ST PATRICKS PLAINS WIND FARM
ENVIRONMENTAL NOISE ASSESSMENT

Rp 001 R05 20190433 | 2 May 2023

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Project: **ST PATRICKS PLAINS WIND FARM**
Environmental Noise Assessment

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Report No.: **Rp 001 R05 20190433**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	-	Issued to client	20 Oct. 2021	C. Delaire	J. Adcock
Complete	01	Revised noise limit (EPA update) and micro-sited layout	22 Apr. 2022	C. Delaire	A. Morabito / J. Adcock
Complete	02	Updated receiver status	15 Jun. 2022	C. Delaire	J. Adcock
Complete	03	Inclusion of blasting in the construction assessment	20 Dec. 2022	C. Delaire	J. Adcock
Complete	04	Change of status of Q13-1	25 Jan. 2023	C. Delaire	J. Adcock
Complete	05	Cross-references update	2 May 2023	C. Delaire	-

Certified System ISO 9001

EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with construction and operation of the St Patricks Plains Wind Farm that is proposed to be developed by Ark Energy Projects Pty Ltd.

The assessment is based on the proposed wind farm layout comprising up to forty-seven (47) multi-megawatt turbines and related infrastructure.

The planning application for the wind farm seeks permission to develop turbines with a maximum tip height of up to 240 m. The actual turbine which would be used at the site would be determined at a later stage in the project, after the project has been granted planning approval. The final selection would be based on a range of design requirements including achieving compliance with the planning permit noise limits at surrounding noise sensitive locations (receivers). In advance of a final selection, the assessment considers a candidate turbine model that is representative of the size and type of turbine which could be used at the site. For this purpose, the Vestas V162-6.2MW with a nominal hub height of 150 m and rotor diameter of 162 m, has been nominated by the proponent for this assessment.

The *Project Specific Guidelines for Preparing an Environmental Impact Statement for Epuron Projects Pty Ltd St Patricks Plains Wind Farm*, dated October 2019 (Project Specific Guidelines) include environmental noise assessment requirements, and specify that consideration be given to the Tasmanian EPA publication *Noise Measurement Procedures Manual* dated July 2008 and the following documents:

- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) specific to the assessment of operational noise associated with the proposed wind turbines; and
- The Tasmanian *Environment Protection Policy (Noise) 2009* (EPP) specific to the assessment of operational noise associated with the proposed related infrastructure.

The assessment considers operational wind turbine noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area, the results of the background noise monitoring survey undertaken between August and November 2020 at selected receivers surrounding the project, and an EPA Board Communiqué concerning the application of NZS 6808 to Tasmanian projects.

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

The noise emission data has been used with international standard ISO 9613-2[1] to predict the level of noise expected to occur at neighbouring receivers. The ISO 9613-2 standard has been applied based on well-established input choices and adjustments, from research and international guidance, that are specific to wind farm noise assessment.

The results of the noise predictions for the St Patricks Plains Wind Farm demonstrate that the predicted noise levels for the proposed turbine layout achieve the base (minimum) noise limits determined in accordance with NZS 6808 and EPA guidance at all neighbouring receivers.

[1] ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

The operational wind turbine noise limits apply to the total combined operational wind farm noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore also considered the operational Cattle Hill Wind Farm located approximately 10 km southwest of the St Patricks Plains Wind Farm. An assessment of the predicted noise levels for the Cattle Hill Wind Farm has demonstrated that cumulative wind farms noise levels do not affect the compliance outcomes for either of the two projects.

The assessment has also considered operational noise of related infrastructure associated with the wind farm, to be located within the site. Noise levels from the related infrastructure have been assessed in accordance with the EPP. The assessment demonstrates that the related infrastructure can be designed and operated to achieve the EPP acoustic environment indicator levels.

For the assessment of construction noise and vibration, the Tasmanian *Environmental Management and Pollution Control (Noise) Regulations 2016* provides a schedule when noise generating construction activities are permitted to occur, but it does not provide noise and vibration limits for construction activities.

Predicted noise levels have been calculated in general accordance with the methodology detailed in Australian Standard 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* and are provided to gauge the potential impact from construction activities at the nearest receivers. The predicted noise levels are typical of the range expected for the construction of a wind farm and are readily manageable with standard good practices.

In lieu of Tasmanian guidance for construction vibration, reference was made to the recommended minimum working distances documented in the NSW Roads and Maritime Service's publication *Construction Noise and Vibration Guideline* dated August 2016. The separating distances between between receivers and vibration generating construction plant were found to be significantly greater than recommended minimum working distances.

Following the guidance provided in the Tasmanian EPA *Quarry Code of Practice 3rd Edition*, dated May 2017, consideration was also given to potential blasting activities that may be required to prepare the foundations of the turbines. A high level assessment indicates that the controls needed to comply with the Quarry Code of Practice would need to be defined according to the characteristics of the site.

Noise and vibration associated with construction of the wind farm can therefore be managed by the adoption of best practice and considerate working practices. These measures should be documented in a construction noise management plan prepared for review and approval by the responsible authority prior to commencing the work. The plan should include dedicated blast management procedures if blasting is ultimately required.

The noise assessment therefore demonstrates that the proposed St Patricks Plains Wind Farm is able to be designed and developed to achieve the requirements for operational and construction noise from the Project Specific Guidelines issued by the Tasmanian Environment Protection Authority.

If the wind farm is approved for development, and consistent with current best practice and standard wind farm approval requirements, the noise modelling and assessments presented in this report would be updated to verify the final wind farm design and equipment selections.

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1.0 INTRODUCTION

Ark Energy Projects Pty Ltd[2] is proposing to develop a wind farm known as the St Patricks Plains Wind Farm within the Tasmanian Local Government Area of Central Highlands.

The St Patricks Plains Wind Farm is proposed to comprise up to forty-seven (47) wind turbines approximately 10 km southeast of the Miena township.

This report presents the results of an assessment of operational and construction noise for the proposed St Patricks Plains Wind Farm in accordance with the *Project Specific Guidelines for Preparing an Environmental Impact Statement for Epuron Projects Pty Ltd St Patricks Plains Wind Farm*, dated October 2019 (Project Specific Guidelines).

The assessment presented in this report is based on:

- Background noise data from surveys undertaken at selected receivers around the site;
- Operational noise limits determined in accordance with New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) and the Tasmanian *Environment Protection Policy (Noise) 2009* (EPP), accounting for local land zoning, background noise levels, and an EPA Board Communiqué concerning the application of NZS 6808 to Tasmanian projects;
- Predicted noise levels for the wind turbines, based on the proposed site layout and a candidate turbine model that is representative of the size and type of turbine that the planning application seeks consent for;
- Predicted noise levels for the proposed related infrastructure, based on empirical noise emission data; and
- A comparison of the predicted noise levels for different turbine models with the criteria derived in accordance with NZS 6808 and the EPP.

This report also includes an assessment of construction noise and vibration to provide an indication of the potential impact from construction activities at the nearest receivers, having regard to the Tasmanian *Environmental Management and Pollution Control (Noise) Regulations 2016*.

This report is to be read in conjunction with the Background Noise Report[3] which details the results of a survey of existing noise levels in the area around the wind farm.

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

2 Formerly Epuron Projects Pty Ltd

3 MDA Report Rp 002 20190433 *St Patricks Plains Wind Farm – Background noise monitoring report*, dated 20 Oct. 2021

2.0 PROJECT DESCRIPTION

The St Patricks Plains Wind Farm is proposed to comprise up to forty-seven (47) wind turbines. The coordinates of the proposed wind turbines are tabulated in Appendix B.

The proponent is seeking consent for a wind farm including wind turbines extending to a tip height of up to 240 m. The Vestas V162-6.2MW, with a rotor diameter of 162 m and a power output of 6.2 MW, has been selected as the candidate turbine model for this assessment. Further detail on the proposed candidate turbine model is presented in Section 6.2.

A total of twenty-five (25) noise sensitive locations (generally referred to as *receivers* herein) located within 3 km of the proposed turbines have been considered in this noise assessment, comprising:

- Three (3) host landholders and two (2) landholders where an agreement has been established with the proponent (subsequently referred to as *involved receivers* herein); and
- Twenty (20) non-involved receivers.

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the turbine layout and receivers is provided in Appendix D, including additional receivers that are not formally assessed in this report on account of being located further than 3 km from a proposed turbine.

3.0 RELEVANT POLICY

3.1 Project Specific Guidelines

The Tasmanian EPA issued the *Project Specific Guidelines for Preparing an Environmental Impact Statement for Epuron Projects Pty Ltd St Patricks Plains Wind Farm* in October 2019 (Project Specific Guidelines), which sets out requirements for the assessment of noise associated with the project.

Specifically, Section 6.4 of the Project Specific Guidelines requires the following:

> *Discuss impacts of the proposal on pre-existing noise levels (during both the construction and operational phases), including:*
>
> - *Identifying and describing all major sources of noise.*
> - *A map of the location(s) of all major sources of noise.*
> - *The potential for noise emissions (during both the construction and operational phases) to cause nuisance for nearby land users, particularly at noise sensitive premises.*[4]
>
> *Noise modelling is required. Noise assessment should follow the general requirements of section 17 of the Noise Measurement Procedures Manual, Second Edition July 2008. The noise assessment proposed in the Notice of Intent is supported.*

In addition to the Tasmanian EPA publication *Noise Measurement Procedures Manual*, dated July 2008, the Project Specific Guidelines also specify that the assessment should consider the following documents:

- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808); and
- The Tasmanian *Environment Protection Policy (Noise) 2009* (EPP).

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

3.2 Noise Measurement Procedure Manual

Section 17 of the Tasmanian EPA publication *Noise Measurement Procedures Manual* (NMPM), dated July 2008, addresses the measurement and assessment of wind turbine noise and notes that procedures are generally drawn from NZS 6808 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*, dated 1998.

However, the NMPM was published prior to the release of the updated version of NZS 6808 published in 2010. The NMPM also establishes the principle of referring to updated standards when listing Australian Standards, noting that it is best practice to use the current Standard unless otherwise specified.

Based on the above, and given that the measurement guidance presented in the NMPM is consistent with the requirements of the current version of NZS 6808, the current version of the standards is considered the applicable reference for the assessment.

[4] *'noise sensitive premise' is defined as: residences and residential zones (whether occupied or not), schools, hospitals, caravan parks and similar land uses involving the presence of individual people for extended periods, except in the course of their employment or for recreation.*

3.3 NZS 6808

NZS 6808 provides methods for the prediction, measurement, and assessment of sound from wind turbines. The following sections provide an overview of the objectives of NZS 6808 and the key elements of the standard's assessment procedures.

3.3.1 Objectives

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

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

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

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

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

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

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

3.3.2 Noise sensitive locations

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

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

This is consistent with the definition of *noise sensitive premise* detailed in the Project Specific Guidelines.

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

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

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

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

Based on the above definitions and statutory context, noise predictions are normally prepared for involved receivers irrespective of whether they are inside or outside of the boundary. However, the noise limits specified in the Standard are not applied to these locations on account of their participation with the project. Separate consideration is given to alternative guidance values for these locations, having regard to participating landowners both within and outside the site boundary, and participating neighbours outside the site boundary. In addition to consistency with NZS 6808 and its statutory context, this approach is also consistent with policy and guidance applied in other Australian states.

3.3.3 Noise limit

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

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

This arrangement of limits requires the noise associated with a wind farm to be restricted to a permissible margin above background noise, except in instances when both the background and source noise levels are low. In this respect, the 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.

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

The noise limits … should apply to the cumulative sound level of all wind farms affecting any noise sensitive location.

3.3.4 High amenity

Section 5.3.1 of NZS 6808 states that the base noise limit of 40 dB L_{A90} detailed in Section 3.3.3 above is "*appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations*.". It goes on to note that the application of a high amenity noise limit may require additional consideration:

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

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

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

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

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

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

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

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

3.3.5 Special audible characteristics

Section 5.4.2 of NZS 6808 requires the following:

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

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

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

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

3.4 EPA Board communiqué

During the impact assessment process, after the background noise monitoring had concluded, the proponent was made aware of a communiqué[5] by the EPA Board from Regular Meeting 140 which imposes a reduced NZS 6808 base noise limit of 35 dB L_{A90} for all new projects in Tasmania, including St Patricks Plains Wind Farm, irrespective of land zoning.

The relevant extract for the communiqué is reproduced below.

> ***Noise limits for wind energy projects***
>
> *A proposal to set a new noise limit for future wind energy projects was put to the Board in March. The Board requested further clarification on how the proposed new limit would apply to projects currently in the assessment process, which was provided to this meeting.*
>
> *The Board discussed and agreed to adopt as policy the proposed lower noise limit of 35 dB(A) at residences or land zoned for sensitive uses for new wind energy projects. This level is becoming the accepted standard elsewhere in Australia. The previous criterion for Tasmania was 40 dB(A), based on a New Zealand standard. The 35dB(A) criterion, or background + 5 dB(A), will now be Board policy for the assessment of new wind farm proposals. The Board agreed that the St Patricks Plains wind farm proposal was still in the early development stages and there should be adequate flexibility regarding turbine location to comply with this new limit.*

3.5 Tasmanian Environment Protection Policy (Noise) 2009

The Tasmanian *Environment Protection Policy (Noise) 2009* (EPP) is a strategic framework document which defines overarching principles and objectives to provide a basis for reducing health risks and amenity impacts associated with environmental noise. The EPP notes that the provisions of the policy should be considered in the context of other policy frameworks, including the Resource Management and Planning System, and that other environmental issues and the social and economic needs of the community should be taken into account when addressing noise issues.

In Part 5, the EPP defines general principles specific to *Commercial and Industrial Activities*, however it does not set specific acoustic requirements. The following general principles are noted:

- Regulatory authorities should assess, manage and regulate proposed commercial and industrial activities that are sources of noise with the objective of protecting the environmental values;
- Best practice environmental management should be employed in every activity to reduce noise emissions to the greatest extent that is reasonably practical;
- Dominant or intrusive noise characteristics of noise emissions from an activity should be reduced to the greatest extent that is reasonably practical; and
- To retain a reserve capacity in the acoustic environment at a particular location, no activity should be permitted to emit noise at a level or in a manner that, allowing for other reasonable emissions of noise in the vicinity, would prejudice the protection of the environmental values at that location.

These types of principles are consistent with noise requirements for commercial and industrial activities in other Australian jurisdictions.

In addition to the above, the EPP provides acoustic environment indicator levels which are defined to provide a reference for considering the condition of the acoustic environment and the effectiveness of noise control measures and strategies.

5 EPA Tasmania weblink

The relevant acoustic environment indicator levels for external noise at residential locations are reproduced in Table 1. The EPP states that these values are *indicative, not mandatory noise levels*.

Table 1: Residential locations – outdoor acoustic environment indicator levels

Specific environment	Critical health effect(s)	Average noise level	Maximum noise level
Outdoor living area	Serious annoyance, daytime and evening	55 dB $L_{Aeq, 16 hour}$	-
	Moderate annoyance, daytime and evening	50 dB $L_{Aeq, 16 hour}$	-
Outside bedrooms	Sleep disturbance, window open	45 dB $L_{Aeq, 8 hour}$	60 dB L_{AFmax}

The average outdoor acoustic environment indicator level of 45 dB L_{Aeq}, applicable outside bedrooms, is referenced in the assessment for operational noise from the related infrastructure.

4.0 ASSESSMENT METHODOLOGY

4.1 Overview

Based on the policies and guidelines outlined in Section 3.0, assessing the operational noise levels of a proposed wind farm (including the turbines and the related infrastructure associated with the wind farm) involves:

- assessing background noise levels at receivers around the project;
- assessing the land zoning of the project site and surrounding areas;
- establishing suitable noise criteria accounting for background noise levels and land zoning;
- predicting the level of noise expected to occur as a result of the proposed turbines and substation; and
- assessing whether the development can achieve the requirements of Tasmanian policy and guidelines by comparing the predicted noise levels to the relevant noise criteria.

4.2 Background noise levels

Background noise level information is used to inform the setting of limits for the wind turbine components of a wind farm project.

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

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

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

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

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

The results of the survey are then analysed to determine the trend between the background noise levels and the site wind speeds at the proposed hub height of the turbines. This trend defines the value of the background noise for the different wind speeds in which the turbines will operate. At the wind speeds when the value of the background noise is above 30 dB L_{A90}, the background noise levels are used to set the noise limits for the wind farm.

4.3 Noise predictions

Operational wind farm noise levels (turbines and related infrastructure) are predicted using:

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

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

The method is generally applied in a comparable manner to both wind turbine and substation noise levels. For example, for both types of sources, equivalent ground and atmospheric conditions are used for the calculations. However, when applied to wind turbine noise, additional and specific input choices apply, as detailed below.

Key elements of the noise prediction method are summarised in Table 2. Further discussion of the method and the calculation choices is provided in Appendix G.

Table 2: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method for wind farm noise predictions are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix G.
Source characterisation	Each source of operational noise is modelled as a point source of sound. The total sound of the component of the wind farm being modelled (i.e. the wind turbines or the related infrastructure) is then calculated on the basis of simultaneous operation of all elements (e.g. all wind turbines) and summing the contribution of each. To model the turbine components of the wind farm, the following specific procedures are noted: • Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine. Further discussion of terrain screening effects is provided below.
Terrain data	10 m resolution, downloaded from LISTmap.

Detail	Description
Terrain effects (turbine-specific procedures)	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix G. • Valley effects: + 3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground were flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. For reference purposes, the ground elevations at the turbine and receivers are tabled in Appendix B and Appendix C respectively. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK good practice guide and research outlined in Appendix G. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 °C and relative humidity 70 % These represent conditions which result in relatively low levels of atmospheric sound absorption. The calculations are based on sound speed profiles[6] which increase the propagation of sound from each turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point.
Receiver heights	1.5 m above ground level It is noted that the UK Institute of Acoustics guidance refers to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which results in lower noise levels. However, importantly, predictions in Australia do not generally subtract a margin recommended by the UK Institute of Acoustics guidance to account for differences between L_{Aeq} and L_{A90} noise levels (this is consistent with NZS 6808 which indicates that predicted L_{Aeq} levels should be taken as the predicted L_{A90} sound level of the wind farm). The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels.

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

4.4 Post-approval assessments

Consistent with current best practice and standard wind farm approval requirements, the following would be required if the wind farm is approved for development:

- Before development starts, a pre-development noise assessment would be submitted to the responsible authority demonstrating that the Project is expected to achieve compliance with the operational noise requirements established in accordance with NZS 6808.

  The pre-development noise assessment would be prepared in accordance with NZS 6808, based on the final turbine layout, representative noise emission data for the final selected turbine(s) for the Project and the location of all noise sensitive receivers around the Project (existing or approved receivers at the date of the Project's approval). The pre-development assessment would identify all involved receivers where noise agreements have been established.

- After the Project is commissioned, a post-construction noise assessment would be undertaken in accordance with NZS 6808, demonstrating compliance, or otherwise, with the operational noise requirements.

5.0 EXISTING NOISE ENVIRONMENT

Preliminary noise modelling of an earlier sixty-seven (67) turbine layout was undertaken to determine whether background noise monitoring was warranted in accordance with NZS 6808 and, if so, the locations where noise monitoring should be undertaken.

Based the preliminary noise predictions, background noise monitoring was only required in accordance with NZS 6808 at one (1) receiver (L19-1). However, Epuron elected to commission a survey of background noise levels at a broader range of locations than was strictly required by NZS 6808. The objective of the additional noise monitoring was to obtain data that would assist with providing context to the predicted noise levels of the proposed wind farm. Accordingly, monitoring was undertaken between 12 August 2020 and 10 November 2020 at a total of seven (7) locations, comprising L19-1 (a non-involved receiver at the time of the survey) and an additional six (6) locations surveyed for reference purposes.

After the background noise monitoring was completed, receiver L19-1 and Q13-1 became involved with the project. Notwithstanding this change, the results obtained from the survey at L19-1 and Q13-1 are provided for reference purposes.

The noise monitoring, analysis procedures and results are detailed in the Background Noise Report[7].

Permission was not able to be obtained at one (1) of the seven (7) preferred locations (receiver K17-1). After review of potential substitute locations, an alternative receiver location positioned approximately 1 km northwest of receiver K17-1 was selected for monitoring. Background noise data obtained at the substitute location is used solely as a reference for the potential contribution of background noise to any future post-construction noise measurements undertaken at K17-1 (i.e. not for the purpose of setting noise limits).

Due to travel restrictions surrounding the Australian response to COVID-19, MDA staff members could not travel to Tasmania for the deployment or retrieval of the noise monitoring equipment. The equipment was therefore deployed and retrieved by pitt&sherry with remote guidance from MDA.

The data presented in Table 3 summarises the background noise levels determined in accordance with NZS 6808.

The data in these tables is provided for the key wind speeds relevant to the assessment of wind farm noise. The results for all surveyed wind speeds are illustrated in the graphical data provided for each receiver in the appendices of the Background Noise Report.

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7 MDA Report Rp 002 20190433 *St Patricks Plains Wind Farm – Background noise monitoring report*, dated 20 Oct. 2021

Table 3: Background noise levels, dB L_{A90}

Receiver	Hub height wind speed [1], m/s											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
D10-13 [2]	*29.4*	*30.0*	*30.7*	*31.4*	*32.2*	*33.0*	*33.9*	*34.8*	*35.7*	*36.6*	*37.6*	*38.5*
F16-1	25.4	26.4	27.5	28.7	30.1	31.5	33.0	34.6	36.3	38.0	39.7	41.4
K17-1 (sub) [3]	*24.2*	*24.9*	*25.8*	*26.9*	*28.2*	*29.6*	*31.1*	*32.6*	*34.3*	*36.0*	*37.7*	*39.5*
L19-1 (I)	25.7	26.4	27.2	28.2	29.2	30.4	31.6	32.9	34.3	35.7	37.2	38.8
M5-1	23.1	24.1	25.4	27.0	28.8	30.7	32.7	34.8	37.0	39.1	41.1	43.0
O7-2	24.0	25.2	26.5	27.9	29.5	31.1	32.7	34.4	36.1	37.8	39.5	41.1
Q13-1 (I)	25.5	26.0	26.6	27.4	28.3	29.3	30.5	31.7	33.1	34.5	35.9	37.3

(I) Involved receiver

[1] 150 m above ground level at mast reference SPP1 (488,767 m E, 5,33–,591 N - GDA 94 zone 55)

[2] Values provided for information only as background noise levels are believed to have been affected by extraneous noise due to increased water flow in the nearby Shannon River

[3] Values provided for information only

6.0 WIND TURBINE ASSESSMENT

6.1 Noise limits

6.1.1 High amenity

As detailed in Section 3.3.4, the applicability of a high amenity noise limit is based on a two-step approach comprising:

1. A land zoning review to determine whether the planning guidance for the area warrants consideration of a high amenity noise limit. If it does, then the second step should be considered
2. 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.

To assess high amenity area considerations in accordance with NZS 6808, a review of the land zoning around the St Patricks Plains Wind Farm has been carried out.

In terms of the extent of areas that require consideration of high amenity limits, the standard states that there is no need to consider noise sensitive locations outside the predicted 35 dB L_{A90} contour. This is consistent with the minimum noise limit for high amenity areas being set at a value of 35 dB L_{A90}.

Based on the predicted noise level contours presented subsequently in Section 6.4, and the zoning map for the area presented in Appendix F, all areas within the predicted 35 dB L_{A90} noise contour are designated as Rural Resource.

The following table presents the Zone Purpose Statements as defined by the Central Highlands Interim Planning Scheme 2015.

Table 4: Zone Purpose Statements

Zone	Zone Purpose Statement
26. Rural Resource	26.1.1.1 To provide for the sustainable use or development of resources for agriculture, aquaculture, forestry, mining and other primary industries, including opportunities for resource processing. 26.1.1.2 To provide for other use or development that does not constrain or conflict with resource development uses.

Based on the stated purpose for the Rural Resource, the area in the vicinity of the of the proposed St Patricks Plains Wind Farm does not warrant consideration of a high amenity noise limit.

On 12 August 2019, the Tasmanian EPA advised the following:

> [...] *it is considered that the area has significant rural living use despite the rural resource zoning and therefore there is potentially a case for high amenity classification is some areas in the vicinity of the site.*

It is our understanding that the areas with *significant rural living* refer to the townships of Flinstone and Wilburville to the northeast, the Shannon settlement to the northwest and the Penstock settlement to the west. However, all receivers within these areas are located outside the 35 dB L_{A90} predicted noise contour, and the high amenity noise limits therefore do not warrant further consideration.

Notwithstanding these findings, a reduced base noise limit of 35 dB L_{A90} is applicable in accordance with the EPA Board Communiqué.

6.1.2 Involved receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes dwellings located within a wind farm site boundary. The discussion earlier in this report in Section 3.3.2 also provides details of the statutory context of NZS 6808 and indicates the method is not intended to be applied to noise sensitive locations outside the site boundary where a noise agreement exists between the occupants and the proponent of the development.

It is our understanding that a noise agreement is in place between Epuron and the landowners of five (5) receivers (H8-1, L19-1, M10-1, M12-1 and Q13-1), and that this noise agreement establishes an increased base level of 45 dB L_{A90}. This is consistent with recommendations from other states.

Noise levels at involved receivers will ultimately need to be managed in accordance with the commercial agreements established between the proponent and the landowners.

6.1.3 Applicable noise limits

Accounting for the relevant base noise limit values and the EPA Board Communiqué, the noise criteria applicable to the St Patricks Plains Wind Farm are summarised in Table 5.

Table 5: Applicable noise criteria

Receivers	Noise criteria, dB L_{A90}
Non-involved	35 dB or the background L_{A90} + 5 dB, whichever is higher
Involved	Noise limits do not apply Reference levels defined as 45 dB or the background L_{A90} + 5 dB, whichever is higher, are presented for informative purposes only

Applicable noise limits (and indicative limits provided for information) for non-involved receivers, based on the background noise levels presented in Table 3, are summarised in Table 6,.

Table 6: Background dependent noise limits, dB L_{A90}

Receiver	Hub height wind speed [1], m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
D10-13 [2]	*35.0*	*35.0*	*35.7*	*36.4*	*37.2*	*38.0*	*38.9*	*39.8*	*40.7*	*41.6*	*42.6*	*43.5*
F16-1	35.0	35.0	35.0	35.0	35.1	36.5	38.0	39.6	41.3	43.0	44.7	46.4
K17-1 (sub) [3]	*35.0*	*35.0*	*35.0*	*35.0*	*35.0*	*35.0*	*36.1*	*37.6*	*39.3*	*41.0*	*42.7*	*44.5*
M5-1	35.0	35.0	35.0	35.0	35.0	35.7	37.7	39.8	42.0	44.1	46.1	48.0
O7-2	35.0	35.0	35.0	35.0	35.0	36.1	37.7	39.4	41.1	42.8	44.5	46.1

[1] 150 m above ground level at mast reference SPP1 (488,767 m E, 5,336,591 N - GDA 94 zone 55)

[2] Values provided for information only, as background noise levels are believed to have been affected by extraneous noise due to increased water flow in the nearby Shannon River

[3] Values provided for information only

6.2 Wind turbine model

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

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

For this assessment, the proponent has nominated the Vestas V162-6.2MW as the candidate turbine model.

This model is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis).

Unless specified otherwise, this assessment has been based on all turbine models using unconstrained generation modes (i.e. no noise reduced operating modes) and with blade serrations. Blade serrations are now routinely used to reduce wind turbine noise emissions, and we understand that their use is now the market standard for turbines being offered in the Australian market.

A range of sound optimised modes are also available reducing the maximum power output and sound power levels.

Details of the assessed candidate wind turbines are provided in Table 7.

Table 7: Selected candidate wind turbine model

Item	Wind turbine model detail
Make	Vestas
Model	V162
Rotor diameter	162 m
Hub height	150 m
Operating mode	PO6200 [1]
Rated power	6.2 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	12.0 m/s
Cut-out wind speed (hub height)	24 m/s

[1] It is our understanding that 'PO6200' is a manufacturer designation which indicates a power optimised operational mode to achieve a power output of 6,200 kW
This is an unconstrained mode of operation (i.e. without noise curtailment)

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

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

6.3 Wind turbine noise emissions

6.3.1 Sound power levels

The noise emissions of the wind turbines are described in terms of the sound power level for different wind speeds. The sound power level is a measure of the total sound energy produced by each turbine and is distinct from the sound pressure level which depends on a range of factors such as the distance from the turbine.

Sound power level data for the candidate turbine model, including sound frequency characteristics, has been sourced from the following Vestas document:

- 0105-5200_00 *Third octave noise emission EnVentus™ V162-6.2MW* dated 21 April 2021
- 0079-5298_01 *V162-5.6MW Third octave noise emission* dated 23 January 2019

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

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

Table 8: Sound power levels versus hub height wind speed, dB L_{WA}

Operating mode	Power output, MW	Hub height wind speed, m/s								
		4	5	6	7	8	9	10	11	≥12
PO6200	6.2	95.1	95.3	97.2	100.2	103.0	105.3	105.8	105.8	105.8
Mode 0	5.6	94.7	95.3	98.3	101.2	103.9	105.0	105.0	105.0	105.0
SO2	5.0	94.7	95.3	98.3	101.2	103.0	103.0	103.0	103.0	103.0
SO3	4.8	94.7	95.3	98.3	101.2	102.0	102.0	102.0	102.0	102.0
SO4	4.6	94.7	95.3	98.3	100.7	101.0	101.0	101.0	101.0	101.0

Note: Other sound optimisation modes are available

The reference octave band values used as the basis for this assessment are presented in Table 9 and were adjusted to the overall A-weighted noise levels detailed in Table 8.

Table 9: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz								
Operating mode	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
V162-6.2MW [1]	76.7	87.1	94.6	99.2	100.9	99.8	95.7	88.8	79.0	105.8

[1] Based on one-third octave band levels at 10 m/s

These sound power levels are also illustrated in Appendix I.

The values presented above are considered to be generally typical of the upper range of noise emissions associated with comparable multi-megawatt wind turbines.

Review of available sound power data for a range of turbine models has shown that there is no 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).

6.3.2 Special Audible Characteristics

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

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

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

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

6.4 Predicted noise levels

This section of the report presents the predicted operational wind turbine noise levels of the St Patricks Plains Wind Farm at surrounding receivers.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

Noise levels from the proposed St Patricks Plains Wind Farm have been predicted based on the sound power level data detailed in Section 6.3.1, using the PO6200 operating mode, and are summarised in Table 10 for for the wind speeds which result in the highest predicted noise levels (hub height wind speed ≥10 m/s).

The locations of the predicted 30 dB, 35 dB and 40 dB L_{A90} noise contours are illustrated in Figure 1, for the wind speed which results in the highest predicted noise levels.

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

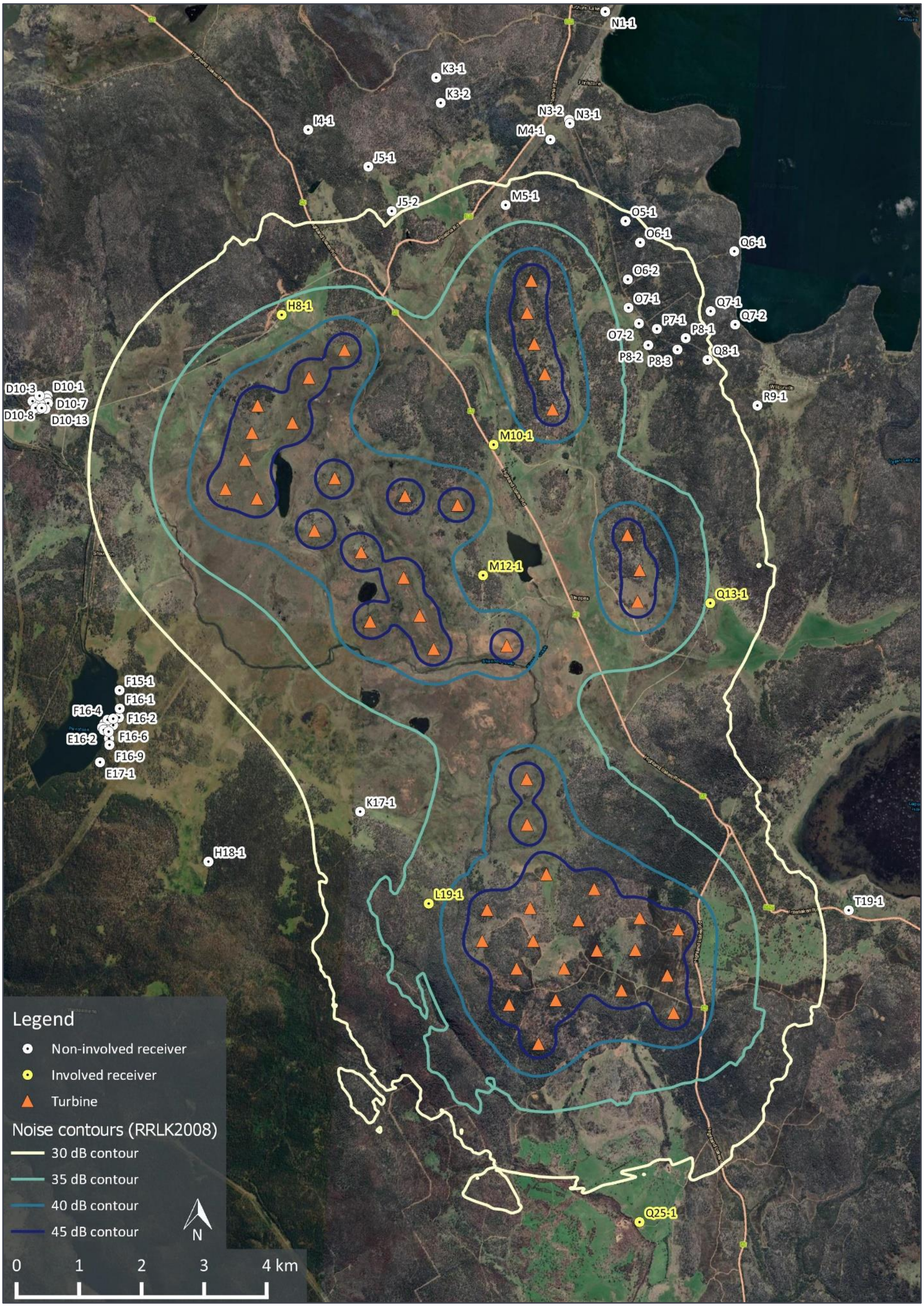
Table 10: Highest predicted noise level at receivers with predicted levels greater than 30 dB L_{A90} (PO6200)

Receiver	Predicted level, dB L_{A90}
H8-1 (I)	36.3
K17-1	31.8
L19-1 (I)	38.0
M5-1	32.7
M10-1 (I)	37.3
M12-1 (I)	38.2
O5-1	30.3
O6-1	31.0
O6-2	32.8
O7-1	33.6
O7-2	33.1
P7-1	31.9
P8-1	31.0
P8-2	32.8
P8-3	30.9
Q8-1	31.5
Q13-1 (I)	34.4

(I) Involved receiver

It can be seen from Table 10 that the predicted noise levels from the proposed St Patricks Plains Wind Farm are below the base noise limit of 35 dB L_{A90} at all assessed non-involved receivers.

Figure 1: Highest predicted noise level contours (PO6200), dB L_{A90}



6.5 Cumulative assessment

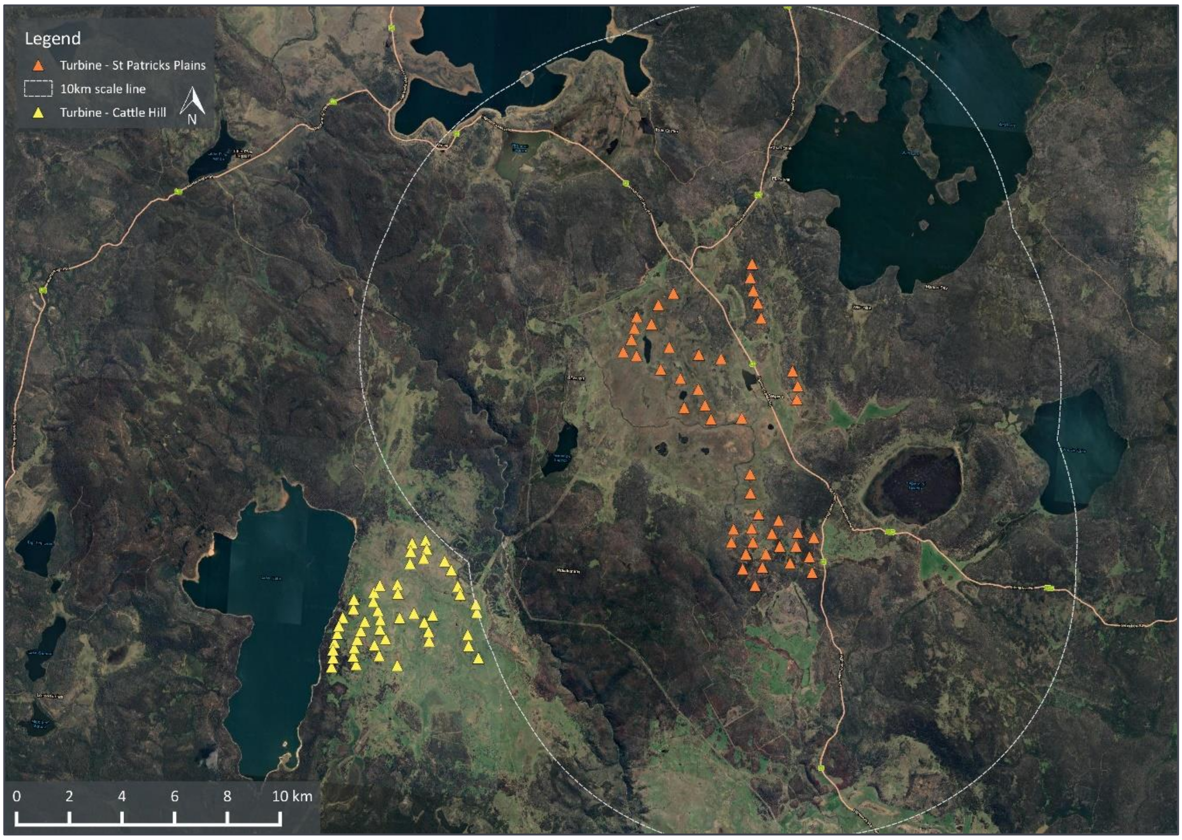
The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind farm noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore considered other approved and/or operational wind farm projects in the surrounding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

Based on publicly available information, the operational Cattle Hill Wind Farm has been identified within 10 km of the proposed St Patricks Plains Wind Farm for the review of potential cumulative noise considerations. Wind farms located farther than 10 km from the proposed project would not have cumulative effects.

6.5.1 Cattle Hill Wind Farm

The Cattle Hill Wind Farm is located approximately 10 km southwest of the St Patricks Plains Wind Farm. A site plan showing the location of the Cattle Hill Wind Farm in relation to the St Patricks Plains Wind Farm is provided in Figure 2.

Figure 2: St Patricks Plains Wind Farm and Cattle Hill Wind Farm



It has been fully operational since August 2020 and comprises forty-eight (48) GW140 wind turbines with individual power outputs ranging from 3.0 to 3.2 MW and a hub height of 100 m, as detailed in Section 2.1 of the Annual Compliance Report, dated November 2020[8]. The coordinates of the turbines were digitised from the aerial imagery available on the LISTmap website.

Sound power level data for the GW140 wind turbines was sourced from a publicly available noise report[9].

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8 *Cattle Hill Wind Farm – EPBC 2009/4839 Annual Compliance Report 2020*, dated November 2020 (web link)

9 Table 3 of Rp 001 R01 20169260 *Coppabella Wind Farm Modification Application - Noise Assessment,* dated 18 August 2017 (web link)

6.5.2 Assessment results

To inform the assessment of potential cumulative noise considerations, reference is made to Clause 5.6.4 of NZS 6808:2010 which states:

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

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

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

Based on the above guidance, and considering the relatively large separating distances between the two wind farms, a simplified assessment of potential cumulative noise considerations can be made by comparing the predicted contour for one wind farm, corresponding to a noise level 10 dB below the applicable base noise limit, and the applicable noise limit of the other wind farm, as follows:

- To assess the potential cumulative impact from the St Patricks Plains Wind Farm to the Cattle Hill Wind Farm, the predicted 30 dB L_{A90} noise contour from the St Patricks Plains Wind Farm is plotted against the predicted 40 dB L_{A90} noise contour from the Cattle Hill Wind Farm (the Cattle Hill Wind Farm applicable base noise limit).

  The relevant noise contours are presented in Figure 3.

- To assess the potential cumulative impact from the Cattle Hill Wind Farm to the St Patricks Plains Wind Farm, the predicted 25 dB L_{A90} noise contour from the Cattle Hill Wind Farm is plotted against the predicted 35 dB L_{A90} noise contour from the St Patricks Plains Wind Farm (the St Patricks Plains Wind Farm applicable base noise limit).

  The relevant noise contours are presented in Figure 4.

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

Figure 3: Predicted noise contours relevant to the cumulative assessment on Cattle Hill Wind Farm

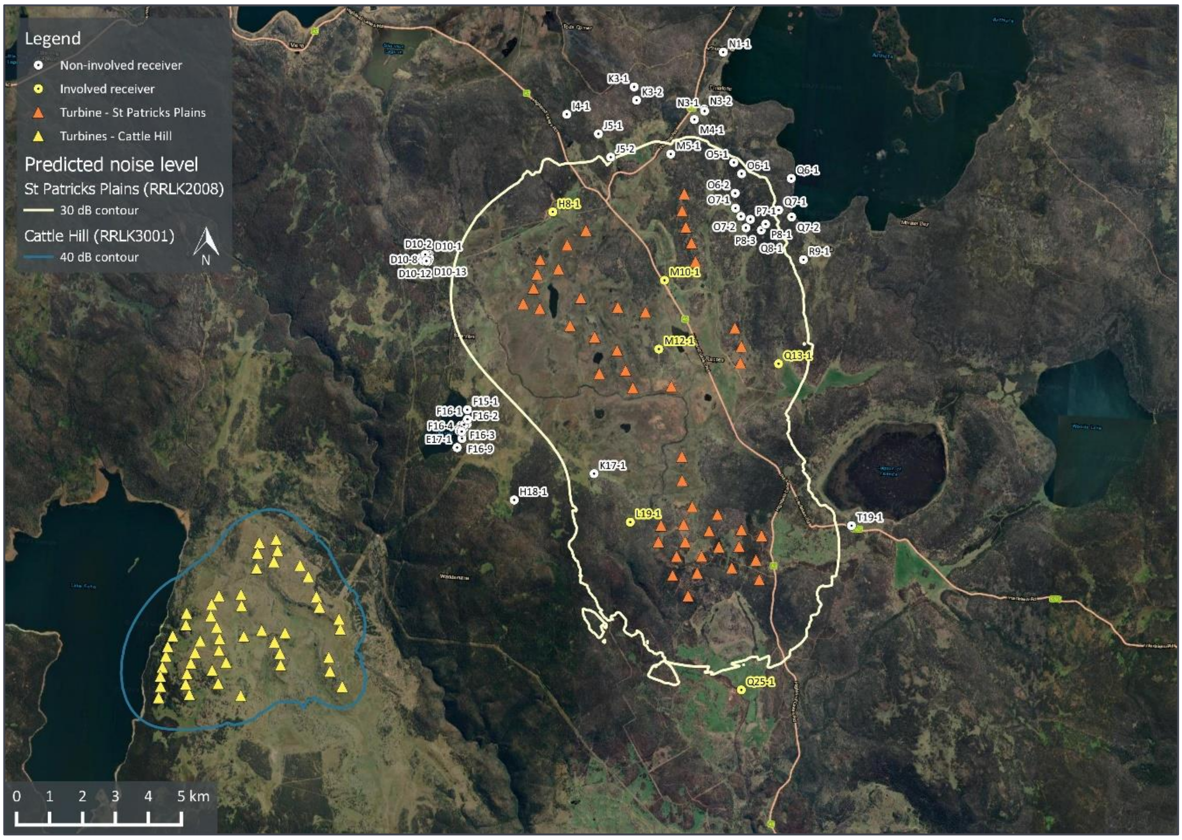
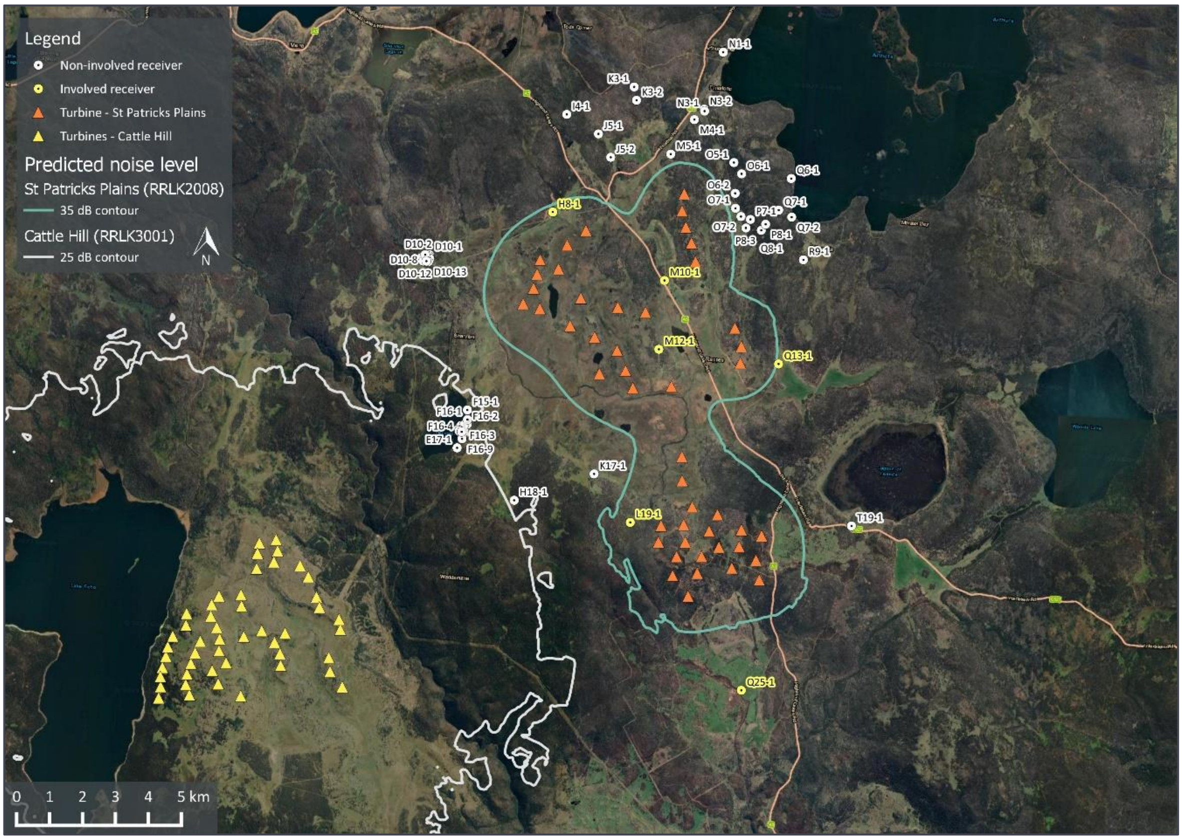


Figure 4: Predicted noise contours relevant to the cumulative assessment on St Patricks Plains Wind Farm



The results demonstrate that the relevant predicted noise contours for each project do not overlap. This means that at any receiver where the predicted noise level from one of the wind farms approaches the applicable base noise limit, the predicted noise level associated with the other wind farm will be more than 10 dB lower. Based on the guidance of NZS 6808:2010, the cumulative effect does not need to be taken in account for the nearest receivers to each wind farm development.

The predicted noise levels therefore demonstrate that cumulative wind farm noise considerations between the St Patricks Plains Wind Farm and Cattle Hill Wind Farm are not applicable. Specifically, the predicted noise contribution of the Cattle Hill Wind Farm is sufficiently low to be inconsequential to the noise assessment for the St Patricks Plains Wind Farm. Conversely, the predicted noise contribution of the St Patricks Plains Wind Farm at the receivers in the vicinity of the Cattle Hill Wind Farm would not affect the compliance outcomes for this project.

7.0 RELATED INFRASTRUCTURE NOISE ASSESSMENT

This section presents an assessment of the proposed substation (referred to herein as 'related infrastructure') to be installed within the site.

At this stage of the development, the location for the substation has not been finalised and two (2) options are being considered as detailed in Table 11.

Table 11: Proposed substation location options - MGA94, Zone 55

Item	Easting, m	Northing, m
Substation	486,774	5,341,704
Substation (alternative)	484,296	5,343,779

Note: The coordinates correspond to the centroid of the areas provided by the proponent

The two (2) location options for the substation are presented in Appendix D.

7.1 Related infrastructure noise emissions

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

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 substation, the proponent advised that two (2) transformers rated to 180 MVA each are proposed.

In lieu of measured sound power level data for a specific transformer selection, reference has been made to Australian Standard AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009) which provides a method for estimating transformer sound power levels. Specifically, Figure ZA1 from AS 60076-10:2009 has been used to determine an estimated standard maximum sound power level of 98 dB L_{WA} for each transformer.

The sound power levels include the noise from ancillary plant such as cooling plant.

AS 60076-10:2009 does not provide estimated sound frequency spectra for transformer noise emissions. However, the noise emissions of transformers and ancillary plant typically exhibit tonal characteristics which must be accounted for in the noise assessment. This is addressed in subsequent sections of the report.

7.2 Predicted noise levels

Predicted noise levels have been determined on the basis of:

- the indicative equipment noise emission data detailed in Section 7.1; and
- the ISO 9613-2 noise prediction method described in Section 4.3.

Section 6.2 of the NMPM specifies a maximum adjustment of +5 dB to account for the presence of audible tonality.

Predicted noise levels (including the +5 dB adjustment) at the nearest receiver for each location option are detailed in Table 12.

Table 12: Related infrastructure predicted noise levels at the nearest receiver, dB L_{Aeq}

Location option	Nearest receiver	Distance to nearest receiver, m	Predicted noise level, dB L_{Aeq}
Substation	M12-1 (I)	1,037	29
Substation (alternative)	H8-1 (I)	2,917	18

(I) Involved receiver

The predicted noise levels in Table 12 are below the EPP average outdoor acoustic environment indicator level of 45 dB L_{Aeq}, applicable outside bedrooms, by at least 16 dB.

These results indicate that noise levels from the proposed related infrastructure associated with the St Patricks Plains Wind Farm 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.

8.0 CONSTRUCTION NOISE AND VIBRATION

Construction of a wind farm project will generate noise and vibration as a result of activities occurring both on and off the site of the proposed development.

On-site works include a range of activities such as construction of access tracks, connection infrastructure, turbine foundations and erection of the turbines. Off-site noise generating activities primarily relate to heavy goods vehicle movements to and from the site.

Construction of a wind farm mostly occurs at relatively large separation distances from receivers.

It is our understanding that construction activities are proposed to occur between 0700-1900 hrs, Monday to Saturday. In order to reduce the impact of traffic associated with the construction, hours may be extended into a night shift between 1900-0700 hrs during turbine delivery and erection.

8.1 Assessment guideline

8.1.1 Environmental Management and Pollution Control (Noise) Regulations 2016

The Tasmanian *Environmental Management and Pollution Control (Noise) Regulations 2016* (EMPC) is the primary mechanism for controlling construction noise and defines prohibited hours for equipment and machinery used on construction and demolition sites (excluding road construction) which can be heard in any neighbouring residential premises.

Part 1 (4) of the EMPC noise regulations notes that the prohibited hours apply to sources of noise that are not subject to noise control requirements specified in an approved instrument. Accordingly, unless dedicated noise control requirements are established via an approved instrument, construction work which could result in audible noise inside any neighbouring residential premises (with windows open) must not occur during the prohibited hours.

The relevant restrictions of use are summarised in Table 13 based on times of the day.

Table 13: EMPC noise regulations – relevant provisions relating to operation of equipment

Equipment	Day of the week	Prohibited hours of use
(2) Mobile machinery, forklift or portable equipment	Monday-Friday	Before 0700 hrs and after 1800 hrs
	Saturday	Before 0800 hrs and after 1800 hrs
	Sunday or public holiday	Before 1000 hrs and after 1800 hrs
(3) Motor vehicles (unless the vehicle…is being operated to move into or out of…a construction or demolition site)	Monday-Friday	Before 0700 hrs and after 1800 hrs
	Saturday	Before 0900 hrs and after 1800 hrs
	Sunday or public holiday	Before 1000 hrs and after 1800 hrs

An exemption from the above prohibited hours may be sought from the Tasmanian EPA, if required, to align with the proposed construction hours detailed in Section 8.0.

8.1.2 Construction vibration guidelines

There is no standard or regulation that specifies criteria for the control of construction vibration levels in Tasmania.

In the absence of Tasmanian guidance for construction vibration, reference is made to the NSW Roads and Maritime Service's publication *Construction Noise and Vibration Guideline* dated August 2016 (the NSW RMS Guideline).

The NSW publication was selected as the best available Australian government guidance on the subject, and it is commonly referenced in other states for this purpose.

Section 7.1 of the NSW RMS Guideline sets out minimum working distances from sensitive receivers for typical items of vibration intensive plant. The minimum distances are quoted for effects relating to cosmetic damage and human comfort, based on guidance contained in BS 7385-2[10] and the NSW DECC publication *Assessing Vibration: A Technical Guideline* dated February 2006 (the NSW DECC Vibration Guideline) respectively.

The minimum working distances are reproduced below in Table 14.

Table 14: Recommended minimum working distances for vibration intensive plant from sensitive receivers (reproduced from Table 2 of Section 7.1 of the NSW RMS Guideline)

Plant item	Rating / description	Minimum working distance	
		Cosmetic damage	Human response
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg – 5 to 12 t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18 t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34 t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Handheld	1 m (nominal)	2 m

The NSW RMS Guideline notes that the minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions. The guideline also notes the values are defined in relation to cosmetic damage of typical buildings under typical geotechnical conditions and recommends vibration monitoring to confirm the minimum working distances at specific sites.

In relation to human comfort, the NSW RMS Guideline notes that the minimum working distances relate to continuous vibration. The guideline further notes that for most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed.

The data presented in Table 14 indicates that the minimum working distances for human comfort are significantly greater than for the avoidance of cosmetic damage. This is based on the thresholds for human exposure to vibration being generally well below accepted thresholds for minor cosmetic damage to lightweight structures.

[10] BS 7385-2:1993 *Evaluation and measurement for vibration in buildings - Guide to damage levels from groundborne vibration*

8.1.3 Blasting

The Tasmanian EPA *Quarry Code of Practice 3rd Edition*, dated May 2017 (Quarry Code of Practice), provides guidance for assessing blast-induced airblast and vibration effects from quarries.

Although it is understood that blasting may be required for the construction of turbine foundations, and not as part of quarrying activities, the requirements detailed in the Quarry Code of Practice have been used for this project.

Section 7.4.2 of the Quarry Code of Practice specifies the following criteria:

- Airblast overpressure at sensitive sites must be:
  - below 115 dB L_{Zpeak} for 95 % of all blasts; and
  - below 120 dB L_{Zpeak} at all times.
- Ground vibration at sensitive sites must be:
  - below 5 mm/s (PPV) for 95 % of all blasts; and
  - below 10 mm/s (PPV) at all times.

The above criteria are based on the Australian and New Zealand Environment Council report *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, dated September 1990 (ANZEC 1990 Report).

From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 115 dB L_{Zpeak}. The probability of damage increases as the airblast levels increase above this level. Windows are the building element currently regarded as most sensitive to airblast, and damage to windows is considered as improbable below 140 dB L_{Zpeak}.

Based on the ANZEC 1990 Report, a limit of 115 dB L_{Zpeak} is referenced to practically minimise the risk of cosmetic or structural damage to typical residential constructions from airblast.

The Quarry Code of Practice also requires that, where blasting is expected within 1 km of sensitive receivers, modelling and monitoring of ground vibration and air blast overpressure must be undertaken in accordance with AS 2187.2:2006 *Explosives – Storage and use, Part 2: Use of explosives* (AS 2187.2).

8.1.4 Off-site construction traffic noise

There is no Tasmanian guidance document in relation to the assessment of construction traffic noise levels on public roads.

As a result of practical constraints related to the timing of component deliveries to the port in Tasmania, oversized turbine component deliveries may occur during both the day and night. Some oversized deliveries may also be specifically timed to occur at night in order to reduce potential traffic disruptions on local roads.

The following management measures are noted in relation to oversized component deliveries at night:

- All drivers shall be instructed to not use exhaust brakes when travelling through populated local areas;
- All vehicles and associated exhaust noise control systems shall be maintained and in good working order; and
- Local communities to be notified in advance of oversized turbine component deliveries occurring outside of normal working hours.

8.2 Construction noise sources

It is anticipated that a variety of construction equipment would be used for this project.

Sound power levels for the proposed construction equipment have been sourced from our internal noise dataset and the following standards to determine typical sound power levels for equipment commonly in operation at construction sites:

- Australian Standard 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* (AS 2436); and
- British Standard 5228–1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise* (BS 5228-1).

Table 15 summarises the noise emissions used to represent key items of plant associated with construction.

Table 15: Construction noise sources sound power data

Noise source	Sound power level, dB L_{WA}
Batching Plant	110
Bulldozer	108
Concrete pump	108
Concrete trucks	108
Crane (200 t)	105
Crane (500 t)	110
Crane (1200 t)	115
Delivery Trucks	107
Dump truck	117
Excavator (100 to 200kW)	107
Grader	110
Rock crusher	120

Overall aggregated total sound power levels for key construction tasks have been determined on the basis of an indicative schedule of equipment associated with each task. The actual equipment choices and equipment numbers for each task are not presently defined in detail, and therefore the schedule of equipment listed here does not represent a final or definitive list of plant. The equipment schedule has therefore been adopted in this assessment solely for the purpose of a risk assessment of construction noise levels.

The overall total aggregated sound power levels for each of the key construction tasks are detailed in Table 16, and conservatively assume that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

Table 16: Overall sound power levels of key construction tasks

Construction task	Plant/equipment	Approximate overall sound power level, dB L_{WA}
Access road and tracks construction	1 x Bulldozer, 7 x Delivery Trucks, 2 x Dump truck, 2 x Excavators (100 to 200kW), 1 x Grader	120
Cable trench digging	1 x Bulldozer, 1 x Dump truck, 1 x Excavator (100 to 200kW)	120
Concrete Batching	1 x Batching Plant, 1 x Concrete pump, 6 x Concrete trucks	115
Permanent met mast	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete trucks, 1 x Crane (500t), 1 x Excavator (100 to 200kW)	115
Powerline pole	1 x Bulldozer, 1 x Concrete truck, 1 x Crane (200t), 1 x Excavator (100 to 200kW)	115
Site Compound	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Excavator (100 to 200kW)	115
Substation	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Excavator (100 to 200kW)	115
Switchyard	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Excavator (100 to 200kW)	115
Turbine foundations and assembly	1 x Bulldozer, 1 x Concrete pump, 2 x Concrete trucks, 1 x Crane (1200t), 1 x Dump truck, 1 x Excavator (100 to 200kW), 1 x Rock crusher	125

A map showing the location of the construction activities detailed above is presented in Appendix J.

8.3 Predicted construction noise levels

Noise levels associated with each of the main construction tasks have been predicted at the nearest noise sensitive receivers to provide an indication of the upper range of noise levels.

Predicted noise levels have been calculated in general accordance with the methodology detailed in AS 2436. This method enables the prediction of noise levels for sound propagation over hard or soft ground, but does not provide the ability to calculate predicted noise levels for mixed ground cover with varied soil conditions. The standard also notes that caution must be applied when considering predicted noise levels at distances beyond 100 m. For these reasons, predicted noise levels have been determined as the arithmetic average of the hard and soft ground prediction methods. This approach is broadly consistent with the equivalent prediction procedure in BS 5228-1 (document referenced in AS 2436) and provides a margin of caution with respect to ground conditions and the typical magnitude of separating distances between construction activities and neighbouring sensitive receivers.

Given that the precise equipment selections and methods of working would be determined during the development of a construction plan, and that the noise associated with construction plant and activity varies significantly, the predicted noise levels are provided as an indicative range of levels which may occur in practice.

Table 17 details the predicted noise levels for each of the main construction tasks.

Table 17: Indicative range of construction task noise predictions, dB L_{Aeq}

Construction task	Non-involved receivers		Involved receivers	
	Nearest receiver	Predicted level range	Nearest receiver	Predicted level range
Access road and tracks construction	M5-1	40-45	M12-1 (I)	50-55
Cable trench digging	M5-1	40-45	M12-1 (I)	50-55
Concrete Batching	T19-1	30-35	M12-1 (I)	40-45
Permanent met mast	K17-1	30-35	Q13-1 (I)	35-40
Powerline pole	K17-1	30-35	M12-1 (I)	40-45
Site Compound	T19-1	30-35	M12-1 (I)	40-45
Substation	K17-1	30-35	M12-1 (I)	40-45
Switchyard	F15-1	25-30	M12-1 (I)	30-35
Turbine foundations and assembly	M5-1	45-50	L19-1 (I)	50-55

(I) Involved receiver

The predicted noise levels presented in Table 17 are typical of the range expected for the construction of a wind farm. To reduce potential noise impacts, best practice measures detailed in Section 8.6 should be adhered to, wherever practicable.

8.4 Predicted construction vibration levels

The nearest sensitive location to construction activities is an involved receiver, M12-1 (I), located approximately 660 m from proposed access tracks construction works.

This separating distance is significantly greater than the recommended minimum working distances for cosmetic damage (≤ 25 m) and human response (≤ 100 m) presented in Table 14.

As such, the vibration levels at all receivers are expected to be well below the thresholds for both cosmetic damage and human comfort for all construction equipment detailed in Table 15.

8.5 Blasting

Blasting may be required for the construction of turbine foundations.

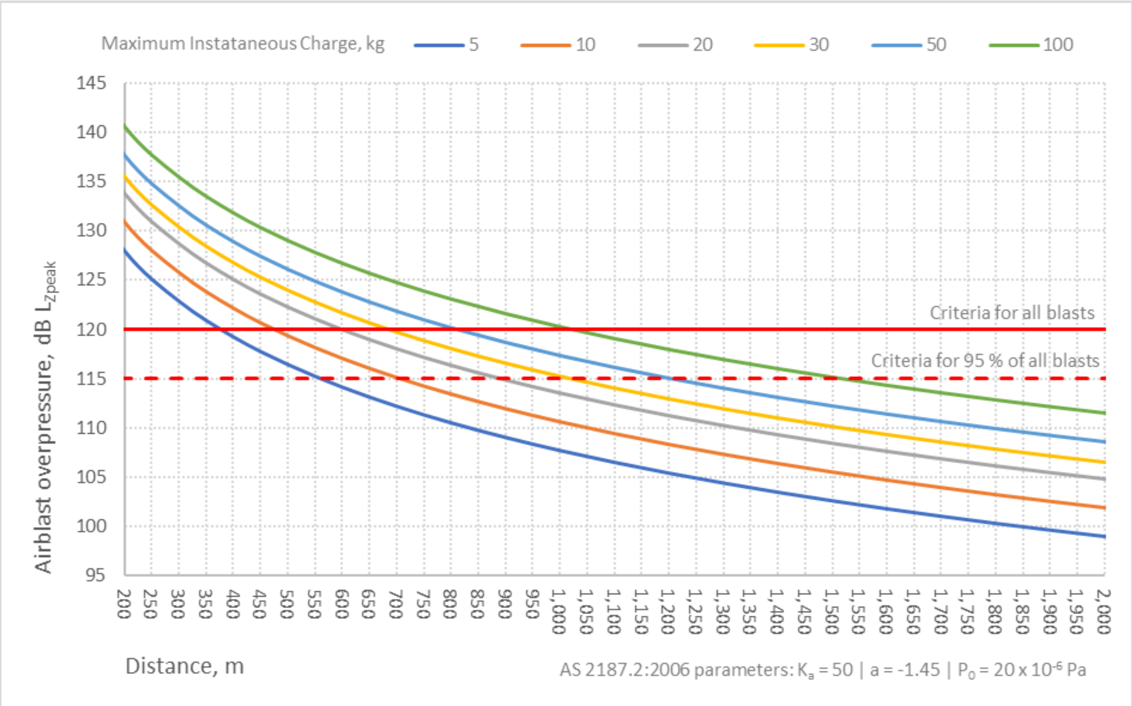
Theoretical modelling of airblast and ground vibration is complex and subject to considerable uncertainty. The blasting process is highly non-linear and the variability of ground and rock conditions limits the accuracy of predictions.

However, the receiver to turbine separating distances documented in Appendix C demonstrate that the receivers are located farther than 1 km from any potential blasting activities, with the exception of an involved receiver (L19-1) located 950 m from the nearest turbine. Given the separating distances, and that the excavation methods needed to prepare the turbine foundations would not be determined until subsequent stages of the project, a detailed study of vibration and air blast overpressure is not warranted at this stage and has not been conducted as part of this assessment.

Notwithstanding the above, to provide an indication of the effects of blasting, overpressure levels have been estimated using the method detailed in AS 2187.2. The method accounts for the separating distance, the mass of the charge detonated in any given instant (referred to as the maximum instantaneous charge), the configuration of the charge (unconfined versus confined blastholes), and site characteristics that can be evaluated from measurements of test shots.

For confined blasthole charges, as may be used for this project, and accounting for example site characteristics[11] described in AS 2187.2, estimated airblast overpressure levels are presented in Figure 5 for a range of separating distances and maximum instantaneous charge weights. The criteria specified in the Quarry Code of Practice are also shown in Figure 5.

Figure 5: Estimated airblast overpressure levels for K_a = 50 and a = -1.45



11 Site-specific characteristics are defined in terms of a site exponent and site constant. AS 2187.2 refers to a site exponent (a) of -1.45 for estimating overpressure, with corresponding site constants (K_a) commonly ranging from 10 to 100. In lieu of site-specific data, a site exponent of -1.45 and a mid-value site constant of 50 was used for estimating overpressure.

The results in Figure 5 demonstrate that, for the assumed site characteristics, achieving compliance with the applicable airblast criteria is dependent on selection of suitable maximum instantaneous charge weights, accounting for the site characteristics of the locations where blasting may be needed.

Accordingly, if blasting is ultimately required, the activities would need to be controlled using blast management procedures documented in an approved construction management plan. The procedures would need to identify the locations where blasting could be conducted, and describe the testing, management and monitoring measures which would be implemented to achieve the Quarry Code of Practice criteria. This is expected to involve conducting test shots to evaluate site-specific characteristics, in turn enabling the selection of suitable maximum instantaneous charge weights that are appropriate for the site.

8.6 Best Practice

Noise and vibration associated with construction of a wind farm can usually be satisfactorily addressed by the adoption of best practice and considerate working practices.

Best practice means the most practical and efficient combination of techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of that industry sector or activity.

All practical noise management measures should be applied, including time restrictions, management of activities and using lower-noise movement alarm systems (for example, broadband reversing alarms).

Best practice measures recommended for this project are listed below:

- Restricting operations to day period only (See Section 8.1.1), when possible;
- Selecting as-new low-noise plant and equipment, where possible;
- Use of 'broadband alarms' to minimise annoyance related to traditional tonal reversing alarms;
- Regular maintenance of equipment to manufacturer standards; and
- Communication with residents nearest to construction activities.

8.7 Construction management plan

Should approval for the wind farm be granted, these measures are normally documented and agreed in a construction management plan as a condition of consent, to be prepared for review and approval by the responsible authority prior to commencing the work.

9.0 SUMMARY

An assessment of operational noise for the proposed St Patricks Plains Wind Farm has been carried out. The assessment is based on the proposed wind farm layout comprising up to forty-seven (47) multi-megawatt turbines.

Operational noise associated with the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) as specified in the *Project Specific Guidelines for Preparing an Environmental Impact Statement for Epuron Projects Pty Ltd St Patricks Plains Wind Farm*, issued by the Tasmanian EPA in October 2019 (Project Specific Guidelines). The assessment also accounts for the EPA Board Communiqué when determining applicable noise limits.

Noise modelling was carried out based on a candidate turbine model (Vestas V162-6.2MW) which has been selected as being representative of the size and type of turbines which could be used at the site. The results of the modelling demonstrate that St Patricks Plains Wind Farm is predicted to achieve compliance with the applicable noise limits at all receivers.

The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind farm noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore also considered the Cattle Hill Wind Farm, located within 10 km of the St Patricks Plains Wind Farm. An assessment of the predicted noise levels for the Cattle Hill Wind Farm has demonstrated that cumulative wind farms noise levels do not affect the compliance outcomes for the St Patricks Plains Wind Farm or the Cattle Hill Wind Farm.

The assessment has also considered operational noise associated with the proposed related infrastructure (e.g. substation). These noise levels have been assessed in accordance with the Tasmanian *Environment Protection Policy (Noise) 2009* (EPP). The assessment demonstrates that the related infrastructure is expected to result in noise levels significantly lower than the applicable EPP outdoor acoustic environment indicator level.

As required by the Project Specific Guidelines, consideration was also given to the noise and vibration associated with construction of the project, including potential blasting. A construction management plan should be prepared for review and approval by the responsible authority prior to commencing the work, including dedicated blast management procedures if blasting is ultimately required.

The noise assessment has therefore demonstrated that the proposed St Patricks Plains Wind Farm is able to be designed and developed in accordance with requirements for operational and construction noise, as referenced in the Project Specific Guidelines issued by the Tasmanian Environment Protection Authority.

If the wind farm is approved for development, and consistent with current best practice and standard wind farm approval requirements, the noise modelling and assessments presented in this report would be updated to verify the final wind farm design and equipment selections.

APPENDIX A 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
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 B TURBINE COORDINATES

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

(Data received from the proponent on 15 March 2022).

Table 18: Turbine coordinates – MGA 94 zone 55

Turbine	Easting, m	Northing, m	Terrain elevation, m
1	487,523	5,346,922	970
2	487,672	5,346,435	930
3	487,875	5,345,968	950
4	488,037	5,345,412	901
6	489,373	5,343,489	940
7	489,608	5,342,943	902
8	489,610	5,342,440	885
9	484,652	5,346,126	910
11	485,781	5,343,864	900
12	486,630	5,343,776	891
13	484,115	5,345,642	906
14	483,902	5,344,904	900
15	484,640	5,344,067	900
16	484,374	5,343,208	894
17	485,143	5,342,917	900
18	485,852	5,342,557	890
19	486,150	5,341,967	890
20	486,410	5,341,453	880
25	485,365	5,341,819	884
29	483,327	5,345,140	910
30	483,267	5,344,700	906
31	482,908	5,343,774	900
32	483,189	5,344,262	901
33	483,423	5,343,658	898
39	487,573	5,341,586	870
42	488,041	5,339,481	860
43	488,098	5,338,755	860
44	488,462	5,337,982	880
45	487,556	5,337,348	890
46	487,512	5,336,845	880

Turbine	Easting, m	Northing, m	Terrain elevation, m
47	488,014	5,335,860	880
48	488,240	5,337,428	908
49	488,325	5,336,902	920
50	489,242	5,337,801	920
51	489,025	5,337,283	930
52	488,850	5,336,501	915
53	488,753	5,335,985	886
54	488,526	5,335,267	850
55	490,000	5,337,390	880
56	489,789	5,336,214	854
57	489,966	5,336,876	883
58	490,505	5,336,505	841
59	490,648	5,335,912	840
68	487,553	5,347,444	955
69	488,093	5,336,443	930
70	489,354	5,336,821	885
71	490,624	5,337,253	840

APPENDIX C RECEIVER LOCATIONS

The following table sets out the twenty-five (25) assessed receivers located within 3 km of the proposed turbines considered in the environmental noise assessment together with their respective distance to the nearest turbine. This includes five (5) involved receivers.

(Data received from the proponent on 22 January 2021 and change in status of L19-1 and Q13-1 advised on 20 May 2022 and 13 January 2023, respectively)

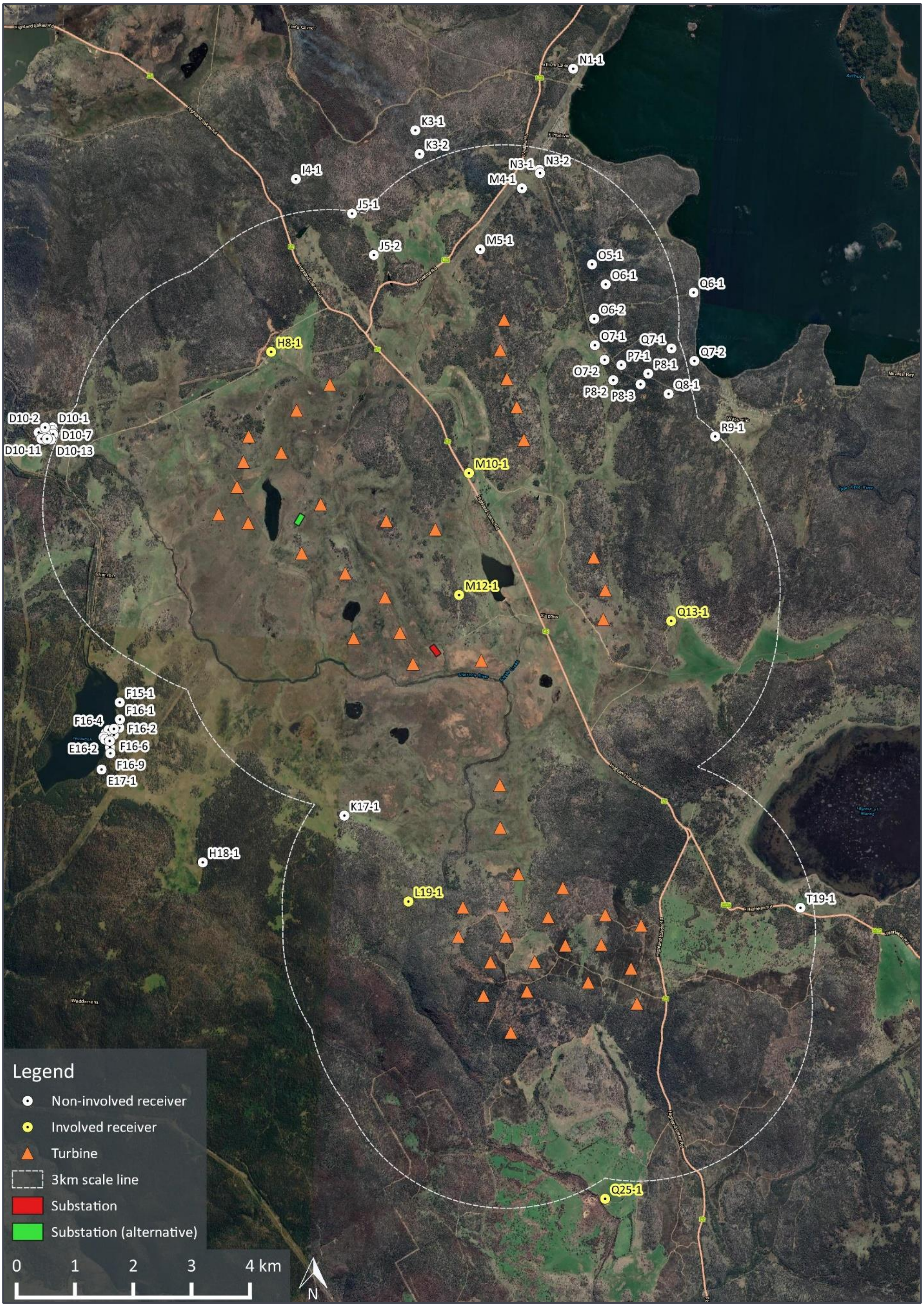
Table 19: Receivers within 3 km of the proposed turbines – MGA 94 zone 55

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine
H8-1 (I)	483,610	5,346,615	914	1,106	13
J5-1	484,827	5,349,077	939	2,960	9
J5-2	485,250	5,348,395	927	2,351	9
K17-1	485,420	5,338,772	893	2,571	45
L19-1 (I)	486,619	5,337,381	875	950	45
M4-1	487,701	5,349,714	980	2,279	68
M5-1	487,060	5,348,620	978	1,283	68
M10-1 (I)	487,138	5,344,780	884	1,109	4
M12-1 (I)	487,116	5,342,683	890	1,198	39
N3-1	487,992	5,349,993	981	2,591	68
N3-2	487,977	5,350,051	980	2,646	68
O5-1	488,990	5,348,498	974	1,788	68
O6-1	489,248	5,348,171	986	1,851	68
O6-2	489,094	5,347,569	939	1,553	68
O7-1	489,136	5,347,117	925	1,622	2
O7-2	489,320	5,346,879	929	1,713	2
P7-1	489,612	5,346,811	950	1,937	3
P8-1	490,082	5,346,697	993	2,329	3
P8-2	489,493	5,346,541	932	1,723	3
P8-3	489,964	5,346,505	966	2,161	3
Q7-1	490,450	5,347,154	1,012	2,839	3
Q8-1	490,456	5,346,374	1,025	2,607	4
Q13-1 (I)	490,773	5,342,494	884	1,173	8
R9-1	491,302	5,345,702	1,010	2,939	6
T19-1	493,327	5,337,746	770	2,752	71

(I) Involved receiver

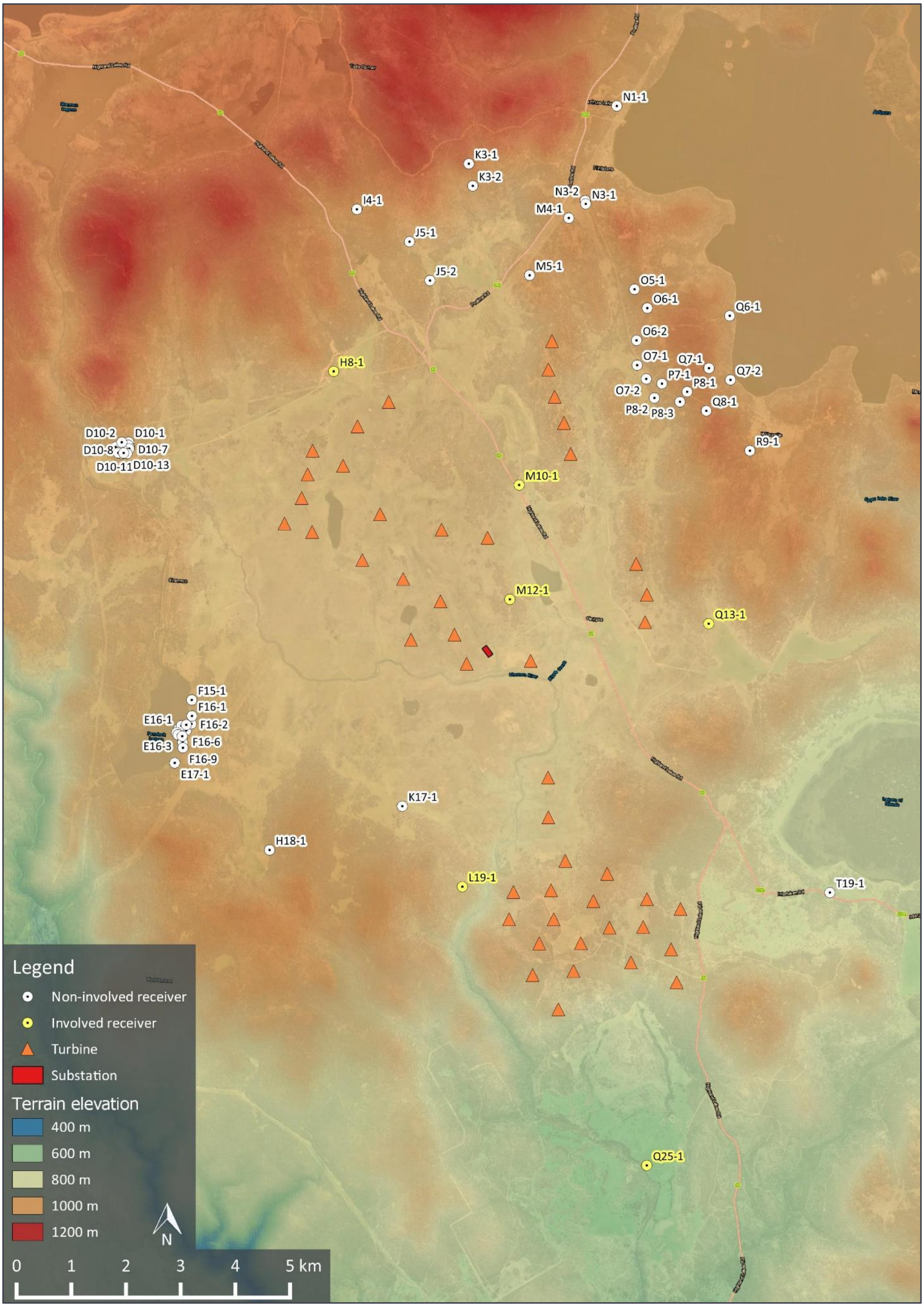
APPENDIX D SITE LAYOUT PLAN

Figure 6: Proposed turbine layout, related infrastructure and receivers



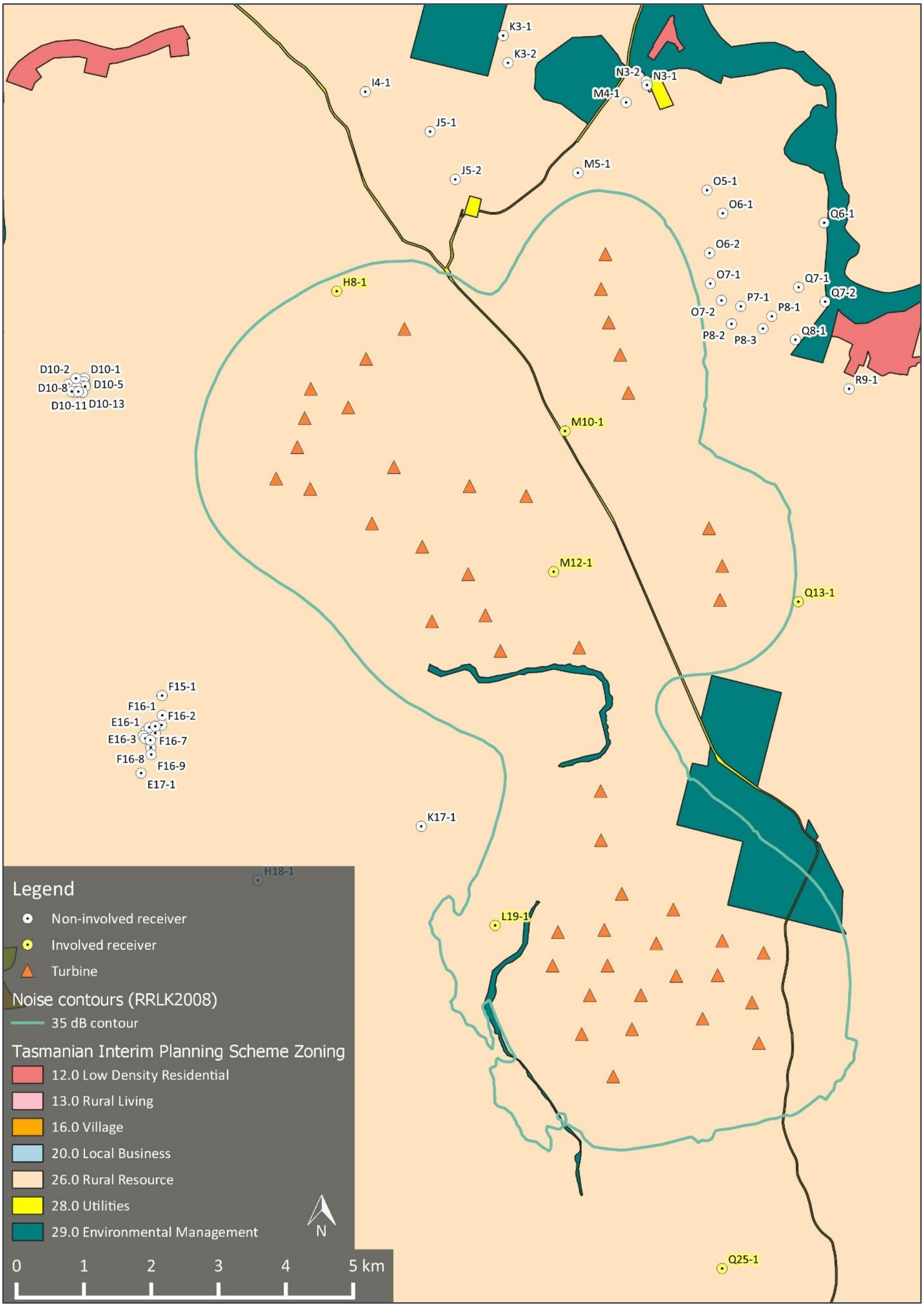
APPENDIX E SITE TOPOGRAPHY

Figure 7: Terrain elevation map for the subject site and surrounding area



APPENDIX F ZONING MAP

Figure 8: Zoning map for the subject site and surrounding area



APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in NZS 6808:2010 *Acoustics – Wind farm noise*, AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and the South Australian EPA 2009 wind farm noise guidelines.

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

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

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

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

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

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 ^{o}C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

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

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant;
- NZS 6808:2010 refers to ISO 9613 as an appropriate prediction methodology for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of G = 0.5;
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613 method generally tends to marginally over predict noise levels expected in practice;
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise (UK IOA good practice guide). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methodologies.

A range of measurement and prediction studies[12, 13, 14] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

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

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

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12 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

13 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

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

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

- Screening effects as a result of terrain are limited to 2 dB;
- Screening effects are assessed based on each turbine being represented by a single noise source located at the maximum tip height of the turbine rotor;
- An adjustment of 3 dB is added to the predicted noise contribution of a turbine if the terrain between the turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50 % greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLAN 8.2 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each turbine and receiver pairing, and then subsequently applies the adjustments to each turbine's predicted noise contribution where appropriate.

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

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

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

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

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

APPENDIX H TABULATED PREDICTED NOISE LEVELS

Table 20: Predicted noise levels (PO6200), dB L_{A90}

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
H8-1 (I)	25.6	25.8	27.7	30.7	33.5	35.8	36.3
J5-1	16.9	17.1	19.0	22.0	24.8	27.1	27.6
J5-2	18.9	19.1	21.0	24.0	26.8	29.1	29.6
K17-1	21.1	21.3	23.2	26.2	29.0	31.3	31.8
L19-1 (I)	27.3	27.5	29.4	32.4	35.2	37.5	38.0
M4-1	15.0	15.2	17.1	20.1	22.9	25.2	25.7
M5-1	22.0	22.2	24.1	27.1	29.9	32.2	32.7
M10-1 (I)	26.6	26.8	28.7	31.7	34.5	36.8	37.3
M12-1 (I)	27.5	27.7	29.6	32.6	35.4	37.7	38.2
N3-1	15.6	15.8	17.7	20.7	23.5	25.8	26.3
N3-2	15.4	15.6	17.5	20.5	23.3	25.6	26.1
O5-1	19.6	19.8	21.7	24.7	27.5	29.8	30.3
O6-1	20.3	20.5	22.4	25.4	28.2	30.5	31.0
O6-2	22.1	22.3	24.2	27.2	30.0	32.3	32.8
O7-1	22.9	23.1	25.0	28.0	30.8	33.1	33.6
O7-2	22.4	22.6	24.5	27.5	30.3	32.6	33.1
P7-1	21.2	21.4	23.3	26.3	29.1	31.4	31.9
P8-1	20.3	20.5	22.4	25.4	28.2	30.5	31.0
P8-2	22.1	22.3	24.2	27.2	30.0	32.3	32.8
P8-3	20.2	20.4	22.3	25.3	28.1	30.4	30.9
Q7-1	16.0	16.2	18.1	21.1	23.9	26.2	26.7
Q8-1	20.8	21.0	22.9	25.9	28.7	31.0	31.5
Q13-1 (I)	23.7	23.9	25.8	28.8	31.6	33.9	34.4
R9-1	16.1	16.3	18.2	21.2	24.0	26.3	26.8
T19-1	17.8	18.0	19.9	22.9	25.7	28.0	28.5

(I) Involved receiver

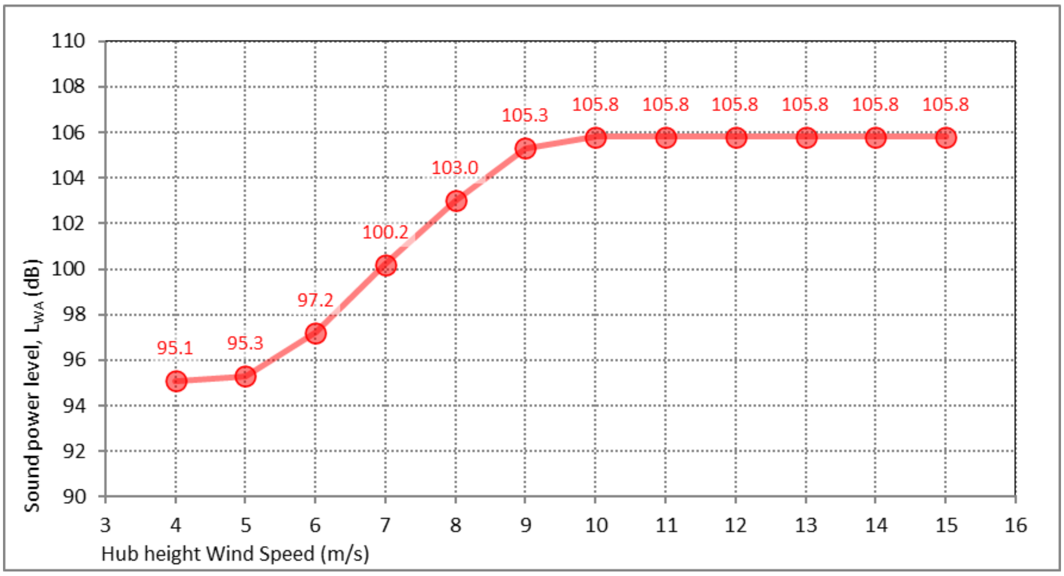
APPENDIX I NZS 6808 DOCUMENTATION

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

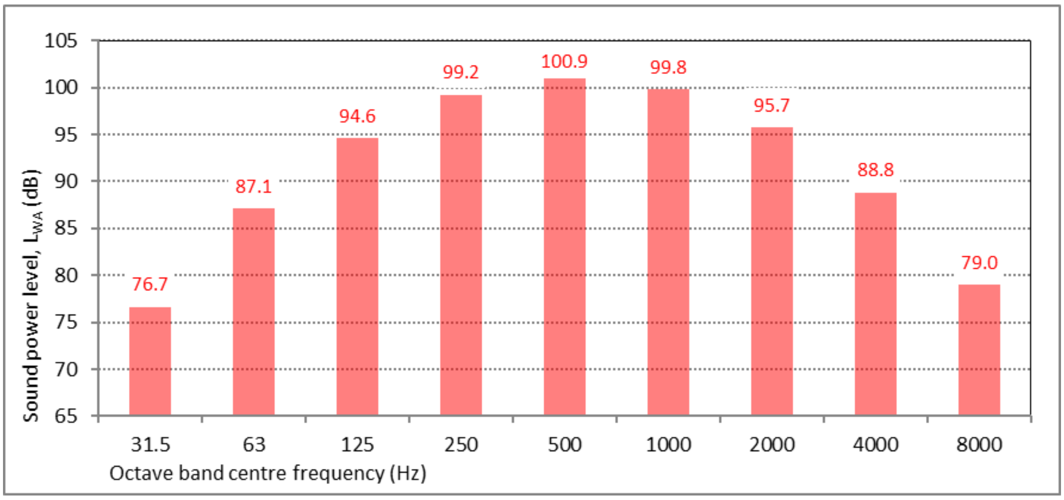
(b) Noise sensitive locations: See Section 2.0 and Appendix C

(c) Wind turbine sound power levels, L_{WA} dB (refer to Section 6.3.1)

Sound power levels (manufacturer specification +1 dB margin for uncertainty), dB L_{WA} – PO6200



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



(d) Wind turbine model: See Table 7 of Section 6.2

(e) Turbine hub height: See Table 7 of Section 6.2

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

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v8.2 (See Section 4.3 and Appendix G)

(h) Meteorological conditions assumed:

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

(i) Air absorption parameters:

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

(j) Topography/screening: 10 m resolution elevation contours – See Appendix E

(k) Predicted far-field wind farm sound levels: See Section 6.4 and Appendix H.

APPENDIX J CONSTRUCTION ACTIVITIES

Figure 9: Construction activities within the subject site