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**COPPABELLA WIND FARM**  
**MODIFICATION APPLICATION NOISE ASSESSMENT**

Rp 001 R01 20169260 | 18 August 2017

Project: **COPPABELLA WIND FARM  
MODIFICATION APPLICATION NOISE ASSESSMENT**

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Report No.: **Rp 001 R01 20169260**

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## 1.0 INTRODUCTION

This report presents the results of an operational noise assessment for the latest design of the proposed Coppabella Wind Farm (formerly the Yass Valley Wind Farm).

Planning approval for the Yass Valley Wind Farm was provided by the NSW Planning Assessment Commission (PAC) in March 2016 for a wind farm layout comprising seventy nine (79) turbines. It is understood the project was subsequently renamed as the Coppabella Wind Farm in March 2017. The updated name is used throughout this report.

Goldwind Australia Pty (Goldwind), in agreement with Epuron (the original applicants for the project), are seeking modify the approval to allow larger turbines.

This report was commissioned by Goldwind to supplement the modification application to the NSW Department of Planning and Environment.

The report presents:

- Operational noise criteria applicable to the project, derived from the conditions of consent attached to the planning approval and current NSW policy
- Predicted noise levels for the proposed Coppabella Wind Farm
- An assessment of compliance with the applicable noise criteria.

The changes requested as part of the modification application primarily relate to the size of the proposed turbines. These changes are expected to be insignificant with respect to the noise associated with construction of the project. Construction noise is therefore not considered further in this report.

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2003 *Acoustics - Description measurement and assessment of environmental noise – Part 1: 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.

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

Throughout this report, the term *receiver* is used to identify locations in the vicinity of existing or planned residential locations around the proposed Coppabella Wind Farm.

## 2.0 PROJECT DESCRIPTION

### 2.1 Overview

The proposed Coppabella Wind Farm is located approximately 30 km west-northwest of Yass, in the Yass and Harden local government areas.

The planning approval for the wind farm allows for the construction of seventy nine (79) turbines with a maximum tip height of 150 m.

The revised wind farm design submitted in the modification application retains the seventy nine (79) turbine layout but proposes an increased maximum turbine height of 170 m.

The coordinates of the proposed wind turbines are tabulated in Appendix B.

A total of fifty-seven (57) receiver locations located within a distance of 5 km of the Coppabella Wind Farm have been considered in this report. In accordance with the Development Consent discussed subsequently in Section 3.1, valid receiver locations for assessment are residences defined as follows:

*Any dwelling in existence at the date of this consent, or a dwelling that is either the subject of a development consent or a development application that was lodged but not yet determined at the date of this consent once construction of the dwelling is complete*

The fifty-seven (57) receiver locations comprise:

- Fifty-one (51) non-associated residences where the noise requirements of the Development Consent apply
- Six (6) associated residences where the noise requirements of the Development Consent Approval do not apply

The coordinates of the assessed receiver locations are tabulated in Appendix C.

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

The turbine layouts and the nearest receiver locations are also illustrated in the predicted noise contour map provided in Appendix G.

## 2.2 Wind turbine model

The wind farm is proposed to comprise seventy nine (79) Goldwind GW140-3.4MW wind turbines based on Goldwind's GW3S turbine platform.

The GW140-3.4MW is a variable speed wind turbine. The speed of rotation and the amount of power generated by each turbine is regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis).

Power transmission between the rotor and the generator within the turbine nacelle occurs via a Permanent Magnet Direct Drive system (i.e. no gearbox within the turbine nacelle).

Details of the proposed wind turbines are provided in Table 1.

**Table 1: Proposed Goldwind wind turbines**

Detail	GW140-3.4MW
Rotor diameter	140 m
Hub height	100 m
Maximum tip height	171 m*
Blade orientation	Upwind
Blade configuration	Variable pitch and non-serrated
Maximum rated power generating capacity	3.4 MW
Cut-in wind speed (hub height)	2.5 m/s
Rated power wind speed (hub height)	11 m/s
Cut-out wind speed (hub height)	20 m/s

\* For noise modelling purposes, the rotor diameter was assumed to be 142 m to reach the maximum tip height of 171 m

## 2.3 Noise emissions

Sound power level test data for the Goldwind GW140-3.4MW turbine is presently unavailable.

In lieu of test data, Goldwind has provided a specification containing theoretical sound power level data for the purpose of the pre-development noise assessment.

The sound power levels are summarised in Table 2.

**Table 2: Guaranteed sound power levels, dB L<sub>WA</sub>**

Turbine	Hub-height wind speed (m/s)				
	8	9	10	11	12
GW140-3.4MW <sup>1</sup>	106.4	107.5	107.5	107.5	107.5

The guaranteed sound power levels in Table 2 are considered typical of the upper range of noise emissions associated with comparable multi-megawatt wind turbines.

<sup>1</sup> Goldwind document *GW140-3.4MW Wind Turbine Guaranteed Noise Curve* received 23/2/2017

The data is therefore considered appropriate to reference in this 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 61400-11:2012), consistent with the recommendation of NZS 6808:2010. Further, the sound power values have been adopted as the maximum apparent sound power level which would be measured from a sample of turbines. Adjustments for test uncertainty have therefore not been applied to the sound power levels.

In addition to the total sound power levels, Goldwind specification states the following with respect to tonality:

*The Goldwind turbine has no tonality or special audible characteristics.*

In the absence of test data GW140-3.4MW turbines, a representation of the sound frequency characteristics of the noise emissions has been derived from test data for a Goldwind GW121-2.5MW turbine, and adjusted to correspond to the total sound power levels presented in Table 2. The sound frequency characteristics (spectra) referenced in this assessment are presented in Table 3.

**Table 3: Goldwind GW140-3.4MW sound power levels, dB L<sub>WA</sub>**

Hub Height Wind Speed (m/s)	Octave Band Centre Frequency Hz								
	63	125	250	500	1000	2000	4000	8000	Total
8	86.1	94.0	100.5	102.0	98.7	92.2	91.9	94.2	106.4
9	87.2	95.1	101.6	103.1	99.8	93.3	93.0	95.3	107.5
10	87.2	95.1	101.6	103.1	99.8	93.3	93.0	95.3	107.5

### 3.0 ASSESSMENT CRITERIA

#### 3.1 Development Consent

The NSW Planning Assessment Commission Determination Report (the PAC report) for the Coppabella Wind Farm dated 30 March 2016 provided planning approval for the wind farm, subject to a set of Development Consent conditions detailed in Appendix 3 of the PAC report.

Condition 11 of Schedule 3 of the Development Consent details the following with respect to operational noise criteria:

*The Applicant shall ensure that the noise generated by the operation of wind turbines does not exceed the relevant criteria in Table 3 at any non-associated residence.*

Table 3: Noise criteria dB(A)

Residence	Criteria (dB(A)) with Reference to Hub Height Wind Speed (m/s)											
	3	4	5	6	7	8	9	10	11	12	13	14
C04	35	35	35	35	35	35	35	35	36	37	38	38
C74	35	35	35	35	35	35	35	38	39	41	43	44
All other non-associated residences	The higher of 35 dB(A) or the existing background noise level (LA90 (10-minute)) plus 5 dB(A)											

Note: To identify the residences referred to in Table 3, see the applicable figures in Appendix 2.

Noise generated by the operation of the wind turbines is to be measured in accordance with the relevant requirements of the South Australian Environment Protection Authority's Wind Farms – Environmental Noise Guidelines 2009 (or its latest version), as modified by the provisions in Appendix 5. If this guideline is replaced by an equivalent NSW guideline, then the noise generated is to be measured in accordance with the requirements in the NSW guideline.

Appendix 5 of the Development Consent, as referenced in Condition 11 of Schedule 3, specifies the modifications to the 2009 SA Guideline<sup>2</sup> which apply to the measurement of wind turbine noise. The modifications comprise:

- Penalties which apply when special noise characteristics are present – these characteristics include tonality and low frequency noise
- Specifying that the noise limits defined in Condition 11 apply under all meteorological conditions.

Conditions 13 and 14 of Schedule 3 of the Development Consent also specify requirements for noise compliance monitoring after the wind farm commences operation.

<sup>2</sup> South Australian EPA Wind Farms environmental noise guidelines dated July 2009 (2009 SA Guideline)

### 3.2 NSW Noise Assessment Bulletin

The NSW Department of Planning and Environment publication *Wind Energy: Noise Assessment Bulletin* (the NSW Noise Assessment Bulletin) dated December 2016 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 applies to:

- All new State significant development wind energy proposals that obtain the Secretary's environmental assessment requirements after the bulletin's date of publication
- Modification applications made after the bulletin's date of publication.

The NSW Noise Assessment Bulletin states that the 2009 SA 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 2009 SA Guideline. The criteria in the NSW Noise Assessment Bulletin are subsequently defined as follows:

*The predicted equivalent noise level ( $L_{Aeq,10\text{ minute}}$ )\*, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed 35 dB(A) or the background noise ( $L_{A90(10\text{ minute})}$ ) 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.*

In relation to features of the sound referred to as special noise characteristics, the NSW Noise Assessment Bulletin defines the following variations to the 2009 SA Guideline:

- An objective procedure is defined for assessing tonality. The general procedure is based on assessment of one-third octave band noise levels in accordance with the simplified procedure referred to in ISO 1996.2:2007<sup>3</sup>, supported by the use of the reference method in the standard (narrow frequency band analysis) where required by the consent / regulatory authority
- Low frequency noise is defined as a special noise characteristic which requires assessment to determine if a penalty should apply to the noise of the wind farm. Excessive low frequency noise is defined as levels which repeatedly exceed 60 dB  $L_{Aeq,10\text{ min}}$ , unless a detailed assessment of internal noise levels in the dwelling indicates compliance with a UK publication concerning low frequency noise levels
- A maximum combined penalty of 5 dB is defined for the repeated and excessive tonality, low frequency noise, or both
- Occurrence of tonality or low frequency for more than 10 % of an assessment period (defined as being present for more than 144 minutes in any day) is defined as a repeated occurrence.

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<sup>3</sup> ISO 1996.2:2007 *Acoustics - Description, measurement and assessment of environmental noise – Determination of environmental noise levels*

The noise monitoring related variations defined in the NSW Noise Assessment Bulletin establish general compliance monitoring requirements which apply after a wind farm commences operating.

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.*

### 3.3 Applicable noise limits

The noise criteria of the Development Consent and the NSW Noise Assessment Bulletin are generally consistent. In particular, both refer to the 2009 SA Guideline as the relevant assessment standard, subject to procedural variations which apply to NSW projects. These variations include a reduced base noise criterion of 35 dB  $L_{Aeq(10\text{ minute})}$ . The only difference is that the NSW Noise Assessment Bulletin defines a more stringent assessment method for potential low frequency noise, defining 60 dB  $L_{Ceq(10\text{ minute})}$  for all time periods as the threshold when a penalty may be warranted (in lieu of the Development Consent conditions' separate 65 and 60 dB thresholds for day and night respectively).

Irrespective, Appendix 5 of the Development Consent states that if the 2009 SA Guideline is replaced by an equivalent NSW guideline, then the noise of the wind farm is to be measured in accordance with the replacement NSW guideline. While the NSW Noise Assessment Bulletin continues to refer to the 2009 SA Guideline, the bulletin represents a replacement guideline which defines procedures applicable to all projects in NSW, including modification applications. The NSW Noise Assessment Bulletin therefore provides the relevant assessment criteria for the present assessment.

The noise criteria include an allowance for noise limits to increase above a value of 35 dB when the background noise levels, measured in accordance with the SA 2009 guideline, are greater than 30 dB.

Background noise levels were previously measured in the vicinity of the Coppabella Wind Farm as part of the original planning application for the project. The Development Consent condition also include details of noise limits derived from background noise levels for two receiver locations, C04 and C74.

At this stage in the assessment of the proposed modification of the Coppabella Wind Farm, the original background noise data and the Development Consent limits have not been reanalysed. Specifically, the data have not been correlated with wind speeds at the increased hub-height that is presently proposed. Accordingly, for the purposes of the modification application, a simplified and conservative assessment has been carried out by referring to the base noise criterion of 35 dB only.

It is however envisaged that prior to construction of the wind farm, an updated background noise survey would be conducted to determine the specific noise limits which apply at each assessable integer wind speed during any future compliance monitoring.

The assessment criteria apply to all noise sensitive receiver locations that are not associated with the proposed project. However, in accordance with the requirements of the Noise Assessment Bulletin, predicted noise levels are also presented for the associated receiver locations, comprising host properties and receivers where a noise agreement is in place. These associated receivers are assessed against a base criterion of 45 dB – a criterion commonly adopted for associated receivers, and which we understand has been established in the noise agreements for the project.

It is also understood that there are a number of additional receivers around the project that are considered as associated according to the broader definitions of the development consent but do not have an increased base criterion defined in their agreement. As such, these receivers have been designated as non-associated for the purposes of the noise assessment, and are therefore assessed against the 35 dB base criterion in this report.

#### 4.0 PREDICTION METHODOLOGY

Operational noise levels associated with the wind farm have been predicted on the basis of:

- The sound emissions of the proposed turbine as outlined in Section 2.2
- A 3D digital noise model of the site and the surrounding environment
- International standards used for the calculation of environmental sound propagation, with input settings and adjustments specifically suited to wind farm noise assessment.

Details of the prediction methodology are summarised in Table 4 below. The prediction method is consistent with the procedures used to calculate operational noise levels during the planning stages of the project.

**Table 4: Wind farm prediction methodology**

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 7.4 (current release)
Method	<p>International Standard ISO 9613-2:1996 <i>Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation</i> (ISO 9613-2).</p> <p>Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication <i>A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise</i> (UK good practice guide).</p> <p>The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation.</p> <p>Specific details of adjustments are noted below. Further discussion of the prediction method is provided in Appendix E.</p>
Source characterisation	<p>Each wind turbine is modelled as an incoherent 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.</p> <p>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 (91.5 – 92 m AGL according to turbine type).</p> <p>Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine (170 m AGL). Further discussion of terrain screening effects is provided below.</p>
Terrain data	A digital model of the terrain for the site and surrounding areas has been generated on the basis of elevation data obtained via the ELVIS - Foundation Spatial Data web portal <sup>4</sup>
Terrain effects	<p>Adjustments for the effect of terrain are determined and applied on the basis of the UK good practice guide and research outlined in Appendix E.</p> <p>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 deemed 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.</p> <p>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.</p>

<sup>4</sup> SRTM-derived 1 Second Digital Elevation Model Version 1.0 (<http://elevation.fsd.org.au/>)

Detail	Description
Ground conditions	<p>Ground factor of <math>G = 0.5</math> on the basis of the UK good practice guide and research outlined in Appendix E.</p> <p>The ground around the site corresponds porous ground conditions (<math>G=1</math>) according to ISO 9613-2. The adopted value of <math>G = 0.5</math> assumes that 50 % of the ground cover is acoustically hard (<math>G = 0</math>) to account for variations ground porosity and provide a cautious representation of ground effects.</p>
Atmospheric conditions	<p>Temperature 10 °C and relative humidity 70 %</p> <p>This represents conditions which result in relatively low levels of atmospheric sound absorption and is chosen on the basis of the UK good practice guide.</p> <p>The calculations are based on sound speed profiles<sup>5</sup> which increase the propagation of sound from each turbine to each receiver location, whether as a result thermal inversions or wind directed toward each calculation point.</p> <p>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.</p>
Receiver heights	1.5 m above ground level

<sup>5</sup> The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

## 5.0 ASSESSMENT

### 5.1 Predicted noise levels

This section presents the assessed receiver locations where operational wind farm noise levels are predicted to be higher than 30 dB  $L_{Aeq}$ , along with the predicted noise levels for the Coppabella Wind Farm.

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.

**Table 5: Predicted A-weighted noise levels dB  $L_{Aeq}$**

Receiver	Receiver status	Hub-height wind speed	
		8 m/s	9 to 12 m/s
C01	Non-associated	33.7	34.8
C02	Associated	39.0	40.1
C03	Associated	38.6	39.7
C04	Non-associated	35.6	36.7
C05	Associated	33.8	34.9
C06	Non-associated	33.0	34.1
C08	Non-associated	31.0	32.1
C13	Non-associated	31.6	32.7
C22	Non-associated	30.2	31.3
C29	Non-associated	33.4	34.5
C30	Non-associated	31.7	32.8
C34	Non-associated	30.2	31.3
C35	Associated	34.7	35.8
C37	Non-associated	33.0	34.1
C41	Non-associated	30.1	31.2
C53	Non-associated	31.3	32.4
C55	Associated	37.4	38.5
C56	Associated	39.4	40.5
C58	Non-associated	31.4	32.5
C60	Non-associated	30.7	31.8
C71	Non-associated	33.5	34.6

Receiver	Receiver status	Hub-height wind speed	
		8 m/s	9 to 12 m/s
C74	Non-associated	33.9	35.0
C75	Non-associated	31.7	32.8
C76	Non-associated	31.8	32.9
C76a	Non-associated	31.0	32.1
G30	Non-associated	30.5	31.6
G32	Non-associated	30.5	31.6
H30	Non-associated	30.5	31.6

Predicted noise levels at all fifty-seven (57) receiver locations identified within a distance of 5 km of the Coppabella Wind Farm are presented in Appendix F.

A noise contour map illustrating the predicted noise levels for the Coppabella Wind Farm, corresponding to hub height wind speeds of 9-12 m/s, is presented in Appendix F.

## 5.2 Special noise characteristics

### 5.2.1 Tonality

Noise emission test data for the Goldwind GW140-3.4MW is presently not available.

However, in lieu of test data, the Goldwind specification states the following with respect to tonality:

*The Goldwind turbine has no tonality or special audible characteristics.*

The occurrence of tonality in the noise emissions of contemporary multi-megawatt turbine designs is generally limited. The Goldwind specification is therefore considered typical for the type of turbine being considered for the Coppabella Wind Farm.

On the basis that the wind turbine complies with this performance specification, the application of tonality penalties to the predicted noise levels is not considered warranted. This approach is consistent with accepted practice for wind farm noise assessment.

It is however envisaged that sound power level testing of the proposed turbine will be completed prior to the development of the wind farm. The results of this testing will be used to verify:

- the suitability of the noise predictions based on the stated sound power levels presented herein
- the absence of frequency characteristics which would attract a tonality penalty in accordance with the NSW Noise Assessment Bulletin.

### 5.2.2 Low frequency noise

The NSW assessment bulletin defines 60 dB  $L_{Ceq(10\text{ minute})}$  as the threshold when a penalty for low frequency noise may be warranted.

C-weighted noise levels for wind farm developments are problematic to assess due to the absence of well-defined noise prediction procedures. In particular, the prediction methods used for wind farms have been extensively validated for the calculation of A-weighted noise levels. In contrast, the most widely used wind farm noise prediction methods are not intended for modelling C-weighted levels, and are subject to considerably higher uncertainty margins when used for this purpose.

An additional of uncertainty in this instance is that test data is yet to be acquired for the new turbine model that is proposed for the site. In the absence of this data, the A-weighted noise levels presented in the preceding section of this report were calculated using the sound frequency data of an alternative Goldwind turbine model. However, C-weighted noise level predictions are particularly sensitive to the frequency characteristics of the turbine and require sound power level data for lower ranges of frequencies than are used for A-weighted predictions.

Given the above, C-weighted noise levels for the proposed Coppabella Wind Farm cannot be reliably predicted at this time.

Notwithstanding the above, indicative calculations based on the ISO 9613 procedure, adjusted by a nominal allowance associated with the increased uncertainty associated with C-weighted predictions, suggest wind farm noise levels below 60 dB  $L_{Ceq}$  at receiver locations. Penalties for low frequency noise levels have therefore not been applied to the predictions presented in this report. However, the sound power testing that is envisaged to be completed prior to development of the wind farm shall include measurement of the extended low frequencies that are needed to calculate C-weighted noise levels. The assessment of C-weighted noise levels is to be revisited prior to development of the wind farm when this data is available.

### 5.3 Discussion

The results demonstrate that the predicted noise levels generally achieve the base criterion of 35 dB at all non-associated receiver locations at all wind speeds. The exception is receiver C04 where the wind farm noise level is predicted 1.7 dB higher than the base criterion. Options for addressing this margin are discussed in Appendix H.

In relation to associated receiver locations, the highest predicted wind farm noise level is 40.5 dB. The predicted noise levels are therefore below the 45 dB base criterion which is understood to have been referenced in the noise agreements for associated receivers.

## 6.0 SUMMARY

An operational noise assessment has been carried out for the latest design of the proposed Coppabella Wind Farm.

The purpose of this report is to supplement the application to the NSW Department of Planning and Environment to modify the wind farm's planning approval to allow an increase in the maximum turbine height from 150 m to 171 m.

The assessment has been undertaken for the approved wind farm layout comprising seventy nine (79) Goldwind GW140-3.4MW wind turbines based on Goldwind's GW3S turbine platform. Noise emission data provided by Goldwind has been used to prepare the updated noise predictions for the wind farm.

The results of the noise predictions for the Coppabella Wind Farm demonstrate that the predicted noise levels for the proposed turbine layout and turbine model generally comply with the minimum limit of 35 dB for non-associated receiver locations, as determined from the Development Consent and the NSW Noise Assessment Bulletin. The exception is at receiver location C04 where the predicted noise level is approximately 1.7 dB higher than the base criterion. Options for addressing this margin have been described in the report.

Predicted noise level information has also been presented for associated receiver locations comprising host properties and neighbouring receivers where an agreement is in place between Goldwind and the land owner.

The assessment has been based on noise emission data that is considered typical of the upper range of emissions associated with comparable multi-megawatt wind turbines.

It is envisaged that sound power level testing of the proposed turbine will be completed prior to the development of the wind farm. The results of this testing will be used to verify the results of the assessment presented herein.

## APPENDIX A GLOSSARY OF TERMINOLOGY

<b>dB</b>	Decibel. The unit of sound level.
<b><math>L_w</math></b>	The sound power level. The level of total sound power radiated by a sound source.
<b><math>L_{WA}</math></b>	The “A” weighted sound power level.
<b><math>L_{eq}</math></b>	Continuous or semi-continuous noise levels are described in terms of the equivalent continuous sound level ( $L_{eq}$ ). This is the constant sound level over a stated time period which is equivalent in total sound energy to the time-varying sound level measured over the same time period. This is commonly referred to as the average noise level.
<b><math>L_{Aeq}</math></b>	The “A” weighted equivalent continuous sound level.
<b>Octave Band</b>	A range of frequencies where the highest frequency included is twice the lowest frequency. 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.
<b><math>L_{A90}</math></b>	The noise level exceeded for 90% of the measurement period, measured in A-weighted decibels. This is commonly referred to as the background noise level.

**APPENDIX B TURBINE COORDINATES – MGA94 ZONE 55**

ID	Easting	Northing	ID	Easting	Northing
1	641135	6156615	43	638123	6153103
2	642183	6155309	44	637501	6153978
3	641934	6155584	45	637821	6154164
4	641683	6155973	46	638091	6154423
5	641228	6156306	47	639088	6152412
6	644704	6153528	48	639374	6152965
7	643949	6154128	49	639508	6153251
8	643690	6154400	50	639733	6152377
9	642410	6155033	51	639315	6152655
10	642697	6154767	52	637982	6155133
11	644507	6153820	53	637955	6154807
12	645386	6153102	54	637553	6154697
13	645920	6153005	55	637558	6155411
14	645844	6152689	56	638814	6155310
15	643186	6154579	57	638692	6155728
16	640374	6156085	58	638239	6155953
17	640731	6155502	59	638546	6156147
18	640494	6155780	60	637143	6155777
19	641174	6155340	61	636904	6155521
25	639997	6154114	62	636707	6155235
29	641753	6154245	63	636604	6154848
30	640070	6154676	64	637973	6156390
31	640038	6155010	65	638118	6156671
32	639618	6154648	66	638884	6156320
33	639464	6153582	67	639241	6156706
34	638607	6154188	68	638060	6157008
35	638391	6153940	69	635163	6156152
36	639022	6154556	70	635491	6156697
37	638704	6154914	71	635449	6156374
38	639088	6155044	72	635867	6156842
39	638176	6153691	73	646131	6150401
40	637724	6153002	74	646521	6150162

ID	Easting	Northing	ID	Easting	Northing
41	637724	6152676	75	645789	6149787
42	637890	6153483	76	646174	6149496
77	645814	6149346	126	636929	6157657
78	644751	6150491	127	637065	6157311
79	644471	6150212	128	637560	6157324
80	644204	6150650	129	637674	6157619
81	643496	6151799	130	635896	6156000
82	643622	6152119			

Source: coordinates received from Goldwind 8 March 2017

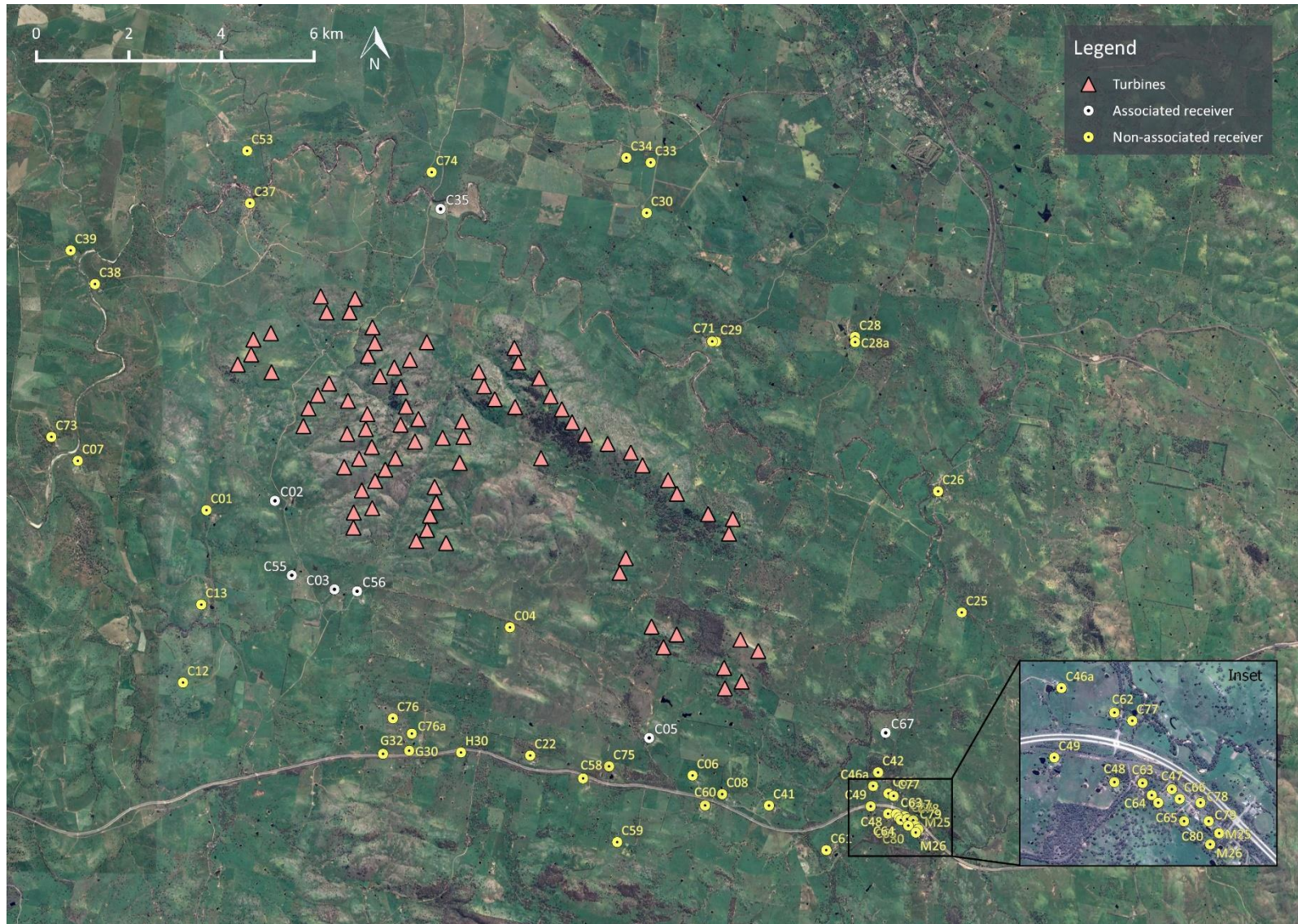
**APPENDIX C RECEIVER COORDINATES WITHIN 5 KM – MGA94 ZONE 55**

Receiver	Easting	Northing	Receiver	Easting	Northing
C01	634541	6152997	C53	635285	6160771
C02 (A)	636018	6153225	C55 (A)	636410	6151622
C03 (A)	637337	6151336	C56 (A)	637828	6151303
C04	641145	6150582	C58	642782	6147348
C05 (A)	644196	6148246	C59	643544	6145985
C06	645147	6147452	C60	645429	6146810
C07	631743	6154014	C61	648065	6145891
C08	645794	6147060	C62	649388	6147137
C12	634099	6149266	C63	649566	6146692
C13	634466	6150956	C64	649624	6146615
C22	641631	6147822	C65	649665	6146568
C25	650904	6151073	C66	649800	6146592
C26	650347	6153680	C67 (A)	649305	6148446
C28	648493	6156982	C71	645409	6156831
C28a	648497	6156869	C73	631162	6154520
C29	645491	6156830	C74	639282	6160379
C30	643944	6159581	C75	643338	6147617
C33	644012	6160671	C76	638649	6148573
C34	643485	6160766	C76a	639064	6148250
C35 (A)	639487	6159589	C77	649501	6147085
C37	635365	6159642	C78	649932	6146568
C38	632047	6157837	C79	649984	6146451
C39	631508	6158554	C80	649828	6146451
C41	646810	6146831	G30	639014	6147880
C42	649156	6147588	G32	638449	6147802
C46a	649053	6147292	H30	640134	6147862
C47	649751	6146653	M25	650050	6146375
C48	649388	6146698	M26	649993	6146305
C49	649008	6146853			

(A) Associated receiver

Source: coordinates received from Goldwind 8 March 2017

APPENDIX D SITE LAYOUT PLAN



## APPENDIX E NOISE PREDICTION MODEL

Operational wind farm noise levels are predicted at all residential dwellings considered within this assessment using a three-dimensional noise model generated in SoundPLAN® version 7.4 software. Specifically, predictions have been carried out using the SoundPLAN implementation of ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO 9613-2:1996) to calculate noise propagation from the wind farm to each receiver location.

The use of this method is supported by international research publications and Marshall Day Acoustics own measurement studies.

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 levels 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 9613-2:1996, the noise levels 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 sound power level data to determine the corresponding octave band and total calculated noise level at relevant 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 9613-2:1996 when a certain set of input parameters are chosen in combination.

A number of Australian and international studies support the assignment of a ground factor of  $G=0.5$  for the source, middle and receiver ground regions between a wind farm and a calculation point. This ground factor of  $G=0.5$  is adopted in combination with several cautious 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 degrees and relative humidity of 70 % (conditions which give rise to low atmospheric absorption). The studies demonstrate that applying the ISO 9613-2:1996 prediction methodology in this way provides a reliable representation of the upper noise levels expected in practice.

The following specific adjustments have been made:

- In instances where the ground terrain provides marginal or partial acoustic screening, the barrier effect should be limited to not more than 2 dB
- Screening attenuation calculated based on the screening expected for the source located at the tip height of the turbine (in contrast to hub height in non-adjusted ISO 9613-2:1996 predictions)
- In instances where the ground falls away significantly between the source and receiver, such as valleys, an adjustment of 3 dB should be added to the calculated sound pressure level. A terrain profile in which the ground falls away significantly is defined as one where the mean sound propagation height is at least 50% greater than would occur over flat ground

In support of the use of ISO 9613-2:1996 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
- NZS 6808:2010 refers to ISO 9613-2:1996 as an appropriate prediction methodology for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of  $G=0.5$
- In 1998, a comprehensive study, part funded by the European Commission, Development of a Wind Farm Noise Propagation Prediction Model<sup>6</sup> found that the ISO 9613-2:1996 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 9613-2:1996 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, including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2:1996 method as the appropriate standard and specifically designated  $G=0.5$  as the appropriate ground characterisation. It is noted that this publication specifically refers to predictions made to receiver heights of 4 m in the interest of representing 2-storey dwellings which are more common in the UK. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation factors, 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 comparative measurement and prediction studies<sup>7,8,9</sup> for wind farms in which Marshall Day Acoustics' staff have been involved have provided further support for the use of ISO 9613-2:1996 and  $G=0.5$  as an appropriate representation of typical upper noise levels expected to occur in practice.

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<sup>6</sup> Bass, Bullmore and Sloth - *Development of a wind farm noise propagation prediction model*; Contract JOR3-CT95-0051, Final Report, January 1996 to May 1998.

<sup>7</sup> 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.

<sup>8</sup> 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.

<sup>9</sup> 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.

The key findings of these studies demonstrated the suitability of the ISO 9613-2:1996 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
- 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.

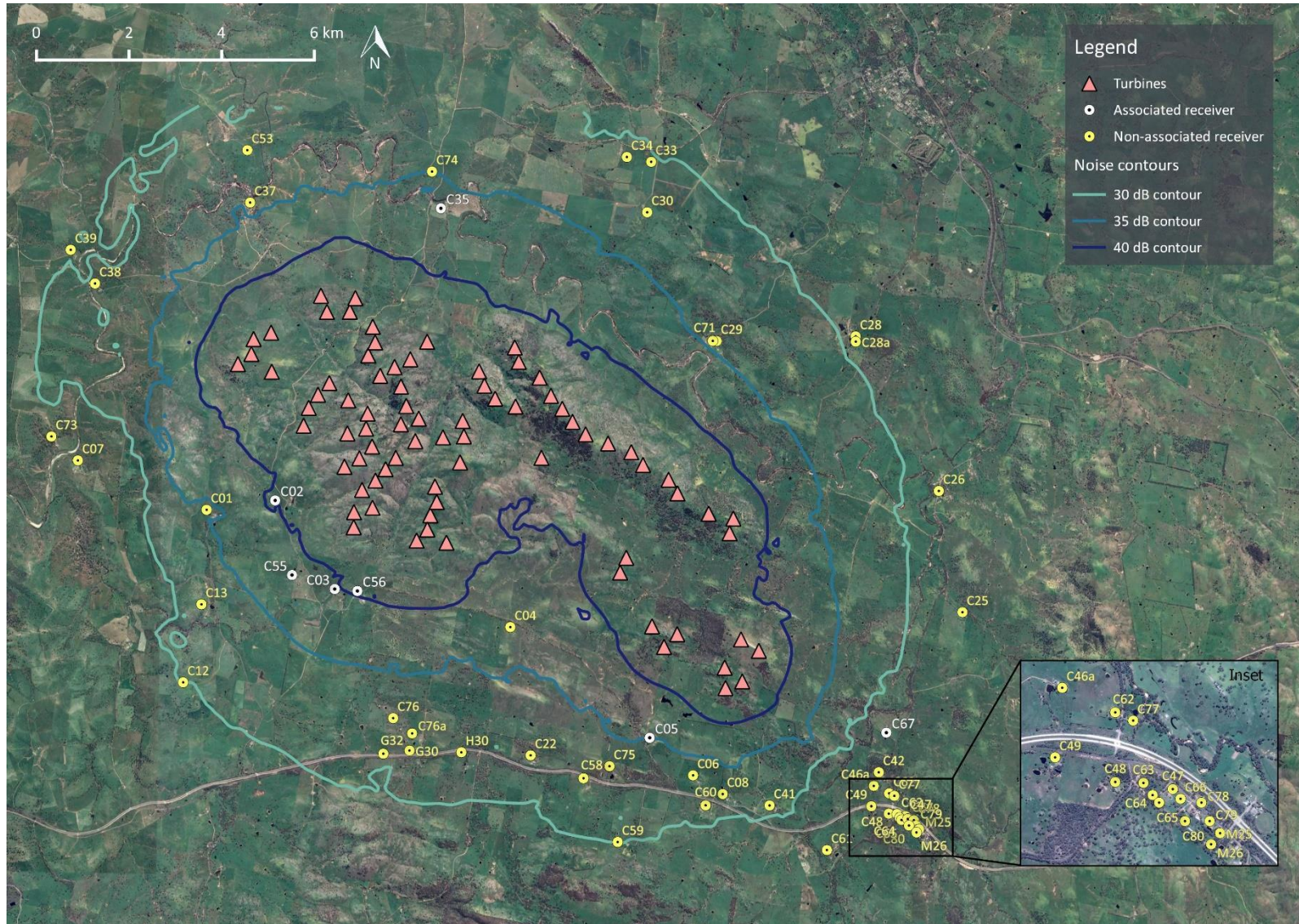
ISO 9613-2:1996 is primarily intended for the prediction of total A-weighted noise levels.

**APPENDIX F PREDICTED NOISE LEVELS – ALL RECEIVER LOCATIONS**

Receiver	Receiver status	Hub-height wind speed	
		8 m/s	9 to 12 m/s
C01	Non-associated	33.7	34.8
C02	Associated	39.0	40.1
C03	Associated	38.6	39.7
C04	Non-associated	35.6	36.7
C05	Associated	33.8	34.9
C06	Non-associated	33.0	34.1
C07	Non-associated	25.8	26.9
C08	Non-associated	31.0	32.1
C12	Non-associated	29.6	30.7
C13	Non-associated	31.6	32.7
C22	Non-associated	30.2	31.3
C25	Non-associated	27.3	28.4
C26	Non-associated	27.5	28.6
C28	Non-associated	28.8	29.9
C28a	Non-associated	28.9	30.0
C29	Non-associated	33.4	34.5
C30	Non-associated	31.7	32.8
C33	Non-associated	29.8	30.9
C34	Non-associated	30.2	31.3
C35	Associated	34.7	35.8
C37	Non-associated	33.0	34.1
C38	Non-associated	29.4	30.5
C39	Non-associated	28.9	30.0
C41	Non-associated	30.1	31.2
C42	Non-associated	27.5	28.6
C46a	Non-associated	26.9	28.0
C47	Non-associated	25.1	26.2
C48	Non-associated	25.9	27.0
C49	Non-associated	26.7	27.8
C53	Non-associated	31.3	32.4

Receiver	Receiver status	Hub-height wind speed	
		8 m/s	9 to 12 m/s
C55	Associated	37.4	38.5
C56	Associated	39.4	40.5
C58	Non-associated	31.4	32.5
C59	Non-associated	29.5	30.6
C60	Non-associated	30.7	31.8
C61	Non-associated	27.4	28.5
C62	Non-associated	26.3	27.4
C63	Non-associated	26.0	27.1
C64	Non-associated	25.9	27.0
C65	Non-associated	25.6	26.7
C66	Non-associated	25.0	26.1
C67	Associated	28.5	29.6
C71	Non-associated	33.5	34.6
C73	Non-associated	26.3	27.4
C74	Non-associated	33.9	35.0
C75	Non-associated	31.7	32.8
C76	Non-associated	31.8	32.9
C76a	Non-associated	31.0	32.1
C77	Non-associated	26.1	27.2
C78	Non-associated	24.7	25.8
C79	Non-associated	24.7	25.8
C80	Non-associated	24.9	26.0
G30	Non-associated	30.5	31.6
G32	Non-associated	30.5	31.6
H30	Non-associated	30.5	31.6
M25	Non-associated	24.5	25.6
M26	Non-associated	24.5	25.6

APPENDIX G NOISE CONTOUR MAP



## APPENDIX H RECEIVER C04

The highest predicted noise level at receiver location C04 is 36.7 dB.

In the absence of updated background noise monitoring data for this location, a conservative assessment has been undertaken in this report on the basis of the 35 dB base criterion for non-associated receivers. This indicates a potential margin of 1.7 dB above the minimum noise limit. Updated background noise monitoring is therefore recommended to be carried out in order to determine the actual noise limits which would apply at receiver C04. Additional modelling has been performed that demonstrates the predicted noise level at this receiver only exceeds the 35 dB base criterion during a certain range of wind directions that result in the receiver being downwind from the wind farm. These wind directions are outside the prevailing wind directions for the site and would therefore be expected to occur less frequently.

It is understood that Goldwind is presently negotiating with the landowner of C04 to become associated with the project. A noise agreement would form part of becoming associated with the project, and the predicted noise level at C04 is within the 45 dB base criterion which is typically referenced in the noise agreements for associated receivers.

If an agreement is unable to be negotiated, the compliance status for this receiver would be dependent on the actual emissions of the turbines which are proposed to be verified through sound power level testing carried out prior to development of the wind farm. The compliance status would also be dependent on the outcomes of updated background noise monitoring to determine the applicable noise limits. However, in advance of this data becoming available, a range of mitigation options have been identified which could be used to achieve the base criterion of 35 dB. These options range from mitigation measures based on turbine shutdowns, reduced power modes, or a combination of the two. The following provides an indication of the types of strategies which could be adopted during a set range of non-dominant wind directions if ultimately required:

- Mitigation based on shutdowns only: shutdown of five (5) turbines.
- Mitigation based on reduced power modes only: configuration of up to twenty seven (27) turbines in a reduced power mode (reduced from 3.4MW to 3.0MW) which corresponds to a 2.5 dB reduction in emissions relative to the sound power levels referenced in this assessment
- Mitigation based on a combination of shutdowns and reduced power modes: a number of additional scenarios have been assessed with a combination of reduced power modes and turbine shutdowns that demonstrate compliance is achievable.

The above are example strategies only which demonstrate the viability of achieving compliance with the base criterion of 35 dB. If ultimately required, the precise form of the mitigation strategy would be dependent on the verified emissions of the turbines and the background noise levels in the vicinity of C04.