MARSHALL DAY Acoustics

RANGOON WIND FARM
PRELIMINARY NOISE ASSESSMENT

Rp 002 20200251 | 30 June 2020

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EXECUTIVE SUMMARY

A preliminary assessment of operational noise for the proposed Rangoon Wind Farm project has been carried out. The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

The preliminary noise assessment has been carried out on the basis of the current project design comprising twenty-five (25) multi-megawatt turbines and associated ancillary infrastructure, including an on-site substation and battery storage system located within the wind farm site.

Noise modelling was carried out on the basis of a candidate turbine model which has been nominated by EPS and is typical of the size and type of turbines which are being considered for the site.

The results of the modelling demonstrate that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin. Once the Secretary's Environmental Assessment Requirements (SEARs) are released for this project, further detailed assessment will be undertaken. This would include background noise monitoring, revised modelling and, if required, layout refinements to demonstrate how compliance would be achieved for the specific noise matters defined by the SEARs for the project.

Cumulative noise levels associated with operation of the White Rock Stage 2 Wind Farm (under construction) to the north-west of the Rangoon Wind Farm project site has also been considered in this assessment. An assessment of the predicted noise levels for each wind farm has demonstrated that cumulative wind farms noise levels do not affect the compliance outcomes for any of the assessed projects.

The assessment has also considered operational noise associated with the transformers and battery storage systems to be located on the site. Noise levels from this ancillary infrastructure have been assessed in accordance with the NSW EPA's *Noise Policy for Industry*, dated October 2017. The assessment demonstrates that the ancillary infrastructure is expected to result in noise levels significantly lower than the noise criteria.

Further noise modelling and assessment work is to be undertaken to support a subsequent development application for the Rangoon Wind Farm project. This is expected to included background noise monitoring at key receiver locations around the site, and assessment of other noise considerations including special noise characteristics, construction and ancillary infrastructure.

TABLE OF CONTENTS

1.0 INTRODUCTION

Environmental Property Services (EPS), on behalf of Meridian Energy Australia Pty Ltd (MEA), is proposing to develop a wind farm known as Rangoon Wind Farm approximately 40 km south of the township of Glen Innes in New South Wales.

This report presents the results of a preliminary noise assessment prepared for submission with a Scoping Report and a Secretary's Environmental Assessment Requirements (SEARs) request.

The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

The preliminary noise assessment is based on:

- The minimum (base) operational noise limit determined in accordance the NSW Noise Assessment Bulletin;
- Preliminary noise modelling for the project based on the current proposed site layout and a candidate turbine model that is representative of the size and type of turbine being considered for the site;
- A comparison of the predicted noise levels with the base noise limit; and
- An assessment of cumulative effects for the proposed Rangoon Wind Farm and one (1) other wind farm project in the broader surrounding area.

Noise associated with operation of the ancillary infrastructure located within the site has also been assessed in accordance with the NSW EPA's *Noise Policy for Industry*, dated October 2017.

Other noise considerations relating to the project would be assessed during the development application stage of the project. This would include the noise of construction, along with any other specific noise matters defined by the SEARs for the project.

Acoustic terminology used in this report is presented in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Overview

The proposed Rangoon Wind Farm is located in northern NSW, approximately 40 km south of the township of Glen Innes. The project comprises two parts, Rangoon Wind Farm South (RWF South) and Rangoon Wind Farm North (RWF North). The sites are separated by approximately 3.5 km boundary to boundary. Each site includes a wind farm component and associated infrastructure such as substations and a battery energy storage facility.

The current project design comprises a total of twenty-five (25) wind turbines. RWF South will include four (4) turbines over an area of 1,000 ha and RWF North site will include twenty-one (21) turbines over an area of 5,000 ha. The coordinates of the wind turbines are presented in tabular and graphical format in Appendix B.

A total of sixty-six (66) noise sensitive receivers within 3 km[1] of the project have been identified by EPS and considered in this preliminary noise assessment. This includes fourteen (14) receivers where a noise agreement is proposed between the landowners and MEA, which are referred to as associated receivers herein.

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the turbine layout and receiver locations is provided in Appendix D.

2.2 Candidate wind turbine model

The turbine model(s) to be assessed in detail as part of the development application will be determined from ongoing project design development. Further, if the project was ultimately approved, the final wind turbine model would only be selected after a tender process to procure the supply of turbines. The final selection would be made on account of a range of design requirements including achieving compliance with relevant noise limits at surrounding noise sensitive receiver locations.

Accordingly, to assess the proposed development at this stage in the project, it is necessary to consider a representative candidate turbine model for the size and type of turbines being considered. The purpose of the candidate turbine is to inform a preliminary assessment of operational noise, accounting for the base noise limit and noise emission levels that are typical of the size of turbines being considered for the development. While a leading turbine manufacturer's data has been relied on for the assessment, the turbine make and model has not been specified at this stage for commercial reasons.

The candidate turbine is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis).

[1] The 3 km distance is a nominal distance commonly referenced on account of being significantly greater than the separation distance required to achieve compliance with the lowest possible noise limit of 35 dB L_{Aeq}.

Details of the candidate wind turbine model are provided in Table 1.

Table 1: Candidate wind turbine model details

Item	Detail
Rated power	5.6 MW
Rotor diameter	162 m
Modelled hub height	169 m
Modelled tip height	250 m
Operating mode	Standard
Serrated trailing edge	Yes

If a wind turbine model with different specifications is considered due to technology updates or other constraints through the preparation of the Environmental Impact Statement (EIS), the noise assessment would need to be revised to reflect the changes.

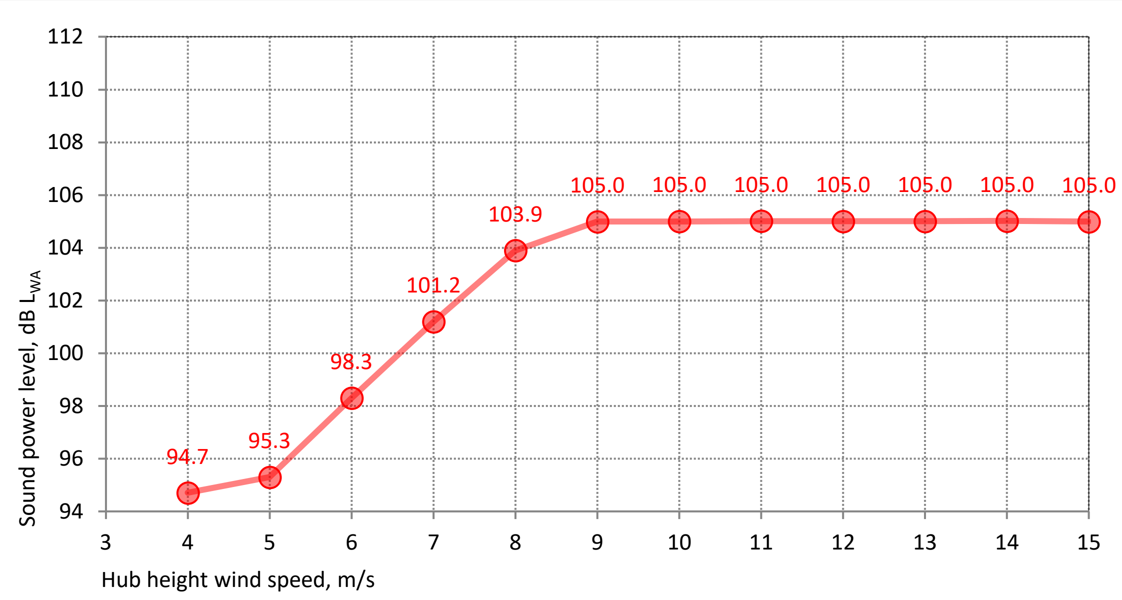
2.3 Wind turbine noise emissions

The noise emissions of wind turbines are described in terms of the sound power level for different wind speeds at the hub height. The sound *power* level is a measure of the total sound energy produced by each turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the turbine.

Sound power level data for the candidate turbine model were sourced from the manufacturer's specification document provided by EPS at the time of reporting. The sound power data provided in the document has been adjusted by the addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The sound power levels referenced in this assessment, including the +1.0 dB adjustment, are illustrated in Figure 1. The overall level represents the total noise emission of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans and internal transformer).

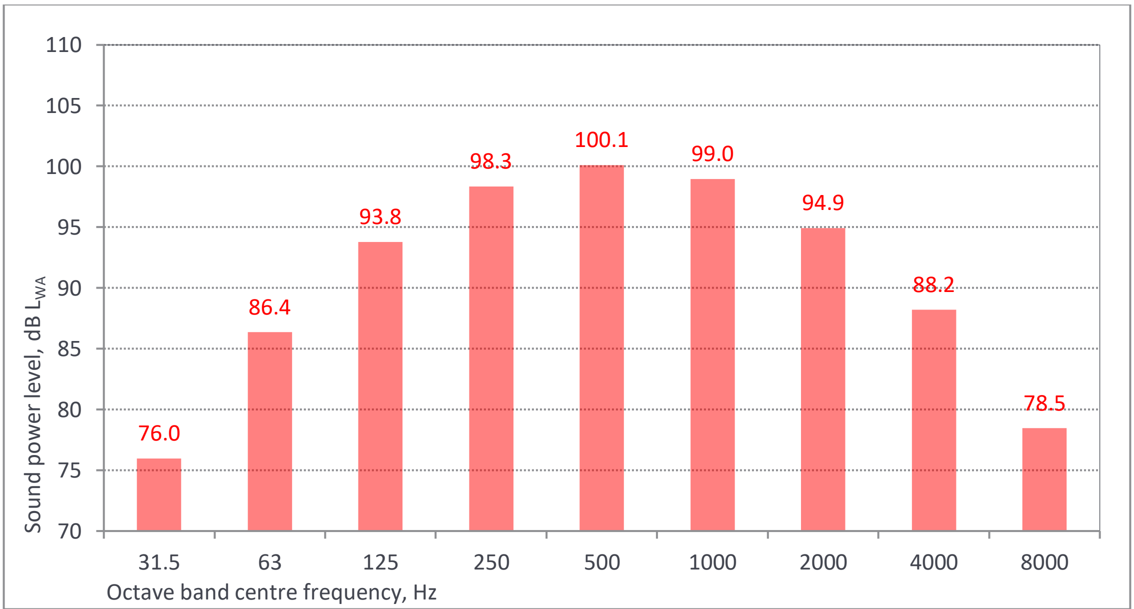
Figure 1: Turbine assessment sound power levels (including +1dB for test uncertainty), dB L_{WA}



The sound power levels in Figure 1 are considered typical of the range of noise emissions associated with comparable multi-megawatt wind turbines. The data is therefore considered appropriate to reference in this preliminary assessment as a representation of the apparent sound power levels of the turbines when tested and rated in accordance with International Electrotechnical Commission publication IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques* (IEC 61400-11).

The sound frequency characteristics of the turbines were sourced from the manufacturer's specification document provided by EPS at the time of reporting. The reference spectrum used as the basis for this assessment is illustrated Figure 2 and corresponds to the highest overall sound power level illustrated in Figure 1.

Figure 2: Turbine assessment sound power level spectrum (including +1dB for test uncertainty), dB L_{WA}



The manufacturer specification for the candidate turbine model does not provide information about tonality.

The occurrence of tonality in the noise of contemporary multi-megawatt turbine designs is generally limited. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receiver locations is atypical. On this basis, adjustments for tonality have not been applied to the predicted noise levels presented in this preliminary assessment. Notwithstanding this, the subject of tonality would be addressed in subsequent assessment stages for the project. As part of this, further information will need to be obtained from the manufacturer concerning tonality.

The other special noise characteristic which is assessable in accordance with the NSW Noise Assessment Bulletin is low frequency noise. While there is a prescribed criterion for the application of low frequency noise penalty adjustments in the NSW Noise Assessment Bulletin (based on C-weighted noise levels), there is no established or verified engineering prediction method of C-weighted noise levels associated with the operation of wind turbines. For the purposes of this report, a risk assessment approach has been adopted using a simplified prediction method to estimate the C-weighted noise levels. Details of the study have been provided in Appendix I. The risk assessment indicates calculated low frequency noise levels below the applicable thresholds for the application of penalties. It is noted that the margin between the predicted levels and the most stringent threshold is of a comparable magnitude to the uncertainty associated with C-weighted predictions.

On the basis of the above, adjustments for special noise characteristics referred to in the NSW Noise Assessment Bulletin have not been applied to the predicted noise levels presented in this assessment. However, assessment of these special noise characteristics would need to be carried out as part of the post-construction compliance assessment.

3.0 ASSESSMENT CRITERIA

3.1 Operational wind farm noise criteria

3.1.1 Non-associated receivers

The NSW Department of Planning and Environment publication *Wind Energy: Noise Assessment Bulletin* dated December 2016 (the NSW Noise Assessment Bulletin) provides guidance on how noise impacts are to be assessed for large-scale wind energy development projects that are State significant development.

The NSW Noise Assessment Bulletin states that the South Australian EPA publication *Wind farms environmental noise guidelines* dated July 2009 (the SA EPA Guideline) is to be used as the relevant assessment standard, subject to a set of variations that apply to the assessment of NSW projects. The variations are defined for:

- noise limits
- special noise characteristics
- noise monitoring.

In relation to noise limits, the variation defined in the NSW Noise Assessment Bulletin sets the base criterion at a value of 35 dB for all projects, in lieu of the 35 to 40 dB base criterion range defined in the SA EPA Guideline. The criteria in the NSW Noise Assessment Bulletin are subsequently defined as follows:

> *The predicted equivalent noise level ($L_{Aeq,10\ minute}$)*, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed 35 dB(A) or the background noise ($L_{A90(10\ minute)}$) by more than 5 dB(A), whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.*
>
> ** Determined in accordance with SA 2009, Section 4.*

Variations are also defined in the NSW Noise Assessment Bulletin for the assessment of special noise characteristics. These procedures will be referenced in subsequent detailed assessment phases for the project.

The NSW Noise Assessment Bulletin notes the following in relation to the types of receiver locations where the noise limits apply:

> *The criteria in this Bulletin have been developed to address potential noise impacts on the amenity of residents and other relevant receivers in the vicinity of a proposed wind energy project. Wind energy proponents commonly negotiate agreements with private land owners where applicable noise limits may not be achievable at relevant receiver locations. A negotiated agreement will be considered as part of the assessment of a wind energy project, as will the requirements of SA 2009 and this Bulletin. The proponent's EIS should clearly identify the expected noise levels at all receiver locations including host properties to ensure that affected persons are appropriately informed regarding the development proposal.*

3.1.2 Associated (Participating) receivers

The assessment criteria detailed in the previous section apply to all noise sensitive receiver locations that are not associated with the proposed project (e.g. by way of land ownership or a negotiated agreement). However, in accordance with the requirements of the NSW Noise Assessment Bulletin, predicted noise levels are also presented for participating receiver locations, comprising host properties and receivers where a noise agreement is in place.

Notwithstanding the above, a reference level of 45 dB L_{Aeq} is presented as a base criterion for participating receivers in order to provide context to the predicted noise levels for these locations. This is consistent with the SA EPA Guideline which recommends a level of 45 dB for *financial stakeholders*. Comparisons between the predicted noise levels and the 45 dB reference level are provided for informative purposes only. Noise levels at these locations will ultimately need to be managed in accordance with the commercial agreements established between the proponent and the landowners.

3.2 Ancillary infrastructure noise criteria

Operational noise associated with the ancillary infrastructure (substation transformers, battery energy storage system) must be assessed in accordance with the NSW EPA's *Noise Policy for Industry*[2] (NPfI). The NPfI sets out a framework for the derivation of noise criteria referred to as Project Noise Trigger Levels. The Project Noise Trigger Levels are used to assess the potential impacts of noise from industry and indicate the noise level at which feasible and reasonable noise management measures should be considered.

For the purposes of this scoping assessment, a conservative approach has been adopted that uses the most stringent noise level criteria, as outlined in Table 2.1 of the NPfI. Under this approach, noise generated by the operation of all ancillary infrastructure must not exceed 35 dB $L_{Aeq, 15\ minute}$.

2 NSW Environment Protection Authority *Noise Policy for Industry* dated October 2017

4.0 ASSESSMENT METHOD

Operational wind farm noise levels are predicted using:

- Noise emission data for the wind turbines;
- A 3D digital model of the site and the surrounding environment; and
- International standards used for the calculation of environmental sound propagation.

At this preliminary stage of assessment, the primary consideration is potential A-weighted noise levels associated with operation of the project. The assessment of special noise characteristics during the subsequent development application stages of the project will involve additional predictions, including further C-weighted noise levels associated with operation of the project.

The method selected to predict A-weighted noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by SA EPA Guideline and has been shown to provide a reliable method of predicting the typical upper A-weighted levels of the noise expected to occur in practice from wind farm developments.

The ISO 9613-2 method is used in conjunction with a set of input choices and procedural modifications that are specific to wind farm noise assessment, based on international research and guidance.

The noise prediction method is summarised in Table 2 with further discussion of the method and the calculation choices is provided in Appendix F.

Table 2: Downwind prediction methodology

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN noise modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix F.
Source characterisation	Each wind turbine is modelled as a point source of sound. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each. Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine. Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine. Further discussion of terrain screening effects is provided below.
Terrain data	Elevation contours in 10 m resolution provided by EPS.

Detail	Description
Terrain effects	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F. • Valley effects: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground was flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. The project is located in a hilly area characterised by significant variations in ground elevation between the turbines and surrounding receivers. These terrain characteristics were sufficient to result in the application of adjustments to the predicted noise levels. Specifically, based on comparison of predicted noise levels with and without terrain elevation data included indicates adjustments for terrain effects typically equated to ±3 dB. For reference purposes, the ground elevations at the turbine and receiver locations are tabled in Appendix B and Appendix C respectively. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK good practice guide and research outlined in Appendix F. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 °C and relative humidity 80 % These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance and the SA EPA Guideline. The calculations are based on sound speed profiles[3] which increase the propagation of sound from each turbine to each receiver location, whether as a result of thermal inversions or wind directed toward each calculation point. The primary consideration for wind farm noise assessment is wind speed and direction. The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every wind turbine at the site. Other wind directions in which part or the entire wind farm is upwind of the receiver will result in lower noise levels. In some cases, it is not physically possible for a receiver to be simultaneously downwind of each turbine and the approach is therefore conservative in these instances.
Receiver heights	1.5 m above ground level This is a deviation from UK Institute of Acoustics guidance. However, the modelling also does not include the 2 dB subtraction recommended by the UK Institute of Acoustics guidance. This approach has been shown to be valid for predicting noise level of wind farms expected to be measured using the L_{A90} parameter (as per the NSW Noise Assessment Bulletin).

3 The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

5.0 WIND TURBINE NOISE ASSESSMENT

5.1 Preliminary predicted noise levels

This section of the report presents the preliminary predicted A-weighted noise levels of Rangoon Wind Farm at surrounding receiver locations, and an assessment of compliance with the base noise limit.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

The receiver locations where operational wind farm noise levels are predicted to be higher than 30 dB L_{Aeq} are listed in Table 3 for non-associated receivers and Table 4 for associated receivers. The predicted noise levels are for conditions when the wind farm's noise emissions have reached their highest level (corresponding to hub height wind speeds of 9 m/s and above) and the wind is directed from the wind farm to each receiver location. The predicted noise levels presented include the +1 dB allowance to account for turbine sound power level measurement uncertainty, as described in Section 2.3 above.

The value of 30 dB is referenced here for informative purposes. The minimum noise limit applicable to the wind farm at non-associated receivers is 35 dB L_{Aeq}.

Predicted noise levels for each integer wind speed are tabulated in Appendix G for all considered receiver locations, including dwellings where the highest predicted noise level is below 30 dB L_{Aeq}.

Table 3: Highest predicted noise level at non-associated receivers with predicted levels over 30 dB L_{Aeq}

Receiver	dB L_{Aeq} *	Distance to the nearest turbine, m	Below the base criterion
104	30.1	1,357	Yes
105	34.1	1,205	Yes
107	30.2	1,574	Yes
109	30.9	1,991	Yes
110	30.8	1,480	Yes
111	33.5	1,414	Yes
201	30.9	1,555	Yes
208	32.3	1,217	Yes
232	32.3	1,204	Yes

* Includes +1 dB allowance to account for turbine sound power level measurement uncertainty

It can be seen from Table 3 that the predicted noise levels from the proposed Rangoon Wind Farm are below the NSW Noise Assessment Bulletin base criterion of 35 dB L_{Aeq} at all of assessed non-associated receiver locations.

The above findings support that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin.

Information relating to associated receiver locations is provided in Table 4.

Table 4: Highest predicted noise level at associated receivers with predicted levels over 30 dB L_{Aeq}

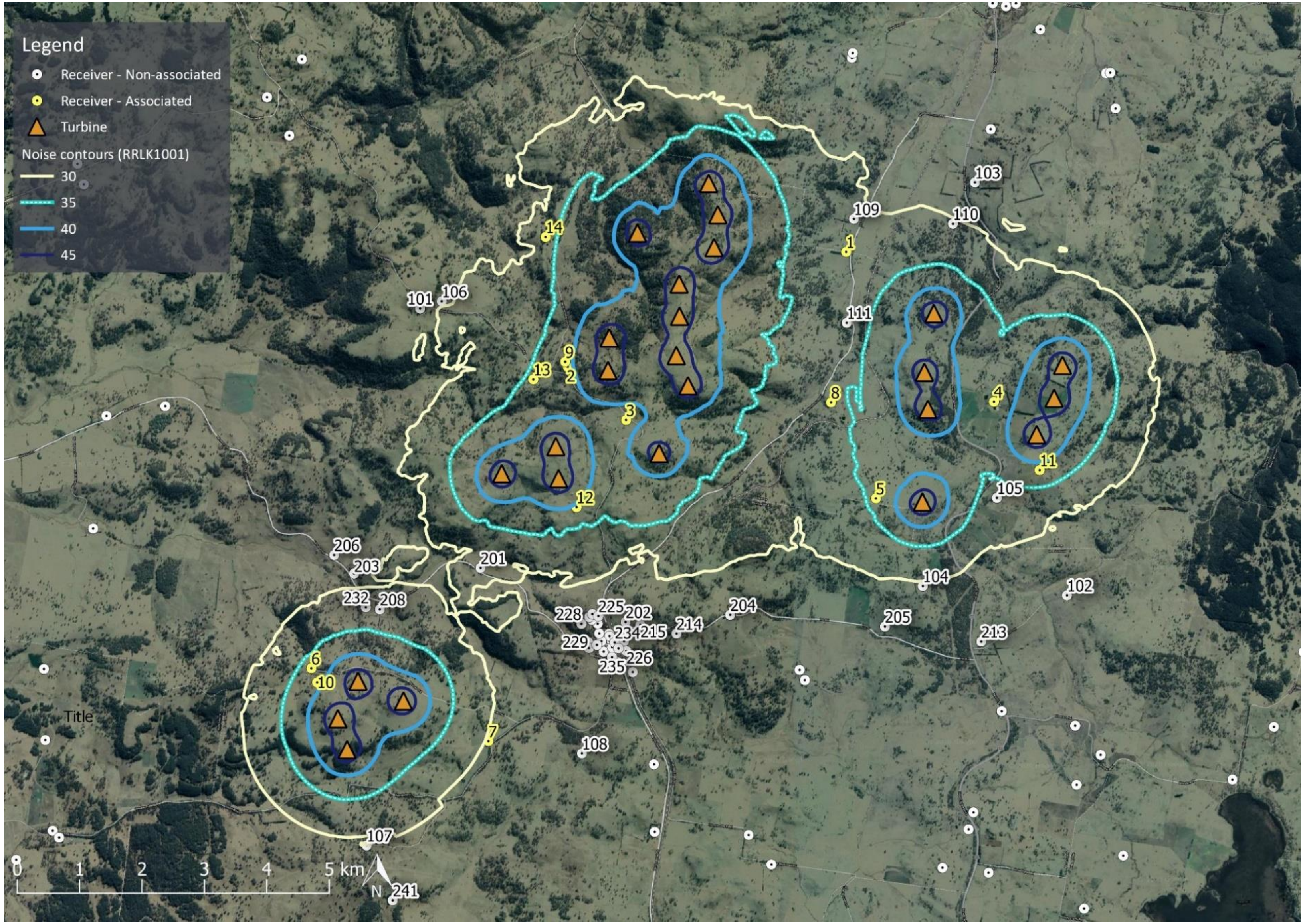
Receiver	dB L_{Aeq} *	Distance to the nearest turbine, m	Comparison to the 45 dB reference level
1	32.1	1,726	Yes
2	39.1	668	Yes
3	39.3	771	Yes
4	38.1	880	Yes
5	36.4	765	Yes
6	36.8	796	Yes
7	30.1	1,514	Yes
8	34.0	1,564	Yes
9	38.8	720	Yes
10	39.0	678	Yes
11	38.2	592	Yes
12	39.3	565	Yes
13	35.7	1,149	Yes
14	33.8	1,482	Yes

* Includes +1 dB allowance to account for turbine sound power level measurement uncertainty

It can be seen from Table 4 that the predicted noise levels from the proposed Rangoon Wind Farm are below the reference level for all associated receivers.

The location of the total predicted 30 dB, 35 dB, 40 dB, and 45 dB L_{Aeq} noise contours is illustrated in Figure 3.

Figure 3: Highest predicted noise level contours (corresponding to hub-height wind speeds of 12 m/s or greater)



5.2 Cumulative wind farm noise levels

Based on information provided by EPS, one (1) wind farm has been identified in the broader area around the proposed Rangoon Wind Farm for the review of potential cumulative noise considerations.

The White Rock Wind Farm is located approximately 7 km north-west of the proposed Rangoon Wind Farm:

- Stage 1 of the project consists of seventy (70) turbines with a tip height of up to 150 m and is fully operational
- Stage 2 of the project consists of forty-eight (48) wind turbines with a tip height of up to 200 m and is currently under construction.

Details of the White Rock Wind Farm are presented in in Table 5.

Table 5: Wind farm development in the broader area around the proposed Rangoon Wind Farm

Wind farm name	Status	Approximate distance to nearest turbine
WRWF Stage 1	Operational	9.2 km to the north-west
WRWF Stage 2	Under construction	7.5 km to the north-west

A site plan showing the location of these projects is provided in Figure H1 of Appendix H.

In relation to other wind farm developments, the NSW Noise Assessment Bulletin does not make specific recommendations concerning cumulative noise. The SA EPA Guidelines do however refer to cumulative noise, noting that the criteria have been specified to allow for other potential development, and that any noise criteria which are set relative to background noise levels should not include the influence of other wind farms. While neither document explicitly states a requirement to assess the combined noise levels of multiple wind farm projects, nor do they define criteria which directly applies to cumulative noise, an assessment of cumulative noise from the project and the neighbouring WRWF is provided herein.

For the purposes of this assessment, cumulative noise has only been considered in detail for turbines associated with the WRWF Stage 2. The reason for this is that the Stage 2 turbines are closest to the Rangoon Wind Farm and will therefore have a greater contribution to cumulative noise compared to the more distant Stage 1 turbines. Furthermore, there is insufficient publicly available information (in particular turbine sound power level data) regarding Stage 1 and so it would not been possible to accurately predict noise from those turbines.

The acoustic report[4] submitted with the planning modification application indicates that the noise assessment was based on a Goldwind GW140-3.57MW turbine with a hub height of 130 m. The sound power level data for the GW140-3.57MW was sourced from Section 4.2.2 of the Sonus Report.

Predicted noise levels from the WRWF Stage 2 do not exceed 20 dB L_{Aeq} at any of the assessed receiver locations in the vicinity of the Rangoon Wind Farm. The noise contribution from the WRWF Stage 2, being at least 15 dB below the base noise of 35 dB L_{Aeq} applicable to non-stakeholder receivers, is sufficiently low and therefore inconsequential to the noise assessment for the Rangoon Wind Farm, even if it is conservatively assumed that there is an equal contribution from the WRWF Stage 1. A site plan showing the location of the 20 dB contours for each wind farm is provided in Figure H2 of Appendix H.

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4 Sonus report S4646C10 *White Rock Wind Farm Stage 2 - Environmental Noise Assessment* dated January 2018 (Sonus Report) web link

6.0 ANCILLARY INFRASTRUCTURE NOISE ASSESSMENT

Ancillary infrastructure associated with the development of a wind farm includes power transmission networks, electrical substations, and battery energy storage system components. Two separate electrical substations are proposed to be developed as part of the project, one within the RWF South site and one within the RWF North site. The battery energy storage system (BESS) will be co-located with the substation at the RWF North site.

The wind farm is proposed to be connected to existing power transmission infrastructure that passes through the wind farm site layout. The new connections to the network will also occur within the wind farm site as follows:

- For RWF South, the connection will be to the existing TransGrid 66 kV Guyra to Glen Innes transmission line
- For RWF North, the connection will be to the existing TransGrid 132 kV Armidale to Glen Innes transmission line.

Accordingly, the proposed wind farm will not introduce any new power transmission lines in the vicinity of noise sensitive receptor locations. Further consideration of noise associated with power transmission infrastructure is therefore not required.

The approximate coordinates used for the assessment of ancillary infrastructure noise are detailed in Table 6.

Table 6: Approximate ancillary infrastructure coordinates (GDA94 Zone 56)

Area	Easting (m)	Northing (m)
RWF North substation/BESS	369,583	6,676,897
RWF South substation	377,979	6,680,446

The nearest receiver location to the RWF North substation/BESS is receiver 011 at a distance of approximately 700 m. The nearest receiver location to the RWF South substation/BESS is receiver 108 at a distance of approximately 750 m.

Specific details of transformer selections are yet to be made, however noise emissions associated with this type of electrical plant are commonly in the range of 95-100 dB L_{Aw}. Similarly, BESS equipment details are not known at this stage however total equipment noise levels from other similar projects is within the range of 95-100 dB L_{Aw}.

While the specific equipment selections would not be finalised until the detailed design phase of the project, the typical emission ranges and separating distances are sufficient to determine that operational noise levels associated with transformers and BESS equipment would be below 30 dB externally at surrounding residential receptors.

The noise of the ancillary electrical infrastructure is therefore expected to be below the most stringent noise level criteria, as outlined in the NPfI, even accounting for any adjustments (if applicable at the receptor) for the potential tonal characteristics associated with transformers.

7.0 DETAILED ASSESSMENT PHASE

A detailed assessment of a NSW wind farm development involves addressing a number of environmental noise considerations detailed in the project specific SEARs. For example, the document titled *Standard Secretary's Environmental Assessment Requirements* dated September 2016 notes that an EIS must address:

- Operational wind turbine noise
- Ancillary infrastructure noise
- Construction noise
- Construction traffic noise
- Construction vibration.

Environmental noise considerations relating to construction and ancillary infrastructure would be addressed at the development application phase of the assessment, once the project specific SEARs have been released.

Further detailed assessment work will involve background noise monitoring at key receiver locations to determine the applicable criteria in accordance with the NSW Noise Assessment Bulletin. The results of any background noise monitoring would be documented in the noise assessment report prepared to accompany the development application for the Rangoon Wind Farm project.

The NSW Noise Assessment Bulletin specifies additional criteria relating to *special characteristics*, defined as tonality and low frequency. While tonality cannot be readily predicted, in relation to low frequency noise, the bulletin states that:

> *Noise assessments for proposed wind energy projects shall assess the potential for non-associated residential receiver locations to experience low frequency noise levels exceeding 60 dB(C).*

Low frequency noise characteristics are highly specific to the turbine being considered, and its assessment can involve detailed modelling using alternative procedures to those used for A-weighted noise levels. In accordance with the NSW Noise Assessment Bulletin, this modelling data is to be provided as part of an application to develop a wind farm. Accordingly, this modelling is to be undertaken and reported at the development application phase of the assessment.

8.0 SUMMARY

A preliminary assessment of operational noise for the proposed Rangoon Wind Farm has been carried out. The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

The preliminary noise assessment has been carried out on the basis of the current project design comprising twenty-five (25) multi-megawatt turbines and associated ancillary infrastructure, including an on-site substation and battery storage system located within the wind farm site.

Noise modelling was carried out on the basis of a candidate turbine model which has been nominated by EPS and is typical of the size and type of turbines which are being considered for the site. While a leading turbine manufacturer's data has been relied on for the assessment, the turbine make and model has not been specified at this stage for commercial reasons.

The results of the modelling demonstrate that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin. Once the Secretary's Environmental Assessment Requirements (SEARs) are released for this project, further detailed assessment will be undertaken. This would include background noise monitoring, revised modelling and, if required, layout refinements to demonstrate how compliance would be achieved for the specific noise matters defined by the SEARs for the project.

Cumulative noise levels associated with operation of the consented White Rock Wind Farm to the north-west of the proposed Rangoon Wind Farm site has also been considered in this assessment. The modelling demonstrates that the cumulative influence of each project is not sufficient to change whether the total predicted wind farm noise level is above the 35 dB L_{Aeq} base criterion which applies to each project. Based on an assessment of predicted noise levels for each wind farm, it has been demonstrated that cumulative wind farm noise considerations are not applicable to the Rangoon Wind Farm.

The assessment of associated ancillary electrical infrastructure found that noise levels are expected to be below the most stringent criteria defined in the NSW EPA's *Noise Policy for Industry*, even accounting for any adjustments for the potential tonal characteristics associated with the equipment.

Further noise modelling and assessment works are to be undertaken to support a subsequent development application for the Rangoon Wind Farm. This is expected to included background noise monitoring at key receiver locations around the site, and further assessment of other noise considerations including special noise characteristics, construction and ancillary infrastructure.

APPENDIX A GLOSSARY OF TERMINOLOGY

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*.

Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report.

For example, sound pressure levels measured using an "A" frequency weighting are expressed as L_A dB. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion above this table.
C- weighting	A method of adjusting sound levels to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).	-
A-weighted 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted equivalent level	The A-weighted equivalent continuous pressure level.	L_{Aeq}
C-weighted equivalent level	The C-weighted equivalent continuous pressure level.	L_{Ceq}
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Low frequency	A sound with perceptible content in the audible frequency range typically below 200 Hz	-
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special characteristics	A term used by the NSW Noise Assessment Bulletin to define sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics are tonality and low frequency.	-
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the current proposed turbine layout supplied by EPS.

Table 7: Turbine coordinates – MGA 94 zone 56

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
MELRNG1	372,218	6,685,574	1,410
MELRNG2	372,365	6,685,073	1,420
MELRNG3	372,305	6,684,548	1,430
MELRNG4	371,076	6,684,781	1,420
MELRNG5	371,746	6,683,962	1,430
MELRNG6	371,752	6,683,446	1,420
MELRNG7	370,625	6,683,100	1,450
MELRNG8	370,606	6,682,578	1,450
MELRNG9	371,700	6,682,818	1,466
MELRNG10	371,887	6,682,334	1,490
MELRNG11	371,425	6,681,250	1,460
MELRNG12	369,815	6,680,847	1,400
MELRNG13	369,770	6,681,360	1,408
MELRNG14	368,902	6,680,925	1,400
MELRNG15	375,827	6,683,491	1,322
MELRNG16	375,675	6,682,550	1,407
MELRNG17	375,731	6,681,957	1,384
MELRNG18	377,890	6,682,662	1,340
MELRNG19	377,755	6,682,134	1,358
MELRNG20	377,475	6,681,550	1,400
MELRNG21	375,644	6,680,473	1,400
MELW1	366,600	6,677,600	1,360
MELW2	366,275	6,677,000	1,380
MELW3	367,327	6,677,284	1,359
MELW4	366,423	6,676,505	1,320

APPENDIX C RECEIVER LOCATIONS

The following table sets out the sixty-six (66) noise sensitive receivers located within 3 km of the proposed project and considered in the preliminary noise assessment, together with their respective distance to the nearest turbine.

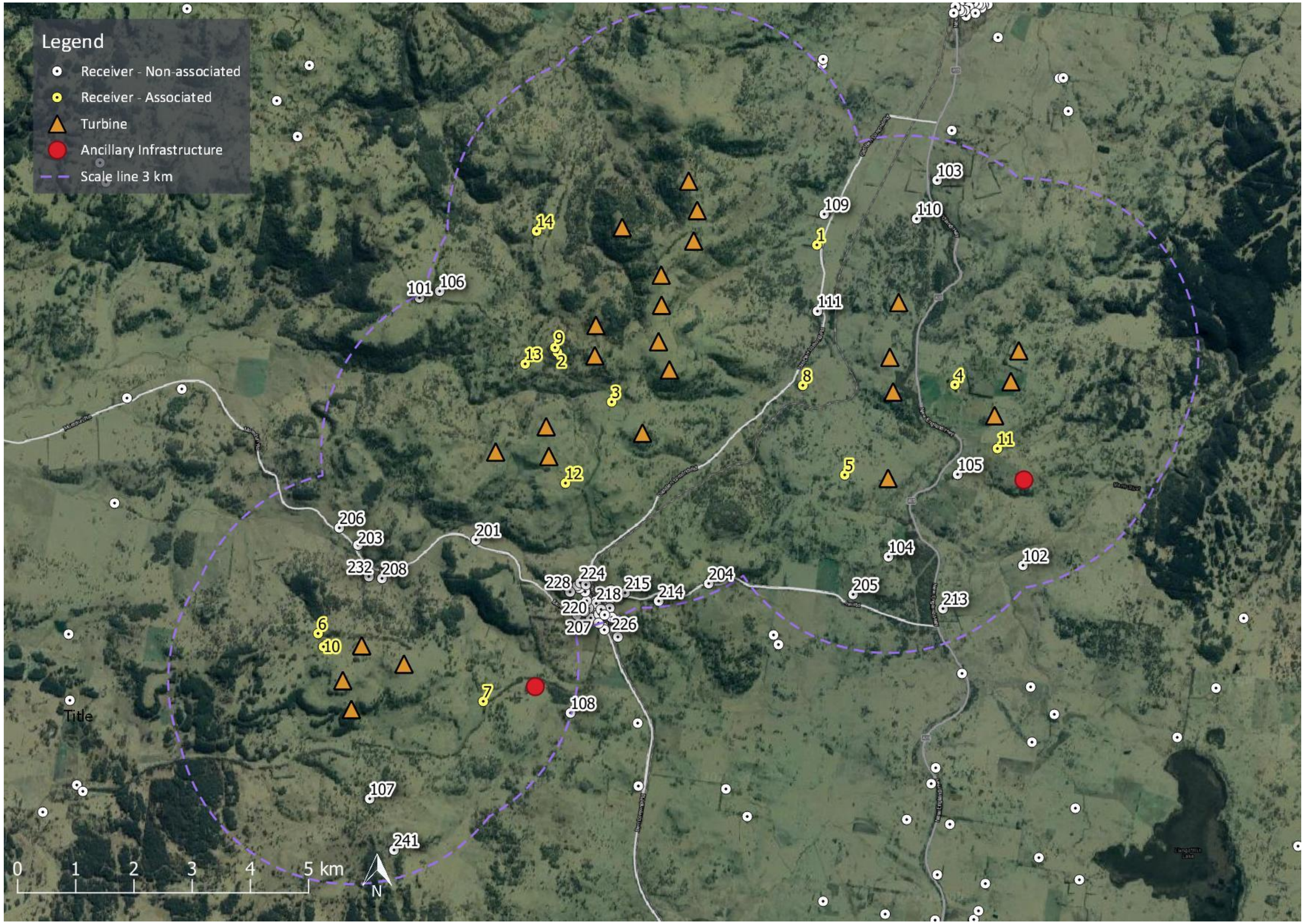
Table 8: Receiver locations – MGA 94 zone 56

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
Non-associated receivers				
101	367,594	6,683,572	1397	2,958
102	377,962	6,678,978	1300	2,623
103	376,487	6,685,591	1210	2,307
104	375,651	6,679,126	1363	1,357
105	376,839	6,680,540	1377	1,206
106	367,939	6,683,686	1386	2,754
107	366,738	6,674,972	1288	1,574
108	370,188	6,676,445	1359	2,986
109	374,547	6,685,008	1181	2,163
110	376,134	6,684,929	1205	1,594
111	374,431	6,683,343	1203	1,485
201	368,563	6,679,416	1258	1,556
202	370,886	6,678,552	1368	2,539
203	366,536	6,679,327	1203	1,737
204	372,563	6,678,666	1420	2,829
205	375,044	6,678,479	1410	2,089
206	366,216	6,679,623	1205	2,066
207	370,536	6,678,075	1360	2,869
208	366,949	6,678,754	1219	1,218
210	370,623	6,678,362	1358	2,619
211	370,869	6,678,396	1364	2,673
213	376,588	6,678,236	1342	2,434
214	371,703	6,678,365	1415	2,903
215	371,125	6,678,507	1375	2,687
216	370,862	6,678,244	1363	2,811
217	370,635	6,678,283	1360	2,697
218	370,630	6,678,324	1359	2,657
219	370,500	6,678,243	1351	2,698

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
220	370,464	6,678,368	1352	2,569
221	370,440	6,678,525	1357	2,411
222	370,343	6,678,587	1357	2,327
223	370,304	6,678,631	1360	2,276
224	370,354	6,678,679	1362	2,241
225	370,452	6,678,647	1361	2,296
226	370,899	6,678,085	1363	2,972
227	370,689	6,678,106	1360	2,882
228	370,180	6,678,522	1353	2,360
229	370,287	6,678,228	1346	2,667
230	370,299	6,678,132	1351	2,763
231	370,427	6,678,182	1354	2,740
232	366,724	6,678,786	1216	1,204
233	370,674	6,678,144	1360	2,841
234	370,713	6,678,222	1360	2,780
235	370,670	6,677,986	1360	2,991
238	370,774	6,678,128	1360	2,888
241	367,156	6,674,091	1333	2,529
Associated receivers				
1	374,422	6,684,480	1185	1,891
2	369,962	6,682,640	1406	669
3	370,895	6,681,785	1397	772
4	376,792	6,682,079	1335	880
5	374,900	6,680,532	1400	766
6	365,851	6,677,808	1313	796
7	368,689	6,676,644	1350	1,514
8	374,180	6,682,069	1236	1,580
9	369,920	6,682,719	1412	721
10	365,943	6,677,582	1323	679
11	377,523	6,680,984	1390	593
12	370,102	6,680,391	1416	566
13	369,409	6,682,438	1380	1,139
14	369,605	6,684,718	1356	1,483

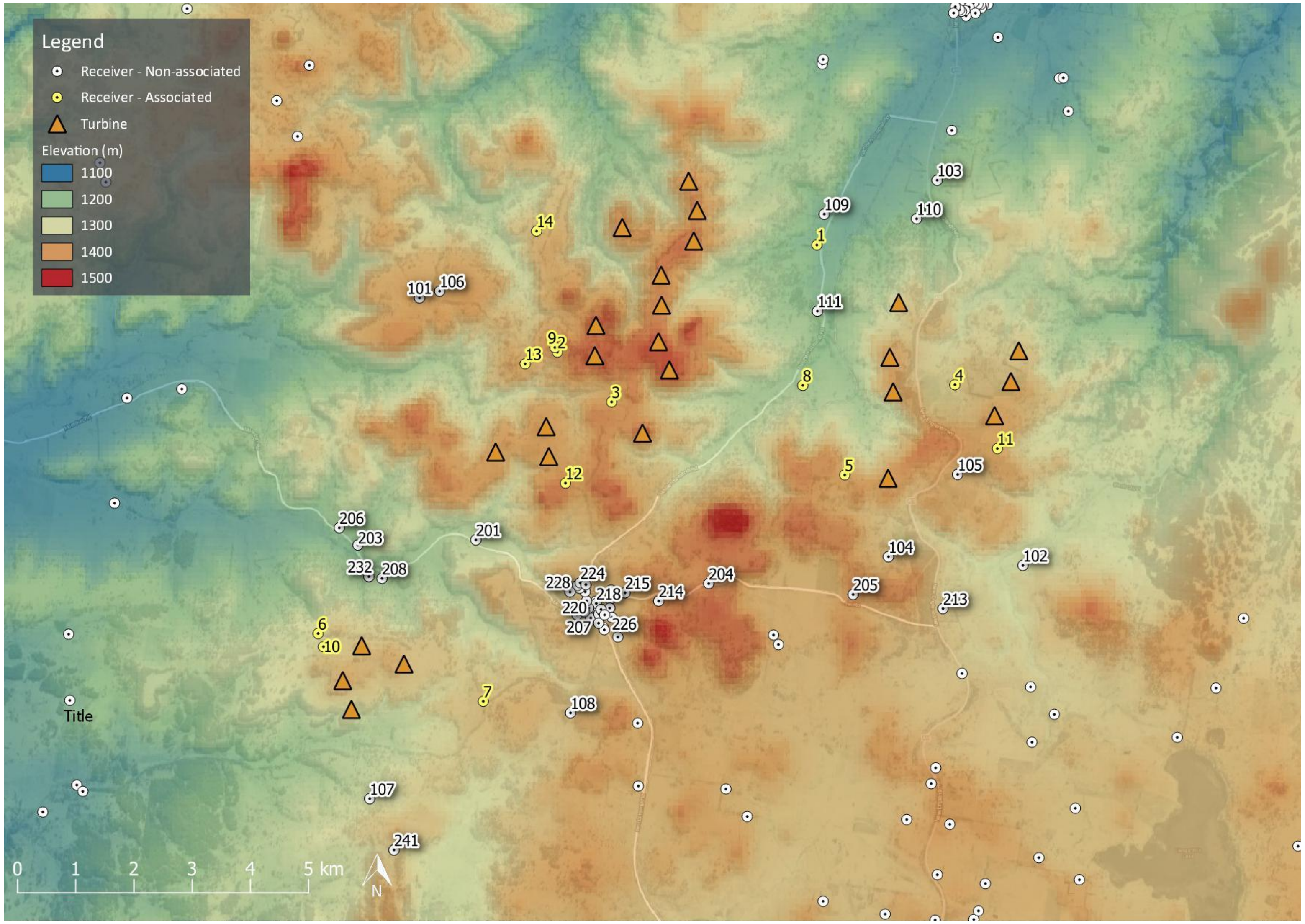
APPENDIX D SITE LAYOUT PLAN

Figure 4: Proposed turbine locations, associated ancillary infrastructure and sensitive receiver locations



APPENDIX E SITE TOPOGRAPHY

Figure 5: Terrain elevation map for the Rangoon Wind Farm project and surrounding area



APPENDIX F NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods.

The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2) has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered to be the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in the South Australian EPA publication *Wind farms environmental noise guidelines*, NZS 6808:2010 *Acoustics – Wind farm noise* and AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators.*

The standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of ±45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion. In this respect, it is noted that at the wind speeds relevant to noise emissions from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to the ISO 9613-2, the noise emissions of each turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence
- Air absorption
- Reflecting obstacles
- Screening
- Vegetation
- Ground reflections.

The octave band attenuation factors are then applied to the noise emission data to determine the corresponding octave band and total calculated noise level at receiver locations.

Calculating the attenuation factors for each effect requires a relevant description of the environment into which the sound propagation such as the physical dimensions of the environment, atmospheric conditions and the characteristics of the ground between the source and the receiver.

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 ^{o}C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613-2 and the choice of G = 0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613-2 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (UK Institute of Acoustics guidance). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methodologies.

A range of measurement and prediction studies[5, 6, 7] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613 method to predict the propagation of wind turbine noise for:

- the types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30 m maximum source heights considered in the original ISO 9613-2;
- the types of environments in which wind farms are typically developed, and the range of atmospheric conditions and wind speeds typically observed around wind farm sites. Importantly, this supports the extended scope of application to wind speeds in excess of 5 m/s.

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5 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

6 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

7 Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

In addition to the choice of ground factor referred to above, adjustments to the ISO 9613-2 standard for screening and valleys effects are applied on the basis of recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK IOA Good Practice Guide. The following adjustments are applied to the calculations:

- screening effects as a result of terrain are limited to 2 dB
- screening effects are assessed on the basis of each turbine being represented by a single noise source located at the maximum tip height of the turbine rotor
- an adjustment of 3 dB is added to the predicted noise contribution of a turbine if the terrain between the turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50 % greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLAN 8.2 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each turbine and receiver pairing, and then subsequently applies the adjustments to each turbine's predicted noise contribution where appropriate.

APPENDIX G TABULATED PREDICTED NOISE LEVEL DATA

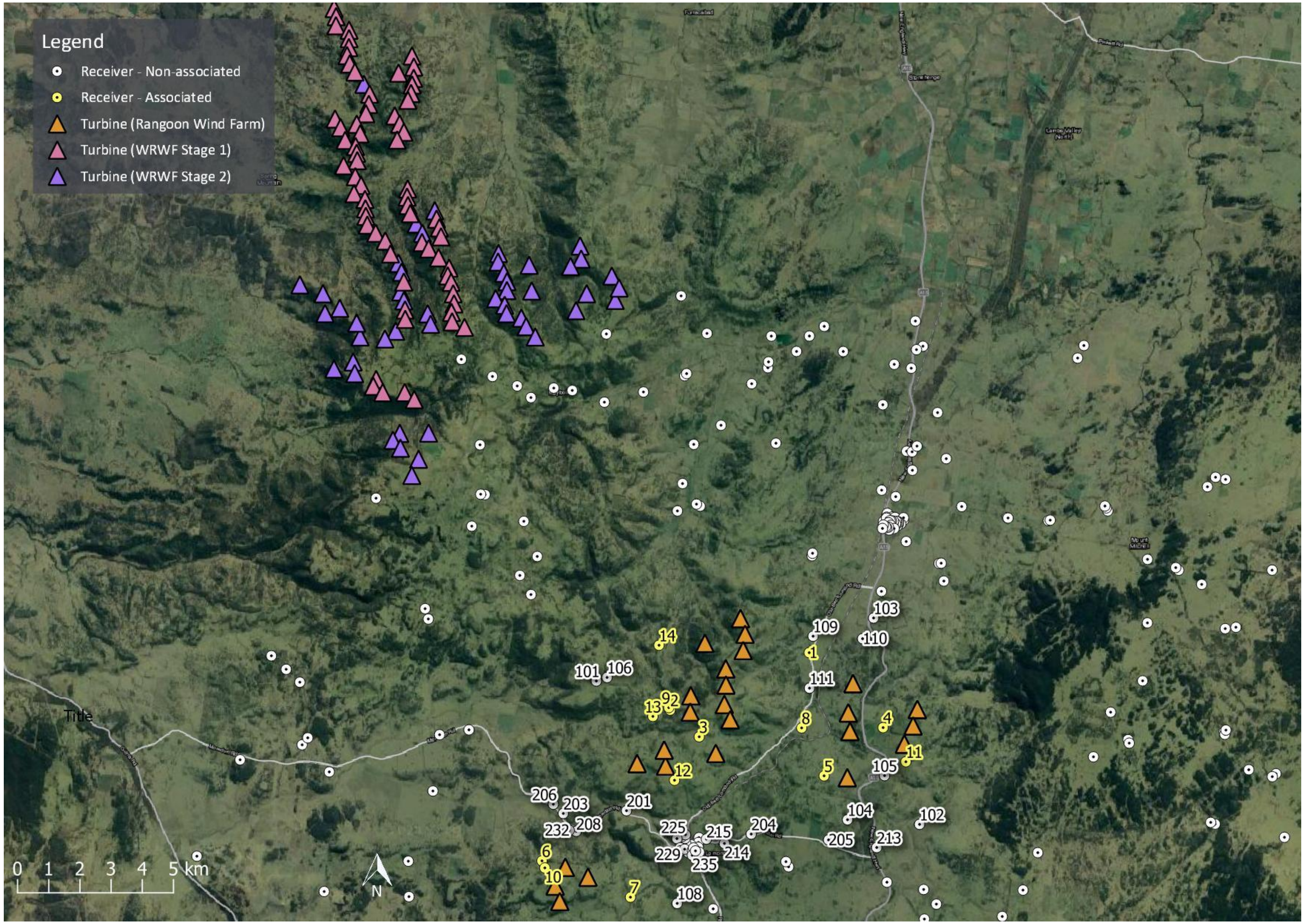
Table 9: Predicted Noise Levels, dB L_{Aeq} (includes +1 dB allowance for measurement uncertainty)

Receiver	Hub-height wind speed (m/s)					
	5	6	7	8	9	≥10
Non-associated receivers						
101	19.8	22.8	25.7	28.4	29.5	29.5
102	15.9	18.9	21.8	24.5	25.6	25.6
103	18.6	21.6	24.5	27.2	28.3	28.3
104	20.4	23.4	26.3	29.0	30.1	30.1
105	24.4	27.4	30.3	33.0	34.1	34.1
106	20.0	23.0	25.9	28.6	29.7	29.7
107	20.5	23.5	26.4	29.1	30.2	30.2
108	15.1	18.1	21.0	23.7	24.8	24.8
109	21.2	24.2	27.1	29.8	30.9	30.9
110	21.1	24.1	27.0	29.7	30.8	30.8
111	23.8	26.8	29.7	32.4	33.5	33.5
201	21.2	24.2	27.1	29.8	30.9	30.9
202	18.0	21.0	23.9	26.6	27.7	27.7
203	19.5	22.5	25.4	28.1	29.2	29.2
204	18.2	21.2	24.1	26.8	27.9	27.9
205	17.4	20.4	23.3	26.0	27.1	27.1
206	18.2	21.2	24.1	26.8	27.9	27.9
207	17.2	20.2	23.1	25.8	26.9	26.9
208	22.6	25.6	28.5	31.2	32.3	32.3
210	17.5	20.5	23.4	26.1	27.2	27.2
211	17.6	20.6	23.5	26.2	27.3	27.3
213	15.5	18.5	21.4	24.1	25.2	25.2
214	18.0	21.0	23.9	26.6	27.7	27.7
215	17.3	20.3	23.2	25.9	27.0	27.0
216	17.3	20.3	23.2	25.9	27.0	27.0
217	17.5	20.5	23.4	26.1	27.2	27.2
218	17.7	20.7	23.6	26.3	27.4	27.4
219	17.4	20.4	23.3	26.0	27.1	27.1
220	17.7	20.7	23.6	26.3	27.4	27.4

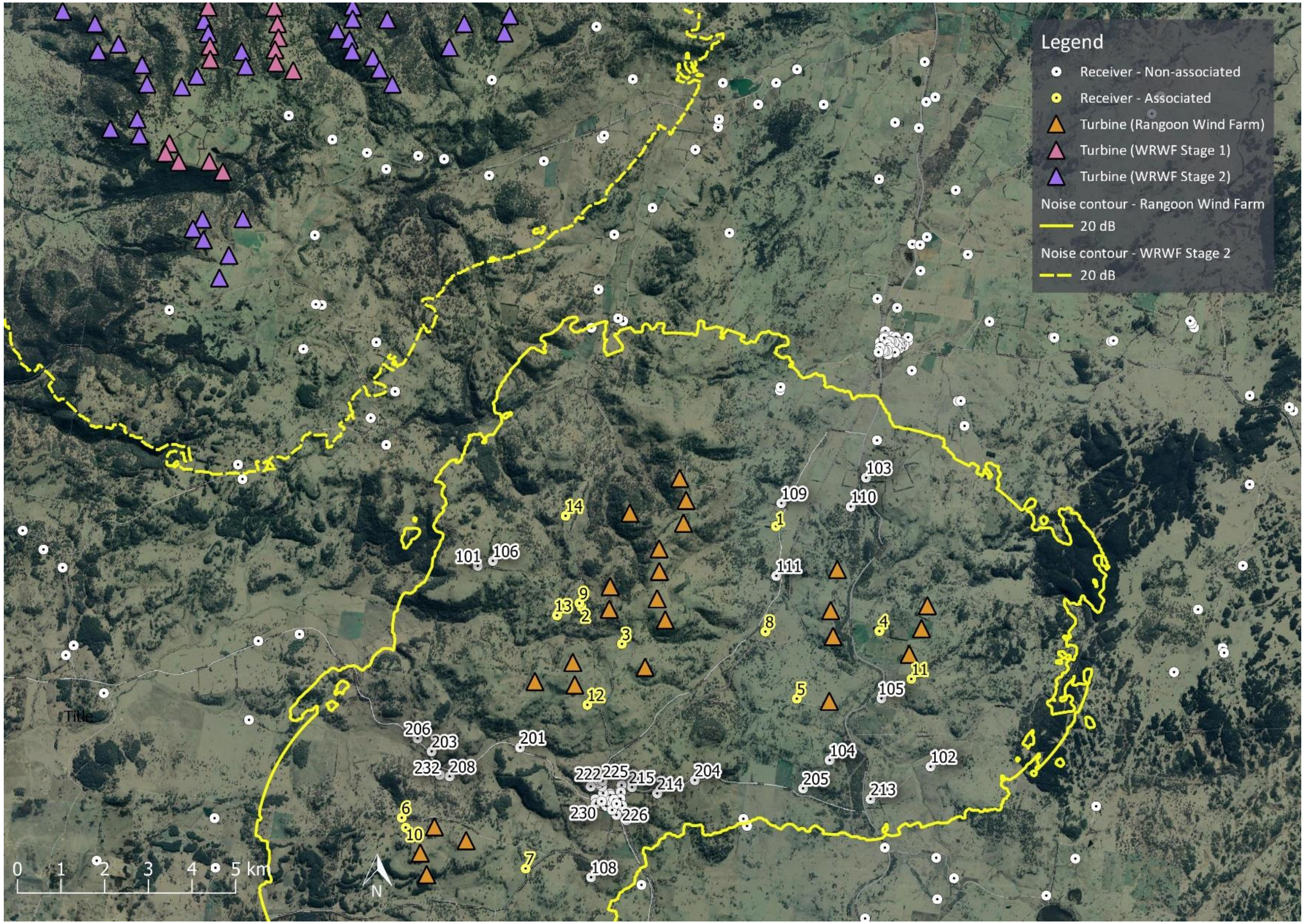
Receiver	Hub-height wind speed (m/s)					
	5	**6**	**7**	**8**	**9**	**≥10**
221	18.2	21.2	24.1	26.8	27.9	27.9
222	18.5	21.5	24.4	27.1	28.2	28.2
223	18.7	21.7	24.6	27.3	28.4	28.4
224	18.9	21.9	24.8	27.5	28.6	28.6
225	18.6	21.6	24.5	27.2	28.3	28.3
226	16.9	19.9	22.8	25.5	26.6	26.6
227	17.1	20.1	23.0	25.7	26.8	26.8
228	18.4	21.4	24.3	27.0	28.1	28.1
229	17.6	20.6	23.5	26.2	27.3	27.3
230	17.4	20.4	23.3	26.0	27.1	27.1
231	17.4	20.4	23.3	26.0	27.1	27.1
232	22.6	25.6	28.5	31.2	32.3	32.3
233	17.2	20.2	23.1	25.8	26.9	26.9
234	17.4	20.4	23.3	26.0	27.1	27.1
235	16.9	19.9	22.8	25.5	26.6	26.6
238	17.1	20.1	23.0	25.7	26.8	26.8
241	14.3	17.3	20.2	22.9	24.0	24.0
Associated receivers						
1	22.4	25.4	28.3	31.0	32.1	32.1
2	29.4	32.4	35.3	38.0	39.1	39.1
3	29.6	32.6	35.5	38.2	39.3	39.3
4	28.4	31.4	34.3	37.0	38.1	38.1
5	26.7	29.7	32.6	35.3	36.4	36.4
6	27.1	30.1	33.0	35.7	36.8	36.8
7	20.4	23.4	26.3	29.0	30.1	30.1
8	24.3	27.3	30.2	32.9	34.0	34.0
9	29.1	32.1	35.0	37.7	38.8	38.8
10	29.3	32.3	35.2	37.9	39.0	39.0
11	28.5	31.5	34.4	37.1	38.2	38.2
12	29.6	32.6	35.5	38.2	39.3	39.3
13	26.0	29.0	31.9	34.6	35.7	35.7
14	24.1	27.1	30.0	32.7	33.8	33.8

APPENDIX H CUMULATIVE ASSESSMENT

H1 Map of wind farms in the surrounding area



H2 Predicted 20 dB L_{Aeq} contours for the White Rock Stage 2 and Rangoon Wind Farms



APPENDIX I C-WEIGHTING ASSESSMENT RESULTS

I1 Introduction

Presented below are details of the risk assessment carried out for the purpose of gauging whether penalties for low frequency, as detailed in the NSW Noise Assessment Bulletin, are applicable.

I2 Assessment requirement

The following excerpt concerning C-weighted wind turbine noise have been reproduced from NSW Noise Assessment Bulletin.

Low Frequency Noise

The presence of excessive low frequency noise (a special noise characteristic) [ie noise from the wind farm that is repeatedly greater than 65dBC during day time or 60dBC during the night-time at any relevant receiver] will incur a 5dB(A) penalty, to be added to the measured noise level for the wind farm, unless a detailed internal low frequency noise assessment demonstrates compliance with the proposed criteria for the assessment of low frequency noise disturbance (UK Department for Environment, Food and Rural Affairs (DEFRA, 2005) for a steady noise source.

I3 Prediction method

As stated in Section 2.3, there are no commonly used, practical methods to accurately predict the wind turbine low frequency noise levels at receptor locations.

In this case, the C-weighted noise levels at receptor locations have been estimated using a simplified approach based on the same noise modelling methods as described above for A-weighted levels, but with the following modifications:

- The range of band frequencies has been expanded to include bands down to the 12.5 Hz frequency band
- The ground absorption parameter has been set to G = 0 (hard ground) to account for the increased influence of ground reflections at low frequencies.

C-weighted noise levels have been predicted for the worst-case wind speed in terms of C-weighted levels (12 m/s)

I4 Results

Table 10 presents the results of the preliminary C-weighted noise predictions.

Table 10: Predicted C-weighted noise levels

Receiver	dB L_{Ceq}
Non-associated receivers	
101	50.0
102	47.1
103	49.3
104	50.2
105	53.0

Receiver	dB L_{Ceq}
106	50.1
107	49.6
108	47.1
109	51.3
110	50.9
111	53.1
201	50.9
202	49.1
203	49.5
204	49.1
205	48.3
206	48.7
207	48.6
208	51.5
210	48.8
211	48.9
213	47.0
214	49.0
215	48.5
216	48.7
217	48.8
218	48.9
219	48.7
220	48.9
221	49.3
222	49.5
223	49.6
224	49.7
225	49.5
226	48.5

Receiver	dB L_{Ceq}
227	48.6
228	49.4
229	48.8
230	48.7
231	48.7
232	51.5
233	48.7
234	48.7
235	48.4
238	48.6
241	45.4
Associated receivers	
1	52.1
2	57.0
3	57.3
4	56.2
5	54.5
6	54.8
7	50.2
8	53.2
9	56.8
10	56.4
11	55.8
12	56.9
13	54.6
14	52.8

I5 Discussion

The results in Table 10 show that preliminary C-weighted noise levels are predicted to be below the most stringent criteria of 60 dB L_{Ceq} at all assessed receiver locations. While there are limitations on the accuracy of the prediction method used, the approach is considered sufficiently conservative for the purposes of this study. On the basis of the results above, it is considered that risk of low-frequency noise exceeding the criteria is low and therefore it is not appropriate to apply penalty adjustment to account for low-frequency noise.