction will occur during standard construction hours and it is therefore considered appropriate that construction noise levels up to 10 dBA above the RBL's would be acceptable. Construction noise levels greater than 10 dBA above RBL could be considered as 'noise affected' as defined by the DECCW guidelines. At levels greater than 75 dBA receptors would be considered 'highly noise affected' by construction noise as defined by the Guidelines.

10.2 Ambient Background Noise Levels

Noise monitoring data presented in **Section 6** was used to determine the RBL for each period in general accordance with the DECCW Guidelines. We note that as 10 minute intervals were used in the logging campaign for the Wind Farm Assessment, this interval was used for derivation of background noise. **Table 21** shows the RBL for each monitoring location.

Table 21 Summary of Rating Background Levels (RBL's) for Monitoring Locations

	RBL (dBA)		
Measurement Location	**Day (0700 h – 1800 h)**	**Evening (1800 h – 2200 h)**	**Night (2200 h – 0700 h)**
R2	26	33	29
R6	26	30	28
R13	26	31	24
R14	23	26	24
R19	27	32	28
R24	27	30	28
R25	22	22	21
R30	25	27	23

Measurement Location	RBL (dBA) Day (0700 h – 1800 h)	Evening (1800 h – 2200 h)	Night (2200 h – 0700 h)
R32	28	30	30
R34	24	43	26
R36	22	18	18
R41	20	21	18
R44	27	29	21
R46	23	26	24
R49	26	24	18
R51	26	21	19
R52	31	24	20
R54	25	29	24
R56	24	27	23
R60	31	33	30

We note that the NSW INP nominates a minimum RBL of 30 dBA. In locations where the measured RBL is lower than this, the RBL reverts to 30 dBA.

10.3 Noise Modelling Parameters

In order to calculate the noise levels at the various noise sensitive receiver locations from construction equipment associated with the project, a SoundPLAN computer noise model was developed.

The model predicts noise levels by taking into account such factors as the source sound power levels and locations of sources and receivers, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions, including wind effects. The noise model was configured to use prediction algorithms in accordance with the Conservation of Clean Air and Water Europe (CONCAWE) prediction methodology which allows for conservative 'worst case' meteorological propagation conditions.

Sound power levels used to derive the predicted construction noise were based on typical data sourced from the SLR Consulting noise source database. Computer noise models of typical construction scenarios were developed which included all anticipated mobile equipment for the activity operating simultaneously at full load. **Table 22** shows typical sound power levels of equipment used in wind farm construction.

Table 22 Typical Construction Equipment

Equipment	Octave band mid frequency - L_{eq} Sound Power Levels dB							
	63	125	250	500	1 K	2 k	4 K	Total, dBA
Excavator	121	126	111	107	106	101	96	113
Grader	118	124	115	114	115	114	113	120
Rock Breaker	113	115	117	122	121	120	118	126
Crane	108	105	109	107	111	105	97	113

To examine the possible worst case construction noise impacts for all nearby receivers, four different construction scenarios were modelled at each turbine location and the highest noise levels for each receiver predicted. These are:

→ Construction of Access Roads

→ Establishment of Turbine Foundations

→ Trench Excavation

→ WTG Erection and Assembly

10.4 Normal Working Hours Operation

Table 23 shows the predicted construction level for all receivers. The Rating Background Level (RBL) obtained during the background noise monitoring campaign and applicable noise limit for the daytime period is included. Locations where the predicted noise levels are deemed 'noise affected' are highlighted in red.

Table 23 Predicted Construction Noise Levels

Location	Construction Activity				RBL	Noise Management Level
	Establishment of Turbine Tower Foundations	Trench Excavation	Construction of Access Roads	WTG Erection & Assembly	Day	Day (RBL+10) OR 40 dBA
R1	52	39	41	39	26	40
R2	59	45	48	45	26	40
R6	49	36	38	36	26	40
R7	49	35	37	35	26	40
R8	47	34	36	34	26	40
R9	47	33	36	33	26	40
R10	45	32	34	32	26	40
R11	50	37	39	37	26	40
R13	55	42	44	42	26	40
R14	56	43	45	43	23	40
R16	57	43	46	43	23	40
R17	45	31	34	31	27	40
R19	47	33	36	33	27	40
R20	44	31	34	31	27	40
R22	43	29	32	29	27	40
R24	43	29	32	29	27	40
R25	49	35	38	35	22	40
R26	44	31	33	31	22	40
R29	46	32	35	32	22	40
R30	57	44	47	44	25	40
R31	48	35	37	35	28	40
R32	55	42	44	42	28	40
R33	49	36	39	36	25	40
R34	56	42	45	42	24	40
R35	55	42	44	42	24	40
R36	52	38	41	38	22	40
R38	49	36	38	36	22	40

Location	Construction Activity				RBL	Noise Management Level
	Establishment of Turbine Tower Foundations	Trench Excavation	Construction of Access Roads	WTG Erection & Assembly	Day	Day (RBL+10) OR 40 dBA
R40	35	21	24	21	27	40
R41	59	45	48	45	20	40
R42	45	32	34	32	20	40
R44	45	31	34	31	27	40
R45	46	32	35	32	23	40
R46	53	40	43	40	23	40
R47	50	37	39	37	26	40
R48	48	35	37	35	26	40
R49	49	36	38	36	26	40
R50	46	33	35	33	26	40
R51	48	34	37	34	26	40
R52	45	31	34	31	31	40
R53	46	33	35	33	26	41
R54	47	34	36	34	25	40
R56	49	36	38	36	24	40
R58	37	24	27	24	24	40
R59	44	31	34	31	31	40
R60	46	33	35	33	31	41
R61	44	31	33	31	31	41
R62	45	32	34	32	31	41
R63	45	31	34	31	31	41
R64	43	29	32	29	22	41
R65	45	31	33	31	27	40

The majority of occurrences of locations being ‘noise affected’ occur when turbine foundation civil works are located nearby and is largely attributed to the operation of a rock breaker. Due to the anticipated short period of localised works this activity would likely be considered acceptable under the Guideline. Operation of the rock-breaker is dependent upon the geotechnical conditions of the foundation site and would be operated intermittently at most. Consideration for mitigation measures such as localised shrouding may be needed if adverse conditions are experienced if and when operating the rock-breaker at the most exposed positions.

No predicted levels exceed 75 dBA and therefore no receptors would be considered as being ‘highly noise affected’ as defined by the Guideline.

10.5 Outside Normal Operating Hours Operation

The only operation that may occur at night is the erection of WTG’s, as low wind conditions are preferable while the towers are being erected by large cranes. **Table 27** shows all noise affected receivers for this construction activity for the night period. Note that the minimum RBL under NSW INP is 30 dBA which therefore creates a minimum noise management level of 35 dBA for the night-time period.

Table 24 Night Construction Noise Levels – Noise Affected Receivers

Location	Construction Activity	RBL	Limit
	WTG Erection & Assembly	Night	Night (RBL+ 5) OR 35 dBA
R1	39	29	35
R2	45	29	35
R6	36	28	35
R7	35	28	35
R11	37	24	35
R13	42	24	35
R14	43	24	35
R16	43	24	35
R25	35	21	35
R26	31	21	35
R29	32	21	35
R30	44	23	35
R32	42	30	35
R33	36	23	35
R34	42	26	35
R35	42	26	35
R36	38	18	35
R38	36	18	35
R41	45	18	35
R42	32	18	35
R44	31	21	35
R45	32	24	35
R46	40	24	35
R47	37	18	35
R48	35	18	35
R49	36	18	35
R50	33	19	35
R51	34	19	35
R52	31	20	35
R53	33	19	35
R54	34	24	35
R56	36	23	35
R64	29	18	35
R65	31	21	35

A total of 19 locations are deemed ‘noise affected’ by the Guideline for night-time construction. Tower erection near these locations should occur during the daytime, if possible. Construction works may also be carried out outside of standard construction hours where it is required in an emergency to avoid the loss of life or property, or prevent environmental harm. No predicted levels exceed 75 dBA and therefore no receptors would be considered as being ‘highly noise affected’.

10.6 Concrete Batching Plants

A number of portable concrete batching plants with a combined Sound Power Level of 115 dBA will be required to supply concrete onsite. The proposed locations of these batching plants are listed in **Table 25**. They are often located within or near to the construction compounds where equipment is stored for the duration of the construction phase of the project.

Table 25 Concrete Batch Plant Locations

Name	Easting	Northing	Nearest Receivers
CBP1	683952	6150712	R59, R60, R61
CBP2	678143	6183725	R13, R14

Using the existing SoundPLAN noise model, predicted noise levels for the proposed batch plant site at the nearest affected properties were calculated under worst case conditions. Results for those locations that exceed the night criteria are shown in **Table 26** together with the RBL and noise management level (NML), for the day and night periods. Additionally, three locations are deemed 'noise affected' for the daytime period; these are shown in bold.

Table 26 Concrete Batch Plant Noise Level Prediction

Location	Predicted Noise Level, dBA	RBL – Day, dBA	NML - Day RBL + 5 OR 35 dBA	RBL – Night, dBA	NML - Night RBL + 5 OR 35 dBA
R2	35.6	26	40	29	35
R13	36.9	26	40	24	35
R14	**49**	23	40	24	35
R16	37.6	23	40	24	35
R41	**46.2**	20	40	18	35
R59	**41.9**	31	41	30	35
R61	35.1	31	41	30	35
R62	39.4	31	41	30	35
R63	38.7	31	41	30	35

All other locations are predicted to be below the night-time NML. Some mitigation may be possible for sources within the concrete batch plants, particularly if they are near other project equipment infrastructure which may provide some localised shielding. This should be addressed in any further management plans for construction noise for the project, as described in **Section 10.7**.

10.7 Mitigation for Construction Noise

The Interim Construction Noise Guidelines recommend that where residences are deemed 'noise affected', that work practices and mitigation measures deemed feasible and reasonable should be applied. Possible mitigation measures may include:

- Scheduling construction works for less critical times of day
- Using alternative, quieter equipment
- Noise controls including temporary walls/earth berms and exhaust silencers
- Keeping the community informed about upcoming works in the area
- Detailed tracking regarding complaints about construction noise, including how each complaint was addressed.

A detailed construction noise management plan will be developed closer to the construction of the wind farm to ensure that all reasonable steps are taken to reduce noise from construction sources including batching plants, and that appropriate community engagement occurs with respect to construction noise.

10.8 Construction Vibration Assessment

The activities and equipment with the potential to generate the highest levels of ground vibration are the operation of the vibratory roller during construction of access roads and the operation of the rock breaker during establishment of turbine tower foundations. Typical vibration levels from these sources are presented in **Table 27**.

Table 27 Typical Vibration Emission Levels from Construction Plant

Activity	PPV Vibration Level (mm/s) at Distance			
	10m	20m	30m	100m
4-Tonne Vibratory Roller	2.0 - 2.4	0.4 - 1.2	0.2 - 0.8	<0.2
Hydraulic Hammer (30t)	3	1.5	1.0	<0.5

It is evident that given the large distances between receptors and structures where construction works are likely to be undertaken (greater than 500 m, refer to **Appendix C**), the building damage and human comfort vibration criteria will easily be met during construction.

10.9 Blasting

10.9.1 Blasting Assessment

Blasting may be required in some areas to clear large rock outcrops to prepare turbine foundations.

The proposed wind farm site is a green field site where no previous blasting or blast monitoring has been conducted and therefore no specific site laws exist. We have therefore adopted a site law derived from measurement data at a different site to give an indicative result.

The 5% site laws for ground vibration and airblast are:

Ground Vibration PVS (5%) = $16202\,(SD_1)^{-2.03}$

Airblast SPL(5%) = $189.3 - 31.8 \log (SD_2)$

where PVS (5%) and SPL (5%) are the levels of ground vibration (Peak Vector Sum - mm/s) and airblast (dB Linear) respectively, above which 5% of the total population (of data points) will lie, assuming that the population has the same statistical distribution as the underlying measured sample.

SD_1 and SD_2 are the ground vibration and airblast scaled distances, where:

$$SD_1 = \frac{\text{Distance}}{\sqrt{\text{MIC}}} = \left(\text{m.kg}^{-0.5}\right) \text{ and } SD_2 = \frac{\text{Distance}}{\sqrt[3]{\text{MIC}}} = \left(\text{m.kg}^{-0.33}\right)$$

Based on the blast emissions site laws, calculations were also conducted to indicate the allowable MIC's for compliance with the general EPA Human Comfort criteria of 115 dB Linear (airblast) and 5 mm/s (ground vibration).

The closest anticipated distance between blasting and residences would be approximately 615 metres (R2). At this distance, based on a site constant K_a of 20, the predicted maximum MIC of up to 43 kg is likely to produce an airblast overpressure below the acceptable level of 115 dB Linear. An MIC of 43 kg is expected to result in a vibration level (Peak Vector Sum) of 0.011 mm/s, well within the recommended maximum level of 5 mm/s in the ANZECC Guidelines.

It is evident that the anticipated blasting is likely to meet all human comfort limits and building damage assessment criteria are easily met. All other sources of vibration would be less than above.

10.10 Traffic Noise

Traffic generated by the project during its construction phase has been evaluated in *Rye Park Wind Farm Traffic and Transport Report* prepared by Epuron Pty Ltd, dated 31 July 2012. The report states that a maximum of approximately 300 trips per day could be expected from the project.

There are no traffic flow records available for Rye Park.

The projected increase in road traffic noise levels on all local roads is expected to be greater than 2 dBA during peak construction periods, however, road traffic noise levels are anticipated to meet the *Environmental Criteria for Road Traffic Noise (ECRTN)* and subsequent *Road Noise Policy (RNP)* target for a local road of daytime $L_{Aeq(1\ hour)}$ = 55 dBA at a typical setback distance of 50m. We note that being a rural farming community that most receptors are at much greater setback distances from their road frontage and therefore will easily meet the ECRTN requirement.

10.10.1 Night-time deliveries

There could potentially be deliveries of equipment scheduled for out of hours, necessitated by traffic congestion considerations and safe passage of heavy vehicle convoys or especially long loads. Night-time traffic has the potential to cause sleep disturbance to residential receivers along the route.

Preliminary calculations indicate that maximum noise levels at a residence approximately 50 metres from the road as a result of a heavy vehicle pass-by would be in the range 45-55 dBA. Assuming a 10dBA transmission loss through an open window this would result in 35 to 45 dBA inside.

The NSW RNP states that:

- *Maximum internal noise levels below 50-55 dBA are unlikely to awaken people from sleep*

and

- *One or two noise events per night, with maximum internal levels of 65-70 dBA are not likely to affect health and wellbeing significantly.*

In order to further minimise potential noise impacts associated with night-time deliveries some potential measures to be considered are:

→ Prior notification of affected public where night-time convoys are scheduled

→ Restricted use of exhaust/engine brakes in built up areas

11 CONCLUSION

Noise from the proposed Rye Park Wind Farm using a mitigated layout of 126 Vestas V112 WTGs, with 12 running in Sound Management Mode (as detailed in **Appendix E**) has been predicted. The predicted noise levels were assessed against the relevant criteria prescribed by the SA EPA Guideline and World Health Organisation (WHO) goals where appropriate. An evaluation of night-time baseline data was also included.

The predicted noise levels of the mitigated layout were determined to meet the relevant criteria at all receptor locations.

The project is yet to select and finalise the WTG make and model. Upon finalising the WTG selection a revised noise prediction and assessment will be completed to confirm compliance.

WTG vibration levels have been evaluated and based upon overseas research available were found to be acceptable.

Construction noise has been predicted to all receivers; a number of these are deemed 'noise affected' under the NSW Construction Noise Guidelines. In order to ensure all appropriate measures are being taken to manage construction noise, a more detailed construction management plan should be developed by the proponent. This document will provide detailed guidance on various noise mitigation strategies for the construction stage.

Vibration impacts from construction have been assessed and the 'worst case' scenarios modelled were found to be acceptable.

Blasting impact has been assessed and found to be acceptable. With a maximum instantaneous charge (MIC) of up to 43 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear for all existing residences. Similarly, vibration levels are anticipated to be well below the acceptable criteria.

Construction traffic noise impact has been assessed and the 'worst case' maximum construction traffic scenario would comply to the NSW RNP requirements, due to the typically large setback of dwellings from the road network. Night-time deliveries are unlikely to cause sleep disturbance based on predicted maximum noise levels.