APPENDIX 2

Crudine Ridge Wind Farm Environmental Noise Assessment – Response to Submissions

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Crudine Ridge Wind Farm

Environmental Noise Assessment

Response to Submissions

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BACKGROUND

The proposed Crudine Ridge Wind Farm is located 45km south of Mudgee and 45km north of Bathurst, New South Wales. The proposal includes two planning layouts, designated A and B, which comprise up to 106 and 77 wind turbine generators (turbines), respectively.

The Crudine Ridge Wind Farm Environmental Noise Assessment report was commissioned to address the Director General's Requirements (DGRs) relating to operational noise and construction noise and vibration, issued in March 2011.

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

The NSW Department of Planning and Infrastructure (DoPI) released the *Draft NSW Planning Guidelines for Wind Farms* (NSW 2011), in December 2011. NSW 2011 requires the background noise levels to be separated into daytime and night-time periods. The assessment therefore goes beyond the requirements of the SA Guidelines and conducts an analysis for both the daytime and night-time periods.

The operational noise assessment was based on Acciona AW77 turbines for Layout A and Siemens SWT2.3-101 for Layout B. These turbines were based on the likely "worst case" (highest noise level) turbine selection available to Wind Prospect CWP at the time of the assessment.

Noise predictions indicate that both layouts achieve the SA Guidelines at all dwellings.

The predictions also indicate that both layouts can achieve the criteria based on the day and night period split at all dwellings, with the implementation of a noise mitigation strategy for Layout A.

GLOSSARY

Ambient noise level	The noise level with the presence of all existing noise sources in the environment
A-weighting	Frequency adjustment applied to measured noise levels to replicated the frequency response of the human ear
Background noise level	The noise level in the absence of intermittent noise sources
Day	The period between 7am and 10pm, when considering day and night periods. The period defined by the INP as 7am to 6pm Monday to Saturday, and 8am to 6pm on Sunday.
Evening	The period defined by the INP as 6pm to 10pm Monday to Sunday.
dB(A)	A-weighted noise or sound power level in decibels
Equivalent noise level	Energy averaged noise level
L_{A90}	A-weighted noise level exceeded 90% of the time measured in decibels, representing the background noise level
L_{Aeq}	A-weighted equivalent noise level measured in decibels
Night	The period between 10pm and 7am, when considering day and night periods. The period defined by the INP as 10pm to 7am Monday to Saturday, and 10pm to 8am on Sunday.
RBL	Rating Background Level
Sound power level	A measure of the sound energy emitted from a source of noise.
Worst-case	Conditions resulting in the highest noise level at or inside residences.

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RESPONSE

Submissions have been received as part of the Crudine Ridge Wind Farm environmental assessment process.

Several submissions include concerns regarding various aspects of noise and vibration. These aspects have been separated into general headings for which a response is provided. A more detailed specific response is also provided for certain issues included in the submissions.

Audible Noise

There are submissions which suggest that the criteria of the South Australian *Environmental Noise Wind Farm Guidelines 2003* (the SA Guidelines), referenced by the Director General's Requirements (DGRs), are inadequate.

The criteria of the SA Guidelines are established to ensure any audible wind farm noise is low enough in level such that it does not adversely impact on the health or amenity of the community. The SA Guidelines are considered to provide the most onerous criteria for wind farms in the World.

Notwithstanding this, the assessment goes beyond the requirements of the SA Guidelines and conducts a specific and more onerous analysis for both the daytime and night-time periods in accordance with the *Draft NSW Planning Guidelines for Wind Farms* (NSW 2011).

In addition to the concerns relating to the inadequacy of the DGRs to address audible noise, concerns are also raised regarding the following:

1. The inability to sleep and the need to keep windows closed to ensure sleep disturbance does not occur;
2. Deafness to family and livestock resulting from exposure;
3. The assessment makes no allowance for topography.
4. Offensive noise (such as that described in the EPA's Noise Guide for Local Government) is ignored in the EA.

5. There is no information presented which clearly demonstrates involved landowners have been made aware of expected or likely noise impacts.

A response to each item is provided below:

1. The SA Guidelines establish a base noise level of 35 dB(A). The base noise level generally applies during low wind speed and background noise conditions. The base noise level is significantly more onerous than the criterion established by the World Health Organisation (WHO) *Guidelines for Community Noise*[1] (the WHO Guidelines) of 45 dB(A) to protect against the potential onset of sleep disturbance. The WHO Guidelines criterion is based on bedroom windows being open.
2. The noise levels associated with wind farms, including noise levels directly underneath a turbine, are significantly lower than noise levels associated with hearing damage. The noise levels associated with wind farms are also well below the noise levels that can be experienced in the natural environment.
3. The noise predictions account for the influence of topography. Further information on the noise prediction methodology is provided in this response.
4. The DGRs refer to SA 2003 as the key assessment tool and measure of acceptance of noise emissions from a wind farm. SA 2003 was established specifically for wind farms and is underpinned by the principle of preventing adverse impacts on the amenity of dwellings in a rural environment. The assessment extends beyond the requirements of the DGRs and SA 2003 and in such a circumstance, all other nuisance related and "offensive noise" related publications are considered to be inherently met, rather than ignored.
5. Potential noise impacts have been discussed with involved landowners, and the results of the noise assessment were provided to landowners on request. Further, involved landowners were taken to an operational wind farm to in order to gain firsthand experience of noise impacts associated with a wind farm.

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

Infrasound and Low Frequency Noise

Concerns have been raised regarding the level of infrasound and low frequency noise produced by wind farms.

Early wind turbines were constructed with blades located downwind of the tower. These turbines produced significant levels of infrasound (sound below 20Hz) as a result of the wake caused by the tower. Modern wind turbines are constructed with blades upwind of the tower resulting in noise levels well below the level of audibility at residential setback distances. International studies have confirmed that the level and character of noise from modern wind turbines is not different to the noise encountered from other natural and non-natural noise sources.

Sonus has conducted studies into the level of infrasound produced by wind turbines. These studies confirm that the level of infrasound from wind turbines is no greater than naturally occurring levels of infrasound from sources such as waves breaking.

The results of these studies were presented at the fourth International Conference Wind Turbine Noise 2011 in Rome[2] and appeared as a peer reviewed paper in "Acoustics Australia", the journal of the Australian Acoustical Society[3].

A recent South Australian Government study by the Environment Protection Authority into infrasound (*Infrasound levels near windfarms and in other environments*, January 2013) provided findings which were consistent with a wide range of national and international peer reviewed studies, including:

- the measured levels of infrasound from wind farms are well below the threshold of perception; and
- the measured infrasound levels around wind farms are no higher than levels measured at other locations where people live, work and sleep; and
- the characteristics of noise produced by wind farms are not unique and are common in everyday life.

[2] Turnbull CP, Turner JP, "*Measurement of Infrasound from Wind Farms and Other Sources*" Fourth International Conference on Wind Turbine Noise Rome 11-14 April 2011
[3] Chris Turnbull, Jason Turner and Daniel Walsh "*Measurement and level of infrasound from wind farms and other sources*" Acoustics Australia Vol 40 No. 1 April 2012

It is for the above reasons that infrasound from wind farms is not required to be assessed in contemporary standards and guidelines used by Australian and International authorities.

In addition to the concerns relating to infrasound and low frequency, concerns are also raised regarding the following:

1. The proposal will cause serious harm to the health of some residents and there will be heart issues, headaches and short tempers;
2. Infrasound will go right through a lightweight house;
3. The background noise measurements should also include infrasound and low frequency noise;
4. The A-weighting scale is inadequate outside the range of hearing of the human ear;
5. There is no information on how the dB(C) levels were calculated.

A response to each item is provided below:

1. Much of the speculation regarding the potential health effects of the noise from wind farms is based on the assumption that the noise from wind turbines is unique and therefore has the potential to cause health effects which other noise sources cannot. Acoustic engineers are not qualified to express opinions about health impacts but the frequency content, character and level of noise from wind turbines, at typical setback distances to residences, is similar to the noise from many naturally occurring and man-made sources.

   Further, the following Government bodies have provided the following conclusions with respect to health impacts:

   National Health and Medical Research Council (NHMRC)

   > *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.*

   The NHMRC is currently conducting a study to supplement its previous review and conclusions.

Vic Health

The predominant sounds produced by wind farms are in the mid to high frequencies. Wind farm sound, including low levels of low frequency sound, may be audible to nearby residents.

Infrasound from wind farms is at levels well below the hearing threshold and is therefore inaudible to neighbouring residents. There is no evidence that sound which is at inaudible levels can have a physiological effect on the human body. This is the case for sound at any frequency, including infrasound.

WorkSafe Victoria:

WorkSafe Victoria has met with other government agencies regarding the possible health effects of wind energy facilities.

The Victorian Department of Health (DH) has examined both the peer-reviewed and validated scientific research and also looked at the health aspects of the current planning process.

The DH has determined that the weight of evidence indicates that there are no direct health effects from noise (audible and inaudible) at the levels generated by modern wind turbines. Numerous international reviews on low frequency and infrasound noise, and case studies of actual noise emissions, have demonstrated that:

- *There is insignificant infrasound generated from modern wind turbines; and*
- *Levels of low frequency sound emitted from modern wind turbines are not at a level that would lead to direct health effects.*

NSW Department of Environment and Climate Change

The World Health Organisation and Australian health authorities, including the NHMRC, have concluded that "there is no published scientific evidence to positively link wind turbines with adverse health effects".

2. The levels of infrasound in the vicinity of wind farms have been measured to be well below the level of audibility at residential setback distances. This will be the case both outside and inside a dwelling;
3. There is no specific requirement in the DGRs or the SA Guidelines to measure the existing (background) levels of infrasound or low frequency content for the reasons outlined in the general response above. However, any such measurements would indicate that the existing levels of infrasound and low frequency content generated by the ambient environment are regularly at or greater than the noise levels associated with a wind farm;
4. The human hearing range includes the frequencies associated with infrasound and low frequency content. Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics of different frequencies. The A-weighting network (dB(A)) is the most commonly used, and it is applied to simulate the human response for sound in the frequency range most applicable to the range of human hearing. The A-weighting network is used by the SA Guidelines.

The assessment has also considered the impacts of the wind farm using other weighting networks.

The C-weighting network is used to indicate the low frequency content. The predicted dB(C) noise levels from the wind farm are well below low frequency noise limits considered by the NSW authorities for recent development.

The G-weighting network has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range. A large range of measurements of infrasound noise emissions from modern upwind turbines indicates that at distances of 200 metres, infrasound is in the order of 25 dB below recognised thresholds of audibility. Infrasound also reduces in level when moving away from the source, and separation distances between wind farms and dwellings are well in excess of 200m for the Crudine Ridge Wind Farm.

5. The dB(C) noise levels have been calculated using the ISO 9613 noise propagation model (the model and its inputs are described further in the Noise Propagation Model section of this response).

   The Acciona AW77 turbine provides measured noise data down to 20 Hz. The availability of manufacturer's data down to such a low frequency is not common and is not available for the Siemens SWT2.3-101 turbine. Therefore, for the Siemens turbine, it is assumed that the energy in the lower frequencies is similar in relative terms to the AW77 turbine.

Authorship

A concern was expressed regarding the qualifications and experience of the persons conducting the assessment.

The Crudine Ridge Wind Farm environmental noise assessment was conducted by Chris Turnbull, Jason Turner and Moharis Kamis in various roles.

Chris Turnbull is a Principal and Director of Sonus Pty Ltd and has approximately 20 years experience as an acoustic engineer. This experience includes the assessment of noise from more than 30 wind farms.

Chris graduated with an Honours Degree in Mechanical Engineering and completed a Master of Engineering Science Degree in 1994. Both degrees concentrated on the field of acoustics and both were obtained from the University of Adelaide.

Chris formed Sonus in March 2002 having worked at Bassett Acoustics for seven years where he was an Associate and State Manager. This followed 5 years as an Acoustic Engineer with the Maritime Operations Division of the Defence Science and Technology Organisation (DSTO).

Chris recently presented a paper to the Wind Turbine Noise Conference held in Rome in April 2011, addressing the development of an infrasound measurement methodology and its associated results for two Australian wind farms

Jason Turner is an Associate of Sonus Pty Ltd and has approximately 15 years experience as an acoustic engineer. This experience includes the assessment of noise from many wind farms in both public and private sector roles.

Jason graduated with an Honours Degree in Mechanical Engineering in 1991. The degree concentrated on the field of acoustics and was obtained from the University of Adelaide.

Prior to joining Sonus in 2006, Jason spent 6 years with the South Australian Environment Protection Authority (EPA) managing the Atmosphere and Noise Branch as well as acting as the EPA's Principal Adviser in the field of Noise and Vehicle Emissions.

Whilst with the EPA, Jason initiated, drafted and implemented the SA Guidelines which have been adopted in a number of other states including NSW in the intervening period prior to release of the final version of NSW 2011. He also represented the National Environment Protection Council on the Australian Standards Technical Committee EV-016, which is responsible for developing the Australian Standard relating to wind farm noise assessment and measurement.

Jason managed a comprehensive review of wind farm noise for the Clean Energy Council and conducted an infrasound assessment at two wind farms for Pacific Hydro.

Jason managed the daily activities associated with the Crudine Ridge Wind Farm assessment including review of all project outputs.

Moharis Kamis joined Sonus in June 2009 after completing his mechanical engineering and applied mathematics degrees at the University of Adelaide.

Moharis is involved in all aspects of acoustic engineering within Sonus and has previously modelled environmental noise levels for a range of sources including compressor stations, LNG facilities, power stations and wind farms such as Stockyard Hill, Snowtown and Allendale wind farms.

Wind Shear Model

Further information has been sought in the submissions on the wind shear model.

The SA Guidelines specifies that the background noise data should be correlated with wind speeds at 10m above ground level (AGL).

Historically, such data have been collected from a wind mast with an anemometer located directly at 10m AGL.

A disadvantage of such an approach is that it might indicate lower wind speeds should high wind shear conditions occur at the site.

Therefore, for the Crudine Ridge Wind Farm assessment, the data analysis went beyond the requirements of the SA Guideline and used the two highest anemometer locations.

The wind shear for each 10 minute measurement period was calculated based on the methodology provided by the Australian Standard AS 4959-2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* using the power law wind profile model:

$$U = U_0 (h/h_0)^{\alpha}$$

Where U is the wind speed at height h, U_0 is the reference wind speed at reference height h_0, and α is the shear coefficient.

The value of α was estimated for each set of 10 minute average wind speeds using the results at the two measurement heights of the mast.

The wind speed at 10m AGL was then determined for each 10 minute data point using the formula above to include the influence of wind shear during the 10 minute measurement period.

Notwithstanding this approach, a hub height analysis has been conducted which considers the wind speed data referenced directly at an 80m hub height. The separate analysis is attached as part of the response documentation.

Sound Power Levels

Concerns have been raised with respect to the validity and use of the manufacturer's data in the assessment.

In order to predict the noise from a wind farm prior to its construction, it is necessary to determine the sound power level produced by the proposed turbines.

The sound power levels for a turbine are determined by the measurement of noise from the turbine in accordance with International Standard IEC 61400-11, "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques". The Standard requires determination of the sound power levels by measuring noise levels relatively close to an individual turbine so that the noise from other sources can be excluded. These tests are generally performed by manufacturers.

The final selection of the make and model of wind turbine for the Crudine Ridge Wind Farm will be determined following a competitive tender, should the proposal gain approval.

Therefore, at the planning stage of the project, the noise from the wind farm has been predicted based on the sound power level data from the manufacturers which include the following:

- Acciona AW77 :
    - warranted sound power levels for wind speeds between 3m/s and 12m/s; and,
    - octave band sound power level spectra for 8m/s and 9m/s, measured at 10m AGL.
- Siemens SWT2.3-101:
    - warranted sound power levels for wind speeds between 4m/s and 18m/s; and,
    - octave band sound power level spectra for 6m/s and 8m/s, referenced at 10m AGL.

It is common for a condition of project approval to require the noise assessment to be repeated when the final turbine model has been procured. Condition 2(a) of the recommended project conditions provided by the Environment Protection Authority (EPA) requires such an assessment.

As part of the contractual arrangement for the supply of turbines, a guarantee will need to be provided by the manufacturer that the wind turbines will achieve the overall sound power levels used in the final approved noise assessment.

In addition to the concerns relating to the manufacturers' data, concerns are also raised regarding the following:

1. There has been no consideration for wind speeds above the rated power of the turbines;
2. The 1/3 octave band data for the wind turbines should be provided when the final turbines are procured.

A response to each item is provided below:

1. Noise from wind farms has greatest potential for annoyance at lower wind speeds, not higher wind speeds. Data from manufacturers of modern wind turbines demonstrate that a maximum noise level is reached at or below rated power and then does not increase further. In addition, at higher wind speeds, the background noise environment also increases to provide a higher level of masking. This can be seen in the following typical background noise graph at the Crudine Ridge Wind Farm. Indeed, in recognition of the above, the SA Guidelines only requires predicted noise levels to be made up to wind speeds associated with the rated power of the turbine (Section 3.3).

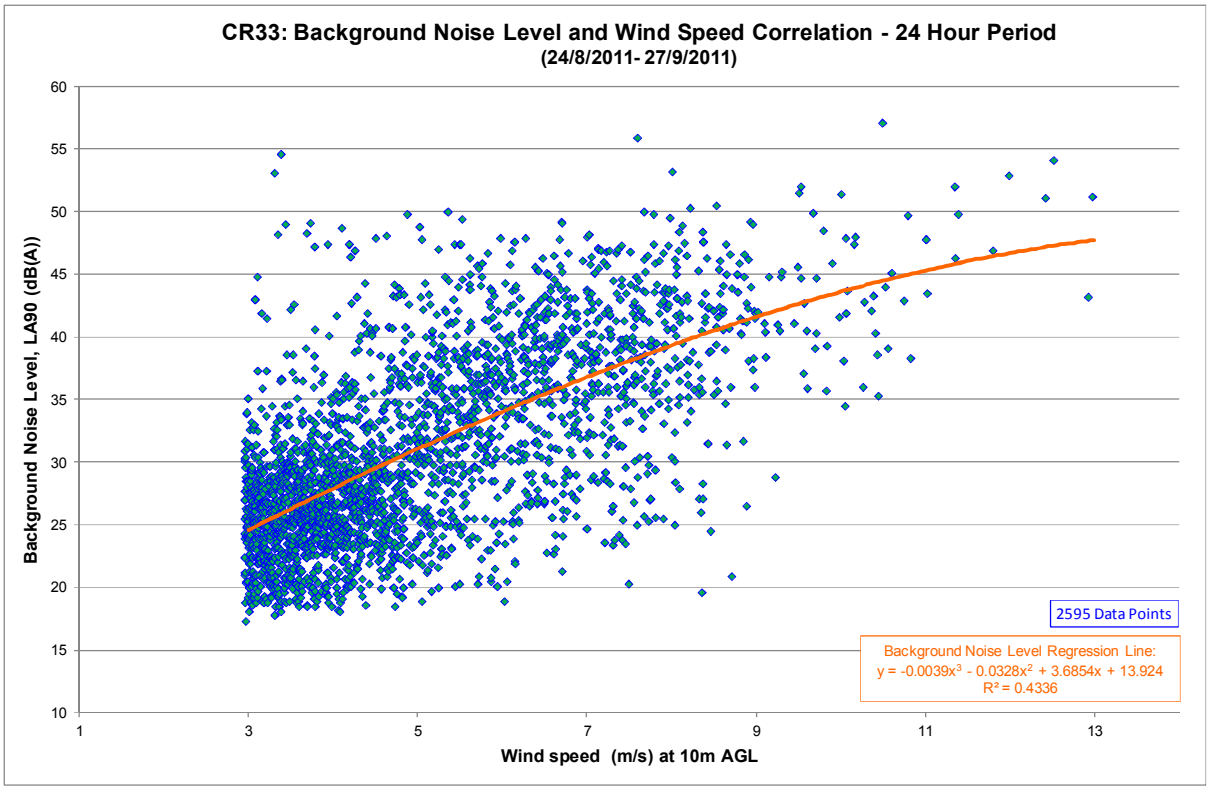

Figure 1: Background noise levels increasing with wind speed

2. As noted previously, the sound power levels for a turbine are determined by the measurement of noise from the turbine in accordance with International Standard IEC 61400-11, "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques". The standard does not require 1/3 octave band data to be collected and therefore such data is not always available for all turbines. The 1/3 octave band data would typically be used to identify the presence of tones from the turbine.

Varying Atmospheric Stability

Whilst the SA Guidelines specifies that the background noise data should be correlated with wind speeds at 10m above ground level (AGL), as discussed in the Wind Shear Model section of this response, the Crudine Ridge Wind Farm assessment uses the two highest anemometer locations to take account of varying atmospheric stability conditions.

The wind shear for each 10 minute measurement period is calculated from the two anemometer locations based on the methodology provided by the Australian Standard AS 4959-2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* using the power law wind profile model.

In addition to the concerns relating to varying atmospheric stability, concerns are also raised regarding the following:

1. The assessment does not account for worst case receivers by taking into account topography and/or meteorological conditions;
2. The assessment does not quantify the probability of occurrences of the Van Den Berg effect.

A response to each item is provided below:

1. Noise predictions were conducted using the propagation model, ISO 9613-2:1996 “Acoustics – Attenuation of sound during propagation outdoors” (ISO 9613) in the SoundPlan noise modelling software. This noise propagation model is widely accepted as an appropriate model for the assessment of wind farms when appropriate inputs are used (refer further information in the Noise Propagation Model section of this response);
2. The Van Den Berg effect is an increase of the modulation depth (“excessive” amplitude modulation) from a wind farm under very specific meteorological and operational conditions. Whilst the Van Den Berg effect has been observed on a flat site in Europe under specific conditions, it is not a common feature of operational wind farms.

   Notwithstanding the above, the assessment has been made with the actual wind shear conditions at the site taken into account, including during the night time period, and using a noise prediction model that is based on temperature inversion conditions for noise propagation.

Background Noise Regression

Further information has been requested with respect to the low correlation co-efficients for the background noise regression curves in Appendices E and F of the assessment.

The correlation co-efficient provided for each regression curve indicates the relationship between the background noise at the dwelling and the wind speed at the wind farm site.

A low correlation co-efficient indicates a limited relationship, as will naturally occur in many circumstances. For example, if the dwelling is in a location that is shielded from the winds across the wind farm site, then a low correlation co-efficient could be expected. A low correlation co-efficient is a measure of and subject to the natural environment and does not indicate any deficiency in the data analysis.

The Crudine Ridge Wind Farm assessment incorporates a detailed background noise measurement methodology and data analysis process which is the same for each noise monitoring location.

Wind Turbine Generator (WTG) Specification

Concerns have been raised that the final make and model of the WTG have not been provided and therefore, the impacts of the project cannot be assessed with certainty.

The final selection of the make and model of wind turbine for the Crudine Ridge Wind Farm will be determined following a competitive tender, should the proposal gain approval.

Therefore, at the planning stage of the project, the noise from the wind farm has been predicted based on manufacturer's sound power level data. The turbine models assessed were based on the likely "worst case" (highest noise level) turbine selection available to Wind Prospect CWP at the time of the assessment. The process included consideration of a number of potential turbines for the each layout and the subsequent selection of the turbines that would result in the highest noise level scenario for that layout.

It is common for a condition of project approval to require the noise assessment to be repeated when the final turbine model has been procured. Condition 2(a) of the recommended project conditions provided by the Environment Protection Authority (EPA) requires such an assessment.

As part of the contractual arrangement for the supply of turbines, a guarantee will need to be provided by the manufacturer that the wind turbines will achieve the overall sound power levels used in the final approved noise assessment.

Tonality

As is normally the case for environmental noise assessments at the planning stage of the project, the predictions have been conducted without a penalty for the presence of tonal characteristics.

To provide certainty, the assessment recommends that a guarantee is sought from the manufacturer as part of the procurement process. The general form of the guarantee should be that a penalty for tonality is not applicable at any residence when tested in accordance with an accepted methodology. Such a methodology may include that provided in the NSW Draft Guidelines or approved final version of those Guidelines.

Notwithstanding the guarantee, Condition 2(b) of the recommended project conditions provided by the Environment Protection Authority (EPA) requires compliance monitoring in accordance with the SA Guidelines. The SA Guidelines provide for a 5 dB(A) penalty to be applied should tonality be present.

Amplitude Modulation

Submissions request the application of a 5 dB(A) penalty for amplitude modulation in accordance with the SA Guidelines.

Amplitude modulation, or "swish", is an inherent noise characteristic associated with wind farms.

The SA Guidelines were developed with "swish" inherently taken into account (Section 4.5). That is, the onerous criteria of the SA Guidelines account for the presence of "swish".

Therefore, a 5 dB(A) penalty for "swish" from a properly maintained and operated wind farm is not required or applicable under the SA Guidelines.

Substations

Submissions request the provision of material to substantiate the use of the relevant standard.

The assessment considers the noise from the proposed substations at the wind farm against the New South Wales Environment Protection Authority's *Industrial Noise Policy 2000* (the INP) in accordance with the DGRs.

The final selection of the make and model of the substation plant and equipment for the Crudine Ridge Wind Farm will be determined following a competitive tender, should the proposal gain approval.

Therefore, at the planning stage of the project, the noise from the substations has been based on the Australian/New Zealand Standard AS/NZS60076.10:2009[4]. The standard provides the maximum noise levels for a transformer of a given capacity. The worst-case (i.e., highest predicted noise level) transformer selections for the potential collector substation arrangement have been used.

Noise from the main and secondary collector substations is predicted to be no greater than 12 dB(A) at any dwelling. This level is negligible and easily achieves the INP, due to the significant separation distances of greater than 3km between the stations and dwellings.

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[4] Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD).*

Rock crushing & concrete batching plant

Concerns were raised regarding noise from the rock crushing and concrete batching plants during construction.

The crushing plant will be addressed as part of the Construction Management Plan recommended as a condition of approval by the EPA. The crushing plant can only be specifically assessed when the need for, the location and the frequency of use are determined through the detailed construction planning phase of the project.

Noise Propagation Model

Concern has been raised that the inputs used in the noise propagation model will under-predict noise levels by 4 dB(A) and higher. The concerns refer to works conducted by Evans & Cooper[5].

Evans and Cooper conduct a comparison of a range of models and inputs against measured wind farm noise levels.

The noise from the Crudine Ridge Wind Farm has been predicted using the International Standard ISO9613[6] noise model. The ISO 9613 model is widely accepted as an appropriate noise propagation model for the assessment of wind farms when appropriate inputs are used. The assessment has been based on the following inputs:

- 10°C air temperature
- 70% relative humidity
- 50% acoustically hard ground and 50% acoustically soft ground
- Receiver height of 4m above ground
- Barrier attenuation of no greater than 2 dB(A)

These are considered the most appropriate inputs because they have been agreed by UK acoustic experts[7] in a joint paper.

The Evans and Cooper study does not consider the above inputs. It is the different inputs that provide the different results and therefore without a calculation based on the inputs used

5 Evans, T & Cooper, J, "Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms", Acoustics Australia, April 2012

6 International Standard ISO9613-2:1996, "Attenuation of sound during propagation outdoors - Part 2 General method of calculation"

7 Institute of Acoustics Vol 34 No 2 March/April 2009, "Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects"

in the assessment, a valid "apples for apples" comparison with the findings of the study cannot be made.

Wind speed measurements

Concerns have been raised regarding the applicability of the wind mast data to a large wind farm site.

The number and location of the wind masts used for the Crudine Ridge Wind Farm are consistent with other wind farm arrangements.

The southern wind mast, SOF2, is located at a similar location to the turbines nearest to dwelling CR34. Dwelling CR34 is the most important location with respect to compliance of the wind farm with the project criteria. Therefore, the southern wind mast provides a good indication of the wind speeds expected at the turbines that are closest to CR34.

SOF2 was commissioned on 7 August 2011, approximately halfway through the background noise monitoring period. Where wind data from SOF2 was not available, prior to this date, wind speed data from the northern mast, SOF1, was used instead for correlation with background noise data.

Although the two wind masts experience very similar wind regimes and a common distribution of wind speeds across direction, SOF1 generally measures higher wind speeds than SOF2 and this was the case during the second half of the background noise monitoring period. Using SOF1 wind data for dwellings closer to SOF2 provides an extra level of conservatism as background noise levels are correlated with higher wind speeds, and thus higher predicted turbine noise levels than what would be produced in reality.

In addition to the concerns relating to wind speed measurements, concerns are also raised regarding the following:

1. There is no documentation of the wind speeds and directions at the wind farm;
2. The use of data from the Mudgee Bureau of Meteorology site is unacceptable;
3. The extrapolation of weather data across the site from a weather logger located at dwelling HER07 is unacceptable.

A response to each item is provided below:

1. The SA Guidelines and the DGRs do not require the wind directions to be collated and documented as part of the environmental noise assessment. However, the wind data collected during the regime covered the range of wind speeds and directions generally expected at the wind farm. The wind speeds collected as part of the background noise monitoring regime are presented in the assessment. The SA Guidelines require the compliance checking procedure to be based on a downwind wind direction.
2. The local weather logger used for the removal of adverse data due to high local wind speeds or rain was damaged during the background noise monitoring regime and the available Bureau of Meteorology data was used as an alternative as documented in the assessment. The SA Guidelines and the DGRs do not require the use of a local weather logger for the identification and removal of adverse data. Notwithstanding this, an analysis of the data removal has been conducted. The rate of removal of high wind speed data is similar for both the local weather and BOM monitoring periods, even though the wind speeds at the wind farm (as identified by the mast) were generally lower during the BOM period. In addition, for any reported rain period, a full hour of data has been removed in lieu of a 10 minute period to ensure a conservative approach.
3. The SA Guidelines and the DGRs do not require the use of a local weather logger for the identification and removal of adverse background noise data. Notwithstanding this, a logger was located at HER07 to assist in determining the adverse data to be removed from the data set. A single weather logger for the Crudine Ridge Wind Farm is consistent with other wind farm arrangements, and HER07 is a relatively high point to provide a conservative indication of wind speed.

Equipment

Concerns have been raised about the type of background noise monitoring equipment (sound level meters) used at the Crudine Ridge Wind Farm site.

The important feature of a sound level meter used for wind farm background noise monitoring is a low “noise floor”.

The noise floor of a meter is the lowest noise level a meter can measure. The noise floor is established by the "internal" noise of the components within a given meter.

If the noise floor of a meter is too high, then the measured background noise levels can be artificially increased. As the project noise level criteria are related to the measured background noise levels, a high noise floor can therefore also artificially increase the project noise criteria.

The background noise was measured with Rion NL21 type 2 sound level meters, calibrated at the beginning and end of the measurement period with a Rion NC74 Calibrator. All microphones were fitted with 90mm weather proof windshields. The noise floor of the NL21 meters is less than 20 dB(A).

The SA Guidelines, NSW 2011 and other jurisdictional approaches such as the New Zealand and Australian Standard allow for the use of "Type 2" meters and therefore "Type 2" meters are the predominant meters used for background noise logging at potential wind farm sites.

Background noise monitoring

Concerns have been raised regarding the siting of the noise logging equipment.

Each noise logger was located in accordance with the SA Guidelines, which recommend a location on the wind farm side of the dwelling, at least 5m away from significant structures and generally within 20m of the dwelling.

The purpose of the logging is to determine the background noise environment at the dwelling and to provide a suitable location for future compliance checking. To this end, the loggers were also located:

1. at an equivalent distance from the facade of the dwelling as any significant trees;
2. at a location that minimised the influence of fixed noise sources such as air conditioning units.

Photographs of the noise monitoring equipment at each location are provided in Appendix D of the environmental noise assessment.

In addition to the concerns relating to noise logging locations, specific concerns were also raised regarding the noise loggers at dwellings SFR05 and HER07:

1. The results indicate the night time noise level is higher than during the day at high wind speeds;
2. Construction activity occurred during the day at SFR05, which might have affected the data and places further doubt on the validity of higher night time noise levels;
3. The equipment was not placed equidistant from the house to significant trees;
4. The equipment was adjacent to an old septic lid which could have generated higher noise levels;
5. The noise logger at HER07 was adjacent to where the car was parked and therefore might have recorded additional noise;
6. The cable to the noise logger was eaten by sheep and yet the data is still presented.

A response to each item is provided below:

1. The SA Guidelines and the DGRs do not require a night time period analysis. However, the assessment conducted such an analysis to provide a conservative approach and to align with NSW 2011, which separates the background noise levels into daytime and night-time periods. Separating the data can result in low data sets at certain wind speeds at night which in turn will affect the regression analysis. An example of what can result from a lower data set is shown by the higher background noise levels at night for SFR05. Notwithstanding this, a conservative approach has been taken whereby the most onerous criteria delivered by any period have been used, rather than just the criteria delivered by the methodology of the SA Guidelines and the DGRs;
2. The predicted noise levels at SFR05 or at any other dwelling that utilises the data from SFR05 do not exceed the base noise level of 35 dB(A) at any wind speed. This means that the background noise levels are not required to show compliance with the SA Guidelines and the DGRs at these dwellings. Notwithstanding this, the L_{A90} descriptor used in the background noise analysis is the noise level that is exceeded for 90% of the 10 minute measurement period, which inherently removes the influence of intermittent noise events from the data. For the avoidance of doubt, Wind Prospect CWP has committed to additional noise monitoring at SFR05. The noise logger was placed at SFR05 in a similar position to the original logging location on the 6th of June, 2013;
3. The noise logging equipment at SFR05 was located at a similar location to the original logging location. Both locations are equidistant from the house to significant trees;
4. Refer to Response Item 2 above with respect to intermittent noise events;
5. Refer to Response Item 2 above with respect to intermittent noise events;
6. The cable to the weather station at HER07 was damaged by sheep. The noise logger at HER07 was not damaged and the data is presented as measured in the assessment.

Noise speaker demonstration at SFR05

One submission raised the concern about the noise demonstration during which the noise speaker at SFR05 could be so clearly heard when this site recorded high background noise levels.

The simulation used a local speaker at SFR05 to generate noise levels representative of the wind farm at rated power. The purpose of the simulation was to assist in understanding the noise levels in SA 2003.

At the time of the simulation, the wind speeds at the wind farm site and at SFR05 were low and below a typical “cut in” speed for turbines. That is, the turbines are unlikely to have been turning in such conditions.

Therefore, listening to a simulation of a wind farm at rated power in an environment when the wind farm is unlikely to operate is conservative and why it could be clearly heard. In practice, the simulated noise level at rated power would only be generated at higher wind speeds, when the background noise levels will also be higher. Higher background noise levels increase masking and reduce the ability for the wind farm to be heard.

This effect and the resulting conservatism were discussed during the simulation.

Data analysis

Concerns have been raised regarding the background noise data analysis.

The analysis was conducted in accordance with the SA Guidelines, which requires the collection of a minimum of 2000 data points. The minimum 2000 data points are not established for segregation into different periods. Data that are below the typical cut-in speed of a wind turbine can be removed as the wind farm will not be operating during these periods.

In addition to the concerns relating to data analysis, specific concerns were also raised that night time noise levels at dwellings SFR05 and HER07 were significantly higher than what would normally be recorded in rural areas and markedly higher than the results from non-associated receivers.

The results at SFR05 and HER07 are not significantly different to other results across the Crudine Ridge Wind Farm and at other similar wind farm sites.

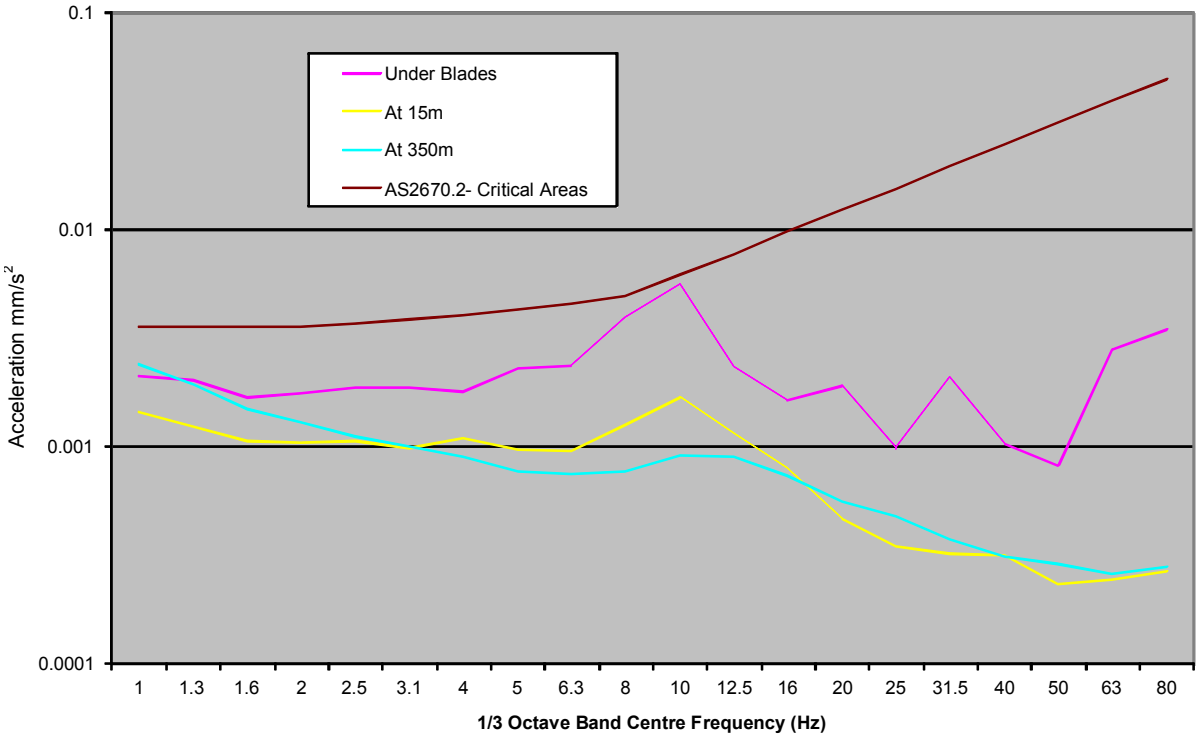
Notwithstanding this, for the avoidance of doubt, Wind Prospect CWP has committed to additional noise monitoring at SFR05.

Vibration

Modern wind farms produce very low levels of ground vibration. Sonus engineers have measured the ground vibration at the base of a turbine of the Challicum Hills Wind Farm and at various distances from the turbine.

The graph below compares the measured level of vibration against the recommendation of Australian Standard AS2670.2 for “critical areas” such as operating theatres. The graph indicates that the level of vibration directly below the turbine, at 15m and at 350m was below the recommendation for “critical areas”. At residential distances, the ground vibration from wind turbines would be undetectable.

Comparison of Measured Vibration with AS2670.2



Environment Protection Authority – Recommended Project Approval Conditions

21 March 2013

Condition 2(e) of the EPA recommended conditions of project approval in the correspondence of 21 March 2013 establishes the project criteria.

Condition 2(e) refers to hub height wind speeds. However, the Sonus report uses the 10m height in accordance with the SA Guidelines.

The project criteria using a hub-height reference have been determined and are summarised in attached documentation.

Should the hub-height reference be retained, then it is recommended the condition is reviewed to align with the revised project criteria in the attached hub height analysis.

In addition, the definition of the measurement location and the measurement method do not align with the SA Guidelines.

To ensure consistency with the SA Guidelines, it is recommended the first line of the condition is modified as follows:

"Noise generated at the premises must not exceed the noise limits in the table below" **when measured in accordance with the Environmental Noise Guidelines: Wind Farms (SA EPA 2003).**

Further references in the condition to the measurement location and the $L_{Aeq(10\ minute)}$ could then be removed and avoid the current conflict with the SA Guidelines.

Environment Protection Authority – Recommended Project Approval Conditions

16 August 2013

The EPA correspondence dated 16 August 2013 provides 3 recommended conditions and retention of "all other conditions previously recommended by the EPA".

Based on the EPA correspondence of 21 March 2013 and 16 August 2013 the following conditions therefore apply:

Condition Reference	Document	Content	Comments
2(a)	EPA 21 March 2013	Requirement to conduct a revised environmental noise assessment following selection of the final turbine model and layout	Noted
2(b)	EPA 21 March 2013	Requirement to prepare a Noise Management Plan including identification and rectification of annoying characteristics such as tonality.	Noted
2(c)	EPA 21 March 2013	Restriction of construction hours	Acceptance of some out of hours activity acknowledged in EPA correspondence of 16 August 2013. However, Condition 2(c) not updated.
2(d)	EPA 21 March 2013	Requirement to prepare a Construction Noise Management Plan	Noted

2(e)	EPA 21 March 2013	Noise limit conditions	Understood to be replaced by Condition L6.1 in EPA correspondence of 16 August 2013.
L6.1	EPA 16 August 2013	Noise limit conditions	Establishes more onerous requirements than the DGRs, SA 2003 and the hub height analysis. Modification recommended.
L6.2	EPA 16 August 2013	Wind speed measurements	Noted
L6.6	EPA 16 August 2013	Tonality	Establishes more onerous requirements than the DGRs and SA 2003. Modification recommended.

Condition 2(c)

Recommendation:

Modify Condition 2(c) to the following or similar:

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

- *works that do not cause noise emissions to be audible at any nearby residences not located on the site; or*
- *the delivery of materials as requested by Police or other authorities for safety reasons; or*

- *emergency work to avoid the loss of lives, property, and/or to prevent environmental harm.*

If any other works are required outside of the specified hours, they will only be carried out with the prior consent of relevant New South Wales authority.

Condition L6.1

Condition L6.1 can be interpreted to require any 10 minute measurement to achieve the noise limits provided in the table rather than the averaging process over 2000 data points required under the SA 2003 methodology.

Recommendation:

To ensure consistency with the SA Guidelines, it is recommended the first line of the condition is modified as follows:

"Noise generated at the premises must not exceed the noise limits in the table below" ***when measured in accordance with the Environmental Noise Guidelines: Wind Farms (SA EPA 2003).***

Condition L6.1

Condition L6.1 establishes criteria at "any other residential receiver not subject to a negotiated agreement" as 35 dB(A) at all wind speeds.

These criteria are more onerous than the DGRs and SA 2003 and will be difficult to measure and confirm in practice.

Recommendation:

Replace the table in L6.1 with the criteria table developed within Appendix C of the Sonus report S3736C7 July 2013 (the hub height analysis).

The following table, repeated from S3737C7, can be inserted into Condition L6.1 to provide consistency with the approach of the Environmental Noise Guidelines: Wind Farms (SA 2003), with the exception that a hub height wind speed is used (refer discussion above):

Residence ID	Criteria (dB(A)) by Hub Height (80m) Wind Speed (m/s)													
	3	4	5	6	7	8	9	10	11	12	13	14	15	16
APR02	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR03	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR04	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR05	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR06	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR07	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR08	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR09	35	35	35	35	35	36	38	39	41	42	44	46	48	48
APR10	35	35	35	35	35	36	38	39	41	42	44	46	48	48
CR10	45	45	45	45	45	45	45	45	45	45	45	46	48	48
CR12	45	45	45	45	45	45	45	45	45	45	45	46	48	48
CR13	45	45	45	45	45	45	45	45	45	45	45	46	48	48
CR14	45	45	45	45	45	45	45	45	45	45	45	46	48	48
CR15	35	35	35	35	35	36	38	39	41	42	44	46	48	48
CR16	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR18	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR19	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR20	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR21	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR24	35	35	35	35	35	35	36	37	38	40	42	44	47	47
CR25	45	45	45	45	45	45	45	45	45	45	45	45	45	45
CR26	35	35	35	35	35	35	35	35	36	38	41	43	45	45

Residence ID	Criteria (dB(A)) by Hub Height (80m) Wind Speed (m/s)													
	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CR27	35	35	35	35	35	35	35	35	36	38	41	43	45	45
CR28	35	35	35	35	35	35	35	35	36	38	41	43	45	45
CR32	35	35	35	35	35	35	37	40	42	45	47	50	52	55
CR33	35	35	35	35	35	35	37	40	42	45	47	50	52	55
CR34	35	35	35	35	35	35	37	40	42	45	47	50	52	55
CR35	35	35	35	35	35	35	37	40	42	45	47	50	52	55
CR36	35	35	35	35	35	35	37	40	42	45	47	50	52	55
CR37	35	35	35	35	35	35	35	36	38	39	40	41	41	41
HER02	45	45	45	45	45	45	45	45	45	45	45	45	45	45
HER03	35	35	35	35	35	35	35	36	38	39	40	41	41	41
HER04	35	35	35	35	35	35	35	36	38	39	40	41	41	41
HER06	45	45	45	45	45	45	45	45	45	46	46	46	46	46
HER07	45	45	45	45	45	45	45	45	45	46	46	46	46	46
HER08	45	45	45	45	45	45	45	45	45	46	46	46	46	46
HER10	35	35	35	35	37	39	41	43	45	46	46	46	46	46
HER11	35	35	35	35	37	39	41	43	45	46	46	46	46	46
HER12	45	45	45	45	45	45	45	45	45	46	46	46	46	46
HER13	35	35	35	35	37	39	41	43	45	46	46	46	46	46
PL01	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PL02	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PL03	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PL04	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PR01	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PR03	35	35	35	35	35	37	39	41	43	44	46	46	46	46

Residence ID	Criteria (dB(A)) by Hub Height (80m) Wind Speed (m/s)													
	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PR04	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PR05	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PR06	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PR07	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PR09	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PR10	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PR11	35	35	35	35	35	37	39	41	43	44	46	46	46	46
PR12	45	45	45	45	45	45	45	45	45	45	46	46	46	46
PR13	45	45	45	45	45	45	45	45	45	45	46	46	46	46
SFR01	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR04	45	45	45	45	45	45	45	45	45	45	46	46	46	46
SFR05	45	45	45	45	45	45	45	45	45	45	46	46	46	46
SFR06	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR07	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR08	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR09	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR10	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR11	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR12	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR13	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR16	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR17	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR18	35	35	35	35	35	37	39	41	43	44	46	46	46	46
SFR19	35	35	35	35	35	37	39	41	43	44	46	46	46	46

Residence ID	Criteria (dB(A)) by Hub Height (80m) Wind Speed (m/s)													
	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TR01	35	35	35	35	35	35	35	36	38	39	40	41	41	41
TR02	35	35	35	35	35	35	35	36	38	39	40	41	41	41
TR03	35	35	35	35	35	35	35	36	38	39	40	41	41	41
TR05	35	35	35	35	35	35	35	36	38	39	40	41	41	41
TR06	35	35	35	35	35	35	35	36	38	39	40	41	41	41

Condition L6.6

Condition L6.6 does not allow a penalty for tonality to occur at a dwelling.

The DGRs and SA 2003 require a 5 dB(A) penalty to be added to the wind farm's measured noise levels where tonality is present.

Therefore, in requiring that the wind farm "must not attract a penalty", Condition L6.6 establishes a requirement which is more onerous than the DGRs and SA 2003.

Recommendation:

Remove condition L6.6 as the modified condition L6.1 (refer above) will require the addition of a 5 dB(A) penalty for the presence of tonality.

Alternatively, modify Condition L6.6 from:

For the purposes of condition L6.1, noise generated at the premises must not attract a penalty for tonal noise emissions when measured in accordance with a method acceptable to the EPA.

To:

For the purposes of condition L6.1, a 5 dB(A) penalty must be added to the wind farm noise at the premises where tonal noise emissions from the wind farm are measured at the premises in accordance with a method which is consistent with the NSW Draft Guidelines or final approved version thereof.

Conditions L6.3 to L6.5 inclusive

Conditions L6.3 to L6.5 have not been provided and might be the subject of separate correspondence. Conditions L6.3, 6.4 and 6.5 might also correlate with Conditions 2(a), 2(b) and 2(d) from the EPA correspondence of 21 March 2013.

The conditions should be reviewed to take into account these proposed changes and a full list provided to enable consideration against the requirements of the DGRs and SA 2003