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HEXHAM WIND FARM
PRELIMINARY NOISE ASSESSMENT

Rp 001 20190086 | 20 December 2021

MARSHALL DAY Acoustics

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Project:	**Hexham Wind Farm** **Preliminary Noise Assessment**
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EXECUTIVE SUMMARY

This report presents the results of a preliminary assessment of operational noise associated with the Hexham Wind Farm that is proposed to be developed by Hexham Wind Farm Pty Ltd (the proponent).

The assessment has been carried out based on the proposed wind farm layout comprising one hundred and eight (108) multi-megawatt wind turbines and associated site infrastructure (i.e. terminal station).

At this stage of the project, details of associated site infrastructure have not been finalised. As such, this preliminary noise assessment only relates to operational noise from the proposed wind turbines.

The planning application for the wind farm seeks permission to develop wind turbines with a maximum tip height of 250 m. 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 V162-6.0MW with a nominal hub height of 149 m and rotor diameter of 162 m, has been nominated by the proponent.

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* and the Victorian Department of Environment, Land, Water and Planning *Policy and planning guidelines for development of wind energy facilities in Victoria* dated July 2021. The operational wind farm noise assessment considers base noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area. Consideration was also given to the general environmental duty introduced by the *Environment Protection Act 2017* in July 2021.

Manufacturer specification data provided by the proponent for the candidate wind turbine model has been used as the basis for the assessment. This 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 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 for the Hexham Wind Farm demonstrate that the predicted noise levels for the proposed wind turbine layout and candidate wind turbine model achieve the base (minimum) noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

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 also considered nine (9) other wind farm projects (operational, approved or in the planning process) in the broader surrounding area. An assessment of the predicted noise level of these wind farms has demonstrated that the Hexham Wind Farm would not alter the compliance outcomes of neighbouring wind farm projects. Conversely, the noise of neighbouring wind farm projects would not alter the compliance outcomes for the Hexham Wind Farm. Accordingly, cumulative wind farm noise considerations are not applicable to the Hexham Wind Farm.

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

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1.0 INTRODUCTION

Hexham Wind Farm Pty Ltd (the proponent) is proposing to develop a wind farm known as the Hexham Wind Farm within the Victorian local government area of the Moyne Shire Council, approximately three (3) kilometres to the southwest of Hexham.

This report presents the results of an assessment of operational noise associated with the wind turbines, undertaken in accordance with the New Zealand Standard 6808 *Acoustics – Wind farm noise* (NZS 6808) as required by the *Environment Protection Regulations 2021* (the EP Regulations) and the Victorian Department of Environment, Land, Water and Planning *Policy and planning guidelines for development of wind energy facilities in Victoria* dated July 2021 (the Victorian Wind Energy Guidelines).

Details of associated site infrastructure, such as the proposed terminal station, have not yet been finalised. As such, operational noise of the proposed terminal station would be assessed at a later stage of the project.

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

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

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

2.0 PROJECT DESCRIPTION

The wind farm is proposed to comprise one hundred and eight (108) wind turbines as tabulated in Appendix A.

The proponent is seeking consent for a wind farm comprising wind turbines extending to a tip height of up to 250 m. The Vestas V162-6.0MW, with a power output of 6.0 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 5.2.

A total of ninety-five (95) noise sensitive locations (generally referred to as 'receivers' or 'non-involved receivers' herein) located within 3 km of the proposed wind turbines have been considered in this noise assessment. This includes forty-seven (47) receivers where a noise agreement is in place between the landowners and the proponent (subsequently referred to as *involved receivers* herein).

The coordinates of the receivers are tabulated in Appendix B.

A site layout plan illustrating the wind turbine layout and receivers is provided in Appendix C.

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 Protection Regulations 2021;*
- *Policy and planning guidelines for development of wind energy facilities in Victoria*, prepared by the Victorian Department of Environment, Land, Water and Planning and dated July 2021; and
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise.*

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* (the 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 provides that noise can be determined as *unreasonable* having regard to general conditions, or where noise is prescribed to be unreasonable noise.

3.2 Environment Protection Regulations 2021

On 1 August 2021, the *Environment Protection Regulations 2021* (the EP Regulations) were amended to specify matters in relation to wind turbine noise by the *Environment Protection Amendment (Wind turbine Noise) Regulations 202*1.

The objectives of the EP Regulations are to further the purposes of, and give effect to, the EP Act.

Part 5.3 Division 5 of the EP Regulations nominates New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) as the relevant standard for assessing operational wind turbine noise in Victoria and introduces additional measures to demonstrate compliance post-construction.

Regulation 131A outlines that 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 'involved receivers'.

As detailed in Regulation 131B, 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.

Regulation 131C subsequently defines the duties of wind energy facilities with respect to wind turbine noise. These duties comprise ensuring compliance with NZS 6808 and a suite of actions to manage and monitor noise from the wind farm.

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 considered *unreasonable*, as defined in the EP Act, if they exceed the relevant applicable noise limits.

3.3 Victorian Wind Energy Guidelines

The Victorian Department of Environment, Land, Water and Planning *Policy and planning guidelines for development of wind energy facilities in Victoria* dated July 2021 (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 stated purpose of the Victorian Wind Energy Guidelines is to 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.*

Section 5 of the Victorian Wind Energy Guidelines outlines the key criteria for evaluating the planning merits of a wind energy facility. Section 5.1.2 details information relating to the amenity of areas surrounding a wind farm development, including information relating to noise levels. In particular, it provides the following guidance for the assessment of noise levels for proposed new wind farm developments:

> *A wind energy facility should comply with the noise limits recommended for dwellings and other noise sensitive locations in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard).* […]
>
> *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.* […]
>
> *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].*

Based on the Victorian Wind Energy Guidelines, the environmental noise of proposed new wind farm developments must be assessed in accordance with NZS 6808 at noise sensitive locations, which are defined in Section 5.1.2 of the Victorian Wind Energy Guidelines as follows:

> *Noise sensitive locations are defined in [NZS 6808] 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 VPP and all planning schemes.*

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

Specifically, 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*
- *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.

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, noise predictions are normally prepared for involved receivers irrespective of whether they are inside or outside of the boundary. However, the noise limits specified in the Standard do not apply to these locations on account of their participation with the wind farm.

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}.

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[2] as follows:

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

   First and foremost, as specified in Section 5.3.1, for a high amenity noise limit to be considered, the land zoning of a receiver location 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.

[2] See Section 8.6.3 of the *EES Inquiry and Planning Permit Application Panel Report - Golden Plains Wind Farm* dated 26 September 2018

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 wind farm. 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 tonal 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.

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 wind farm site and surrounding areas;
- establishing suitable noise limits accounting for background noise levels and land zoning;
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise limits.

4.2 Background noise levels

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.

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}
- 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 will 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 are predicted using:

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

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 1. Further discussion of the method and the calculation choices is provided in Appendix F.

Table 1: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix F.
Source characterisation	Each source of operational noise is modelled as a point source of sound. The total sound of the wind turbines is then calculated on the basis of simultaneous operation of all elements (e.g. all wind turbines) and summing the contribution of each. 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 provided by the proponent

Detail	Description
Terrain effects	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 F. • Valley effects: + 3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the 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 no more than -2 dB. The wind farm is located in a relatively flat area characterised by little variation in ground elevation between the wind turbines and surrounding receivers. These terrain characteristics do not typically result in the application of adjustments to the predicted noise levels. Specifically, based on comparison of predicted noise levels with and without terrain elevation data included indicates terrain effects typically equated to ±0.4 dB. For reference purposes, the ground elevations at the wind turbines and receivers are tabled in Appendix A and Appendix B respectively. The topography of the site is depicted in the elevation map provided in Appendix D.
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 ^{o}C and relative humidity 70 % These represent conditions which result in relatively low levels of atmospheric sound absorption. The calculations are based on sound speed profiles[3] 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.

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

5.0 WIND TURBINE ASSESSMENT

5.1 Noise limits

5.1.1 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 5.4, and the zoning map for the area presented in Appendix E, 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.

5.1.2 Involved receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes dwellings located within a wind farm site boundary. The discussion earlier in this report in Section 3.4.2 also provides details of the statutory context of NZS 6808, and indicates the method is not intended to be applied to noise sensitive locations 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 involved 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.

5.1.3 Applicable noise limits

Accounting for the conclusions of the assessment of high amenity detailed in the previous section, the applicable noise limits are detailed in Table 2.

Table 2: Applicable noise limits, dB L_{A90}

Receiver status	Noise limit
Non-involved	40 dB or background L_{A90} + 5 dB, whichever is the greater
Involved	45 dB or background L_{A90} + 5 dB, whichever is the greater

If required, background noise monitoring would be undertaken during the next stages of the planning process for the project. As such, a simplified and conservative approach has been adopted for the preliminary assessment by comparing the predicted noise levels with the base (minimum) noise limit presented above.

The background noise monitoring conducted as part of the next stages of the planning process would be used to derive background noise dependant noise limits.

5.2 Wind turbine model

The final wind turbine model for the site would be selected after a competitive 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 the applicable 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 V162-6.0MW 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 are provided in Table 3.

Table 3: Selected candidate wind turbine model

Detail	V162-6.0MW
Make	Vestas
Rotor diameter	162 m
Hub height	149 m
Blade serrations	Yes
Operating mode	PO6000 [1]
Rated power	6.0 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	12 m/s
Cut-out wind speed (hub height)	24 m/s

1 It is our understanding that 'PO6000' is a manufacturer designation which indicates a Power Optimisation mode to achieve a power output of 6,000 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.

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.

5.3 Wind turbine noise emissions

5.3.1 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 document No. 0095-3732_00 - *Third octave noise emission EnVentus™ V162-6.0MW*, dated 10 June 2020.

Based on the data sourced from the manufacturer's specification, the noise modelling undertaken for this assessment involved conversion of third octave band level 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 4 with the octave band values presented in Table 5. 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 4: Sound power levels versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s								
Wind turbine	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
V162-6.0MW	95.1	95.3	97.2	100.2	103.0	105.1	105.3	105.3	105.3

Table 5: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz									
Wind turbine	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
V162-6.0MW [1]	76.2	86.6	94.1	98.7	100.4	99.3	95.2	88.3	78.5	105.3

[1] Based on one-third octave band levels at 10 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. Therefore, 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 as 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).

5.3.2 Special Audible Characteristics

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

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 wind farm, following approval of the wind farm, and again following construction of the wind farm.

5.4 Predicted noise levels

This section of the report presents the predicted noise levels of the wind farm at surrounding receivers.

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 5.3.1 for the selected candidate wind turbine model and are summarised in Table 6 for the wind speeds which result in the highest predicted noise levels (hub height wind speed ≥10 m/s).

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 G for all considered receivers, including receivers where the highest predicted noise level is below 30 dB L_{A90}.

Table 6: Highest predicted noise level at receivers with predicted levels 30 dB L_{A90} or above

Receiver	Predicted level, dB L_{A90}
D32 (I)	32.8
D34 (I)	35.6
D35 (I)	34.8
D36	31.9
D37	31.9
D38 (I)	30.2
D39	33.7
D40 (I)	37.4
D197 (I)	37.9
D203 (I)	30.4
D204 (I)	31.2
D205	33.0
D206 (I)	30.6
D294	34.1
D296	31.3
D297 (I)	36.7
D298 (I)	37.9
D299	34.6
D300	30.7
D301	31.0
D336	32.2
D337	33.1
D338 (I)	36.1
D339	31.2
D341	30.4
D343 (I)	39.7
D344 (I)	32.5
D345	32.6
D355 (I)	37.7
D356 (I)	35.9
D357 (I)	40.1
D359 (I)	37.5

Receiver	Predicted level, dB L_{A90}
D361 (I)	38.0
D362 (I)	36.6
D366 (I)	38.5
D367	32.4
D368	30.5
D378 (I)	39.5
D379 (I)	36.8
D380 (I)	43.9
D395 (I)	35.4
D396 (I)	37.2
D397 (I)	39.0
D398 (I)	37.0
D402	31.5
D403 (I)	32.4
D404	33.4
D413	33.3
D414	30.7
D417 (I)	37.3
D418 (I)	37.8
D419	32.9
D420	31.5
D421	32.4
D422 (I)	38.9
D423 (I)	39.0
D424	32.9
D425	33.0
D426	33.1
D428 (I)	36.6
D429 (I)	36.2
D430 (I)	36.5
D431	30.6
D435	31.9
D436	30.8

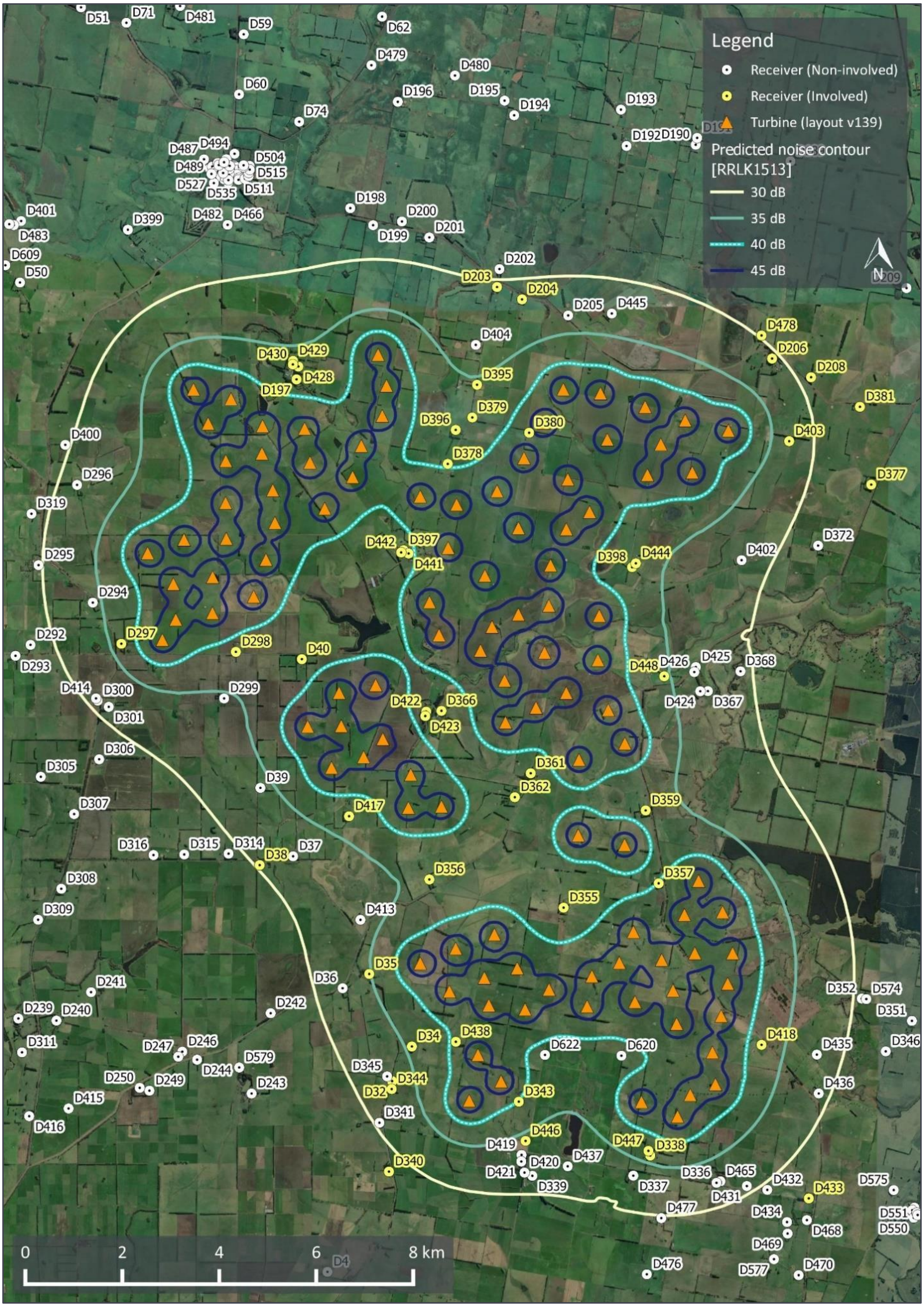
Receiver	Predicted level, dB L_{A90}
D437	31.8
D438 (I)	41.1
D441 (I)	39.4
D442 (I)	38.8
D444 (I)	36.8
D445	32.7
D446 (I)	34.1
D447 (I)	36.7
D448 (I)	35.5
D465	32.1
D620	38.9
D622	38.8

(I) Involved receiver

The following can be concluded from the predicted noise levels detailed in Table 6:

- Compliance with the applicable base noise limit of 40 dB L_{A90} by at least 1.1 dB at non-involved receivers
- Compliance with the applicable base noise limit of 45 dB L_{A90} by at least 1.1 dB at involved receivers.

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



5.5 Cumulative assessment

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

Based on publicly available information[4], nine (9) wind farms in the broader area around the Hexham Wind Farm have been identified for the review of potential cumulative noise considerations. These wind farms are detailed in Table 7.

Table 7: Wind farm developments in the broader area around the Hexham Wind Farm

Wind farm name	Status	Approximate distance to nearest wind turbine
Dundonnell	Operational (Q1 2021)	28 km to the east-northeast
Hawkesdale	Approved	15 km to the west-southwest
Macarthur	Operational (January 2013)	25 km to the west
Mortlake South	Under construction	15 km to the east-southeast
Mortons Lane	Operational (May 2012)	18 km to the north
Mt Fyans	Planning application lodged	9 km to the east
Salt Creek	Operational (June 2018)	14 km to the northeast
Willatook	EES scoping requirements issued	26 km to the west
Woolsthorpe	Approved	17 km to the southwest

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

The following sections provide further reference information for each surrounding wind farm development.

5.5.1 Dundonnell Wind Farm

The Dundonnell Wind Farm is operational (as of Q1 2021) and comprises eighty (80) Vestas V150-4.2MW wind turbines with a hub height of 114 m[5]. The coordinates of the wind turbines were provided by the project developers, Tilt Renewables.

The noise emissions for the Vesta V150-4.2MW candidate wind turbine for the Dundonnell Wind Farm have been represented for this study with data sourced from the publicly available noise assessment report[6] for the Golden Plains Wind Farm.

The planning permit[7] for the Dundonnell Wind Farm establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

4 weblink

5 weblink

6 MDA Report Rp 003 R01 20170122 *Golden Plains Wind Farm - Environmental Noise & Vibration Assessment*, dated 23 February 2018

7 Planning Permit no. 2015/23858/A

5.5.2 Hawkesdale Wind Farm

The amended planning permit[8] for the Hawkesdale Wind Farm allows for the development of a wind farm comprising twenty-six (26) wind turbines with a maximum tip height of 180 m.

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

The most recent publicly available information[9] for the Hawkesdale Wind Farm details of an assessment based on a V136-4.2MW candidate wind turbine with a hub height of 112 m. This information has been referenced in the present study to account for the potential noise levels of the Hawkesdale Wind Farm.

5.5.3 Macarthur Wind Farm

The Macarthur Wind Farm is operational (as of January 2013) and comprises one hundred and forty (140) Vestas V112-3MW wind turbines.

The planning permit conditions define a minimum operational noise limit of 40 dB for receivers around the wind farm. The wind farm layout was sourced from the post-construction noise assessment[10].

5.5.4 Mortlake South Wind Farm

The Mortlake South Wind Farm is currently under construction, comprising thirty-five (35) Nordex N149/4.0-4.5 wind turbines with a hub height of 105 m[11].

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

The application to amend the planning permit was accompanied by a noise assessment[13] for a forty-two (42) wind turbine layout. This information included details of an assessment based on a Nordex N131/3000 candidate wind turbine with a hub height of 114 m. This information has been referenced in the present study as a conservative prediction of potential noise levels for the Mortlake South Wind Farm.

5.5.5 Mortons Lane Wind Farm

The Mortons Lane Wind Farm is operational (as of May 2012) and comprises thirteen (13) Goldwind GW82/1500 wind turbines.

The planning permit[14] establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

Insufficient public information is available to produce noise contours for the Mortons Lane Wind Farm.

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8 Planning Permit no. 20060221-A

9 MDA Report Rp 003 R01 20180787 *Hawkesdale Wind Farm – Pre-construction Noise Assessment* dated 29 October 2020

10 AECOM Report 60279731 *Macarthur Wind Farm - Noise Compliance Assessment* dated 26 April 2013

11 weblink / weblink

12 Planning Permit no. 2008/0538/A

13 MDA Report Rp 001 2015582ML *Mortlake South Wind Farm – NZS 6808:2010 Noise Assessment*, dated 29 March 2016

14 Planning Permit no. PL06/303

5.5.6 Mt Fyans Wind Farm

It is our understanding that the planning application for the Mt Fyans Wind Farm has been submitted to the Department of Environment Land, Water and Planning (DELWP).

The proposed wind farm layout and associated noise contours have been sourced from the preliminary noise assessment[15] submitted as part of the EES referral application.

5.5.7 Salt Creek Wind Farm

The planning permit[16] for the Salt Creek Wind Farm allows for the development of a wind farm comprising fifteen (15) wind turbines with a maximum tip height of 150 m. The planning permit establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

The wind farm is operational (as of June 2018) and comprises Vestas V126 3.6MW wind turbines with a hub height of 87 m.

Coordinates of the wind turbines have been provided by the project developers, Tilt Renewables. Noise emission data for the Vestas V126 3.6MW wind turbine has been sourced from the manufacturer's specification[17].

5.5.8 Willatook Wind Farm

The scoping requirements for the Environment Effects Statement (EES) have been issued by DELWP for the Willatook Wind Farm.

The proposed wind farm layout and associated noise contours have been provided by the proponent.

5.5.9 Woolsthorpe Wind Farm

The amended planning permit[18] for the Woolsthorpe Wind Farm allows for the development of a wind farm comprising up to twenty (20) wind turbines with a maximum tip height of 150 m.

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

Insufficient public information is available to produce noise contours for the Woolsthorpe Wind Farm.

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15 MDA Report Rp 001 2012102ML *Mt Fyans Wind Farm – EES initial submission – Acoustic considerations and preliminary predictions*, dated 9 February 2017

16 Planning Permit no. PL06/304.01

17 Vestas document 0058-2095 VER 00 *3MW full range sound curves*

18 Planning Permit no. 2006/0220/A

5.5.10 Assessment

To inform the assessment of potential cumulative noise considerations, reference is made to Clause 5.6.4 of NZS 6808:2010 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, and the relatively large separating distances between the Hexham Wind Farm and surrounding wind farm developments, a simplified assessment of potential cumulative noise considerations can be made by comparing the predicted 30 dB L_{A90} contours of the Hexham Wind Farm and five (5) of the nine (9) surrounding wind farm developments, where sufficient information was available to produce noise contours.

The predicted 30 dB L_{A90} contours associated with each wind farm operating in isolation are presented on the site layout plan in Appendix H. The predicted 30 dB L_{A90} contour is presented for the wind speeds which give rise to the highest predicted noise level from each site respectively. It is also noted that the noise level contours are predicted on the basis of downwind propagation from each wind turbine; in most instances where cumulative noise is considered, a receiver cannot be simultaneously downwind of all wind turbines of adjoining wind farms. The predictions are therefore conservative for the purpose of considering cumulative noise levels.

The results demonstrate that the predicted 30 dB L_{A90} contours are separated and do not overlap. Based on this finding, the following can be concluded:

- 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 (including the Hexham Wind Farm) approaches the 40 dB minimum limit applicable to the Hexham Wind Farm and surrounding developments, the predicted noise level associated with an adjoining wind farm will be more than 10 dB lower. Based on the guidance of NZS 6808:2010, the cumulative effect does not need to be taken in account for the nearest receivers to each wind farm development.

The predicted noise levels therefore demonstrate that cumulative wind farm noise considerations are not applicable to the Hexham Wind Farm and surrounding wind farms. Specifically, the noise contribution of the other wind farms in the area are sufficiently low to be inconsequential to the noise assessment for the Hexham Wind Farm. Conversely, the predicted noise contribution of the Hexham Wind Farm at the receivers of the other wind farms would not affect the noise assessment for these projects.

While noise contours were not able to be created for four (4) for of neighbouring wind farms considered in this assessment, the above findings are sufficient to conclude that cumulative noise considerations are not applicable to these wind farms either. This is supported by the separation of the Hexham Wind Farm and neighbouring wind farm predicted contours in Appendix H, combined with the relatively large separating distance between these other four (4) wind farms and the proposed Hexham Wind Farm.

6.0 SUMMARY

An assessment of operational noise for the proposed Hexham Wind Farm has been carried out. The assessment is based on the proposed wind farm layout comprising one hundred and eight (108) multi-megawatt wind turbines.

Operational noise associated with 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* and the Victorian Department of Environment, Land, Water and Planning publication *Policy and planning guidelines for development of wind energy facilities in Victoria* dated July 2021.

Noise modelling was carried out based on a candidate wind turbine model (Vestas V162-6.0MW) which has been selected by the proponent as being representative of the size and type of wind turbines which could be used at the site.

The results of the modelling demonstrate that the proposed wind farm is predicted to achieve compliance with the applicable noise limits determined in accordance with NZS 6808.

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 also considered nine (9) other wind farm projects (operational, approved or in the planning process) in the broader surrounding area. An assessment of the predicted noise level of these wind farms has demonstrated that the Hexham Wind Farm would not alter the compliance outcomes of neighbouring wind farm projects. Conversely, the noise of neighbouring wind farm projects would not alter the compliance outcomes for the Hexham Wind Farm. Accordingly, cumulative wind farm noise considerations are not applicable to the Hexham Wind Farm.

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

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 A WIND TURBINE COORDINATES

The following table sets out the coordinates of the proposed wind turbine layout.

(Layout v139, supplied by the proponent on 2 December 2021).

Table 8: Wind turbine coordinates – MGA 94 zone 54

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
T1	631,808	5,789,840	140
T2	632,110	5,788,049	140
T3	632,338	5,789,203	140
T4	632,388	5,788,469	140
T5	632,557	5,790,118	140
T6	632,753	5,793,220	150
T7	633,055	5,792,514	150
T8	633,145	5,788,604	140
T9	633,148	5,789,346	135
T10	633,415	5,790,877	140
T11	633,429	5,790,137	133
T12	633,420	5,791,743	140
T13	633,527	5,793,021	144
T14	634,165	5,791,895	140
T15	634,248	5,789,703	140
T16	633,994	5,788,945	132
T17	634,388	5,791,137	140
T19	634,433	5,790,466	140
T20	635,045	5,792,411	132
T21	635,154	5,791,711	136
T22	635,107	5,786,262	136
T23	635,460	5,790,760	136
T24	635,600	5,785,413	130
T25	634,178	5,792,464	138
T26	635,757	5,786,958	130
T27	636,034	5,791,410	132
T28	635,801	5,786,272	132
T29	636,214	5,792,054	130
T30	636,262	5,785,635	130
T31	636,511	5,787,117	130

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
T32	636,561	5,793,934	130
T33	636,646	5,792,672	130
T34	636,733	5,793,295	130
T35	636,658	5,786,004	130
T36	637,185	5,784,586	130
T37	637,234	5,785,269	130
T38	638,672	5,787,831	130
T39	637,429	5,791,010	130
T40	637,429	5,781,376	130
T41	637,620	5,788,828	127
T42	637,866	5,784,612	130
T43	638,005	5,789,950	130
T44	638,032	5,780,797	130
T45	638,160	5,781,682	130
T46	638,180	5,790,843	130
T47	637,818	5,788,151	125
T48	638,910	5,788,319	130
T49	638,440	5,778,543	124
T50	638,621	5,779,487	130
T51	638,752	5,781,077	130
T52	638,844	5,780,512	130
T53	638,763	5,789,376	130
T54	639,816	5,786,649	130
T55	639,453	5,788,575	130
T56	638,959	5,781,972	130
T57	639,014	5,791,119	129
T58	639,097	5,778,939	130
T59	639,169	5,787,210	130
T60	639,430	5,781,273	130
T61	639,569	5,791,802	126
T62	639,591	5,780,425	130
T63	639,455	5,790,358	126
T64	639,187	5,786,346	130

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
T65	639,977	5,792,529	127
T66	639,992	5,787,787	130
T67	640,086	5,780,835	130
T68	640,117	5,789,588	120
T69	640,081	5,788,756	125
T70	640,379	5,793,221	128
T71	640,441	5,786,955	131
T72	640,473	5,791,362	123
T73	640,688	5,784,019	130
T74	640,704	5,785,574	126
T75	640,442	5,790,334	123
T76	640,871	5,780,488	130
T77	640,969	5,781,110	130
T78	641,094	5,787,634	130
T79	641,147	5,793,136	126
T80	641,121	5,788,549	120
T81	641,288	5,792,184	124
T82	641,308	5,786,605	121
T83	641,535	5,781,388	130
T84	640,922	5,790,690	121
T85	641,644	5,783,822	130
T86	641,651	5,785,913	112
T87	641,826	5,782,025	122
T88	641,858	5,780,580	123
T89	641,992	5,778,517	120
T90	642,068	5,792,857	127
T91	642,114	5,791,453	122
T92	642,643	5,780,816	114
T93	642,392	5,792,085	126
T94	642,717	5,780,127	117
T95	642,736	5,778,215	120
T96	642,878	5,782,377	110
T97	642,998	5,778,662	120

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
T98	642,894	5,792,578	130
T99	642,409	5,781,448	120
T100	643,040	5,791,504	127
T101	643,170	5,783,076	110
T102	643,456	5,779,540	118
T103	643,517	5,778,880	120
T104	643,635	5,780,290	111
T105	643,666	5,782,434	110
T106	643,771	5,780,955	110
T107	643,783	5,792,371	130
T108	643,873	5,781,584	110
T109	643,093	5,781,585	112

APPENDIX B RECEIVER LOCATIONS

The following table sets out the ninety-five (95) assessed receivers identified by the proponent within 3 km of the proposed wind turbines considered in the preliminary noise assessment together with their respective distance to the nearest wind turbine. This includes forty-nine (49) involved receivers.

(Data reference v049a, supplied by the proponent on 2 December 2021).

Table 9: Receivers within 3 km of the proposed wind turbines – MGA 94 zone 54

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
D32 (I)	636,850	5,778,945	127	1,646	T49
D34 (I)	637,257	5,779,660	130	1,383	T50
D35 (I)	636,378	5,781,156	130	1,084	T40
D36	635,828	5,780,862	130	1,688	T40
D37	634,807	5,783,584	130	1,999	T24
D38 (I)	634,118	5,783,402	120	2,502	T24
D39	634,133	5,784,996	136	1,533	T24
D40 (I)	634,988	5,787,652	133	1,046	T26
D197 (I)	634,878	5,793,424	130	1,038	T20
D199	636,458	5,796,606	142	2,678	T32
D200	637,052	5,796,683	144	2,796	T32
D201	637,617	5,796,354	140	2,644	T32
D202	639,064	5,795,701	130	2,811	T70
D203 (I)	639,014	5,795,331	130	2,517	T70
D204 (I)	639,529	5,795,076	130	2,045	T70
D205	640,481	5,794,744	130	1,533	T70
D206 (I)	644,686	5,793,854	130	1,743	T107
D208 (I)	645,490	5,793,469	130	2,035	T107
D292	629,392	5,787,947	130	2,724	T2
D294	630,677	5,788,818	140	1,531	T1
D295	629,557	5,789,592	140	2,269	T1
D296	630,352	5,791,247	140	2,030	T1
D297 (I)	631,265	5,787,970	140	861	T2
D298 (I)	633,627	5,787,802	140	948	T8
D299	633,385	5,786,842	140	1,762	T2
D300	630,779	5,786,797	130	1,834	T2
D301	631,006	5,786,667	130	1,775	T2

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
D306	630,808	5,785,586	130	2,790	T2
D314	633,477	5,783,638	123	2,771	T24
D319	629,411	5,790,652	140	2,535	T1
D336	643,539	5,776,846	120	1,594	T95
D337	641,824	5,776,994	122	1,531	T95
D338 (I)	642,174	5,777,409	120	994	T95
D339	639,742	5,776,991	120	2,031	T49
D340 (I)	636,785	5,777,078	120	2,215	T49
D341	636,588	5,778,086	124	1,913	T49
D343 (I)	639,462	5,778,522	130	575	T58
D344 (I)	636,841	5,778,781	125	1,623	T49
D345	636,747	5,779,043	128	1,771	T49
D352	646,535	5,780,648	110	2,786	T106
D355 (I)	640,386	5,782,525	130	1,531	T73
D356 (I)	637,617	5,783,106	130	1,531	T45
D357 (I)	642,347	5,783,026	130	837	T101
D359 (I)	642,078	5,784,531	130	844	T85
D361 (I)	639,708	5,785,297	130	1,045	T74
D362 (I)	639,380	5,784,803	130	1,533	T73
D366 (I)	637,867	5,786,585	123	1,349	T35
D367	643,362	5,786,992	120	2,029	T86
D368	644,035	5,787,401	110	2,814	T86
D378 (I)	637,997	5,791,680	130	870	T46
D379 (I)	638,503	5,792,638	130	1,363	T61
D380 (I)	639,676	5,792,323	127	393	T65
D381 (I)	646,498	5,792,859	130	2,762	T107
D395 (I)	638,601	5,793,314	130	1,591	T65
D396 (I)	638,160	5,792,382	130	1,531	T61
D397 (I)	637,086	5,789,899	130	932	T43
D398 (I)	641,799	5,789,551	120	1,219	T80
D400	630,109	5,792,074	140	2,810	T1
D402	644,056	5,789,694	130	2,081	T100

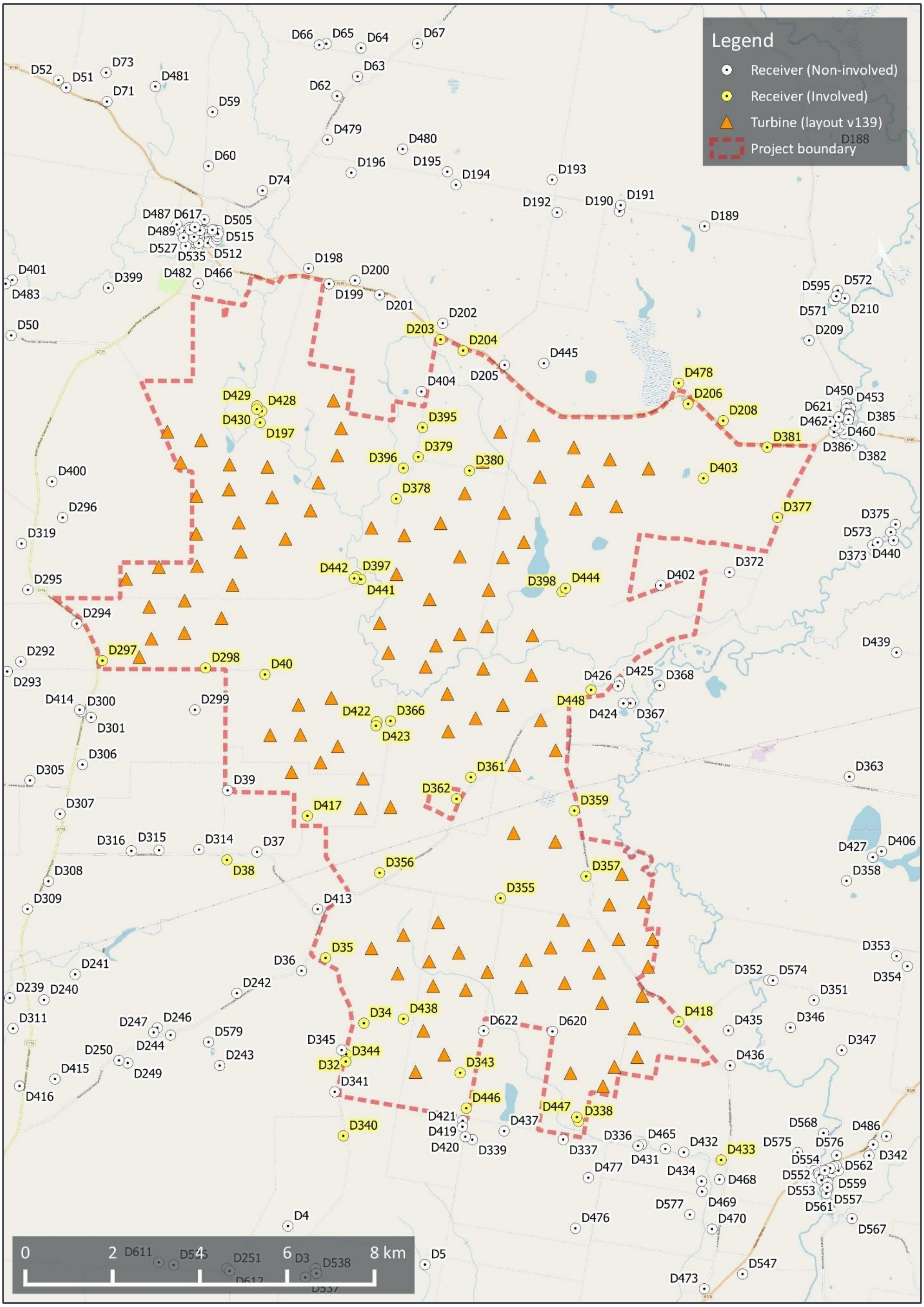
Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
D403 (I)	645,039	5,792,149	130	1,283	T107
D404	638,575	5,794,136	130	2,029	T70
D413	636,197	5,782,273	130	1,531	T40
D414	630,743	5,786,843	130	1,830	T2
D417 (I)	635,962	5,784,411	130	1,075	T24
D418 (I)	644,469	5,779,694	118	1,035	T102
D419	639,519	5,777,423	120	1,563	T49
D420	639,580	5,777,057	120	1,879	T49
D421	639,514	5,777,286	120	1,660	T49
D422 (I)	637,552	5,786,570	120	1,068	T35
D423 (I)	637,533	5,786,478	120	1,006	T35
D424	643,204	5,786,989	120	1,896	T86
D425	643,113	5,787,489	120	2,015	T82
D426	643,081	5,787,386	120	1,943	T82
D428 (I)	634,915	5,793,690	130	1,294	T20
D429 (I)	634,807	5,793,806	130	1,423	T20
D430 (I)	634,802	5,793,733	130	1,352	T20
D431	644,165	5,776,780	120	2,031	T95
D432	644,587	5,776,701	115	2,396	T95
D435	645,609	5,779,492	110	2,134	T104
D436	645,648	5,778,690	116	2,145	T103
D437	640,471	5,777,187	122	2,026	T89
D438 (I)	638,164	5,779,757	130	551	T50
D441 (I)	637,189	5,789,832	130	837	T43
D442 (I)	637,035	5,789,854	130	985	T43
D444 (I)	641,877	5,789,629	120	1,327	T80
D445	641,380	5,794,784	130	1,671	T79
D446 (I)	639,602	5,777,711	126	1,337	T58
D447 (I)	642,135	5,777,506	120	941	T95
D448 (I)	642,462	5,787,298	126	1,355	T82
D465	643,621	5,776,878	120	1,610	T95
D477	642,401	5,776,118	120	2,129	T95

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
D478 (I)	644,468	5,794,331	130	2,082	T107
D574	646,630	5,780,638	110	2,880	T106
D620	641,579	5,779,470	126	1,049	T89
D622	640,002	5,779,485	130	1,036	T62

(I) Involved receiver

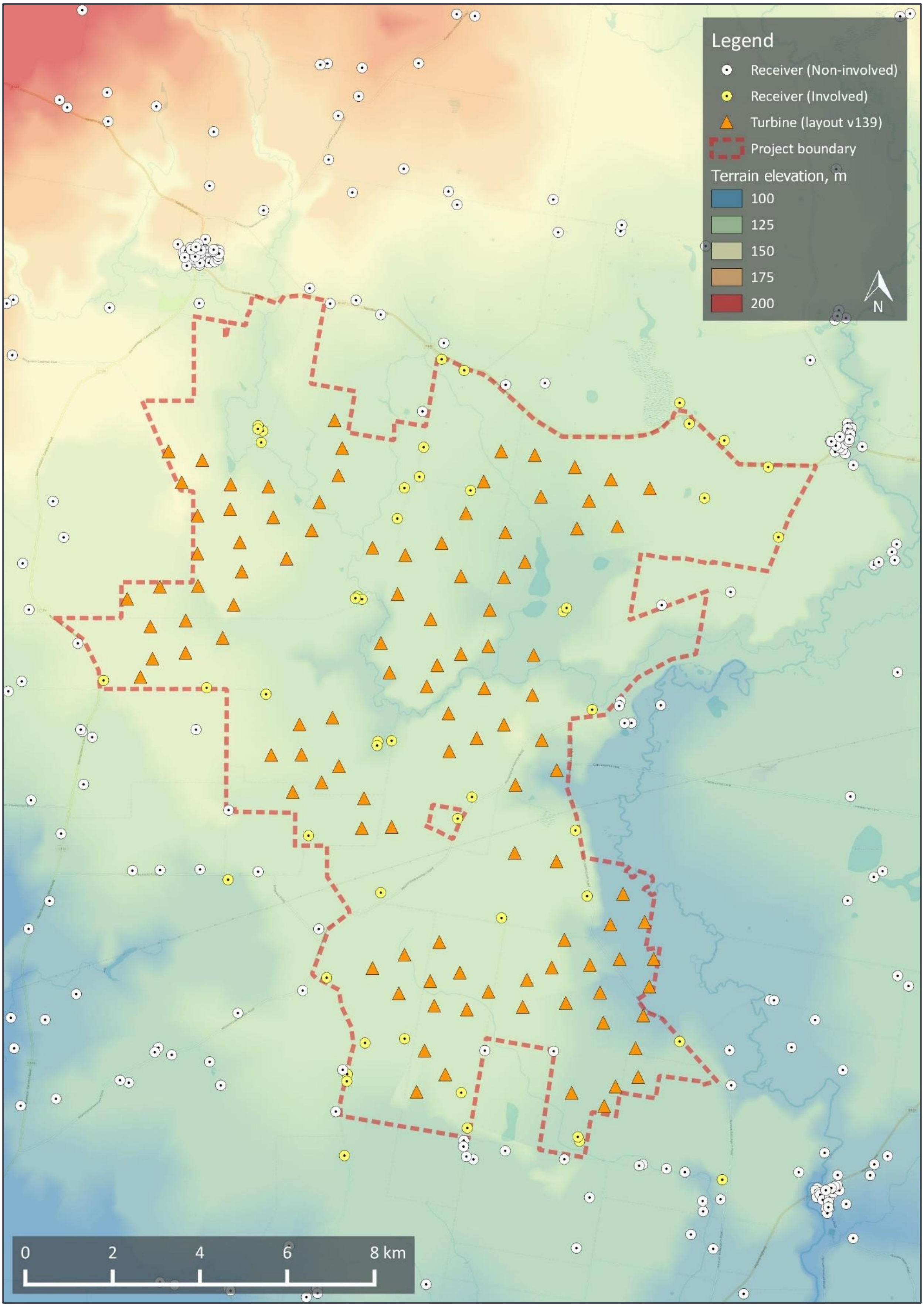
APPENDIX C SITE LAYOUT PLAN

Figure 2: Proposed wind turbine layout and receivers



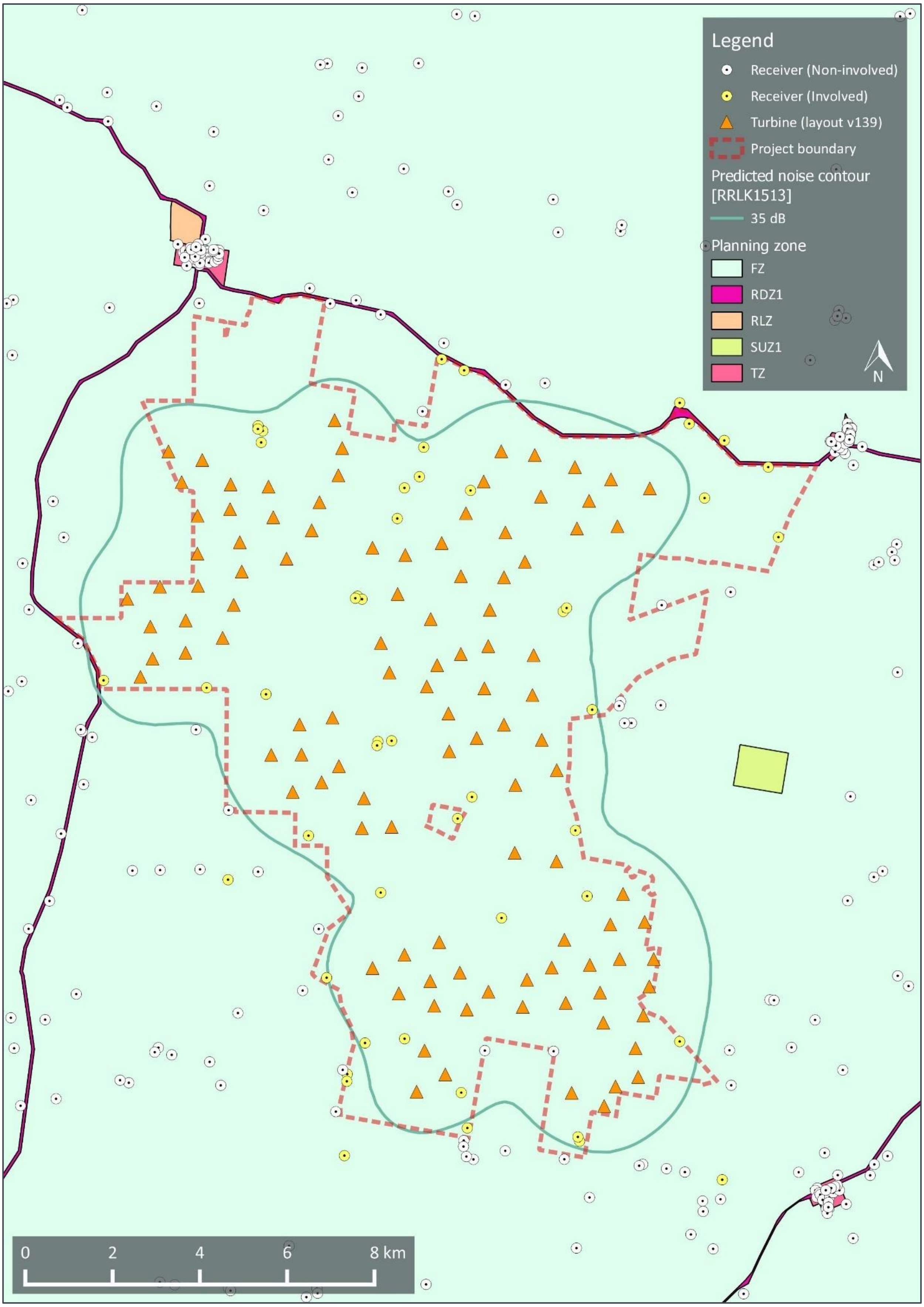
APPENDIX D SITE TOPOGRAPHY

Figure 3: Terrain elevation map for the wind farm and surrounding area



APPENDIX E ZONING MAP

Figure 4: Zoning map for the wind farm and surrounding area



APPENDIX F NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors* (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* (NZS 6808), AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and the South Australian EPA *Wind farms environmental 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 ^{o}C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

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

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- 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[19, 20, 21] 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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19 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.

20 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.

21 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; and
- 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 SoundPLAN 8.2 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each 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 G TABULATED PREDICTED NOISE LEVEL DATA

Table 10: Predicted noise levels, dB L_{A90}

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
D32 (I)	22.6	22.8	24.7	27.7	30.5	32.6	32.8
D34 (I)	25.4	25.6	27.5	30.5	33.3	35.4	35.6
D35 (I)	24.6	24.8	26.7	29.7	32.5	34.6	34.8
D36	21.7	21.9	23.8	26.8	29.6	31.7	31.9
D37	21.7	21.9	23.8	26.8	29.6	31.7	31.9
D38 (I)	20.0	20.2	22.1	25.1	27.9	30.0	30.2
D39	23.5	23.7	25.6	28.6	31.4	33.5	33.7
D40 (I)	27.2	27.4	29.3	32.3	35.1	37.2	37.4
D197 (I)	27.7	27.9	29.8	32.8	35.6	37.7	37.9
D199	17.8	18.0	19.9	22.9	25.7	27.8	28.0
D200	17.6	17.8	19.7	22.7	25.5	27.6	27.8
D201	18.2	18.4	20.3	23.3	26.1	28.2	28.4
D202	19.3	19.5	21.4	24.4	27.2	29.3	29.5
D203 (I)	20.2	20.4	22.3	25.3	28.1	30.2	30.4
D204 (I)	21.0	21.2	23.1	26.1	28.9	31.0	31.2
D205	22.8	23.0	24.9	27.9	30.7	32.8	33.0
D206 (I)	20.4	20.6	22.5	25.5	28.3	30.4	30.6
D208 (I)	18.7	18.9	20.8	23.8	26.6	28.7	28.9
D292	18.3	18.5	20.4	23.4	26.2	28.3	28.5
D294	23.9	24.1	26.0	29.0	31.8	33.9	34.1
D295	19.5	19.7	21.6	24.6	27.4	29.5	29.7
D296	21.1	21.3	23.2	26.2	29.0	31.1	31.3
D297 (I)	26.5	26.7	28.6	31.6	34.4	36.5	36.7
D298 (I)	27.7	27.9	29.8	32.8	35.6	37.7	37.9
D299	24.4	24.6	26.5	29.5	32.3	34.4	34.6
D300	20.5	20.7	22.6	25.6	28.4	30.5	30.7
D301	20.8	21.0	22.9	25.9	28.7	30.8	31.0
D306	17.9	18.1	20.0	23.0	25.8	27.9	28.1
D314	19.2	19.4	21.3	24.3	27.1	29.2	29.4
D319	18.7	18.9	20.8	23.8	26.6	28.7	28.9

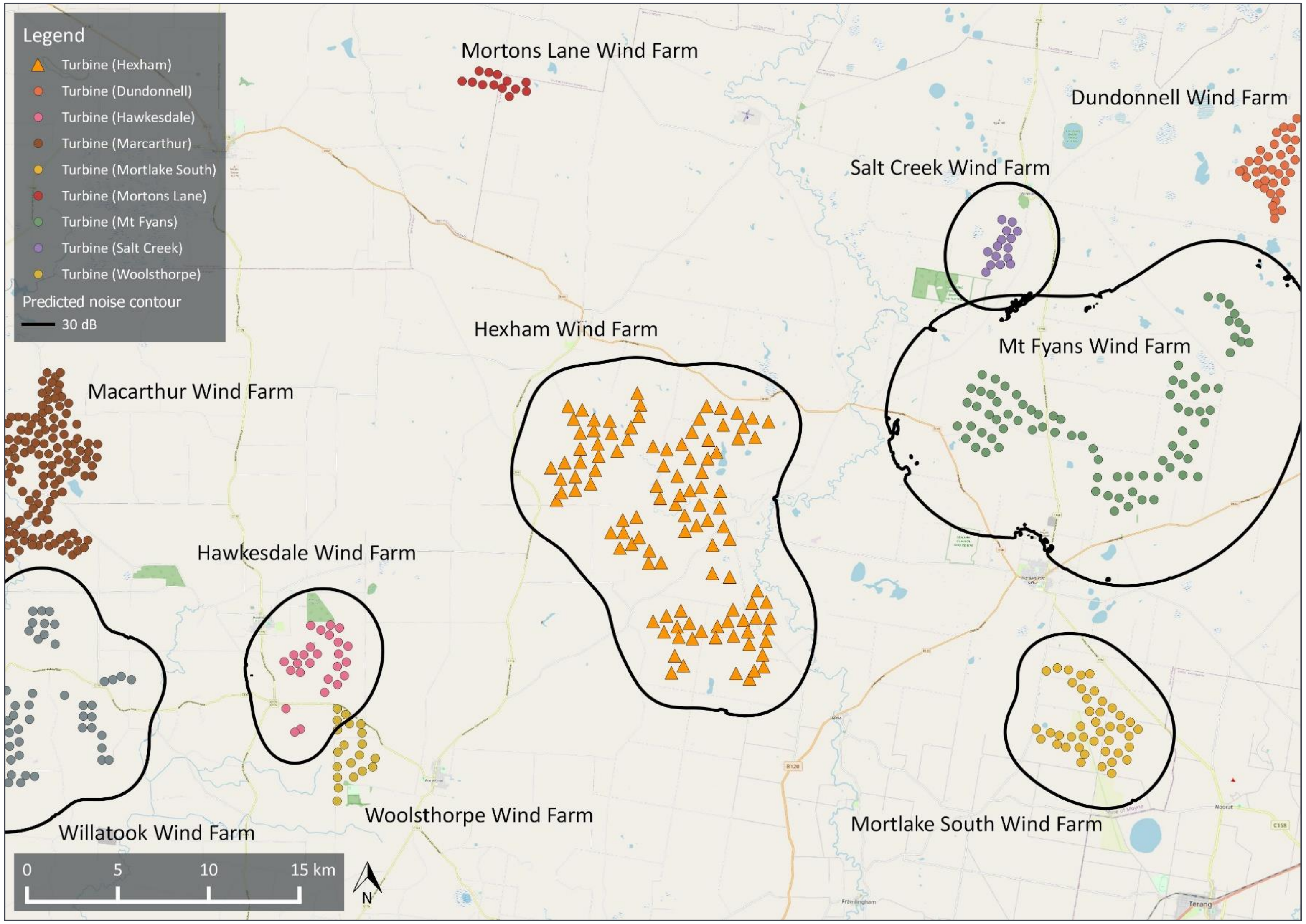
Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
D336	22.0	22.2	24.1	27.1	29.9	32.0	32.2
D337	22.9	23.1	25.0	28.0	30.8	32.9	33.1
D338 (I)	25.9	26.1	28.0	31.0	33.8	35.9	36.1
D339	21.0	21.2	23.1	26.1	28.9	31.0	31.2
D340 (I)	18.4	18.6	20.5	23.5	26.3	28.4	28.6
D341	20.2	20.4	22.3	25.3	28.1	30.2	30.4
D343 (I)	29.5	29.7	31.6	34.6	37.4	39.5	39.7
D344 (I)	22.3	22.5	24.4	27.4	30.2	32.3	32.5
D345	22.4	22.6	24.5	27.5	30.3	32.4	32.6
D352	19.2	19.4	21.3	24.3	27.1	29.2	29.4
D355 (I)	27.5	27.7	29.6	32.6	35.4	37.5	37.7
D356 (I)	25.7	25.9	27.8	30.8	33.6	35.7	35.9
D357 (I)	29.9	30.1	32.0	35.0	37.8	39.9	40.1
D359 (I)	27.3	27.5	29.4	32.4	35.2	37.3	37.5
D361 (I)	27.8	28.0	29.9	32.9	35.7	37.8	38.0
D362 (I)	26.4	26.6	28.5	31.5	34.3	36.4	36.6
D366 (I)	28.3	28.5	30.4	33.4	36.2	38.3	38.5
D367	22.2	22.4	24.3	27.3	30.1	32.2	32.4
D368	20.3	20.5	22.4	25.4	28.2	30.3	30.5
D378 (I)	29.3	29.5	31.4	34.4	37.2	39.3	39.5
D379 (I)	26.6	26.8	28.7	31.7	34.5	36.6	36.8
D380 (I)	33.7	33.9	35.8	38.8	41.6	43.7	43.9
D381 (I)	16.5	16.7	18.6	21.6	24.4	26.5	26.7
D395 (I)	25.2	25.4	27.3	30.3	33.1	35.2	35.4
D396 (I)	27.0	27.2	29.1	32.1	34.9	37.0	37.2
D397 (I)	28.8	29.0	30.9	33.9	36.7	38.8	39.0
D398 (I)	26.8	27.0	28.9	31.9	34.7	36.8	37.0
D400	19.5	19.7	21.6	24.6	27.4	29.5	29.7
D402	21.3	21.5	23.4	26.4	29.2	31.3	31.5
D403 (I)	22.2	22.4	24.3	27.3	30.1	32.2	32.4
D404	23.2	23.4	25.3	28.3	31.1	33.2	33.4
D413	23.1	23.3	25.2	28.2	31.0	33.1	33.3

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
D414	20.5	20.7	22.6	25.6	28.4	30.5	30.7
D417 (I)	27.1	27.3	29.2	32.2	35.0	37.1	37.3
D418 (I)	27.6	27.8	29.7	32.7	35.5	37.6	37.8
D419	22.7	22.9	24.8	27.8	30.6	32.7	32.9
D420	21.3	21.5	23.4	26.4	29.2	31.3	31.5
D421	22.2	22.4	24.3	27.3	30.1	32.2	32.4
D422 (I)	28.7	28.9	30.8	33.8	36.6	38.7	38.9
D423 (I)	28.8	29.0	30.9	33.9	36.7	38.8	39.0
D424	22.7	22.9	24.8	27.8	30.6	32.7	32.9
D425	22.8	23.0	24.9	27.9	30.7	32.8	33.0
D426	22.9	23.1	25.0	28.0	30.8	32.9	33.1
D428 (I)	26.4	26.6	28.5	31.5	34.3	36.4	36.6
D429 (I)	26.0	26.2	28.1	31.1	33.9	36.0	36.2
D430 (I)	26.3	26.5	28.4	31.4	34.2	36.3	36.5
D431	20.4	20.6	22.5	25.5	28.3	30.4	30.6
D432	19.3	19.5	21.4	24.4	27.2	29.3	29.5
D435	21.7	21.9	23.8	26.8	29.6	31.7	31.9
D436	20.6	20.8	22.7	25.7	28.5	30.6	30.8
D437	21.6	21.8	23.7	26.7	29.5	31.6	31.8
D438 (I)	30.9	31.1	33.0	36.0	38.8	40.9	41.1
D441 (I)	29.2	29.4	31.3	34.3	37.1	39.2	39.4
D442 (I)	28.6	28.8	30.7	33.7	36.5	38.6	38.8
D444 (I)	26.6	26.8	28.7	31.7	34.5	36.6	36.8
D445	22.5	22.7	24.6	27.6	30.4	32.5	32.7
D446 (I)	23.9	24.1	26.0	29.0	31.8	33.9	34.1
D447 (I)	26.5	26.7	28.6	31.6	34.4	36.5	36.7
D448 (I)	25.3	25.5	27.4	30.4	33.2	35.3	35.5
D465	21.9	22.1	24.0	27.0	29.8	31.9	32.1
D477	19.6	19.8	21.7	24.7	27.5	29.6	29.8
D478 (I)	19.6	19.8	21.7	24.7	27.5	29.6	29.8
D574	18.9	19.1	21.0	24.0	26.8	28.9	29.1
D620	28.7	28.9	30.8	33.8	36.6	38.7	38.9

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
D622	28.6	28.8	30.7	33.7	36.5	38.6	38.8

(I) Involved receiver

APPENDIX H SURROUNDING AREA WIND FARM DEVELOPMENT MAP & PREDICTED 30 dB L_{A90} CONTOUR OF EACH WIND FARM



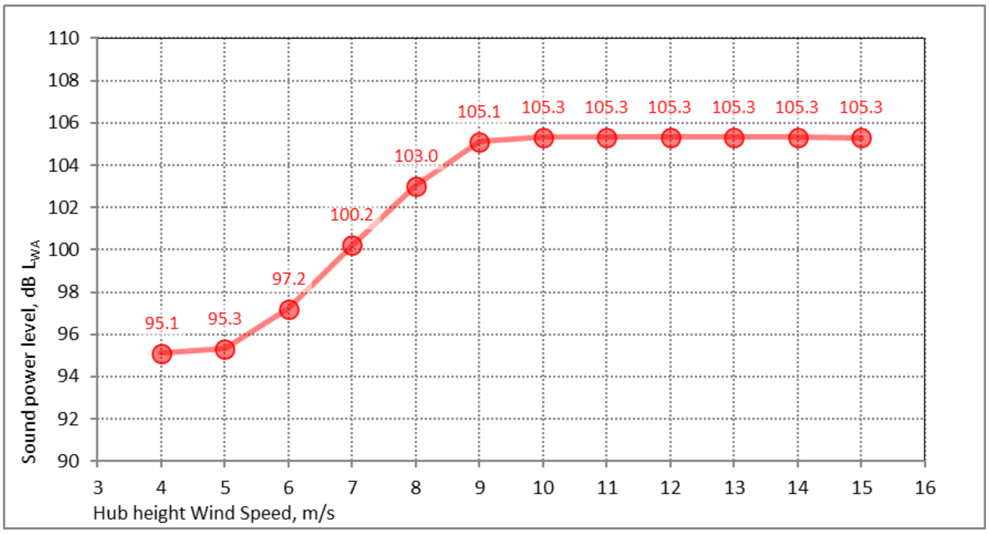
APPENDIX I NZS 6808 DOCUMENTATION

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

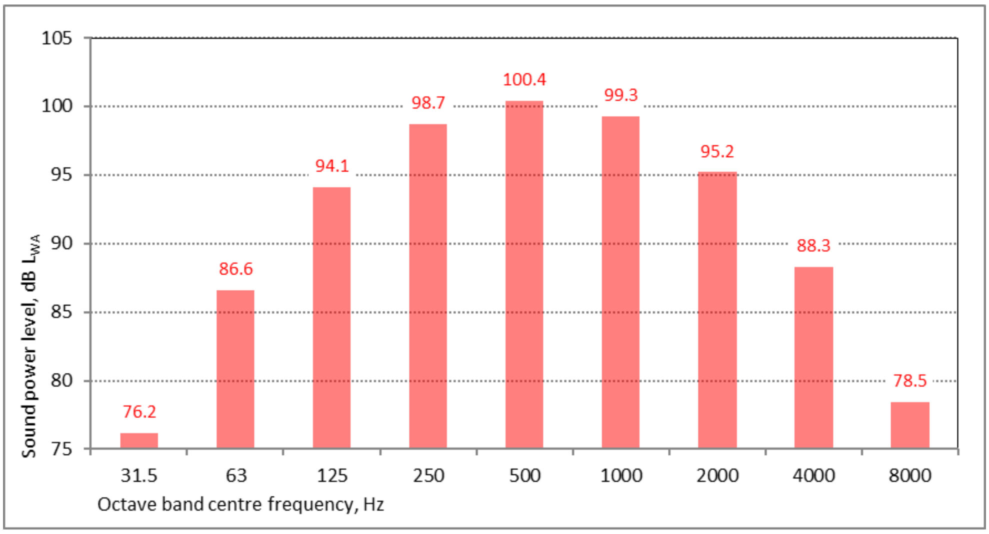
(b) Noise sensitive locations: See Section 2.0 and Appendix B

(c) Wind turbine sound power levels, L_{WA} dB (refer to Section 5.3.1)

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 3 of Section 5.2

(e) Wind turbine hub height: See Table 3 of Section 5.2

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

(g) Calculation procedure used: ISO 9613-2 prediction algorithm as implemented in SoundPLAN v8.2 (See Section 4.3 and Appendix F)

(h) Meteorological conditions assumed:

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

(i) Air absorption parameters:

	Octave band mid frequency, Hz							
Description	**63**	**125**	**250**	**500**	**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: Elevation contours: 10 m resolution elevation data provided by proponent– See Appendix D

(k) Predicted far-field wind farm sound levels: See Section 5.4 and Appendix G.