PLANNING PANELS VICTORIA

IN THE MATTER OF: Delburn Wind Farm

Statement of Evidence of Christophe Frédéric Delaire

Prepared for: Delburn Wind Farm Pty Ltd
Instructed by: White & Case

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1.0 NAME AND ADDRESS

1.1 CHRISTOPHE FREDERIC DELAIRE

1.2 Co-CEO of Marshall Day Acoustics Pty Ltd (MDA)

1.3 6 Gipps Street, Collingwood Victoria 3066

2.0 AREA OF EXPERTISE

2.1 For over 19 years I have worked in the field of acoustics and noise control.

2.2 I am a member of the Australian Acoustical Society (MAAS)

2.3 My qualifications and experience are detailed in Appendix A.

2.4 I have a special interest in environmental noise and have gained extensive experience in the noise assessment of wind farms since 2005.

2.5 I am sufficiently expert to make this statement because I have been involved in environmental noise impact assessments for major environmental projects such as power stations, wind farms and industrial plants.

2.6 My experience extends to all aspects of wind farm noise, including predictions, background noise monitoring, post-construction noise assessments and sound power level testing. This is demonstrated by my involvement in over seventy-five (75) projects across Australia, providing expert witness evidence for over a dozen Victorian wind farms and presentation of multiple papers at international conferences.

3.0 SCOPE

3.1 Marshall Day Acoustics Pty Ltd (MDA) was commissioned by Delburn Wind Farm Pty Ltd (the Proponent) to prepare an environmental noise assessment for the Delburn Wind Farm (the Project) proposed in the vicinity of the Morwell township, across the Victorian Local Government Areas of South Gippsland, Baw Baw and Latrobe.

3.2 The Project is proposed to comprise thirty-three (33) wind turbines and related infrastructure, including a battery energy storage system and a terminal station.

3.3 It is understood that the battery energy storage system was included as part of the wind farm planning application and the terminal station was the subject of a separate application. Considering that both the battery energy storage system and the terminal station are assessed against the same legislative requirements, they are collectively addressed as the related infrastructure.

3.4 This assessment addressed operational and construction noise from the Project in accordance with the Victorian policy requirements which were applicable at the time.

3.5 The assessment was documented in MDA report Rp 003 R01 20190463 *Delburn Wind Farm - Environmental Noise Assessment* dated 26 January 2021 (the MDA Report). The MDA Report was exhibited as Appendix H of the Planning Permit Application Report dated June 2021.

3.6 I have been instructed by White & Case (W&C) on behalf of the proponent to prepare this witness statement and give expert evidence to the panel inquiry.

3.7 I adopt the MDA Report as the basis for my expert witness statement and evidence, subject to the correction noted in Appendix B and accounting for the new regulatory framework which came into effect on 1 July 2021 and 1 August 2021.

3.8 This statement provides a summary of the MDA Report together with a response to the peer-review and key submissions relating to noise.

3.9 Where relevant, current Regulations and guidelines, will substitute any outdated Regulations and guidelines which were referenced in the MDA Report.

3.10 The MDA staff members listed in Table 1 have assisted with the MDA Report and this statement of evidence.

Table 1: Assisting MDA staff members

Staff member	Title	Tasks	Qualification
Justin Adcock	Senior Associate	Review of MDA Report Review of key submissions and statement of evidence	B.Eng (Mech)
Sam Cheney	Consultant	Background noise monitoring (deployment, retrieval, analysis and reporting)	B.Env Sc M.Env Eng
Tim Mower	Consultant	Background noise monitoring (deployment)	B.Eng (Mech)

3.11 The documents I have reviewed and referenced in this statement are listed in Appendix C.

3.12 A glossary of acoustic terminology is provided in Appendix D.

4.0 VICTORIAN POLICY & GUIDELINES

4.1 At the time of preparing the MDA Report, the publications listed in Table 2 were relevant to the assessment of operational and construction noise from proposed wind farm developments in Victoria.

Table 2: Relevant publications at the time of preparing the MDA Report

Noise source	Publication
Wind turbines	Victorian Department of Environment, Land, Water and Planning *Development of Wind Energy Facilities in Victoria - Policy and Planning Guidelines* dated March 2019 (the 2019 Victorian Wind Energy Guidelines) New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808)
Related infrastructure	EPA publication 1411 *Noise from Industry in Regional Victoria – Recommended maximum noise levels from commerce, industry and trade premises in regional Victoria* (NIRV)
Construction	EPA Publication 1254 *Noise Control Guidelines* (EPA Publication 1254)

4.2 A new environmental noise management framework came into effect on 1 July 2021.

4.3 The *Environment Protection Act 2017* (the Act), as amended by the *Environment Protection Amendment Act 2018*, provides the overarching legislative framework for the protection of the environment in Victoria.

4.4 It establishes a general environmental duty to minimise the risks of harm to human health or the environment from pollution or waste, including noise, so far as reasonably practicable.

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

4.6 Table 3 details the current relevant regulation and guidelines for the assessment of operational and construction noise from proposed wind farm developments in Victoria.

Table 3: Current relevant publications

Noise source	Publication
Wind turbines	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) *Environment Protection Regulations 2021* (the Regulations) New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808)
Related infrastructure	*Environment Protection Regulations 2021* (the Regulations) 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)
Construction	EPA Publication 1834 *Civil construction, building and demolition guide* dated November 2020 (EPA Publication 1834)

4.7 Consistent with the requirements detailed in the 2019 Victorian Wind Energy Guidelines, Part 5.3 Division 5 of the Regulations nominates NZS 6808 as the relevant standard for assessing operational wind turbine noise in Victoria and introduces additional measures to demonstrate compliance.

4.8 In terms of noise levels associated with related infrastructure, including battery energy storage system and a terminal station, the assessment procedures prescribed for rural areas in the Noise Protocol are consistent with those detailed in NIRV, with identical applicable noise limits.

4.9 With regard to construction noise, the content of Section 2 of EPA Publication 1254 has largely been reproduced in EPA Publication 1834.

4.10 The effect of the changes to the regulatory framework are summarised as follows:

- Introduction of a general environmental duty to implement all reasonably practicable measures to minimise risks of harm to human health and the environment from pollution or waste. Relevantly noise is included in the definition of pollution;
- Operational noise of wind turbines continues to be assessed using NZS 6808, as referenced in the MDA Report but the EPA becomes the assessment authority; and
- Operational noise from related infrastructure is assessed using an equivalent to that referenced in the MDA Report (NIRV) but is now documented in the Noise Protocol.

5.0 SITE DESCRIPTION

5.1 The Project area is located approximately 10 kilometers to the southwest of Morwell and extends over an area spanning approximately 12 km from north to south and 5 km from east to west (the site).

Turbine Layout

5.2 The Project is proposed to comprise thirty-three (33) wind turbines extending to a tip height of up to 250 m.

5.3 The three (3) candidate wind turbine models from different manufacturers were considered in the assessment presented in the MDA Report.

5.4 The rotor diameters range between 158-170 m and power outputs range between 5.5-6.0 MW.

5.5 A hub height of 160 m for each candidate wind turbine model was considered suitable for noise assessment purposes. It is understood that the final hub height of the selected wind turbine model may differ slightly. However, the magnitude of the potential changes is minor with respect to the assessment.

5.6 An important point of context is that the selection of a final wind turbine model and specification would occur at a later stage in the project after planning approvals have been obtained.

5.7 In particular, the selection would normally occur following detailed layout design work (e.g. micro-siting) and a tender process to procure the supply of wind turbines. The final wind turbine selection would need to achieve the environmental requirements detailed in the regulations.

5.8 All turbines were modelled based on unconstrained operations (i.e. no curtailment modes assumed).

Related infrastructure

5.9 Related infrastructure associated with the Project, including a battery energy storage system and a terminal station, is also proposed to be located to the north of the Project.

Assessed receivers

5.10 NZS 6808 requires that the noise assessment be undertaken at all noise sensitive locations in the vicinity of the proposed wind farm which it defines as follows:

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

5.11 As detailed in Section 5.1.2 of the Victorian Wind Energy Guidelines, this includes the following:

- *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.*

5.12 Specifically, Clause 73.03 of the Victoria Planning Provisions (VPP) lists the following as Accommodation:

- *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*

5.13 Consistent with the Regulations and the Victorian Wind Energy Guidelines, an owner or operator of 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'.

5.14 With regards to the noise assessment for related infrastructure, the Noise Protocol applies to 'noise sensitive areas', as defined in the Regulations. In a rural area, this includes:

> *part of the land within the boundary of—*
>
> *(i) a tourist establishment; or*
>
> *(ii) a campground; or*
>
> *(iii) a caravan park;*

5.15 In contrast to NZS 6808 and the Victorian Wind Energy Guidelines, the Noise Protocol does not differentiate between stakeholder and non-stakeholder receivers.

5.16 A total of three hundred and twenty-eight (328) noise sensitive locations (generally referred to as 'receivers' herein) located within 3 km of the proposed wind turbines have been considered in this noise assessment.

5.17 This includes two (2) receivers located within the project boundary (subsequently referred to as 'stakeholder receivers' herein) and three (3) receivers identified by the proponent as future dwellings on a title without an existing dwelling (subsequently referred to as 'future receivers' herein).

5.18 A further forty-four (44) receivers, located within 3 km of the proposed related infrastructure, have also been considered in the noise assessment.

6.0 ASSESSMENT METHOD

6.1 The environmental noise assessment undertaken for the Project and presented in the MDA Report is structured around the following key elements:

- Identification of receivers in the vicinity of the Project;
- Review of the existing noise environment in the vicinity of the project area and assessment of background noise levels at a selection of representative receivers around the Project; and
- Assessment of operational and construction noise associated with the Project on the basis of Victorian and interstate policies and guidelines that establish or recommend acceptable noise levels and suitable management practices.

7.0 BACKGROUND NOISE MONITORING

7.1 Background noise level information is used as part of setting limits for related infrastructure and 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.

7.2 As the data about existing conditions is primarily used for the assessment of the wind turbine components of the Project, an assessment of background noise levels was carried out on the basis of the method detailed in NZS 6808.

7.3 According to Section 7.1.4 of NZS 6808, background noise monitoring should be carried out where wind farm sound levels at receivers are predicted to be 35 dB L_{A90} or higher. However, these measurements are not mandatory and, as detailed in Section 7.1.2 of NZS 6808, a fixed base noise limit can be used at all wind speeds.

7.4 Preferred noise monitoring locations were selected, based on preliminary noise modelling of an earlier wind farm layout, to represent the nearest receivers at distributed locations around the site within the 35 dB L_{A90} noise contour.

7.5 It is noted that consent to undertake background noise monitoring was not granted at all preferred receivers.

7.6 Unattended noise monitoring was carried out in accordance with NZS 6808 at nine (9) receivers between 6 March and 18 June 2020.

7.7 The results of the survey were then analysed in accordance with NZS 6808 to determine the relationship between background noise levels and hub height wind speeds at the wind farm site.

7.8 Neither NZS 6808 nor the Victorian Wind Energy Guidelines define separate time periods for the analysis of background noise levels or assessment of wind farm noise. However, in accordance with the requirements commonly defined in Victorian wind farm planning permits, the data sets are considered for separate periods as follows:

- All periods: no restriction on hours (i.e. data during day and night hours included); and
- Night period: 2200 to 0700 hours.

7.9 The trend of measured background noise levels was consistent with the noise environment expected in a rural area. In particular, the trend of the data illustrates lower background noise levels at low wind speeds, regularly below 30 dB, and progressively increasing background noise levels with increasing wind speed.

8.0 WIND TURBINE ASSESSMENT

Wind turbine noise limits

8.1 Operational wind turbine noise has been assessed in accordance with NZS 6808 as required by the Regulations and the Victorian Wind Energy Guidelines.

8.2 In accordance with NZS 6808, the operational noise from wind turbines at receivers should not exceed a base noise limit (40 dB L_{A90} or 35 dB L_{A90}, if a high amenity area noise limit is applicable) or the background noise (L_{A90}) by more than 5dB, whichever is the greater.

8.3 As detailed in Section 7.1.1 of the MDA Report, a review of the land zoning surrounding the proposed site indicated that alternative noise limits intended for high amenity zones, detailed in Section 5.3 of NZS 6808, are not applicable.

8.4 Section 5.3.1 of NZS 6808 states that the base noise limit of 40 dB L_{A90} is *appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations* and 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.*

8.5 As prescribed in NZS 6808, the applicability of a high amenity noise limit is based on a two-step approach comprising:

- 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
- If the receiver is located within the 35 dB L_{A90} noise contour, and after conducting the calculation set out in clause C5.3.1, a high amenity noise limit may be justified.

8.6 Based on the zoning map for the area, the land within the predicted 35 dB L_{A90} contour includes thirteen (13) receivers within a Farming Zone, two (2) receivers within a Special Use Zone (area west of the Hazelwood coal mine) and two (2) receivers within a Rural Living Zone (area northwest of the Boolarra township).

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

8.8 The Cherry Tree Wind Farm decision provides guidance that is directly applicable to a Farming Zone, but does not provide guidance that is specific to the Rural Living Zone which requires consideration for the Delburn Wind Farm. Accordingly, for the specific purpose of the Rural Living Zone, it is necessary to consider alternative guidance. As a guide to the Rural Living Zone, reference has been made to the planning panel report[1] for the Golden Plains Wind Farm which addressed land designated as Township Zone and Low Density Residential Zone and determined that the high amenity noise limits were applicable to these zones.

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1 *EES Inquiry and Planning Permit Application Panel Report - Golden Plains Wind Farm* dated 26 September 2018

8.9 Based on the findings of the planning panel for the Golden Plains Wind Farm, and considering that one of the purposes of the Rural Living Zone is residential, a high amenity noise limit may warrant consideration for the two (2) receivers that are in the Rural Living Zone and where predicted noise levels are above 35 dB L_{A90}.

8.10 The calculation presented in C5.3.1 was applied to the two (2) receivers (605 and 4155) where the land zoning review determined a high amenity noise limit may warrant consideration using:

- Predicted noise levels for the candidate turbine model yielding the highest levels; and
- Background noise levels measured at two (2) receivers in the vicinity of the Boolara Township (600 and 4585), as permission was not granted to undertake background noise monitoring at receivers 605 and 4155.

8.11 As the C5.3.1 calculation resulted in levels below the threshold of 8 dB prescribed in NZS 6808, for both the evening and night periods, a high amenity noise limit is therefore unlikely to be justified for the Project based on the current layout and candidate wind turbine models.

8.12 Although Regulation 131B specifies an increased base noise limit of 45 dB L_{A90} for stakeholder receivers, the NZS 6808 base noise limit of 40 dB L_{A90} was applied at the two (2) stakeholder receivers.

8.13 Accounting for the conclusions of the assessment of high amenity, the applicable noise limits for the Project are summarised in Table 4.

Table 4: Applicable noise limits, dB L_{A90}

Land zoning	Noise limit
Farming Zone	40 dB or background L_{A90} + 5dB, whichever is higher
Rural Living Zone	40 or 35 dB* or background L_{A90} + 5 dB, whichever is higher

* the applicable base noise limit is to be based on the calculation detailed in clause C5.3.1 of NZS 6808

Wind turbine noise emissions

8.14 The noise emissions of the candidate wind turbine models have been represented using manufacturer sound power level data for the three (3) candidate wind turbines; the Vestas V162-5.6MW, GE Renewable Energy 5.5-158, and Siemens Gamesa SG 6.0-170.

8.15 A +1.0 dB adjustment was added to the sound power level at each wind speed to provide a margin for typical values of test uncertainty

8.16 The sound power levels used for this assessment are considered typical of the upper range of noise emissions associated with comparable multi-megawatt wind turbines.

8.17 Review of available sound power data for a range of wind turbine models has shown that there is no clear relationship between wind turbine size or power output and the noise emission characteristics of a given wind turbine model. While wind turbine sizes and power ratings of contemporary turbines have increased, the noise emissions of the 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).

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

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

8.20 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.

8.21 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.

Predicted wind turbine noise levels

8.22 Operational wind turbine noise levels from the Project have been predicted in accordance with the International Standard ISO 9613-2[2] with adjustments applied on the basis of the UK Institute of Acoustics guidance[3].

8.23 The ISO 9613-2 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 noise expected to occur in practice.

8.24 Noise levels from the Project were predicted to comply with the NZS 6808 applicable base (minimum) noise limit of 40 dB at all assessed non-stakeholder receivers, by at least 2.9-4.3 dB, depending on the candidate turbine model.

8.25 Noise contours for the GE 5.5-158 turbine is provided in Appendix E, as it yielded the highest predicted wind farm noise levels.

High amenity considerations

8.26 A base limit of 40 dB L_{A90} was determined for receivers in the Rural Living Zone, based on calculations carried out in accordance with C5.3.1 of NZS 6808. However, a lower base limit of 35 dB L_{A90} may warrant consideration for receivers in this zone if indicated by calculations in accordance with C5.3.1 for the final selected turbine model. Wind turbine noise levels were therefore predicted at 6 m/s, the highest wind speed of the range which NZS 6808 recommends the high amenity limit would normally apply to.

8.27 Irrespective of whether a high amenity noise limit may be justified, the wind turbine noise levels, for the wind speed range where high amenity provision may warrant consideration, were predicted to be below 35 dB L_{A90} at all receivers within the Rural Living Zone for all candidate turbine models by at least 7.2 dB.

8.28 These findings demonstrate that the lower base noise limit could be achieved at receivers within the Rural Living Zone if the high amenity provision was found to be applicable.

8.29 The results demonstrate that wind turbine noise levels from the Project are predicted to comply with the operational noise requirements of NZS 6808, as required by the Regulations and the Victorian Wind Energy Guidelines.

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2 ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – General method of calculation* (ISO 9613-2)

3 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)

9.0 RELATED INFRASTRUCTURE ASSESSMENT

Related infrastructure noise limits

9.1 Operational noise from the related infrastructure associated with the Project must now be assessed in accordance with the Noise Protocol.

9.2 The related infrastructure is proposed to operate 24 hours a day and 7 days a week and is expected to produce comparable noise emissions throughout the day, evening and night periods. As such, compliance is assessed against the most stringent limits which apply to the night period.

9.3 Based on the land zoning of the Project area and surrounding noise sensitive areas, the night-time noise limits applicable to the receivers nearest to the proposed related infrastructure are:

- 32 dB L_{eff} at Receiver 674; and
- 36 dB L_{eff} at Receiver 676.

Related infrastructure equipment

9.4 The battery energy storage system is proposed to have a capacity of 50 MW / 200 MWh.

9.5 Equipment details are not known at this stage. However, total equipment noise levels from other battery storage projects indicate sound power levels in the range of 95-100 dB L_{WA}.

9.6 The main sources of noise located within the terminal station will be the transformers and any associated cooling equipment.

9.7 At this stage in the project, specific details of the transformer make and model are yet to be determined. However, to provide a basis for assessing the feasibility of the proposed terminal station, the proponent advised that a single transformer rated to 240 MVA is proposed.

9.8 AS 60076-10:2009[4] has been used to determine an estimated standard maximum sound power level of 99 dB L_{WA} for the proposed transformer.

Predicted related infrastructure noise levels

9.9 Effective noise levels from the proposed related infrastructure were predicted at the two nearest receivers, located approximately 1.5-1.8 km to the northwest of related infrastructure equipment.

9.10 An adjustment of +2 dB has then been applied to the predicted noise levels to account for the potential tonal characteristics of transformer noise.

9.11 The predicted effective noise levels were found to be at least 6 dB below the applicable Noise Protocol night-time noise limits.

9.12 These results indicate that noise levels from the proposed related infrastructure associated with the Project are unlikely to be a significant design consideration. However, noise levels should be reviewed at the time when equipment numbers and selections are finalised, accounting for manufacturer noise emission data.

Cumulative assessment

9.13 To my knowledge, the nearest approved and/or operating wind farm is the Toora Wind Farm (approximately 30 km to the south). Due to the significant separating distance, cumulative assessment of noise levels from the Project and other surrounding wind farm(s) is not warranted.

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[4] Australian Standard 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009)

10.0 CONSTRUCTION NOISE

Relevant guideline

10.1 Guidelines for noise and vibration from construction and demolition works are now detailed in EPA Publication 1834.

10.2 The procedures to assess construction noise detailed in the MDA Report (Section 2 of EPA Publication 1254[5]) are equivalent to the procedures that are now defined in EPA Publication 1834.

10.3 EPA Publication 1834 is primarily aimed at protecting nearby sensitive premises from unreasonable noise. This is generally achieved by recommending that construction is scheduled during 'normal working hours' and EPA Publication 1834 lists various managerial measures which are to be adopted to minimise impacts. In particular, EPA Publication 1834 states that the primary way of minimising the likelihood of noise and vibration causing harm is to limit the frequency of occurrence and its duration.

10.4 Construction of a wind farm mostly occurs at relatively large separating distances from receivers and it is proposed that the majority of constructions works be limited to normal working hours.

10.5 The only exceptions are for unavoidable works or low-noise managed-works.

10.6 Unavoidable works outside of normal hours are expected to comprise the delivery of oversized wind turbine components at times selected to minimise traffic disruption associated with intersection closures, and potentially wind turbine installation activities that are sensitive to weather conditions (e.g. installation of rotors).

10.7 General experience of wind farm developments has indicated that construction noise tends to represent a limited risk of disturbance to neighboring receivers.

10.8 Noise associated with construction of the Project can be satisfactorily addressed by the adoption of general management measures and considerate working practices. These measures are expected to be documented and agreed in a Construction Environmental Management Plan which is typically prepared for review and approval by the responsible authority prior to commencing the work.

5 EPA Publication 1254 *Noise control guidelines*

11.0 RECOMMENDED NOISE MANAGEMENT MEASURES

11.1 The Regulations require the following measures to be taken to address wind turbine noise:

- A noise management plan must be prepared as specified in Regulation 131E, prior to construction.
- Compliance noise monitoring must be undertaken as required by Regulation 131D.

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

- A detailed noise assessment should be prepared by a qualified acoustic consultant, prior to construction, addressing:
  - the final turbine selection and layout
  - the final location and equipment selection for the related infrastructure comprising the battery energy storage system and the terminal station
  - compliance with the applicable noise limits at surrounding receivers
  - whether the high amenity noise limit should apply to the area to the northwest of Boolarra that is zoned Rural Living Area and, if so, the appropriate threshold wind speed, based on the guidance in Clause C5.3.1 of NZS 6808.
- Development of reasonably practicable construction noise mitigation and management measures to be documented in a construction environmental management plan, prior to construction
- Indicative sound power level testing should be undertaken in general accordance with IEC 61400-11 during the early stages of commissioning of the wind farm.

  The results would be used to review at an early stage whether the turbine's noise emissions are consistent with expectations (based on the information used for the detailed noise assessment), particularly with respect to the frequency characteristics of the turbines.

11.3 Furthermore, in accordance with Section 7.3.3 of NZS 6808, simultaneous wind speed measurements should be carried out prior to construction of the wind farm to determine reliable relationships between the site wind speeds at the reference locations for the background noise monitoring and the locations where the wind speeds will be measured during operation of the wind farm. This will provide a basis for determining wake-free wind speeds at the same reference locations during post-construction noise monitoring.

12.0 GENERAL ENVIRONMENTAL DUTY

12.1 As detailed in Section 8.24, predicted wind turbine noise levels are predicted to comply with the relevant noise limits by a margin of at least 2.9 dB.

12.2 Under the Act, the general environmental duty requires all reasonably practicable measures to be taken to reduce noise at receivers.

12.3 In addition to the noise management measures detailed in the previous section, the following design aspects of the Project have already been implemented or should be considered to reduce the risk of noise impact:

- All considered candidate wind turbine models are fitted with serrated blades to reduce noise emissions;
- All turbines were modelled based on unconstrained operations (i.e. no curtailment modes);
- Procurement contract with the wind turbine manufacturer should stipulate that the wind turbines must not produce emissions which would attract a penalty for tonality when assessed in accordance with NZS 6808.

13.0 CONCLUSION

13.1 The MDA Report documents the outcomes of an assessment of operational noise for the proposed Delburn Wind Farm. The assessment is based on the proposed wind farm layout comprising thirty-three (33) multi-megawatt turbines and related infrastructure, including a battery energy storage system and a terminal station.

13.2 Operational noise associated with the proposed wind turbines has been assessed in accordance with NZS 6808 as required by the Regulations and Victorian Wind Energy Guidelines dated July 2021.

13.3 Noise modelling was carried out based on three candidate turbine models which have been selected as being representative of the size and type of turbines which could be used at the site.

13.4 The results of the modelling demonstrate that wind turbine noise from the proposed Delburn Wind Farm is predicted to achieve compliance with the applicable noise limits determined in accordance with NZS 6808.

13.5 The assessment has also considered operational noise associated with the proposed related infrastructure comprising a battery energy storage system and terminal station. These noise levels have been assessed in accordance with the Noise Protocol.

13.6 The assessment demonstrates that the related infrastructure is expected to result in noise levels considerably lower than the applicable night-time noise limits.

13.7 Consideration was also given to construction noise associated with the proposed Delburn Wind Farm. This information has been provided as a reference for the matters that should be considered as part of the preparation of a Construction Environmental Management Plan for the Project.

13.8 The noise assessment therefore demonstrates that the proposed Delburn Wind Farm and associated infrastructure can be designed and developed to achieve the current Victorian policy requirements for operational noise.

14.0 INDEPENDENT REVIEWS

14.1 A peer-review of the MDA Report was undertaken by Sonus Pty Ltd and documented in report S6049C6 *Delburn Wind Farm - Peer review of noise assessment*, dated 22 October 2020 (the peer-review).

14.2 The peer-review was exhibited as Appendix H.03 of the Planning Permit Application Report and concluded as follows:

> *Marshall Day has prepared a Background Noise Monitoring report and an Environmental Noise Assessment for the Delburn Wind Farm.*
>
> *A desktop review has been conducted to compare the methodology of the Assessment against the requirements of the Development of Wind Energy Facilities in Victoria - Policy and Planning Guidelines. Independent predictions of the noise from the wind turbines have also been made.*
>
> *On the basis of the review and predictions, it is concluded that the Assessment has been conducted in accordance with the Policy and Planning Guidelines and the assessed layout will achieve the objective requirements.*

14.3 An environmental audit of the MDA Report was undertaken by David Spink of Senversa Pty Ltd in accordance with Section 53V of the Environment Protection Act 1970 and documented in *Environmental Noise Assessment Audit*, dated 5 May 2021 (the audit).

14.4 The audit was exhibited as Appendix H.04 of the Planning Permit Application Report and concluded as follows:

> *The audit of the proposed Delburn WEF was consistent with these requirements of the EPA Guideline.*

14.5 The findings of the peer-review and the audit confirmed that the MDA report was based on appropriate methods in accordance with the 2019 Victorian Wind Energy Guidelines (applicable at that time), and supported the conclusions presented in the MDA report.

15.0 RESPONSE TO THE HUSON STATEMENT

15.1 A critique of the MDA Report is documented in the expert witness statement of William Leslie Huson, dated 16 August 2021 (the Huson Statement).

15.2 I have reviewed the issues raised in the Huson Statement, and my responses are provided in the following sections, categorized under the following headings:

- Background noise survey;
- Wind speed data;
- High amenity area noise limit;
- Noise modelling parameters;
- Wake effect and turbulence intensity;
- Uncertainty; and
- Special audible characteristics.

Background noise survey

15.3 The evidence of Mr Huson states that two (2) background noise monitoring locations (receivers 832 and 867) were not in accordance with the requirements of NZS 6808 on the basis of being locations more than 20 m away from the dwelling.

15.4 The noise monitor at receiver 832 was positioned at a distance farther than 20 m from the dwelling at the request of the resident. It should be noted that the selected noise monitoring location was positioned nearer to the proposed turbine locations and in an open area with less vegetation than is present within 20 m of the dwelling. The position selected at the request of the resident is therefore likely to have resulted in lower background noise levels, which in turn yielded lower noise limits and a more conservative assessment.

15.5 The noise monitor at receiver 867 was positioned at a distance of approximately 20 m from the nearest facade of the dwelling, as can be scaled from Figure 26 of the MDA Report. The noise monitoring location was selected to be farther from the vegetation than a position closer to the dwelling on the side of the proposed wind turbines.

Wind speed data

15.6 The evidence of Mr Huson expresses opinions about the choice of wind speed reference for background noise monitoring and subsequent post-construction noise monitoring. In particular, Mr Huson is critical of the available wind speed locations on the basis that these locations would be affected by the wake of the wind turbines in the future.

15.7 In making this point, Mr Huson suggests that a wind speed measurement location *must be chosen such that it will not become wake affected by the subsequent construction of the wind farm.*

15.8 This statement is not consistent with Section 7.3.3 of NZS 6808 which states:

> *The same location and height should be used for the wind measurements before and after installation provided the wind at this position is not likely to be affected by the turbines.* […] *Where it is not certain that the original wind speed measurement position will be unaffected by the turbines, another position (unaffected by the turbines) should be selected for the post-installation measurements and, prior to installation of the wind farm, simultaneous wind speed measurements should be made at the two locations. the relationship between the wind speeds at the two positions will allow the post-installation measurements to be referenced to the same wind speeds as background measurements.*

15.9 NZS 6808 therefore acknowledges the potential for situations in which it may not be possible to select a wind speed measurement location that will not be wake affected after construction of the wind turbines. This is a common occurrence and post-construction noise assessments normally involve the use of wind speed data from multiple alternative locations to determine a wake-free wind speed at the original mast location.

High amenity area noise limit

15.10 The evidence of Mr Huson expresses opinions about the method used in the MDA Report to determine whether a high amenity area noise limit is applicable to the Project.

15.11 Mr Huson criticises that the assessment is based on the Victorian Planning Guidelines which recommends referring to the Cherry Tree Wind Farm Decision to inform the assessment of high amenity in Victoria. In this respect, Mr Huson suggests that alternative guidance from the Palmerston North Decision (concerning a wind farm in New Zealand), dated August 2016, should be used an alternative basis as it is more recent that the Cherry Tree Wind Farm Decision. However, the Victorian Planning Guidelines were updated in July 2021 and continue to refer to the Cherry Tree Wind Farm Decision as the applicable guidance that is specific to the Victorian context.

15.12 Based on the Cherry Tree Wind Farm Decision, the high amenity area noise limit does not warrant consideration for receivers located within land designated as Farming Zone.

15.13 As detailed in Section 8.5, applicability of the high amenity area noise limit is first and foremost a planning consideration, based on the land zoning of receivers within the predicted 35 dB L_{A90} noise contour.

15.14 Based on the findings detailed in Section 6.1.1 of the MDA Report, a high amenity area noise limit was not found to be justified for the proposed layout and candidate turbine models.

15.15 Further Mr Huson infers that the assessment approach used for the Delburn Wind Farm differs from the approach recommended by MDA as part of a peer-review for another wind farm. The approach adopted by MDA in both cases is consistent. Specifically, in both cases, the assessment approach recommended and adopted by MDA is based on NZS 6808 and identifies receivers where high amenity area noise limits may warrant consideration by using predicted noise levels at the hub height wind speed that results in the highest noise emissions.

15.16 The important point of distinction that does not appear to have been recognised in Mr Huson's comments is that the predicted noise levels presented in Table 13 of the MDA Report were provided for the hub height wind speed of 6 m/s, corresponding to the upper range of wind speeds which NZS 6808 recommends the high amenity area noise limit should apply (i.e. the wind speed range that the NZS 6808 high amenity area noise limits are intended to apply to is different from the wind speed range that needs to be considered initially when identifying the locations where the high amenity area noise limits may warrant consideration).

15.17 NZS 6808 states that alternative upper range wind speed values may be applied but also notes in Clause C5.3.2 that:

> *Wind farm wind speeds of 6 m/s and lower would generally coincide with the periods of the lowest background sound levels at the noise sensitive locations.*

15.18 The background noise monitoring results referenced in the MDA Report are consistent with the guidance of Clause C5.3.2 of NZS 6808, indicating that the trend of background noise is typically at its lowest below 6 m/s.

Noise modelling parameters

15.19 The evidence of Mr Huson expresses opinions about the limitations of the noise predictions presented in the MDA Report, in particular stating that the noise model inputs from the UK Institute of Acoustics guidance are not considered appropriate in Australia.

15.20 However, it is my view that his opinions are based on incorrect interpretations of the literature referenced in his evidence. The concerns relate to the use of the International Standard ISO 9613 and the effect of ground conditions and terrain profiles.

15.21 It is not clear from Mr Huson's evidence what alternative prediction method should be used for predicting wind farm noise levels, considering that it is specifically referenced in NZS 6808 and is the only method recommended in the UK Institute of Acoustics guidance.

15.22 Mr Huson incorrectly suggest that the 2012 Evans & Cooper paper[6] contradicts the method used in the MDA assessment.

15.23 The 2012 Evans & Cooper paper does note that the ISO 9613-2 method must be used with caution:

> *ISO 9613-2 method with 50% absorptive ground, can under predict noise levels in some situations and should only be used with caution.*

15.24 However, it is important to define the situations that are being referred to in the paper, and what is being referred to when the paper suggests that the method should be used with caution:

- The situations referred to are sites where the ground profile between a turbine and a receiver is characterised by a steep concave ground profile. The cautious approach to this type of situation is to apply a correction to the predictions. This point is acknowledged and addressed in a range of international publications including the UK Institute of Acoustics guidance. It is for this reason that the noise modelling presented in the MDA Report includes an addition of +3 dB to the predicted noise level for any turbine and receiver pair where steep concave ground is identified in the model, consistent with the UK Institute of Acoustics guidance and the findings of the 2012 Evans & Cooper paper
- The modelling referred to in the 2012 Evans & Cooper paper is based on directly measured sound power levels without the application of uncertainty values. The paper specifically notes that manufacturer data usually includes margins for guarantees, and that the inclusion of such margins would increase the likelihood of over prediction of noise levels in practice. As detailed in the MDA Report and Section 8.15, the manufacturer's emission data has been increased by the addition of +1 dB to provide a cautious approach.

  It is noted that the UK Institute of Acoustics guidance recommends a margin for uncertainty of 1-2 dB be added to specification sound power data. Based on the results of compliance monitoring by MDA at a large number of wind farm sites and monitoring locations, a value of 1 dB is considered suitable

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6 *Comparison of Predicted and Measured Wind Farm Noise Levels and Implications for Assessments of New Wind Farms*, T. Evans and J. Cooper, Acoustics Australia Journal, Volume 40 April 2012

- The situations referred to in the 2012 Evans & Cooper paper are sites where compliance assessments are conducted in accordance with the South Australian EPA guidelines. The paper then goes on to specifically note that the SA EPA guidelines yield different outcomes to NZS 6808, noting the following in relation to all of the prediction methods considered in the paper (which includes ISO 9613-2 and G = 0.5):

  for wind farms assessed under NZS 6808:1998 and NZS 6808:2010, under-prediction appears unlikely even in the case of a concave slope. Similarly, where the topography is relatively flat around a wind farm or there is a steady downward slope between turbines on a hill and receivers below, the prediction methods considered in this paper would be expected to result in larger over-predictions than shown in Table 2

15.25 In addition to the above, the findings in the 2012 Evans & Cooper paper are equivalent to those of a 2011 Evans & Cooper paper[7] which is directly referenced by the UK Institute of Acoustics guidance, among other studies, to support the use of ISO 9613-2 and G = 0.5. However, Mr Huson's interpretation of the reference paper contrasts with that of the UK Institute of Acoustics guidance which actually refers to the work of Evans & Cooper as supporting evidence when recommending the use of ISO 9613 and G = 0.5 with appropriate adjustments for site terrain.

15.26 Mr Huson also notes that the UK Institute of Acoustics guidance refers to predictions made at receiver heights of 4 m when using G = 0.5. Predictions in Australia are generally based on a lower height of 1.5 m which results in lower noise levels.

15.27 However, conversely, an important point of difference between predictions done in accordance with NZS 6808 and the UK Institute of Acoustics guidance is that the latter recommends subtracting a margin to account for differences between L_{Aeq} and L_{A90} noise levels. However, NZS 6808 specifies that predicted L_{Aeq} levels should be taken as the predicted L_{A90} sound level of the wind farm. The magnitude of differences from these factors is comparable and therefore balance each other out to provide similar predicted noise levels.

Wake effect and turbulence intensity

15.28 The evidence of Mr Huson expresses opinions about potential effects from wake effect and turbulence intensity on wind farm noise levels predicted at receivers.

15.29 Turbine wake effects are an important consideration for wind farm layout designers to factor into the arrangement and spacing of proposed turbine locations. Specifically, I understand that wake effects can potentially reduce the efficiency and reliability of the turbines; turbine locations and spacings are therefore chosen to reduce these effects.

15.30 To predict the wind turbine noise levels detailed in the MDA Report, it has been assumed that all of the wind turbines simultaneously experience the same inflow wind speed. Subsequently, it has been assumed that all turbines simultaneously emit sound power levels that are equivalent to the manufacturer's data. This method is consistent with NZ 6808, and is accepted international practice for the prediction of operational wind turbine noise levels.

[7] *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*, T. Evans and J. Cooper, Paper Number 30, Proceedings of Acoustics 2011, Gold Coast Australia

15.31 In practice, wind speeds across the wind farm will inevitably vary, and the inflow air conditions at each turbine location will vary from the conditions in which the manufacturer's sound power data was derived. These variations may lead to changes in the sound emission characteristics of the turbines. For example, an increase in air turbulence as a result of terrain, atmospheric conditions or upwind turbines can potentially give rise to an increase in the sound emission characteristics of an individual turbine when compared to the manufacturer's data for a particular inflow wind speed. Conversely, the effect of upwind turbines can result in reduced wind speed at the downwind turbines compared to the assumed wind speed across the wind farm. This in turn may lower the sound emission characteristics of an individual turbine compared to the assumed value.

15.32 In considering the implications of these variations in conditions across a wind farm layout, the key point to note is that the predicted noise levels at receivers are the result of the combined influence of a number of turbines. The types of variations described above are unlikely to equally apply simultaneously to all of the turbines. In practice, some of the wind turbines would experience wind conditions which result in a slight increase above the assumed sound power level, while others would experience wind conditions which result in a slight reduction below the assumed sound power level. Accordingly, a change in the emission characteristic of any individual turbine would therefore generally not give rise to an equivalent change in the total operational noise level of the wind farm. Specifically, the balance of slight increases and decreases in turbine emissions across the wind farm reduces the likelihood of variations of any individual turbine's emissions translating to an equivalent variation in the total combined noise level of the wind farm.

15.33 While there is no precise method or recommended procedure to evaluate the likelihood or magnitude of these types of effects on individual turbine emissions, post-construction measurements of operational wind farms have consistently demonstrated that the assumptions of constant wind speed and manufacturer's sound power data provides a reliable basis for estimating total operational wind farm noise levels. An example of this type of study[8], which considered the effect of variations in wind conditions across a commercial scale wind farm layout, indicated that the effect of reduced wind speed at turbines located downwind of other turbines tended to reduce the total noise levels at downwind receptor locations, noting:

> *The findings have also shown that the assumption of a single wind speed reference for all turbines that form a large wind farm site may overestimate the actual wind speed seen by each individual turbine. This is particularly the case for the turbines nearest to a location of interest which may be partly shielded by the furthest upwind turbines which experience uninterrupted (by the wind farm) and higher wind speed conditions. This means that a single wind speed reference will likely overestimate the sound emissions of the turbines nearest to a location of interest. This effect appears to be most significant at higher wind speeds for the sites studied.*

15.34 Further, a paper[9] presented at Inter-noise in 2014 by Cooper et al., investigating the accuracy of wind turbine noise predictions under non-standard meteorological conditions concluded:

> *The excellent agreement between predicted and measured noise levels at this site despite the significant wake induced turbulence suggests that turbulence is of negligible importance to A-weighted noise levels at receivers.*

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8 *Wind Farm Noise Predictions and Comparison with Measurements*, A. Bullmore, J. Adcock, M. Cand, M. Jiggins, Third International Meeting on Wind Turbine Noise, Denmark 2009

9 *Influence of non-standard atmospheric conditions on turbine noise levels near wind farms*, J. Cooper, T. Evans, V, Alamshah, Inter-noise, Melbourne 2014

15.35 The evidence of Mr Huson focuses on the aspect of wake effects which give rise to variations on site which may increase the emissions of the turbines, based on theoretical studies. As per the discussion above, wake effects can result in increased noise emissions of individual turbines, but wake effects also result in reduced wind speeds at the downwind turbines that most strongly influence the noise levels at downwind receivers.

Uncertainty

15.36 The wind turbine noise levels that occur in practice are inherently variable and depend on a range of factors such as hub height wind speed and direction, other atmospheric conditions related to sound propagation, and the difference in wind speeds across the turbines. These variations translate to differences between the predicted noise levels and the actual noise levels that occur in a set of conditions occurring over a measurement survey.

15.37 This uncertainty is commonly addressed in one of two ways.

One approach is to adopt a prediction method which yields typical values without any account for uncertainty in the selection of input parameters; uncertainty is then considered and applied to the resulting predicted noise level.

The alternative approach more commonly adopted, and used in the MDA Report, is to address uncertainty by adopting a cautious but balanced approach to selecting modelling input parameters accounting for uncertainty; the uncertainty is therefore inherently addressed in the modelling by determining predicted noise levels expected to represent the typical upper range of values that occur in practice.

For example, the following conservative modelling inputs were adopted:

- the ground factor of G = 0.5 is selected in lieu of G = 1.0, in strict accordance with ISO 9613-2 for *farming land*;
- all turbines simultaneously emitting sound power levels higher than the manufacturer's specification values; and
- each receiver being simultaneously downwind from every turbine.

15.38 This approach has been used consistently by MDA for wind farm developments throughout Australia. Post-construction noise measurements at multiple locations in the vicinity of over a dozen of these wind farms (including measurements that have been subject to independent peer review by third-party acoustic consultants and EPA accredited auditors) have demonstrated noise levels that are compliant with NZS 6808 and consistent the predicted noise levels determined using this modelling approach. The method has therefore been proven to provide an effective representation of typical upper levels that occur at receivers in practice, and supports the suitability of the method as a reliable basis for assessing new proposed wind farm developments.

15.39 Further, post-construction noise measurements carried out by MDA now routinely include measurements at intermediate locations positioned nearer to the wind turbines. Wind turbine noise levels at intermediate locations are higher, and background noise levels are generally lower (on account of their usually being less vegetation at these locations), so these locations provide an opportunity to obtain noise measurement data which is more representative of the noise emissions that are solely attributable to the operation of a wind farm. Importantly, these locations are much nearer to the wind turbines that are most likely to be influenced by wake effects; the measurements at these locations would therefore be much more likely to exhibit variations in noise levels if wake effects were leading to significant increases in wind turbine noise emissions. However, noise measurement results at these locations consistently show a very close agreement with the predicted noise levels (typically within 1 dB) using the approach adopted for the MDA Report. This measurement data provides further support for the validity and suitability of the noise modelling approach that has been consistently used by MDA for assessing new wind farm developments.

15.40 In contrast, Mr Huson provides an opinion that MDA's predictions would underestimate wind turbine noise levels in practice by referring to a combination of theoretical factors which would imply noise levels more than 10 dB above the predicted values. The levels of variation suggested by the theoretical factors referred to by Mr Huson have not been observed in the actual measured noise levels.

16.0 RESPONSE TO KEY SUBMISSIONS

16.1 I have reviewed key submissions that raise issues relating to noise that are specific to the Project.

16.2 The key issues raised in submissions, and my responses, are provided in Table 5.

Table 5: Response to key submissions

Issue raised	Comment
Audibility of wind farm noise and increase in noise levels	As with any other type of infrastructure project, it is not feasible or practical to design new development to inaudible noise levels. The noise limits are therefore set at values that are intended to provide a balance between protecting the amenity of neighbouring noise sensitive locations and enabling the development of renewable sources of energy. Achieving compliance with the noise limits therefore means that operational wind turbine noise will be audible at some locations during certain periods. Attitudes and reactions to sound are highly variable, and will depend on a complex set of acoustic and non-acoustic factors (i.e. factors that are unrelated to sound level or character). This means that, irrespective of how low a noise limit is set, there will always be a residual risk that some individuals may find a noise annoying. However, compliance with the noise limits will result in noise levels that are deemed to be acceptable in policy terms by providing a reasonable level of amenity protection for the majority of people. Recent findings from Flinders University indicate that some sound characteristics associated with wind turbines can be audible at large distances from turbines, and more predominantly during the night period. These findings are plausible as wind turbine noise can be audible at low levels if background noise conditions are sufficiently low. In terms of potential increases in noise levels, the noise limits provided by NZS 6808 require 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 criteria 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. Additional information is provided in Appendix F.
Application of high amenity area noise limits	As detailed in Section 8.5, applicability of the high amenity area noise limit is first and foremost a planning consideration, based on land zoning of receivers within the predicted 35 dB L_{A90} noise contour. Based on the findings detailed in Section 6.1.1 of the MDA Report, a high amenity area noise limit was not found to be justified based on the proposed layout and candidate turbine models. As outlined in Section 11.0, the pre-construction noise assessment should include the following: • a specific acknowledgement that the area to the northwest of Boolarra that are zoned Rural Living Area are a high amenity area for the purposes of NZS 6808; and • an assessment as to whether the high amenity noise limit should apply to these areas and the appropriate threshold wind speed, based on the guidance in Clause C5.3.1 of NZS 6808.

Issue raised	Comment
Wind turbine size	The Project is proposed to consist of thirty-three (33) wind turbines with a maximum tip height of 250 m, a maximum rotor diameter of 180 m and a power output of up to 7 MW. I am not aware of any onshore wind turbine model being available with the maximum characteristics above. Therefore, as detailed in Section 6.2 of the MDA Report, candidate wind turbine models have been used to *assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of turbines being considered for the site.* Further, Section 6.3.1 of the MDA Report states: *Review of available sound power data for a range of turbine models has shown that there isn't a clear relationship between turbine size or power output and the noise emission characteristics of a given turbine model. In practice, the overall noise emissions of a turbine are dependent on a range of factors, including the turbine size and power output, and other important factors such as the blade design and rotational speed of the turbine. Therefore, while turbine sizes and power ratings of contemporary turbines have increased, the noise emissions of the turbines are comparable to, or lower than, previous generations of turbines as a result of design improvements (notably, measures to reduce the speed of rotation of the turbines, and enhanced blade design features such as serrations for noise control).* As outlined in Section 11.0, a noise assessment based on the final turbine selection and layout is recommended to be prepared prior to construction of the wind farm, demonstrating compliance with the applicable noise limits at surrounding receivers.
Noise levels at nearby schools	As detailed in Section 5.10, NZS 6808 requires that the noise assessment be undertaken at all noise sensitive locations in the vicinity of the proposed wind farm which it defines as follows: *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site.* Noise sensitive locations therefore include schools located in the vicinity of the Project. The nearest school to the Project is the Narracan Primary School, located approximately 2.5 km from the nearest proposed wind turbine and referenced as Receiver 1261 in the MDA Report. Noise levels from the Project at the nearby schools are predicted to comply with the applicable NZS 6808 base noise limit of 40 dB L_{A90} by at least 14 dB.
Vibration	Vibration levels from wind turbines are well below perception thresholds at receivers. Additional information is provided in Appendix G.
Infrasound	Section 5.5.1 of NZS 6808 states that *although wind turbines may produce some sound at (ultrasound and infrasound) frequencies considered to be outside the normal range of human hearing these components will be well below the threshold of human perception.* Additional information is provided in Appendix G.

17.0 DECLARATION

17.1 I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Planning Panel.

Signed ....

Dated 2 October 2021

APPENDIX A QUALIFICATIONS

Qualifications

M.Eng – Masters' Degree in Engineering (French Equivalent), France 2001

Professional associations

MAAS – Member of the Australian Acoustical Society

Member of the Association of Australian Acoustical Consultants (AAAC) Wind Farm Subcommittee

Employment history and achievements

2017- Present	Co-CEO Marshall Day Acoustics Pty Ltd, Melbourne, Australia. Consultants in acoustics and noise control.
2002- 2017	Associate Marshall Day Acoustics Pty Ltd, Melbourne, Australia. Responsibilities include consulting work in industrial noise control and environmental noise impact, including wind farms. Noise assessments of wind farm developments: Alberton, Allendale, Bald Hills, Berrimal, Berrybank, Ceres, Challicum Hills, Chepstowe, Collector, Coonooer Bridge, Coopers Gap, Coppabella, Crowlands, Delburn, Diapur (Nhill), Dundonnell, Ferguson, Flinders Island, Golden Plains, Granville Harbour, Gullen Range, Hawkesdale, Hexham, High Road, Jung, Kiata, Lal Lal, Hepburn, Lincoln Gap, Low Head, Macintyre / Karara, Maroona, Moorabool, Mortlake South, Mt Emerald, Mt Fyans, Mt Gellibrand, Mt Mercer, Musselroe, Newfield, Oakland Hill, Port Latta, Portland, Rangoon, Rifle Butts, Robertstown, Rugby, Ryan Corner, Sidonia Hills, St Patricks Plains, Stockyard Hill, Stony Gap, Timboon West, Waterloo 2, Waubra, Western Plains, Wimmera Plains, Winchelsea, Wonthaggi, Yaloak South, Yawong Post-construction noise assessment of wind farm developments: Bald Hills, Challicum Hills, Chepstowe, Collector, Coonooer Bridge, Crowlands, Granville Harbour, Gullen Range, Gunning, Kiata, Hepburn, Maroona, Mt Emerald, Mt Mercer, Murra Warra, Portland, Waterloo, Waubra, Studland Bay
2001	Vacation Employment Marshall Day Acoustics Pty Ltd, Melbourne, Australia

APPENDIX B ERRATUM

Due to a transcription error, the wind turbine coordinates presented in Appendix C of the MDA Report did not reflect the wind turbine layout (reference 3.4), supplied by the proponent on 5 May 2020.

I confirm that the correct wind turbine coordinates, presented in Table 6 for completeness, were used for the assessment presented in the MDA report, as reflected in the site layout figures and noise contour maps.

Table 6: Turbine coordinates – MGA 94 zone 55

Turbine	Easting, m	Northing, m	Terrain elevation, m
T01	437,223	5,764,842	206
T02	436,464	5,764,422	237
T03	436,525	5,765,561	272
T04	435,819	5,765,128	300
T05	435,296	5,764,592	299
T06	435,648	5,763,965	227
T07	435,562	5,762,911	212
T08	436,508	5,761,045	178
T09	436,574	5,760,048	215
T10	435,933	5,759,594	231
T11	435,580	5,758,395	250
T12	436,043	5,758,962	241
T13	436,975	5,758,811	202
T14	437,368	5,759,666	190
T15	437,301	5,760,459	176
T16	437,789	5,761,008	177
T17	436,184	5,757,839	204
T18	437,039	5,758,139	179
T19	436,935	5,757,281	189
T20	435,123	5,757,829	259
T21	434,250	5,757,623	222
T22	434,458	5,758,419	210
T23	435,046	5,758,935	220
T24	433,800	5,760,517	243
T25	434,294	5,759,876	200
T26	434,761	5,760,476	203
T27	434,768	5,757,077	257
T28	434,290	5,756,512	258
T29	435,818	5,755,871	175
T30	433,871	5,755,768	242
T31	433,005	5,755,169	216
T32	433,276	5,754,264	188
T33	432,628	5,753,703	184

APPENDIX C DOCUMENTS TAKEN INTO ACCOUNT

I have reviewed the following documents to the extent necessary to inform the environmental noise assessment detailed in the MDA Report and this statement of evidence:

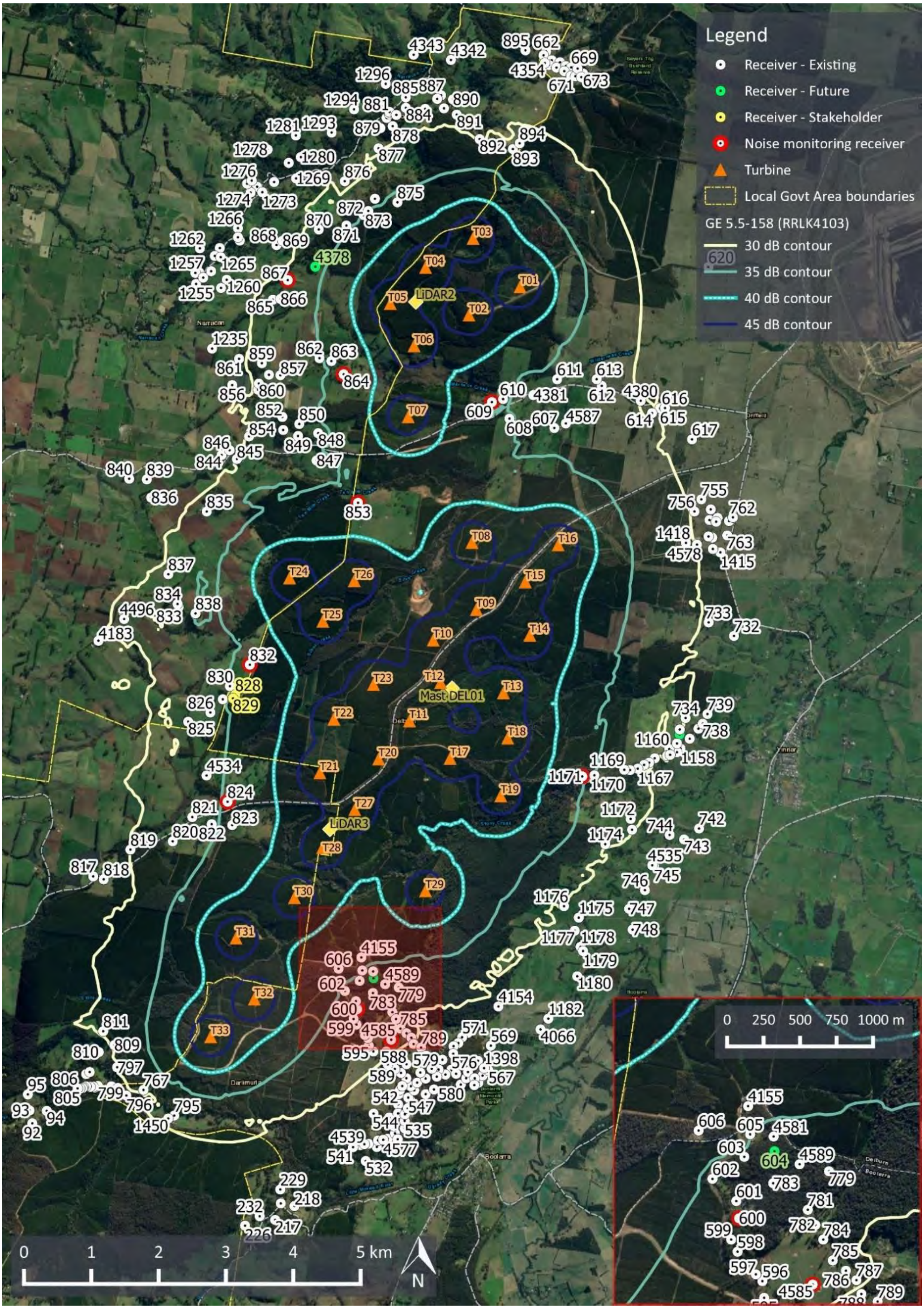
- MDA report Rp 003 R01 20190463 *Delburn Wind Farm - Environmental Noise Assessment* dated 26 January 2021 (the MDA Report)
- *Environment Protection Act 2017* (the Act)
- *Environment Protection Regulations 2021* (the Regulations)
- Victorian Department of Environment, Land, Water and Planning Development of *Wind Energy Facilities in Victoria - Policy and Planning Guidelines* dated March 2019 (the 2019 Victorian Wind Energy Guidelines)
- 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)
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808)
- EPA Publication 1254 *Noise Control Guidelines* (EPA Publication 1254)
- EPA publication 1411 *Noise from Industry in Regional Victoria – Recommended maximum noise levels from commerce, industry and trade premises in regional Victoria* (NIRV)
- 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)
- EPA Publication 1834 *Civil construction, building and demolition guide* (EPA Publication 1834)
- 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)
- Australian Standard AS 60076-10:2009 *Power transformers – Determination of sound levels* (AS 60076-10:2009)
- ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation (ISO 9613-2:1996)
- Vestas document No. 0079-5298_V01 *V162-5_6MW Third Octaves*, dated 23 January 2019
- GE Renewable Energy document *Technical Documentation Wind Turbine Generator Systems 5.3/5.5-158 - 50 Hz - Product Acoustic Specifications Normal Operation according to IEC Incl. Octave and 1/3rd Octave Band Spectra* dated 2019
- Siemens Gamesa Renewable Energy document No. D2359593/002 *Standard Acoustic Emission, Rev. 0, AM 0 - AM-6, N1 - N7 - SG 6.0-170* dated 27 February 2020
- *EES Inquiry and Planning Permit Application Panel Report - Golden Plains Wind Farm* dated 26 September 2018 (Golden Plains Panel Report)
- Sonus Pty Ltd report S6049C6 *Delburn Wind Farm - Peer review of noise assessment*, dated 22 October 2020 (the peer review)
- Senversa Pty Ltd report *Environmental Noise Assessment Audit*, dated 5 May 2021 (the audit)
- Expert witness statement of William Leslie Huson, dated 16 August 2021 (the Huson Statement)
- Statements of grounds from objectors.

APPENDIX D GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion 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}
Decibel	The unit of sound level.	dB
Effective noise level	The effective noise level of commercial or industrial noise determined in accordance with the Noise Protocol. This is the L_{Aeq} noise level over a half-hour period, adjusted for the character of the noise. Adjustments are made for tonality, intermittency and impulsiveness.	L_{eff}
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special Audible Characterises	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 E NOISE CONTOUR MAP (GE -5.5-158)



APPENDIX F EFFECTS OF WIND FARM NOISE

Sound is an important feature of the environment in which we live; it provides information about our surroundings and is a key influence on our overall perception of amenity and environmental quality. Sound is therefore an environmental quality that must be considered as part of any proposal to develop new infrastructure that could influence the sound environment of neighbouring communities.

Excessive or unwanted sound is commonly referred to as noise and can have a range of effects on people, depending on a range of physical and contextual factors. The *Guidelines for Community Noise* 1999 prepared by the World Health Organisation (WHO) provides a health-based framework of guideline limits and values to address the broad definition of health given as:

> *A state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity*

This broad definition means that effects ranging from community annoyance, sleep disturbance and speech interference, through to direct physiological impacts such as hearing damage, are all identified as potential health considerations. An important aspect of this range of considerations is that some effects will be highly dependent on the listener's perception and attitude to the noise in question, such as annoyance, while other effects are primarily related to the level of sound and the direct physiological risks these may represent, such as hearing damage.

Environmental noise policies, including those applied to wind farms, establish objective noise criteria to address these health considerations. In particular, environmental noise policies define criteria which are chosen to prevent direct physiological risks of sound, and minimise as far as practically possible adverse health considerations such as annoyance and sleep disturbance.

Practically minimising the risks of noise effects related to annoyance and sleep disturbance requires the potential range of responses to sound to be considered. In this respect, it is important to note that individual attitudes and reactions to sound are highly variable, and will depend on a complex set of acoustic and non-acoustic factors. These include the level and character of the sound in question, the time of day the sound occurs, the regularity of the sound, the environment in which the sound is heard, the individuals hearing acuity, and an individual's personal opinion and perception of the sound source or development in question. The latter will in turn depend on other complicating factors such as visual impressions of the source in question and the perceived community benefit, or otherwise, of the source in question.

Due to the complexity and range of potential responses to sound, it is not possible to define limits that will guarantee an audible sound will be acceptable to all individuals; this will always be a matter of personal judgement for each individual. Further, it is usually not feasible or practical to design new development or infrastructure to inaudible noise levels. As a result, minimising the risks of noise effects involves setting criteria which prevents the majority of people from being disturbed. This requires regulatory authorities to strike a balance between amenity and development, setting noise limits which are as stringent as can be practically achieved without preventing new development.

In recognition of this, the Foreword of NZS 6808 states:

> *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.*

This type of approach to noise policy was outlined by the Victorian Department of Health in their 2013 publication on wind farm sound and health which states:

> *Noise standards are used not only for environmental noise (such as wind farms and traffic noise) but also for industry and even household appliances.*
>
> *Noise standards are set to protect the majority of people from annoyance. The wide individual variation in response to noise makes it unrealistic to set standards that will protect everyone from annoyance. A minority of people may still experience annoyance even at sound levels that meet the standard. This is the case not only for wind farms, but for all sources of noise.*

The subject of health effects related to operational wind farms in Australia has been extensively considered by the Commonwealth Government's National Health and Medical Research Council (NHMRC) and the Australian Medical Association; in particular, the NHMRC has undertaken and coordinated a systematic review of evidence related to wind farms and health. The research reviews[10] and public statements[11, 12] produced by these peak health bodies support that, as with any audible sound, wind farm noise can represent a potential source of annoyance or sleep disturbance for some individuals. Their findings did however indicate that there was no reliable evidence to support a relationship between wind farm noise and direct adverse effects on human health.

In July 2012, Health Canada undertook a large-scale epidemiology study in response to community health concerns expressed in relation to wind turbines. The following conclusions[13] were made from this research.

> *The following were not found to be associated with* [Wind Turbine Noise] *exposure:*
>
> - *self-reported sleep (e.g., general disturbance, use of sleep medication, diagnosed sleep disorders);*
> - *self-reported illnesses (e.g., dizziness, tinnitus, prevalence of frequent migraines and headaches) and chronic health conditions (e.g., heart disease, high blood pressure and diabetes); and*
> - *self-reported perceived stress and quality of life.*
>
> *While some individuals reported some of the health conditions above, the prevalence was not found to change in relation to* [Wind Turbine Noise] *levels.*
>
> [...]
>
> *The following was found to be statistically associated with increasing levels of* [Wind Turbine Noise]*:*
>
> - *annoyance towards several wind turbine features (i.e. noise, shadow flicker, blinking lights, vibrations, and visual impacts).*

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10 *Systematic review of the human health effects of wind farms* 2013, Adelaide University, commissioned by the NMRC

11 *NHMRC Statement: Evidence on Wind Farms and Human Health*, dated February 2015, National Health and Medical Research Council

12 AMA Position Statement – *Wind Farms and Health* 2014, Australian Medical Association

13 https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/everyday-things-emit-radiation/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html

In 2018, the World Health Organization released the *Environmental Noise Guidelines for the European Region*[14] which concluded:

> *In accordance with the prioritization process, the GDG set a guideline exposure level of 45.0 dB L_{den} for average exposure, based on the relevant increase of the absolute %HA. The GDG stressed that there might be an increased risk for annoyance below this noise exposure level, but it could not state whether there was an increased risk for the other health outcomes below this level owing to a lack of evidence. As the evidence on the adverse effects of wind turbine noise was rated low quality, the GDG made the recommendation conditional.*
>
> [...]
>
> *Based on the low quantity and heterogeneous nature of the evidence, the GDG was not able to formulate a recommendation addressing sleep disturbance due to wind turbine noise at night time.*

As detailed in the MDA paper *WHO Environmental Noise Guidelines for the European Region: conditional recommendation for wind turbine noise in the context of Australian regulations*[15], achieving compliance with NZS 6808 corresponds to noise levels that are consistent with the recommendations of the 2018 WHO European Noise Guidelines.

These findings lend support to the suitability of the wind farm noise controls applied in Victoria, which are intended to provide reasonable protection of health and amenity at noise sensitive locations. This is consistent with the objectives of NZS 6808 discussed in Section 3.2.1 of the MDA Report. Importantly, the Standard notes that the consensus view of the committee responsible for the development of NZS 6808, including New Zealand representatives from the Ministry of Health and Institute of Environmental Health, was that the Standard provides a reasonable way of protecting health and amenity at nearby noise sensitive locations, without unreasonably restricting the development of wind farms.

Further discussions of specific noise considerations related low-frequency sound and infrasound are provided in Appendix G.

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14 https://www.euro.who.int/en/health-topics/environment-and-health/noise/environmental-noise-guidelines-for-the-european-region

15 *WHO Environmental Noise Guidelines for the European Region: conditional recommendation for wind turbine noise in the context of Australian regulations*, J. Adcock,C. Delaire, 8th International Conference on Wind Turbine Noise, Lisbon 2019 http://tinyurl.com/WTN2019-Delaire

APPENDIX G LOW FREQUENCY NOISE, INFRASOUND AND GROUND VIBRATION

The limits adopted for the assessment of operational noise from wind farms represent relatively low levels which have been specified in recognition of the quieter rural environments in which wind farms are normally located.

However, consistent with noise policies applied to other forms of development, the criteria are not intended to restrict wind farm noise to inaudible levels. Accordingly, a wind farm which achieves compliance with the criteria may still be audible at surrounding receiver locations on some occasions; this will depend on a range of factors such as the time of day, the speed and direction of the wind, the proximity to turbines, the extent of vegetation around the dwelling, and the degree to which the dwelling is sheltered from prevailing wind conditions. Irrespective of the relatively low levels which operational wind farm noise is restricted to, an individual’s judgement of the audible noise from a wind farm is highly subjective and will be influenced by a range of contextual factors.

The subject of wind farm noise and its characteristics has attracted considerable attention. Specific attention has been directed to alleged matters relating to low frequency sound as well as infrasound and vibration. Low frequency sounds are generally regarded as sounds above 20 Hz and extending upwards into the range of 100-200 Hz. The definition of infrasound often varies in different jurisdictions, but is generally accepted to refer to frequencies of sound which lie below 20 Hz. While 20 Hz is commonly cited as the lower bound of audibility, frequencies below 20 Hz can still be audible, provided that the level of the sound is sufficiently high to exceed the threshold of audibility at those frequencies.

In common with many other sources of noise, wind turbines emit infrasound, low frequency sound and ground vibrations. However, what is often overlooked is that these types of sound and vibration are a feature of the everyday environment in which we live and arise from a wide range of natural sources such as the wind and the ocean to man-made sources such as domestic appliances, transportation and agricultural equipment. The important point in relation to wind turbines is that the levels of these types of emissions are low and therefore, in many cases, cannot generally be reliably measured amidst normal background levels.

NZS 6808 provides specific advice concerning infrasound at Section 5.5 noting:

> *Although wind turbines may produce some sound at (ultrasound and infrasound) frequencies outside the normal range of human hearing these components will be well below the threshold of human perception.*
>
> *Claims have been made that low frequency sound and vibration from wind turbines have caused illness and other adverse physiological effects among a very few people worldwide living near wind farms. The paucity of evidence does not justify at this stage, any attempt to set a precautionary limit more stringent than those recommend [in the Standard].*

These types of emissions have been the subject of considerable misrepresentation in media commentary. Notably, the work of Dr Geoff Leventhall, a prominent UK consultant in the field of acoustics and vibration, and researcher in the field of low frequency noise is often cited in some documents which continue to claim concerns about infrasound and low frequency noise from wind turbines. However, Dr Leventhall has regularly made clear statements to assert that there is no significant infrasound from current designs of wind turbines and very little low frequency sound, neither of which are anywhere near the sorts of levels which would represent a direct health risk for neighbouring residents of modern wind farms. An example such publication, co-authored by Dr Leventhall, was published in the UK Institute of Acoustics Bulletin in March 2009[16].

[16] Institute of Acoustics Bulletin – Bowdler, Bullmore, Davis, Hayes, Jiggins, Leventhall, McKenzie - *Prediction and Assessment of Wind Turbine Noise* –March 2009

This publication was prepared as an agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed by local councils and community groups campaigning against wind farm developments. The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern.

On the subject of infrasound and low frequency noise, the article notes:

> *Infrasound is the term generally used to describe sound at frequencies below 20Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles. Sounds at frequencies from about 20Hz to 200Hz are conventionally referred to as low frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view.*
>
> *A Portuguese group has been researching 'Vibro-acoustic Disease' (VAD) for about 25 years. Their research initially focussed on aircraft technicians who were exposed to very high overall noise levels, typically over 120dB. A range of health problems has been described for the technicians, which the researchers linked to high levels of low frequency noise exposure. However other research has not confirmed this. Wind farms expose people to sound pressure levels orders of magnitude less than the noise levels to which the aircraft technicians were exposed. The Portuguese VAD group has not produced evidence to support their new hypothesis that infrasound and low frequency noise from wind turbines causes similar health effects to those experienced by the aircraft technicians.*

Another example of the misrepresentations made in relation to the environmental effects of wind turbines centred around work carried out by Keele University in the UK on ground vibration. Professor Peter Styles and his team at Keele University undertook a study of the effects of wind turbines on the seismic detection array at Eskdalemuir, Scotland. The results of this work were widely misinterpreted and resulted in a statement[17] from Professor Styles:

> *We are writing to clarify some misconceptions [...] about wind farm noise. Whilst it is technically correct that 'vibrations can be picked up as far away as 10km', to give the impression that they can be felt at this distance is highly misleading. The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect. The Dunlaw study was designed to measure effects of extremely low level vibration on one of the quietest sites (Eskdalemuir) in the world, and one which houses one of the most sensitive seismic installations in the world. Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health. It is, however, an issue for the Eskdalemuir seismic array, as it can detect this level of vibration. It is designed to detect explosions and earthquakes of a low magnitude from all over the world. The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect the low frequency sound. There is no scientific evidence to suggest that infrasound has an impact on human health.*

[17] *Keele University Rejects Renewable Energy Foundation's Low Frequency Noise Research Claims*

Further measurements[18, 19] have demonstrated that infrasound and low frequency sound produced by regularly encountered natural and man-made sources, such as the infrasound produced by the wind or distant traffic, is comparable to that of modern wind turbines, noting that:

> *Infrasound levels in the rural environment appear to be controlled by localised wind conditions. During low wind periods, levels as low as 40dB(G) were measured at locations both near to and away from wind turbines. At higher wind speeds, infrasound levels of 50 to 70dB(G) were common at both wind farm and non-wind farm sites.*
>
> *Organised shutdowns of the wind farms adjacent to* [measurement locations] *indicate that there did not appear to be any noticeable contribution from the wind farm to the G-weighted infrasound level measured at either house. This suggests that wind turbines are not a significant source of infrasound at houses located approximately 1.5 kilometres away from wind farm sites*

In 2010, the UK Health Protection Agency published a report[20] on the health effects of exposure to ultrasound and infrasound. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

> *Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*
>
> [...]
>
> *For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects.*

Also in 2010, State Government of Victorian Department of Health document[21] concludes the following in relation to infrasound from wind farms:

> *Infrasound is audible when the sound levels are high enough. The hearing threshold for infrasound is much higher than other frequencies. Infrasound from wind farms is at levels well below the hearing threshold and is therefore inaudible to neighbouring residents.*

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[18] Sonus report for Pacific Hydro - *Infrasound measurements from wind farms and other sources*, November 2010

[19] Evans, T., Cooper, J. & Lenchine, V., *Infrasound levels near wind farms and in other environments*, South Australian Environment Protection Authority, Adelaide, 2013

[20] Health Protection Agency UK – *Health Effects of Exposure to Ultrasound and Infrasound – Report of the independent Advisory Group on Non-ionising Radiation* - 2010

[21] *Public Statement: Wind Turbines and Health*, July 2010

In 2015, the National Health and Medical Research Council (NHMRC) released a report[22] addressing human health effects of wind farms which includes consideration of noise.

From 2,850 articles which were identified during the NHMRC review, eleven (11) studies across Europe, North America and Australia satisfied a set of pre-specified eligibility criteria for detailed review and therefore form the basis of the report, which concludes:

> *There is no consistent evidence that noise from wind turbines—whether estimated in models or using distance as a proxy—is associated with self-reported human health effects. Isolated associations may be due to confounding, bias or chance.*
>
> *There is consistent evidence that noise from wind turbines—whether estimated in models or using distance as a proxy—is associated with annoyance, and reasonable consistency that it is associated with sleep disturbance and poorer sleep quality and quality of life. However, it is unclear whether the observed associations are due to wind turbine noise or plausible confounders.*

The NHMRC subsequently issued a statement[23] based on this research which concluded:

> *After careful consideration and deliberation of the body of evidence, NHMRC concludes that there is currently no consistent evidence that wind farms cause adverse health effects in humans.*

The NSW *Noise Assessment Bulletin* issued in December 2016 refers to this advice and states the following in its section on Noise and Health:

> *High levels of noise are associated with adverse health outcomes. To examine this potential relationship the National Health and Medical Research Council (NHMRC) undertook a comprehensive assessment of the scientific evidence on wind farms and human health. In 2015, the NHMRC concluded that "there is no direct evidence that exposure to wind turbine noise affects physical or mental health", and there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans relating to infrasound. More specifically, they stated that, "while exposure to environmental noise is associated with health effects, these effects occur at much higher levels of noise than are likely to be perceived by people living in close proximity to wind farms in Australia".*

These studies all indicate that infrasound levels are anticipated to be comparable with existing ambient levels and, as such, are not expected to represent an impact from the proposed Delburn Wind Farm. Similarly, vibration levels from wind turbines are well below perception thresholds, and low frequency levels are typically low.

22 NHMRC *Systematic review of the human health effects of wind farms*, dated February 2015

23 *NHMRC Statement: Evidence on Wind Farms and Human Health*, dated February 2015, National Health and Medical Research Council