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HIRINGA WIND TURBINES

KAPUNI

ASSESSMENT OF NOISE

Report No 20075

Prepared for:

Hiringa Energy Limited
New Plymouth
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Prepared by: .....

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1. INTRODUCTION

Hiringa Energy Limited (Hiringa) and Ballance Agri-nutrients are developing a wind to hydrogen project at the Ballance Agri-nutrients site near Kapuni, South Taranaki. To provide power to the planned development it is proposed to develop a four turbine wind generation facility consisting of up to four 6MW turbines at 271, 291, 331 and 359 Kokiri Road as shown on Figure 1. The turbines will have a hub height of up to 125m and a blade diameter of 158m.

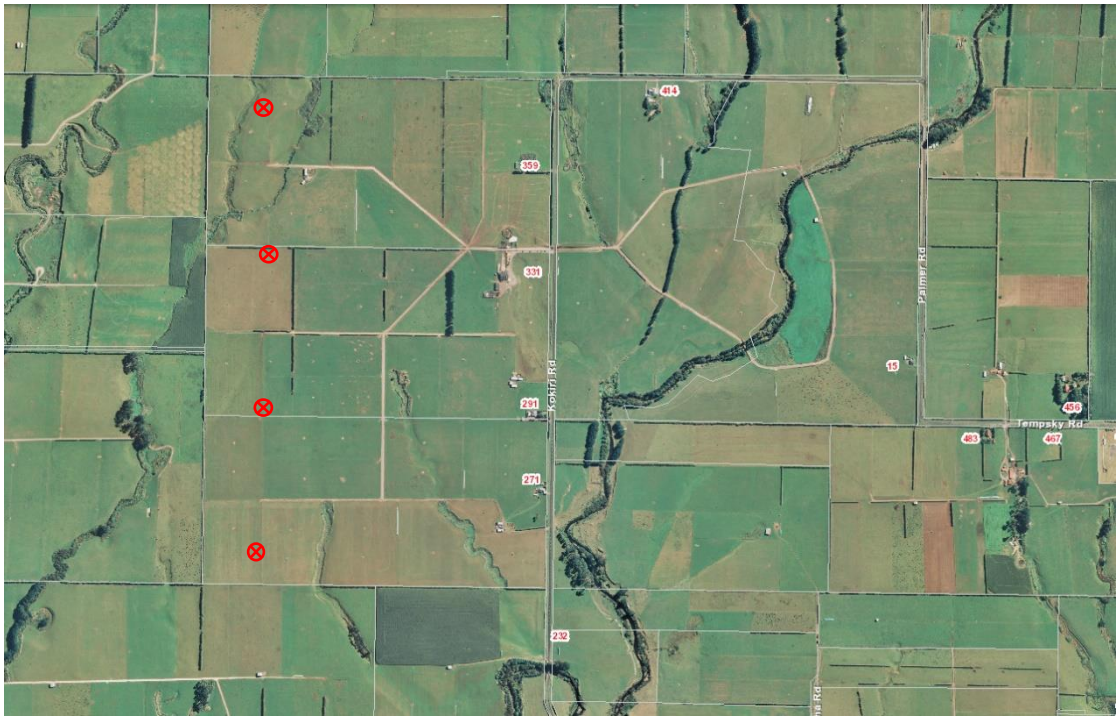

Figure 1. Location of proposed wind turbines

This report assesses the noise from the proposed wind turbines to ensure the level of noise will be reasonable for the neighbours.

2. DESIGN CRITERIA

The site is located on flat land at 271, 291, 331 and 359 Kokiri Road approximately 2km south of the Ballance Agri-nutrients industrial plant at Kapuni in South Taranaki. The site is zoned Rural in the Proposed South Taranaki District Plan. There is no specific rule in the Proposed District Plan that relates to wind turbine noise although a consent order as a result of an appeal[1] determined that:

> *Sounds specifically generated by wind turbines as part of large-scale renewable electricity generation activities shall be assessed, managed and controlled by reference to NZS 6808:2010 Acoustics - Wind farm Noise.*

In addition to the noise from the wind turbine generators (WTGs), the following sections of the District Plan will be applicable for any non-turbine related aspects of the proposed development.

As a result of appeal ENV-2016-WLG-000074 and a subsequent consent order, Rule 11.2.2.1 of the Proposed District Plan now states:

> *Noise generated by any activity in the Rural Zone and Township Zone shall not exceed the following noise limits:*
>
> *a. when measured at any point within the boundary of any other Rural Zoned site:*
>
> | | |
> |---|---|
> | *All times* | *55dB $L_{Aeq(15\ min)}$* |
> | *10pm to 7am* | *85dB L_{Amax}* |
>
> *b. when measured at any point within the notional boundary of any dwelling on any other Rural Zoned site:*
>
> | | |
> |---|---|
> | *7am to 7pm* | *55dBA $L_{Aeq(15\ min)}$* |
> | *7pm to 10pm* | *50dBA $L_{Aeq(15\ min)}$* |
> | *10pm to 7am* | *45dBA $L_{Aeq(15\ min)}$* |
> | *10pm to 7am* | *75dBA L_{Amax}* |

[1] Via an appeal – Tararua Wind Power Ltd – ENV-2016-WLG-000078

Rule 11.2.6.2 states:

> *Where these standards specifically refer to previous versions of NZS 6801:2008 and NZS 6802:2008 then measurement and assessment shall continue to be made in accordance with those versions, otherwise measurement and assessment shall be made in accordance with the 2008 version of those standards, ie NZS 6801:2008 and NZS 6802:2008 respectively.*

Rule 11.2.1(d) states:

> *Sounds specifically generated by construction, maintenance and demolition activities which shall be assessed, managed and controlled by reference to NZ S6803:1999 Acoustics - Construction noise.*

Table 2 of *NZS6803:1999 Acoustics – Construction Noise* sets out the noise limits to be complied with when measured at one metre from the façade of a dwelling. This measurement position is different to the notional boundary location that is adopted for general operation noise and reflects the aim to protect the dwelling from the effects of construction noise rather than the outdoor area. As construction noise is a transient sound this approach is considered reasonable when adopting NZS6803. Table 2 of the Construction Standard sets the following noise limits:

Recommended Upper Limits for Construction Noise Received in Residential Zones and Dwellings in Rural Areas

Time of week	Time period	Typical duration (dBA)		Short term duration		Long term duration	
		L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
Weekdays	0630-0730	60	75	65	80	55	75
	0730-1800	75	90	80	95	70	85
	1800-2000	70	85	75	90	65	80
	2000-0630	45	75	45	75	45	75
Saturdays	0630-0730	45	75	45	75	45	75
	0730-1800	75	90	80	95	70	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75
Sundays and public holidays	0630-0730	45	75	45	75	45	75
	0730-1800	55	80	55	85	55	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75

Where:

(a) "Short-term"	means construction work at any one location for up to 14 calendar days;
(b) "Typical duration"	means construction work at any one location for more than 14 calendar days but less than 20 weeks; and
(c) "Long-term"	means construction work at any one location with a duration exceeding 20 weeks.

For this project it is expected the construction noise for any given receiver position will be more than 14 calendar days but less than 20 weeks for the total construction period so the typical duration noise limits will be applicable as shown shaded in the above table.

Paragraph C1.1 NZS 6808:2010 Acoustics - Wind Farm Noise (NZS6808) states:

> *This Standard covers the prediction, measurement, and assessment of the received sound from wind farms.*
>
> ***C1.1*** *This Standard is intended to avoid adverse noise effects on people caused by the operation of wind farms while enabling sustainable management of natural wind resources. This can be achieved through resource planning measures to address the management of effects of wind farm sound on noise sensitive activities. This approach is consistent with other acoustics Standards, for example those relating to airports, heliports, and ports (NZS 6805, NZS 6807, and NZS 6809).*
>
> *This Standard incorporates guidelines for best practice assessment of projects. Application of this Standard will enable assessment of potential noise effects on people and communities and identify appropriate mitigation measures and suitable noise limits.*

Clause 5.2 of NZS6808 recommends the following noise limits for wind turbines:

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 5dB, or a level of 40dB $L_{A90(10\ min)}$, whichever is the greater.

Rule 5.3.1 of NZS6808 states for a high amenity area:

The wind farm noise limit of 40dB $L_{A90(10\ min)}$ in 5.2 is appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations. 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 nighttime. 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 40dB $L_{Aeq(15\ min)}$ or 40dBA 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.

C5.3.1 *The following steps provide guidance on whether a high amenity noise limit may be justified:*

(a) There is no need to consider noise sensitive locations outside the predicted 35dB $L_{A90(10\ min)}$ wind farm sound level contour;

(b) Using predicted wind farm sound levels and measured background sound levels relating to any particular noise sensitive location under investigation, calculate for each 10-minute time interval in the evening or night-time prescribed time frames the arithmetic difference between the estimated post-installation sound level and the background sound level. The post-installation sound level should be estimated by an energy addition of the background sound level and predicted wind farm sound level. The background and wind farm sound levels should be for a range of wind conditions representative of long-term wind sampling at the wind farm;

(c) The differences calculated in (b) for all 10-minute time intervals in the prescribed time frame should be arithmetically averaged (there should typically be in excess of 540 data points at night – see C7.2.1);

(d) If the average difference in an evening or night-time prescribed time frame is less than 8 dB then a high amenity noise limit is unlikely to be justified;

(e) If the average difference in an evening or night-time prescribed time frame is greater than 8dB then a high amenity noise limit is likely to be justified.

There are no specific provisions in the Proposed District Plan that suggest this area should be classed as a high amenity area. Further, as the locality is essentially flat topography there is not the potential for houses to be located in a gully and hence screened from the wind (and experience low noise levels) with WTGs located on top of a ridge where they are exposed to high winds and hence generate the maximum noise. Thus, the criterion for a high amenity area as set out in NZS6808 does not need to be achieved at this site.

3 EXISTING NOISE ENVIRONMENT

The site is located in a rural area well clear of any busy roads and the closest industry is approximately 2km away to the north. The main effects on the existing noise environment are from any turbine activities that may take place, minor road traffic noise for some sites and wind generated noise. When determining the location to undertake measurements of the existing noise environment Clause 7.1.4 of NZS6808 has been considered which states:

> *Background sound level measurements and subsequent analysis to define the relative noise limits should be carried out where wind farm sound levels of 35dB $L_{A90(10\ min)}$ 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 35dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

Although there are no dwellings within the 35dB $L_{A90(10\ min)}$ noise contour, background noise monitoring has been undertaken at four of the closer neighbours that are representative of the closer dwellings to the site as shown on Figure 2.

Figure 2. Noise Monitoring Sites

Figures 3 - 6 show the results of the measured background sound (L_{A90}) at noise monitoring locations (as shown on Figure 2) and from representative wind speed measurements from the relevant wind monitoring mast on the proposed wind turbine site during the same period.

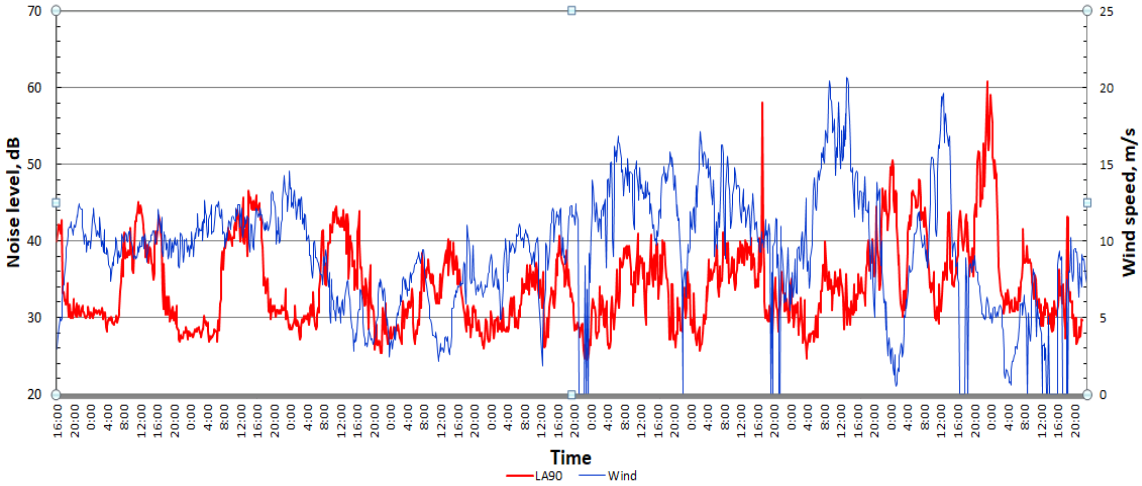

Figure 3. Noise and Wind Measurements at Site 1

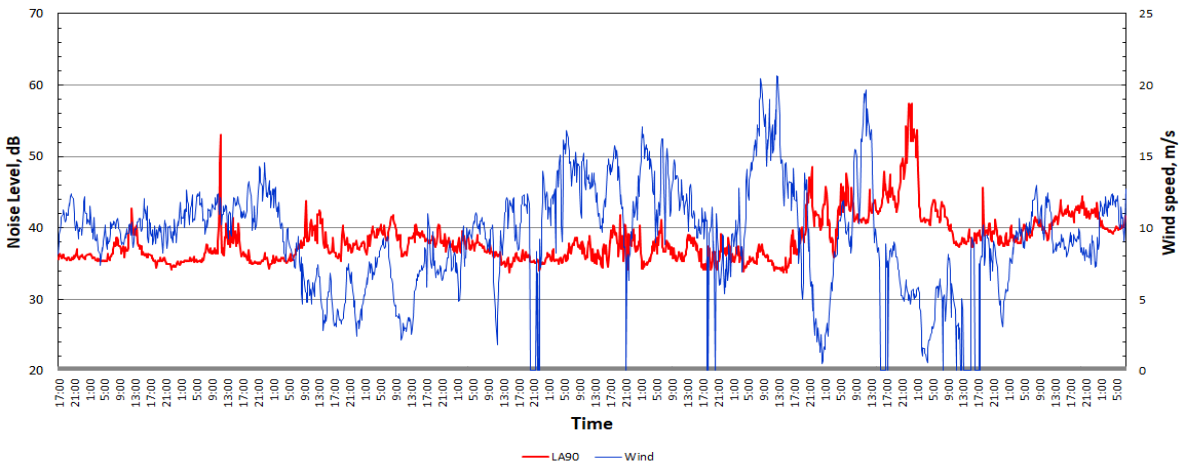

Figure 4. Noise and Wind Measurements at Site 2

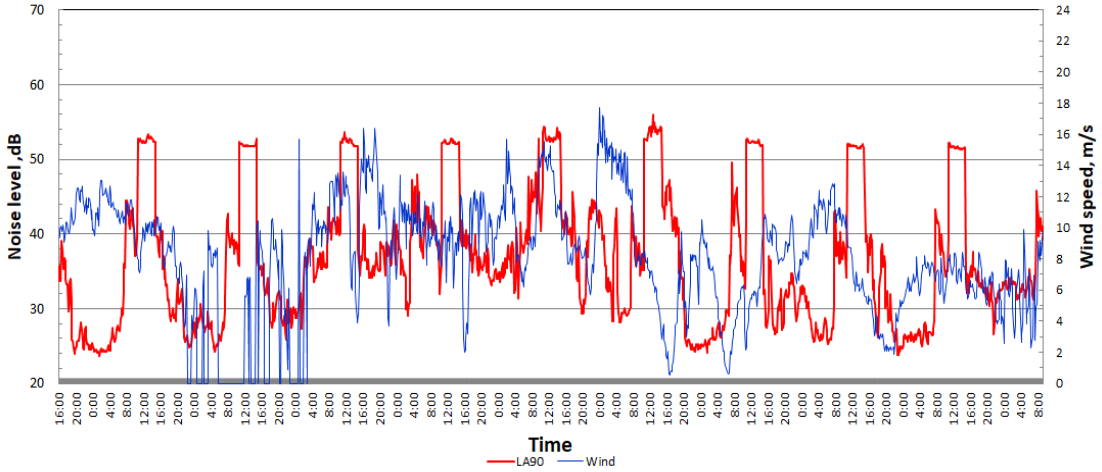

Figure 5. Noise and Wind Measurements at Site 3

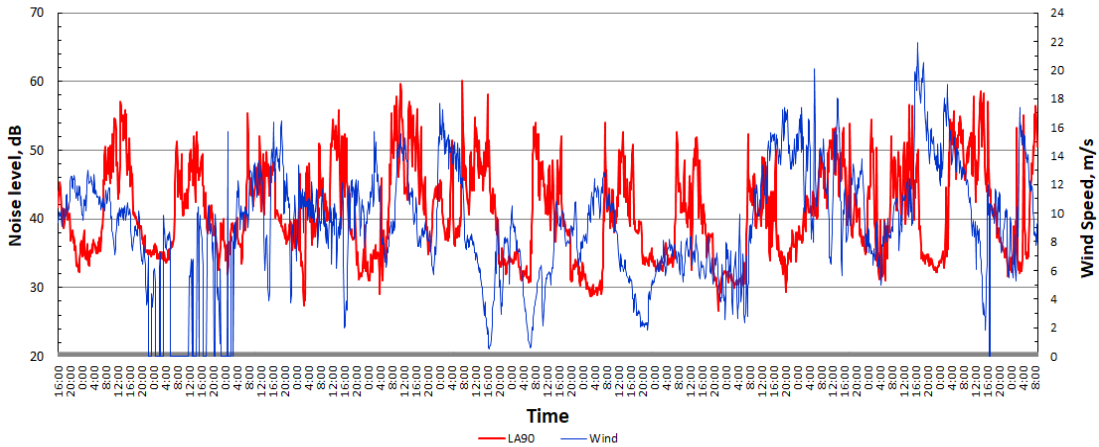

Figure 6. Noise and Wind Measurements at Site 4

There are a number of samples where the wind speed was not available, and this is shown by the wind speed dropping to zero. Although plotted on Figures 3 – 6, where the wind speed is not available the measured noise level has not been used in any subsequent assessment.

The relationship between the wind speed and the resulting noise level is not as close as normally expected. For some periods there is little direct correlation between the noise at the monitoring site and the measured wind speed. This is

likely to be due to the flat nature of the site compared to on the ridges which are the typical location for turbines.

To determine an acceptable noise level for the proposed wind turbines in accordance with the requirements of *NZS 6808:2010 Acoustics – Wind Farm Noise*, the measured background sound ($L_{A90\ 10\ min}$) at the closer houses to the proposed wind turbines has been plotted against the wind speed at the wind turbine site. The results are shown on Figures 7 – 10.

On Figures 7 - 10 the background noise levels ($L_{A90\ 10\ min}$) are plotted on the y-axis (as measured at 10 minute intervals throughout the monitoring period) against wind speed (measured at the same time), which is plotted along the x-axis. The average background sound ($L_{A90\ 10\ min}$) for the measured points has then been calculated in accordance with the requirements of NZS6808 (as shown by the black line). The related formula of the typical background sound is given in the top right corner of the graph. The design requirement for the wind turbines, in accordance with NZS6808, is the background sound ($L_{A90\ (10min)}$) plus 5dB or a level of 40dB $L_{A90\ (10\ min)}$, whichever is the greater (as shown by the green line).

The maximum predicted wind turbine noise for the site is also plotted. This is the predicted noise level for the site in terms of the requirements of NZS6808.

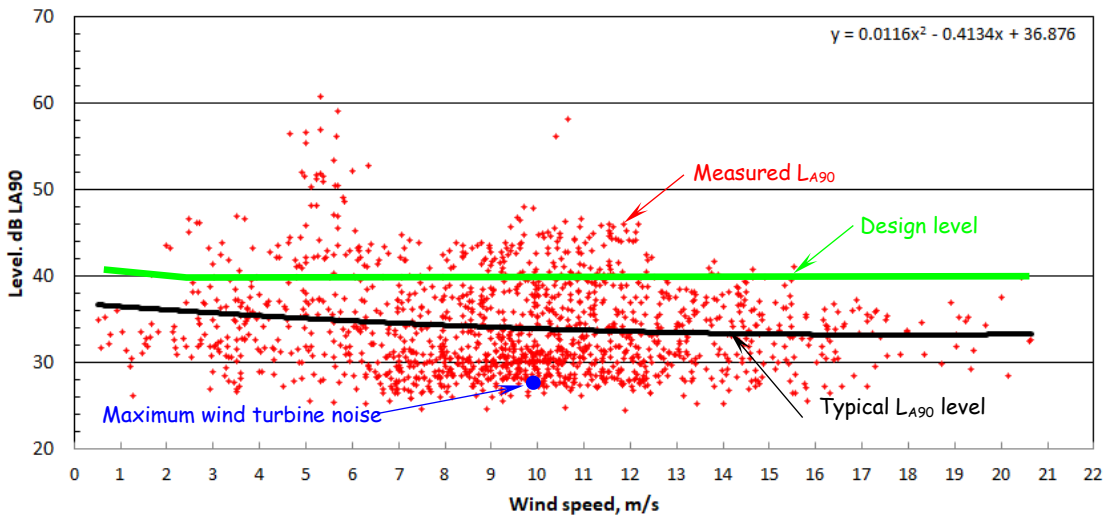

Figure 7. Design Limits for Site 1

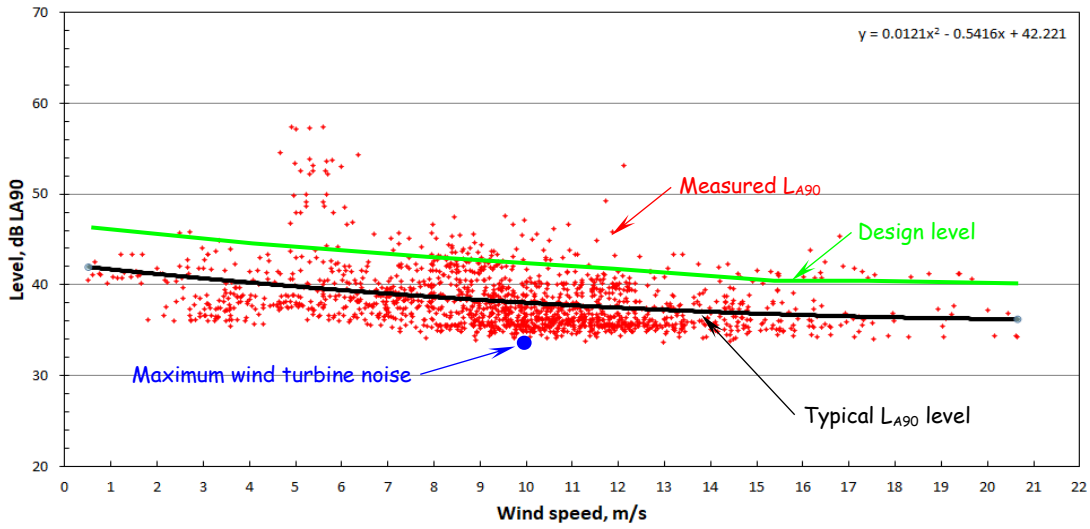

Figure 8. Design Limits for Site 2

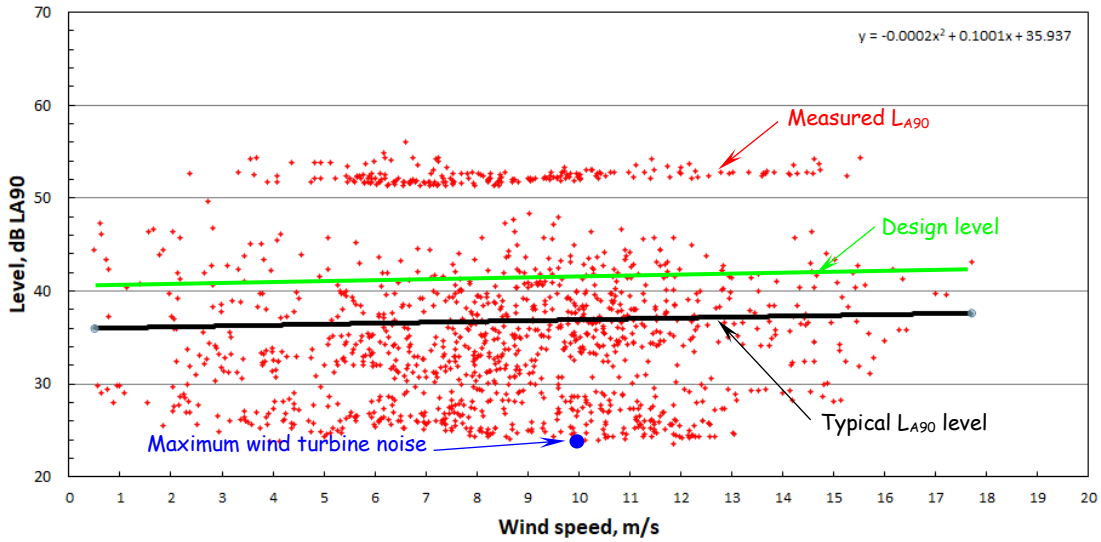

Figure 9. Design Limits for Site 3

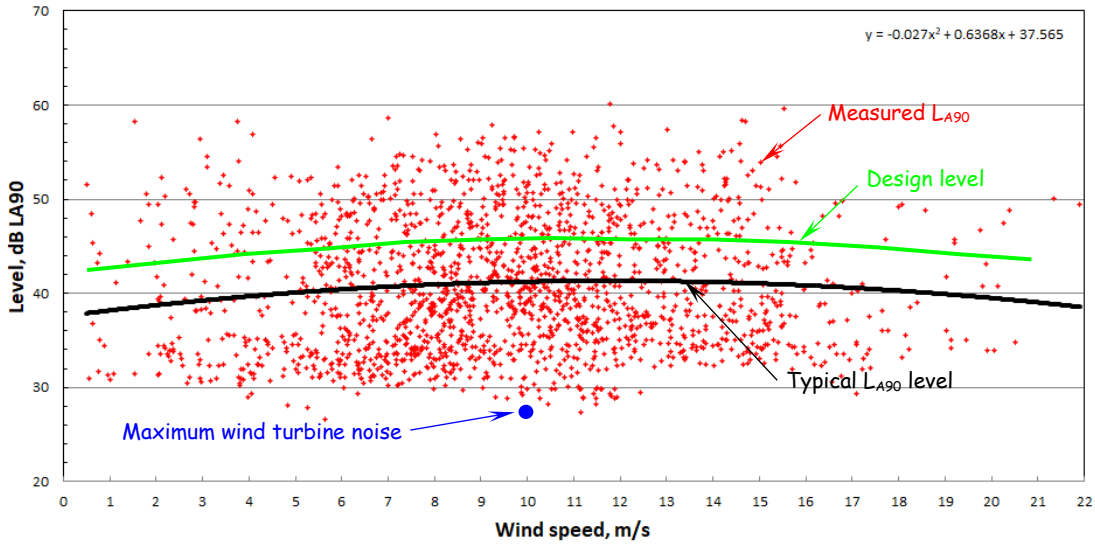

Figure 10. Design Limits for Site 3

It is recognised there may be periods when the background sound is low at the houses yet there may be wind in the WTGs so the residents may hear noise from the WTGs. However, audibility is not the design criterion with respect to the noise assessment. The design criterion is the background sound ($L_{A90\ (10min)}$) plus 5dB or a level of 40dB $L_{A90\ (10\ min)}$, whichever is the greater although in this case the proposed wind turbines will comply with a design level of 40dB $L_{A90\ (10\ min)}$ at all dwellings. This approach is no different to the criteria adopted for any other development, including typical industrial sites where a level of 55/45dB L_{Aeq} is adopted in the District Plan for the day/night period.

At a design level of the background sound ($L_{A90\ (10min)}$) plus 5dB or a level of 40dB $L_{A90\ (10\ min)}$, whichever is the greater, the noise from wind turbines is within a limit that will allow undisturbed sleep for a great majority of people under all conditions, which is the aim of any design criterion. This is confirmed in section 5.1 of *NZS6808: 2010,* where it is stated:

5.1.1 Limits for wind farm sound are required to provide protection against sleep disturbance and maintain reasonable amenity at noise sensitive locations.

C5.1.1 Wind farm sound may be audible at times at noise sensitive locations. Effective, ongoing consultation with the community, beginning at the early planning stages of a wind farm, is important to encourage good communication among all the interested parties. This can help to identify and address any community concerns and can reduce the likelihood of adverse effects such as annoyance from audible sounds at different wind speeds and wind directions when the wind farm begins operating.

5.1.2 To provide a satisfactory level of protection against sleep disturbance, this Standard recommends a limit of wind turbine sound levels outdoors at noise sensitive locations of 40dB $L_{A90(10\ min)}$ (see 5.2).

C5.1.2 This is based on an internationally accepted indoor sound level of 30dB L_{Aeq} to protect against sleep disturbance (refer to Berglund, Lindvall, and Schwela). This assumes a reduction

from outdoors to indoors of typically 15dB with windows partially open for ventilation. The typical reduction of 15 dB would reduce an external level of 40dB L_{A90} to 25dB L_{A90}. Given that the internal target is 30dB L_{Aeq} this allows for the difference between LEQ and L_{90}, and for variations in the outside to inside reduction.

5.1.3 The wind farm noise limit of 40dB $L_{A90(10\,min)}$ (outdoors) recommended for protection of sleep is also appropriate for protecting the health and amenity of residents for most noise sensitive activities.

C5.1.3 In certain situations (see 5.3), consideration of a noise limit more stringent than 40dB $L_{A90\ (10min)}$ may be appropriate to further protect amenity for particular noise sensitive locations.

The scatter of the noise levels for a given wind speed is only of potential concern where the predicted noise level exceeds 40dB $L_{A90\ 10min}$, which is greater than the predicted noise level for these wind turbines.

4 PREDICTED NOISE LEVELS

4.1 Construction Noise

During the construction of the proposed wind turbine activities will include but will not be limited to earthmoving equipment to prepare the roads and foundations for the WTGs, trucks delivering concrete and other materials and cranes to erect the WTGs.

During the formation of the internal roads the closest dwellings, not on the same land as the access road, are expected to be a minimum of 250m from the road so the predicted level of noise from the access road construction is not expected to be more than 48dBA (L_{eq}) for the residents during calm weather conditions.

The closest dwelling to a wind turbine site that is not on the same land as the wind turbine is 232 Kohiri Road as shown on Figure 1. This dwelling is just under 1km from the closest wind turbine where the noise from placing concrete pads will be up to 39dBA L_{eq}.

The towers will be lifted into place using an 180t crane, or similar, as shown on Figure 11. Figure 12 shows a noise trace of an 180t Hitachi crane at 60m and a 120t truck mounted Hitachi crane at 35m from the measurement position. Figure 12 also shows the 120t crane leaving the site and then only the 180t crane operating. Based on these levels the noise from constructing the towers will be up to 19dBA L_{eq} at the closest dwelling not on the same sites as the wind turbines

Figure 11. 180t Hitachi Crane

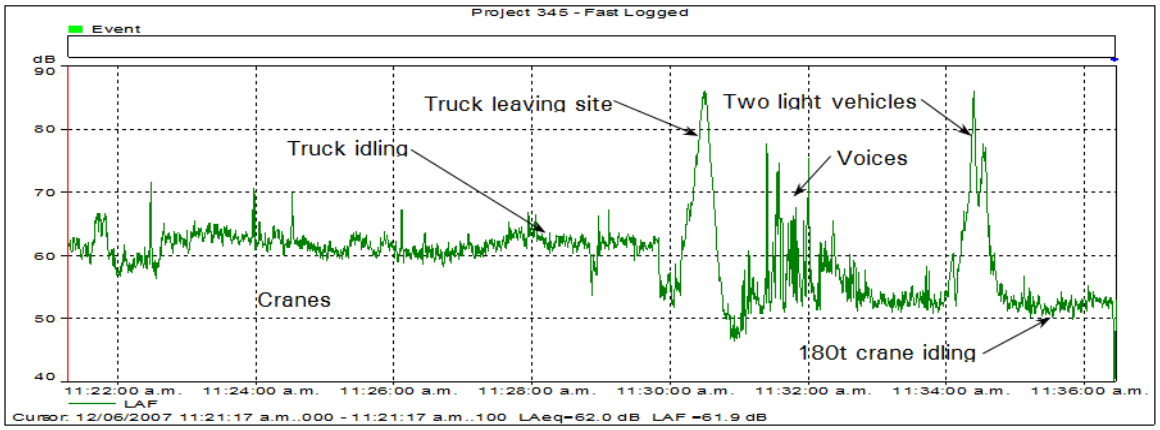

Figure 12. Crane noise

The proposal is to construct gravity foundations with the concrete being trucked in from an existing batching plant in Hawera, Normanby or other local batching plant. The main noise from the construction of the foundations will be the pumping of concrete. Taking into account the distance from the turbine foundations to the closest dwelling the noise from this activity will be no more than 37dBA L_{eq} and 41dBA L_{max}.

The main noise when constructing the towers will be generated from bolting the tower sections together. As shown on Figure 13 the noise of an impact wrench used inside of the tower to tighten the connecting bolts will be 69dBA L_{eq} at 80m. This will give a level of 42dB L_{eq} and a maximum level (L_{max}) of 48dB at the closest existing dwelling (232 Kohiri Road) to the closest wind turbine.

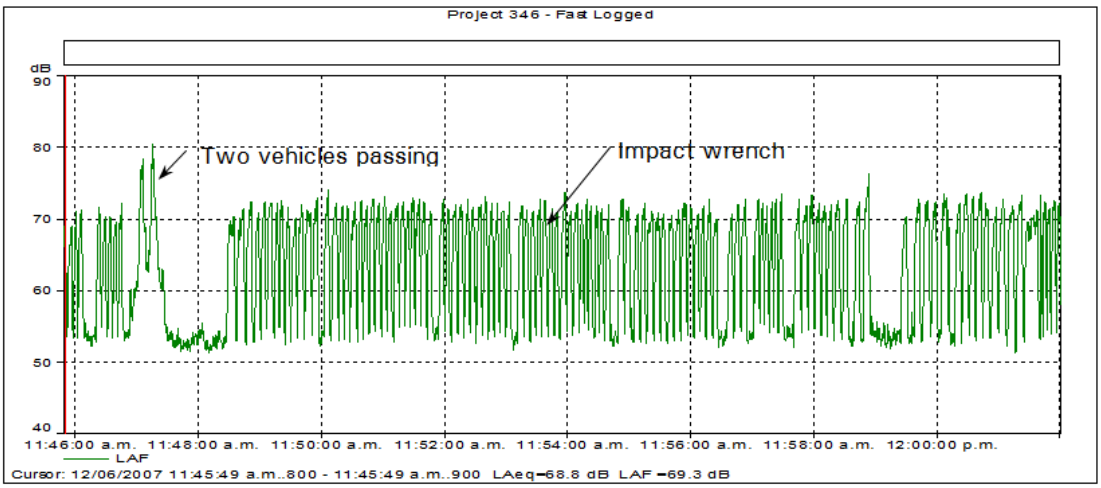

Figure 13. Impact wrench assembling tower

The nacelle and WTG blades will be lifted into position with a 400t crane or similar as shown on Figure 14. The noise from this operation when measured at 50m is typically 65dBA L_{eq} and 73dBA L_{max} as shown on Figure 15. This will give a level of up to 33dBA L_{eq} and 41dBA L_{max} from constructing the WTG at the closest existing dwelling (232 Kohiri Road) to the closest wind turbine.

Figure 14. 400t Crane lifting the Nacelle

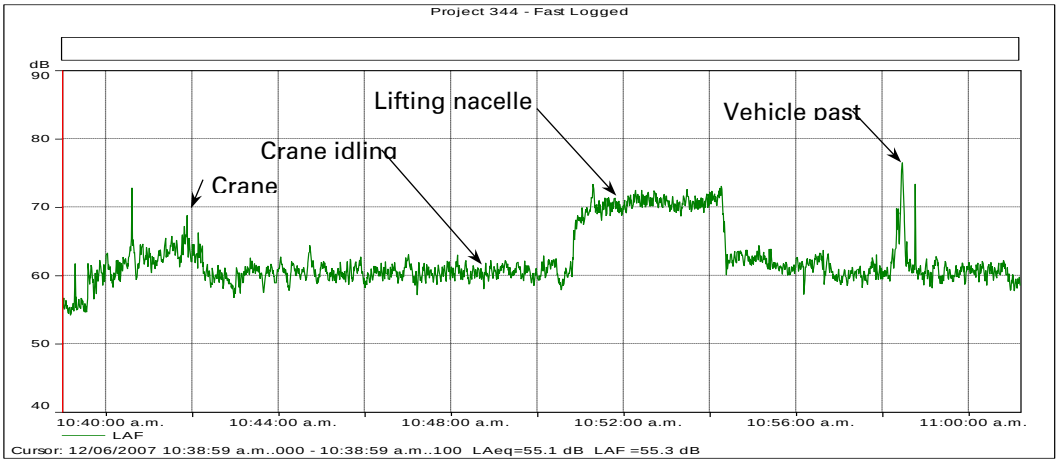

Figure 15. Noise Trace of 400t Crane

From the above, the resulting noise levels from the closest WTG site being constructed will be well within the requirements of the Construction Standard

(NZS6803) at all times. These levels are generally either below or just above the existing noise environment during the daytime, so the noise is unlikely to cause a nuisance for the neighbours in the area.

4.2 Operational Noise

The two main noise sources from the proposed WTGs are mechanical noise and aerodynamic noise. All mechanical noise sources will be located within the WTG nacelle on the top of the tower as shown on Figure 16. The noise from the gearbox (if utilised) and drive motors will be minimised by the manufacturer's design, making any mechanical noise secondary to the aerodynamic noise from the rotating blades.

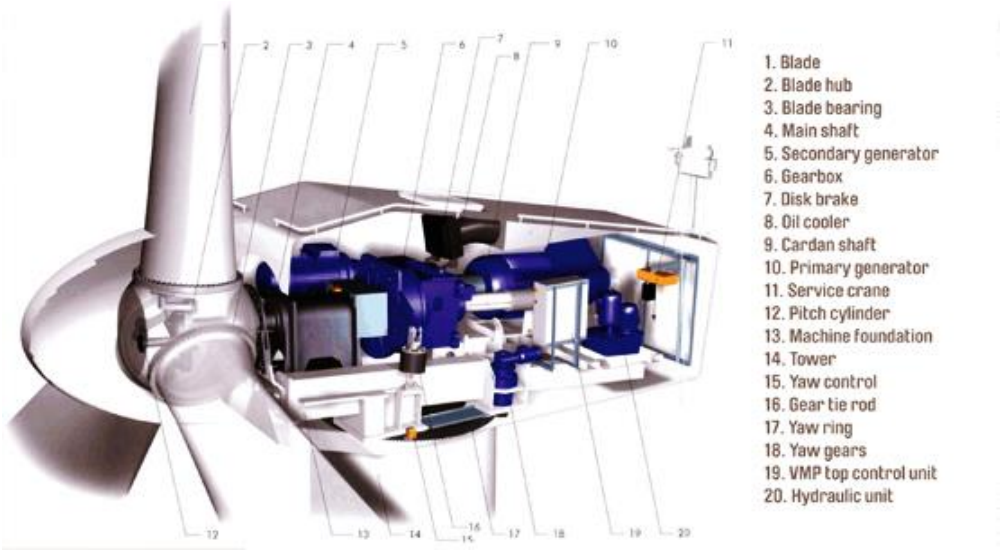

Figure 16. Typical Nacelle Noise Sources

The noise specifications for the WTGs are available from the manufacturer. An example of the test data available for the maximum sound power level is set out below for the indicative WTGs being considered for this site (such as the Vestas V162 6MW turbine).

Table 1. WTG Sound Power Levels

Octave Band, centre frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Sound power level (L_{WA} dB)	84.8	92.5	97.4	99.2	98.0	93.9	86.4	76.7

The WTGs typically start generating or 'cut in' at approximately 4m/s and once the wind speed reaches approximately 25m/s the WTG is temporarily shut down to prevent possible damage to the equipment.

When close to the operating WTGs (within approximately 50m) the characteristic sound of the blades passing is apparent. However, at distances of more than approximately 300m, this noise becomes steady with little variation to the noise level. With more than one WTG operating, the cumulative noise is a steady sound with the only variation being due to turbulent wind effects. It is noted that the noise from wind turbines does not have any significant directivity characteristics so the direction that the WTGs face is not critical in the analysis of the noise effects. The highest noise level would be experienced when directly downwind of a wind turbine and this situation has been modelled.

During calm weather conditions (<3 - 4m/s) the WTGs will be either stationary or idle without generating any power. It follows that under these conditions there will not be any noise from the WTG. This is also the condition for the minimum noise in the environment.

If a WTG has a special audible characteristic (determined at a noise sensitive dwelling) such as a tonal component, there is a 5dB penalty for the sound as required by NZS6808. However, by selecting modern WTGs the potential for special audible characteristics at noise sensitive dwellings will be eliminated.

The noise from the wind turbines has been predicted based on the standard reduction of noise at the rate of 6dBA for each doubling of distance between the

source and receiver position (geometrical spreading). The effects of atmospheric absorption and the ground effects of the topography have also been included. Although the model takes any ground screening effects into account there is no screening by the topography at this site.

The effect of sound transmission is influenced by wind direction with higher noise levels being received downwind than upwind. As any monitoring of the wind turbines would include downwind effects (which is representative of the noise level that would be experienced by residents at times), these effects have been included in the analysis of the predicted noise levels. This raises the predicted noise by typically 5dB at 1km when compared to no wind effects. Similarly, if upwind, the noise level will be reduced by typically 8dB at 1km. In both cases, the difference increases as the distance increases.

The noise levels have been predicted based on the requirements of *ISO 9613 Acoustics – Attenuation of Sound during Propagation Outdoors, Part 1:Calculation of the absorption of sound by the atmosphere and Part 2: General method of calculation* based on the existing ground contours over an area of approximately 7km x 5km. It should be noted that the noise contours have been based on a downwind condition in all directions, that is, the wind is blowing from each WTG to each receiver position. This will not occur in practice but has been calculated with the computer model so represents the worst case scenario for each dwelling in all locations at the same time.

In a gentle to moderate breeze (7 - 10m/s) the WTGs will generate the maximum noise level. Based on wind speeds of between 7 - 10m/s the resulting noise contours have been predicted as shown on Figure 17.

Figure 17. Wind turbine noise, dB $L_{A90(10min)}$

In addition to the noise contours the noise level has been calculated at the notional boundary at each of the sites as shown on Figure 18.

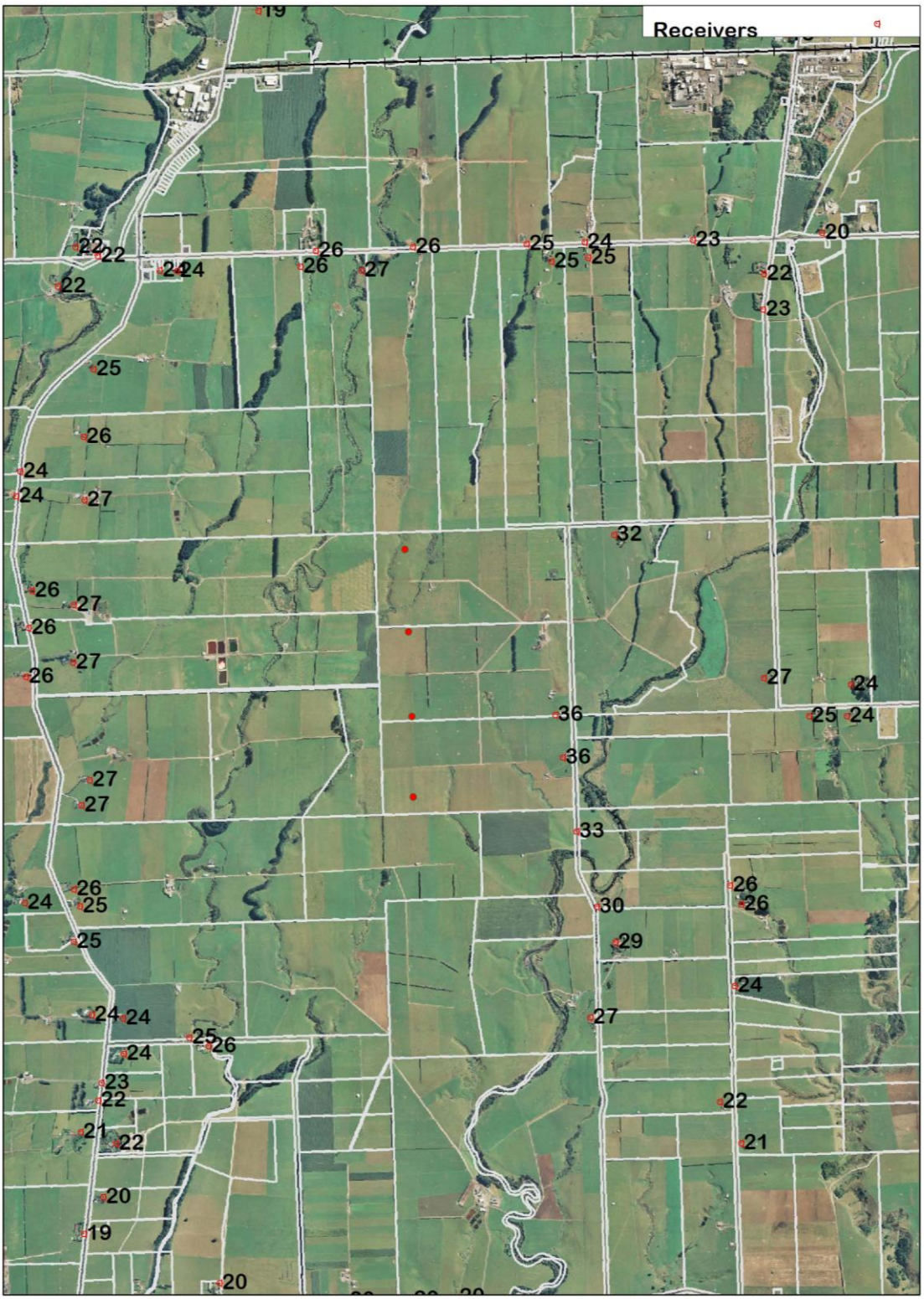

Figure 18. Predicted Noise Levels at the notional boundary, dB $L_{A90(10min)}$

When considering the downwind predicted noise, the levels at the houses (as shown on Figure 22) are all within the requirements of *NZS 6808: 2010 Acoustics – Wind Farm Noise*. That is, the predicted noise levels do not exceed a level of 40dB $L_{A90\ (10\ min)}$ with the highest noise level at any notional boundary being 36dB $L_{A90(10min)}$.

4.3 Low Frequency Noise

The effect of low frequency noise is addressed in NZS6808: 2010 where it is stated in Clause 5.5:

5.5.1 Although wind turbines may produce some sound at (ultrasound and infrasound) frequencies considered to be outside the normal range of human hearing these components will be well below the threshold of human perception.

5.5.2 Claims have been made that low frequency sound and vibration from wind turbines have caused illness and other adverse physiological effects among a very few people worldwide living near wind farms. The paucity of evidence does not justify at this stage, any attempt to set a precautionary limit more stringent than those recommended in 5.2 and 5.3.

Clause 5.2 and 5.3 are set out above.

In addition, numerous acoustic publications on wind turbines and low frequency noise have been researched, including by the committee reviewing NZS6808. This includes standard textbook literature, acoustic publications such as the Journal of the Acoustical Society of America and the Acoustic Archives, which cover some 20,000 references from over 400 sources over the last five years.

The results of a measurement undertaken at the Tararua Wind Farm, which has 3MW WTGs with 90m rotor diameter, with wind speeds of approximately 20m/s at the WTG and 15m/s at the measurement position are shown on Figure 19. The

closest WTG was 117m from the measurement position with 26 WTGs visible, seven being within 400m.

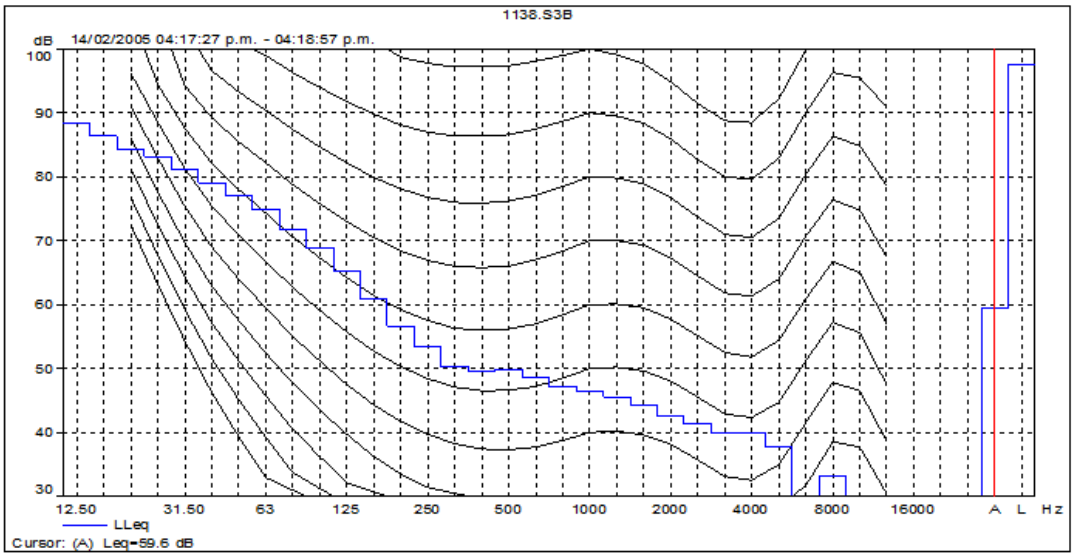

Figure 19. Tararua WTGs, 117m to closest WTG

Figure 19 shows a family of equal loudness curves, that is, if the frequency level follows any particular curve, the loudness sounds the same to the observer at the different frequencies. This shows the noise level must be higher at the lower frequencies to sound as loud at the higher frequencies. For the Tararua WTGs the frequencies between 50 – 200Hz all sound the same with the higher and lower frequencies dropping off and hence not sounding as loud to the receiver. These WTGs do not have any high levels of low frequency noise. A similar result was found at the Te Apiti Wind Farm and the Te Uku Wind Farm.

The BWEA (British Wind Energy Association) has reported[2] that, *to date, there is no evidence which links the levels of low frequency noise emitted by wind turbines with impacts on human health. With over 50,000 wind turbines in operation around the world, some of which have been in place for 20 years, there has been ample opportunity for any ill effects to have been identified; that none*

[2] BWEA Briefing Sheet, Low frequency noise, wind turbines and health effects, March 2004

have is further proof of the benign nature of this technology. This is referring to what is sometimes called vibroacoustic disease.

The WTGs selected have been evaluated and do not have high levels of low frequency noise. When considering this and the fact there is no substantiated evidence that indicates the modern WTG generates high levels of low frequency noise, there is no reason to suspect the proposed wind turbines will generate high levels of low frequency noise.

4.4 Vibration Effects

Clause 5.3.3 of NZS6808 states:

> *No recommendations for assessing the potential impact of ground-borne vibration are made because such vibration is not perceptible beyond the boundary of the wind farm.*

This has been confirmed by Hegley Acoustic Consultants by undertaking vibration monitoring at the base of a 3MW WTG tower where no unusual vibrations were measured. This result is consistent with published data for all modern WTGs such as those proposed at this site.

4.5 Noise Effects on Farm Animals

The effects of noise from the wind turbines on farm animals on and around the proposed wind turbines has been considered. Very little research is available on the relatively low levels of noise that would be experienced by animals from wind turbines. The main research available is from overflying aircraft and sonic booms from aircraft, particularly from sonic booms. The level of noise from activities such as overflying aircraft and sonic booms is higher than will be experienced from the proposed wind turbines. However, if the higher noise levels do not cause adverse noise affects it is reasonable to conclude the lower wind turbine

noise will not cause any adverse nose effects as it is not noise level that is important, not the source of the noise.

In a report of well controlled experiments of the sonic boom problem it is plain that the behaviour of farmed animals (10,000 beef cattle, 100 horses, 150 sheep, 320 dairy cattle, 125,000 turkeys, 35,000 chicken broilers and 50,000 pheasants) was unaffected by repeated sonic booms. The only reported case of sonic boom effect on animals' concerns honey-bees and this was in temperatures of below 10°C which were considered to be a significant contributing factor.

It was concluded[3] in a review of the effect of noise (principally from aircraft) that there was no evidence of noise having a significant impact on cattle (milk production).

Another survey[4] was undertaken to determine if there was any measurable effect of jet aircraft noise and fly-overs on the production of dairy herds located in the vicinity of existing air bases. Data covering a period of 12 months was obtained on the daily milk deliveries from 182 herds located within 3 miles of 8 Air Force Bases using jet aircraft. Of these herds 13% were within 1 mile of the end of an active runway; 31% were between 1 and 2 miles and 56% were between 2 and 3 miles distant. The herds were also classified as "exposed" or "not exposed" to flight activity according to their location regarding the path of take-off and landing for the aircraft. An analysis of data from the 42 herds surrounding the Lockbourne Air Force Base and from complete data on flight activity at that base did not show any evidence that fly-overs or the proximity to the ends of the active runways influenced the milk production of the herds.

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[3] Memphis State University. 1971. Effects of noise on wildlife and other animals. United States Environmental Protection Agency Office of Noise Abatement and Control Washington, D.C. Document NTID300.5

[4] United States Department of Agriculture1960 Vol. 60 pp. 22 pp

A more recent paper[5] stated that in response to concerns about overflight effects on pregnant cattle, milk production and cattle safety, the U.S. Air Force prepared a handbook for environmental protection that summarises the literature on the impacts of low-altitude flights on livestock (and poultry) and includes specific case studies conducted in numerous airspaces across the country.

A majority of the studies reviewed suggests that there is little or no effect of aircraft noise on cattle. Studies presenting adverse effects on domestic animals have been limited. A number of studies[6] investigated the effects of jet aircraft noise and sonic booms on the milk production of dairy cows. Through the compilation and examination of milk production data from areas exposed to jet aircraft noise and sonic boom events, it was determined that milk yields were not affected. This was particularly evident in those cows that had been previously exposed to jet aircraft noise.

There is limited evidence that sheep adapt to continuous sound, provided it is not too loud (above ≈80 - 85dBA)[7].

As shown on Figure 20 horses do not hear as well as humans (10 – 15dB below that of humans) below approximately 8kHz but hear better above 8kHz. Noise from a wind turbine is all below 8kHz so in general terms the wind turbines would sound less than half as loud to horses as it does to humans.

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5 Noise Basics and the Effect of Aviation Noise on the Environment, Wyle publication
6 Parker and Bayley 1960; Casady and Lehmann 1967; Kovalcik and Sottnik 1971
7 Animal Welfare, Volume 17, Number 3, August 2008, Universities Federation for Animal Welfare

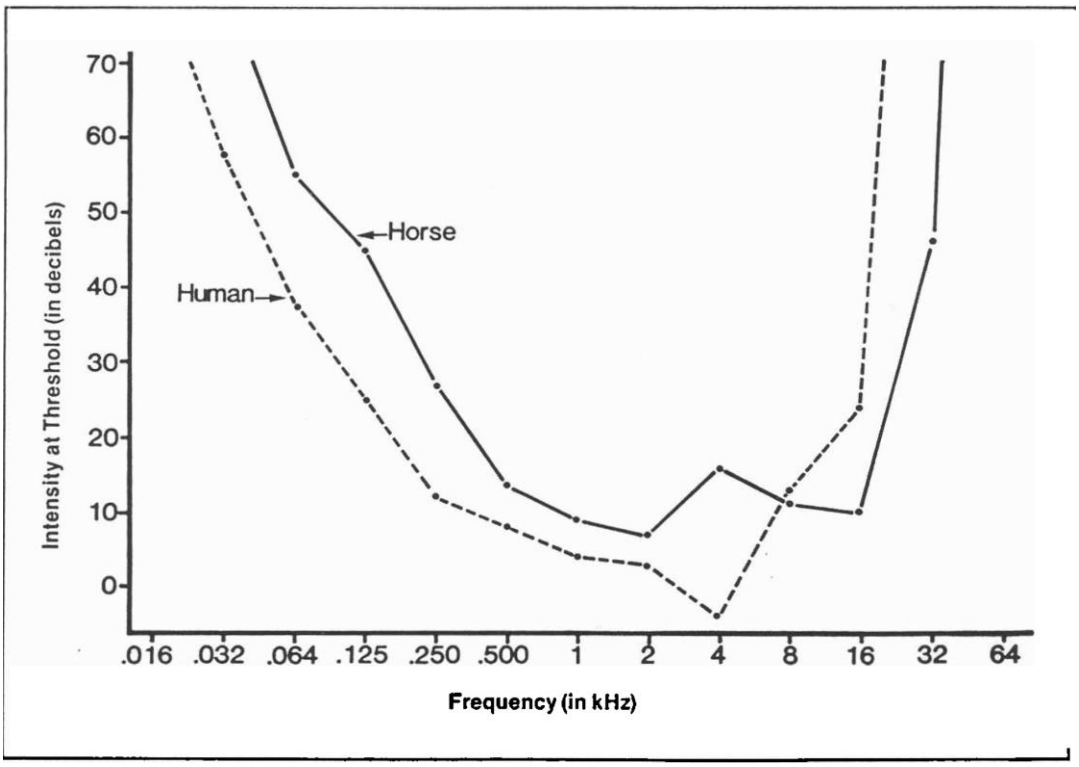

Figure 20. Audiogram of Horses

There is not a lot of research available on the noise effects on horses. However, the British Horse Society has published a report Access and Bridleways Leaflet 20 - Wind Farms ACCESS - Wind Farms where it states:

> *The British Horse Society advises that - before planning permission is granted for the installation of a wind turbine or turbines - consideration be given to requiring a safety margin between the proposed turbine(s) and the nearest public right of way or other access route available for use by horse riders and/or horse drawn vehicle (HDV) drivers. The Society is urging Government to revise its guidance so as to relate the safe minimum distance to the proposed height of the nearest turbine on the basis of at least three times the height - reflecting the guidance given in earlier times. In the meantime, the Society urges that all developers and planners recognise a 200 metre safety margin as being the absolute minimum for limiting the potential impact on equestrian interests.*

The British Wind Energy Association (BWEA) report, Frequently Asked Questions, Do wind turbines frighten livestock? states that wind farming is popular with farmers, because their land can continue to be used for growing crops or grazing

livestock. Sheep, cows and horses are not disturbed by wind turbines. The first wind turbines built in the UK, Delabole, has a stud farm and riding school.

Figure 21 shows a riding school in the UK that operates successfully on a wind farm.

Figure 21. Horses on a wind farm

4.6 Noise Monitoring

During the construction period he noisiest activity for any dwelling will be the development of the roads at up to 48dBA L_{eq} and for the construction work associated with the turbines themselves the highest noise predicted at any dwelling is 39dBA L_{eq} with the maximum level being typically 5 – 8dBA L_{max} above the L_{eq} level. As the design limit set out in NZS 6803:1999 Acoustics – Construction Noise is 70dBA L_{eq} and 85dBA L_{max} there is a large factor of safety, so monitoring is not considered necessary in this case. However, to provide certainty and some reassurance for the neighbours it is recommended a condition is included with any consent granted that allows Council to request

monitoring in the event there are concerns expressed by any neighbour that construction noise is a problem.

Once operational the wind turbines are often measured to confirm compliance with the relevant noise condition. For this project the highest predicted noise level at any notional boundary not on the same site as the wind turbines is 33dB $L_{A90\ (10\ min)}$. Clause C5.3.1 of NZS 6808 states

> ***C5.3.1*** *The following steps provide guidance on whether a high amenity noise limit may be justified:*
>
> *(a) There is no need to consider noise sensitive locations outside the predicted 35dB $L_{A90(10\ min)}$ wind farm sound level contour;*

That is, where under 35dB $L_{A90\ (10\ min)}$ a full analysis is not generally required, although in this case has been undertaken. Based on this it is recommended that operational monitoring would only be necessary should there be concerns expressed by the neighbours.

5 TRAFFIC NOISE

It is expected that over the course of the construction phase of the project, the trucks that transport the WTG blades, towers and nacelles will arrive at the site typically twice a day (2 arrivals and 2 departures). Additional heavy vehicle movements for on-site construction, which includes importing base course for the onsite roads and turbine platforms, concrete deliveries and general deliveries, are up to approximately 100 movements per day.

There is no specific control of traffic noise in either the Proposed District Plan, Resource Management Act or any other current legislation. The only guideline available is NZS 6806:2010 Acoustics – Road Traffic Noise - New and Altered Roads and the lowest noise level adopted in these guidelines is 57dB measured as a 24 hour L_{Aeq}. This level of 57dB is for new roads with a predicted traffic volume of 2,000 – 75,000 AADT at the design year. This is the level adopted for the quietest noise environments. There are no recommended noise limits for the 1 hour L_{Aeq}, although generally the 1 hour L_{Aeq} does not exceed the 24 hour L_{Aeq} by more than 2 – 4dB.

The existing traffic flows vary between a low of 27 vehicles per day (vpd) on the roads near the proposed wind turbine site to a high of 893vpd with 10% heavy commercial vehicles on Manaia Road.

Although there will be a significant increase in the existing traffic flows on the local roads during the construction of the wind turbines, the total flows are light relative to many other roads around the country. The traffic flow on all roads in the immediate area of the proposed wind turbines is below the minimum so reliable traffic noise predictions cannot be undertaken.

Traffic noise is calculated to the façade position of any dwelling and the traffic noise has been calculated at various distances from the edge of the carriageway to give the following levels based on a busy one hour traffic flow. For houses

near Manaia Road the traffic noise for a dwelling 10m from the edge of the road will be approximately 56dB $L_{Aeq\ (24hr)}$ reducing to 52dB $L_{Aeq\ (24hr)}$ at 20m.

Even for the closest sites to the road the 1 hour levels are within the lowest value of 57dB $L_{Aeq\ (24hr)}$ as set out in NZS6806. In addition, the noise is only generated during the daytime, as there will not be any additional traffic generated during the night time so eliminating any possible sleep disturbance for the neighbours. This noise is only related to the maximum likely traffic flows during construction of the wind turbines so is of limited duration compared to the ongoing traffic noise addressed by NZS6806.

Although the daily noise exposure will remain low and well within a level generally considered to be reasonable, it should be kept in mind that individual truck movements will be clearly audible for anyone living close to the road. As the truck movements will generally be limited to the daytime rather than the night time (10:00pm – 7:00am), sleep will not be disturbed. The exception is that it may be necessary to transport the wind turbine components at night time due to the size of the blades and nacelle to minimise disruption to traffic. As the transport of these wind turbine components will be at relatively low vehicle speeds the noise from this activity will be slightly lower than experienced from other trucks that may pass, such as a milk tankers, so the noise effects will be similar to those trucks. However, it should be kept in mind that any additional noise source will only occur for the neighbours during the construction period.

6 RECOMMENDED CONDITIONS

Clause 7.1.4 of NZS6808 states:

> *Background sound level measurements and subsequent analysis to define the relative noise limits should be carried out where wind farm sound levels of 35dB $L_{A90(10\ min)}$ 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 35dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

As set out above, because the proposed wind turbines will not exceed 35dB $L_{A90(10\ min)}$ at any noise sensitive location it is unnecessary to carry out any background sound level measurements and subsequent analysis. Regardless, to provide a detailed understanding of the project both a background survey and detailed analysis has been undertaken to provide transparency for the neighbours.

Although not considered to be required, should the expert panel consider noise conditions are necessary such conditions may be as simple as simply requiring compliance with the requirements of NZS6803:1999 *Acoustics - Construction Noise* and NZS 6808:2010 *Acoustics - Wind Farm Noise* or the more detailed draft conditions as provided below.

Construction Noise

1 Noise from all construction work shall be measured and assessed in accordance with the requirements of *NZS 6803:1999 Acoustics – Construction Noise*.

2 A Construction Noise Management Plan (CNMP) shall be prepared prior to the commencement of any construction works and shall be properly implemented at all times. The CNMP shall be generally in accordance with section 8 and the relevant annexures of NZS6803, which detail the relevant types of construction to which the CNMP is to apply, and procedures that will be carried out to ensure compliance with that Standard.

3 The CNMP shall be prepared by an appropriately qualified and experienced acoustical consultant and shall be submitted to the Environmental Services Group of the Council for certification. Should a response not be received

within 30 working days of receipt, the Consent Holder shall be entitled to proceed in accordance with the conditions of consent.

4 Noise monitoring of construction activities must be undertaken by the applicant if reasonably requested by the Environmental Services Group of the Council and the results provided to Council within two weeks of the monitoring being undertaken.

Operation Noise (Non Turbine Related)

5 Noise generated by any activity (other than wind turbine generator operation and construction activities) in the Rural Zone shall not exceed the following limits when measured at or within the notional boundary of any other Rural Zoned site:

7am to 7pm	*55dBA* $L_{Aeq(15\ min)}$
7pm to 10pm	*50dBA* $L_{Aeq(15\ min)}$
10pm to 7am	*45dBA* $L_{Aeq(15\ min)}$
10pm to 7am	*75dBA* L_{Amax}

6 Except where otherwise expressly provided for, the noise is to be measured in accordance with the requirements of NZS6801:1991 "Measurement of Sound" and assessed in accordance with the requirements of NZS6802:1991 "Assessment of Environmental Sound".

Operation Noise (Turbines)

7 The turbines shall be designed, constructed, operated and maintained so that wind turbines sound levels comply with the requirements of NZS6808. For the avoidance of doubt, this condition shall require the turbines to be designed, constructed, operated and maintained so that wind turbines sound levels ($L_{A90\ (10\ min)}$) shall not exceed the background sound ($L_{A90\ (10min)}$) plus 5dB or a level of 40dB $L_{A90\ (10\ min)}$, whichever is the greater.

8 Wind turbine sound shall be measured and assessed in accordance with NZS 6808 within the notional boundary of any residential dwelling either existing or consented at the date of this consent (excluding residential dwellings on properties on which turbines are located or where the owner has provided written consent to the wind turbines).

9 Noise monitoring of the wind turbines must be undertake by the applicant if reasonably requested by the Environmental Services Group of the Council and the results provided to Council within two weeks of the monitoring being undertaken.

7 CONCLUSIONS

The noise during the construction of the WTGs will comply with the requirements of *NZS 6803:1999 Acoustics – Construction Noise* with a good factor of safety.

The proposed wind turbine analysis has been based on the maximum proposed number of 4 WTGs at the maximum size of 6MW. The noise contours developed for this scenario has then been used to develop noise contours.

Once operating, the noise from the wind turbines will also be within the requirements of *NZS 6808:2010 Acoustics – Wind Farm Noise* of the background sound ($L_{A90\ (10min)}$) plus 5dB or a level of 40dB $L_{A90\ (10\ min)}$, whichever is the greater.

From the analysis, it has been shown that the proposed wind turbines will achieve the design limit with a significant factor of safety. Section 16 of the Resource Management Act requires the best practicable option to be adopted to minimise noise and this requirement would be achieved by installing one of the modern quieter types of WTG on the market that will not result in any special audible characteristics to the sound at noise sensitive locations.

When taking the above into account, the noise effects of the proposed wind turbines will be no more than minor in terms of the requirements of the Resource Management Act.

* * *