MARSHALL DAY Acoustics

MT MUNRO WINDFARM DEVELOPMENT
NOISE EFFECTS ASSESSMENT

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1.0 INTRODUCTION

Meridian Energy is seeking resource consents to construct and operate a wind farm across the boundary of the Tararua and Masterton District Councils (and Horizons and Greater Wellington Regional Councils) known as the Mt Munro project. Marshall Day Acoustics has been engaged by Meridian Energy to undertake a noise effects assessment to inform the Assessment of Environmental Effects (AEE).

This report considers noise related to the construction and operation of the wind farm, including establishing the site, building internal roads and turbine platforms, concrete batching and vehicle noise, as well as the operation of turbines and other operational noise sources.

1.1 Location

The project site is located approximately 5 km south of Eketahuna to the east of State Highway 2 between Old Coach Road at the northern end and Opaki-Kaiparoro Road at the south. Pūkaha National Wildlife Centre is located on the slopes of Mt Bruce approximately 4 km to the south of the proposed site.

The project site is a compact landform, rising steeply from all sides to a longer main ridge and two smaller ridges. It has been pastoral farmland for well over a century.

Mt Munro was originally part of the "Wairarapa Bush" which began further south and continued to near Woodville. Mt Bruce is now one of the last major remnants of mature native forest that remains of that feature. The Tararua Ranges are to the west and north-west of the site.

The Makakahi River flows towards Eketahuna to the west of the project site between it and SH2. Access to the site for construction is proposed from Old Coach Road.

The proposed Mt Munro project site is shown as red outline in Figure 1.

Figure 1 — Site Location

Thirty-three dwellings have been identified in the general vicinity of the Wind Farm. Five of these dwellings are contracted to the project; noise effects at these properties are not considered in this report.

Dwellings are numbered according to the property database provided by Meridian Energy. Each dwelling is assigned a Mt Munro House (MTMH) number.

1.2 Proposal

The wind farm is proposed to consist of up to 20 turbines, each with blade diameters of up to 136m and a ground level to tip height of up to 160m, with an approximate capacity of 4.5 MW each.

To allow for flexibility in turbine placement, the turbine locations are proposed to be positioned within a designated design envelope. Figure 2 illustrates the site outline as a red line, in which all relevant infrastructure and activities will be established, and the turbine design envelope shown in blue, where all turbines will be located. To ensure the noise effects assessment is sufficiently robust, a conservative approach has been taken, using the highest noise level of five possible layouts within the envelope and from four typical turbine models which would fit the specifications of the wind farm.

Figure 2 — Overview of project site (red line) and turbine design envelope (shaded blue area)

2.0 NOISE PERFORMANCE STANDARDS

This section describes the relevant noise standards and limits which apply to the site.

2.1 Background Comments

Acoustic amenity in the rural environment focuses on dwellings within the rural zone. At dwellings, and for the immediate land surrounding them, peaceful living conditions (particularly during sleeping hours) are to be protected. Away from residences, rural amenity is manifested in the ability to carry out production activities, which often produce noise.

Thus the implementations of the RMA regarding noise generally apply at a "notional boundary", which is defined as a line (for example) 20m from a dwelling in the rural zone. Within this notional boundary, noise protection is similar to that found in residential zones. Outside this boundary, noise limits usually do not apply, so that rural production activities can continue unfettered.

Without this distinction, significant areas of production land would need to be set aside as buffers between properties. With the notional boundary concept in place, both neighbours at a given boundary can carry out production activities up to their property boundaries.

Wind farms in most cases produce noise which have the same effect as any other noise sources in the rural environment, although slightly different measurement methods are required to measure under varying wind conditions.

While normal district plan noise rules apply directly to some elements of wind farms (such as transformers, fans, and vehicles on private roads), special provisions for measurement and assessment are required for the measurement and assessment of turbine noise. This considers that wind turbines only generate noise when wind speeds cause difficulty for noise measurements, and when the background level is elevated due to wind noise. The special techniques which address these issues are presented in New Zealand Standard NZS6808:2010. Where a District Plan does not make reference to this standard, NZS6808:2010 is nevertheless understood to describe the best practice method.

2.2 Referenced Standards

Descriptions of the standards which are referred to in the following sections are as follows.

NZS 6801:1999	New Zealand Standard NZS 6801:1999 - *Acoustics - Measurement of Sound*
NZS 6802:1991	New Zealand Standard NZS 6802:1991 - *Acoustics - Assessment of Environmental Sound*
NZS 6801:2008	New Zealand Standard NZS 6801:2008 - *Acoustics - Measurement of Environmental Sound*
NZS 6802:2008	New Zealand Standard NZS 6802:2008 - *Acoustics - Environmental Noise*
NZS 6803:1999	New Zealand Standard NZS 6803:1999 - *Acoustics – Construction Noise*
NZS 6808:1998	New Zealand Standard NZS 6808:1998 - *Acoustics – The assessment and measurement of sound from wind turbine generators*
NZS 6808:2010	New Zealand Standard NZS 6808:2010 - *Acoustics – Wind farm noise*

2.3 Horizons Regional Council and Greater Wellington Regional Council

Neither Regional Council relevant to this site controls noise effects, except in some cases in relation to off-shore activities which do not apply to this application.

2.4 Operative Tararua District Plan

Rule 5.4.1.2 (a) of the Operative Tararua District Plan states that general noise sources are to be "*measured in accordance with NZS6801: 2008 and shall be assessed in accordance with NZS6802: 2008. Where NZS6802: 2008 does not include the type of noise in question, the appropriate standard or regulation which covers that type of noise shall be used*."

This reference to other standards covering specific noise types applies directly to the use of NZS6808 for wind farm measurement and assessment. This has been successfully applied at other wind farms in the district.

Permitted activity noise criteria are controlled by the following limits:

> *5.4.1.2 (b): 7.00 am - 7.00 pm daily 55 dB LAeq(15min)*
> *7.00 pm - 7.00 am daily 45 dB LAeq(15min) and 75 dB LAFmax*
>
> *These noise limits are not to be exceeded at any point within the boundary of any site used for residential activities or, in the Rural Management Area, at any point within the "notional boundary" of any dwellinghouse on land held in a separate certificate of title or, if the complainant's dwellinghouse is on the same certificate of title, at any point within the notional boundary of the complainant's dwellinghouse.*

Section 5.3.7.4 (g) states that the criteria for assessment specifically include NZS 6808:2010:

> *The expected noise effects arising from the construction, maintenance and operation of the facility, with particular regard to the impact of noise on existing dwellings and the ability of the proposal to meet any relevant standards such as NZS6808:2010 Acoustics – Wind Farm Noise and the NZS6803:1999 Construction Noise or any subsequent versions of these standards.*

2.5 Masterton District Council

The relevant District Plan document is the Operative Combined Wairarapa District Plan.

Wind farms are a Discretionary Activity under this plan, with noise effects requiring specific consideration under the following assessment criteria:

> ***22.1.20 Wind Energy Facilities***
>
> *(v) The actual or potential noise effects of the construction, development and operation of the wind energy facilities, including particular consideration of the special audible characteristics, and the proximity to and effect on settlements or dwellings, and the ability to meet NZS 6808:1998 "Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators; and other relevant standards such as NZS 6803:1999 "Construction Noise"".*
>
> *(viii) The cumulative effects of the proposal.*

Section 27 "Definitions" of the Combined Wairarapa District Plan Part C-Consent Process contains the following definition:

Noise Emission Level - *means a level of sound measured in accordance with NZS 6801: 1999 "Acoustics - Measurement of Sound" and assessed in accordance with NZS 6802: 1991 "Assessment of Environmental Sound" except as expressly provided for in this Plan. Where NZS 6802:1991 does not include assessment of the type of noise in question, one of the following appropriate Standards may be used;*

(iii) NZS 6808:1998 Acoustics – The Assessment and Measurement of Sound From Wind Turbine Generators.

Section 4.5.2 *"Standards for Permitted Activities"* of the *Combined Wairarapa District Plan Part A-Environmental Zones 4. Rural Zone* contains the permitted activity noise criteria which as are follows:

(f) Noise Limits

(i) The sound level from activities within any site, excluding mobile sources associated with primary production (e.g. tractors, harvesters), shall not exceed the following limits within any measurement time interval in the stated time-frames, when assessed at any point within the notional boundary of any dwelling on any site within the Rural Zone but excluding any dwelling on the property where the sound levels are generated, and at any point within the boundary of any site within the Residential Zone:

Daytime *7.00am – 7.00pm 55dBA L_{10}*

Night-time *7.00pm – 7.00am 45dBA L_{10}.*
9.00pm – 7.00am 75dBA L_{max}

(ii) All sound levels shall be measured in accordance with NZS 6801:1999 "Acoustics –Measurement of Environmental Sound", and assessed in accordance with NZS 6802:1991 "Assessment of Environmental Sound".

Noise from other sources are addressed in *Part B – District-Wide Issues.* Section 21.1.13 states:

21.1.13 Noise

(a) Noise Emission Levels shall be subject to zone rules for noise, and shall comply with the standards below.

(b) General

(i) Sound levels shall be measured in accordance with NZS 6801:1999 "Acoustics –Measurement of Sound", and assessed in accordance with NZS 6802:1991 "Assessment of Environmental Sound".

Note:

Where NZS 6802:1991 does not include assessment of the type of noise in question, other appropriate Standards may be used as specified in the definition for "Noise Emission Level".

2.6 Discussion

The noise provisions which are stated or referenced in the relevant District Plans are summarised as follows.

2.6.1 Construction Noise

Construction noise is controlled in the District Plans by NZS6803:1999. This standard sets noise limits which trigger additional consideration of mitigation methods, and propose methods to manage and control noise to reasonable levels.

For a long-term project (longer than 20 weeks) the applicable trigger limits for construction noise received at residential locations (assessed at the façade of dwellings) are as follows:

Table 1 - Construction Noise Limits

Time Period		dB L_{Aeq}	dB L_{Amax}
Weekdays	0630-0730	55	75
	0730-1800	70	85
	1800-2000	65	80
	2000-0630	45	75
Saturdays	0630-0730	45	75
	0730-1800	70	85
	1800-2000	45	75
	2000-0630	45	75
Sundays and Public Holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75

2.6.2 Operational Noise (other than turbines)

Noise from operational activity other than turbines, such as substation noise, vehicle noise on internal roads, and normal maintenance activities, are limited to 55 dBA during daytime (7am – 7pm), 45 dBA night-time, and 75 dB L_{Amax} at night-time.

In the Tararua District Plan these limits are implemented as L_{Aeq} limits; in the Combined Wairarapa District Plan the limits are L_{A10} limits. In both cases noise is assessed at or within the notional boundary of a dwelling.

2.6.3 Wind Turbine Operational Noise

Wind Turbine noise is controlled by the methods and recommended noise limits in NZS6808, either by direct reference or by the exclusion of wind turbines from the scope of NZS6801 and NZS6802. There is reference to the 1998 version of this standard in the Combined Wairarapa District Plan, and reference to the 2010 version of the standard in the Operative Tararua District Plan as Amended by Decisions (2009).

The 2010 version of the Standard contains improvements to the 1998 version which are generally accepted as best practice. The improvements to the standard provide a more rigorous method of measuring and assessing wind farm sound, which assists both the developer and the Councils in ensuring adequate protection from noise effects for the community.

We therefore consider it appropriate that the 2010 version of the NZS6808 should be applied for setting noise limits, and for measurement and assessment of wind turbine noise.

With respect to the provision in NZS6808:2010 to apply a high amenity noise limit of 35 dB L_{A90} or Background + 5 dB at night-time under certain wind conditions, the dwellings adjacent to the wind farm site do not constitute "special circumstances" as described in that standard, as detailed below:

- The relevant permitted activity limit (45 dBA L_{10} night-time in all District Plans) is the least stringent limit available and cannot be construed as indicative of a highly protected noise environment. In both the Tararua and Combined Wairarapa District Plans, these limits have recently been reviewed and subjected to public comment.
- The Policies and Methods related to environmental quality and amenity in the Operative Tararua District Plan do not propose that a distinct "high amenity" rural residential provision be included. In general, the plan seeks to avoid conflict between production activities and residential activities by encouraging residential growth to occur in Urban zones, and by providing a permitted activity limit that, while not overly stringent, achieves a reasonable degree of noise amenity in the rural environment.
- Similarly, the Combined Wairarapa District Plan recognises that conflict can arise between rural lifestyle residential activities and production activities, and seeks to restrict such residential activities, while providing a reasonable degree of protection for rural residences. No "high amenity" protection is included in this plan.

On the basis of the protections and intentions of the relevant District Plans, there is no indication that any of the properties near the proposed Wind Farm justify bring the "special circumstances" provisions as discussed in NZS6808:2010 into play. Accordingly, the resulting recommended noise limit for turbine noise is 40 dB L_{A90} or the background sound level + 5 dB, whichever is the greater.

3.0 ASSESSMENT METHODOLOGY

Noise has the potential to cause adverse environmental effects and is a factor which is considered as part of the resource consent process.

The presence of noise does not necessarily constitute an adverse effect. The level and character of noise, and other factors such as the duration, frequency of occurrence, and also the ambient noise environment are factors in considering noise effects.

Noise standards propose measurement and assessment methods which sometimes include limits and thresholds above which noise can produce adverse effects. Methods for assessing noise character and for considering other noise-related factors are also provided in the standards.

It is generally agreed that compliance with the limits recommended by NZS6808:2010 results in an appropriate degree of amenity and health protection for the majority of those exposed. It is not intended that noise levels will be undetectable, nor that the noise environment will not change as a result of new noise sources. However, it seeks that any resulting noise levels will not be unreasonable.

In the pre-lodgement stages of a wind farm project, these noise standards are used to assist the project design such that a design may be proposed which complies with the relevant noise standards. Thus, an Assessment of Environmental Noise Effects report submitted with an application will generally have already considered the reasonableness of noise effects and be able to state whether any noise effects are proposed which are above these standards.

The assessment of noise effects from a wind farm consists of the following:

- Determining appropriate standards;
- Prediction of noise levels from proposed activities;
- Assessing the existing noise environment and establishing noise limits; and
- Evaluation of the predicted noise levels in light of the relevant standards and the existing environment.

The following sections describes the means by which appropriate standards and predicted noise levels are determined.

3.1 Determining Appropriate Standards

Section 2.0 of this report describes the consideration taken of district plan documents and relevant standards, as well as describes the resulting set of standards that form the basis for this assessment.

The relevant District Plans refer to New Zealand Standards NZS 6801 (measurement of noise), NZS 6802 (assessment of noise), NZS 6803 (assessment of construction noise) and NZS 6808 (assessment of wind turbine noise). These standards provide further guidance on the specific steps to be taken in the prediction, measurement, and assessment of potential noise sources.

In some cases, the applicable noise limits depend on the activity being assessed, such as the construction noise limits which depend on the likely duration of the construction, or the wind turbine noise limit which depends in part on the existing background noise of the environment.

3.2 Predicted Noise Levels

The prediction of noise levels in general is done by applying “propagation losses” to “sound power levels”.

Sound power levels are measured values which describe the total amount of sound energy emitted by a noise source such as a turbine or collection of construction machinery. In the case of wind turbines, the sound power level is provided by manufacturers of wind turbines in the form of an independently conducted noise measurement report. The specific turbines used to represent the wind farm are discussed in Operational Noise Effects.

Propagation losses describe the amount of sound which is lost to the environment before arriving at a nominated receiver and are calculated on the basis of the proximity of the receiver to the source, and from information about ground and atmospheric characteristics.

Noise level predictions of wind turbines and other fixed-location activities such as substations and construction machinery are carried out by the use of noise propagation models implemented in SoundPLAN software. In this software, the ISO 9613-2 industrial noise propagation model is used. This is an internationally recognised model which is referenced for wind farm predictions by NZS6808:2010.

3.2.1 ISO9613-2 Propagation Model

The ISO9613-2 industrial noise model predicts the sound pressure level at receiving locations by calculating the sound attenuation due to distance, air absorption, shielding from topographic features and ground attenuation, and subtracting these from the measured octave-band sound power spectrum of the sound source. The numerical value which results from this prediction is expressed as decibels $L_{Aeq.}$

In the case of wind turbine noise, this value is compared against the L_{A90} noise limit as if it were an L_{A90} value. In practice the L_{A90} value tends to be around 2 dB quieter than the L_{Aeq} value, which means there is a slight conservatism in the wind farm’s ability to comply with the L_{A90} noise limit. This conservatism is built into the NZS6808:2010 assessment method. In summary, the predicted wind farm L_{Aeq} levels will generally be 2 dB greater than the resulting measured L_{A90} levels.

Subsequent to the publication of NZS6808:2010, a “best practice” document for the assessment of wind turbine noise was published by the UK Institute of Acoustics, and generally adopted in New Zealand as best practice. This document includes comment on calculation of wind farm noise predictions, and generally results in a more conservative (higher noise level) prediction. The key feature is that it limits the amount of shielding the terrain may provide, so if a turbine is obscured from view of a dwelling, the new methodology would treat it as mostly exposed, rather than subtracting a significant amount of noise due to the screening.

Noise Statistics – A Brief Overview

Sound levels which vary over time can be represented statistically by single-number values which have been shown to agree well with human response to noise level.

Within a measurement period (such as the 10-minute period used for wind farm analysis), a number of commonly used statistics includes L_{Amax}, L_{A10}, L_{Aeq}, and L_{A90}. Each of these statistics is represented by a decibel *level* scale and is derived from *A*-weighted sound which mimics the frequency response of human hearing—hence the "L_A" designation in each.

L_{Amax} represents the single noisiest event within the measurement period. This is generally not relevant during daytime noise assessment when people typically respond to "the average noise level", but it is important for sleep disturbance at night.

L_{A10} represents the sound level exceeded for 10% of the measurement period, and L_{Aeq} represents the average sound level. Both of these statistics are used to describe the sound level "when events are occurring", such as vehicle activity on a road.

L_{A90} represents the sound level exceeded for 90% of the measurement period. This is referred to as the "background sound level" and is used to describe the noise environment when transitory events such as vehicle activity cease. In the case of wind farms L_{A90} allows the relatively steady wind farm noise to be measured in the presence of other transitory noises such as traffic, wind gusts, or animal noises.

Typical sound levels are illustrated in Appendix C.

3.3 Modelling Assumptions

ISO9613-2 assumes a slight downwind condition in all directions; this provides a conservative scenario for all noise receivers. In contrast, the noise level at a receiver which is upwind from the noise source will be less than predicted by ISO9613-2 because sound does not propagate equally in all directions when wind is present.

For most noise sensitive locations, particularly those near to a wind farm, the prediction provided by this noise model will be higher than actually experienced, because in reality the receivers will be upwind of some of the noise sources and therefore those sources will contribute less sound than predicted by this method.

The "downwind in all directions" case is the one required to be considered by NZS6808:2010 in assessing whether the wind farm is capable of meeting the prescribed limits and is presented in this report as the primary prediction level.

3.4 Evaluation of predicted noise levels

The predicted noise levels are compared with the limits of acceptable noise established for the respective noise sources.

For construction noise and non-turbine operational noise sources, this test of acceptability is established within District Plan noise rules. For operational noise from the wind turbines themselves, NZS6808 offers a means of assessment of the acceptability of the noise level as follows.

NZS6808 requires that the L_{A90} noise level at any residential site caused by a wind turbine generator or wind farm should not exceed a limit of the existing background level (L_{A90}) plus 5 decibels, or 40dB L_{A90}, whichever is the greater. In carrying out a pre-construction assessment of effects, the predicted L_{Aeq} value is to be used to approximate the L_{A90} value which will be measured post-construction.

This level of 40 dB L_{A90} has been based on an internationally accepted indoor noise limit of 30 – 35dB L_{Aeq} designed to protect against sleep disturbance and assumes a reduction from outdoors to indoors of 10 decibels with partly open windows (Berglund et al). It is noted that this is another conservative approach, as up to a 15-decibel reduction is typically achieved by a dwelling, with windows open approximately 200-300 mm.

The portion of the limit which depends on existing background sound level recognises that in the presence of wind, noise levels increase due to vegetation and other objects with which wind interacts, which typically results in a natural increase in noise levels.

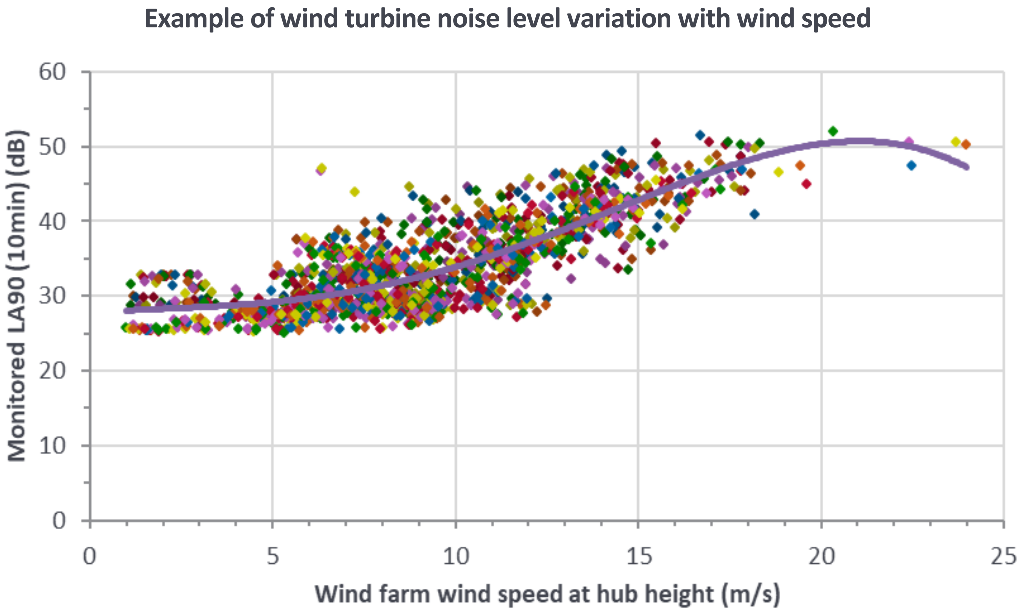
Wind turbine noise is usually most noticeable during lower wind speeds of 6–8 m/s (22–29 km/hr) when the sound level produced by the wind farm can be comparable with, or greater than, the background noise generated by the wind. At higher wind speeds, the background noise due to the wind itself can partially mask the turbine noise, and this forms the basis for the increasing noise limit when the pre-installation background noise level increases with wind speed.

To assess wind farm noise against this limit, measurements of pre-installation background noise level are plotted against measured wind speed. In accordance with the method described in NZS6808:2010, a regression line through these measurement points is used to represent the pre-installation noise level, and the corresponding noise limit is derived from this line.

The predicted wind farm noise level can then be compared with this noise limit line, and if the limit is exceeded, redesign of the wind farm or other mitigation measures are considered.

An example of a measurement of background noise and wind speed is given in Figure 3. In this case note that the background sound level appears to be controlled by steady noise sources below 6 m/s, and begins to rise along with increased wind speed above 6 m/s.

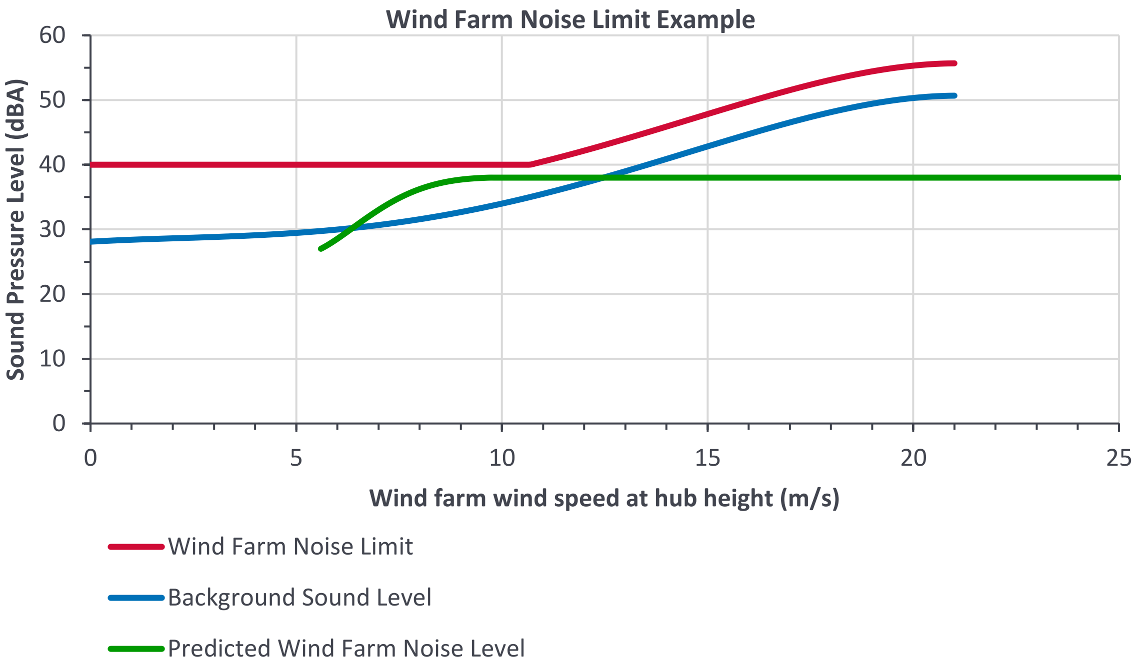
Figure 3—Typical Background Noise Measurement



The resulting comparison of predicted wind farm noise relative to wind speed against the background sound regression line and the corresponding noise limit is shown in Figure 4.

In this example the noise limit is determined by the “40 dB L_{A90}” part of the rule when wind speeds are below 11 m/s, and by the “background + 5 dB” part of the rule when above 11 m/s. The green line takes the shape of the particular wind turbine’s noise level / wind speed relationship. The peak level which occurs around 10 m/s is the level used to describe the sound level of the wind farm when presented numerically.

Figure 4 - Determination of Wind Farm Noise Limit



In the example in Figure 4, the predicted noise level from the wind farm at this particular site is, at all wind speeds, less than the NZS6808:2010 noise limit. If the green line lies above the red line at any point, it indicates non-compliance at the wind speeds where this occurs.

It should be noted that compliance with NZS6808 noise limits does not indicate inaudibility of the wind farm. Under some circumstances the wind farm may be the dominant noise source in the environment. In other circumstances the wind farm may not be dominant but would still be audible. In other circumstances the wind farm may in fact be inaudible.

However, whether dominant or simply audible, the noise levels produced by wind farms which comply with this limit are considered by NZS6808:2010 to be acceptable, and of sufficiently low level to avoid sleep disturbance, intrusion on normal activities, erosion of amenity, or to cause any adverse health effects.

The degree to which the turbine level exceeds the background level (in Figure 4, the area above the blue line but beneath the green line) informs the likely change to the noise environment resulting from the turbines.

4.0 CONSTRUCTION NOISE

This section describes the inputs, assumptions, and outputs associated with the prediction of noise from construction noise, and considers the effects of construction noise and appropriate mitigations.

4.1 Construction Noise Predictions

Noise modelling, as described in section 3.2, has been carried out to estimate the noise level from construction activities. In the following sections we separately address the most significant construction activities:

- Construction of turbine foundations and platforms
- Operation of a concrete batching plant
- Construction of internal roads
- Construction traffic noise on internal roads

We note that no quarrying within the Site is proposed, although some crushing of extracted material could occur at the site of extraction, should suitable material be discovered.

4.1.1 Turbine Foundation and Platform Construction

During turbine foundation and platform construction (including O&M building and substation site construction) the dominant noise sources will involve the following:

- Large Bulldozer or Scraper
- Loader
- Dump trucks
- Trucks delivering turbine components

Calculation of noise levels from the foundation and platform construction assumes the above fleet of machinery operates at each turbine site. Noise levels are calculated at each dwelling's notional boundary.

The sound power levels used for the assessment are as follows:

Table 2—Turbine Platform construction equipment sound power levels

		Equipment Sound Power Levels Octave Band Frequency (Hz)						
	A	63	125	250	500	1000	2000	4000
Bulldozer/Scraper	113	117	111	105	109	106	105	105
Loader	110	114	115	108	106	105	103	97
Dump trucks x 3	116	102	109	117	114	111	105	100
Trucks delivering turbine components	98	98	98	96	95	94	90	85
Total Platform Construction Package	**118**	**119**	**117**	**118**	**116**	**113**	**109**	**107**

The calculated sound levels at dwellings for turbine platform construction is detailed in Table 3. The maximum sound level received from the construction of all turbine platforms is less than 45 dB L_{Aeq} at all dwellings external to the project site.

At all noise sensitive locations, the calculated noise from turbine foundation and platform construction activities complies by a very large margin with the daytime construction noise limit (70 dB L_{Aeq}) and complies with night-time construction noise limit of 45 dB L_{Aeq}.

4.1.2 Entrance and Village Construction

Construction of the project village and entrance facilities will occur at the Site Entrance to north of the project site as illustrated in Figure 5. The construction of this facility will be done using the same construction equipment as described in Section 4.1.1 - Turbine Foundation and Platform Construction.

The calculated sound levels at dwellings for entrance and village construction is detailed in Table 3.

The construction of the village would produce noise levels which comply with the night-time construction noise limit, except at dwellings MTMH 29 and 30, and MTMH12 which is a contracted property. At those dwellings the noise levels easily comply with daytime construction noise limits.

Figure 5 – Site Entrance Location

4.1.3 Concrete Batching Plants

We understand that temporary concrete batching plants will be established within the turbine envelope (or exclusion zones). These locations are well represented by the turbine pad locations, and so these have been used to determine the noise level likely to arise at dwellings.

The sound power levels used for the assessment of this activity are taken from recent measurements of a batching plant of similar size to the proposed plant, and are as follows:

Table 3—Concrete Batching Activity sound power levels

		Equipment Sound Power Levels Octave Band Frequency (Hz)						
	A	63	125	250	500	1000	2000	4000
Total Concrete Batching Activity Sound Power Level	**108**	**110**	**108**	**106**	**108**	**101**	**98**	**94**

The calculated sound levels at dwellings for turbine platform construction is detailed in Table 5. The maximum sound level received from concrete batching activities is less than 45 dB L_{Aeq} at all dwellings external to the project site. A noise level of 45 dB L_{Aeq} is the most stringent (night-time) limit for construction noise specified in NZS6803:1999.

At all noise sensitive locations, the calculated noise from concrete batching plants located within the turbine envelope complies by a very large margin with the daytime construction noise limit (70 dB L_{Aeq}), and complies with night time construction noise limits by at least 11 decibels.

The batching plant may be located outside the envelope, but within the exclusion area. Provided the batching plant is at least 35 metres from a dwelling, this plant would still comply with the daytime construction noise standard limit of 70 dBA. To operate during the night (meeting the 45 dBA night-time construction noise limit) the plant would need to be at least 560 metres from a dwelling.

4.1.4 Internal Road Construction

For most dwellings, construction of internal roads will occur at similar distances as turbine platform construction. For these dwellings the road construction noise is well described by the noise levels in Section 4.1.1.

Several dwellings are significantly nearer to internal road construction activities than to turbine platforms. For these dwellings we have separately assessed construction noise activities occurring at the locations where the roads come nearest to these dwellings.

Modelling of the construction of these roads has been carried out using the same construction equipment as described in Section 4.1.1 - Turbine Foundation and Platform Construction.

The calculated sound levels at dwellings for turbine platform construction is detailed in Table 5.

The construction of roads as it draws nearest to the three external dwellings (MTMH 10,11, and 30) would produce noise levels which exceed the night-time construction noise limit. Road construction noise is calculated to comply with the daytime construction noise limit at all locations.

4.1.5 Construction Traffic Noise on Internal Roads

Noise from construction traffic on Internal Roads (those roads constructed on private property) must also comply with the noise limits in the Construction Noise Standard NZS6803:1999.

The most critical activity from a noise emissions perspective will be the movement of aggregate and concrete. We have reviewed the roading and envelope layout for this project, and assumed that for the most noise-intensive construction period, around 100 - 150 trucks per day will enter at the north road entrance and move to each portion of the turbine envelope. This intensity of activity represents the constant presence of a truck on each of the roading sections, which is a likely constraint during the most intensive portion of construction activity. Noise levels would therefore be concentrated near the site entrance, and subsequently spread out as trucks diverge to the various turbine sites.

The trucks used in this assessment have sound power levels described in Table 4.

Table 4—Construction Traffic Sound Power Levels

		Equipment Sound Power Levels Octave Band Frequency (Hz)						
	A	63	125	250	500	1000	2000	4000
Dump truck	111	97	104	112	109	106	100	95
Total Steady Traffic Noise	**111**	**97**	**104**	**112**	**109**	**106**	**100**	**95**

The noise levels described by this assessment are listed in Table 5.

At all dwellings the calculated construction traffic noise levels are less than the night-time permitted activity noise limit (45 dBA L_{eq}).

4.2 Summary of Construction Noise Levels

The noise levels calculated in the above sections are summarised in the following table. Properties shaded blue are internal to the project, and noise effects are not to be considered in this assessment.

Table 5 – Predicted Construction Noise levels

Dwelling	Sound Level (dB L_{Aeq})					
	Turbine Pad Construction - All sites	Turbine Pad Construction - Loudest site	Village Construction	Concrete Batching Plant	Internal Road Construction	Internal Road Traffic
MTMH 01	46	42	26	31	37	23
MTMH 02	39	31	22	21	27	15
MTMH 03	42	37	20	28	32	18
MTMH 04	40	33	21	24	28	16
MTMH 05	40	33	21	23	29	16
MTMH 06	34	27	21	18	25	11
MTMH 07	35	26	20	17	24	11
MTMH 08	41	36	32	26	40	23
MTMH 09	42	36	34	26	41	24
MTMH 10	41	35	41	25	50	28
MTMH 11	41	36	41	26	47	28
MTMH 12	41	38	58	28	69	43
MTMH 13	41	36	42	27	42	23
MTMH 14	39	33	35	23	35	18
MTMH 15	38	32	36	23	35	19
MTMH 16	44	38	10	27	30	16
MTMH 17	42	35	10	25	30	14
MTMH 18	41	32	12	22	29	15
MTMH 19	39	30	14	20	27	12
MTMH 20	40	32	14	21	27	14
MTMH 21	43	39	8	28	25	15
MTMH 22	41	35	15	24	25	15
MTMH 23	42	35	18	25	24	15
MTMH 24	42	38	14	28	22	16
MTMH 25	40	34	42	24	42	25
MTMH 26	37	31	21	21	26	13
MTMH 27	38	29	15	19	26	12
MTMH 28	42	35	13	25	27	15
MTMH 29	41	35	46	26	43	25
MTMH 30	41	37	60	27	57	36
MTMH 31	41	34	14	24	26	14
MTMH 32	40	33	14	23	26	14
MTMH 33	40	33	14	23	27	13

4.3 Construction Noise Effects

The noise from construction activities will in most cases to the southeast of the wind farm be received in the context of daytime rural activities, characterised by quiet periods dominated by bird and insect noise, stock and dog noise, and wind in vegetation, and punctuated by vehicles and farm machinery. To the northwest of the wind farm, daytime noise will commonly be dominated by traffic noise from SH2.

The ambient sound levels existing at various locations around the site are described in more detail in the following "operational noise" section. In general, the daytime background sound level at neighbouring residential sites (as described in Section 6.1) is around 30 dB L_{A90} during relatively calm wind conditions.

The effects of noise from construction can be considered against the existing noise environment. Noise levels which are 10 decibels above the background (L_{A95}) sound level generally are considered acceptable as normal, ongoing activities; construction noise activities are tolerated at significantly higher levels due to being temporary.

The calculations of construction noise at external dwellings given in the preceding section can be summarised as follows:

Table 6—Construction Noise Summary

Construction Activity	Typical Sound Level Range dB L_{Aeq}
Turbine Foundation and Platform construction	34 – 44
Entry and Village Construction	10 - 60
Concrete Batching	17 – 28
Internal road construction	22 – 57
Traffic noise from construction traffic	11 – 36

For most properties the construction noise effects will be slight, as they are of the same level as typical daytime activity noise, and not more than 10 decibels above the "calm conditions" background noise level. For much of the time, wind noise would significantly mask construction noise sound, rendering it a negligible effect.

For a number of properties, initial entrance and road construction will cause a noticeable increase in daytime noise levels, although noise levels will comply with daytime permitted activity noise limits, and comply by a large margin with construction noise limits for long-term construction activities.

Following the initial establishment of the entrance and site roads, construction activities are predicted to comply with daytime and night-time permitted activity limits (and with the construction noise limits at all times) and to have a negligible noise effect.

4.4 Construction Traffic on External Roads

Noise from construction traffic on external roads, like noise from any other vehicles on the roads, is not controlled by the district plan.

The increase in traffic on SH2 due to construction activities is not significant; the increase on Old Coach Road is however very significant – at the peak of construction there will likely be of the order of 100 to 150 truck return trips per day carrying aggregate into the site, over a period of 8 months.

The transportation Assessment report[1] indicates that current traffic on Old Coach Road is typically around 60 vehicles per day, with 6% heavy vehicles.

It is generally not appropriate to directly apply traffic noise models for such low volume roads as they are intended to model continuous traffic activity. A more relevant qualitative measure of effect is that there would be a fairly constant presence of heavy vehicles on the road during construction hours, rather than several cars per hour, and occasionally a truck.

For the intensive period where aggregate is being brought to site, residents along Old Coach Road will experience significantly more traffic noise from public roads than they presently do. This will be a temporary activity with temporary effect, and as such will be more readily tolerated than if it were a permanent operational activity.

Temporarily elevated noise effects associated with construction are not uncommon and would typically be managed through a Construction Effects Management Plan (CEMP) or similar, controlling matters such as hours of construction traffic movement, to ensure reasonable amenity is maintained and to avoid sleep disturbance to adjoining occupiers.

[1] Tonkin & Taylor Ltd – *Mount Munro Windfarm – Traffic and Transportation Effects Assessment*

5.0 OPERATIONAL NOISE —WIND TURBINE NOISE

This section documents the details used in the modelling process.

5.1 Turbine Models Assessed

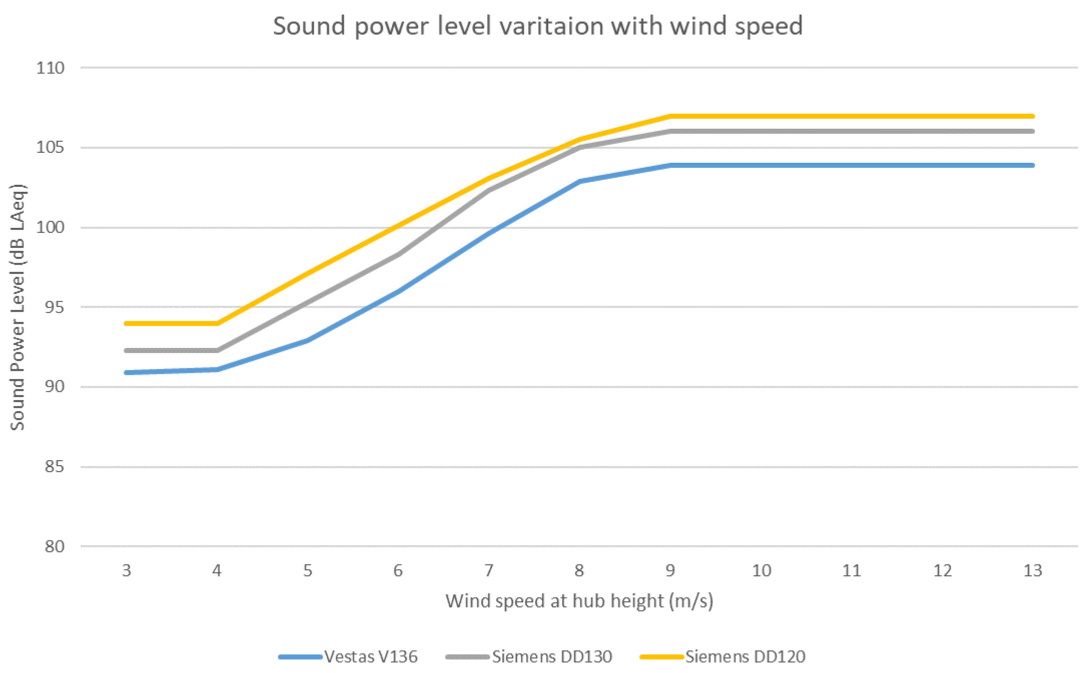
The turbine models considered in this assessment are:

- Siemens DD120
- Siemens DD130
- Vestas V136

5.2 Model Inputs—Wind Curve

The sound emitted from a wind turbine varies with wind speed. The wind/noise relationship is described by the wind curve for the turbine. When reported as a single-number value, turbine noise is modelled on the basis of the wind speed at which the peak in sound power level occurs. The peak sound power level for the turbines modelled can be seen in Figure 6.

Figure 6 – Sound Power Level Curves



The wind speed at which the peak sound power level occurs for the V136, DD120, and DD130 is 9m/s. The peak sound power level for the turbines assessed range between 104 and 107 dBA. In the sound level predictions which follow, this 3-decibel range of sound power levels is reflected in a corresponding range of sound pressure levels.

5.3 Model Inputs—Frequency Spectrum

The shape of the frequency spectrum used in the noise modelling is taken from technical documents for each turbine model provided by the relevant manufacturer. The manufacturer-supplied values are shown in Table 7. Where the supplied spectrum data was for a wind speed less than that which produces the maximum sound output, an adjustment was made so that our model correctly reflects the highest sound power level across the noise/windspeed curve for each turbine. For instance, 1.5 dB was added to each octave-band value given for the Siemens DD120 to reflect its full power noise level of 107.0 dBA at 10 m/s and higher.

Table 7 – Modelled Turbine Sound Power Level Spectra

			Octave Band Frequency (Hz)							
	m/s	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Siemens DD120	**8**	**105.5**	87.1	90.3	92.0	94.6	99.0	102.2	96.6	87.9
Siemens DD130	**8**	**105.0**	87.2	91.7	93.6	96.1	98.5	99.9	97.6	88.2
Vestas V136	**10**	**103.9**	79.8	86.8	91.3	93.6	93.4	91.0	86.1	78.9

5.4 Model Inputs—Source Location

Each turbine has been modelled as a point source at the height of the nacelle for each model. This appropriately represents the observation that the noise generated by a wind turbine is mainly emitted from the tip of each blade, which reaches its maximum output as it passes downward through horizontal (at approximately the height of the hub), and to a nearly negligible extent from the nacelle (which houses the rotating machinery) and the body of the tower itself, which can radiate mechanical noise from the generator housing if not properly isolated.

The wind-turbine-specific implementation of ISO 9613 which includes the IOA best practice advice includes additional consideration of tip height when evaluating shielding from the turbine source, effectively placing some sound power at highest point of the tip of the rotor.

5.5 Model Inputs—Propagation Path

The path taken by noise as it travels from turbine to dwelling affects the level and spectrum of sound received. The noise level decreases as it propagates further from the turbine, at a rate of approximately 6 decibels per doubling of distance, as the sound is spread over progressively larger areas.

Additional attenuation of sound occurs due to absorption by air (primarily at high frequencies), by interaction with the ground (primarily at mid frequencies), and by limited shielding from terrain or other structures. These factors are accounted for in the ISO 9613 sound propagation model and are introduced into the SoundPLAN model by incorporating detailed ground contours of the land between turbines and dwellings.

5.6 Model Outputs

Predicted noise levels for dwellings near the wind farm are listed in Table 8 below. Properties shaded blue are internal to the project, and noise effects are not to be considered in this assessment.

The predicted noise levels are expressed as decibels L_{Aeq} Sound Pressure Level, and do not include contribution from noise sources other than the wind turbines. Noise levels relate to the peak sound output, which typically occurs at wind speeds of 9 - 10 m/s at hub height. The sound level at lower wind speeds will be less, as determined by the wind turbine noise curves shown in Figure 6. The range of noise levels relates to the varying sound power level of the four tested turbine models.

Table 8 - Predicted Turbine Noise Levels

Dwelling Number	Noise Level (dB L_{Aeq})
MTMH 01	40 – 43
MTMH 02	35 – 38
MTMH 03	36 – 38
MTMH 04	33 – 36
MTMH 05	33 – 36
MTMH 06	28 – 31
MTMH 07	29 – 31
MTMH 08	34 – 37
MTMH 09	35 – 38
MTMH 10	34 – 38
MTMH 11	34 – 37
MTMH 12	37 – 40
MTMH 13	33 – 36
MTMH 14	31 – 33
MTMH 15	31 – 34
MTMH 16	36 – 39
MTMH 17	34 – 37
MTMH 18	34 – 36
MTMH 19	32 – 34
MTMH 20	33 – 35
MTMH 21	36 – 38
MTMH 22	34 – 36
MTMH 23	34 – 37
MTMH 24	33 – 37
MTMH 25	33 – 36
MTMH 26	34 – 37
MTMH 27	31 – 32
MTMH 28	35 – 37
MTMH 29	33 – 36
MTMH 30	35 – 38
MTMH 31	34 – 35
MTMH 32	33 – 35
MTMH 33	34 – 35

The predicted noise level at each dwelling for each turbine and layout combination are listed in Appendix D. The extent of operational turbine noise levels for each turbine option are presented graphically as noise contour line maps in Appendix E.We note that dwellings further from the wind farm than those listed above will receive lower noise levels which comfortably comply with the noise limits in NZS6808:2010.

6.0 ASSESSMENT OF OPERATIONAL NOISE EFFECTS

To provide a noise assessment which supports an envelope approach to consenting, we have considered the highest level of noise received at each dwelling in Table 8 – which relates to the noise generated by the Siemens DD120 turbine. These noise levels are compared with measured background noise levels to inform discussion around the likely changes to the noise environment caused by wind turbines.

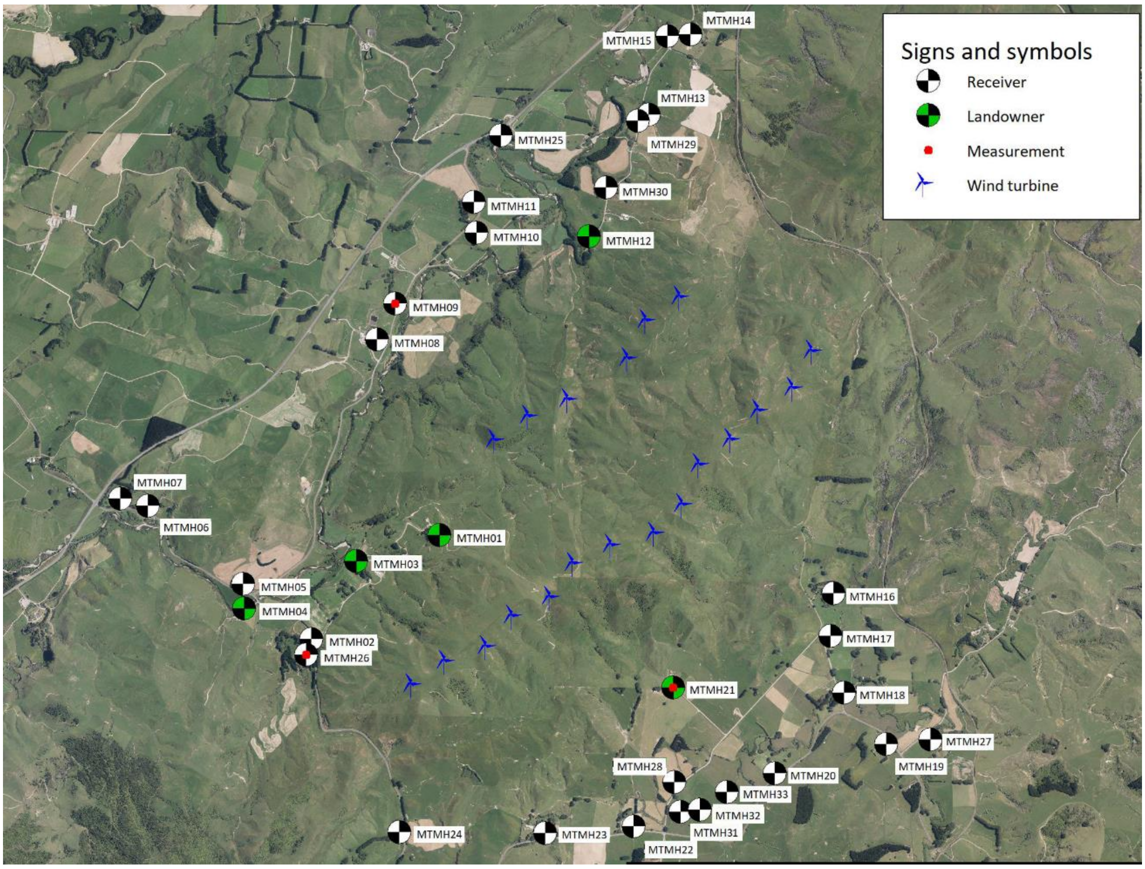
6.1 Background Sound Level Measurement Locations

Background sound level measurements have been taken at locations representative of clusters of noise-sensitive dwellings. These measurements are used in NZS6808:2010 to establish turbine noise limits, and to allow comparison of pre- and post-construction noise levels.

Background noise measurements were conducted during Dec 2022 – Jan 2023 at the following locations as shown in Figure 7:

- MTMH 09
- MTMH 21
- MTMH 26

Figure 7—Assessed Dwelling Locations



The following figures show the measured sound level vs wind speed data for these sites – each data point represents a 10-minute noise level measurement. The full set of data for both daytime and night-time is provided in the first figure of each pair, and the night-time only data is shown in a second figure. It is the night-time only data which is used to establish the noise limits applicable to the wind farm.

Each graph also includes a line of best fit, with its describing equation displayed at the top of the chart. This line of fit is used to represent the background sound level in the comparison of turbine noise in the section which follows.

6.1.1 Dwelling MTMH 09

Figure 8 – Background Noise Measurements at MTMH09

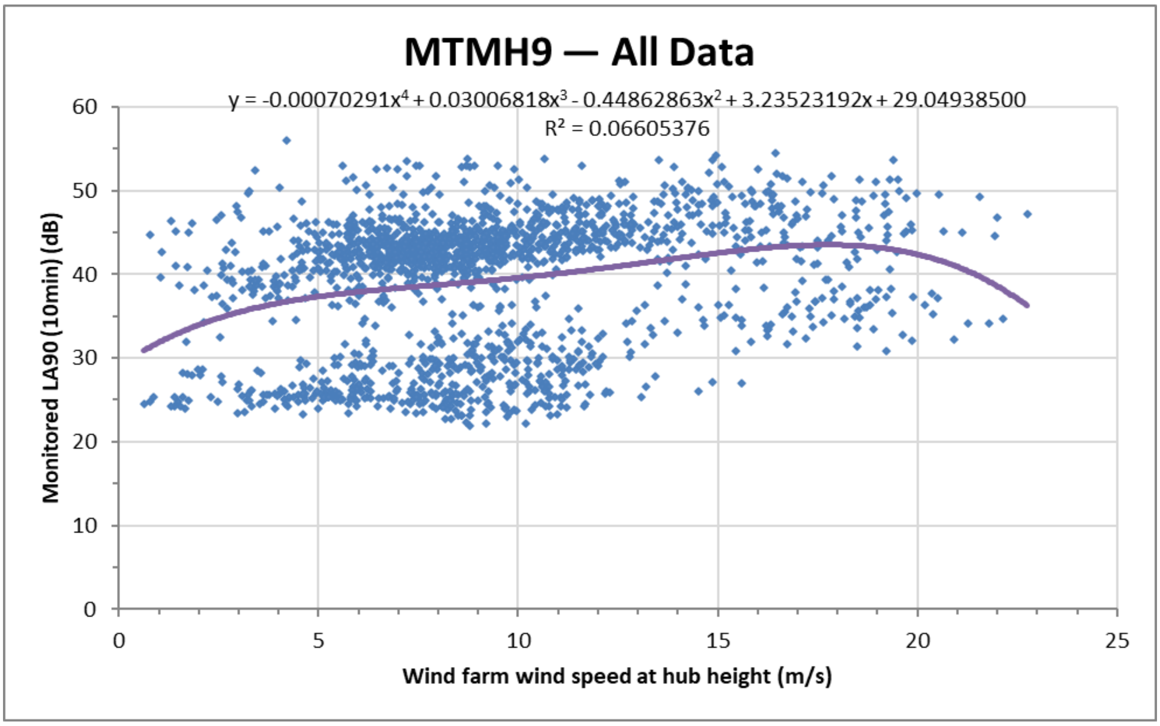
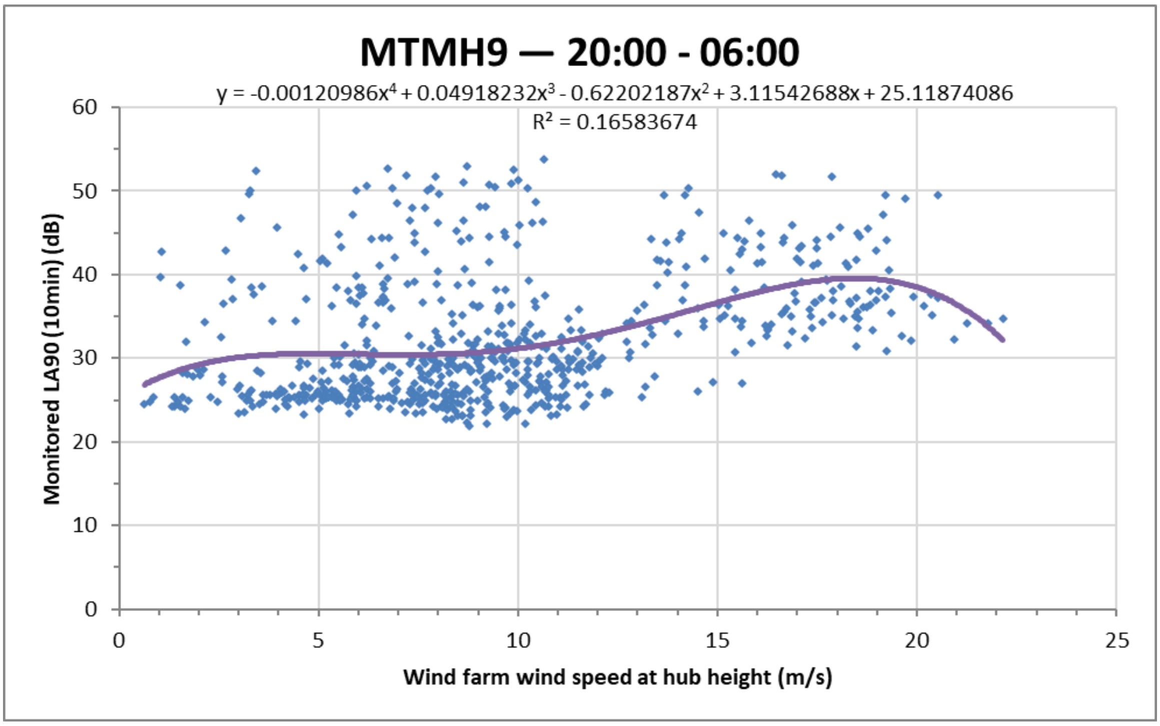


Figure 9 – Background Noise Measurements at MTMH09, Night-time Only



6.1.2 Dwelling MTMH 21

Figure 10 – Background Noise Measurements at MTMH21

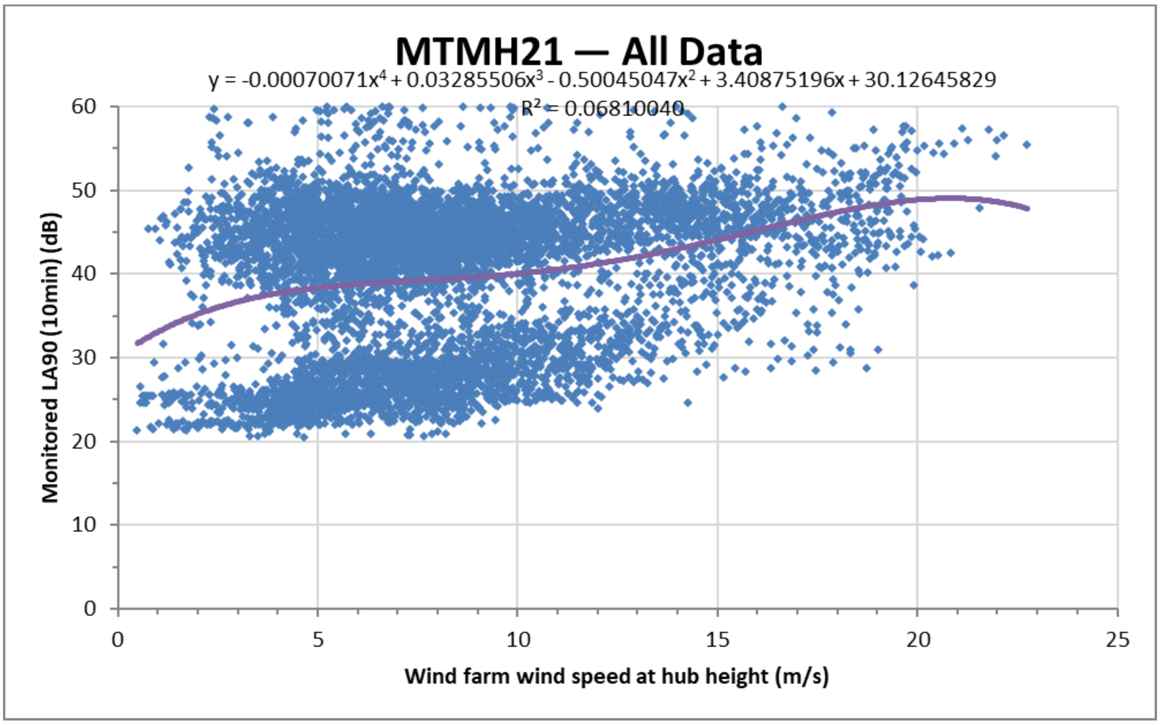
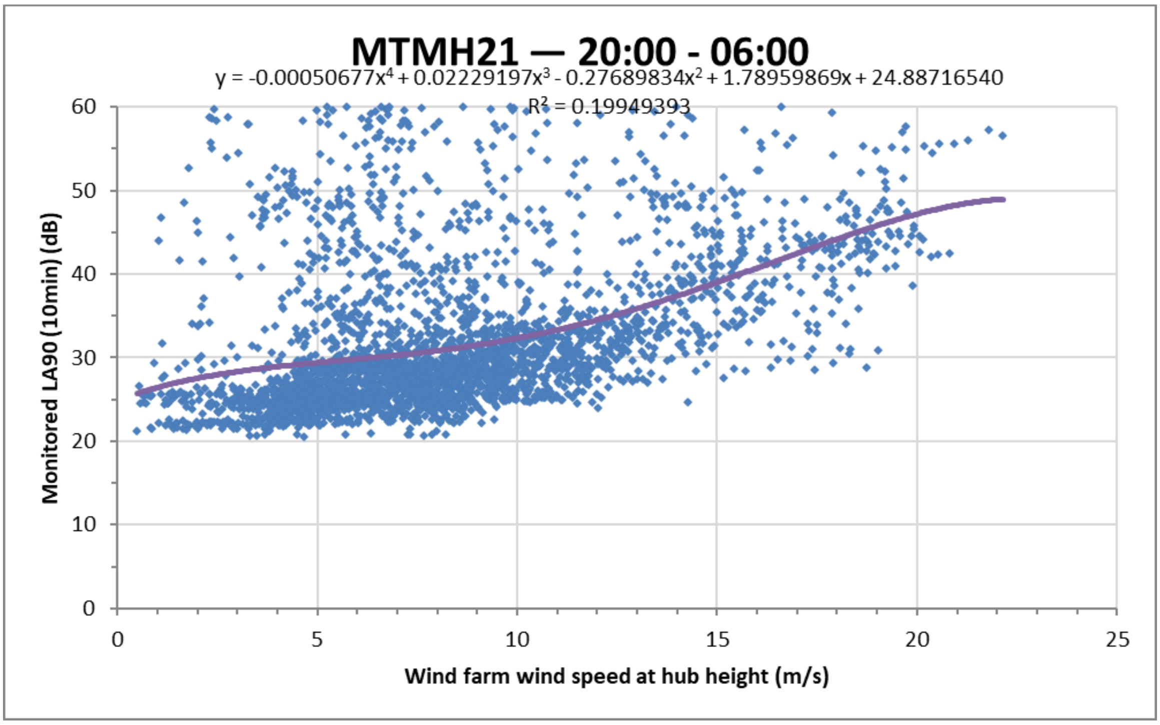


Figure 11 – Background Noise Measurements at MTMH21, Night-time Only



6.1.3 Dwelling MTMH 26

Figure 12 – Background Noise Measurements at MTMH26

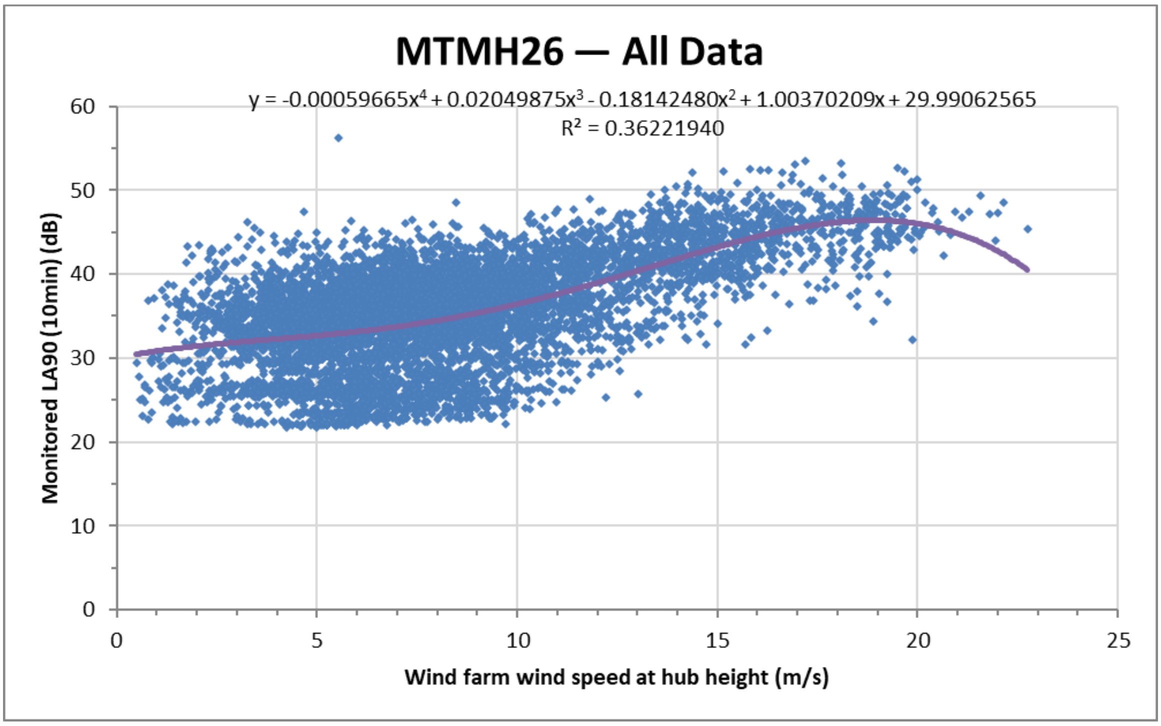
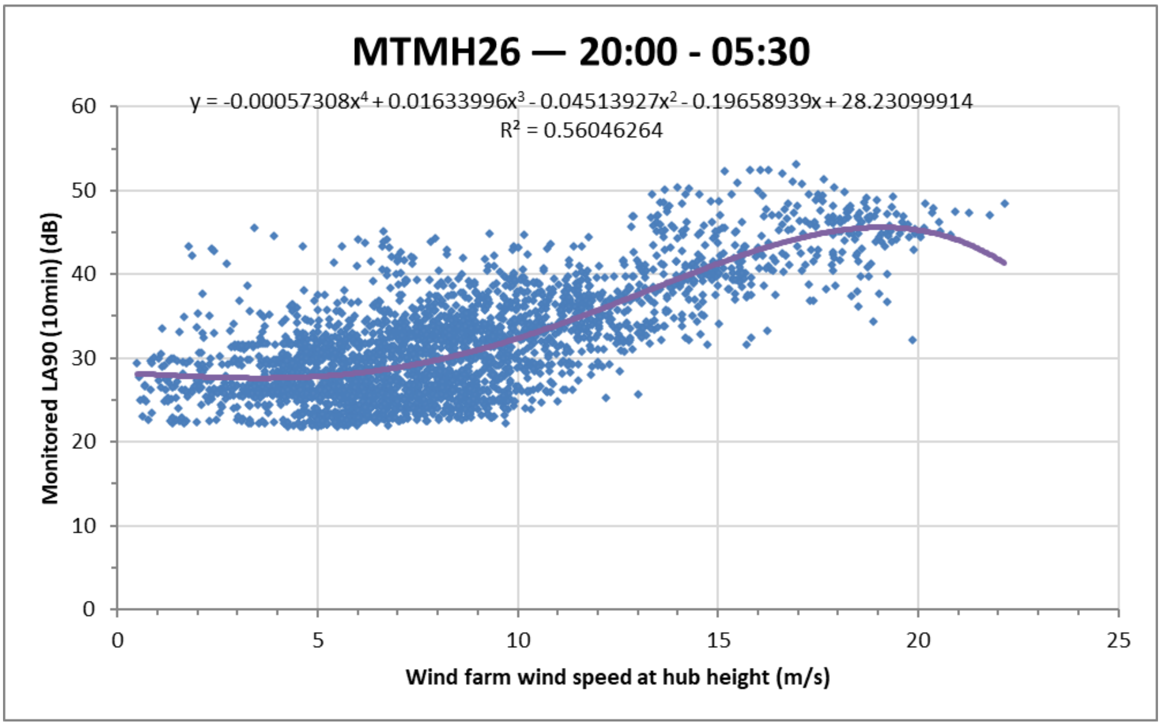


Figure 13 – Background Noise Measurements at MTMH26, Night-time Only



6.2 Assessment of Turbine Noise Effects

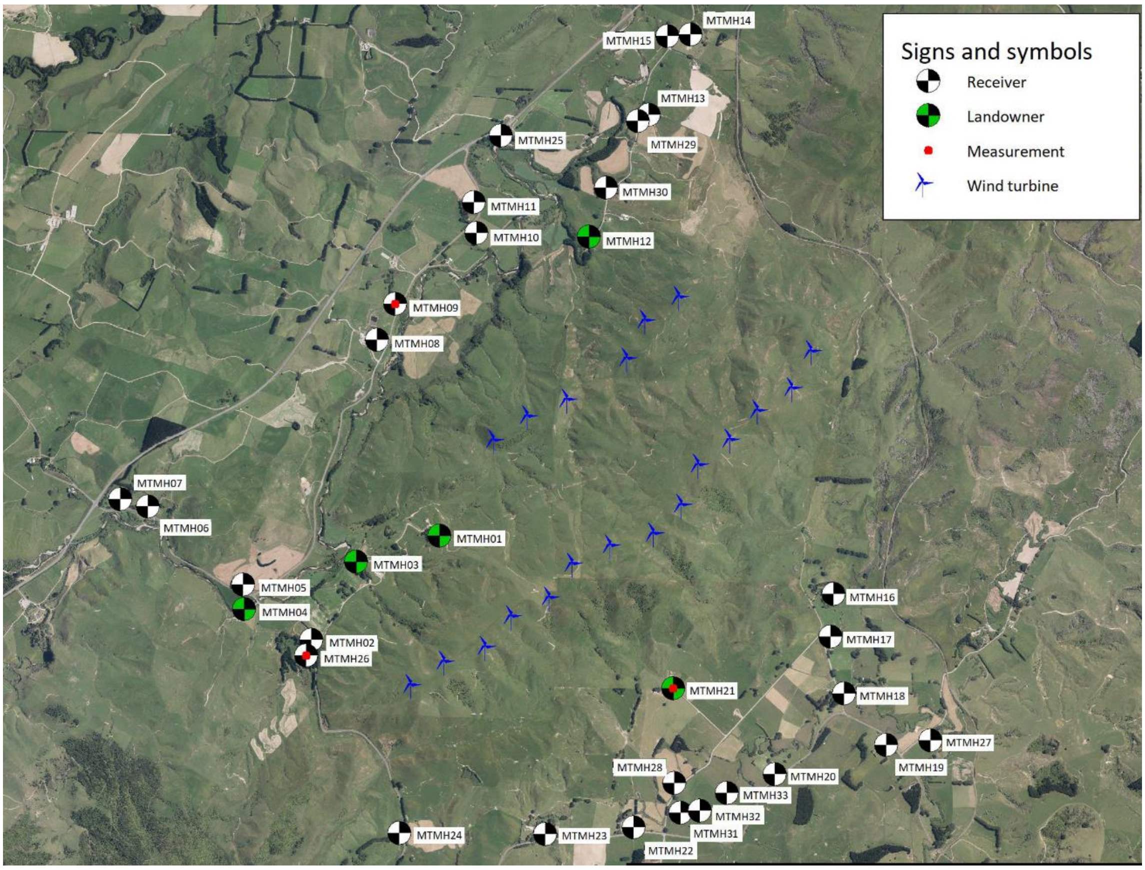
Operational wind farm noise at the noise sensitive locations listed in Table 8 has been assessed by comparing the calculated turbine noise levels with the background noise measurements taken at the dwellings, or at nearby representative dwellings.

These assessments are presented in the following section. For each dwelling, the following information is provided:

- The location of the dwelling and the location of the measurement position used to establish the dwelling's noise environment
- A description of the background noise environment; and
- A graph comparing the calculated wind farm noise curve (based on the highest noise level across turbine models and layouts) against the background sound vs wind speed curve and the limit derived from this curve.

The dwellings described in this section are shown in Figure 14.

Figure 14—Assessed Dwelling Locations



6.2.1 MTMH 02, MTMH 05, MTMH 26

Sites MTMH 02 and MTMH 05 are dwellings located to the southwest of the turbines. Noise from the turbines is calculated to be 38 dB L_{Aeq} at full power at MTMH 02, and 36 dB L_{Aeq} at MTMH 05, and 37 dB L_{Aeq} at MTMH 26 .

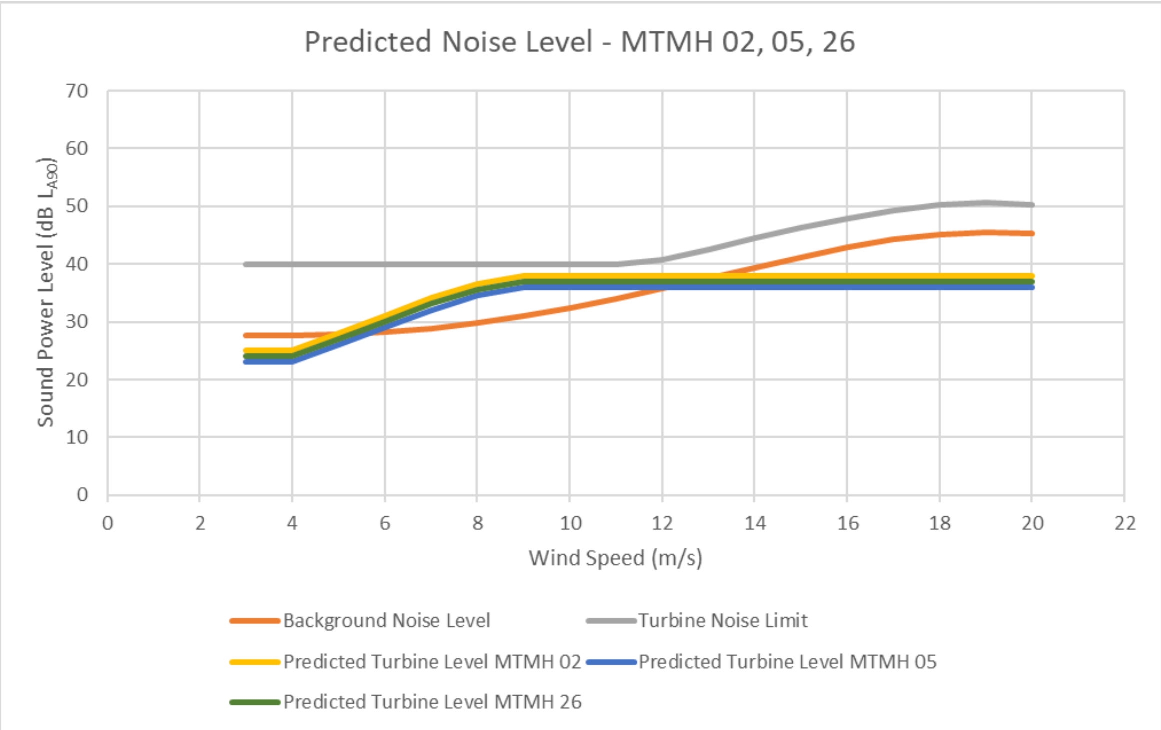
The background noise level was measured at MTMH 26, which reasonably represents the background noise environment at both properties. These measurements show that the site is significantly wind-affected at moderate to high wind speeds. When the wind is not blowing, background noise levels are typically 25 – 35 dB L_{A90} during daytime, and 25 – 30 dB L_{A90} at night-time.

Turbine noise would comply with the NZS6808:2010 noise limit at all wind speeds at these dwellings.

Noise from the turbines is calculated to be the dominant noise source in the noise environment at moderate wind speeds – 6 to 12 m/s, but at lower and higher wind speeds would be dominated by other wind noise.

The noise level produced would be at levels considered reasonable – less than the night-time permitted activity noise limit, and such that World Health Organisation recommendations for sleeping environments would be met with windows open.

Figure 15—MTMH 02, 05, and 26 Turbine and Background Noise Relationship



6.2.2 MTMH 08, 09, 10, 11, 13, 25, 29, 30

Sites MTMH 08 – 13 and MTMH 25, 29 and 30 are dwellings located to the northwest of the turbines. Noise from the turbines at full power is calculated to be 36 dB L_{Aeq} at MTMH 13 ,25 and 29; 37 dB L_{Aeq} at MTMH 08 and 11; and 38 dB L_{Aeq} at MTMH 09, 10 and 30.

The background noise level measured at MTMH 09 has been used to understand the background noise level in this area. The exposure of these properties to SH2 causes high daytime noise levels, and to a lesser extent causes some increase in average noise level at night. This can be seen in the scatter of high noise levels even at low wind speeds in the measurements shown in Figure 8 and Figure 9 of the preceding section.

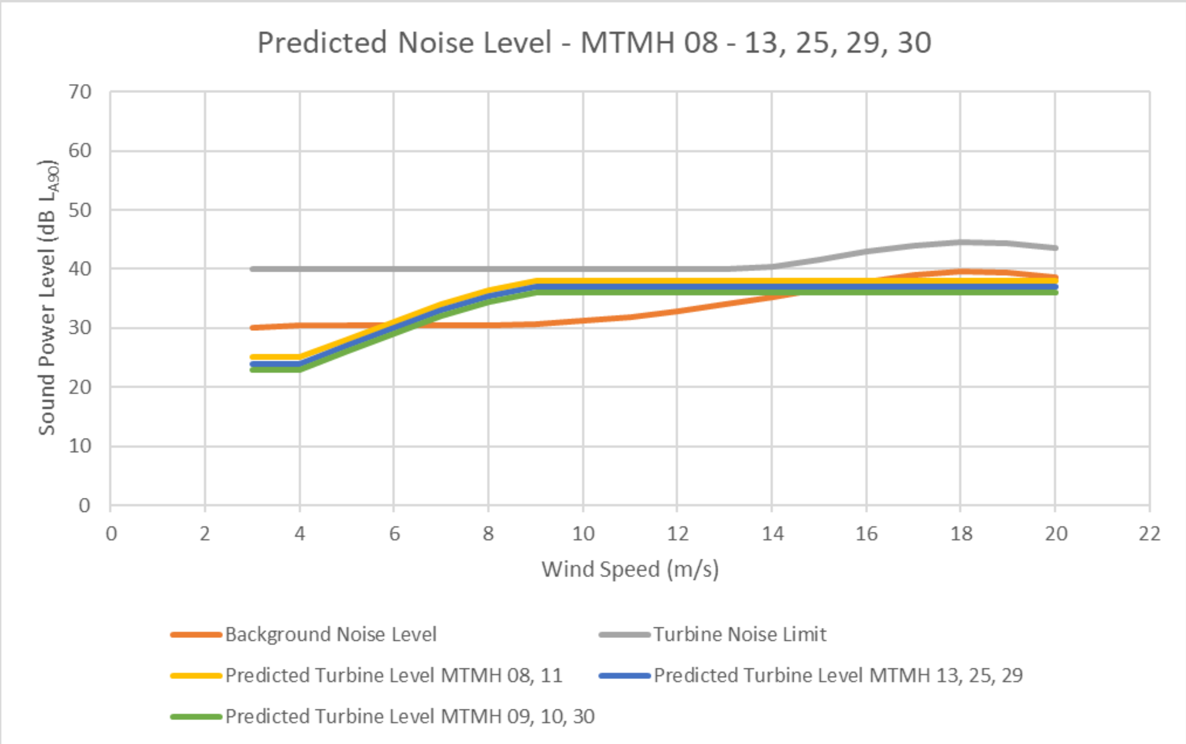
The measurements at MTMH 09 indicate that the site is significantly wind-affected at moderate to high wind speeds. When the wind is not blowing, the night-time background noise levels are typically around 30 dB L_{A90}.

Turbine noise would comply with the NZS6808:2010 noise limit at all wind speeds.

Noise from the turbines is calculated to be the dominant noise source in the noise environment at moderate wind speeds – 6 to 12 m/s, but at lower and higher wind speeds would be dominated by other wind noise at night, and by traffic during daytime.

The noise level produced would be at levels considered reasonable – less than the night-time permitted activity noise limit, and such that World Health Organisation recommendations for sleeping environments would be met with windows open.

Figure 16—MTMH 08 – 13; MTMH 25, 29 and 30 Turbine and Background Noise Relationship



6.2.3 MTMH 16 – 24, 28, 31, 33

Sites MTMH 16 through 24 and 28, 31 and 33 are dwellings located to the southeast of the turbines. Noise from the turbines at full power is calculated to be 35 dB L_{Aeq} at MTMH 31 and 33; 36 dB L_{Aeq} at MTMH 18 and 22; 37 dB L_{Aeq} at MTMH 17, 23, 24, and 28; and 39 dB L_{Aeq} at MTMH 16.

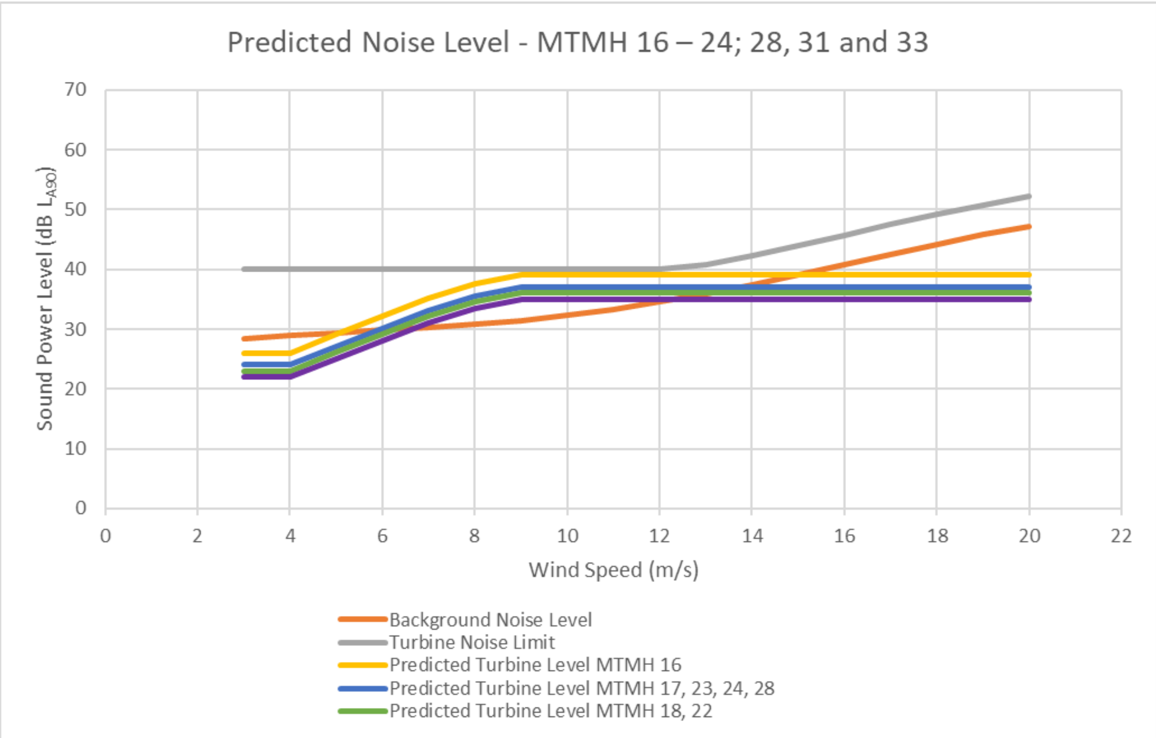
The background noise level was measured at MTMH 21, which reasonably represents the background noise environment at these properties. These measurements show that the site is significantly wind-affected at moderate to high wind speeds. When the wind is not blowing, background noise levels are typically 28 – 36 dB L_{A90} during daytime, and 28 – 30 dB L_{A90} at night-time.

Turbine noise would comply with the NZS6808:2010 noise limit at all wind speeds.

Noise from the turbines is calculated to be the dominant noise source in the noise environment at moderate wind speeds – 6 to 13 m/s, but at lower and higher wind speeds would be dominated by other wind noise.

The noise level produced would be at levels considered reasonable – less than the night-time permitted activity noise limit, and such that World Health Organisation recommendations for sleeping environments would be met with windows open.

Figure 17—MTMH 16 – 24, 28, 31, 33 Turbine and Background Noise Relationship



7.0 NON – TURBINE OPERATIONAL NOISE

Other operational noise sources include substations, activities in the Operations and Maintenance facilities, and on-site road traffic. In this section the noise calculations and assessments of these sources are presented.

These noise sources are required to meet the noise limits for permitted activities in the respective District Plans – 55 dBA during daytime, 45 dBA during night-time, and 75 dB L_{Amax} at night-time.

7.1 Substation Noise Level Predictions

An internal substation would be located near the southwest-most turbine platform. This will connect to an external terminal substation located on the north side of SH2, which is shown in Figure 18.

Figure 18 – Terminal Substation and Nearby Dwellings

We have calculated the sound level received by the nearest dwellings to these substation transformers. The sound power spectrum used for modelling has been taken from a review of three modern substation transformers which are substantially larger than required for this project but are typical of modern substation transformers. Specifically, we have used the highest noise level from three such transformers we have measured, which is a 180 MVA 3-phase transformer, including cooling fan noise.

The sound power level spectrum used for the modelling is as follows:

Table 9–Transformer Sound Power Level

Octave Band Frequency (Hz)	A	63	125	250	500	1000	2000	4000
Sound Power Level (dB)	**91**	87	99	91	89	85	81	74

The calculated sound pressure levels at the nearest external residential dwellings to each substation are given in Table 10.

Table 10– Sound levels at dwellings near Substation

Dwelling	Calculated Sound Pressure Level (dB L_{Aeq})
MTMH02	15 dBA (from Internal Substation)
MTMH03	16 dBA (from Internal Substation)
SW of Terminal	25 dBA (from Terminal Substation)
East of Terminal	26 dBA (from Terminal Substation)

At all external noise sensitive locations, the calculated sound level from either substation is less than the District Plan night-time noise limits (including a 5-decibel penalty for tonality, which can sometimes be applied to transformer noise) by at least 15 dB, and noise effects will be negligible.

7.2 Operations and Maintenance Facilities

We understand that an operations and maintenance (O&M) facility would be built at the Site Entrance as shown in Figure 19.

Figure 19 – Site Entrance Location

We have assumed that operational noise from these facilities would include noise from air conditioner outdoor units, and machine shop noise breaking out through the fabric of the building, assumed to be a steel shed with internal linings.

The outdoor sound power levels used to calculate noise emission from the sum of these activities is as follows:

Table 11–Combined O&M Activity Sound Power Level

Octave Band Frequency (Hz)	A	63	125	250	500	1000	2000	4000
Sound Power Level (dB)	69	69	73	70	65	62	58	61

The calculated noise from the above O&M activity is below 10 dB L_{Aeq} at all dwellings – far less than the existing background noise level under calm conditions. This will easily comply with District Plan noise limits and will have negligible noise effects.

7.3 Road Traffic Noise—Operational Stage

During the operation of the wind farm some access to the site will be required for ongoing maintenance and management of the wind farm. We have considered the noise effects from these vehicles on public roads and within the site.

7.3.1 Road traffic – External Roads

We understand that four to eight full-time equivalent staff may be employed to undertake routine operational maintenance of the turbines.

As this does not significantly change the flow rates on public roads, we conclude that there will be negligible noise effect resulting from operational road traffic.

7.3.2 Road traffic – Internal Roads

The impact of vehicles travelling along internal roads has been assessed by the same method as was used for construction traffic. Although most operational traffic is likely to involve light vehicles, heavy vehicles may occasionally be required for maintenance purposes.

The noise level from heavy vehicle activity will be 36 dB L_{Aeq} or less at all external dwellings and would occur only occasionally. This noise level easily complies with daytime and night-time noise limits and will have negligible noise effects.

8.0 RECOMMENDED OPERATIONAL NOISE MANAGEMENT MEASURES

To ensure that compliance is achieved, and to address noise which may arise upon commencement of operation of the wind farm, we recommend the following matters be adopted into consent conditions:

- Noise emissions, as assessed by NZS6801, NZS6802, and NZS 6808, will comply with provisions in the District Plans and with those derived by the method in NZS6808:2010 as appropriate.
- The noise assessment presented in the report should be reviewed prior to construction of the wind farm. This review shall include a re-calculation of the windfarm sound output once the wind turbine selection has been finalised and their operating parameters are known. This investigation shall produce a Final Operational Noise Assessment Report, in which it shall be determined that the noise limits established in NZSS680:2010 shall be met for all dwellings external to the windfarm project.
- A suitable monitoring programme should be established, ensuring that the sound levels produced by the operational windfarm do not exceed the noise limits at the sites investigated and modelled in this report.

9.0 CONCLUSIONS

- New Zealand Standard 6808:2010 provides a suitable noise performance standard for windfarms which has been applied to this assessment. The standard establishes a noise limit for turbine noise of 40 dBA L_{90} or 5 decibels above the existing ambient L_{90}, whichever is the higher. The predicted noise levels from turbine operational activity complies with the limits recommended by NZS6808:2010 at all dwellings external to the wind farm.
- Noise levels predicted from other operational activities from the proposed windfarm will comply with the limits recommended by the District Plans' noise provisions.
- Construction activities will comply with the provisions of NZS6803:1999.
- During the final design and wind turbine selection process, further consideration must be had in regard to the wind turbine selection to ensure that the limits are met.

On the basis of this assessment, all noise emissions related to this project are reasonable.

APPENDIX A GLOSSARY OF TERMINOLOGY

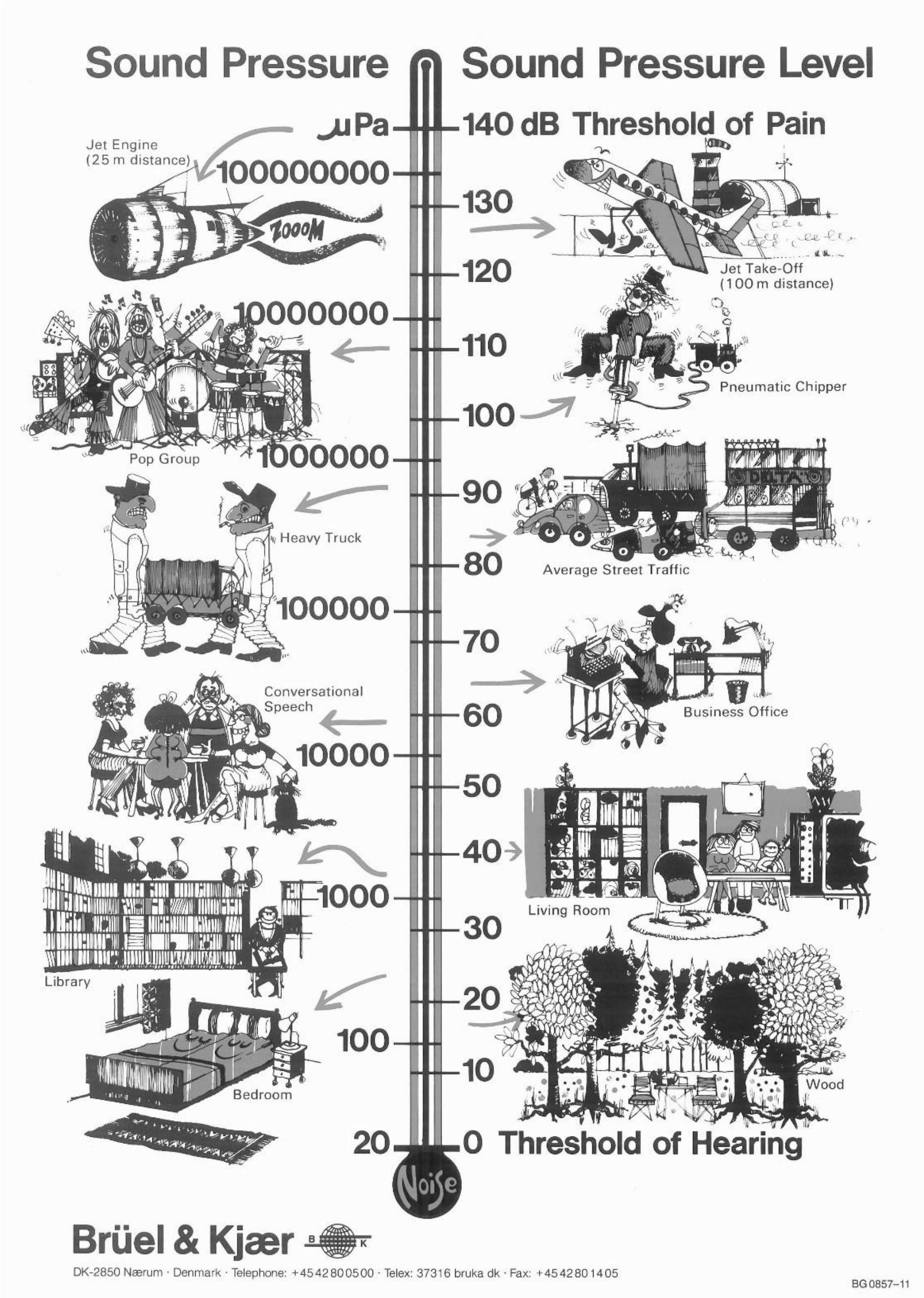
Background sound	The sound that is continuously present in a room our outdoor location. Often expressed as the A-weighted sound level exceeded for 90 % of a given time period i.e. L_{A90}.
Frequency	Sound occurs over a range of frequencies, extending from the very low (e.g. thunder) to the very high (e.g. mosquito buzz). Measured in units of Hertz (Hz). Humans typically hear sounds between 20 Hz and 20 kHz. High frequency acuity naturally reduces with age most adults can hear up to 15 kHz.
Noise	A subjective term used to describe sound that is unwanted by, or distracting to, the receiver.
Notional boundary	A line 20 metres from any side of a dwelling, or the legal boundary where this is closer to the dwelling. This definition is from NZS 6802:2008.
Octave band	The interval between one frequency and its double. Sound is divided into octave bands for analysis. The typical octave band centre frequencies are 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz.
Rating level	A derived level used for comparison with a noise limit. Takes into account any and all corrections described in NZS 6801 and NZS 6802, e.g. duration, special audible character, residual sound etc. This definition is from NZS 6802:2008.
A-weighting	A set of frequency-dependent sound level adjustments that are used to better represent how humans hear sounds. Humans are less sensitive to low and very high frequency sounds. Sound levels using an "A" frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels are dBA or dB(A).
dB	Decibel. The unit of sound level.
L_{A90}	The A-weighted sound level exceeded for 90 % of the measurement period, measured in dB. Commonly referred to as the background noise level.
L_{Aeq}	The equivalent continuous A-weighted sound level. Commonly referred to as the average sound level and is measured in dB.
L_{dn}	The day-night sound level calculated from the measured L_{Aeq} over a 24 hour period with a 10 decibel penalty applied to the night-time period (2200-0700 hours)

APPENDIX B REFERENCED STANDARDS

NZS 6801:1991	New Zealand Standard NZS 6801:1991 - *Measurement of Sound*
NZS 6802:1991	New Zealand Standard NZS 6802:1991 - *Assessment of Environmental Sound*
NZS 6801:1999	New Zealand Standard NZS 6801:1999 *Acoustics - Measurement of Environmental Sound*
NZS 6802:1999	New Zealand Standard NZS 6802:1999 - *Acoustics - Assessment of Environmental Noise*
NZS 6808:1998	New Zealand Standard NZS 6808:1998 - *Acoustics – The assessment and measurement of sound from wind turbine generators*
NZS 6808:2010	New Zealand Standard NZS 6808:2010 - *Acoustics – Wind farm noise*

APPENDIX C TYPICAL SOUND LEVELS

The figure below is provided to give a day-to-day context for various sound pressure levels. A comparison can be drawn between the predicted noise levels in the preceding tables and typical noise situations shown in the illustration below , resulting from the given noise sources.



APPENDIX D PREDICTED NOISE LEVELS AT EACH DWELLING

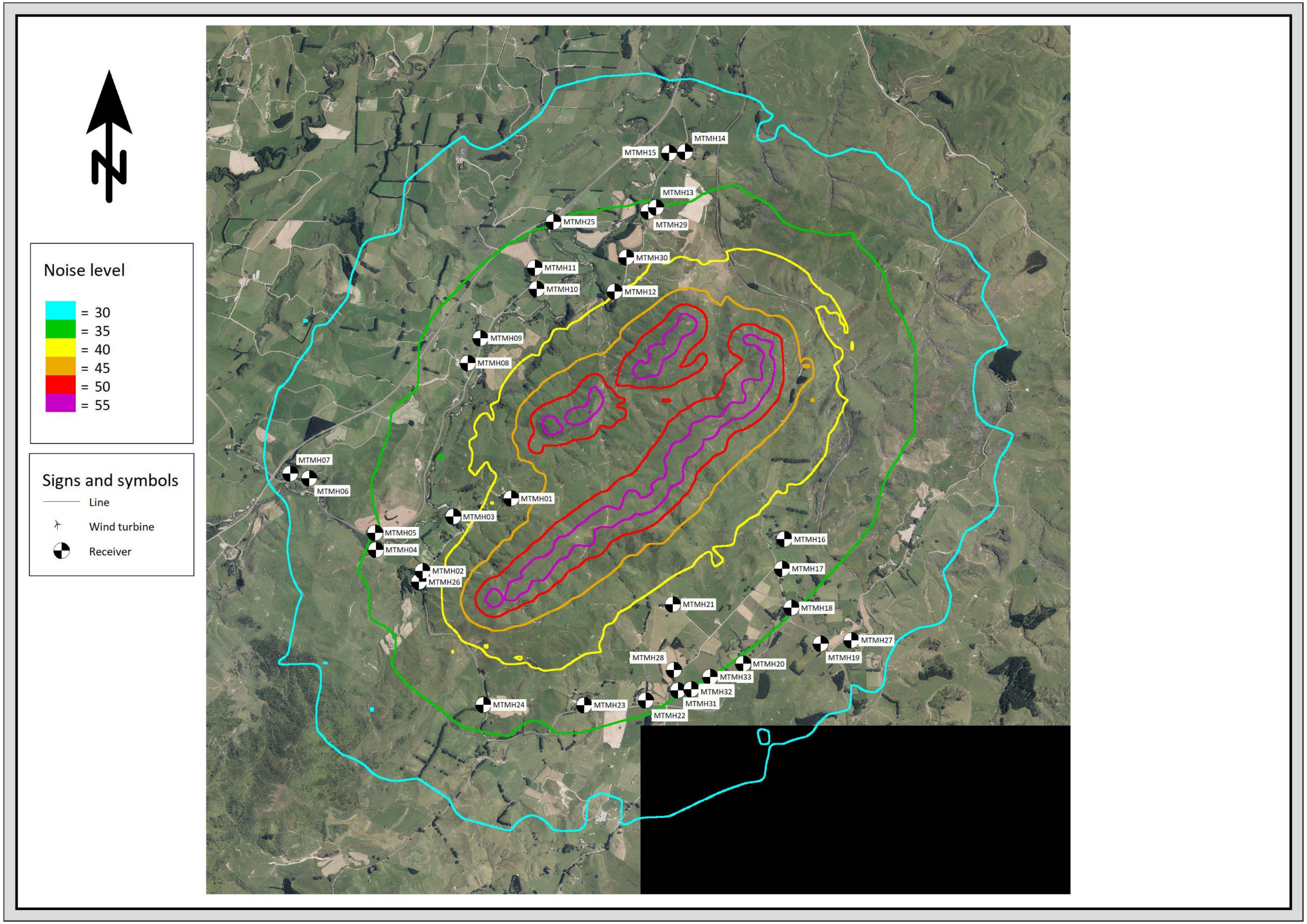
Turbine Model	DD120					DD130					V136				
Layout option	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Dwelling															
MTMH01	42.3	42.4	41.9	42.8	42.5	41.3	41.4	40.9	41.8	41.5	39.7	40.0	39.6	40.0	40.1
MTMH02	37.9	37.5	36.1	37.5	37.5	37.1	36.7	35.5	36.8	36.8	35.9	35.5	34.5	35.6	35.7
MTMH03	38.2	38.1	37.6	38.1	38.1	37.4	37.3	36.8	37.3	37.4	36.2	36.1	35.7	36.1	36.2
MTMH04	34.8	34.4	34.0	35.1	35.0	34.2	33.8	33.5	34.5	34.4	33.1	32.8	32.5	33.5	33.0
MTMH05	35.1	35.0	34.3	35.1	35.0	34.6	34.5	33.9	34.6	34.6	33.3	33.4	32.9	33.6	33.5
MTMH06	29.5	29.9	29.1	29.4	29.4	29.5	29.8	29.0	29.6	29.3	28.7	28.9	28.1	28.8	28.9
MTMH07	30.2	30.0	29.5	30.0	30.3	30.2	30.1	29.4	29.9	30.2	29.4	29.3	28.7	29.2	29.5
MTMH08	36.9	36.4	36.8	35.6	36.3	36.3	35.7	36.2	35.1	35.7	34.6	34.7	34.4	33.9	34.6
MTMH09	37.1	37.8	38.0	37.2	37.4	36.5	37.2	37.4	36.7	36.8	35.5	36.3	35.8	34.7	35.3
MTMH10	37.2	37.2	37.0	36.6	36.4	36.6	36.6	36.4	36.0	35.9	35.2	35.5	35.3	34.5	34.2
MTMH11	36.0	36.2	36.7	35.9	35.9	35.5	35.6	36.1	35.5	35.4	34.5	34.5	34.8	34.5	34.4
MTMH12	39.7	39.6	39.7	39.5	38.9	38.8	38.7	38.8	38.6	38.1	37.5	37.4	37.5	37.4	36.9
MTMH13	35.2	35.7	36.0	34.8	34.6	34.7	35.2	35.4	34.3	34.1	33.5	34.1	34.2	33.0	33.1
MTMH14	32.1	32.5	33.0	32.8	32.4	31.8	32.2	32.7	32.5	32.1	30.8	31.1	31.3	31.2	31.1
MTMH15	32.0	32.7	32.6	32.7	32.5	31.7	32.4	32.3	32.4	32.2	30.8	31.4	31.3	31.5	31.2
MTMH16	38.1	38.3	38.0	38.1	37.6	37.5	37.6	37.3	37.5	37.0	36.1	36.4	36.3	36.4	36.0
MTMH17	36.7	36.5	36.5	36.8	35.9	36.1	36.0	35.9	36.2	35.4	35.2	35.1	34.9	35.2	34.1
MTMH18	35.2	35.1	35.2	35.2	34.8	34.9	34.8	34.9	34.8	34.5	34.0	33.9	34.0	33.9	33.6
MTMH19	32.9	32.8	32.8	32.8	32.7	32.7	32.6	32.6	32.6	32.4	31.8	31.7	31.7	31.7	31.5
MTMH20	34.6	34.4	34.4	34.3	34.3	34.2	34.1	34.1	34.0	33.9	33.4	33.1	33.2	33.1	33.1
MTMH21	38.2	37.9	37.8	37.7	37.5	37.5	37.2	37.0	36.9	36.8	36.0	35.8	35.9	35.8	35.7
MTMH22	35.6	35.4	35.2	35.3	35.4	35.2	34.9	34.8	34.9	35.0	34.0	34.0	33.7	34.0	34.0
MTMH23	36.6	36.0	35.9	36.1	36.1	36.0	35.5	35.3	35.5	35.6	34.9	34.1	34.2	34.5	34.4
MTMH24	37.0	36.1	35.5	36.3	36.4	36.3	35.4	34.9	35.6	35.7	35.0	34.3	33.1	34.5	34.5
MTMH25	34.4	35.1	35.3	35.0	34.9	33.9	34.7	34.9	34.6	34.6	33.0	33.5	33.6	33.3	33.6
MTMH26	37.2	36.6	35.4	36.8	36.8	36.3	35.8	34.7	36.0	36.0	35.1	34.6	33.6	34.7	34.7
MTMH27	32.0	31.9	32.0	31.9	31.8	31.8	31.7	31.8	31.7	31.6	30.9	30.8	30.9	30.8	30.6
MTMH28	36.5	36.3	36.2	36.3	36.3	36.0	35.8	35.8	35.8	35.8	35.0	34.9	34.8	34.9	34.9
MTMH29	35.3	35.8	35.9	34.8	34.2	34.7	35.3	35.3	34.3	33.7	33.0	34.3	33.4	33.0	32.7
MTMH30	37.0	38.4	37.4	37.4	37.2	36.3	37.7	36.7	36.7	36.5	35.2	35.3	35.5	35.5	35.4
MTMH31	35.2	35.0	35.0	35.0	35.0	34.9	34.6	34.6	34.7	34.6	33.9	33.7	33.7	33.8	33.7
MTMH32	34.9	34.7	34.7	34.7	34.7	34.6	34.3	34.3	34.4	34.3	33.7	33.4	33.4	33.5	33.4
MTMH33	35.0	34.7	34.8	34.8	34.7	34.6	34.4	34.4	34.4	34.4	33.7	33.5	33.5	33.5	33.5

LEGEND
Contracted Property
Level ≥ 40 dBA
Level ≥ 35 dBA

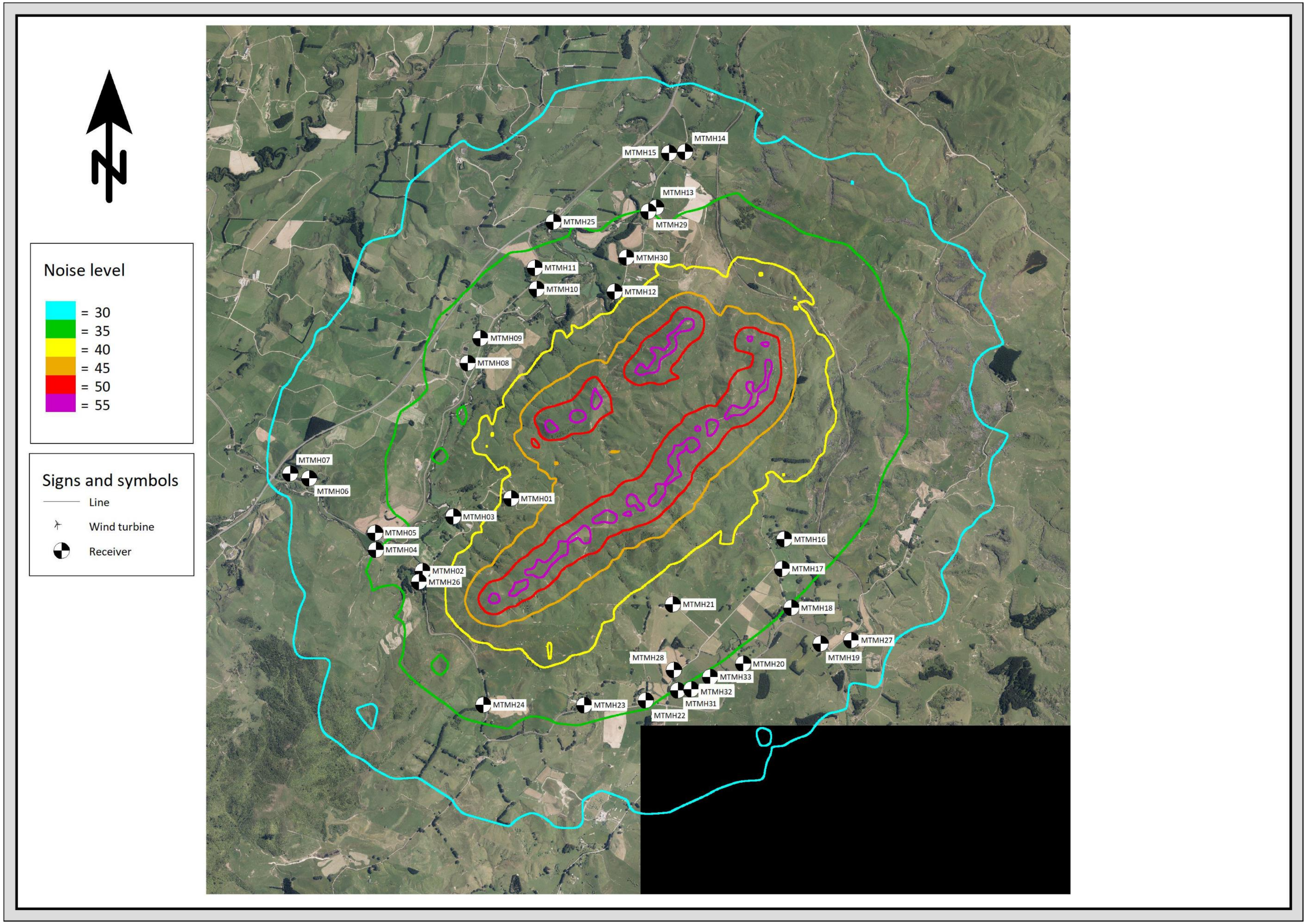
MARSHALL DAY Acoustics

APPENDIX E NOISE CONTOUR MAPS

E1 DD120



E2 DD130


Noise level
= 30
= 35
= 40
= 45
= 50
= 55
Signs and symbols
Line
Wind turbine
Receiver
MTMH14
MTMH15
MTMH13
MTMH29
MTMH25
MTMH30
MTMH11
MTMH10
MTMH12
MTMH09
MTMH08
MTMH07
MTMH06
MTMH01
MTMH03
MTMH05
MTMH04
MTMH02
MTMH26
MTMH16
MTMH17
MTMH21
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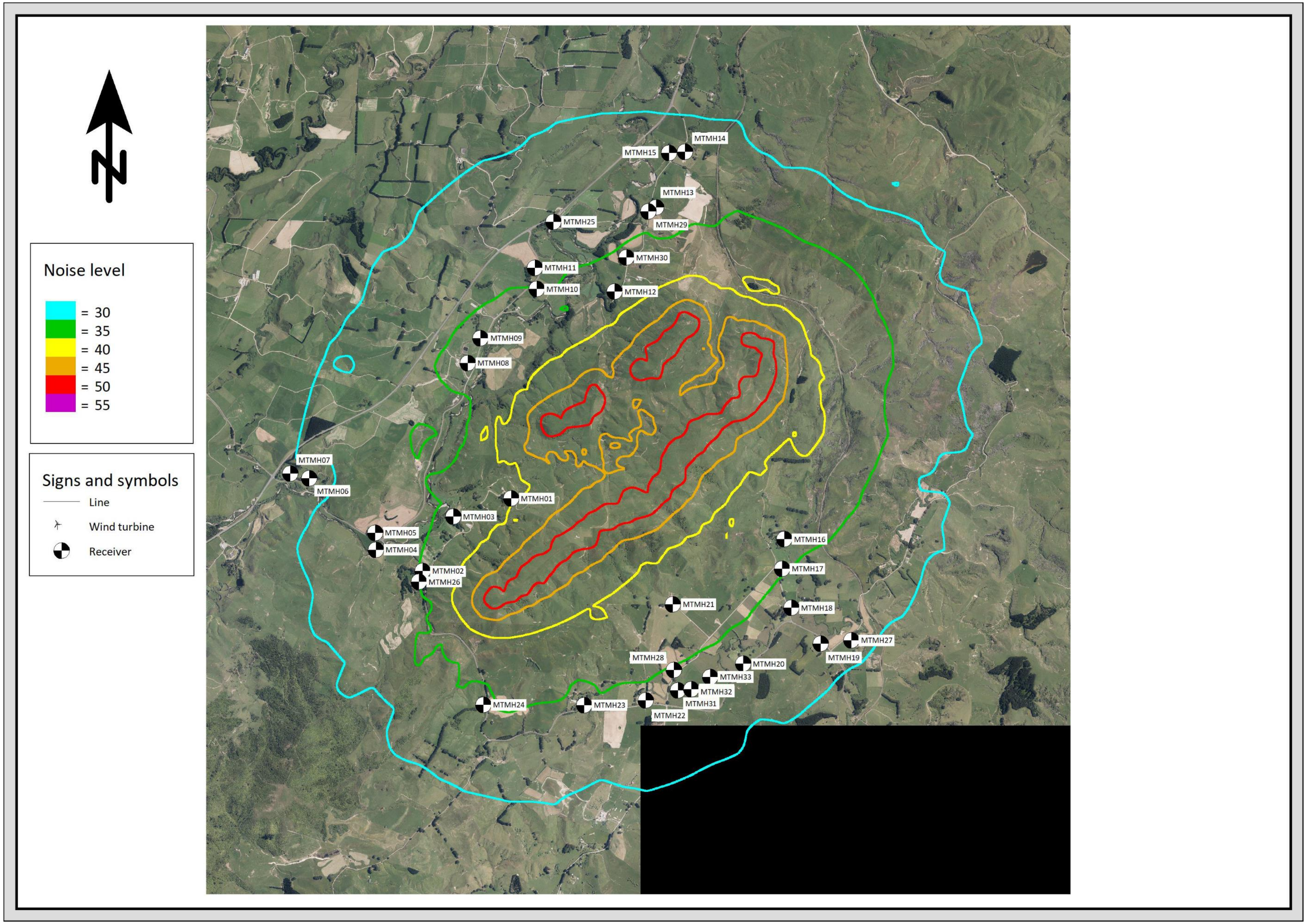
MTMH22
MTMH24
MTMH23

E3 V136


Noise level
= 30
= 35
= 40
= 45
= 50
= 55
Signs and symbols
Line
Wind turbine
Receiver
MTMH14
MTMH15
MTMH13
MTMH29
MTMH25
MTMH30
MTMH11
MTMH10
MTMH12
MTMH09
MTMH08
MTMH07
MTMH06
MTMH01
MTMH03
MTMH05
MTMH04
MTMH02
MTMH26
MTMH16
MTMH17
MTMH21
MTMH18
MTMH27
MTMH19
MTMH28
MTMH20
MTMH33
MTMH32
MTMH31
MTMH24
MTMH23
MTMH22

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