MARSHALL DAY Acoustics

MORETON HILL WIND FARM ENVIRONMENTAL NOISE ASSESSMENT

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EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with the Moreton Hill Wind Farm that is proposed to be developed by MHWF NOMINEES PTY LTD. The assessment has been prepared to inform an EES referral and is based on the proposed wind farm layout comprising sixty-two (62) multi-megawatt wind turbines with a maximum tip height of 252 m and related infrastructure (battery energy storage system and substation).

The actual wind turbine which would be used at the site would be determined at a later stage in the project, after the project has been granted planning approval. The final selection would be based on a range of design requirements including achieving compliance with the planning permit noise limits at surrounding noise sensitive locations (receivers). In advance of a final selection, this assessment considers a candidate wind turbine model that is representative of the size and type of wind turbine which could be used at the site. For this purpose, the Vestas V162-6.8MW model with a hub height of 166 m and rotor diameter of 162 m, has been nominated by the proponent.

Subsequent revision of this assessment will be prepared for the planning application and will be informed by a background noise assessment and additional details on the proposed related infrastructure (battery energy storage system and substation).

Operational noise from the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* (EP Regulations) and the Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023. The operational wind farm noise assessment considers the base (minimum) noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area.

Manufacturer specification data for the candidate wind turbine model has been used as the basis for the assessment. The specification provides noise emission data in accordance with the international standard referenced in NZS 6808. The noise emission data is consistent with the range of values expected for comparable types of multi megawatt wind turbine models that are being considered for the site.

The noise emission data has been used with international standard ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2) to predict the level of noise expected to occur at neighbouring receivers. The ISO 9613-2 standard has been applied using 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 modelling demonstrate that the predicted noise levels for the proposed wind turbine layout and candidate wind turbine model achieve the base noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

The EP Regulations require operational noise of the related infrastructure associated with the wind farm to be assessed in accordance with EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues*, dated May 2021 (Noise Protocol). The assessment demonstrates that the related infrastructure can be designed and operated to achieve the noise limits determined in accordance with the Noise Protocol.

Consideration was also given to the general environmental duty introduced by the *Environment Protection Act 2017* in July 2021.

The noise assessment therefore demonstrates that the proposed Moreton Hill Wind Farm can be designed and developed to achieve Victorian policy requirements.

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TABLE OF CONTENTS

1.0 INTRODUCTION 6

2.0 PROJECT DESCRIPTION 7

3.0 VICTORIAN LEGISLATION & GUIDELINES 8

3.1 Environment Protection Act 2017 8

3.2 Environment Protection Regulations 2021 9

3.2.1 Wind turbine noise 9

3.2.2 Related infrastructure noise 9

3.3 Victorian Wind Energy Guidelines 10

3.4 NZS 6808 12

3.4.1 Objectives 12

3.4.2 Noise sensitive locations 12

3.4.3 Noise limit 13

3.4.4 High amenity 13

3.4.5 Special audible characteristics 14

3.5 Noise Protocol 14

3.6 Environment Reference Standard 15

4.0 ASSESSMENT METHOD 18

4.1 Overview 18

4.2 Background noise levels 18

4.3 Noise predictions 19

5.0 EXISTING NOISE ENVIRONMENT 21

6.0 WIND TURBINE NOISE ASSESSMENT 22

6.1 Noise limits 22

6.1.1 High amenity 22

6.1.2 Stakeholder receivers 22

6.1.3 Applicable noise limits 23

6.2 Wind turbine noise emissions 23

6.2.1 Wind turbine model 23

6.2.2 Sound power levels 24

6.2.3 Special audible characteristics 25

6.3 Predicted noise levels 26

6.4 Cumulative assessment 30

6.4.1 Stockyard Hill Wind Farm 30

6.4.2 Chepstowe Wind Farm 30
6.4.3 Berrybank Wind Farm 31
6.4.4 Golden Plains Wind Farm 31
6.4.5 Assessment 31
7.0 RELATED INFRASTRUCTURE 34
7.1 Description 34
7.2 Noise limits 34
7.3 Related infrastructure noise 35
7.3.1 Substation 35
7.3.2 Battery energy storage system 35
7.4 Predicted noise levels 36
8.0 ENVIRONMENTAL REFERENCE STANDARD 38
8.1 Identified natural areas 38
8.2 Guidance on noise in natural areas 38
8.3 Existing noise environment in natural areas 38
8.4 Project noise levels in natural areas 39
9.0 RECOMMENDED NOISE MANAGEMENT MEASURES 40

APPENDIX A GLOSSARY OF TERMINOLOGY
APPENDIX B SOURCE COORDINATES
APPENDIX C RECEIVER COORDINATES
APPENDIX D SITE LAYOUT PLAN
APPENDIX E SITE TOPOGRAPHY
APPENDIX F ZONING MAP
APPENDIX G NOISE PREDICTION MODEL
APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA
APPENDIX I NZS 6808 DOCUMENTATION

1.0 INTRODUCTION

MHWF NOMINEES PTY LTD (the proponent) is proposing to develop a wind farm known as the Moreton Hill Wind Farm within the Victorian local government area of the Corangamite Shire, approximately 5 km east of Skipton. The wind farm is proposed to comprise sixty-two (62) wind turbines and associated related infrastructure (battery energy storage system and substation). Throughout this report, the term 'wind farm' refers to both the wind turbines and the related infrastructure.

This report presents the results of an assessment of operational wind turbine noise in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* (the EP Regulations) and the Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (the Victorian Wind Energy Guidelines).

Operational noise of the proposed related infrastructure associated with the project is to be assessed in accordance with EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated May 2021 (Noise Protocol), as required by the EP Regulations. The general environment duty introduced by the *Environment Protection Act 2017* (EP act) in July 2021 must also be considered.

The noise assessment presented in this report is based on:

- Operational noise limits determined in accordance with NZS 6808 and the Noise Protocol, accounting for local land zoning;
- Predicted operational noise levels for the wind turbines, based on the proposed site layout and a candidate wind turbine model that is representative of the size and type of wind turbine that the planning application seeks consent for;
- Predicted operational noise levels for the proposed related infrastructure, based on empirical noise emission data; and
- A comparison of the predicted noise levels with the applicable base noise limits determined in accordance with NZS 6808 and the noise limits defined by the Noise Protocol.

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

2.0 PROJECT DESCRIPTION

The proponent is developing a wind farm comprising wind turbines and related infrastructure.

The Vestas V162-6.8MW, with a power output of 6.8 MW and a rotor diameter of 162 m, has been selected as the candidate wind turbine model for this assessment. Further details of the candidate wind turbine model are presented in Section 6.2.

The coordinates of the sixty-two (62) proposed wind turbines are tabulated in Appendix B.

The related infrastructure, comprising a 150 MW battery energy storage system (BESS) and a substation , is also proposed to be located to the southwest of the wind farm (see coordinates in Appendix B).

A total of one hundred and sixty-eight (168) noise sensitive locations (generally referred to as *receivers* herein) located within 5 km of the proposed wind turbines have been considered in this noise assessment. This includes twenty-three (23) receivers where a noise agreement is in place or proposed between the landowners and the proponent (subsequently referred to as *stakeholder receivers* herein).

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the wind turbine layout, substation and receivers is provided in Appendix D.

3.0 VICTORIAN LEGISLATION & GUIDELINES

The following publications are relevant to the assessment of operational noise from proposed wind farm developments in Victoria:

- *Environment Protection Act 2017*
- *Environment Reference Standard*
- *Environment Protection Regulations 2021*
- Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*
- EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated May 2021.

Details of the guidance and noise limits provided by these publications are provided below.

3.1 Environment Protection Act 2017

The *Environment Protection Act 2017* (EP Act) provides the overarching legislative framework for the protection of the environment in Victoria.

The EP Act establishes a general environmental duty to minimise the risks of harm to human health or the environment from pollution or waste, including noise related amenity impacts, so far as reasonably practicable.

The EP Act also prohibits the emission of unreasonable noise from commercial and industrial trade premises. Specifically, the EP Act states that:

> *A person must not, from a place or premises that are not residential premises—*
>
> *(a) emit an unreasonable noise; or*
>
> *(b) permit an unreasonable noise to be emitted*

Under the EP Act, unreasonable noise means noise that:

> *(a) is unreasonable having regard to the following—*
>
> > *(i) its volume, intensity or duration;*
> >
> > *(ii) its character;*
> >
> > *(iii) the time, place and other circumstances in which it is emitted;*
> >
> > *(iv) how often it is emitted;*
> >
> > *(v) any prescribed factors; or*
>
> *(b) is prescribed to be unreasonable noise:*

Further information about noises that are prescribed to be unreasonable are separately defined in regulations made under the EP Act (see next section).

3.2 Environment Protection Regulations 2021

The *Environment Protection Regulations 2021* (EP Regulations) give effect to the EP Act by establishing prescriptive requirements for a range of environmental considerations including noise.

The noise requirements are defined according to the type of noise generating activity under consideration, and include definitions such as the types of noise sensitive areas where these requirements apply and assessment time periods.

3.2.1 Wind turbine noise

Part 5.3 Division 5 of the EP Regulations nominates NZS 6808 (see Section 3.4) as the relevant standard for assessing operational wind turbine noise in Victoria and introduces additional measures to demonstrate compliance post-construction.

Specifically, the EP Regulations outline the following:

- Noise agreements

  An owner or operator of a wind energy facility may enter into a written agreement with a relevant landowner to modify the noise limits which apply at the premises of the relevant landowner. These locations are referred to as 'stakeholder receivers'.

  If a noise agreement is made after 1 November 2021, an increased base noise limit of 45 dB L_{A90} would apply. If a noise agreement was made prior to 1 November 2021, the noise limit can be modified as specified in the noise agreement.

- Wind energy facility operators' duties

  The duties of wind energy facility operators comprise ensuring compliance with NZS 6808 and a suite of actions to manage and monitor noise from the wind farm, as prescribed in Regulation 131C.

  Providing that the operator of a wind farm complies with the requirements of Regulation 131C, their duty with respect to the general environmental duty under the EP Act has been addressed.

In accordance with the EP Regulations, noise levels from a wind farm are prescribed to be *unreasonable* for the purposes of the EP Act, if they exceed the relevant applicable noise limits.

3.2.2 Related infrastructure noise

In relation to noise from commercial, industrial and trade premises (related infrastructure), the EP Regulations specify that the prediction, measurement, assessment or analysis of noise within a noise sensitive area must be conducted in accordance with the Noise Protocol (see Section 3.5). Noise from the related infrastructure is prescribed by the EP Regulations to be unreasonable for the purposes of the EP Act if it exceeds a noise limit or alternative assessment criterion determined in accordance with the Noise Protocol.

3.3 Victorian Wind Energy Guidelines

The Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (Victorian Wind Energy Guidelines) provide advice to responsible authorities, proponents and the community about suitable sites to locate wind energy facilities and to inform planning decisions about a wind energy facility proposal. The Victorian Wind Energy Guidelines set out:

- *a framework to provide a consistent and balanced approach to the assessment of wind energy projects across the state;*
- *a set of consistent operational performance standards to inform the assessment and operation of a wind energy facility project;*
- *guidance as to how planning permit application requirements might be met; and*
- *a framework for the regulation of wind turbine noise.*

Section 4.3.2 of the Victorian Wind Energy Guidelines outlines the application requirements for a wind energy facility. Specifically, to following written reports are required to be submitted to address potential noise impacts:

- *A pre-construction (predictive) noise assessment report prepared by a suitably qualified and experienced acoustician that:*
  - *reports on a pre-construction (predictive) noise assessment conducted following New Zealand Standard NZS6808:2010, Acoustics – Wind Farm Noise*
  - *provides an assessment of whether the proposed wind energy facility will comply with the noise limit for that facility*
  - *where the proposed wind energy facility will be the subject of a wind turbine noise agreement under the Environment Protection Regulations 2021, specifies the premises of the relevant landowner (including any particular buildings) to which the agreement relates and provides an assessment of whether the proposed wind energy facility will comply with the modified noise limit for that facility specified in the agreement*
  - *is prepared on the basis that the relevant noise standard will be the New Zealand Standard NZS6808:2010, Acoustics – Wind Farm Noise and includes an assessment of whether a high amenity noise limit is applicable under Section 5.3 of the standard.*
- *A report prepared by an environmental auditor appointed under Part 8.3 of the Environment Protection Act 2017 that verifies whether or not the pre-construction (predictive) noise assessment was conducted under New Zealand Standard NZS6808:2010, Acoustics – Wind Farm Noise*

In Section 5.1.2, the Victorian Wind Energy Guidelines outlines the key criteria for evaluating the planning merits of a wind energy facility. The following guidance is provided for the assessment of noise levels from proposed new wind farm developments:

> *A wind energy facility must comply with the noise limits in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard).* […]
>
> *The Standard specifies a general 40 decibel limit (40 dB $L_{A90(10min)}$) for wind energy facility sound levels outdoors at noise sensitive locations, or that the sound level should not exceed the background sound level by more than five decibels (referred to as 'background sound level +5 dB'), whichever is the greater.*

Noise sensitive locations are defined in the Standard as, "The location of a noise sensitive activity, associated with a habitable space or education space in a building not on a wind farm site", and include:

- *any part of land zoned predominantly for residential use*
- *residential land uses included in the accommodation group at clause 73.03, Land use terms of the VPP and all planning schemes*
- *education and child care uses included in the child care centre group and education centre group at clause 73.03 of the of the VPP and all planning schemes.* […]

A 45-decibel limit is recommended for stakeholder dwellings. A stakeholder dwelling is a dwelling located on the same land as the wind energy facility, or one that has an agreement with the wind energy facility to exceed the noise limit. […]

Under Section 5.3 of the Standard, a 'high amenity noise limit' of 35 decibels may be justified in special circumstances. All wind energy facility 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 5.3.1 of the Standard. Guidance can be found on this issue in the VCAT determination for the Cherry Tree Wind Farm[1].

Measurement and compliance assessment methods are set out in the Standard. The assessment must be made without relying on noise reduction operation modes to achieve compliance.

As discussed in Section 3.2.1, and consistent with the above, receivers within the project boundary and/or with a noise agreement are referred herein as 'stakeholder receivers'.

Clause 73.03 of the Victoria Planning Provisions (VPP) defines *Accommodation* as *land used to accommodate persons* and lists the following uses:

- *Camping and caravan park*
- *Corrective institution*
- *Dependent person's unit*
- *Dwelling*
- *Group accommodation*
- *Host farm*
- *Residential aged care facility*
- *Residential building*
- *Residential village*
- *Retirement village*

Consideration must also be given to whether a high amenity noise limit is warranted to reflect special circumstances at specific locations.

[1] *Cherry Tree Wind Farm v Mitchell Shire Council* (2013)

3.4 NZS 6808

New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) provides methods for the prediction, measurement, and assessment of sound from wind turbines. The following sections provide an overview of the objectives of NZS 6808 and the key elements of the standard's assessment procedures.

3.4.1 Objectives

The foreword of NZS 6808 provides guidance about the objectives of the noise limits outlined within the standard:

> *Wind farm sound may be audible at times at noise sensitive locations, and this Standard does not set limits that provide absolute protection for residents from audible wind farm sound. Guidance is provided on noise limits that are considered reasonable for protecting sleep and amenity from wind farm sound received at noise sensitive locations.*

The *Outcome Statement* of NZS 6808 then goes on to provide information about the objective of the standard in a planning context:

> *This Standard provides suitable methods for the prediction, measurement, and assessment of sound from wind turbines. In the context of the* [New Zealand] *Resource Management Act, application of this Standard will provide reasonable protection of health and amenity at noise sensitive locations.*

Section C1.1 of the standard provides further information about the intent of the standard, which is:

> [...] *to avoid adverse noise effects on people caused by the operation of wind farms while enabling sustainable management of natural wind resources.*

Based on the objectives outlined above, NZS 6808 addresses health and amenity considerations at noise sensitive locations by specifying noise limits which are to be used to assess wind farm noise.

3.4.2 Noise sensitive locations

The provisions of NZS 6808 are intended to protect noise sensitive locations (also generally referred to as *receivers* herein) that existed before the development of a wind farm. Noise sensitive locations are defined by the Standard as:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site. Noise sensitive locations include:*
>
> *(a) Any part of land zoned predominantly for residential use in a district plan;*
>
> *(b) Any point within the notional boundary of buildings containing spaces defined in (c) to (f);*
>
> *(c) Any habitable space in a residential building including rest homes or groups of buildings for the elderly or people with disabilities …*
>
> *(d) Teaching areas and sleeping rooms in educational institutions …*
>
> *(e) Teaching areas and sleeping rooms in buildings for licensed kindergartens, childcare, and day-care centres; and*
>
> *(f) Temporary accommodation including in hotels, motels, hostels, halls of residence, boarding houses, and guest houses.*
>
> *In some instances holiday cabins and camping grounds might be considered as noise sensitive locations. Matters to be considered include whether it is an established activity with existing rights.*

For the purposes of an assessment according to the Standard, the notional boundary is defined as:

> *A line 20 metres from any side of a dwelling or other building used for a noise sensitive activity or the legal boundary where this is closer to such a building.*

NZS 6808 was prepared to provide methods of assessment in the statutory context of New Zealand. Specifically, NZS 6808 notes that in the context of the New Zealand Resource Management Act, application of the Standard will provide reasonable protection of health and amenity at noise sensitive locations. This is an important point of context, as the New Zealand Resource Act states:

> *(3)(a)(ii): A consent authority must not, when considering an application, have regard to any effect on a person who has given written approval to the application.*

Based on the above definitions and statutory context, NZS 6808 only applies to the assessment of wind turbine noise levels at receivers that are not stakeholders, as defined in Section 3.2.1 and Section 3.3 (i.e. receivers within the project boundary and/or with a noise agreement).

3.4.3 Noise limit

Section 5.2 *Noise limit* of NZS 6808 defines acceptable noise limits as follows:

> *As a guide to the limits of acceptability at a noise sensitive location, at any wind speed wind farm sound levels ($L_{A90(10\,min)}$) should not exceed the background sound level by more than 5 dB, or a level of 40 dB $L_{A90(10\,min)}$, whichever is the greater.*

This arrangement of limits requires the noise associated with a wind farm to be restricted to a permissible margin above background noise, except in instances when both the background and source noise levels are low. In this respect, the noise limits indicate that it is not necessary to continue to adhere to a margin above background when the background noise levels are below the range of 30-35 dB L_{A90}.

As detailed in the preceding section, the NZS 6808 noise limits do not apply to stakeholder receivers.

The noise limits specified in NZS 6808 apply to the combined wind turbine noise level of all wind farms influencing the environment at a receiver. Specifically, section 5.6.1 states:

> *The noise limits* [...] *should apply to the cumulative sound level of all wind farms affecting any noise sensitive location.*

3.4.4 High amenity

Section 5.3.1 of NZS 6808 states that the base noise limit of 40 dB L_{A90} detailed in Section 3.4.3 above is *appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations*. It goes on to note that the application of a high amenity noise limit may require additional consideration:

> [...] *In special circumstances at some noise sensitive locations a more stringent noise limit may be justified to afford a greater degree of protection of amenity during evening and night-time. A high amenity noise limit should be considered where a plan promotes a higher degree of protection of amenity related to the sound environment of a particular area, for example where evening and night-time noise limits in the plan for general sound sources are more stringent than 40 dB $L_{Aeq(15\,min)}$ or 40 dBA L_{10}. A high amenity noise limit should not be applied in any location where background sound levels, assessed in accordance with section 7, are already affected by other specific sources, such as road traffic sound.*

The definition of the high amenity noise limit provided in NZS 6808 is specific to New Zealand planning legislation and guidelines. A degree of interpretation is therefore required when determining how to apply the concept of high amenity in Victoria.

In accordance with Section 5.3 of NZS 6808, if a high amenity noise limit is justified, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5 dB or 35 dB L_{A90}, whichever is the greater. The standard recommends that this reduced noise limit would typically apply for wind speeds below 6 m/s at hub height. A high amenity noise limit is not applicable during the daytime period.

The method for assessing the applicability of the high amenity noise limit, detailed in NZS 6808, is a two-step approach as follows:

1. Determination of whether the planning guidance for the area warrants consideration of a high amenity noise limit

   First and foremost, for a high amenity noise limit to be considered, the land zoning of a receiver must promote a higher degree of acoustic amenity.

2. Evaluation of whether a high amenity noise limit is justified

   Following the guidance presented in C5.3.1, if the planning guidance for the area warrants consideration of a high amenity noise limit, and the receiver is located within the predicted 35 dB L_{A90} noise contour, then a calculation should be undertaken to determine whether background noise levels are sufficiently low.

3.4.5 Special audible characteristics

Section 5.4.2 of NZS 6808 requires the following:

> *Wind turbine sound levels with special audible characteristics (such as tonality, impulsiveness and amplitude modulation) shall be adjusted by arithmetically adding up to +6dB to the measured level at the noise sensitive location.*

Notwithstanding this, the standard requires that wind farms be designed with no special audible characteristics at nearby residential properties while concurrently noting in Section 5.4.1 that:

> […] *as special audible characteristics cannot always be predicted, consideration shall be given to whether there are any special audible characteristics of the wind farm sound when comparing measured levels with noise limits.*

NZS 6808 emphasises assessment of special audible characteristics during the post-construction measurement phase of a project. An indication of the potential for tonality to be a characteristic of the noise emission from the assessed wind turbine model is sometimes available from tonality audibility assessments conducted as part of manufacturer wind turbine noise emission testing. However, this data is frequently not available at the planning stage of an assessment.

3.5 Noise Protocol

EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) sets noise limits that apply to commercial, industrial and trade premises and entertainment venues in Victoria. Compliance with the noise limits is mandatory under the EP Act.

The proposed related infrastructure is considered a ‘commercial, industrial and trade premises’ under the EP Act.

The Noise Protocol prescribes noise limits that are used to assess whether a noise is prescribed to be unreasonable in accordance with the EP Regulations. The noise limits apply at a ‘noise sensitive area’, which is defined in Section 4 of the EP Regulations as being *within 10 metres of the outside of the external walls* of buildings including dwellings, hotels, schools and campgrounds.

The procedures for setting noise limits are defined separately for urban and rural areas. However, in both cases, the noise limits are defined by considering the land zoning in the area and the noise environment of the receiver. The noise limits are defined separately for day, evening and night periods.

In contrast to NZS 6808 and Part 5.3 Division 5 of the EP Regulations, the Noise Protocol does not differentiate between stakeholder and non-stakeholder receivers.

The measurement and analysis procedures outlined in the Noise Protocol include adjustments which are to be applied to noise that is characterised by audible tones, impulses or intermittency. Further details of the noise limits applicable to this project are provided in Section 7.2 of this report.

3.6 Environment Reference Standard

The *Environment Reference Standard* (ERS) is a legislative instrument made under the EP Act which sets out environmental values for ambient sound that are sought to be achieved and maintained in Victoria and standards to support those values. The indicators and objectives within the standard provide a benchmark for comparing desired outcomes to the actual state of the environment, and a basis for assessing actual and potential risks to the environmental values.

The ERS is an environmental benchmark. It brings together a collection of environmental values, indicators and objectives that describe environmental and human health outcomes to be achieved or maintained in the whole or in parts of Victoria. These values, indicators and objectives are used to assess and report on changing environmental conditions by providing a reference point for decision makers to consider whether a proposal or activity is consistent with the environmental values identified in the ERS. The ERS also allows decision makers to evaluate potential impacts on human health and the environment that may result from a proposal or activity. The ERS does not specify requirements that must be met by environmental managers or other duty holders.

The ERS is primarily relevant for aspects of the environment that are not the subject of prescriptive regulation. These aspects include the noise from commercial premises and construction activities in natural areas, or the additional noise from public roads as a result of traffic associated with commercial activities.

Further, in the situations where the ERS is a relevant consideration, it is important to note that the ERS is not a compliance standard. Specifically, the values listed within the ERS are not prescribed noise limits, nor are they design criteria for proposed development.

Indicators and objectives within the ERS are generally not relevant considerations where they relate to an aspect of the environment that is the subject of prescriptive regulation. For example, the ambient sound indicators and objectives will not be relevant when considering noise from wind turbines and commercial, industrial and trade premises at noise sensitive areas, as defined in the EP Regulations. This is because noise in these circumstances is regulated by specific provisions and noise limits in the EP Regulations and the associated Noise Protocol and NZS 6808.

The environmental values presented in the ERS and a description of each is provided in Table 1.

Table 1: Environmental values of the ambient sound environment

Environmental value	Description of environmental value
Sleep during the night	An ambient sound environment that supports sleep during the night
Domestic and recreational activities	An ambient sound environment that supports recreational and domestic activities in a residential setting
Normal conversation	An ambient sound environment that allows for normal conversation indoors without the need to raise voices
Child learning and development	An ambient sound environment that supports cognitive development and learning in children
Human tranquillity and enjoyment outdoors in natural areas	An ambient sound environment that allows for the appreciation and enjoyment of the environment for its natural condition and the restorative benefits of tranquil soundscapes in natural areas
Musical entertainment	An ambient sound environment that recognises the community's demand for a wide range of musical entertainment.

The ERS land use categories and their descriptions are provided in Table 2.

Table 2: Land use categories for the ambient sound environment

Land use category	General description	Planning zones
Category I	An urban form with distinctive features or characteristics of taller buildings, high commercial and residential intensity and high site coverage.	Industrial Zone 1 (IN1Z) Industrial Zone 2 (IN2Z) Port Zone (PZ) Road 1 Zone (RDZ1) Capital City Zone (CCZ) Docklands Zone (DZ)
Category II	Medium rise building form with a strong urban or commercial character. Typically contains mixed land uses including activity centres and larger consolidated sites, and an active public realm.	Industrial Zone 3 (IN3Z) Commercial 1 Zone (C1Z) Commercial 2 Zone (C2Z) Commercial 3 Zone (C3Z) Activity Centre Zone (ACZ) Mixed Use Zone (MUZ) Road 2 Zone (RDZ2)
Category III	Lower rise building form including lower density residential development and detached housing typical of suburban residential settings or in towns of district or regional significance.	Residential Growth Zone (RGZ) General Residential Zone (GRZ) Neighbourhood Residential Zone (NRZ) Urban Floodway Zone (UFZ) Public Park and Recreation Zone (PPRZ) Urban Growth Zone (UGZ) [1]
Category IV	Lower density or sparse populations with settlements that include smaller hamlets, villages and small towns that are generally unsuited for further expansion. Land uses include primary industry and farming.	Low Density Residential Zone (LDRZ) Township Zone (TZ) Rural Living Zone (RLZ) Green Wedge A Zone (GWAZ) Rural Conservation Zone (RCZ) Public Conservation and Resource Zone (PCRZ) Green Wedge Zone (GWZ) Farming Zone (FZ) Rural Activity Zone (RAZ)

Land use category	General description	Planning zones
Category V	Unique combinations of landscape, biodiversity and geodiversity. These natural areas typically provide undisturbed species habitat and enable people to see and interact with native vegetation and wildlife.	Natural areas are classified as land within Category V irrespective of the planning zones that apply to that land.
Category I, II, III or IV depending on surrounding land uses and the intent of the specific planning zone (which may have a diversity of uses) as specified in a schedule to the planning zone		Comprehensive Development Zone (CDZ) Priority Development Zone (PDZ) Special Use Zone (SUZ) Public Use Zone (PUZ)

1 Urban Growth Zone (UGZ) is a Category III land use until the relevant precinct structure plan is adopted, at which time the approved land uses will determine the land use category.

The ERS indicators and objectives relevant to each land use category are described in Table 3.

Table 3: Indicators and objectives for the ambient sound environment

Land use category	Indicators	Objectives
Category I	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	55 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	60 dB L_{Aeq}
Category II	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	50 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	55 dB L_{Aeq}
Category III	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	40 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	50 dB L_{Aeq}
Category IV	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	35 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	40 dB L_{Aeq}
Category V	Qualitative	A sound quality that is conducive to human tranquillity and enjoyment, having regard to the ambient natural soundscape

Natural areas are a land-use category for which the ERS details desired outcomes in terms of noise level to be achieved or maintained in Victoria. The ERS defines natural areas as national parks, state parks, state forests, nature conservation reserves and wildlife reserves.

4.0 ASSESSMENT METHOD

4.1 Overview

Based on the legislation and guidelines outlined in Section 3.0, assessing the operational noise levels of the proposed wind turbines involves:

- assessing background noise levels at noise sensitive locations around the wind farm;
- assessing the land zoning of the project site and surrounding areas;
- establishing suitable noise limits accounting for background noise levels and land zoning;
- predicting the level of noise expected to occur as a result of the proposed wind turbines;
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise limits; and
- recommending reasonably practicable measures to minimise the risk of noise impact.

4.2 Background noise levels

Background noise level information is used to inform the setting of limits for both the substation and the wind turbine components of a wind farm project. However, in rural areas where wind farms are typically developed, the background noise level data is most relevant to the assessment of the wind turbines. This is due to the need to consider the changes in background noise levels and wind turbine noise levels for different wind conditions.

In accordance with the Victorian Wind Energy Guidelines and NZS 6808, background noise level information is used for setting noise limits for the wind turbine component of a wind farm project.

The procedures for determining background noise levels are defined in NZS 6808. The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 7.1.4 of the standard provides the following guidance:

> *Background sound level measurements and subsequent analysis to define the relative noise limits should be carried out where wind farm sound levels of 35 dB $L_{A90(10\ min)}$ or higher are predicted for noise sensitive locations, when the wind turbines are at 95% rated power. If there are no noise sensitive locations within the 35 dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

The initial stage of a background noise monitoring program in accordance with NZS 6808 therefore comprises:

- Preliminary wind turbine noise predictions to identify all receivers where predicted noise levels are higher than 35 dB L_{A90}; and
- Identification of selected receivers where background noise monitoring should be undertaken prior to development of the wind farm, if required.

If required, the surveys involve measurements of background noise levels at receivers, and simultaneous measurement of wind speeds at the site of the proposed wind farm. The survey typically extends over a period of several weeks to enable a range of wind speeds and directions to be measured.

The results of the survey are then analysed to determine the trend between the background noise levels and site wind speeds at the proposed hub height of the wind turbines. This trend defines the value of the background noise for the different wind speeds in which the wind turbines would operate. At the wind speeds when the background noise level is above 35 dB L_{A90} (or 30 dB L_{A90} in special circumstances where high amenity limits apply), the background noise levels are used to set the noise limits for the wind farm.

4.3 Noise predictions

Operational wind farm noise levels (wind turbines and associated substation) are predicted using:

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

The method selected to predict noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by NZS 6808 and has been shown to provide a reliable method of predicting the typical upper levels of the wind turbine noise expected to occur in practice.

Key elements of the noise prediction method are summarised in Table 4. Further discussion of the method and the calculation choices is provided in Appendix G.

Table 4: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software *SoundPLANnoise* version 9.0
Method	ISO 9613-2 method 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* (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 and are discussed in Appendix G.
Source characterisation	Each source of operational noise is modelled as a point source of sound. The total sound of the component of the wind farm being modelled (i.e. the wind turbines or the substation) is then calculated on the basis of simultaneous operation of all elements (e.g. all wind turbines) and summing the contribution of each. To model the wind turbine components of the wind farm, the following specific procedures are noted: • Calculations of wind 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 wind turbine. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each wind turbine. Further discussion of terrain screening effects is provided below.
Terrain data	10 m resolution within the site and surrounds, obtained from ELVIS - Elevation and Depth - Foundation Spatial Data.

Detail	Description
Terrain effects (wind turbine-specific procedures)	Adjustments for the effects 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 wind turbine and calculation point is 50 % greater than would occur if the ground were flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the wind turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB. The project is located in a relatively flat area characterised by little variations in ground elevation between the wind turbines and surrounding receivers, with the exception of some hilly terrain to the northeast. Based on comparison of predicted noise levels with and without terrain elevation data included, calculated terrain effects range between -2.2 dB and +1.1 dB for receivers within 5 km of the proposed wind turbines. For reference purposes, the ground elevations at the wind turbines and receivers 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 Institute of Acoustics guidance and research outlined in Appendix F. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 °C / relative humidity 70 % / atmospheric pressure: 101.325 kPa These represent conditions which result in relatively low levels of atmospheric sound absorption. The calculations are based on sound speed profiles[2] which increase the propagation of sound from each wind turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point.
Receiver heights	1.5 m above ground level It is noted that the UK Institute of Acoustics guidance refers 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 results in lower noise levels. However, importantly, predictions in Australia do not generally subtract a margin recommended by the UK Institute of Acoustics guidance to account for differences between L_{Aeq} and L_{A90} noise levels (this is consistent with NZS 6808 which indicates that predicted L_{Aeq} levels should be taken as the predicted L_{A90} sound level of the wind farm). The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels.

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

5.0 EXISTING NOISE ENVIRONMENT

The noise modelling results that are subsequently presented in Section 6.3 demonstrate that predicted noise levels are between 35 and 40 dB L_{A90} at three (3) non-stakeholder receivers. As such, in accordance with NZS 6808, background noise monitoring would require to be undertaken at these receivers.

A background noise monitoring program is being prepared. The background noise assessment will be used to derive applicable noise limits which will be detailed in subsequent revisions of this report.

At this stage in the project, the applicable base (minimum) noise limits determined in accordance with NZS 6808 have been adopted for this assessment. This approach is conservative, as the background noise monitoring results only increases the noise limits above the applicable base limit values.

6.0 WIND TURBINE NOISE ASSESSMENT

6.1 Noise limits

6.1.1 High amenity

In accordance with NZS 6808, an assessment is required for all receivers located within the predicted 35 dB L_{A90} contour to determine whether a high amenity noise limit may be justified. As detailed in Section 3.4.4, this is based on a two-step approach comprising:

1. A land zoning review to determine whether the planning guidance for the area warrants consideration of a high amenity noise limit. If it does, then the second step should be considered
2. A review of the relationship between the background noise levels and predicted noise levels, using the calculation set out in clause C5.3.1.

Based on the predicted noise level contours presented subsequently in Section 6.3, and the zoning map for the area presented in Appendix F, the area within the predicted 35 dB L_{A90} contour is identified as Farming Zone.

Following guidance from the VCAT determination for the Cherry Tree Wind Farm, as required by the Victorian Wind Energy Guidelines, the areas within the Farming Zone do not warrant consideration of the high amenity noise limit.

Based on the above, the high amenity noise limit is not justified for the proposed wind farm.

6.1.2 Stakeholder receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes stakeholder dwellings located within a wind farm site boundary. The discussion in Section 3.4.2 of this report also provides details of the statutory context of NZS 6808, and indicates the method is not intended to be applied to stakeholder receivers outside the site boundary where a noise agreement exists between the occupants and the proponent of the development.

However, consistent with the Victorian Wind Energy Guidelines, Regulation 131B of the EP Regulations specifies a noise limit for stakeholder receivers of 45 dB L_{A90} or background noise (L_{A90}) + 5 dB, whichever is the greater, where a noise agreement between the owner or operator of a wind energy facility and a landowner is made on or after 1 November 2021.

The proponent advised that noise agreements are currently in place or proposed between the landowners and the proponent at twenty-three (23) receivers, as presented in Appendix D.

Further, consistent with the Victorian Wind Energy Guidelines, it is recommended that wind turbine noise levels not exceed a reference level of 45 dB L_{A90} or background noise (L_{A90}) +5 dB at stakeholder receivers within the project boundary.

6.1.3 Applicable noise limits

Accounting for the conclusions of the assessment of high amenity detailed in the previous section, the applicable noise limits at noise sensitive locations are detailed in Table 5.

Table 5: Applicable noise limits, dB L_{A90}

Receiver status	Noise limit
Non-stakeholder	40 dB or background L_{A90} + 5 dB, whichever is the greater
Stakeholder with a noise agreement	45 dB or background L_{A90} + 5 dB, whichever is the greater
Stakeholder within the project boundary	Not applicable Reference level of 45 dB or background L_{A90} + 5 dB, whichever is the greater

In the absence of background noise data for the project, the wind farm has been conservatively assessed using the relevant base (minimum) noise limits presented above.

6.2 Wind turbine noise emissions

6.2.1 Wind turbine model

The final wind turbine model for the site would be selected after a tender process to procure the supply of wind turbines. The final selection would be based on a range of design requirements including achieving compliance with any planning permit noise limits at surrounding receivers.

Accordingly, to assess the proposed wind farm at this stage in the project, it is necessary to consider a candidate wind turbine model that is representative of the size and type of wind turbines being considered. The purpose of the candidate wind turbine is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of wind turbines being considered for the site.

For this assessment, the proponent has nominated the Vestas V162-6.8MW as the candidate wind turbine model. This model is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the wind turbines being regulated by control systems which vary the pitch of the wind turbine blades (the angular orientation of the blade relative to its axis).

This assessment has been based on the wind turbines operating in an unconstrained mode of generation (i.e. without noise reduced operating modes) and with blade serrations. Blade serrations are now routinely used to reduce wind turbine noise emissions, and it is understood that their use is now the market standard for wind turbines being offered in the Australian market.

Details of the assessed candidate wind turbine model are provided in Table 6.

Table 6: Selected candidate wind turbine model

Item	Detail
Make	Vestas
Model	V162
Rotor diameter	162 m
Operating mode	PO6800 [1]
Rated power	6.8 MW
Hub height	166 m
Blade serrations	Yes
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	13 m/s
Cut-out wind speed (hub height)	25 m/s

1 It is our understanding that 'PO6800' is a manufacturer designation which indicates a Power Optimisation mode to achieve a power output of 6,800 kW
This is an unconstrained mode of operation (i.e. without noise reduction)

The hub height detailed above is suitable for noise assessment purposes. It is our understanding that the final hub height of the selected wind turbine model may differ slightly. However, the magnitude of the potential changes is expected to be minor and inconsequential with respect to predicted noise levels at receivers.

The final hub height would be used for the pre-construction noise assessment once the wind turbine layout has been finalised and the final wind turbine model selected.

6.2.2 Sound power levels

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 wind turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the wind turbine.

Sound power level data for the candidate wind turbine model, including sound frequency characteristics, has been sourced from the Vestas Technical Documentation *Third octave noise emission EnVentus™ V162-6.8MW 50/60 Hz* dated 7 January 2022.

Based on the data sourced from the manufacturer's documentation, the noise modelling undertaken for this assessment involved conversion of third octave band levels to octave band levels (where applicable), and adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The overall A-weighted sound power levels (including the +1.0 dB addition) as a function of hub height wind speed are presented in Table 7 with the octave band values presented in Table 8. These represent the total noise emissions of the wind turbine for each sound mode, including the secondary contribution of ancillary plant associated with each wind turbine (e.g. cooling fans).

Table 7: Sound power levels (including the +1.0 dB addition) versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
L_{WA}	95.0	95.0	96.0	99.3	102.5	104.3	104.3	104.4	104.8	105.1	105.3	105.5

Table 8: Octave band sound power levels, dB L_{WA} [1]

	Octave band centre frequency, Hz									
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
L_{WA}	75.6	86.0	93.6	98.4	100.5	99.7	96.2	89.8	80.7	105.5

1 Based on one-third octave band levels at 15 m/s

These sound power levels are also illustrated in Appendix I.

Review of available sound power data for a range of wind turbine models has shown that there isn't a clear relationship between wind turbine size, or power output, and the noise emission characteristics of a given wind turbine model. In practice, the overall noise emissions of a wind turbine are dependent on a range of factors, including the wind turbine size and power output, and other important factors such as the blade design and rotational speed of the wind turbine.

While wind turbine sizes and power ratings of contemporary wind turbines have increased, the noise emissions of the wind turbines are comparable to, or lower than, previous generations of wind turbines. This is a result of design improvements, notably, measures to reduce the speed of rotation of the wind turbines, and enhanced blade design features such as serrations for noise control.

6.2.3 Special audible characteristics

Special audible characteristics relate to potential tonality, amplitude modulation and impulsiveness of a wind turbine.

Information concerning potential tonality is often limited at the planning stage of a wind farm, and test data for tonality is presently unavailable for the selected candidate wind turbine model. However, the occurrence of tonality in the noise of contemporary multi-megawatt wind turbine designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Amplitude modulation and impulsiveness are not able to be predicted, however the evidence of operational wind farms in Australia indicates that their occurrence is limited and atypical.

Given the above, adjustments for special audible characteristics have not been applied to the predicted noise levels presented in this assessment. Notwithstanding this, the subject of special audible characteristics would be addressed in subsequent assessment stages for the project, following approval of the wind farm, and again following construction of the wind farm.

6.3 Predicted noise levels

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 wind 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.

Noise levels from the proposed wind farm have been predicted using the sound power level data detailed in Section 6.2.2 for the selected candidate wind turbine model and are summarised in Table 9 for the hub height wind speed which results in the highest predicted noise levels (15 m/s).

Predicted noise levels at receivers within the project boundary, where noise limits do not apply, are presented for information only.

The locations of the predicted 35 dB and 40 dB L_{A90} noise contours are illustrated in Figure 1, for the hub height wind speed which results in the highest predicted noise levels.

Predicted noise levels for each integer wind speed are tabulated in Appendix H for all considered receivers, including receivers where the highest predicted noise level is below 30 dB L_{A90}.

Table 9: Highest predicted noise level at receivers with predicted levels 30 dB L_{A90} or above

Receiver	Predicted level, dB L_{A90}
Outside the project boundary	
28	31.9
40	31.6
43	31.7
45	32.6
59	33.3
82	34.5
84 (S)	39.6
88 (S)	33.8
95	30.6
98 (S)	31.3
99	35.4
100	30.2
104 (S)	36.1
105 (S)	36.2
106 (S)	36.4
113	31.7

Receiver	Predicted level, dB L_{A90}
120	34.3
122 (S)	30.5
124	35.7
131	35.8
132	33.3
135	31.4
138	31.0
139	31.0
140	31.1
141	32.7
142 (S)	34.8
Within the project boundary	
39 (S)	34.2
97 (S)	39.4
102 (S)	36.5
107 (S)	36.4
117 (S)	34.2
118 (S)	37.4
128 (S)	39.4
129 (S)	37.0
137 (S)	36.5
143 (S)	36.7

(S) Stakeholder

The following can be concluded from the predicted noise levels detailed in Table 9:

- Compliance with the applicable base noise limit of 40 dB L_{A90} by at least 4.2 dB at all non-stakeholder receivers; and
- Compliance with the applicable base noise limit of 45 dB L_{A90} by at least 5.4 dB at all stakeholder receivers outside the project boundary.

Predicted noise levels at stakeholder receivers within the project boundary are predicted below the reference noise level of 45 dB L_{A90}, by at least 5.6 dB.

Figure 1: Highest predicted noise level contours (north), dB L_{A90}

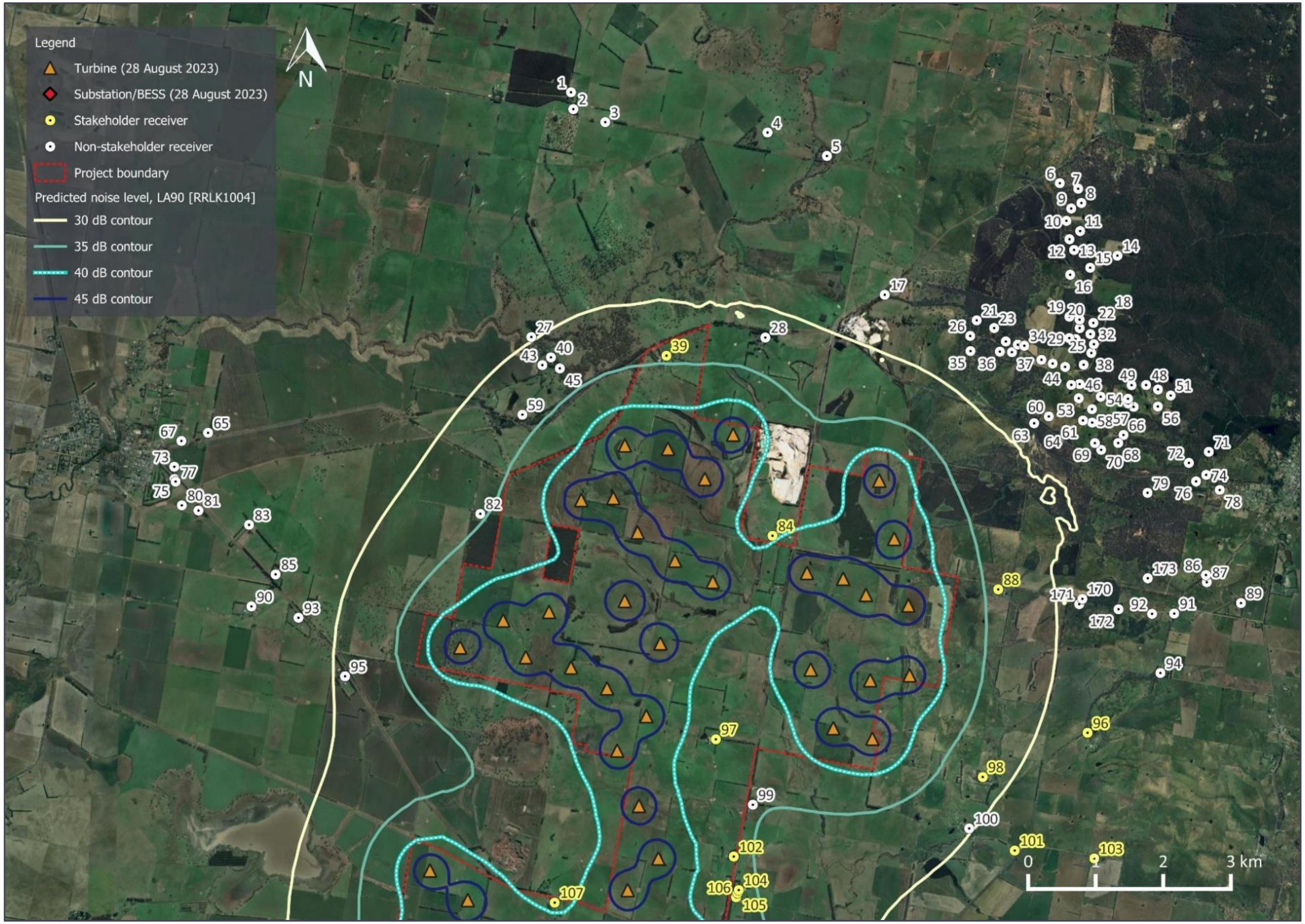
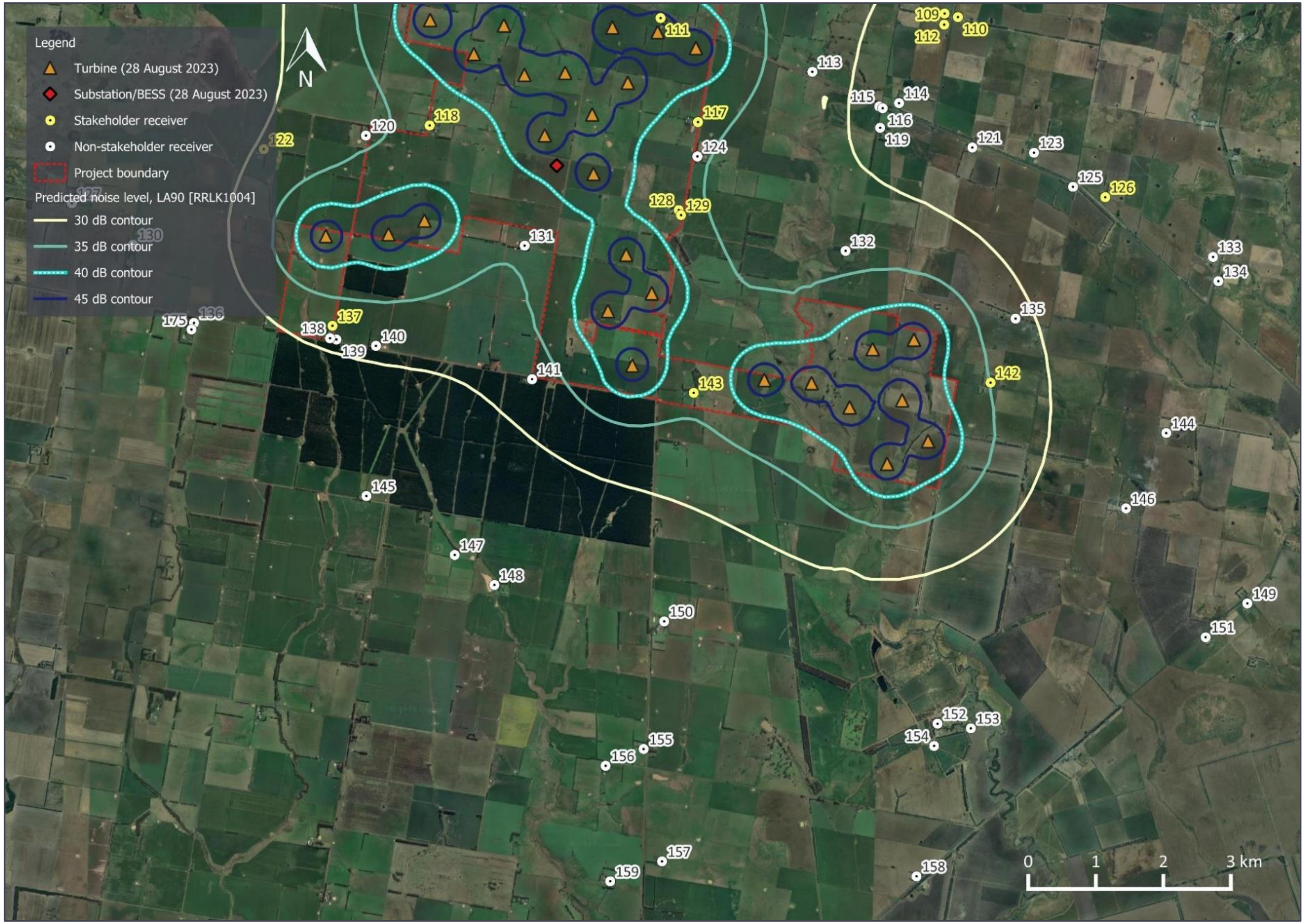


Figure 2: Highest predicted noise contours (south), dB L_{A90}



6.4 Cumulative assessment

The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind turbine noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore considered other wind farm projects in the surrounding area.

Based on publicly available information (dated 18 December 2023)[3], four (4) wind farms have been identified within 15 km of the proposed wind farm for the review of potential cumulative noise considerations. These wind farms are detailed in Table 10.

Table 10: Wind farm development in the broader area around the Moreton Hill Wind Farm

Wind Farm Name	Status	Approximate distance to nearest turbine
Stockyard Hill Wind Farm	Operating	3 km to the northwest
Chepstowe Wind Farm	Operating	10 km to the north
Berrybank Wind Farm	Operating	11 km to the south
Golden Plains Wind Farm	Under construction	14 km to the north-northeast

Wind farms located farther than 15 km from the proposed project, would not have cumulative effects likely to affect the assessment outcome, however, two wind farms have been included for contextual information.

6.4.1 Stockyard Hill Wind Farm

The Stockyard Wind Farm commenced operation in December 2020 and comprises one hundred and forty-nine (149) Goldwind 3S wind turbines with a hub height of 110 m[4].

The noise emissions for the Goldwind 3S wind turbines have been represented for this study with data sourced from the pre-development noise assessment report[5].

The planning permit[6] establishes a minimum operational noise limit of 40 dB for non-stakeholder receivers around the wind farm.

6.4.2 Chepstowe Wind Farm

The Chepstowe Wind Farm commenced operation in April 2015 and comprises three (3) Senvion MM92 wind turbines with a hub height of 80 m[7].

The noise emissions for the Senvion MM92 wind turbines have been represented for this study with data sourced from the noise assessment report for the Maroona Wind Farm[8].

The planning permit[9] establishes a minimum operational noise limit of 40 dB for non-stakeholder receivers around the wind farm.

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3 https://mapshare.vic.gov.au/planningwebmaps/RenewablesSummary.html

4 https://www.stockyardhillwindfarm.com.au/

5 MDA Report Rp 001 R04 20170840 *Stockyard Hill Wind Farm – Pre-development noise assessment*, dated 20 Dec. 2017

6 Planning Permit no. PL-SP/05/0548/B

7 https://chepstowewindfarm.com.au/

8 MDA Report Rp 001 2015352ML *Maroona Wind Farm – Noise assessment*, dated 16 Sep. 2015

9 Planning Permit no. PA1676/10

6.4.3 Berrybank Wind Farm

The Berrybank Wind Farm commenced operation in July 2021 and comprises forty-three (43) V136-4.2MW wind turbines with a hub height of 112 m[10].

The noise emissions for the V136-4.2MW wind turbines have been represented for this study with data sourced from a publicly available noise assessment report[11].

The planning permit[12] establishes a minimum operational noise limit of 40 dB for non-stakeholder receivers around the wind farm.

6.4.4 Golden Plains Wind Farm

The Golden Plains Wind Farm is currently under construction, comprising two hundred and twenty-eight (228) turbines with a maximum tip height of 230 m[13].

The noise emissions for the V162-6.0MW wind turbines have been represented for this study with data sourced from a publicly available noise assessment report[14].

The planning permit establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

6.4.5 Assessment

To inform the assessment of potential cumulative noise considerations, reference is made to Clause 5.6.4 of NZS 6808 which states:

> *For the purposes of 5.6.1, if the predicted wind farm sound levels for a new wind farm are at least 10 dB below any existing wind farm sound levels permitted by any resource consent or plan, then the cumulative effect shall not be taken into account.*

Additional contextual information is provided in the commentary to Clause 5.6.4 which notes:

> *If an existing wind farm sound level is say 40 dB and the predicted wind farm sound level for a new wind farm is say 30 dB then the combined level would be 40.4 dB. This increase of less than 0.5 dB cannot be reliably measured and would be undetectable to people, and will therefore not give rise to any adverse cumulative effect.*

Based on this guidance, a preliminary simplified assessment of potential cumulative noise considerations can be made by comparing the individual predicted 30 dB L_{A90} contours of each wind farm operating in isolation, as presented in Figure 3.

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10 https://www.berrybankwindfarm.globalpower-generation.com.au/

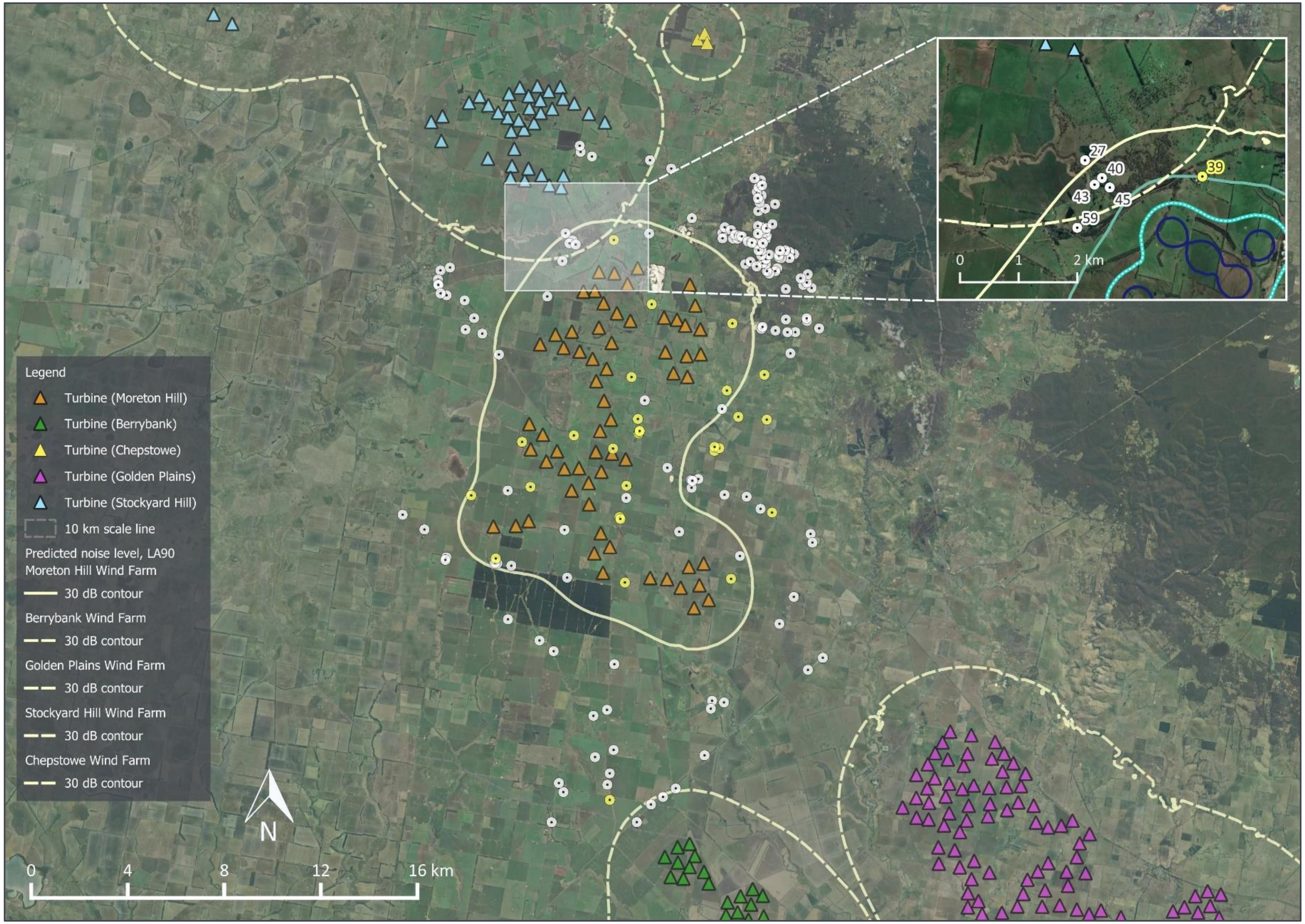
11 MDA Report Rp 002 R02 20180495 *BBWF – Pre-construction noise assessment*, dated 8 April 2019

12 Planning Permit no. 20092821-A

13 https://goldenplainswindfarm.com.au/about-golden-plains-wind-farm/

14 MDA Report Rp 001 R02 20200919 *Golden Plains Wind Farm - Environmental Noise Assessment*, dated 4 Jan. 2020

Figure 3: Predicted 30 dB L_{A90} contours for the Moreton Hill Wind Farm and neighbouring wind farms



The results demonstrate that the predicted 30 dB L_{A90} contour of the Moreton Hill Wind Farm (using the candidate turbine model) do not overlap with the predicted 30 dB L_{A90} contour of the Berrybank, Chepstowe and Golden Plains wind farms. Based on this finding, the following can be concluded for these three neighbouring wind farms:

- At any receiver where the predicted noise level of one of the wind farms is between 30 and 40 dB, the predicted noise level from an adjoining wind farm will be less than 30 dB, and significantly lower in most cases
- At any receiver where the predicted noise level from one of the wind farms approaches the 40 dB base noise limit applicable to each site, the predicted noise level associated with each of neighbouring wind farms will be more than 10 dB lower. Based on the guidance of NZS 6808, the cumulative effect does not need to be taken in account for the nearest receivers to each of these wind farm developments.

The predicted noise levels therefore demonstrate that cumulative wind farm noise considerations between the Moreton Hill, Berrybank, Chepstowe and Golden Plains wind farms are not applicable. Specifically, the noise contribution of the Berrybank, Chepstowe and Golden Plains wind farms is sufficiently low to be inconsequential to the noise assessment for the Moreton Hill Wind Farm. Conversely, the predicted noise contribution of the Moreton Hill Wind Farm at the receivers in the vicinity of the Berrybank, Chepstowe and Golden Plains wind farms would not affect the compliance outcomes for these developments.

As a visual guide to identify potential cumulative noise considerations between the Moreton Hill Wind Farm and the Stockyard Hill Wind Farm, the inset of Figure 3 presents the overlap area between the respective predicted 30 dB L_{A90} noise contours.

The predicted noise levels presented in Table 11, at the receivers identified in the overlap area, are for the wind speeds which give rise to the highest noise emissions from each site respectively. It is also noted that the noise level contours are predicted on the basis of downwind propagation from each turbine; in most instances where cumulative noise is considered, a noise sensitive receiver cannot be simultaneously downwind of all wind turbines of adjoining projects. The predictions are therefore conservative[15] for the purpose of considering cumulative noise levels.

Table 11: Cumulative assessment

Receiver	Predicted noise level, dB L_{A90}			Change in compliance outcome due to cumulative effects
	Moreton Hill only	Stockyard Hill only	Cumulative	
40	31.4	31.6	34.5	No
43	31.4	31.8	34.6	No
45	32.6	31.1	34.9	No

It can be concluded from the above table that the compliance outcome for both the Moreton Hill Wind Farm and the Stockyard Hill Wind Farm would not be affected by the noise contribution from the other project.

15 By a margin of up to 3 dB when compared to downwind predictions from each wind farm individually. This is distinct to variation of noise levels when a receiver is upwind of each wind farm when noise levels would be significantly lower than the downwind predictions.

7.0 RELATED INFRASTRUCTURE

7.1 Description

Related infrastructure associated with the project is understood to comprise a battery energy storage system (BESS) and a substation.

At this stage of the project equipment selections and infrastructure layout are yet to be determined. Information provided by the proponent is limited to the substation incorporating a single transformer rated to 500 MVA and the BESS having a capacity of 150 MW.

In order to provide a basis for assessing the feasibility of the proposed related infrastructure, assumptions with respect to equipment counts and selections have been made for the BESS, based on recent experience with similar projects.

As the factors dictating equipment counts and selection lie mostly outside the expertise and responsibility of MDA, the assumptions and derived modelling scenarios are presented as indicative only for the purpose of assessing whether the project may be designed and operated to achieve the noise limits determined in accordance with the Noise Protocol.

7.2 Noise limits

The procedure for determining the noise limits according to the Noise Protocol depends on whether the noise source or the receivers are located in a rural or urban area. The procedures for rural areas, applicable for the subject site, are based on determining the zone levels according to the land zoning of the area in which the noise source and receivers are located. These zone levels are then adjusted, where appropriate, for a range of factors.

The zone levels are determined on the basis of the substation and surrounding residential receivers both being located on land designated as Farming Zone (FZ) (see land zoning map in Appendix F).

Considering that the land zoning is continuous between the substation and the receivers, a distance adjustment is not applicable.

Adjustments for 'background relevant areas' are not warranted in this instance, as the background noise levels during the relevant assessment conditions for the substation (i.e. low wind speeds) are expected to be relatively low; adjustments for background noise levels are therefore not warranted in this instance.

Based on the above and considering that the substation would be defined in the Victorian Planning Provisions as a *utility*, the noise limits applicable at the nearest receivers, are summarised in Table 12.

Table 12: Noise Protocol time periods and noise limits, dB ENL[16]

Period	Day of week	Start time	End time	Noise limit
Day	Monday- Saturday	0700 hrs	1800 hrs	45
Evening	Monday- Saturday	1800 hrs	2200 hrs	39
	Sunday, Public holidays	0700 hrs	2200 hrs	
Night	Monday-Sunday	2200 hrs	0700 hrs	34

As the substation is proposed to operate 24 hours a day and 7 days a week, meeting the applicable night-time noise limit of 34 dB ENL, infers meeting the noise limits during all other time periods.

[16] The effective noise level (ENL) of commercial or industrial noise determined in accordance with the Noise Protocol. This is L_{Aeq} noise level over a half-hour period, adjusted for the character of the noise. Adjustments are made for tonality, intermittency, and impulsiveness.

7.3 Related infrastructure noise

7.3.1 Substation

In lieu of measured sound power level data for a specific transformer selection, reference has been made to Australian Standard AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009) which provides a method for estimating transformer sound power levels. Specifically, Figure ZA1 from AS 60076-10:2009 has been used to determine the estimated standard maximum sound power level of 104 dB L_{WA} for the proposed 500 MVA transformer.

AS 60076-10:2009 does not provide estimated sound frequency spectra for transformer noise. Spectral data for the transformer was estimated by applying corrections from Table 11.27 *Location 1a for outdoor transformer noise* of Bies and Hansen[17] to the estimated standard maximum sound power level of 104 dB L_{WA}.

It should be noted that noise relating to transformers typically exhibits tonal characteristics at source. On this basis evaluation of tonality at the noise sensitive receivers must be considered. This is addressed in subsequent sections of the report.

7.3.2 Battery energy storage system

To provide practical assessment of potential noise levels associated with the BESS, it has been necessary to develop conceptual operational parameters i.e. equipment selection, equipment counts, due to the limited information available at this stage.

To demonstrate the range of noise levels that may be associated with the BESS two (2) modelling scenarios have been developed. The noise data and equipment counts used within each modelling scenario is based on equipment used on our recent experience with other BESS projects.

As the factors dictating equipment counts and selection lie mostly outside the expertise and responsibility of MDA, the assumptions and derived modelling scenarios are presented as indicative only for the purpose of assessing whether the project may be designed and operated to achieve the noise limits determined in accordance with the Noise Protocol. These do not represent the upper and lower range of noise emissions from a BESS with the proposed capacity.

As no information with respect to equipment layouts is available at this stage of the project, a simplified modelling approach has been adopted that sums equipment noise levels into a single cumulative point source.

BESS projects traditionally comprise battery units, inverters and MV transformers. Inverters are typically the dominant noise sources. On this basis, and in line with the simplified modelling approach, the derived BESS noise modelling scenarios for the project consider noise emissions from the inverters only.

In some cases, other noise sources may contribute to the predicted noise level at the receiver, particularly if noisy battery units or large MV transformers are included in the project. For this reason, calculations incorporate a +2 dB uncertainty factor. Whilst this is an attempt to mitigate modelling uncertainty (given the breadth of assumptions necessary at this stage), it may not account for all variations that may occur.

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[17] Bies, & Hansen, C. H. (2009). *Engineering noise control: theory and practice (Fourth edition.).* p. 601

The two noise modelling scenarios are as follows:

- Scenario 1

  48 x Power Electronics inverters, with a cumulative sound power level of 113 dB L_{WA}.

  This is based on an example project of 200 MW comprising 64 x Power Electronics inverters.

- Scenario 2

  60 x SMA inverters (with OEM provided noise control package) with a cumulative sound power level of 106 dB L_{WA}.

  This is based on an example project of 300 MW comprising 120 x SMA inverters (with OEM provided noise control package).

7.4 Predicted noise levels

Predicted noise levels have been determined on the basis of:

- the indicative equipment noise emission data detailed in Section 7.3; and
- the ISO 9613-2 noise prediction method described in Section 4.3.

Two adjustments have been applied to the predicted noise level, which include the following adjustements:

- +2 dB to account for the potential tonal characteristics of transformer noise; and
- +2 dB to account for factors of uncertainty that cannot be accurately evaluated at this stage (estimated number of units, layout, equipment selection, etc).

Due to the limited information available at this stage, and necessarily simplified modelling and assessment method, the modelling results should be viewed as a general indication of potential feasibility providing an assessment tool to evaluate future acoustic factors relevant for project development. They should not be viewed as upper and lower range of noise predictions for a BESS with the proposed capacity.

The nearest receivers and the predicted effective noise level (including the adjustments) are detailed in Table 13 and Table 14 accounting for the substation and each BESS scenario.

Table 13: Related infrastructure predicted noise levels, dB ENL – Substation and BESS Scenario 1

Receiver	Total predicted noise level [1]	Noise limit (night)	Exceedance
131	36	34	+2
124	34	34	---
128	32	34	---
129	32	34	---
118	31	34	---

1 Includes +2 dB uncertainty adjustment and +2 dB tonality adjustment

Table 14: Related infrastructure predicted noise levels, dB ENL – Substation and BESS Scenario 2

Receiver	Total predicted noise level [1]	Noise limit (night)	Exceedance
131	29	34	---
124	27	34	---
128	25	34	---
129	25	34	---
118	25	34	---

1 Includes +2 dB uncertainty adjustment and +2 dB tonality adjustment

The results presented above indicate that compliance is feasible provided appropriate equipment selections (targeting equipment with lower noise levels at source) and/or incorporating the range of engineering noise controls that are typically available (barriers, bunds etc) that have not been investigated at this stage of the project.

Noise levels from the proposed related infrastructure will require further review during the design stage. In particular, noise levels should be reviewed at the time when equipment numbers and selections are finalised, accounting for manufacturer noise emission data. In accordance with the general environmental duty under the EP Act, all reasonably practicable measures will need to be implemented to minimise the risk of harm associated with the noise of the BESS and substation.

8.0 ENVIRONMENTAL REFERENCE STANDARD

The Environmental Reference Standard (ERS) is a relevant consideration for natural areas located in the vicinity of the project and is addressed in this section.

8.1 Identified natural areas

Natural areas are a land-use category for which the ERS details desired outcomes in terms of noise levels to be achieved or maintained in Victoria. The ERS defines natural areas as national parks, state parks, state forests, nature conservation reserves and wildlife reserves.

To provide an indication of the proximity of natural areas to the project, reference has been made to the land zoning of the surrounding area presented in Appendix F. Specifically, areas zoned as PCRZ and PPRZ, have been identified, where the ERS may be relevant. For this project, the nearest identified natural area is the Mount Bute Scenic Reserve, approximately 2.1 km northeast of the project.

8.2 Guidance on noise in natural areas

Clause 7 of the ERS sets out the environmental values for the ambient sound environment that are to be achieved or maintained in Victoria. The ERS also sets out the indicators and objectives to support those values. The environmental value relevant to natural areas and the indicator to support this value is contained in Table 15.

Table 15: Environmental values of the ambient sound environment

Environmental value	Description of environmental value
Human tranquillity and enjoyment outdoors in natural areas	An ambient sound environment that allows for the appreciation and enjoyment of the environment for its natural condition and the restorative benefits of tranquil soundscapes in natural areas

8.3 Existing noise environment in natural areas

The natural areas identified in Appendix F extend over relatively large areas, predominantly to the northeast of the project, which will comprise a broad range of ambient noise environments. For example, natural areas located beside the transportation network (Linton-Carngham Road and Glenelg Highway), would be characterised by intermittent road traffic noise. Further away from the transportation network, noise sources are expected to be predominantly related to natural sources such as fauna and wind disturbance of vegetation.

As a result of these factors, and the extent of the natural areas, background noise levels are likely to vary significantly. For example, background noise levels are likely to be elevated at locations immediately adjacent to the transportation network. At other locations where wind disturbance of vegetation is a key influence, the background noise would vary significantly according to factors such as ground elevation (in turn affecting exposure to the wind) and the type and density of vegetation in the surrounding area.

8.4 Project noise levels in natural areas

The potential for the environmental value of *human tranquillity and enjoyment outdoors in natural areas* to be affected by noise is dependent on the audibility of the noise. Audibility of the project in the identified natural areas will be highly dependent on a range of factors, including:

- Proximity and scale of the project;
- Operating conditions of the project;
- Extent of the identified natural areas;
- Natural background noise sources (e.g., ocean, vegetation, fauna, etc.); and
- Anthropogenic background noise sources (e.g., road traffic, farming and forestry activities, etc.); and
- Wind conditions (e.g., wind speed and wind direction).

The proximity of the identified natural areas to the project is such that there would be parts of these areas where activities associated with both construction and operation of the project could contribute to the soundscape.

With respect to operational noise of the project in natural areas, the primary consideration is noise from wind turbines (the proposed substation is much further from natural areas than the turbines).

Wind turbine noise levels of approximately 30 dB L_{A90} are predicted within the Mount Bute Scenic Reserve. At this level, it is possible that wind turbine noise could be audible on some occasions. However, the likelihood of wind turbine noise levels being audible would depend on the level of background noise in the reserve during windy conditions. A relevant consideration in this respect is that the Mount Bute Scenic Reserve is elevated relative to the proposed turbine locations. As such, the locations within the reserve where wind turbine noise could be audible are likely to be exposed to prevailing wind conditions and, as a result, background noise levels associated with wind disturbed vegetation are also likely to be increased. This means that the aerodynamic noise associated with operation of the wind farm is likely to be difficult to discern in these conditions. Accordingly, instances of audible wind turbine noise within the reserve are likely to be infrequent.

9.0 RECOMMENDED NOISE MANAGEMENT MEASURES

Providing that the operator of a wind energy facility complies with the requirements of Regulation 131C, their obligations with respect to the general environmental duty (GED) under the EP Act will be addressed with regard to wind turbine noise.

Specifically, the operator of the wind facility:

- Must ensure that wind turbine noise complies with NZS 6808; and
- Must implement all applicable actions under Division 5.3 of the EP Regulations to manage and review wind turbine noise from the facility, including:
  - preparation of a noise management plan;
  - conducting noise compliance testing when the wind farm begins operating;
  - preparing annual compliance statements; and
  - conducting verification wind turbine noise monitoring every 5 years.

In addition to the above, the following noise management measures should be implemented as part of the subsequent stages of development:

- The transformer equipment should be specified and selected to achieve noise emissions not exceeding the empirical values specified in AS 60076-10:2009
- The BESS equipment should be specified and selected to achieve the lowest reasonably practicable noise emissions
- A detailed noise assessment should be prepared by a qualified acoustic consultant, prior to construction, addressing:
  - the final wind turbine selection and layout
  - the final location and equipment selection for the related infrastructure (battery energy storage system and substation)
  - background noise monitoring at the required non-stakeholder receivers
  - compliance with the applicable noise limits at surrounding receivers
  - recommendation of reasonably practicable noise mitigation measures to control noise from the related infrastructure.
- Development of reasonably practicable construction noise mitigation and management measures to be documented in a construction environmental management plan, prior to construction.

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
Amplitude modulation	Sound that is characterised by a rhythmic and higher than normal rise and fall in sound level at regular intervals.	-
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted average noise level	The equivalent continuous (time-averaged) A-weighted sound level.	L_{Aeq}
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Impulsiveness	Sound that is characterised by a distinct and very rapid rise in sound level (e.g. a car door closing or the impact sound of a hammer)	-
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special Audible Characteristics	A term used to define a set group of Sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics comprise tonality, impulsiveness and amplitude modulation.	SAC
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report. For example, sound pressure levels measured using an “A” frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

APPENDIX B SOURCE COORDINATES

The following table sets out the coordinates of the proposed wind turbine layout (Reference *20230828 MHWF WTG Rev 1_Issued*, supplied by the proponent on 29 August 2023).

The terrain elevations for the wind turbines are based on terrain data obtained from ELVIS - Elevation and Depth - Foundation Spatial Data (downloaded on 7 March 2023).

This data may differ slightly from actual terrain elevations for each individual wind turbine; however, it provides a sufficiently accurate representation for the purpose of this assessment.

Table 16: Wind turbine coordinates – MGA 94 zone 54

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
MHT01	717,599	5,826,548	312
MHT02	715,995	5,826,389	337
MHT03	716,634	5,826,338	327
MHT04	717,179	5,825,891	310
MHT05	719,764	5,825,867	335
MHT06	715,824	5,825,609	324
MHT07	715,349	5,825,580	349
MHT08	716,184	5,825,101	320
MHT09	719,984	5,825,006	310
MHT10	716,738	5,824,683	310
MHT11	718,692	5,824,502	295
MHT12	719,228	5,824,415	290
MHT13	717,297	5,824,368	292
MHT14	719,566	5,824,176	300
MHT15	715,993	5,824,088	312
MHT16	720,194	5,824,020	314
MHT17	714,872	5,823,925	380
MHT18	714,193	5,823,798	366
MHT19	716,521	5,823,458	297
MHT20	713,555	5,823,398	325
MHT21	714,528	5,823,255	326
MHT22	715,197	5,823,101	330
MHT23	718,747	5,823,072	290
MHT24	720,212	5,822,987	360
MHT25	719,629	5,822,913	306
MHT26	715,730	5,822,793	320
MHT27	716,313	5,822,383	310

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
MHT28	719,082	5,822,204	280
MHT29	719,661	5,822,049	285
MHT30	715,881	5,821,873	309
MHT31	716,203	5,821,056	290
MHT32	716,491	5,820,278	284
MHT33	713,108	5,820,100	304
MHT34	716,037	5,819,810	295
MHT35	713,668	5,819,661	315
MHT36	713,166	5,819,053	310
MHT37	714,258	5,818,973	322
MHT38	715,865	5,818,943	299
MHT39	716,535	5,818,874	291
MHT40	717,102	5,818,638	288
MHT41	713,813	5,818,549	311
MHT42	715,166	5,818,272	297
MHT43	714,562	5,818,242	303
MHT44	716,093	5,818,125	294
MHT45	715,566	5,817,656	290
MHT46	714,863	5,817,347	295
MHT47	715,585	5,816,777	284
MHT48	713,081	5,816,085	285
MHT49	712,549	5,815,883	277
MHT50	711,621	5,815,856	269
MHT51	716,069	5,815,581	275
MHT52	716,448	5,815,010	270
MHT53	715,799	5,814,748	270
MHT54	720,331	5,814,322	267
MHT55	719,719	5,814,184	263
MHT56	716,160	5,813,941	270
MHT57	718,115	5,813,727	254
MHT58	718,815	5,813,680	250
MHT59	720,157	5,813,426	260
MHT60	719,378	5,813,322	258

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
MHT61	720,540	5,812,821	250
MHT62	719,934	5,812,487	243

The following table sets out the coordinates of the proposed related infrastructure (Reference *20230828 MHWF Site Substation Rev 1_Issued*, supplied by the proponent on 29 August 2023).

Table 17: Preliminary substation coordinates – MGA 94 zone 54

Item	Easting, m	Northing, m	Terrain elevation, m
Substation/BESS	715,158	5,816,948	291

APPENDIX C RECEIVER COORDINATES

The following table sets out the assessed receivers considered in the environmental noise assessment. (Reference *20230314 MHWF Building Register*, supplied by the proponent on 23 March 2023).

Table 18: Receivers within 5 km of the proposed wind turbines – MGA 94 zone 55

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
Outside the project boundary					
1	715,197	5831613	359	5,287	MHT1
2	715,232	5831362	367	5,034	MHT1
3	715,705	5831170	350	4,793	MHT1
4	718,108	5831017	339	4,501	MHT2
5	718,988	5830670	330	4,353	MHT2
8	722,756	5829974	371	5,084	MHT5
9	722,606	5829892	362	4,930	MHT5
10	722,535	5829710	361	4,741	MHT5
11	722,738	5829558	372	4,743	MHT5
12	722,580	5829438	372	4,551	MHT5
13	722,648	5829279	373	4,471	MHT5
14	723,290	5829195	400	4,851	MHT5
15	722,887	5829016	385	4,438	MHT5
16	722,591	5828912	371	4,158	MHT5
17	719,844	5828616	365	2,756	MHT5
18	723,184	5828367	394	4,239	MHT5
19	722,579	5828292	408	3,719	MHT5
20	722,730	5828249	405	3,808	MHT5
21	721,206	5828238	400	2,780	MHT5
22	722,934	5828200	390	3,939	MHT5
23	721,465	5828124	392	2,831	MHT5
24	722,731	5828123	405	3,731	MHT5
25	722,890	5828034	395	3,807	MHT5
26	721,110	5828007	366	2,534	MHT5
27	714,610	5827991	310	2,125	MHT1
28	718,076	5827983	350	1,521	MHT2
30	722,672	5827960	410	3,587	MHT5
31	721,637	5827925	402	2,788	MHT5

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
32	722,942	5827885	399	3,768	MHT5
33	721,815	5827878	420	2,877	MHT5
34	721,912	5827862	420	2,936	MHT5
35	721,114	5827783	360	2,350	MHT5
36	721,549	5827775	400	2,618	MHT5
37	721,728	5827767	413	2,738	MHT5
38	722,904	5827755	400	3,667	MHT5
40	714,900	5827690	321	1,709	MHT1
41	722,165	5827655	443	2,998	MHT5
42	722,790	5827582	410	3,482	MHT5
43	714,773	5827576	320	1,712	MHT1
44	722,516	5827549	437	3,229	MHT5
45	715,032	5827527	326	1,500	MHT1
46	722,731	5827295	438	3,297	MHT5
47	722,607	5827283	437	3,180	MHT5
48	723,715	5827281	409	4,199	MHT8
49	723,500	5827279	410	3,997	MHT5
50	723,891	5827215	410	4,344	MHT5
51	724,080	5827126	410	4,499	MHT5
52	723,043	5827108	440	3,510	MHT5
53	722,718	5827085	440	3,199	MHT5
54	723,447	5827078	407	3,880	MHT5
55	723,450	5827007	410	3,862	MHT5
56	723,889	5826963	389	4,271	MHT5
57	723,532	5826958	403	3,926	MH14
58	722,914	5826923	427	3,326	MHT5
59	714,478	5826842	330	1,543	MHT1
60	722,274	5826816	408	2,688	MHT5
61	722,780	5826756	440	3,148	MHT5
62	722,917	5826725	430	3,272	MHT8
63	722,057	5826715	384	2,450	MHT5
64	722,530	5826618	435	2,871	MHT5
65	709,821	5826575	309	4,905	MHT17

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
66	723,380	5826542	408	3,682	MHT5
67	709,427	5826454	303	5,139	MHT17
68	723,302	5826423	395	3,585	MHT5
69	722,957	5826422	403	3,245	MHT5
70	723,050	5826322	393	3,321	MHT5
71	724,644	5826293	375	4,837	MHT5
72	724,349	5826129	360	4,510	MHT5
73	709,322	5826072	302	5,010	MHT17
74	724,605	5825952	351	4,719	MHT14
75	709,323	5825890	300	4,914	MHT17
76	724,455	5825855	356	4,554	MHT14
77	709,341	5825853	300	4,880	MHT17
78	724,806	5825728	350	4,878	MHT14
79	723,736	5825686	382	3,816	MHT8
81	709,680	5825424	302	4,376	MHT17
82	713,854	5825375	368	1,518	MHT16
83	710,429	5825213	323	3,619	MHT17
84 (S)	721,525	5824258	303	768	MHT10
85	710,822	5824479	320	2,944	MHT17
86	724,601	5824470	378	4,433	MHT14
87	724,614	5824364	379	4,436	MHT14
88 (S)	717,343	5822040	303	1,362	MHT14
89	725,120	5824056	370	4,929	MHT14
90	710,464	5824006	305	3,155	MHT17
91	724,132	5823900	383	3,943	MHT14
92	723,803	5823896	422	3,615	MHT21
93	711,161	5823838	318	2,440	MHT17
94	723,927	5823021	405	3,718	MHT21
95	711,851	5822972	314	1,764	MHT17
96	722,848	5822136	310	2,774	MHT21
98 (S)	721,296	5821482	284	1,738	MHT26
99	717,891	5821072	276	1,618	MHT29
100	721,095	5820721	273	1,961	MHT26

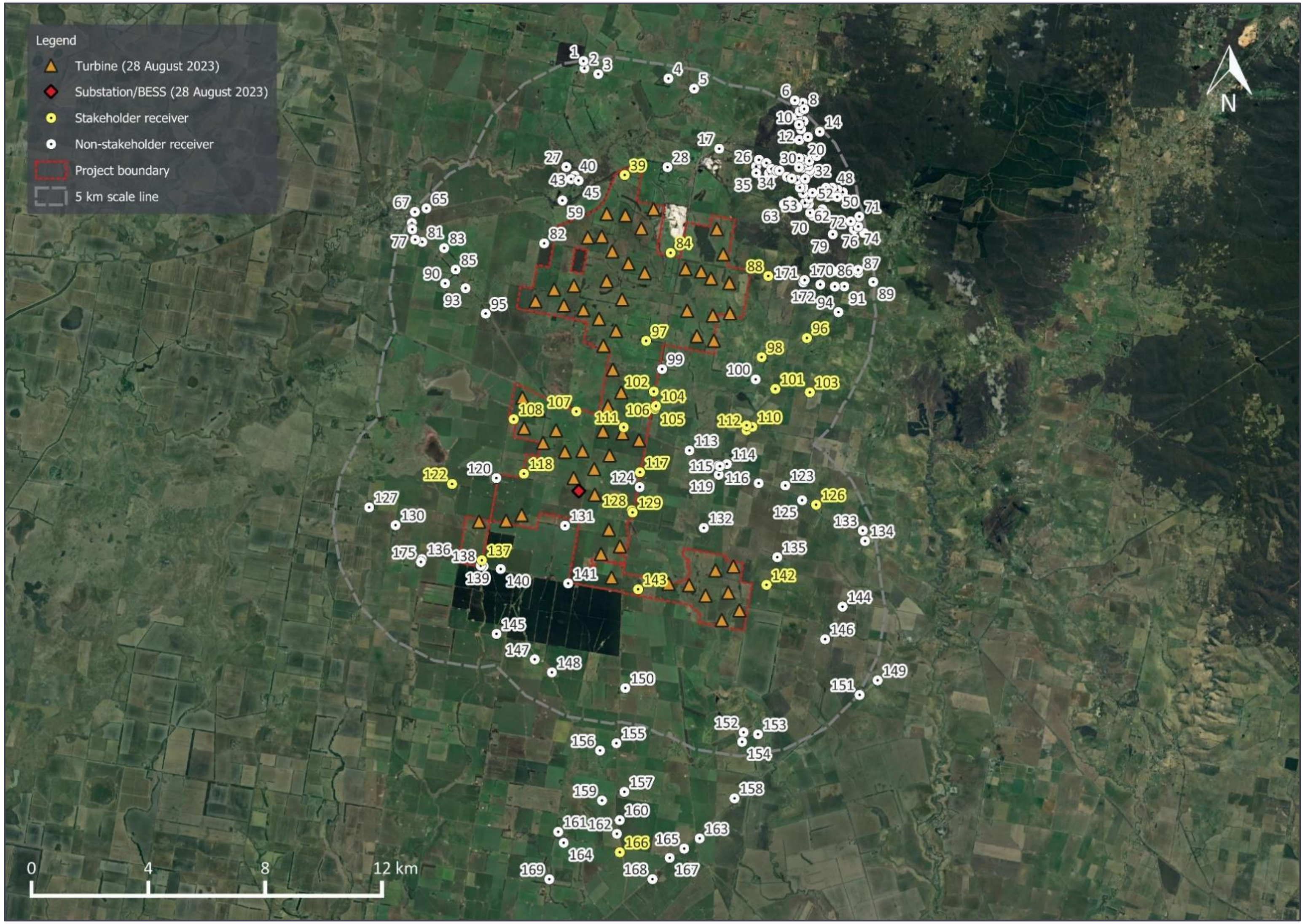
Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
101 (S)	721,769	5820394	276	2,684	MHT26
103 (S)	722,948	5820278	286	3,737	MHT26
104 (S)	717,682	5819809	276	1,290	MHT29
105 (S)	717,665	5819766	277	1,272	MHT36
106 (S)	717,643	5819703	279	1,206	MHT36
109	720,785	5819149	271	3,115	MHT26
110	720,983	5819096	273	3,239	MHT26
112 (S)	720,780	5818984	272	3,266	MHT26
113	718,827	5818286	265	1,768	MHT36
114	720,111	5817823	271	3,121	MHT36
119	719,831	5817458	270	2,977	MHT36
120	712,214	5817344	295	1,508	MHT45
121	721,196	5817167	279	2,978	MHT50
122 (S)	710,701	5817142	276	1,589	MHT46
123	722,110	5817090	291	3,294	MHT50
124	717,124	5817035	280	1,509	MHT40
125	722,687	5816586	292	3,271	MHT50
126 (S)	723,165	5816431	291	3,536	MHT50
127	707,860	5816342	300	3,796	MHT46
130	708,764	5815731	290	2,864	MHT46
131	714,565	5815715	280	1,481	MHT43
132	719,318	5815638	263	1,517	MHT51
133	724,761	5815547	265	4,599	MHT50
134	724,840	5815189	254	4,594	MHT50
135	721,836	5814636	267	1,546	MHT50
136	709,668	5814572	267	2,343	MHT46
138	711,683	5814345	260	1,521	MHT46
139	711,778	5814327	260	1,546	MHT46
140	712,363	5814232	261	1,669	MHT45
141	714,676	5813739	263	1,507	MHT52
142 (S)	721,466	5813689	262	1,280	MHT57
144	724,068	5812943	240	3,534	MHT57
145	712,222	5812012	250	3,888	MHT45

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
146	723,472	5811828	230	3,100	MHT57
147	713,529	5811139	240	3,847	MHT52
148	714,118	5810696	240	3,838	MHT52
150	716,632	5810155	248	3,819	MHT52
152	720,681	5808642	270	3,920	MHT57
153	721,174	5808574	233	4,108	MHT57
154	720,630	5808314	259	4,234	MHT57
156	715,765	5808020	234	5,936	MHT52
160	716,440	5805639	233	7,689	MHT56
163	719,176	5805013	201	7,514	MHT57
171	722,725	5824039	368	2,536	MHT24
172	723,306	5823964	420	3,117	MHT24
173	723,739	5824423	380	3,572	MHT16
174	722,331	5827599	448	3,101	MHT05
175	709,631	5814475	266	2,428	MHT50
Within the project boundary					
39 (S)	716,611	5827715	347	1,089	MHT1
97 (S)	718,182	5825051	304	1,097	MHT24
102 (S)	717,608	5820305	275	1,129	MHT29
107 (S)	714,955	5819624	328	1,109	MHT31
117 (S)	717,133	5817543	283	1,108	MHT36
118 (S)	713,158	5817494	304	1,252	MHT38
128 (S)	716,848	5816242	277	1,035	MHT47
129 (S)	716,882	5816167	276	1,015	MHT47
137 (S)	711,720	5814529	262	1,340	MHT46
143 (S)	717,070	5813538	272	1,009	MHT52

(S) Stakeholder

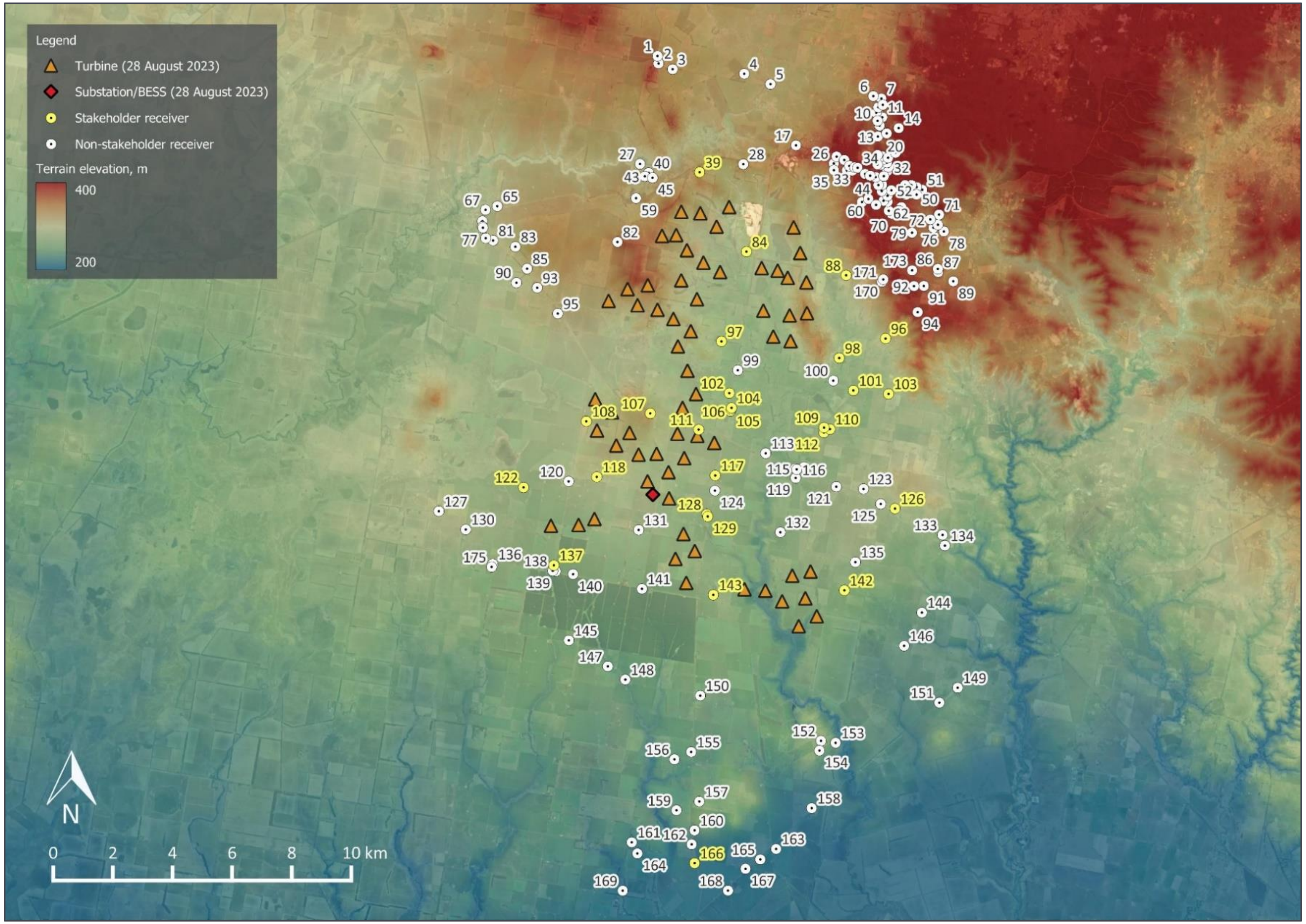
APPENDIX D SITE LAYOUT PLAN

Figure 4: Proposed wind turbine layout and receivers



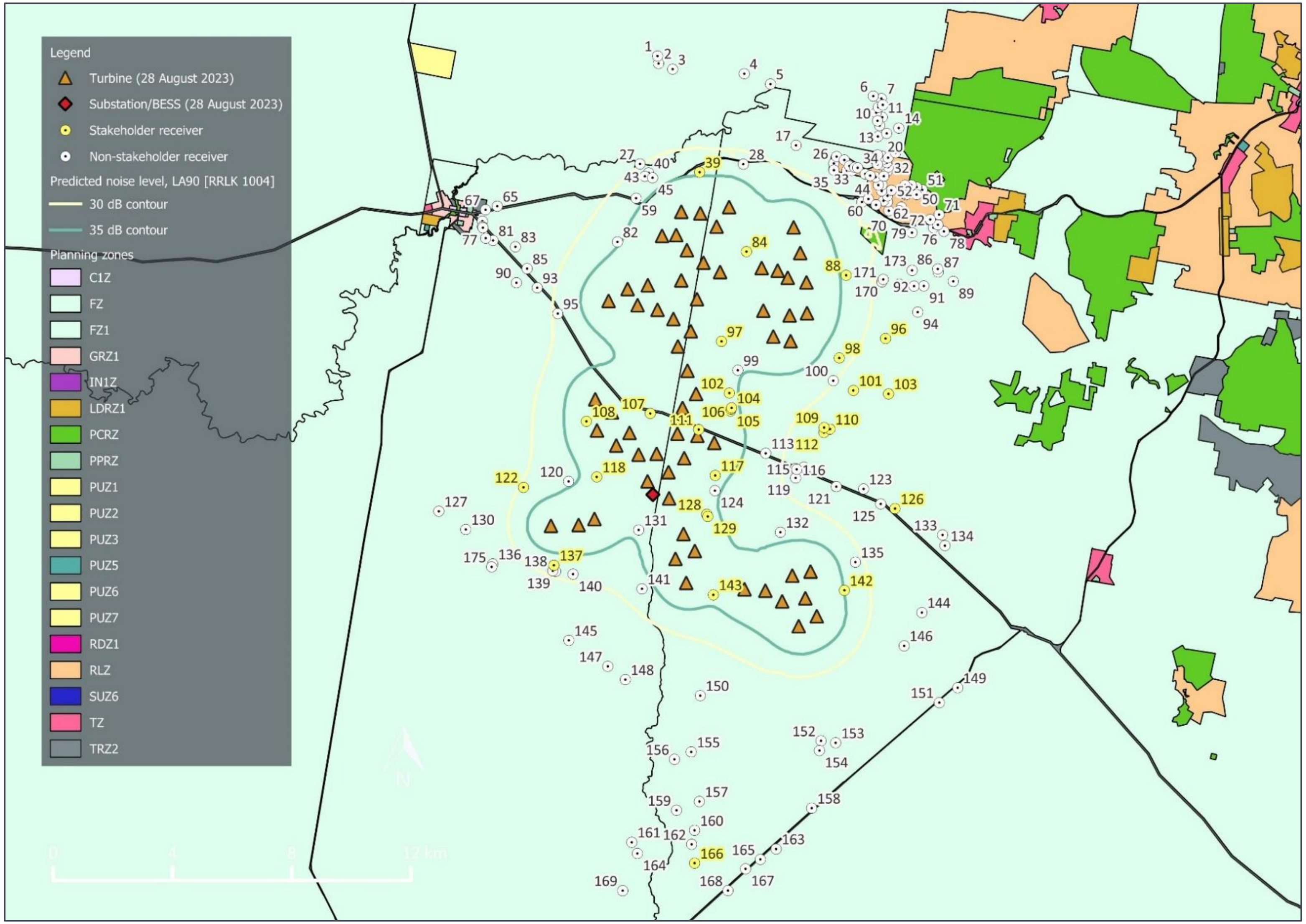
APPENDIX E SITE TOPOGRAPHY

Figure 5: Terrain elevation map for the wind farm and surrounding area



APPENDIX F ZONING MAP

Figure 6: Zoning map for the wind farm and surrounding area



APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors* (ISO 9613-2) has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered 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 NZS 6808:2010 *Acoustics – Wind farm noise*, AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and the South Australian EPA 2009 wind farm noise guidelines.

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

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

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

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

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

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all wind 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 ºC and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

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

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- NZS 6808 refers to ISO 9613-2 as an appropriate prediction method 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 9613-2 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative methods such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613-2 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (UK Institute of Acoustics guidance). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methods.

A range of measurement and prediction studies[18, 19, 20] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613-2 method to predict the propagation of wind turbine noise for:

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

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[18] 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.

[19] 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.

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

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

- Screening effects as a result of terrain are limited to 2 dB
- Screening effects are assessed based on each wind turbine being represented by a single noise source located at the maximum tip height of the wind turbine rotor
- An adjustment of 3 dB is added to the predicted noise contribution of a wind turbine if the terrain between the wind 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 SoundPLANnoise 9.0 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 wind turbine and receiver pairing, and then subsequently applies the adjustments to each wind turbine's predicted noise contribution where appropriate.

The prediction method inherently accounts for uncertainty through a combination of an uncertainty margin added to the input sound power level, and the use of conservative input parameters to the model, as described in this appendix, which have been shown to enable a reliable prediction of upper wind farm noise levels.

As an example of this, the ISO 9613-2 indicates an uncertainty margin of the order of +/-3 dB in relation to calculated noise levels at distances between 100 m and 1000 m for situations with an average propagation height between 5 m and 30 m (noting the information provided earlier in this appendix regarding the validation work undertaken to support the application of ISO 9613-2 to greater propagation heights). However, the uncertainty margins are noted for a prediction conducted in accordance with the inputs described in ISO 9613-2. A strict application of ISO 9613-2 would involve designating a ground factor of G = 1 (instead of the more conservative G = 0.5 ground factor used in the calculations) to represent the porous ground conditions around the site which ISO 9613-2 defines as follows:

> ***Porous ground****, which includes ground covered by grass, trees or other vegetation, and all other ground surfaces suitable for the growth of vegetation, such as farming land. For porous ground G = 1.*

A prediction based on a ground factor of G = 1 instead of G = 0.5 used in the modelling would typically result in predicted noise levels approximately 3 dB lower, thus effectively offsetting the quoted uncertainty margin. This also does not account for the other conservative aspects of the model, such as the assumption that all wind turbines are operating simultaneously at their maximum noise emissions and that each receiver is simultaneously downwind of every wind turbine at all times (in contrast to NZS 6808 compliance procedures which are based on assessing noise levels for a range of wind directions, consistent with broader Victorian noise assessment policies which do not evaluate compliance based solely on downwind noise levels).

Given the above, it is not necessary to apply uncertainty margins to the prediction results, as the results represent the upper predicted noise levels associated with the operation of the wind farm when measured and assessed in accordance with NZS 6808. This finding is supported by extensive post-construction noise compliance monitoring undertaken at wind farm sites across Australia.

APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA

Table 19: Predicted noise levels, dB L_{A90}

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
Outside the project boundary												
1	10.4	10.4	11.4	14.7	17.9	19.7	19.7	19.8	20.2	20.5	20.7	20.9
2	11.7	11.7	12.7	16.0	19.2	21.0	21.0	21.1	21.5	21.8	22.0	22.2
3	12.1	12.1	13.1	16.4	19.6	21.4	21.4	21.5	21.9	22.2	22.4	22.6
4	12.5	12.5	13.5	16.8	20.0	21.8	21.8	21.9	22.3	22.6	22.8	23.0
5	12.8	12.8	13.8	17.1	20.3	22.1	22.1	22.2	22.6	22.9	23.1	23.3
8	10.3	10.3	11.3	14.6	17.8	19.6	19.6	19.7	20.1	20.4	20.6	20.8
9	10.3	10.3	11.3	14.6	17.8	19.6	19.6	19.7	20.1	20.4	20.6	20.8
10	10.3	10.3	11.3	14.6	17.8	19.6	19.6	19.7	20.1	20.4	20.6	20.8
11	10.5	10.5	11.5	14.8	18.0	19.8	19.8	19.9	20.3	20.6	20.8	21.0
12	10.9	10.9	11.9	15.2	18.4	20.2	20.2	20.3	20.7	21.0	21.2	21.4
13	11.0	11.0	12.0	15.3	18.5	20.3	20.3	20.4	20.8	21.1	21.3	21.5
14	11.0	11.0	12.0	15.3	18.5	20.3	20.3	20.4	20.8	21.1	21.3	21.5
15	11.1	11.1	12.1	15.4	18.6	20.4	20.4	20.5	20.9	21.2	21.4	21.6
16	10.8	10.8	11.8	15.1	18.3	20.1	20.1	20.2	20.6	20.9	21.1	21.3
17	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
18	10.9	10.9	11.9	15.2	18.4	20.2	20.2	20.3	20.7	21.0	21.2	21.4
19	12.6	12.6	13.6	16.9	20.1	21.9	21.9	22.0	22.4	22.7	22.9	23.1
20	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
21	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
22	11.1	11.1	12.1	15.4	18.6	20.4	20.4	20.5	20.9	21.2	21.4	21.6
23	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
24	11.9	11.9	12.9	16.2	19.4	21.2	21.2	21.3	21.7	22.0	22.2	22.4
25	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
26	16.6	16.6	17.6	20.9	24.1	25.9	25.9	26.0	26.4	26.7	26.9	27.1
27	19.3	19.3	20.3	23.6	26.8	28.6	28.6	28.7	29.1	29.4	29.6	29.8
28	21.4	21.4	22.4	25.7	28.9	30.7	30.7	30.8	31.2	31.5	31.7	31.9
30	12.0	12.0	13.0	16.3	19.5	21.3	21.3	21.4	21.8	22.1	22.3	22.5
31	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
32	11.6	11.6	12.6	15.9	19.1	20.9	20.9	21.0	21.4	21.7	21.9	22.1

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
33	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
34	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
35	17.2	17.2	18.2	21.5	24.7	26.5	26.5	26.6	27.0	27.3	27.5	27.7
36	16.9	16.9	17.9	21.2	24.4	26.2	26.2	26.3	26.7	27.0	27.2	27.4
37	16.7	16.7	17.7	21.0	24.2	26.0	26.0	26.1	26.5	26.8	27.0	27.2
38	11.9	11.9	12.9	16.2	19.4	21.2	21.2	21.3	21.7	22.0	22.2	22.4
40	21.1	21.1	22.1	25.4	28.6	30.4	30.4	30.5	30.9	31.2	31.4	31.6
41	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
42	12.5	12.5	13.5	16.8	20.0	21.8	21.8	21.9	22.3	22.6	22.8	23.0
43	21.2	21.2	22.2	25.5	28.7	30.5	30.5	30.6	31.0	31.3	31.5	31.7
44	15.3	15.3	16.3	19.6	22.8	24.6	24.6	24.7	25.1	25.4	25.6	25.8
45	22.1	22.1	23.1	26.4	29.6	31.4	31.4	31.5	31.9	32.2	32.4	32.6
46	15.1	15.1	16.1	19.4	22.6	24.4	24.4	24.5	24.9	25.2	25.4	25.6
47	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
48	11.8	11.8	12.8	16.1	19.3	21.1	21.1	21.2	21.6	21.9	22.1	22.3
49	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
50	11.9	11.9	12.9	16.2	19.4	21.2	21.2	21.3	21.7	22.0	22.2	22.4
51	11.9	11.9	12.9	16.2	19.4	21.2	21.2	21.3	21.7	22.0	22.2	22.4
52	15.3	15.3	16.3	19.6	22.8	24.6	24.6	24.7	25.1	25.4	25.6	25.8
53	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
54	11.7	11.7	12.7	16.0	19.2	21.0	21.0	21.1	21.5	21.8	22.0	22.2
55	11.8	11.8	12.8	16.1	19.3	21.1	21.1	21.2	21.6	21.9	22.1	22.3
56	11.6	11.6	12.6	15.9	19.1	20.9	20.9	21.0	21.4	21.7	21.9	22.1
57	12.0	12.0	13.0	16.3	19.5	21.3	21.3	21.4	21.8	22.1	22.3	22.5
58	13.8	13.8	14.8	18.1	21.3	23.1	23.1	23.2	23.6	23.9	24.1	24.3
59	22.8	22.8	23.8	27.1	30.3	32.1	32.1	32.2	32.6	32.9	33.1	33.3
60	17.2	17.2	18.2	21.5	24.7	26.5	26.5	26.6	27.0	27.3	27.5	27.7
61	16.6	16.6	17.6	20.9	24.1	25.9	25.9	26.0	26.4	26.7	26.9	27.1
62	15.2	15.2	16.2	19.5	22.7	24.5	24.5	24.6	25.0	25.3	25.5	25.7
63	17.3	17.3	18.3	21.6	24.8	26.6	26.6	26.7	27.1	27.4	27.6	27.8
64	17.4	17.4	18.4	21.7	24.9	26.7	26.7	26.8	27.2	27.5	27.7	27.9
65	12.4	12.4	13.4	16.7	19.9	21.7	21.7	21.8	22.2	22.5	22.7	22.9

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
66	13.8	13.8	14.8	18.1	21.3	23.1	23.1	23.2	23.6	23.9	24.1	24.3
67	11.9	11.9	12.9	16.2	19.4	21.2	21.2	21.3	21.7	22.0	22.2	22.4
68	13.3	13.3	14.3	17.6	20.8	22.6	22.6	22.7	23.1	23.4	23.6	23.8
69	14.3	14.3	15.3	18.6	21.8	23.6	23.6	23.7	24.1	24.4	24.6	24.8
70	13.5	13.5	14.5	17.8	21.0	22.8	22.8	22.9	23.3	23.6	23.8	24.0
71	11.1	11.1	12.1	15.4	18.6	20.4	20.4	20.5	20.9	21.2	21.4	21.6
72	11.1	11.1	12.1	15.4	18.6	20.4	20.4	20.5	20.9	21.2	21.4	21.6
73	12.0	12.0	13.0	16.3	19.5	21.3	21.3	21.4	21.8	22.1	22.3	22.5
74	11.0	11.0	12.0	15.3	18.5	20.3	20.3	20.4	20.8	21.1	21.3	21.5
75	12.1	12.1	13.1	16.4	19.6	21.4	21.4	21.5	21.9	22.2	22.4	22.6
76	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
77	12.1	12.1	13.1	16.4	19.6	21.4	21.4	21.5	21.9	22.2	22.4	22.6
78	10.7	10.7	11.7	15.0	18.2	20.0	20.0	20.1	20.5	20.8	21.0	21.2
79	12.6	12.6	13.6	16.9	20.1	21.9	21.9	22.0	22.4	22.7	22.9	23.1
81	12.8	12.8	13.8	17.1	20.3	22.1	22.1	22.2	22.6	22.9	23.1	23.3
82	24.0	24.0	25.0	28.3	31.5	33.3	33.3	33.4	33.8	34.1	34.3	34.5
83	14.1	14.1	15.1	18.4	21.6	23.4	23.4	23.5	23.9	24.2	24.4	24.6
84 (S)	29.1	29.1	30.1	33.4	36.6	38.4	38.4	38.5	38.9	39.2	39.4	39.6
85	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
86	12.6	12.6	13.6	16.9	20.1	21.9	21.9	22.0	22.4	22.7	22.9	23.1
87	12.6	12.6	13.6	16.9	20.1	21.9	21.9	22.0	22.4	22.7	22.9	23.1
88 (S)	23.3	23.3	24.3	27.6	30.8	32.6	32.6	32.7	33.1	33.4	33.6	33.8
89	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
90	15.6	15.6	16.6	19.9	23.1	24.9	24.9	25.0	25.4	25.7	25.9	26.1
91	12.3	12.3	13.3	16.6	19.8	21.6	21.6	21.7	22.1	22.4	22.6	22.8
92	15.4	15.4	16.4	19.7	22.9	24.7	24.7	24.8	25.2	25.5	25.7	25.9
93	17.5	17.5	18.5	21.8	25.0	26.8	26.8	26.9	27.3	27.6	27.8	28.0
94	14.6	14.6	15.6	18.9	22.1	23.9	23.9	24.0	24.4	24.7	24.9	25.1
95	20.1	20.1	21.1	24.4	27.6	29.4	29.4	29.5	29.9	30.2	30.4	30.6
96	17.1	17.1	18.1	21.4	24.6	26.4	26.4	26.5	26.9	27.2	27.4	27.6
98 (S)	20.8	20.8	21.8	25.1	28.3	30.1	30.1	30.2	30.6	30.9	31.1	31.3
99	24.9	24.9	25.9	29.2	32.4	34.2	34.2	34.3	34.7	35.0	35.2	35.4

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
100	19.7	19.7	20.7	24.0	27.2	29.0	29.0	29.1	29.5	29.8	30.0	30.2
101 (S)	17.6	17.6	18.6	21.9	25.1	26.9	26.9	27.0	27.4	27.7	27.9	28.1
103 (S)	15.1	15.1	16.1	19.4	22.6	24.4	24.4	24.5	24.9	25.2	25.4	25.6
104 (S)	25.6	25.6	26.6	29.9	33.1	34.9	34.9	35.0	35.4	35.7	35.9	36.1
105 (S)	25.7	25.7	26.7	30.0	33.2	35.0	35.0	35.1	35.5	35.8	36.0	36.2
106 (S)	25.9	25.9	26.9	30.2	33.4	35.2	35.2	35.3	35.7	36.0	36.2	36.4
109	17.6	17.6	18.6	21.9	25.1	26.9	26.9	27.0	27.4	27.7	27.9	28.1
110	17.2	17.2	18.2	21.5	24.7	26.5	26.5	26.6	27.0	27.3	27.5	27.7
112 (S)	17.5	17.5	18.5	21.8	25.0	26.8	26.8	26.9	27.3	27.6	27.8	28.0
113	21.2	21.2	22.2	25.5	28.7	30.5	30.5	30.6	31.0	31.3	31.5	31.7
114	18.1	18.1	19.1	22.4	25.6	27.4	27.4	27.5	27.9	28.2	28.4	28.6
119	18.7	18.7	19.7	23.0	26.2	28.0	28.0	28.1	28.5	28.8	29.0	29.2
120	23.8	23.8	24.8	28.1	31.3	33.1	33.1	33.2	33.6	33.9	34.1	34.3
121	16.9	16.9	17.9	21.2	24.4	26.2	26.2	26.3	26.7	27.0	27.2	27.4
122 (S)	20.0	20.0	21.0	24.3	27.5	29.3	29.3	29.4	29.8	30.1	30.3	30.5
123	15.6	15.6	16.6	19.9	23.1	24.9	24.9	25.0	25.4	25.7	25.9	26.1
124	25.2	25.2	26.2	29.5	32.7	34.5	34.5	34.6	35.0	35.3	35.5	35.7
125	15.1	15.1	16.1	19.4	22.6	24.4	24.4	24.5	24.9	25.2	25.4	25.6
126 (S)	14.3	14.3	15.3	18.6	21.8	23.6	23.6	23.7	24.1	24.4	24.6	24.8
127	12.2	12.2	13.2	16.5	19.7	21.5	21.5	21.6	22.0	22.3	22.5	22.7
130	14.0	14.0	15.0	18.3	21.5	23.3	23.3	23.4	23.8	24.1	24.3	24.5
131	25.3	25.3	26.3	29.6	32.8	34.6	34.6	34.7	35.1	35.4	35.6	35.8
132	22.8	22.8	23.8	27.1	30.3	32.1	32.1	32.2	32.6	32.9	33.1	33.3
133	11.6	11.6	12.6	15.9	19.1	20.9	20.9	21.0	21.4	21.7	21.9	22.1
134	11.4	11.4	12.4	15.7	18.9	20.7	20.7	20.8	21.2	21.5	21.7	21.9
135	20.9	20.9	21.9	25.2	28.4	30.2	30.2	30.3	30.7	31.0	31.2	31.4
136	15.5	15.5	16.5	19.8	23.0	24.8	24.8	24.9	25.3	25.6	25.8	26.0
138	20.5	20.5	21.5	24.8	28.0	29.8	29.8	29.9	30.3	30.6	30.8	31.0
139	20.5	20.5	21.5	24.8	28.0	29.8	29.8	29.9	30.3	30.6	30.8	31.0
140	20.6	20.6	21.6	24.9	28.1	29.9	29.9	30.0	30.4	30.7	30.9	31.1
141	22.2	22.2	23.2	26.5	29.7	31.5	31.5	31.6	32.0	32.3	32.5	32.7
142 (S)	24.3	24.3	25.3	28.6	31.8	33.6	33.6	33.7	34.1	34.4	34.6	34.8

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
144	13.4	13.4	14.4	17.7	20.9	22.7	22.7	22.8	23.2	23.5	23.7	23.9
145	14.0	14.0	15.0	18.3	21.5	23.3	23.3	23.4	23.8	24.1	24.3	24.5
146	14.1	14.1	15.1	18.4	21.6	23.4	23.4	23.5	23.9	24.2	24.4	24.6
147	13.7	13.7	14.7	18.0	21.2	23.0	23.0	23.1	23.5	23.8	24.0	24.2
148	13.5	13.5	14.5	17.8	21.0	22.8	22.8	22.9	23.3	23.6	23.8	24.0
150	14.5	14.5	15.5	18.8	22.0	23.8	23.8	23.9	24.3	24.6	24.8	25.0
152	12.0	12.0	13.0	16.3	19.5	21.3	21.3	21.4	21.8	22.1	22.3	22.5
153	11.3	11.3	12.3	15.6	18.8	20.6	20.6	20.7	21.1	21.4	21.6	21.8
154	10.9	10.9	11.9	15.2	18.4	20.2	20.2	20.3	20.7	21.0	21.2	21.4
156	10.2	10.2	11.2	14.5	17.7	19.5	19.5	19.6	20.0	20.3	20.5	20.7
160	5.2	5.2	6.2	9.5	12.7	14.5	14.5	14.6	15.0	15.3	15.5	15.7
163	6.4	6.4	7.4	10.7	13.9	15.7	15.7	15.8	16.2	16.5	16.7	16.9
171	18.8	18.8	19.8	23.1	26.3	28.1	28.1	28.2	28.6	28.9	29.1	29.3
172	17.8	17.8	18.8	22.1	25.3	27.1	27.1	27.2	27.6	27.9	28.1	28.3
173	14.1	14.1	15.1	18.4	21.6	23.4	23.4	23.5	23.9	24.2	24.4	24.6
174	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
175	15.2	15.2	16.2	19.5	22.7	24.5	24.5	24.6	25.0	25.3	25.5	25.7
Within the project boundary												
39 (S)	23.7	23.7	24.7	28.0	31.2	33.0	33.0	33.1	33.5	33.8	34.0	34.2
97 (S)	26.9	26.9	27.9	31.2	34.4	36.2	36.2	36.3	36.7	37.0	37.2	37.4
102 (S)	25.7	25.7	26.7	30.0	33.2	35.0	35.0	35.1	35.5	35.8	36.0	36.2
107 (S)	28.9	28.9	29.9	33.2	36.4	38.2	38.2	38.3	38.7	39.0	39.2	39.4
117 (S)	26.5	26.5	27.5	30.8	34.0	35.8	35.8	35.9	36.3	36.6	36.8	37.0
118 (S)	26.0	26.0	27.0	30.3	33.5	35.3	35.3	35.4	35.8	36.1	36.3	36.5
128 (S)	26.2	26.2	27.2	30.5	33.7	35.5	35.5	35.6	36.0	36.3	36.5	36.7
129 (S)	26.2	26.2	27.2	30.5	33.7	35.5	35.5	35.6	36.0	36.3	36.5	36.7
137 (S)	21.5	21.5	22.5	25.8	29.0	30.8	30.8	30.9	31.3	31.6	31.8	32.0
143 (S)	25.9	25.9	26.9	30.2	33.4	35.2	35.2	35.3	35.7	36.0	36.2	36.4

(S) Stakeholder

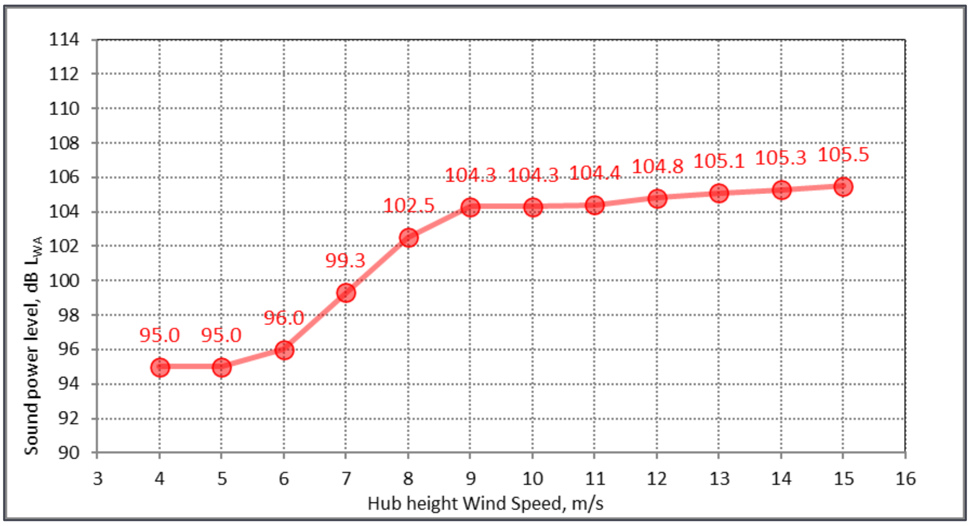
APPENDIX I NZS 6808 DOCUMENTATION

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

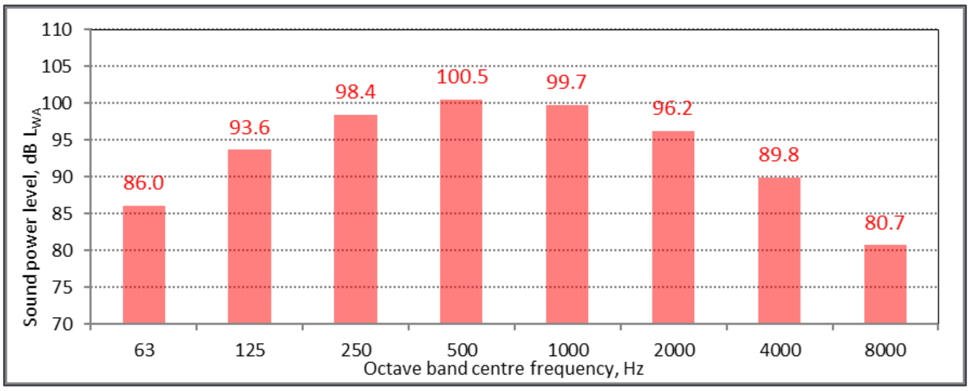
(b) Noise sensitive locations: See Appendix C

(c) Wind turbine sound power levels, L_{WA} dB (refer to Section 6.2.2)

Sound power levels (manufacturer specification +1 dB margin for uncertainty), dB L_{WA}



Reference octave band spectra adjusted to the highest sound power level detailed above, dB L_{WA}



(d) Wind turbine model: See Table 6 of Section 6.2

(e) Wind turbine hub height: See Table 6 of Section 6.2

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

(g) Calculation procedure used: ISO 9613-2 prediction algorithm as implemented in SoundPLANnoise v9.0 (See Section 4.3 and Appendix G)

(h) Meteorological conditions assumed: See Table 4 of Section 4.3

(i) Air absorption parameters:

	Octave band mid frequency, Hz							
Description	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
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 resolution elevation contours – See Appendix E

(k) Predicted far-field wind farm sound levels: See Section 6.3 and Appendix H.