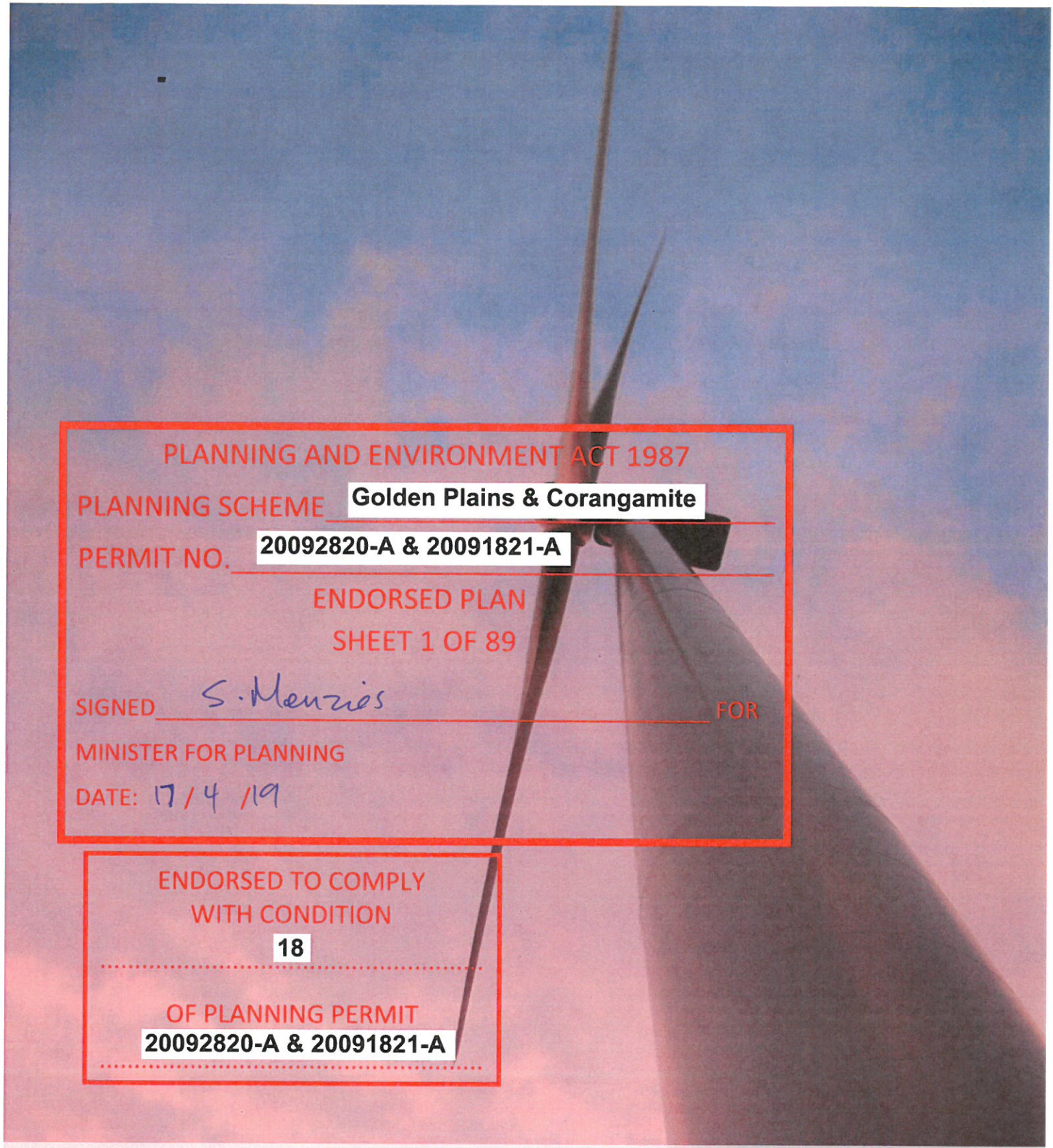

PLANNING AND ENVIRONMENT ACT 1987

PLANNING SCHEME Golden Plains & Corangamite

PERMIT NO. 20092820-A & 20091821-A

ENDORSED PLAN

SHEET 1 OF 89

SIGNED S. Menzies FOR

MINISTER FOR PLANNING

DATE: 17 / 4 /19

ENDORSED TO COMPLY
WITH CONDITION

18

OF PLANNING PERMIT

20092820-A & 20091821-A

MARSHALL DAY Acoustics

BERRYBANK WIND FARM
PRE-DEVELOPMENT NOISE ASSESSMENT

Rp 002 R02 20180495 | 8 April 2019

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SHEET 2 OF 89

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Pre-construction noise assessment

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Report No.: **002 R02 20180459**

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Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	-	For external issue	27 June 2018	C. Delaire	J. Adcock
Complete	01	Response to DEWLP comments	12 Mar. 2019	C. Delaire	-
Complete	02	Response to further DEWLP comments	8 Apr. 2019	C. Delaire	-

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EXECUTIVE SUMMARY

This report presents the results of an updated assessment of operational wind turbine noise for the approved Berrybank Wind Farm (the wind farm) that is being developed by Global Power Generation Australia Pty Ltd, through its subsidiary Berrybank Development Pty Ltd (BDPL).

Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, were issued on 4 February 2018 (the Planning Permits).

This report has been prepared to satisfy Condition 18 of the Planning Permits which requires an updated noise assessment to be completed prior to the commencement of development of the wind farm. Condition 17 of the Planning Permits requires the assessment to be conducted in accordance with the noise criteria specified in NZS 6808:2010 *Acoustics – Wind farm noise*, consistent with current wind farm noise guidelines in Victoria.

The updated assessment has been carried out on the basis of the proposed layout comprising seventy-nine (79) Vestas V136-4.2MW wind turbines with a hub height of 112 m.

Vestas performance specifications for the V136-4.2MW were provided as the basis for the assessment, comprising noise emissions data based on results in accordance with IEC 61400-11:2012 *Wind turbines – Part 11: Acoustic noise measurement techniques* (IEC 61400-11:2012) for a range of configurations of the turbine. The standard configuration of the turbine has been selected for the Berrybank Wind Farm, which incorporates serrated turbine blades and does not utilise sound management modes. The noise emission data for the standard configuration is consistent with the range of values expected for the class of turbine being installed at the site.

The noise emission data has been used with international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2) to predict the level of noise expected occur at neighbouring sensitive receiver locations. The ISO 9613-2 standard has been applied on the basis of well-established input choices and adjustments, based on research and international guidance, that are specific to wind farm noise assessment.

The results of the noise predictions for the Berrybank Wind Farm demonstrate that the predicted noise levels for the proposed turbine model and associated layout achieve the noise limits determined in accordance with NZS 6808:2010, as required by the Planning Permits.

The updated noise assessment therefore demonstrates that the Berrybank Wind Farm is expected to comply with the operational noise requirements of the Planning Permits.

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1.0 INTRODUCTION

This report presents the results of a pre-construction operational noise assessment for the approved Berrybank Wind Farm.

The Berrybank Wind Farm (the wind farm) is a consented project located across the Golden Plains Shire and Corangamite Shire, near the township of Berrybank, Victoria. The Planning Permits for the Berrybank Wind Farm include conditions which specify requirements for the control of environment noise associated with the project.

Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, were issued on 4 February 2018 (the Planning Permits).

The Planning Permits allow for the use and development of a wind energy facility comprising a maximum of seventy-nine (79) wind turbines[1], subject to a set of conditions relating to matters including environmental noise levels.

Global Power Generation Australia Pty Ltd, through its subsidiary Berrybank Development Pty Ltd (BDPL), is developing the wind farm and commissioned this report to address Condition 18 of the Planning Permits which requires an updated assessment of operational noise to be carried out prior to construction of the wind farm.

The updated noise assessment presented in this report is based on:

- Operational noise limits derived in accordance with Condition 17 of the Planning Permits
- Predicted noise levels for the proposed Berrybank Wind Farm design comprising seventy-nine (79) Vestas V136-4.2MW wind turbines with rated power of 4.2 MW per turbine and a hub height of 112 m
- A comparison of the predicted noise levels with the criteria derived in accordance with NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as specified in the Planning Permits.

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016[2]. 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 dB L_A. 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 any dwelling existing on land in the vicinity of the proposed wind energy facility as at 3 April 2017 as stated in the Planning Permits.

[1] Forty-one (41) turbines within the Corangamite Shire and thirty-eight (38) turbines in the Golden Plains Shire.

[2] ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures.*

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2.0 PROJECT DESCRIPTION

2.1 Overview

The Berrybank Wind Farm comprise seventy-nine (79) wind turbines extending over an area spanning approximately 12.5 km from north to south and 8.5 km east to west. The coordinates of the proposed wind farm are tabulated in Appendix B.

A total of sixty-five (65) noise receivers surrounding and within the Berrybank Wind Farm have been considered in this noise assessment. The assessed noise receivers consist of the following:

- Twelve (12) receivers located within the wind farm site boundary, which are collectively referred to as stakeholder receivers herein
- Fifty-three (53) receivers located outside of the wind farm site boundary, which are collectively referred to as noise sensitive locations.

In accordance with Section 2.4 of NZS 6808:2010, *noise sensitive locations* are defined as follows:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site.*

Therefore, all dwellings located within the wind farm boundaries (stakeholder dwellings) are not considered to be noise sensitive receptors in accordance with the NZS 6808:2010. As such, noise limits required by the standard do not apply to stakeholder dwellings.

For the purposes of this assessment, the recommended noise limits included in the final report by *The European Working Group on Noise from Wind Turbines* (ETSU-R-97) have been used as reference level for stakeholder dwellings.

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.

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2.2 Wind turbine model

The wind farm is to comprise seventy-nine (79) Vestas V136-4.2MW wind turbines with a rotor diameter of 136 m and a hub height of 112 m.

The Vestas V136-4.2MW model 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).

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

Table 1: Proposed wind turbine model

Detail	Description
Make	Vestas
Model	V136
Rated power	4.2 MW
Rotor diameter	136 m
Hub height	112 m
Tip height	180 m
Blade orientation	Upwind
Turbine regulation method	Variable blade pitch
Cut-in wind speed (hub height)	3.0 m/s
Rated power wind speed (hub height)	13.0 m/s
Cut-out wind speed (hub height)	25.0 m/s

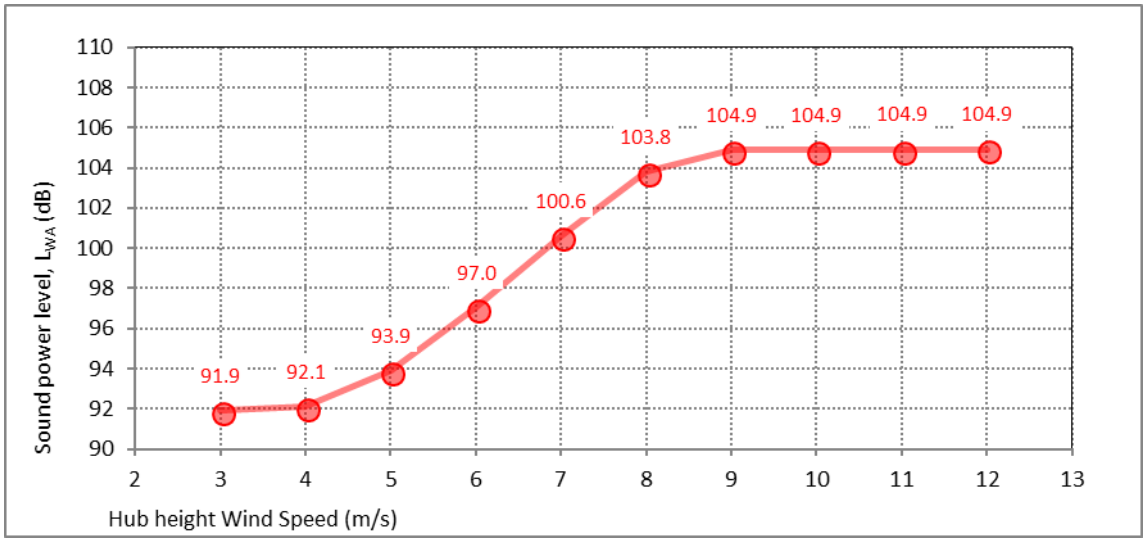
2.3 Noise emissions

The noise emissions of the wind turbines are described in terms of the sound power level for different wind speeds. 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 proposed turbine model were sourced from specification data detailed in Vestas document No. 0067-4732_02 *V136-4.0/4.2 MW Third octave noise emission* dated 20 March 2018. The sound power data has been adjusted by the additional of +1 dB at each wind speed to provide a margin for typical values of test uncertainty.

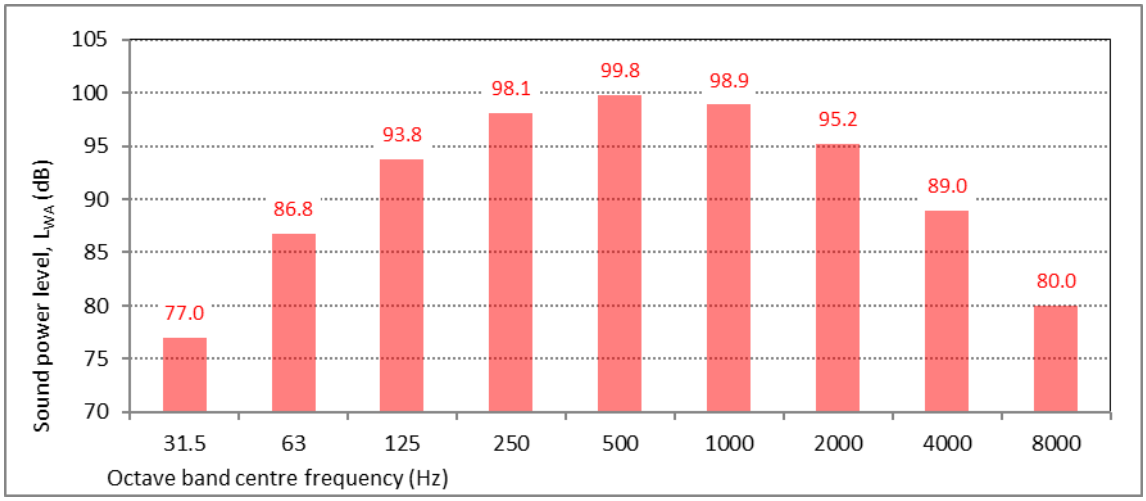
The sound power levels referenced in this assessment (including the +1 dB adjustment) for the standard configuration of the turbine (PO1 operating mode with serrated trailing edge – sound management modes not utilised), are summarised in Figure 1 and represent the total emissions of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans).

Figure 1: Vestas V136-4.2MW sound power level versus hub height wind speed, dB L_{WA}



The reference spectrum used as the basis for this assessment is illustrated in Figure 2, corresponding to the highest overall sound power level presented in Figure 1 (including the +1 dB adjustment).

Figure 2: Vestas V136-4.2MW assessment sound power level spectrum, dB L_{WA}



The sound power levels illustrated in Figure 1 and Figure 2 are considered typical of the upper range of noise emissions associated with comparable multi-megawatt wind turbines.

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Test emission data indicating tonal audibility levels for the Vestas V136-4.2MW turbine were unavailable at the time of this assessment. In lieu of test data that is specific to the 4.2 MW variant, Vestas provided data for a lower powered variant, the V136-3.6MW. The tonal audibility levels for the Vestas V136-3.6MW have been provided in an IEC 61400-11:2012 noise emission test report[3] and have been referenced herein as an indication of potential tonal audibility levels for the V126-4.2 MW turbine. The results are reproduced in Table 2 and indicate tonal audibility levels below 0 dB at all assessed wind speeds.

Table 2: Measured tonal audibility

Hub height wind speed (m/s)	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**	**10.5**	**11.0**	**11.5**	**12.0**
$\Delta L_{a,k}$, dB	NRT	NRT	-1.1	NRT	NRT	NRT	NRT	NRT	NRT	NRT

Note: NRT (No Relevant Tone) indicates that no tones with tonal audibility higher than -3 dB were identified within the relevant wind speed bin

The occurrence of tonality in the noise emissions of contemporary multi-megawatt turbine designs is generally limited. The test results reproduced in Table 2 are considered typical for the type of turbine being considered for the Berrybank Wind Farm. Adjustments for tonality have therefore not been applied to the predicted noise levels presented in this assessment.

[3] Vestas document titled *Wind Turbine Noise Measurement, IEC 61400-11 Ed.3.0 – VESTAS V136-3.6MW, P01* (Report No.: P6.042.17 dated 20 September 2017)

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3.0 ASSESSMENT CRITERIA

3.1 Planning Permit

Conditions 17 to 19 of the Planning Permits establishes requirements relevant to operational noise associated with the project. The key requirements of the conditions are provided in Table 3 below and reproduced in full in Appendix E.

Table 3: Planning Permit – summary of operational noise related requirements

Condition	Summary of key requirements
17	Specifies the criteria that operational wind farm noise must comply with at noise sensitive locations, and specifies exemptions for dwellings where an agreement exists between a land owner and the project developer.
18	Establishes a requirement for a pre-construction noise assessment of operational wind turbine noise for the final turbine layout and turbine selection before development of the wind farm starts.
19	Specifies that a Noise Compliance Testing Plan (NCTP) must be prepared prior to commencement of development of the wind farm, addressing both construction and operational noise associated with the wind farm.

The Planning Permits refer to New Zealand Standard NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as the applicable standard for:

- The measurement and analysis of background noise levels; and
- The measurement, rating and assessment of operational wind farm noise levels, including the assessment of any Special Audible Characteristics associated with the sound of the wind farm.

This report addresses the requirement of Condition 18 for a pre-construction noise assessment of the wind farm in accordance with NZS 6808:2010, and provides information to address the assessment requirements specified in the Planning Permits. Specifically, compliance with applicable noise limits must be demonstrated *without operation in noise management mode unless the Minister for Planning consents to the use of noise management mode*.

3.2 Operational noise criteria

Operational wind farm noise limits apply at noise sensitive locations (as defined Section 2.4 of NZS 6808:2010) in the vicinity of the Berrybank Wind Farm, except where a noise agreement is in place with the landowner (participating receiver).

The noise criteria detailed in NZS 6808:2010 are defined using a combination of fixed values limits and background noise related limits. Section 5.2 of the NZS 6808:2010 specifies that wind farm sound levels at noise sensitive locations should not exceed the background sound level by more than 5dB, or a level of 40 dB $L_{A90,}$ whichever is greater.

The fixed value component of the limits is set at a value of 40 dB L_{A90} except in those instances where the high amenity provisions of NZS 6808:2010 are applicable.

The subject of high amenity limits was considered as part of the panel hearing associated with the amendment of the planning permits for the Berrybank Wind Farm. The panel report dated 19 December 2017 addressed the subject in Section 6.4.2 and notes that the Panel concluded:

> *From the evidence provided to it, the Panel is of the opinion that the Berrybank wind farm is not in an area where the 'high amenity noise limit' would apply.*
>
> *There is nothing substantive in the amended proposal that affects the Panel's further consideration of Berrybank as a "High Amenity Area."*

Accordingly, the high amenity noise limits are not applicable to the Berrybank Wind Farm. The applicable noise limits in accordance with NZS 6808:2010 at noise sensitive locations in the vicinity of the wind farm are therefore defined as 40 dB L_{A90} or the background noise level L_{A90} + 5dB, whichever is higher.

In relation to the background conditions in the area, background noise levels were measured at multiple receiver locations in the vicinity of the wind farm as part of the planning stage noise assessment for the Berrybank Wind Farm. Prior to commencement of operation of the wind farm, it is proposed that repeat background noise monitoring will be undertaken to obtain an updated data set. In advance of this monitoring being carried out, a simplified and conservative approach has been adopted herein by comparing the predicted noise levels with the minimum limits which apply at non-participant receiver locations.

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4.0 NOISE PREDICTION METHODOLOGY

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

- The sound emissions of the Vestas V136-4.2MW wind turbines as outlined in Section 2.3
- A 3D digital 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.

The prediction method is consistent with the guidance provided by NZS 6808:2010, as referenced in the Planning Permits. This method has been shown to provide a reliable method of predicting the level of noise expected in practice.

The noise prediction method is summarised in Table 4 below.

Table 4: Downwind prediction methodology

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.0
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 modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below. Further discussion of the prediction method is provided in Appendix G.
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	10 m elevation contours downloaded from the Victorian Government Data Directory

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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 G. 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 Berrybank Wind Farm will be positioned across reasonably flat terrain at similar ground elevations to that of the surrounding receivers. As such, adjustments relating to valley effects and terrain screening are not a significant consideration for site. To verify this, a comparison of results from the detailed terrain-based modelling and a simplified flat site model indicate a small difference of predicted noise levels of up to 0.3 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 G. 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 ^{o}C and relative humidity 70 % 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. The calculations are based on sound speed profiles[4] 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.
Receiver heights	1.5 m above ground level

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[4] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

5.0 ASSESSMENT

This section of the report presents the predicted noise levels of the Berrybank Wind Farm at surrounding receiver locations, and an assessment of compliance with the applicable noise limits.

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 35 dB L_{A90} are listed in Table 5, along with the predicted noise levels when the wind farm's noise emissions have reached their highest level (corresponding to hub-height wind speeds of 9 m/s and above).

The location of the predicted 35 dB and 40 dB L_{A90} noise contours is illustrated in Figure 3.

Predicted noise levels for each integer wind speed are tabulated in Appendix H for all considered receiver locations, including dwellings where the highest predicted noise level is below 35 dB L_{A90}.

Table 5: Predicted noise level at receivers on or within the 35 dB L_{A90} predicted noise contour

Receiver Location	Highest predicted noise level dB L_{A90}	Compliance with NZS 6808:2010 base noise limit of 40 dB L_{A90}
9	37.9	Yes
10	37.5	Yes
18	36.0	Yes
27	35.1	Yes
54 (S)	40.6	Not applicable
55 (S)	38.7	Not applicable
56	38.9	Yes
57	38.3	Yes
58	36.0	Yes
61 (S)	41.2	Not applicable
62 (S)	41.2	Not applicable
63	38.4	Yes
64	36.0	Yes
65 (S)	46.1	Not applicable
66 (S)	42.2	Not applicable
67 (S)	37.3	Not applicable
68 (S)	37.3	Not applicable
69	37.6	Yes

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Receiver Location	Highest predicted noise level dB L_{A90}	Compliance with NZS 6808:2010 base noise limit of 40 dB L_{A90}
70	37.5	Yes
71	37.2	Yes
72	37.2	Yes
73	35.5	Yes
76 (S)	46.7	Not applicable
78 (S)	40.8	Not applicable
79	38.8	Yes
80	38.9	Yes
81 (S)	38.2	Not applicable
83	37.7	Yes
102	36.3	Yes
103	38.6	Yes
108	37.2	Yes
109	37.2	Yes
112 (S)	40.2	Not applicable

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(S) Stakeholder receiver

The results presented in Table 5 demonstrate that the predicted noise levels are below the minimum limit of 40 dB L_{A90} at all assessed noise sensitive receiver locations.

The predicted noise levels at all other receiver locations not listed in Table 5 are less than 35 dB L_{A90} (see Appendix H for results at these locations).

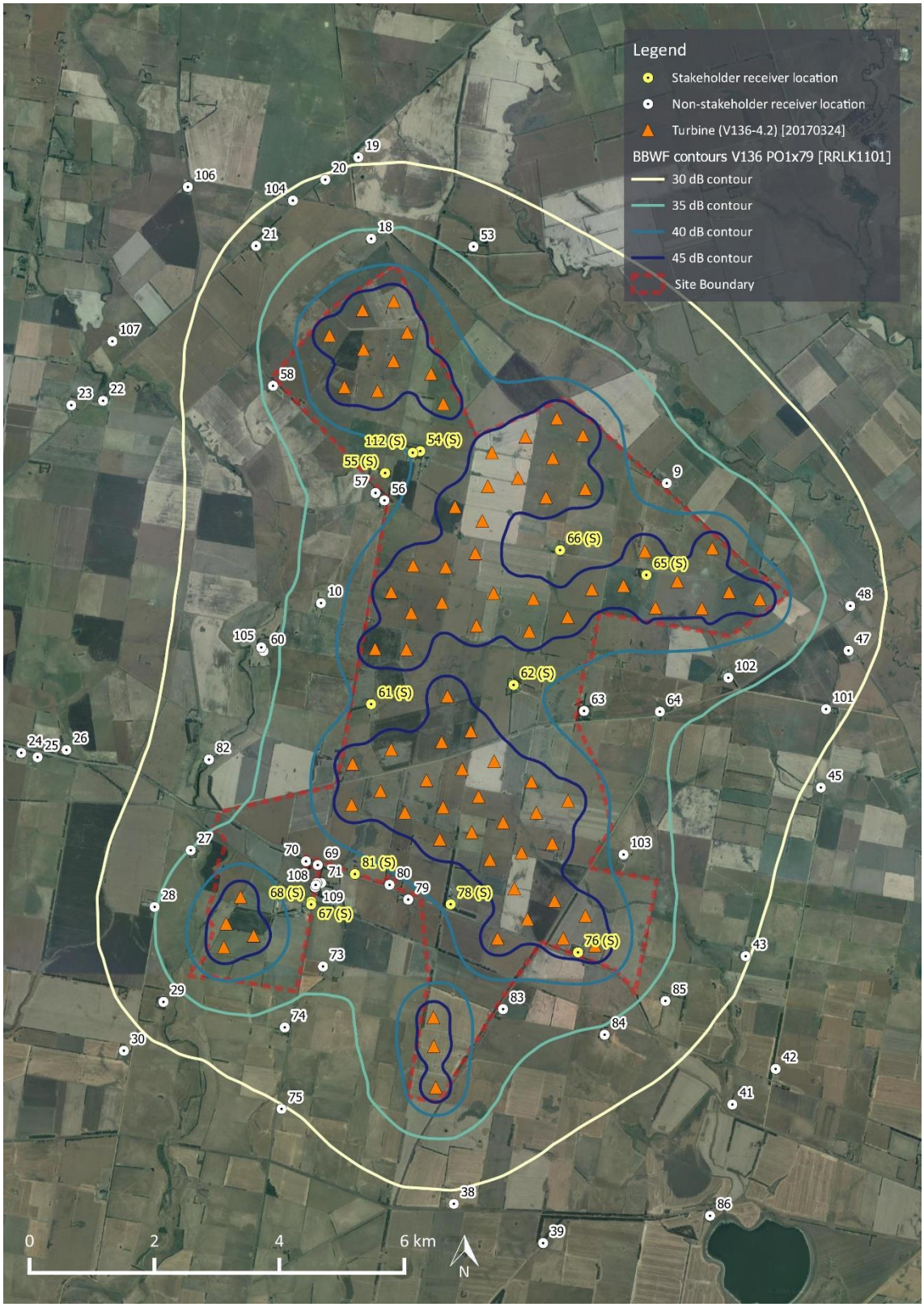
The results demonstrate that the Berrybank Wind Farm is predicted to comply with the operational noise requirements of the permit without operation in noise management mode. As such, no noise agreements are required to be obtained with landowners located outside of the wind farm site boundary (noise sensitive receivers).

For stakeholder receivers, it is current practice to use the recommendations outlined in the final report by *The European Working Group on Noise from Wind Turbines* (ETSU-R-97) which allows for the 40 dB L_{A90} minimum noise limit to be increased to a 45 dB L_{A90} reference noise level. This is consistent with the Victorian Wind Energy Guideline which recommends a level of 45 dB for this type of receiver.

Table 5 indicates that wind farm levels are predicted to exceed the 45 dB reference noise level at stakeholder receivers 65 and 76 by up to 1.1 and 1.7 dB, respectively.

We have been advised that landowners of stakeholder receivers 65 and 76 have agreed to the predicted exceedance over the reference level of 45 dB L_{A90}. Evidence of this agreement will be provided to the Minister for Planning by BDPL.

Figure 3: Berrybank Wind Farm - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)



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6.0 SUMMARY

An updated assessment of operational wind turbine noise for the Berrybank Wind Farm has been carried out. The purpose of the assessment was to address Condition 18 of the Planning Permits which require an updated noise assessment to be completed prior to the commencement of development of the wind farm.

The assessment has been undertaken on the basis of the proposed layout comprising seventy-nine (79) Vestas V136-4.2MW wind turbines. Vestas performance specifications for the V136-4.2MW were provided as the basis for the assessment, comprising noise emissions data based on results in accordance with IEC 61400-11:2012, for the standard configuration incorporating serrated turbine blades and without sound management modes. The noise emission data for this standard configuration is consistent with the range of values expected for the class of turbine being installed at the site.

Data relating to tonal audibility values has been provided for an alternative variant, the Vestas V136-3.6MW, and has been referenced as an indication of tonality for the V136-4.2MW turbine.

The available data supports that noise at surrounding receivers as a result of the Berrybank Wind Farm is not expected to be tonal. Adjustments for special audible characteristics have therefore not been applied to the predictions. In the event that test results in accordance with IEC 61400-11:2012 are not available prior to energisation of the wind farm, noise emissions of the turbines, including sound frequency and tonality characteristics, are proposed to be verified by on-site emission testing of the first turbines to commence operating at the site. The results of this testing will be used to verify the noise emission characteristics of the proposed V136-4.2MW turbine model.

The results of the noise predictions for the Berrybank Wind Farm demonstrate that the predicted noise levels for the proposed turbine model and associated layout achieve the noise criteria established by the permit. The updated noise assessment therefore demonstrates that the Berrybank Wind Farm is expected to comply with operational noise requirements of the Planning Permits. As such, no noise agreements are required to be obtained with landowners located outside of the wind farm site boundary.

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APPENDIX A GLOSSARY OF TERMINOLOGY

dB	Decibel. The unit of sound level.
L_W	The sound power level. The level of total sound power radiated by a sound source.
L_{WA}	The "A" weighted sound power level.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
L_{A90}	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.
Octave Band	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.

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APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed seventy-nine (79) wind turbine layout of the Berrybank Wind Farm (data supplied by ERM on behalf of BDPL on 27 April 2018 – layout reference v4 dated 24 March 2017).

Table 6: Berrybank Wind Farm turbine coordinates – WGS 84 zone 54

Turbine	Easting	Northing	Terrain elevation	Turbine	Easting	Northing	Terrain elevation
1	718723	5802176	187.9	51	725119	5798064	162.4
2	719252	5802580	192.4	52	722922	5798109	172.3
3	719751	5802721	200.0	54	722535	5797663	171.2
4	720031	5797730	178.5	55	720424	5790132	154.7
6	719967	5802221	199.5	57	720523	5797897	182.3
7	719492	5801285	194.5	58	720518	5795662	170.9
9	719747	5801765	196.9	59	720985	5795834	173.0
12	718962	5801349	190.0	60	721985	5797957	178.3
13	720348	5801559	200.0	61	721349	5798047	183.3
14	720545	5801081	199.6	62	717031	5792379	150.0
15	721921	5797435	177.4	63	720391	5790792	158.3
17	721258	5799760	191.1	64	723429	5798169	170.0
18	720733	5799429	190.0	65	719954	5797147	177.1
19	721859	5800552	190.4	66	720611	5796396	175.9
20	722364	5800847	190.0	67	719453	5797154	175.3
21	721322	5800299	193.4	69	721076	5797527	180.0
22	722296	5800211	186.5	72	719092	5795312	170.0
23	722817	5799718	181.4	73	719710	5795545	170.0
24	722780	5800575	187.1	74	717068	5792757	150.2
25	719710	5798063	177.8	75	719076	5794661	170.0
26	721169	5799204	189.5	76	719538	5794878	170.0
27	721740	5799891	190.0	77	720541	5794620	170.0
28	722189	5799582	184.2	78	720275	5795050	170.0
31	720387	5791255	160.0	79	720845	5795231	170.0
32	721000	5794218	167.1	80	722289	5794039	160.0
33	717508	5792561	151.4	82	719929	5794535	170.0
34	719266	5801952	192.9	84	721290	5793778	163.5
36	720062	5798490	181.5	85	721955	5795028	166.4
37	720583	5798464	187.0	86	722325	5793119	157.7
38	721057	5798686	189.0	88	720489	5794103	168.0
39	723772	5798717	171.2	89	721109	5794788	170.0
40	722821	5792881	152.3	90	721503	5794377	165.0

Turbine	Easting	Northing	Terrain elevation	Turbine	Easting	Northing	Terrain elevation
42	721414	5792516	162.0	93	722543	5794720	160.8
43	722465	5792519	157.4	94	722034	5794531	162.2
44	725612	5797947	159.9	96	721796	5793893	160.8
45	724851	5798766	168.9	97	721893	5792827	160.8
46	724683	5797804	162.4	98	721681	5793316	161.5
47	724291	5798236	167.0	99	722975	5792402	150.7
48	717298	5793181	152.1	100	721359	5795356	170.0
49	723942	5797816	164.2				

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APPENDIX C RECEIVER LOCATIONS

The following table sets out the sixty-five (65) noise sensitive receiver locations considered in the revised assessment. The receiver location data was provided by BDPL and was reviewed by MDA to confirm general consistency with noise sensitive locations evident in public aerial photography for the site. The variations were typically 20-30 m from the centre of the dwelling's roof which is inconsequential for the outcome of the noise assessment.

Table 7: Receiver locations – WGS84 zone 54

Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
9	724123	5799807	180.3	1,150
10	718587	5797888	172.7	1,141
18	719391	5803724	200.0	1,071
19	719185	5805026	196.9	2,376
20	718656	5804668	200.0	2,174
21	717547	5803608	190.0	1,856
22	715098	5801127	190.0	3,775
23	714589	5801057	191.6	4,284
24	713788	5795489	167.6	4,202
25	714049	5795420	165.3	3,947
26	714511	5795536	162.7	3,650
27	716501	5793929	160.0	1,099
28	715923	5793021	151.0	1,180
29	716065	5791501	141.4	1,310
30	715431	5790719	143.0	2,308
38	720714	5788267	143.7	1,891
39	722143	5787638	140.0	3,031
41	725172	5789858	130.4	3,363
42	725866	5790427	140.0	3,503
43	725385	5792233	150.0	2,418
45	726590	5794934	150.0	3,170
47	727033	5797127	152.3	1,644
48	727061	5797842	152.9	1,457
53	721028	5803596	191.1	1,552
54 (S)	720176	5800321	192.8	852
55 (S)	719613	5799970	189.1	1,249
56	719602	5799532	184.1	1,141

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Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
57	719459	5799651	183.5	1,298
58	717818	5801367	180.0	1,149
60	717667	5797118	165.3	1,790
61 (S)	719390	5796269	171.2	799
62 (S)	721670	5796577	178.9	901
63	722798	5796160	170.0	1,416
64	724012	5796148	160.0	1,673
65 (S)	723797	5798337	170.0	397
66 (S)	722414	5798736	177.3	814
67 (S)	718431	5793106	160.2	1,078
68 (S)	718429	5793061	160.0	1,054
69	718535	5793693	164.8	1,114
70	718346	5793752	163.8	1,171
71	718590	5793405	163.6	1,316
72	718520	5793406	163.2	1,247
73	718619	5792068	151.9	1,220
74	718006	5791092	150.0	1,555
75	717955	5789787	146.4	2,495
76 (S)	722702	5792294	154.4	314
78 (S)	720663	5793064	166.4	936
79	719983	5793140	168.9	1,093
80	719684	5793375	170.0	1,091
81 (S)	719130	5793548	168.0	1,120
82	716793	5795383	160.0	2,262
83	721502	5791385	157.3	1,128
84	723128	5790975	150.0	1,439
85	724101	5791516	147.7	1,437
86	724815	5788076	130.0	4,702
101	726673	5796189	150.6	2,056
102	725109	5796692	157.8	1,196
103	723431	5793860	153.6	1,159
104	718137	5804335	197.5	2,082
105	717630	5797179	163.3	1,827

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Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
106	716455	5804551	204.4	3,286
107	715247	5802080	190.0	3,479
108	718494	5793339	162.6	1,211
109	718502	5793373	162.9	1,224
112 (S)	720055	5800295	192.2	933

(S) Stakeholder receiver

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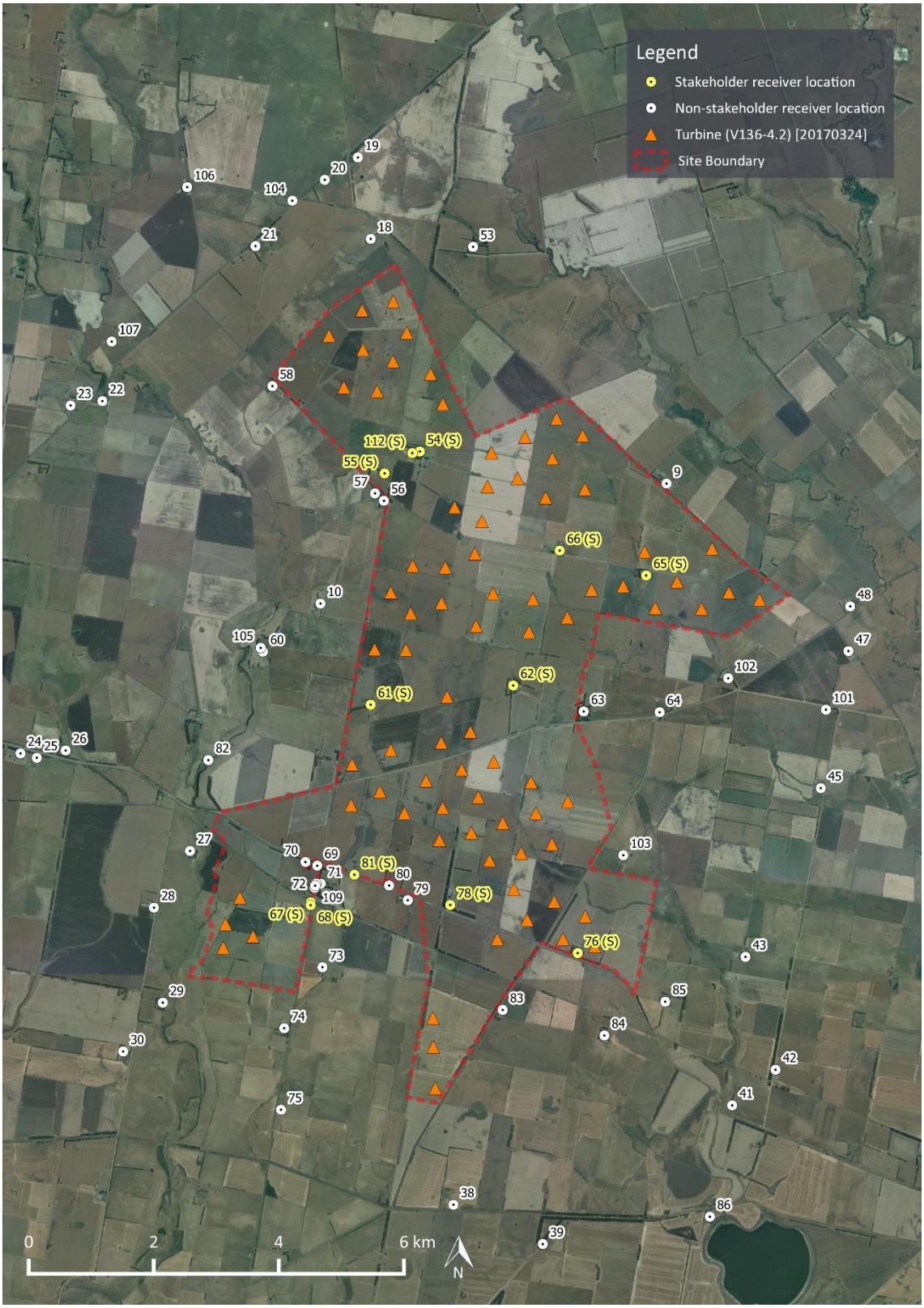
APPENDIX D SITE LAYOUT PLAN



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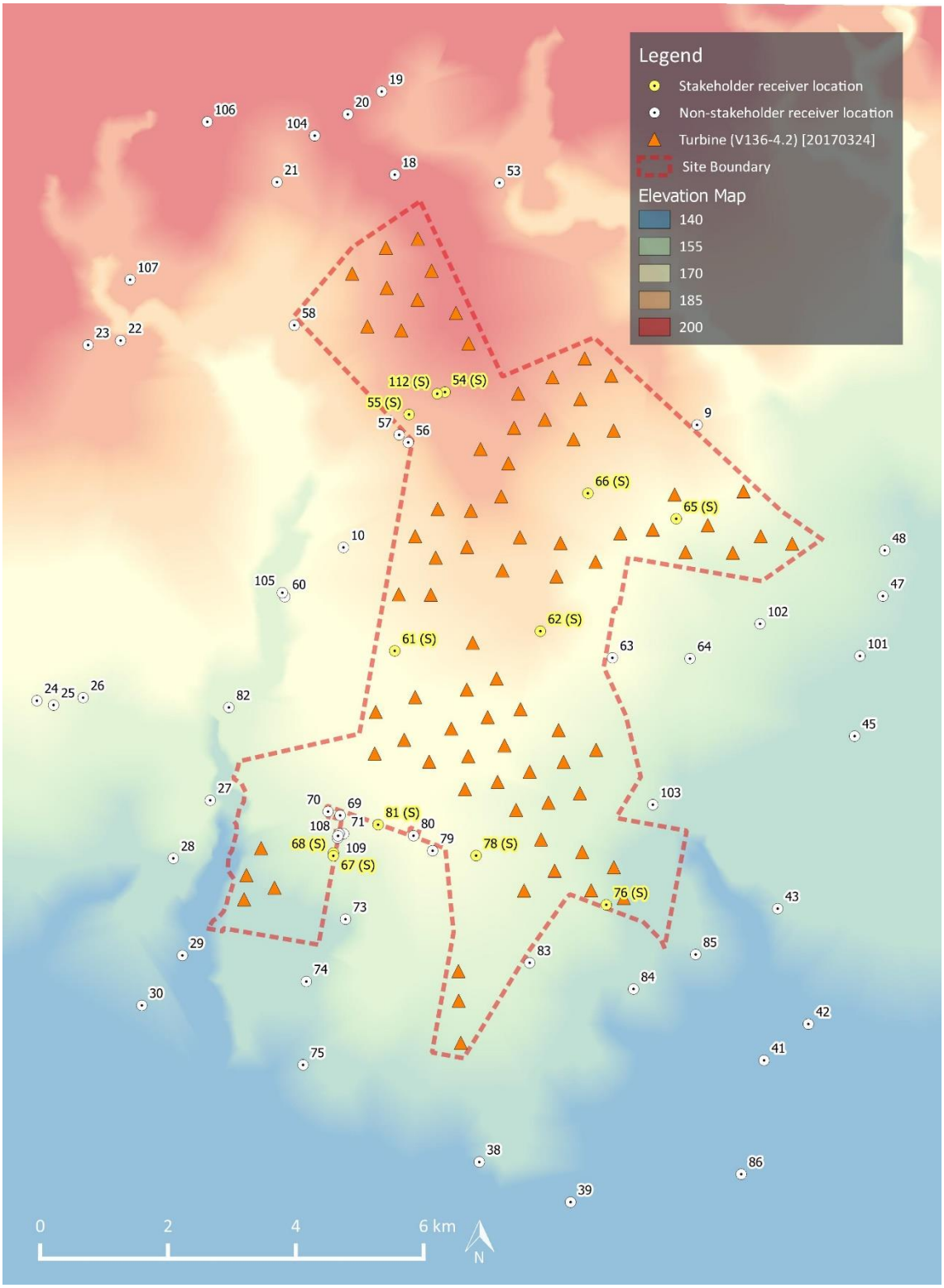
APPENDIX E SITE TOPOGRAPHY



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APPENDIX F PLANNING PERMIT – NOISE REQUIREMENTS

The following noise related conditions are defined in Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, issued on 4 February 2018

NOISE STANDARD

17. *Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808: 2010 'Acoustics – Wind farm noise' at any noise sensitive location that existed at 3 April 2017, to the satisfaction of the Minister for Planning.*

    The limits specified under this condition do not apply if an agreement has been into with the relevant landowner waiving the limits. Evidence of the agreement must be provided to the satisfaction of the Minister for planning upon request, and be in a form that applies to the land for the life of the wind energy facility.

PRE-CONSTRUCTION NOISE ASSESSMENT

18. *Before development starts, a pre-construction noise assessment based on the final turbine layout and turbine model to be installed must be undertaken and the results submitted to the Minister for Planning.*

    The pre-construction noise assessment must be prepared in accordance with the Standard and must demonstrate to the satisfaction of the responsible authority that the facility will comply with the performance requirements specified in Condition 17 without operation in noise management mode unless the Minister for Planning consents to the use of noise management mode.

    The pre-construction noise assessment report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the pre-construction assessment.

    If the proponent considers that a suitable cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the pre-construction noise assessment instead.

NOISE COMPLIANCE ASSESSMENT

19. *Before the development starts a noise compliance testing plan must be prepared by a suitably qualified acoustics expert to the satisfaction of the Minister for Planning.*

    When approved, the noise compliance testing plan will be endorsed by the Minister for Planning and will then form part of this permit.

    The noise testing must be carried out in accordance with the noise compliance testing plan to the satisfaction of the Minister for Planning.

    The noise compliance testing plan must include:

    a) *a determination of the noise limits to be applied during construction using the methodology prescribed in the EPA Noise Control Guidelines – publication 1254 released October 2008;*

    b) *a program of compliance testing to be implemented during the construction of the wind energy facility that:*

        (i) *Is designed by a suitably qualified acoustic expert; and*

        (ii) *Utilises the methodology prescribed in State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No N-1, to demonstrate compliance with the limits determined in (a) above.*

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c) a procedure for a near field compliance test of the first turbine commissioned at the wind energy facility; and

d) a procedure for a final compliance test of the wind energy facility after the commissioning of the last turbine, such testing to:

(i) consider compliance of the operational wind energy facility as a whole with the noise limits set under condition 17;

(ii) be carried out according to the method described in NZS6808: 2010 'Acoustics – Wind farm noise'; and

(iii) be submitted to the responsible authority within 6 months of the first turbine operating. Further post-construction acoustic compliance reports prepared in accordance with this condition must be submitted to the responsible authority annually from the date of the first report being submitted until the final turbine is operating.

The final compliance testing report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the compliance testing.

If the proponent considers that a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the noise compliance testing instead.

Compliance test results must be publicly available.

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APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* 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 2009 wind farm noise guidelines, AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and NZS 6808:2010 *Acoustics – Wind farm noise*.

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, 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

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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 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 °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 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 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 (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613 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 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 IOA good practice guide). 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 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;
- 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 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 8.0 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.

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APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA

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Table 8: Predicted Noise Levels

Receiver	Hub-height wind speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
9	24.9	25.1	26.9	30.0	33.6	36.8	37.9	37.9	37.9	37.9
10	24.5	24.7	26.5	29.6	33.2	36.4	37.5	37.5	37.5	37.5
18	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0
19	16.5	16.7	18.5	21.6	25.2	28.4	29.5	29.5	29.5	29.5
20	17.3	17.5	19.3	22.4	26.0	29.2	30.3	30.3	30.3	30.3
21	18.4	18.6	20.4	23.5	27.1	30.3	31.4	31.4	31.4	31.4
22	14.1	14.3	16.1	19.2	22.8	26.0	27.1	27.1	27.1	27.1
23	13.2	13.4	15.2	18.3	21.9	25.1	26.2	26.2	26.2	26.2
24	13.2	13.4	15.2	18.3	21.9	25.1	26.2	26.2	26.2	26.2
25	13.7	13.9	15.7	18.8	22.4	25.6	26.7	26.7	26.7	26.7
26	14.4	14.6	16.4	19.5	23.1	26.3	27.4	27.4	27.4	27.4
27	22.1	22.3	24.1	27.2	30.8	34.0	35.1	35.1	35.1	35.1
28	21.7	21.9	23.7	26.8	30.4	33.6	34.7	34.7	34.7	34.7
29	19.8	20.0	21.8	24.9	28.5	31.7	32.8	32.8	32.8	32.8
30	15.4	15.6	17.4	20.5	24.1	27.3	28.4	28.4	28.4	28.4
38	16.0	16.2	18.0	21.1	24.7	27.9	29.0	29.0	29.0	29.0
39	13.4	13.6	15.4	18.5	22.1	25.3	26.4	26.4	26.4	26.4
41	14.2	14.4	16.2	19.3	22.9	26.1	27.2	27.2	27.2	27.2
42	13.9	14.1	15.9	19.0	22.6	25.8	26.9	26.9	26.9	26.9
43	17.2	17.4	19.2	22.3	25.9	29.1	30.2	30.2	30.2	30.2
45	16.5	16.7	18.5	21.6	25.2	28.4	29.5	29.5	29.5	29.5
47	18.5	18.7	20.5	23.6	27.2	30.4	31.5	31.5	31.5	31.5
48	19.2	19.4	21.2	24.3	27.9	31.1	32.2	32.2	32.2	32.2
53	20.7	20.9	22.7	25.8	29.4	32.6	33.7	33.7	33.7	33.7
54 (S)	27.6	27.8	29.6	32.7	36.3	39.5	40.6	40.6	40.6	40.6
55 (S)	25.7	25.9	27.7	30.8	34.4	37.6	38.7	38.7	38.7	38.7
56	25.9	26.1	27.9	31.0	34.6	37.8	38.9	38.9	38.9	38.9
57	25.3	25.5	27.3	30.4	34.0	37.2	38.3	38.3	38.3	38.3
58	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0
60	21.0	21.2	23.0	26.1	29.7	32.9	34.0	34.0	34.0	34.0
61 (S)	28.2	28.4	30.2	33.3	36.9	40.1	41.2	41.2	41.2	41.2
62 (S)	28.2	28.4	30.2	33.3	36.9	40.1	41.2	41.2	41.2	41.2
63	25.4	25.6	27.4	30.5	34.1	37.3	38.4	38.4	38.4	38.4
64	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0

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Receiver	Hub-height wind speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
65 (S)	33.1	33.3	35.1	38.2	41.8	45.0	46.1	46.1	46.1	46.1
66 (S)	29.2	29.4	31.2	34.3	37.9	41.1	42.2	42.2	42.2	42.2
67 (S)	24.3	24.5	26.3	29.4	33.0	36.2	37.3	37.3	37.3	37.3
68 (S)	24.3	24.5	26.3	29.4	33.0	36.2	37.3	37.3	37.3	37.3
69	24.6	24.8	26.6	29.7	33.3	36.5	37.6	37.6	37.6	37.6
70	24.5	24.7	26.5	29.6	33.2	36.4	37.5	37.5	37.5	37.5
71	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
72	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
73	22.5	22.7	24.5	27.6	31.2	34.4	35.5	35.5	35.5	35.5
74	20.4	20.6	22.4	25.5	29.1	32.3	33.4	33.4	33.4	33.4
75	16.8	17.0	18.8	21.9	25.5	28.7	29.8	29.8	29.8	29.8
76 (S)	33.7	33.9	35.7	38.8	42.4	45.6	46.7	46.7	46.7	46.7
78 (S)	27.8	28.0	29.8	32.9	36.5	39.7	40.8	40.8	40.8	40.8
79	25.8	26.0	27.8	30.9	34.5	37.7	38.8	38.8	38.8	38.8
80	25.9	26.1	27.9	31.0	34.6	37.8	38.9	38.9	38.9	38.9
81 (S)	25.2	25.4	27.2	30.3	33.9	37.1	38.2	38.2	38.2	38.2
82	19.4	19.6	21.4	24.5	28.1	31.3	32.4	32.4	32.4	32.4
83	24.7	24.9	26.7	29.8	33.4	36.6	37.7	37.7	37.7	37.7
84	21.0	21.2	23.0	26.1	29.7	32.9	34.0	34.0	34.0	34.0
85	20.3	20.5	22.3	25.4	29.0	32.2	33.3	33.3	33.3	33.3
86	11.9	12.1	13.9	17.0	20.6	23.8	24.9	24.9	24.9	24.9
101	17.9	18.1	19.9	23.0	26.6	29.8	30.9	30.9	30.9	30.9
102	23.3	23.5	25.3	28.4	32.0	35.2	36.3	36.3	36.3	36.3
103	25.6	25.8	27.6	30.7	34.3	37.5	38.6	38.6	38.6	38.6
104	17.7	17.9	19.7	22.8	26.4	29.6	30.7	30.7	30.7	30.7
105	20.8	21.0	22.8	25.9	29.5	32.7	33.8	33.8	33.8	33.8
106	13.8	14.0	15.8	18.9	22.5	25.7	26.8	26.8	26.8	26.8
107	14.0	14.2	16.0	19.1	22.7	25.9	27.0	27.0	27.0	27.0
108	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
109	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
112 (S)	27.2	27.4	29.2	32.3	35.9	39.1	40.2	40.2	40.2	40.2

(S) Stakeholder receiver

APPENDIX I DOCUMENTATION

(a) Map of the site showing topography, turbines and residential properties: See Appendix D

(b) Noise sensitive locations: See Section 2.1 and Appendix C

(c) Wind turbine sound power levels, L_{WA} dB (also refer to Section 2.3)

Sound power levels (including + 1dB margin for uncertainty)

	Hub height wind speed (m/s)									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
L_{WA} (dB)	91.9	92.1	93.9	97.0	100.6	103.8	104.9	104.9	104.9	104.9

Reference octave band spectrum adjusted to 104.9 dB L_{WA}

	Octave Band Centre Frequency (Hz)								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
L_{WA} (dB)*	77.0	86.8	93.8	98.1	99.8	98.9	95.2	89.0	80.0

* Based on octave band spectral information at 20 m/s

(d) Wind turbine model: Vestas V136-4.2MW, details provided in Table 1 of Section 2.2

(e) Turbine hub height: 112 m

(f) Distance of noise sensitive locations from the wind turbines: See Appendix C

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v8.0 (See Section 4.0 and Appendix G)

(h) Meteorological conditions assumed:

- Temperature: 10 °C
- Relative humidity: 70 %
- Atmospheric pressure: 101.325 kPa

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(i) Air absorption parameters:

	Octave band mid frequency (Hz)							
Description	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Atmospheric attenuation (dB/km)	0.12	0.41	1.04	1.93	3.66	9.66	32.8	116.9

(j) Topography/screening:

10 m elevation contours downloaded from the Victorian Government Data Directory

Refer to turbine and receiver elevation data contained in Appendix B and Appendix C, and the topographical data illustrated in Appendix E.

(k) Predicted far-field wind farm sound levels: See Table 5 of Section 5.0 and Appendix H.

Peer Review Berrybank Wind Farm Pre-construction Noise Assessment

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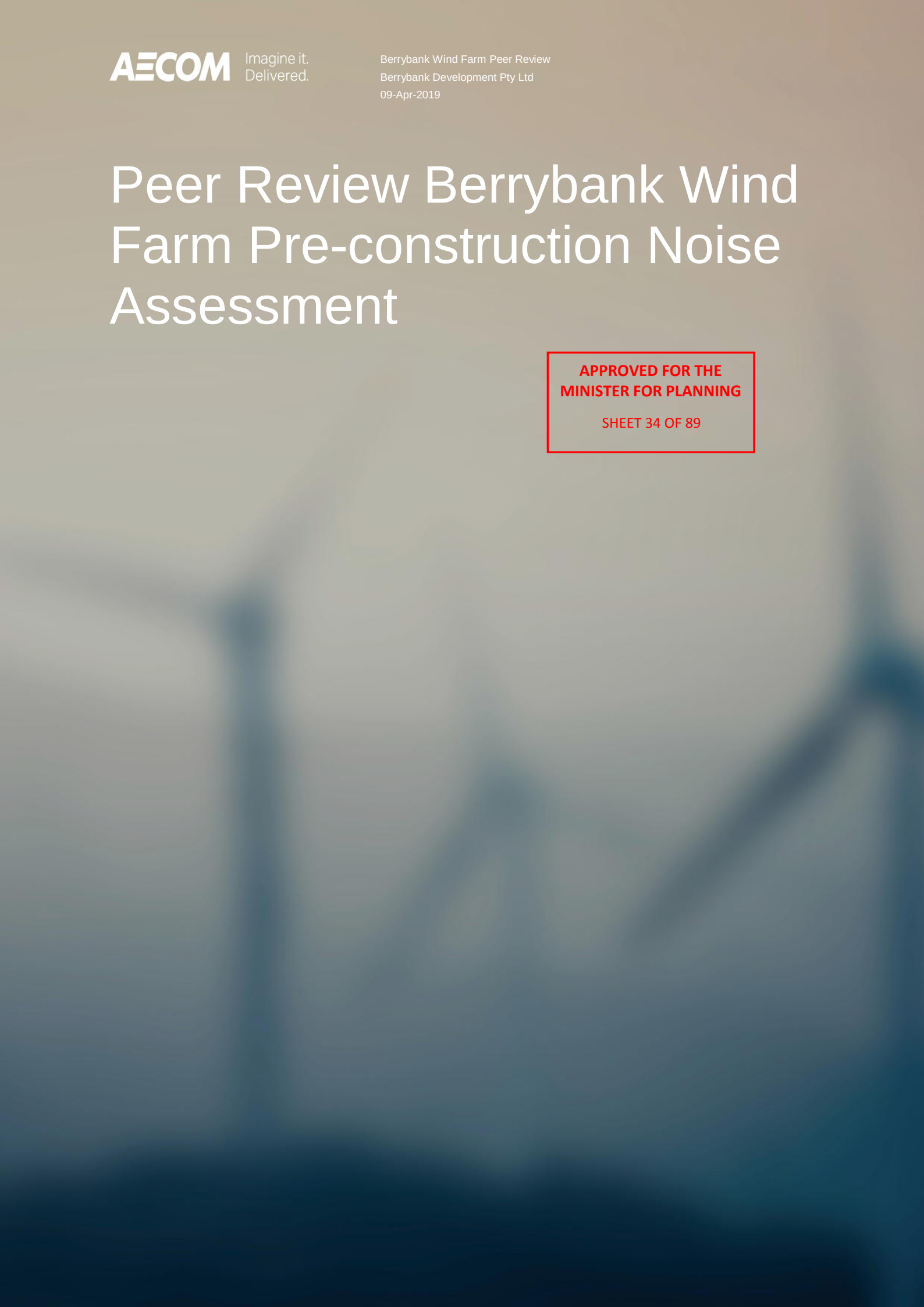

Peer Review Berrybank Wind Farm Pre-construction Noise Assessment

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Client: Berrybank Development Pty Ltd

ABN: 94146466882

Prepared by

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09-Apr-2019

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Quality Information

Document Peer Review Berrybank Wind Farm Pre-construction Noise Assessment

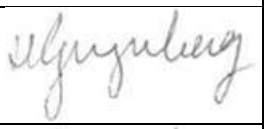
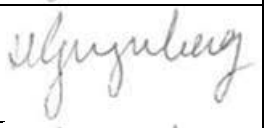
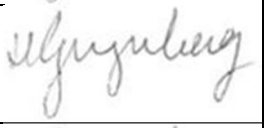
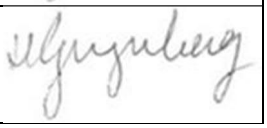
Ref c:\users\harry.grynberg\documents\windfarms\berrybank\reporting\noise compliance test plan april 2019\final\berrybank preconstruction noise assessemnt report_final_v4_ signed.docx

Date 09-Apr-2019

Prepared by Alex Dundon

Reviewed by Harry Grynberg

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
1	19 June 2018	issue	Harry Grynberg Technical Director	
2	11 March 2019	Revised based on DELWP comments	Harry Grynberg Technical Director	
3	8 April 2019	Revised based on Updated Preconstruction Noise Assessment April 2019	Harry Grynberg Technical Director	
4	9 April 2019	Revised based on DELWP request	Harry Grynberg Technical Director	

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Wind Farm Layout A

Appendix B
Pre-construction Noise Assessment Report B

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Declaration

I, Dr Harry Grynberg of AECOM Australia Pty Ltd, an environmental auditor (appointed pursuant to the Environment Protection Act 1970; 'the Act'), having:

1. been requested by Berrybank Development Pty Ltd to assess that the Pre-construction Noise Assessment prepared for the site located at Berrybank ('the site') for the purposes of construction of a proposed wind farm ('the works');

2. having had regard to, among other things:

Victorian Government Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated March 2019 except that the requirement for a Section 53V audit does not apply to this wind farm on the basis that, the wind farm was initially approved in 2010 with the planning permit amended in February 2018, as such November 2017 guidelines were used together with the following relevant documents: Standards New Zealand 2010; NZ6808:2010 Acoustics-Wind Farm Noise; Institute of Acoustics May 2013 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and rating of Windfarm noise; IEC 2012 Wind Turbines- Part 11: Acoustic Noise Measurement Techniques Ed 3 61400-11; and the planning permit conditions

3. considered the following documents: (i) Berrybank Wind Farm Pre-development Noise Assessment Marshall Day Acoustics April 2019 (ii) Vestas Turbine information (iii) site layout plan

4. with the support of Alex Dundon Principal Acoustics Engineer, Acoustic team Lead AECOM South Australia, Member of Australia Acoustical Society

5. concluding that the Berrybank Wind Farm Pre-development Noise Assessment Marshall Day Acoustics April 2019 has been prepared in accordance with Standards New Zealand 2010; NZ6808:2010 Acoustics-Wind Farm Noise

HEREBY DECLARE that I am of the opinion that the Pre-construction Noise Assessment contains adequate information of suitable quality to meet the planning permit requirements i.e. that the Pre-construction Noise Assessment for the wind turbines would not be contrary to, or inconsistent with, any applicable noise policy, the wind turbines are not likely to cause or contribute to noise pollution, or likely to cause an environmental hazard due to noise and that the noise requirements would be complied with should the works proceed.

DATED: 8 April 2019

Signed:

ENVIRONMENTAL AUDITOR (APPOINTED PURSUANT TO THE ENVIRONMENT PROTECTION ACT 1970)

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1.0 Introduction

Dr Harry Grynberg an Environmental Auditor (Industrial Facilities) appointed pursuant to the Environment Protection Act 2007 as amended was appointed by Berrybank Development Pty Ltd to undertake a peer review of the Pre-construction Noise Assessment of the proposed Berrybank Wind Farm.

1.1 Regulatory Requirements

The Victorian Government has issued Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated March 2019 in which the requirements of the Environmental Auditor Review are described. These are:

What is a statutory environmental audit conducted by an EPA appointed auditor?
An environmental audit of the wind energy facility noise assessments is conducted to verify that the noise assessments carried out by acoustic consultants on behalf of the proponent have been conducted in accordance with the Standard. The goal of including environmental audits in wind energy facility planning permit conditions is to assist responsible authorities in determining whether a proposed and / or operating wind energy facility will be able to operate in compliance with the Standard. In addition, conducting these audits will demonstrate that noise assessments have been carried out as per the methodology and requirements stated in the Standard. Environmental audits are required to be conducted on both the pre-construction (predictive) noise assessment and the post-construction noise assessment.
Reporting from an environmental audit will consist of a section 53V audit report stating the auditor's findings.
The report issued by the EPA appointed auditor is a declaration that the noise assessments:
1. have been conducted in accordance with the Standard; and
2. meet the requirements of the permit or other regulatory instruments.
The section 53V 'Risk of Harm' audit report, signed by the auditor, must address matters 1 and 2 above and detail the considerations they have relied upon in forming their views. This report should be thorough but concise. The report must have adequate detail including an annexure listing all documents examined or relied upon to permit any reader to follow the deliberations that the auditor undertook in forming their view.
Auditor duties

An EPA appointed auditor is expected in undertaking any function to apply sound engineering and audit practices, behaving in an ethical manner upholding the reputation of the "audit system" and adhere to the wording and intent of relevant guidelines. EPA has guidelines detailing the duties and responsibilities of an EPA appointed auditor. To find out more about the roles and responsibilities of an EPA appointed auditor, please visit the EPA website. A good starting point is EPA publication 865 Environmental Auditor Guidelines for Appointment and Conduct.

These requirements post-dated the planning permit (issued on 4 February 2018) and hence are not applicable to this development as the planning permit was issued before the revised policy and guidelines in March 2019. Therefore this is not a 53V "Risk of Harm" audit but is a Peer Review by an EPA appointed auditor. On this basis, the Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated November 2017 were applied as follows:

An assessment of compliance consists of two documents, being a declaration and a report supporting the declaration (an example of a similar declaration can be found in the EPA publication Landfill Licensing Guidelines, Publication 1323.2).

The declaration referred to above, issued by an EPA appointed auditor is a declaration that the noise assessment meets the requirements of:

1. *the appropriate standards*
2. *the permit or other regulatory instrument.*

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The declaration must be accompanied by a report, signed by the auditor, addressing the matters 1 and 2 above and detailing the considerations they have relied upon in forming their view. This report should be thorough but concise. The report must have adequate detail including an annexure listing all documents examined or relied up on to permit any reader to follow the deliberations that the auditor undertook in forming their view.

Auditor duties

An EPA appointed auditor is expected in undertaking any function to apply sound engineering and audit practices, behaving in an ethical manner upholding the reputation of the "audit system" and adhere to the wording and intent of relevant guidelines. EPA has guidelines detailing the duties and responsibilities of an EPA appointed auditor.

The Victorian EPA issued Guidelines in October 2018, for the conduct of the audit. As noted above these post-dated the planning permit and hence are not applicable to the peer review of the Berrybank Pre-construction Noise Assessment reported herein.

Approach to the Pre-construction predictive noise assessment peer review

The audit of the predictive noise assessment was conducted in a manner deemed appropriate by the environmental auditor and included the steps of:

- *Familiarization with the Wind Farm development proposal and planned operation.*
- *Inspection of the Wind farm project site and verification of the identified surrounding sensitive receptors (i.e. dwellings, etc.).*
- *Review of the pre-construction noise assessment considering the WEF development proposal and operations including, turbine technical specifications and power ratings, tower locations, topography, transformer stations and other relevant factors.*
- *Review of background noise assessments.*
- *Detailed review (audit) of the predictive noise assessment, including:*
  - *Methodology applied to conduct the assessment*
  - *Noise monitoring equipment and parameters used*
  - *Sound modelling programs employed*
  - *An assessment of Special Audible Characteristics (SACs) – Amplitude Modulation, Tonality and Impulsivity (described in Section 6.7 of the Standard).*
- *Risk assessments*
- *Preparation of the environmental noise peer review report*

1.2 Planning Permit Noise Conditions

The following are the noise conditions applicable to the development.

1.2.1 Corangamite and Golden Plains Planning Permit Noise Conditions

NOISE STANDARD

17 Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808:2010 *' Acoustics - Wind farm noise'* at any noise sensitive location that existed at 3 April 2017, to the satisfaction of the Minister for Planning.

The limits specified under this condition do not apply if an agreement has been entered into with the relevant landowner waiving the limits. Evidence of the agreement must be provided to the satisfaction of the Minister for Planning upon request, and be in a form that applies to the land for the life of the wind energy facility.

PRE-CONSTRUCTION NOISE ASSESSMENT

18 Before development starts, a pre-construction noise assessment based on the final turbine layout and turbine model to be installed must be undertaken and the results submitted to the Minister for Planning.

The pre-construction noise assessment must be prepared in accordance with the Standard, and must demonstrate to the satisfaction of the responsible authority that the facility will comply with the performance requirements specified in Condition 17 without operation in noise management mode unless the Minister for Planning consents to use of noise management mode.

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The pre-construction noise assessment report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the pre-construction assessment.

If the proponent considers that a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the pre-construction noise assessment instead.

NOISE COMPLIANCE ASSESSMENT

18 Before the development starts, a noise compliance testing plan must be prepared by a suitably qualified acoustics expert to the satisfaction of the Minister for Planning.

When approved, the noise compliance testing plan will be endorsed by the Minister for Planning and will then form part of this permit.

The noise testing must be carried out in accordance with the noise compliance testing plan to the satisfaction of the Minister for Planning.

The noise compliance testing plan must include:

a. a determination of the noise Limits to be applied during construction using the methodology prescribed in the EPA Noise Control Guidelines - publication 1254 released October 2008;
b. a program of compliance testing to be implemented during the construction of the wind energy facility that:
   (i) Is designed by a suitably qualified acoustic expert; and
   (ii) Utilises the methodology prescribed in *State Environment Protection Policy; (Control of Noise from Commerce, Industry, and Trade) No N-1,* to demonstrate compliance with the limits determined in (a) above.
c. a procedure for a near field compliance test of the first turbine commissioned at the wind energy facility; and
d. a procedure for a final compliance test of the wind energy facility after the commissioning of the last turbine, with such testing to:
   (i) consider compliance of the operational wind energy facility as a whole with the noise limits set under condition 17;
   (ii) be carried out according to the method described in New Zealand Standard 6808:2010 *' Acoustics - Wind farm noise' ;* and
   (iii) be submitted to the responsible authority within 6 months of the first turbine operating. Further post-construction acoustic compliance reports prepared in accordance with this condition must be submitted to the responsible authority annually from the date of the first report being submitted until the final turbine is operating.

The final compliance testing report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the compliance testing.

If the proponent considers that a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the noise compliance testing instead.

Compliance test results must be publicly available.

1.2.2 Corangamite Specific Additional Condition

20 A detailed noise assessment must be carried out in consultation with the owners of Lot 2 TP1324239C, Crown Allotment 16-21 Poliah South to determine an appropriate dwelling location, to

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the satisfaction of the Minister for Planning. The noise assessment under this condition must be carried out prior to commencement of operation of the wind farm unless varied with the written consent of the Minister for Planning.

1.3 Scope of Work

The scope of work has been prepared taking the requirements of the planning permit and guidance at the time of issuing the planning permit. The Victorian Government produced Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated March 2019. The Victorian EPA issued Wind energy facility noise Auditor guidelines (Publication1692 dated October 2018) that align with the Planning and Policy guidelines. As noted on the EPA website the guidelines are applicable to wind farms that obtain planning approval after October 2018. Therefore the March 2019 Section 53 audit requirements are not applicable to this peer review.
The subject of this report is the Pre-Construction Noise Assessment report. The detailed noise assessment report for "lot 2" is to be carried out before operation and was excluded from consideration in this report. The Noise Compliance Assessment has been reviewed in a separate document and is not part of this scope of work.
On this basis the scope is:

- Familiarization with the Wind Farm development proposal and planned operation.
- Discussion with Marshall Day regarding its approach and methodology
- Verification of the identified surrounding sensitive receptors (i.e. dwellings, etc) based on Google Maps.
- Review of the pre-construction noise assessment considering the WEF development proposal and operations including, turbine technical specifications and power ratings, tower locations, topography, transformer stations and other relevant factors.
- Review of background noise assessments.
- Detailed review (audit) of the predictive noise assessment, including:
  - Methodology applied to conduct the assessment
  - Noise monitoring equipment and parameters used
  - Sound modelling programs employed
  - An assessment of Special Audible Characteristics (SACs) – Amplitude Modulation, Tonality and Impulsivity (described in Section 6.7 of the Standard).
- Site inspection
- Preparation of the environmental noise peer review report and declaration.

2.0 Proposed Development

2.1 Site Location and layout

It is proposed to develop a wind farm area at Berrybank. The Berrybank Wind Farm site is located within the Corangamite and Golden Plains Shires, approximately 15 kilometres east of Lismore, 50 kilometres southwest of Ballarat and 70 kilometres west of Geelong. A total of 38 turbines are permitted is in the Corangamite Shire and 41 turbines in the Golden Plains Shire. The proposed layouts are shown in Figure 1 in Appendix A

2.2 Turbines

It is proposed to install 79 turbines manufactured by Vestas, model V136-4_4.2 MW. The hub height of the turbines is 112m and the diameter of the rotors is 136m. It is proposed to use trailing edge serrated blades.

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3.0 Review of the Pre-construction Noise Assessment

Marshall Day Acoustics (MDA) undertook the pre-development noise assessment and prepared a report Berrybank Wind Farm Pre-development Noise Assessment April 2019 (Appendix B). The following is the findings of the peer review of the assessment and report.

3.1 Review of Input data

As part of our peer review, we have reviewed the input data used in the noise assessment. This information includes:

- Location of proposed turbines
- Technical data for proposed turbines, including sound power levels
- Location of sensitive receptors

In reviewing the information, we have the following findings:

- The locations used by MDA for noise modelling are consistent with the locations shown in the MDA report.
- Sound power levels have been adjusted by 1 dB to account for uncertainty. Data provided by Vestas appears to be measured data under IEC 61400-11 ed.3. The IOA Good Practice Guide suggests that where data is based on measured data under IEC 61400-11 ed.3, the test uncertainty should be added to the source level. In the absence of test uncertainty, a factor of +2 dB should be added.
- The data provided by Vestas is based on an L_{eq} sound power level. While we note that NZS 6808:2010 is not clear on the approach for converting between L_{Aeq} and L_{A90}, we note that the advice of the IOA Good Practice Guide suggests a −2 dB correction to obtain a sound power level on an L_{A90} basis. We note the commentary provided by Marshall Day within their report.
- We note that no non-associated receivers are above 39 dB(A). Therefore, we believe that the above items would not result in a change in the conclusions of the preconstruction noise assessment.
- There are no details on Special Audible Characteristics (SACs) for the specific wind turbines proposed for this project. We note that tonal audibility information is available for a similar wind turbine, and on this basis, we agree that no adjustment is required for tonality. However, post construction testing should confirm tonal audibility of the turbines following completion.
- The locations used for noise modelling of the most affected sensitive receptors (at which monitoring was also conducted) are considered appropriate. However, it was noted that receiver 107 does not appear to be in a location corresponding to the nearby residence. We suggest that this location should be corrected to the nearby residence, although we note that this should not affect the outcomes of the assessment.
- While we were provided a copy of the off-site transformer noise assessment, this was not reviewed as part of the audit, as it is not included as a condition under the planning permits, and is not a requirement under NZS 6808:2010. However, we note that this transformer is still required to achieve noise criteria under Noise from Industry in Rural Victoria (NIRV) (EPA publication 1411).

3.2 Review of Modelling Methodology

As part of our review of methodology, we have reviewed Marshall Day's assumptions, as well as the noise model used for prediction of noise levels. The review makes the following findings:

- The noise model was completed through the use of SoundPLAN 8.0 implementing the ISO 9613-2 prediction algorithm. We agree that this software and algorithm is appropriate for modelling of noise from wind turbines.

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- The inputs as documented within the preconstruction noise assessment report were used for the noise modelling.
- The IOA methodology as used by MDA in their assessment provides appropriate assumptions for modelling of wind turbine noise.
- Turbine locations and source levels provided in the MDA report were input into the noise model, as were receptor locations. Heights for sources and receptors were consistent with requirements.
- Based on onsite verification, and analysis of calculation results, in our opinion, ISO 9613-2 with a ground absorption factor of G = 0.5 is the appropriate methodology for the Berrybank Wind Farm. The approach is considered conservative.

3.3 Review of Output data

All outputs from this modelling methodology complied with the requirements of NZ6808:2010 (i.e. complied with 40 dB(A), or background +5, whichever is higher). At all non-associated locations, predicted noise levels were equal to or below 40 dB(A) for all wind speeds.

3.4 Compliance with NZ6808:2010 Acoustics-Wind Farm Noise

The planning permit conditions require that the wind farm is operated in accordance with the NZ6808:2010 Acoustics-Wind Farm Noise (the standard). The assessment against the requirements of the standard relevant to the pre-construction noise assessment is presented in Table 1.

3.5 Compliance with the Planning Permit conditions

The summary of the assessment against the planning permit conditions is summarised in Table 2

3.6 Compliance with Pre-construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria.

The Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria (November 2017) require that this assessment address compliance with the guidelines. The assessment against this guideline is presented in Table 3.

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Table 1 Assessment of Preconstruction Noise assessment against NZ 6808:2010 Requirements

Relevant NZ 6808:2010 Requirement	Information	Commentary	Compliance
Section 3.1.2 A frequency weighted L_{90} to be used	MDA Report Section 5	It is noted that the provided sound power levels within the Vestas report are in L_{Aeq} terms. We understand that no adjustment has been made to convert this to L_{A90} terms. This will result in the project predicting higher noise levels.	Comply
Section 5.2 Noise limits	MDA Report	A noise limit of 40 dB L_{A90} has been applied for all receptors. This is more stringent than the background + 5 criteria that may apply at high wind speeds.	Comply
Section 5.3 High Amenity Areas requiring more stringent noise controls	MDA Report	As per the Berrybank Wind Farm Panel Report, no High Amenity Areas have been identified for the project.	Comply
Section 5.4 Special Audible Characteristics	MDA Report	Details on tonal audibility have been provided for a similar wind turbine model. No information on amplitude modulation has been provided at this stage; however, this is impractical to determine until after construction.	Comply – with post construction verification
Section 5.5 other factors (ultrasound and infrasound and building vibration)	MDA Report	Per NZS 6808:2010, other factors are not required to be assessed.	Comply
Section 5.6 Cumulative effects	MDA Report	No other wind turbines in the near vicinity.	Comply
Section 5.7 Uncertainty	MDA Report	An adjustment of 1 dB has been made to account for uncertainty. In the absence of measurement uncertainty data from Vestas, we recommend an adjustment of 2 dB.	Comply
Section 6.1.1 Methods	MDA Report	Prediction methods used are in accordance with industry standards and NZS 6808:2010	Comply
6.1.2 variables to be included	MDA Report	Required adjustments have been incorporated. While the Standard references directivity, and this has not been specifically incorporated; this will not affect the outcomes of the assessment.	Comply

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Relevant NZ 6808:2010 Requirement	Information	Commentary	Compliance
6.1.3 modelling	MDA Report	Use of ISO 9613-2 compliant with NZS 6808:2010.	Comply
6.1.4 octave bands to be addressed (63Hzto 4kHz)	MDA Report	Assessment looked at 31.5 Hz to 8 kHz	Comply
6.1.5 wind speed range (6-10 m/s)	MDA Report	Assessment from 3 to 12 m/s.	Comply
6.1.6 use of 95% rated power	MDA Report	Sound power used at 100% of rated power.	Comply
6.2.1 Use of Wind Turbine Sound Power Levels (SPL)	MDA Report	Sound power used in accordance with NZS 6808:2010	Comply
6.2.2 use of SPL against wind speed	MDA Report	Used in accordance with NZS 6808:2010	Comply
Appendix B-3 Amplitude Modulation		No amplitude modulation assessment has been made at this stage. However, it is noted that amplitude modulation is difficult to predict before construction, and an assessment should be made following construction.	Comply
Appendix C Uncertainty		An adjustment of 1 dB has been incorporated to account for uncertainty. Uncertainty was not provided to auditor for wind turbine sound power levels provided by Vestas.	Comply

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Table 2 Compliance with Planning Conditions

Planning Permit Condition	Information	Commentary	Compliance
3(a) 38 wind turbines (Corangamite PP) 3(a) 41 wind turbines (Golden Plains PP)	Proposed site Layout ERM Drawing0124588_BBWF_SITE_ LAYOUT_20180517.mxd dated 17/5/2018	The drawings show the 79 turbines	Comply
3(b) max height 180m	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The hub height of 112m and a diameter of 136m comply with this requirement	Comply
3(d) rotor tip blade at least 40m above ground level	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The hub height of 112m and a diameter of 136m comply with this requirement	Comply
Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808:2010 *' Acoustics - Wind farm noise'* at any noise sensitive location that existed at 3 April 2017, to the satisfaction of the Minister for Planning.	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The report demonstrates compliance with the noise condition 40 dBA_{L90} .	comply
The limits specified under this condition do not apply if an agreement has been entered into with the relevant landowner waiving the limits. Evidence of the agreement must be provided to the satisfaction of the Minister for Planning upon request, and be in a form that applies to the land for the life of the wind energy facility.	Berrybank Wind Farm Pty Ltd has advised that agreements are in place for the associated dwellings (54, 55,61,62,65,66,67,68,71,76,78,81and proposed 112). In addition agreements are being negotiated with dwellings 69,71,72,85,108 and 109.	Berrybank Wind Farm Pty Ltd should provide the Minister of Planning with the agreements	Comply subject to provision of the information
Before development starts, a pre-construction noise assessment based on the final turbine layout and turbine model to be installed must be undertaken and the results submitted to the Minister for Planning. The pre-construction noise assessment must be prepared in accordance with the Standard, and must demonstrate to the satisfaction of	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The report has been prepared in accordance with this condition	Comply

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Planning Permit Condition	Information	Commentary	Compliance
the responsible authority that the facility will comply with the performance requirements specified in Condition 17 without operation in noise management mode unless the Minister for Planning consents to use of noise management mode.			
The pre-construction noise assessment report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the pre-construction assessment.	Peer Review Berrybank Wind farm Pre – construction Wind Farm Pre-construction Noise assessment AECOM April 2019	This report has been prepared to address this requirement.	Comply
If the proponent considers that a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the pre-construction noise assessment instead	N/A	Independent Peer review conducted by and EPA accredited Auditor.	comply

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Table 3 Assessment of Compliance with Pre Construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria

Requirement of the Planning Policy (November 2017) as it relates to Noise and the Preconstruction Noise Assessment	Document	Comments	Compliance
A wind energy facility should comply with the noise limits recommended for dwellings and other noise sensitive locations in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard)	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The MDA Report demonstrates Compliance with this requirement.	Comply
The Standard specifies a general 40 decibel limit for wind farm sound levels, or the sound should not exceed the background sound level by more than five decibels, whichever is the greater. A 45 decibel limit is recommended for stakeholder dwellings. Under section 5.3 of the Standard, a 'high amenity noise limit' of 35 decibels applies in special circumstances. All wind farm applications must be assessed using section 5.3 of the Standard to determine whether a high amenity noise limit is justified for specific locations, following procedures outlined in clause C5.3.1 of the Standard. Guidance can be found on this issue in the VCAT determination for the Cherry Tree Wind Farm.	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	The 40dBA_{L90} criteria was used and complied with. The 45 decibel limit is discussed in section 5 and stakeholder agreements are being obtained and will be submitted to the department.	Comply
Certification of whether a wind energy facility complies with the Standard and other applicable noise requirements must be undertaken by an acoustic engineer. The wind energy facility operator must provide the responsible authority with appropriate documentation signed by an independent, appropriately qualified and experienced person. The certifier must be able to demonstrate to the responsible authority appropriate independence, qualifications and experience to carry out the task.	MDA Berrybank Wind Farm Pre-development Noise Assessment Report April 2019	This addresses the requirement	Comply
Wind farm noise compliance must be established by testing and reporting by specialist noise and acoustic consultants familiar with the application of the applicable standards and requirements. In seeking to achieve compliance, parties may seek to engage an environmental auditor, appointed under the Environment Protection Act 1970, to	See separate report Peer Review Berrybank Wind Farm Noise Compliance Test Plan	This addresses the requirement for a wind farm noise compliance assessment plan.	Comply to provision of a report on Wind Farm Operational

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Requirement of the Planning Policy (November 2017) as it relates to Noise and the Preconstruction Noise Assessment	Document	Comments	Compliance
conduct an assessment and verification of wind farm noise compliance. This assessment would verify noise compliance, with regard to the relevant standards and planning permit conditions, and this guideline.	AECOM April 2019		Noise Compliance.

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4.0 Conclusions

4.1 Compliance with the Appropriate Standards

The appropriate noise standards are defined in the planning permit and refers to standards derived from the **NZ 6808:2010.** The Pre-construction Noise Assessment was assessed and the results are presented in section 3 of this report. Based on that assessment it was concluded that the MDA report demonstrates compliance with the Appropriate Standards. We have relied on the Noise data provided by Vestas. Special Audible Characteristics will need to be assessed post construction. It was concluded that the Berrybank Wind Farm Pre-development Noise Assessment Marshall Day Acoustics April 2019 has been prepared in accordance with Standards New Zealand 2010; NZ68 08:2010 Acoustics-Wind Farm Noise

4.2 Compliance with the Pre Construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria.

Based on the assessment provided in Section 3, this assessment concludes with respect to the Pre-construction noise assessment, the guidelines have been complied with. . It was concluded that the Berrybank Wind Farm Pre-development Noise Assessment Marshall Day Acoustics April 2019 has been prepared in accordance with Standards New Zealand 2010; NZ68 08:2010 Acoustics-Wind Farm Noise

4.3 Compliance with the planning permit

Based on the assessment provided in section 3, the preconstruction noise assessment demonstrates compliance with the planning permit's requirements (clauses 17 and18) for the noise assessment.

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5.0 References

- Institute of Acoustics May 2013 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and rating of Windfarm noise
- IEC 2012 Wind Turbines- Part 11: Acoustic Noise Measurement Techniques Ed 3 61400-11
- Government of Victoria, November 2017, October 2018 and March 2019; Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria
- Standards New Zealand 2010; NZ6808:2010 Acoustics-Wind Farm Noise
- Marshall Day Acoustics 13 March 2019 Berrybank Wind Farm Noise Compliance Test Plan.R003
- Marshall Day Acoustics April 2019 Berrybank Wind Farm Pre-development Noise Assessment R002
- ERM May 2018 Site layout 1. 0124589_BBWF_Site_Layout_20180517.
- ERM August 2013 13. BBWF Endorsed EMP (Ref. 0124589 Berrybank EMP_Final_Rev03_August2013)
- Vestas 0067-4732_V02 - V136-4_0&4_2MW Third Octaves
- Vestas 0067-7065_V05 - Performance Specification V136-4.0_4.2MW
- Berrybank Development Pty Ltd Copy of 20150826 - BBWF House Coordinates (GDA94) v2 Excel Spreadsheet
- Planning Permit 20092820-A Golden Plains Planning Scheme dated 4 Feb 2018
- Planning Permit 20092821-A Corangamite Planning Scheme dated 4 Feb 2018

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6.0 Limitations

Dr Harry Grynberg (Technical Director – Environment) along with his support team from AECOM Australia Pty Ltd (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Berrybank Development Pty Ltd. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report. It is prepared in accordance with the scope of work and for the purpose outlined in the proposal dated.

It is acknowledged that the Audit Report may be used by Berrybank Development Pty Ltd in reaching conclusions about the site. The scope of work performed in connection with the audit may not be appropriate to satisfy the needs of any other person. Any other person's use of, or reliance on, the Audit Report, or the findings, conclusions, recommendations or any other material presented to them, is at that person's sole risk.

This Report was prepared between 1 June 2018 and 20 June 2018 and revised in April 2019, and is based on the conditions encountered and information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time.

The methodology adopted and sources of information used by Dr Harry Grynberg and the support team are outlined in this report. Dr. Harry Grynberg and the support team have made no independent verification of this information beyond the agreed scope of works and we assume no liability for any inaccuracies in or omissions to that information. No indications were found during our investigations that information contained in this report as provided to Dr Harry Grynberg and the support team was false.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Appendix A

Wind Farm Layout

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Legend

- Approved Wind Farm Layout (2017)
- Stakeholder Dwelling
- Stakeholder Dwelling (Uninhabitable)
- Non-stakeholder Dwelling
- Non-stakeholder Dwelling (Uninhabitable)
- Site Access Road Entrances
- Emergency Break Barrier
- Water Storage (BBWF-DP-08-v01)
- Proposed Access Tracks
- Proposed Underground Cabling
- Overhead Powerline (Existing)
- Approved 220kV Powerline Alignment
- Approved Off-Site Substation
- 1km Approved Turbine Buffer
- Site Boundary
- Site Batching Plant (BBWF-DP-07-v01 & BBWF-DP-06-v01)
- On-site Substation (endorsed) (BBWF-DP-03-v01)
- Site Compound: Completed Early Works
- LGA Boundary

Source: Stage 1 Proposed Layout v181031, Client Provided

Layout Infrastructure	Distance to Nearest Site Boundary
Concrete Batching Plant	1682 m
On-site Substation	937 m

Proposed Layout

Drawing No:	0124589_BBWF_Site_Layout_20190114.mxd		Berrybank Wind Farm
Date:	14/01/2019	Drawing Size: A3	
Drawn By:	GR	Reviewed By: CH	Client: Berrybank Development Pty Ltd

Coordinate System: GDA 1994 MGA Zone 54

0 1 2km N

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

ERM

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Appendix B

Pre-construction Noise Assessment Report

MARSHALL DAY Acoustics

BERRYBANK WIND FARM
PRE-DEVELOPMENT NOISE ASSESSMENT

Rp 002 R02 20180495 | 8 April 2019

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Pre-construction noise assessment

Prepared for: **Berrybank Development Pty Ltd**
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Suite 4, Level 3
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Attention: **Guillermo Alonso Castro**

Report No.: **002 R02 20180459**

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Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	-	For external issue	27 June 2018	C. Delaire	J. Adcock
Complete	01	Response to DEWLP comments	12 Mar. 2019	C. Delaire	-
Complete	02	Response to further DEWLP comments	8 Apr. 2019	C. Delaire	-

EXECUTIVE SUMMARY

This report presents the results of an updated assessment of operational wind turbine noise for the approved Berrybank Wind Farm (the wind farm) that is being developed by Global Power Generation Australia Pty Ltd, through its subsidiary Berrybank Development Pty Ltd (BDPL).

Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, were issued on 4 February 2018 (the Planning Permits).

This report has been prepared to satisfy Condition 18 of the Planning Permits which requires an updated noise assessment to be completed prior to the commencement of development of the wind farm. Condition 17 of the Planning Permits requires the assessment to be conducted in accordance with the noise criteria specified in NZS 6808:2010 *Acoustics – Wind farm noise*, consistent with current wind farm noise guidelines in Victoria.

The updated assessment has been carried out on the basis of the proposed layout comprising seventy-nine (79) Vestas V136-4.2MW wind turbines with a hub height of 112 m.

Vestas performance specifications for the V136-4.2MW were provided as the basis for the assessment, comprising noise emissions data based on results in accordance with IEC 61400-11:2012 *Wind turbines – Part 11: Acoustic noise measurement techniques* (IEC 61400-11:2012) for a range of configurations of the turbine. The standard configuration of the turbine has been selected for the Berrybank Wind Farm, which incorporates serrated turbine blades and does not utilise sound management modes. The noise emission data for the standard configuration is consistent with the range of values expected for the class of turbine being installed at the site.

The noise emission data has been used with international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2) to predict the level of noise expected occur at neighbouring sensitive receiver locations. The ISO 9613-2 standard has been applied on the basis of well-established input choices and adjustments, based on research and international guidance, that are specific to wind farm noise assessment.

The results of the noise predictions for the Berrybank Wind Farm demonstrate that the predicted noise levels for the proposed turbine model and associated layout achieve the noise limits determined in accordance with NZS 6808:2010, as required by the Planning Permits.

The updated noise assessment therefore demonstrates that the Berrybank Wind Farm is expected to comply with the operational noise requirements of the Planning Permits.

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1.0 INTRODUCTION

This report presents the results of a pre-construction operational noise assessment for the approved Berrybank Wind Farm.

The Berrybank Wind Farm (the wind farm) is a consented project located across the Golden Plains Shire and Corangamite Shire, near the township of Berrybank, Victoria. The Planning Permits for the Berrybank Wind Farm include conditions which specify requirements for the control of environment noise associated with the project.

Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, were issued on 4 February 2018 (the Planning Permits).

The Planning Permits allow for the use and development of a wind energy facility comprising a maximum of seventy-nine (79) wind turbines[1], subject to a set of conditions relating to matters including environmental noise levels.

Global Power Generation Australia Pty Ltd, through its subsidiary Berrybank Development Pty Ltd (BDPL), is developing the wind farm and commissioned this report to address Condition 18 of the Planning Permits which requires an updated assessment of operational noise to be carried out prior to construction of the wind farm.

The updated noise assessment presented in this report is based on:

- Operational noise limits derived in accordance with Condition 17 of the Planning Permits
- Predicted noise levels for the proposed Berrybank Wind Farm design comprising seventy-nine (79) Vestas V136-4.2MW wind turbines with rated power of 4.2 MW per turbine and a hub height of 112 m
- A comparison of the predicted noise levels with the criteria derived in accordance with NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as specified in the Planning Permits.

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016[2]. 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 dB L_A. 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 any dwelling existing on land in the vicinity of the proposed wind energy facility as at 3 April 2017 as stated in the Planning Permits.

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[1] Forty-one (41) turbines within the Corangamite Shire and thirty-eight (38) turbines in the Golden Plains Shire.

[2] ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures.*

2.0 PROJECT DESCRIPTION

2.1 Overview

The Berrybank Wind Farm comprise seventy-nine (79) wind turbines extending over an area spanning approximately 12.5 km from north to south and 8.5 km east to west. The coordinates of the proposed wind farm are tabulated in Appendix B.

A total of sixty-five (65) noise receivers surrounding and within the Berrybank Wind Farm have been considered in this noise assessment. The assessed noise receivers consist of the following:

- Twelve (12) receivers located within the wind farm site boundary, which are collectively referred to as stakeholder receivers herein
- Fifty-three (53) receivers located outside of the wind farm site boundary, which are collectively referred to as noise sensitive locations.

In accordance with Section 2.4 of NZS 6808:2010, *noise sensitive locations* are defined as follows:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site.*

Therefore, all dwellings located within the wind farm boundaries (stakeholder dwellings) are not considered to be noise sensitive receptors in accordance with the NZS 6808:2010. As such, noise limits required by the standard do not apply to stakeholder dwellings.

For the purposes of this assessment, the recommended noise limits included in the final report by *The European Working Group on Noise from Wind Turbines* (ETSU-R-97) have been used as reference level for stakeholder dwellings.

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.

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2.2 Wind turbine model

The wind farm is to comprise seventy-nine (79) Vestas V136-4.2MW wind turbines with a rotor diameter of 136 m and a hub height of 112 m.

The Vestas V136-4.2MW model 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).

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

Table 1: Proposed wind turbine model

Detail	Description
Make	Vestas
Model	V136
Rated power	4.2 MW
Rotor diameter	136 m
Hub height	112 m
Tip height	180 m
Blade orientation	Upwind
Turbine regulation method	Variable blade pitch
Cut-in wind speed (hub height)	3.0 m/s
Rated power wind speed (hub height)	13.0 m/s
Cut-out wind speed (hub height)	25.0 m/s

2.3 Noise emissions

The noise emissions of the wind turbines are described in terms of the sound power level for different wind speeds. 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 proposed turbine model were sourced from specification data detailed in Vestas document No. 0067-4732_02 *V136-4.0/4.2 MW Third octave noise emission* dated 20 March 2018. The sound power data has been adjusted by the additional of +1 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 dB adjustment) for the standard configuration of the turbine (PO1 operating mode with serrated trailing edge – sound management modes not utilised), are summarised in Figure 1 and represent the total emissions of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans).

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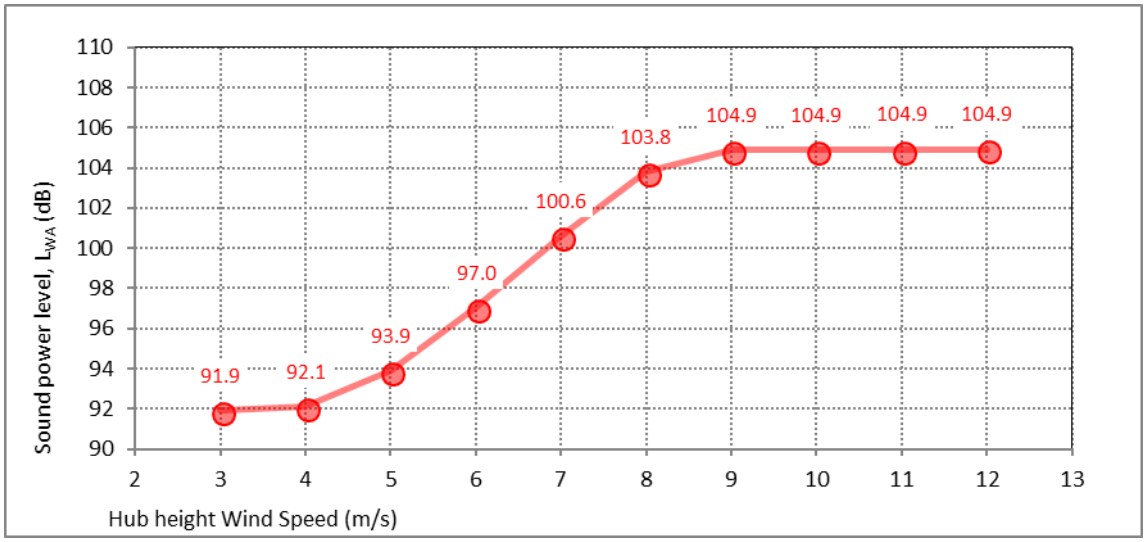
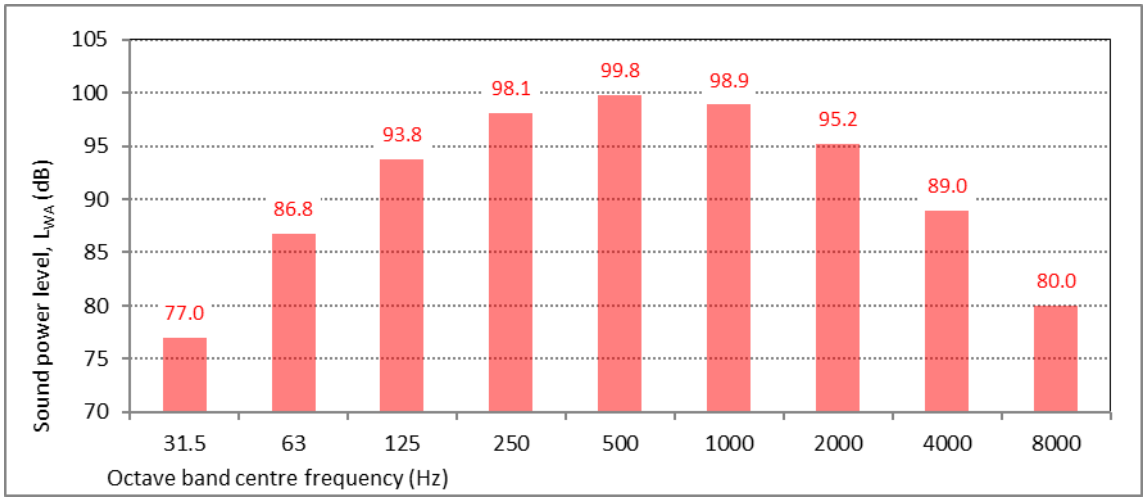
Figure 1: Vestas V136-4.2MW sound power level versus hub height wind speed, dB L_{WA}



The reference spectrum used as the basis for this assessment is illustrated in Figure 2, corresponding to the highest overall sound power level presented in Figure 1 (including the +1 dB adjustment).

Figure 2: Vestas V136-4.2MW assessment sound power level spectrum, dB L_{WA}



The sound power levels illustrated in Figure 1 and Figure 2 are considered typical of the upper range of noise emissions associated with comparable multi-megawatt wind turbines.

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Test emission data indicating tonal audibility levels for the Vestas V136-4.2MW turbine were unavailable at the time of this assessment. In lieu of test data that is specific to the 4.2 MW variant, Vestas provided data for a lower powered variant, the V136-3.6MW. The tonal audibility levels for the Vestas V136-3.6MW have been provided in an IEC 61400-11:2012 noise emission test report[3] and have been referenced herein as an indication of potential tonal audibility levels for the V126-4.2 MW turbine. The results are reproduced in Table 2 and indicate tonal audibility levels below 0 dB at all assessed wind speeds.

Table 2: Measured tonal audibility

Hub height wind speed (m/s)	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**	**10.5**	**11.0**	**11.5**	**12.0**
$\Delta L_{a,k}$, dB	NRT	NRT	-1.1	NRT	NRT	NRT	NRT	NRT	NRT	NRT

Note: NRT (No Relevant Tone) indicates that no tones with tonal audibility higher than -3 dB were identified within the relevant wind speed bin

The occurrence of tonality in the noise emissions of contemporary multi-megawatt turbine designs is generally limited. The test results reproduced in Table 2 are considered typical for the type of turbine being considered for the Berrybank Wind Farm. Adjustments for tonality have therefore not been applied to the predicted noise levels presented in this assessment.

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[3] Vestas document titled *Wind Turbine Noise Measurement, IEC 61400-11 Ed.3.0 – VESTAS V136-3.6MW, P01* (Report No.: P6.042.17 dated 20 September 2017)

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3.0 ASSESSMENT CRITERIA

3.1 Planning Permit

Conditions 17 to 19 of the Planning Permits establishes requirements relevant to operational noise associated with the project. The key requirements of the conditions are provided in Table 3 below and reproduced in full in Appendix E.

Table 3: Planning Permit – summary of operational noise related requirements

Condition	Summary of key requirements
17	Specifies the criteria that operational wind farm noise must comply with at noise sensitive locations, and specifies exemptions for dwellings where an agreement exists between a land owner and the project developer.
18	Establishes a requirement for a pre-construction noise assessment of operational wind turbine noise for the final turbine layout and turbine selection before development of the wind farm starts.
19	Specifies that a Noise Compliance Testing Plan (NCTP) must be prepared prior to commencement of development of the wind farm, addressing both construction and operational noise associated with the wind farm.

The Planning Permits refer to New Zealand Standard NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as the applicable standard for:

- The measurement and analysis of background noise levels; and
- The measurement, rating and assessment of operational wind farm noise levels, including the assessment of any Special Audible Characteristics associated with the sound of the wind farm.

This report addresses the requirement of Condition 18 for a pre-construction noise assessment of the wind farm in accordance with NZS 6808:2010, and provides information to address the assessment requirements specified in the Planning Permits. Specifically, compliance with applicable noise limits must be demonstrated *without operation in noise management mode unless the Minister for Planning consents to the use of noise management mode*.

3.2 Operational noise criteria

Operational wind farm noise limits apply at noise sensitive locations (as defined Section 2.4 of NZS 6808:2010) in the vicinity of the Berrybank Wind Farm, except where a noise agreement is in place with the landowner (participating receiver).

The noise criteria detailed in NZS 6808:2010 are defined using a combination of fixed values limits and background noise related limits. Section 5.2 of the NZS 6808:2010 specifies that wind farm sound levels at noise sensitive locations should not exceed the background sound level by more than 5dB, or a level of 40 dB $L_{A90,}$ whichever is greater.

The fixed value component of the limits is set at a value of 40 dB L_{A90} except in those instances where the high amenity provisions of NZS 6808:2010 are applicable.

The subject of high amenity limits was considered as part of the panel hearing associated with the amendment of the planning permits for the Berrybank Wind Farm. The panel report dated 19 December 2017 addressed the subject in Section 6.4.2 and notes that the Panel concluded:

> *From the evidence provided to it, the Panel is of the opinion that the Berrybank wind farm is not in an area where the 'high amenity noise limit' would apply.*
>
> *There is nothing substantive in the amended proposal that affects the Panel's further consideration of Berrybank as a "High Amenity Area."*

Accordingly, the high amenity noise limits are not applicable to the Berrybank Wind Farm. The applicable noise limits in accordance with NZS 6808:2010 at noise sensitive locations in the vicinity of the wind farm are therefore defined as 40 dB L_{A90} or the background noise level L_{A90} + 5dB, whichever is higher.

In relation to the background conditions in the area, background noise levels were measured at multiple receiver locations in the vicinity of the wind farm as part of the planning stage noise assessment for the Berrybank Wind Farm. Prior to commencement of operation of the wind farm, it is proposed that repeat background noise monitoring will be undertaken to obtain an updated data set. In advance of this monitoring being carried out, a simplified and conservative approach has been adopted herein by comparing the predicted noise levels with the minimum limits which apply at non-participant receiver locations.

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4.0 NOISE PREDICTION METHODOLOGY

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

- The sound emissions of the Vestas V136-4.2MW wind turbines as outlined in Section 2.3
- A 3D digital 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.

The prediction method is consistent with the guidance provided by NZS 6808:2010, as referenced in the Planning Permits. This method has been shown to provide a reliable method of predicting the level of noise expected in practice.

The noise prediction method is summarised in Table 4 below.

Table 4: Downwind prediction methodology

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.0
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 modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below. Further discussion of the prediction method is provided in Appendix G.
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	10 m elevation contours downloaded from the Victorian Government Data Directory

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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 G. 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 Berrybank Wind Farm will be positioned across reasonably flat terrain at similar ground elevations to that of the surrounding receivers. As such, adjustments relating to valley effects and terrain screening are not a significant consideration for site. To verify this, a comparison of results from the detailed terrain-based modelling and a simplified flat site model indicate a small difference of predicted noise levels of up to 0.3 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 G. 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 ^{o}C and relative humidity 70 % 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. The calculations are based on sound speed profiles[4] 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.
Receiver heights	1.5 m above ground level

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[4] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

5.0 ASSESSMENT

This section of the report presents the predicted noise levels of the Berrybank Wind Farm at surrounding receiver locations, and an assessment of compliance with the applicable noise limits.

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 35 dB L_{A90} are listed in Table 5, along with the predicted noise levels when the wind farm's noise emissions have reached their highest level (corresponding to hub-height wind speeds of 9 m/s and above).

The location of the predicted 35 dB and 40 dB L_{A90} noise contours is illustrated in Figure 3.

Predicted noise levels for each integer wind speed are tabulated in Appendix H for all considered receiver locations, including dwellings where the highest predicted noise level is below 35 dB L_{A90}.

Table 5: Predicted noise level at receivers on or within the 35 dB L_{A90} predicted noise contour

Receiver Location	Highest predicted noise level dB L_{A90}	Compliance with NZS 6808:2010 base noise limit of 40 dB L_{A90}
9	37.9	Yes
10	37.5	Yes
18	36.0	Yes
27	35.1	Yes
54 (S)	40.6	Not applicable
55 (S)	38.7	Not applicable
56	38.9	Yes
57	38.3	Yes
58	36.0	Yes
61 (S)	41.2	Not applicable
62 (S)	41.2	Not applicable
63	38.4	Yes
64	36.0	Yes
65 (S)	46.1	Not applicable
66 (S)	42.2	Not applicable
67 (S)	37.3	Not applicable
68 (S)	37.3	Not applicable
69	37.6	Yes

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Receiver Location	Highest predicted noise level dB L_{A90}	Compliance with NZS 6808:2010 base noise limit of 40 dB L_{A90}
70	37.5	Yes
71	37.2	Yes
72	37.2	Yes
73	35.5	Yes
76 (S)	46.7	Not applicable
78 (S)	40.8	Not applicable
79	38.8	Yes
80	38.9	Yes
81 (S)	38.2	Not applicable
83	37.7	Yes
102	36.3	Yes
103	38.6	Yes
108	37.2	Yes
109	37.2	Yes
112 (S)	40.2	Not applicable

(S) Stakeholder receiver

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The results presented in Table 5 demonstrate that the predicted noise levels are below the minimum limit of 40 dB L_{A90} at all assessed noise sensitive receiver locations.

The predicted noise levels at all other receiver locations not listed in Table 5 are less than 35 dB L_{A90} (see Appendix H for results at these locations).

The results demonstrate that the Berrybank Wind Farm is predicted to comply with the operational noise requirements of the permit without operation in noise management mode. As such, no noise agreements are required to be obtained with landowners located outside of the wind farm site boundary (noise sensitive receivers).

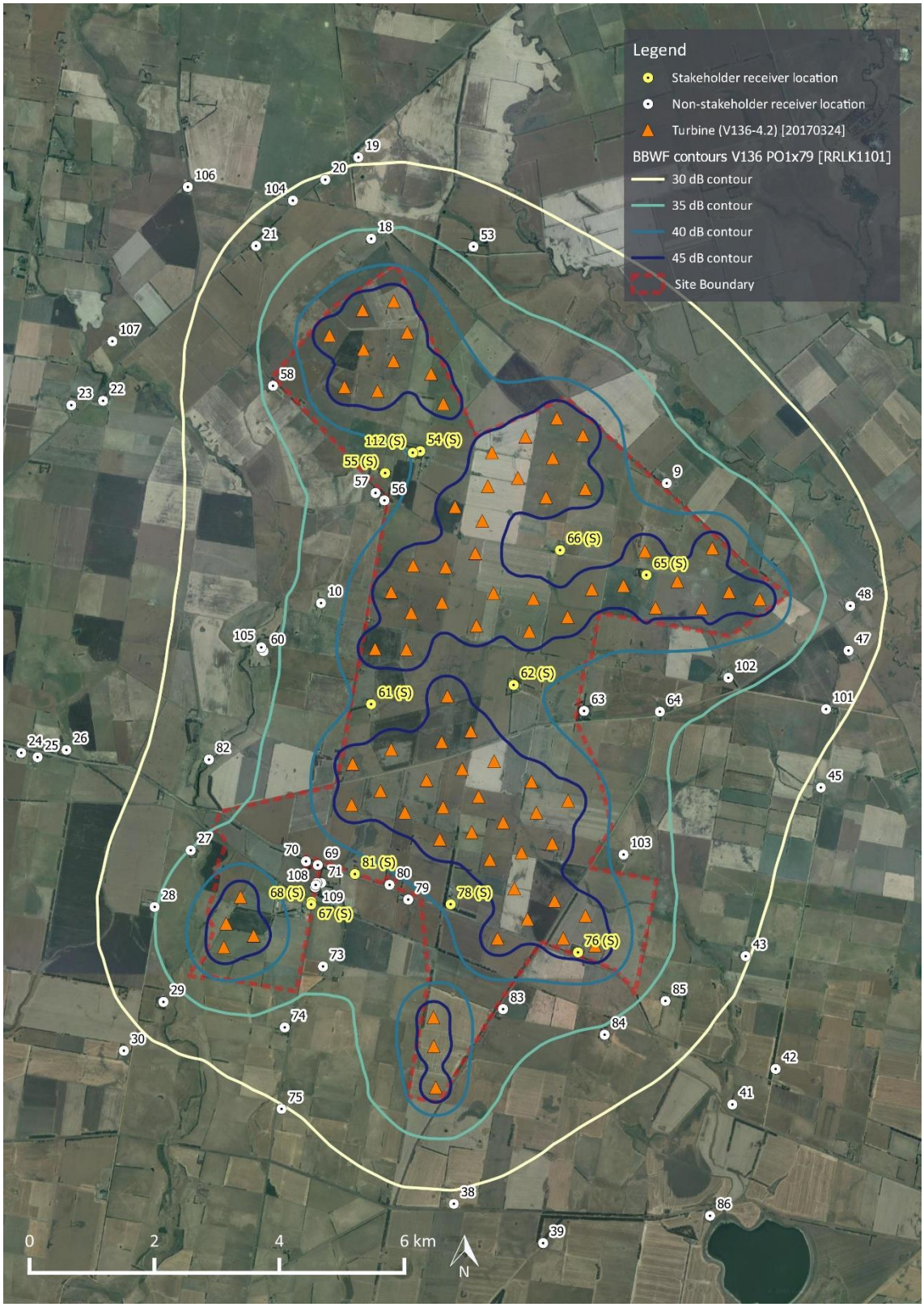
For stakeholder receivers, it is current practice to use the recommendations outlined in the final report by *The European Working Group on Noise from Wind Turbines* (ETSU-R-97) which allows for the 40 dB L_{A90} minimum noise limit to be increased to a 45 dB L_{A90} reference noise level. This is consistent with the Victorian Wind Energy Guideline which recommends a level of 45 dB for this type of receiver.

Table 5 indicates that wind farm levels are predicted to exceed the 45 dB reference noise level at stakeholder receivers 65 and 76 by up to 1.1 and 1.7 dB, respectively.

We have been advised that landowners of stakeholder receivers 65 and 76 have agreed to the predicted exceedance over the reference level of 45 dB L_{A90}. Evidence of this agreement will be provided to the Minister for Planning by BDPL.

MARSHALL DAY Acoustics

Figure 3: Berrybank Wind Farm - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)



6.0 SUMMARY

An updated assessment of operational wind turbine noise for the Berrybank Wind Farm has been carried out. The purpose of the assessment was to address Condition 18 of the Planning Permits which require an updated noise assessment to be completed prior to the commencement of development of the wind farm.

The assessment has been undertaken on the basis of the proposed layout comprising seventy-nine (79) Vestas V136-4.2MW wind turbines. Vestas performance specifications for the V136-4.2MW were provided as the basis for the assessment, comprising noise emissions data based on results in accordance with IEC 61400-11:2012, for the standard configuration incorporating serrated turbine blades and without sound management modes. The noise emission data for this standard configuration is consistent with the range of values expected for the class of turbine being installed at the site.

Data relating to tonal audibility values has been provided for an alternative variant, the Vestas V136-3.6MW, and has been referenced as an indication of tonality for the V136-4.2MW turbine.

The available data supports that noise at surrounding receivers as a result of the Berrybank Wind Farm is not expected to be tonal. Adjustments for special audible characteristics have therefore not been applied to the predictions. In the event that test results in accordance with IEC 61400-11:2012 are not available prior to energisation of the wind farm, noise emissions of the turbines, including sound frequency and tonality characteristics, are proposed to be verified by on-site emission testing of the first turbines to commence operating at the site. The results of this testing will be used to verify the noise emission characteristics of the proposed V136-4.2MW turbine model.

The results of the noise predictions for the Berrybank Wind Farm demonstrate that the predicted noise levels for the proposed turbine model and associated layout achieve the noise criteria established by the permit. The updated noise assessment therefore demonstrates that the Berrybank Wind Farm is expected to comply with operational noise requirements of the Planning Permits. As such, no noise agreements are required to be obtained with landowners located outside of the wind farm site boundary.

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APPENDIX A GLOSSARY OF TERMINOLOGY

dB	Decibel. The unit of sound level.
L_W	The sound power level. The level of total sound power radiated by a sound source.
L_{WA}	The "A" weighted sound power level.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
L_{A90}	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.
Octave Band	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.

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APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed seventy-nine (79) wind turbine layout of the Berrybank Wind Farm (data supplied by ERM on behalf of BDPL on 27 April 2018 – layout reference v4 dated 24 March 2017).

Table 6: Berrybank Wind Farm turbine coordinates – WGS 84 zone 54

Turbine	Easting	Northing	Terrain elevation	Turbine	Easting	Northing	Terrain elevation
1	718723	5802176	187.9	51	725119	5798064	162.4
2	719252	5802580	192.4	52	722922	5798109	172.3
3	719751	5802721	200.0	54	722535	5797663	171.2
4	720031	5797730	178.5	55	720424	5790132	154.7
6	719967	5802221	199.5	57	720523	5797897	182.3
7	719492	5801285	194.5	58	720518	5795662	170.9
9	719747	5801765	196.9	59	720985	5795834	173.0
12	718962	5801349	190.0	60	721985	5797957	178.3
13	720348	5801559	200.0	61	721349	5798047	183.3
14	720545	5801081	199.6	62	717031	5792379	150.0
15	721921	5797435	177.4	63	720391	5790792	158.3
17	721258	5799760	191.1	64	723429	5798169	170.0
18	720733	5799429	190.0	65	719954	5797147	177.1
19	721859	5800552	190.4	66	720611	5796396	175.9
20	722364	5800847	190.0	67	719453	5797154	175.3
21	721322	5800299	193.4	69	721076	5797527	180.0
22	722296	5800211	186.5	72	719092	5795312	170.0
23	722817	5799718	181.4	73	719710	5795545	170.0
24	722780	5800575	187.1	74	717068	5792757	150.2
25	719710	5798063	177.8	75	719076	5794661	170.0
26	721169	5799204	189.5	76	719538	5794878	170.0
27	721740	5799891	190.0	77	720541	5794620	170.0
28	722189	5799582	184.2	78	720275	5795050	170.0
31	720387	5791255	160.0	79	720845	5795231	170.0
32	721000	5794218	167.1	80	722289	5794039	160.0
33	717508	5792561	151.4	82	719929	5794535	170.0
34	719266	5801952	192.9	84	721290	5793778	163.5
36	720062	5798490	181.5	85	721955	5795028	166.4
37	720583	5798464	187.0	86	722325	5793119	157.7
38	721057	5798686	189.0	88	720489	5794103	168.0
39	723772	5798717	171.2	89	721109	5794788	170.0
40	722821	5792881	152.3	90	721503	5794377	165.0

Turbine	Easting	Northing	Terrain elevation	Turbine	Easting	Northing	Terrain elevation
42	721414	5792516	162.0	93	722543	5794720	160.8
43	722465	5792519	157.4	94	722034	5794531	162.2
44	725612	5797947	159.9	96	721796	5793893	160.8
45	724851	5798766	168.9	97	721893	5792827	160.8
46	724683	5797804	162.4	98	721681	5793316	161.5
47	724291	5798236	167.0	99	722975	5792402	150.7
48	717298	5793181	152.1	100	721359	5795356	170.0
49	723942	5797816	164.2				

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APPENDIX C RECEIVER LOCATIONS

The following table sets out the sixty-five (65) noise sensitive receiver locations considered in the revised assessment. The receiver location data was provided by BDPL and was reviewed by MDA to confirm general consistency with noise sensitive locations evident in public aerial photography for the site. The variations were typically 20-30 m from the centre of the dwelling's roof which is inconsequential for the outcome of the noise assessment.

Table 7: Receiver locations – WGS84 zone 54

Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
9	724123	5799807	180.3	1,150
10	718587	5797888	172.7	1,141
18	719391	5803724	200.0	1,071
19	719185	5805026	196.9	2,376
20	718656	5804668	200.0	2,174
21	717547	5803608	190.0	1,856
22	715098	5801127	190.0	3,775
23	714589	5801057	191.6	4,284
24	713788	5795489	167.6	4,202
25	714049	5795420	165.3	3,947
26	714511	5795536	162.7	3,650
27	716501	5793929	160.0	1,099
28	715923	5793021	151.0	1,180
29	716065	5791501	141.4	1,310
30	715431	5790719	143.0	2,308
38	720714	5788267	143.7	1,891
39	722143	5787638	140.0	3,031
41	725172	5789858	130.4	3,363
42	725866	5790427	140.0	3,503
43	725385	5792233	150.0	2,418
45	726590	5794934	150.0	3,170
47	727033	5797127	152.3	1,644
48	727061	5797842	152.9	1,457
53	721028	5803596	191.1	1,552
54 (S)	720176	5800321	192.8	852
55 (S)	719613	5799970	189.1	1,249
56	719602	5799532	184.1	1,141

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Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
57	719459	5799651	183.5	1,298
58	717818	5801367	180.0	1,149
60	717667	5797118	165.3	1,790
61 (S)	719390	5796269	171.2	799
62 (S)	721670	5796577	178.9	901
63	722798	5796160	170.0	1,416
64	724012	5796148	160.0	1,673
65 (S)	723797	5798337	170.0	397
66 (S)	722414	5798736	177.3	814
67 (S)	718431	5793106	160.2	1,078
68 (S)	718429	5793061	160.0	1,054
69	718535	5793693	164.8	1,114
70	718346	5793752	163.8	1,171
71	718590	5793405	163.6	1,316
72	718520	5793406	163.2	1,247
73	718619	5792068	151.9	1,220
74	718006	5791092	150.0	1,555
75	717955	5789787	146.4	2,495
76 (S)	722702	5792294	154.4	314
78 (S)	720663	5793064	166.4	936
79	719983	5793140	168.9	1,093
80	719684	5793375	170.0	1,091
81 (S)	719130	5793548	168.0	1,120
82	716793	5795383	160.0	2,262
83	721502	5791385	157.3	1,128
84	723128	5790975	150.0	1,439
85	724101	5791516	147.7	1,437
86	724815	5788076	130.0	4,702
101	726673	5796189	150.6	2,056
102	725109	5796692	157.8	1,196
103	723431	5793860	153.6	1,159
104	718137	5804335	197.5	2,082
105	717630	5797179	163.3	1,827

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Receiver ID	Easting	Northing	Terrain elevation	Distance to the nearest turbine (m)
106	716455	5804551	204.4	3,286
107	715247	5802080	190.0	3,479
108	718494	5793339	162.6	1,211
109	718502	5793373	162.9	1,224
112 (S)	720055	5800295	192.2	933

(S) Stakeholder receiver

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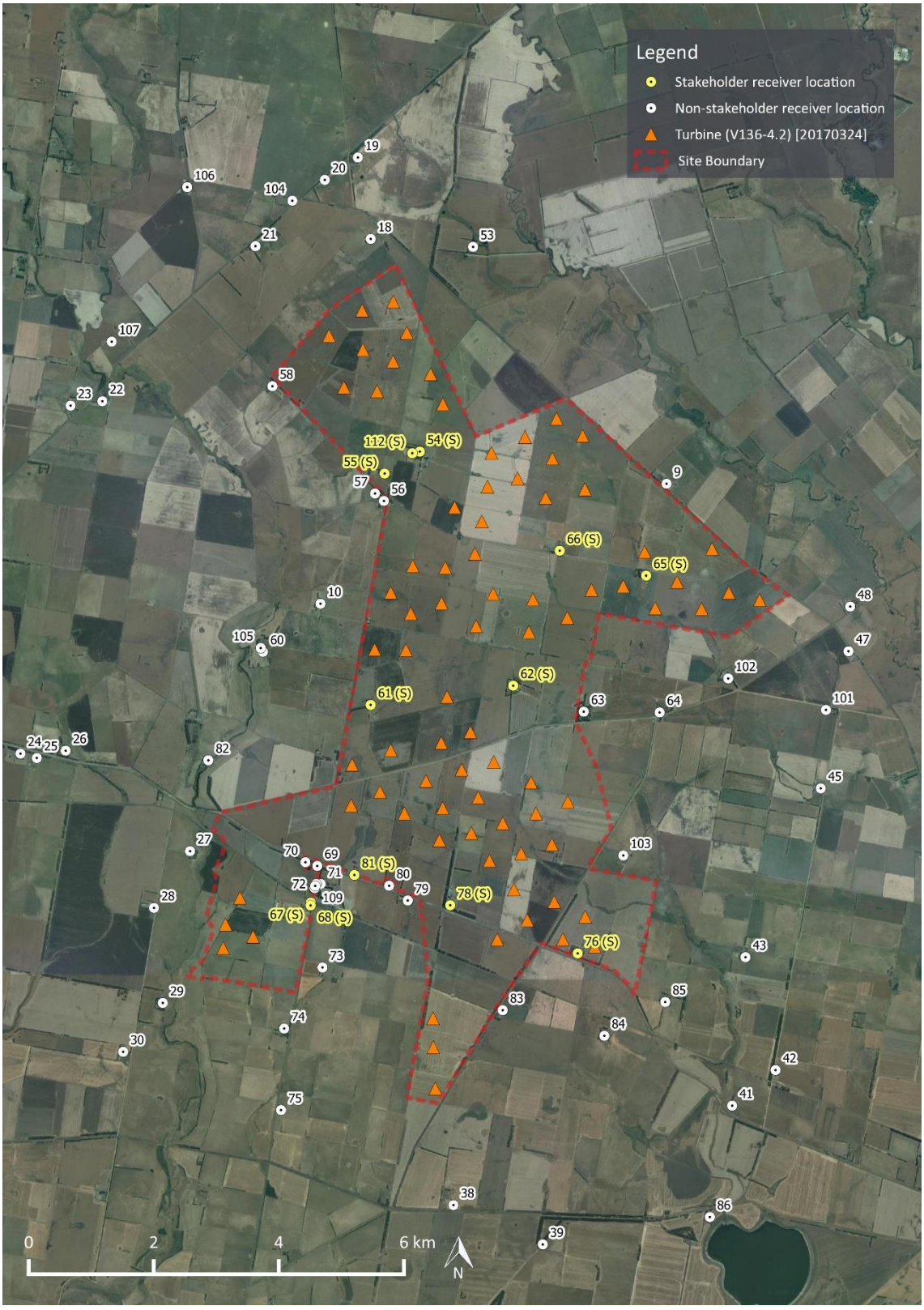
APPENDIX D SITE LAYOUT PLAN



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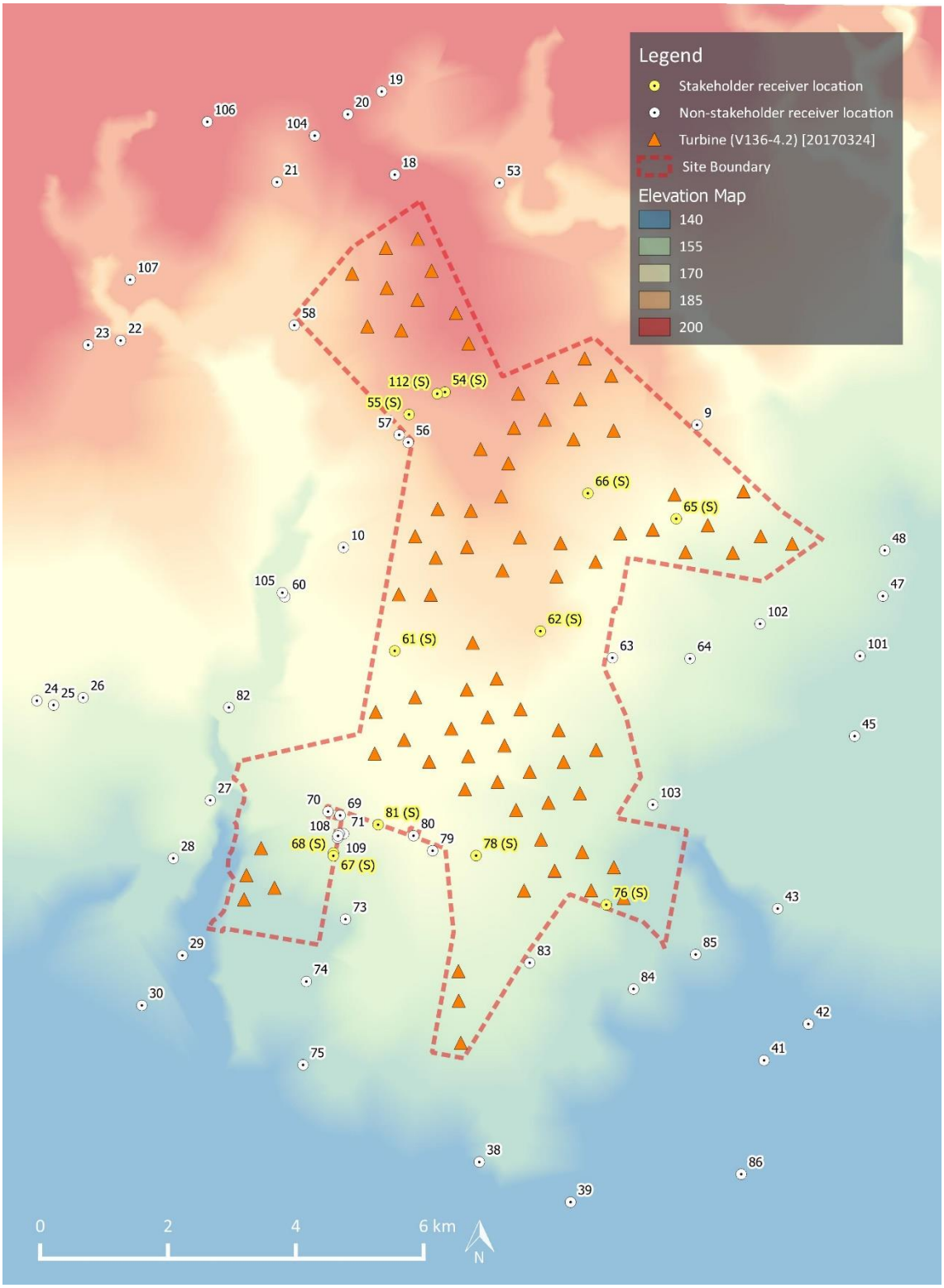
APPENDIX E SITE TOPOGRAPHY



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APPENDIX F PLANNING PERMIT – NOISE REQUIREMENTS

The following noise related conditions are defined in Planning Permit No. 20092820-A and Planning Permit No. 20092821-A, for the Golden Plains Shire and Corangamite Shire sections of the wind farm respectively, issued on 4 February 2018

NOISE STANDARD

17. *Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808: 2010 'Acoustics – Wind farm noise' at any noise sensitive location that existed at 3 April 2017, to the satisfaction of the Minister for Planning.*

    The limits specified under this condition do not apply if an agreement has been into with the relevant landowner waiving the limits. Evidence of the agreement must be provided to the satisfaction of the Minister for planning upon request, and be in a form that applies to the land for the life of the wind energy facility.

PRE-CONSTRUCTION NOISE ASSESSMENT

18. *Before development starts, a pre-construction noise assessment based on the final turbine layout and turbine model to be installed must be undertaken and the results submitted to the Minister for Planning.*

    The pre-construction noise assessment must be prepared in accordance with the Standard and must demonstrate to the satisfaction of the responsible authority that the facility will comply with the performance requirements specified in Condition 17 without operation in noise management mode unless the Minister for Planning consents to the use of noise management mode.

    The pre-construction noise assessment report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the pre-construction assessment.

    If the proponent considers that a suitable cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the pre-construction noise assessment instead.

NOISE COMPLIANCE ASSESSMENT

19. *Before the development starts a noise compliance testing plan must be prepared by a suitably qualified acoustics expert to the satisfaction of the Minister for Planning.*

    When approved, the noise compliance testing plan will be endorsed by the Minister for Planning and will then form part of this permit.

    The noise testing must be carried out in accordance with the noise compliance testing plan to the satisfaction of the Minister for Planning.

    The noise compliance testing plan must include:

    a) a determination of the noise limits to be applied during construction using the methodology prescribed in the EPA Noise Control Guidelines – publication 1254 released October 2008;

    b) a program of compliance testing to be implemented during the construction of the wind energy facility that:

        (i) Is designed by a suitably qualified acoustic expert; and

        (ii) Utilises the methodology prescribed in State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No N-1, to demonstrate compliance with the limits determined in (a) above.

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c) a procedure for a near field compliance test of the first turbine commissioned at the wind energy facility; and

d) a procedure for a final compliance test of the wind energy facility after the commissioning of the last turbine, such testing to:

(i) consider compliance of the operational wind energy facility as a whole with the noise limits set under condition 17;

(ii) be carried out according to the method described in NZS6808: 2010 'Acoustics – Wind farm noise'; and

(iii) be submitted to the responsible authority within 6 months of the first turbine operating. Further post-construction acoustic compliance reports prepared in accordance with this condition must be submitted to the responsible authority annually from the date of the first report being submitted until the final turbine is operating.

The final compliance testing report provided to the Minister for Planning must include a summary of the results in terms that are aimed at a lay person, and must be accompanied by a report by an environmental auditor appointed under the Environment Protection Act 1970, containing the auditor's opinion on the methodology of the compliance testing.

If the proponent considers that a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the results of the noise compliance testing instead.

Compliance test results must be publicly available.

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APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* 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 2009 wind farm noise guidelines, AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and NZS 6808:2010 *Acoustics – Wind farm noise*.

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, 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

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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 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 °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 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 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 (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613 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 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 IOA good practice guide). 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 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;
- 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 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 8.0 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.

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APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA

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Table 8: Predicted Noise Levels

Receiver	Hub-height wind speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
9	24.9	25.1	26.9	30.0	33.6	36.8	37.9	37.9	37.9	37.9
10	24.5	24.7	26.5	29.6	33.2	36.4	37.5	37.5	37.5	37.5
18	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0
19	16.5	16.7	18.5	21.6	25.2	28.4	29.5	29.5	29.5	29.5
20	17.3	17.5	19.3	22.4	26.0	29.2	30.3	30.3	30.3	30.3
21	18.4	18.6	20.4	23.5	27.1	30.3	31.4	31.4	31.4	31.4
22	14.1	14.3	16.1	19.2	22.8	26.0	27.1	27.1	27.1	27.1
23	13.2	13.4	15.2	18.3	21.9	25.1	26.2	26.2	26.2	26.2
24	13.2	13.4	15.2	18.3	21.9	25.1	26.2	26.2	26.2	26.2
25	13.7	13.9	15.7	18.8	22.4	25.6	26.7	26.7	26.7	26.7
26	14.4	14.6	16.4	19.5	23.1	26.3	27.4	27.4	27.4	27.4
27	22.1	22.3	24.1	27.2	30.8	34.0	35.1	35.1	35.1	35.1
28	21.7	21.9	23.7	26.8	30.4	33.6	34.7	34.7	34.7	34.7
29	19.8	20.0	21.8	24.9	28.5	31.7	32.8	32.8	32.8	32.8
30	15.4	15.6	17.4	20.5	24.1	27.3	28.4	28.4	28.4	28.4
38	16.0	16.2	18.0	21.1	24.7	27.9	29.0	29.0	29.0	29.0
39	13.4	13.6	15.4	18.5	22.1	25.3	26.4	26.4	26.4	26.4
41	14.2	14.4	16.2	19.3	22.9	26.1	27.2	27.2	27.2	27.2
42	13.9	14.1	15.9	19.0	22.6	25.8	26.9	26.9	26.9	26.9
43	17.2	17.4	19.2	22.3	25.9	29.1	30.2	30.2	30.2	30.2
45	16.5	16.7	18.5	21.6	25.2	28.4	29.5	29.5	29.5	29.5
47	18.5	18.7	20.5	23.6	27.2	30.4	31.5	31.5	31.5	31.5
48	19.2	19.4	21.2	24.3	27.9	31.1	32.2	32.2	32.2	32.2
53	20.7	20.9	22.7	25.8	29.4	32.6	33.7	33.7	33.7	33.7
54 (S)	27.6	27.8	29.6	32.7	36.3	39.5	40.6	40.6	40.6	40.6
55 (S)	25.7	25.9	27.7	30.8	34.4	37.6	38.7	38.7	38.7	38.7
56	25.9	26.1	27.9	31.0	34.6	37.8	38.9	38.9	38.9	38.9
57	25.3	25.5	27.3	30.4	34.0	37.2	38.3	38.3	38.3	38.3
58	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0
60	21.0	21.2	23.0	26.1	29.7	32.9	34.0	34.0	34.0	34.0
61 (S)	28.2	28.4	30.2	33.3	36.9	40.1	41.2	41.2	41.2	41.2
62 (S)	28.2	28.4	30.2	33.3	36.9	40.1	41.2	41.2	41.2	41.2
63	25.4	25.6	27.4	30.5	34.1	37.3	38.4	38.4	38.4	38.4
64	23.0	23.2	25.0	28.1	31.7	34.9	36.0	36.0	36.0	36.0

Receiver	Hub-height wind speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
65 (S)	33.1	33.3	35.1	38.2	41.8	45.0	46.1	46.1	46.1	46.1
66 (S)	29.2	29.4	31.2	34.3	37.9	41.1	42.2	42.2	42.2	42.2
67 (S)	24.3	24.5	26.3	29.4	33.0	36.2	37.3	37.3	37.3	37.3
68 (S)	24.3	24.5	26.3	29.4	33.0	36.2	37.3	37.3	37.3	37.3
69	24.6	24.8	26.6	29.7	33.3	36.5	37.6	37.6	37.6	37.6
70	24.5	24.7	26.5	29.6	33.2	36.4	37.5	37.5	37.5	37.5
71	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
72	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
73	22.5	22.7	24.5	27.6	31.2	34.4	35.5	35.5	35.5	35.5
74	20.4	20.6	22.4	25.5	29.1	32.3	33.4	33.4	33.4	33.4
75	16.8	17.0	18.8	21.9	25.5	28.7	29.8	29.8	29.8	29.8
76 (S)	33.7	33.9	35.7	38.8	42.4	45.6	46.7	46.7	46.7	46.7
78 (S)	27.8	28.0	29.8	32.9	36.5	39.7	40.8	40.8	40.8	40.8
79	25.8	26.0	27.8	30.9	34.5	37.7	38.8	38.8	38.8	38.8
80	25.9	26.1	27.9	31.0	34.6	37.8	38.9	38.9	38.9	38.9
81 (S)	25.2	25.4	27.2	30.3	33.9	37.1	38.2	38.2	38.2	38.2
82	19.4	19.6	21.4	24.5	28.1	31.3	32.4	32.4	32.4	32.4
83	24.7	24.9	26.7	29.8	33.4	36.6	37.7	37.7	37.7	37.7
84	21.0	21.2	23.0	26.1	29.7	32.9	34.0	34.0	34.0	34.0
85	20.3	20.5	22.3	25.4	29.0	32.2	33.3	33.3	33.3	33.3
86	11.9	12.1	13.9	17.0	20.6	23.8	24.9	24.9	24.9	24.9
101	17.9	18.1	19.9	23.0	26.6	29.8	30.9	30.9	30.9	30.9
102	23.3	23.5	25.3	28.4	32.0	35.2	36.3	36.3	36.3	36.3
103	25.6	25.8	27.6	30.7	34.3	37.5	38.6	38.6	38.6	38.6
104	17.7	17.9	19.7	22.8	26.4	29.6	30.7	30.7	30.7	30.7
105	20.8	21.0	22.8	25.9	29.5	32.7	33.8	33.8	33.8	33.8
106	13.8	14.0	15.8	18.9	22.5	25.7	26.8	26.8	26.8	26.8
107	14.0	14.2	16.0	19.1	22.7	25.9	27.0	27.0	27.0	27.0
108	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
109	24.2	24.4	26.2	29.3	32.9	36.1	37.2	37.2	37.2	37.2
112 (S)	27.2	27.4	29.2	32.3	35.9	39.1	40.2	40.2	40.2	40.2

(S) Stakeholder receiver

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APPENDIX I DOCUMENTATION

(a) Map of the site showing topography, turbines and residential properties: See Appendix D

(b) Noise sensitive locations: See Section 2.1 and Appendix C

(c) Wind turbine sound power levels, L_{WA} dB (also refer to Section 2.3)

Sound power levels (including + 1dB margin for uncertainty)

	Hub height wind speed (m/s)									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
L_{WA} (dB)	91.9	92.1	93.9	97.0	100.6	103.8	104.9	104.9	104.9	104.9

Reference octave band spectrum adjusted to 104.9 dB L_{WA}

	Octave Band Centre Frequency (Hz)								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
L_{WA} (dB)*	77.0	86.8	93.8	98.1	99.8	98.9	95.2	89.0	80.0

* Based on octave band spectral information at 20 m/s

(d) Wind turbine model: Vestas V136-4.2MW, details provided in Table 1 of Section 2.2

(e) Turbine hub height: 112 m

(f) Distance of noise sensitive locations from the wind turbines: See Appendix C

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v8.0 (See Section 4.0 and Appendix G)

(h) Meteorological conditions assumed:

- Temperature: 10 °C
- Relative humidity: 70 %
- Atmospheric pressure: 101.325 kPa

(i) Air absorption parameters:

	Octave band mid frequency (Hz)							
Description	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Atmospheric attenuation (dB/km)	0.12	0.41	1.04	1.93	3.66	9.66	32.8	116.9

(j) Topography/screening:

10 m elevation contours downloaded from the Victorian Government Data Directory

Refer to turbine and receiver elevation data contained in Appendix B and Appendix C, and the topographical data illustrated in Appendix E.

(k) Predicted far-field wind farm sound levels: See Table 5 of Section 5.0 and Appendix H.

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