monitoring experts Sonus[5] provides a comparative assessment of infrasound measurements. The dark green line shows the perception threshold for infrasound as established in international research as 85 dB(G). Under this line, infrasound has been recorded from a range of sources: wind farms (orange), central business district (pink), a gas-fired power station (light green), a beach (blue) and an ambient area (grey).

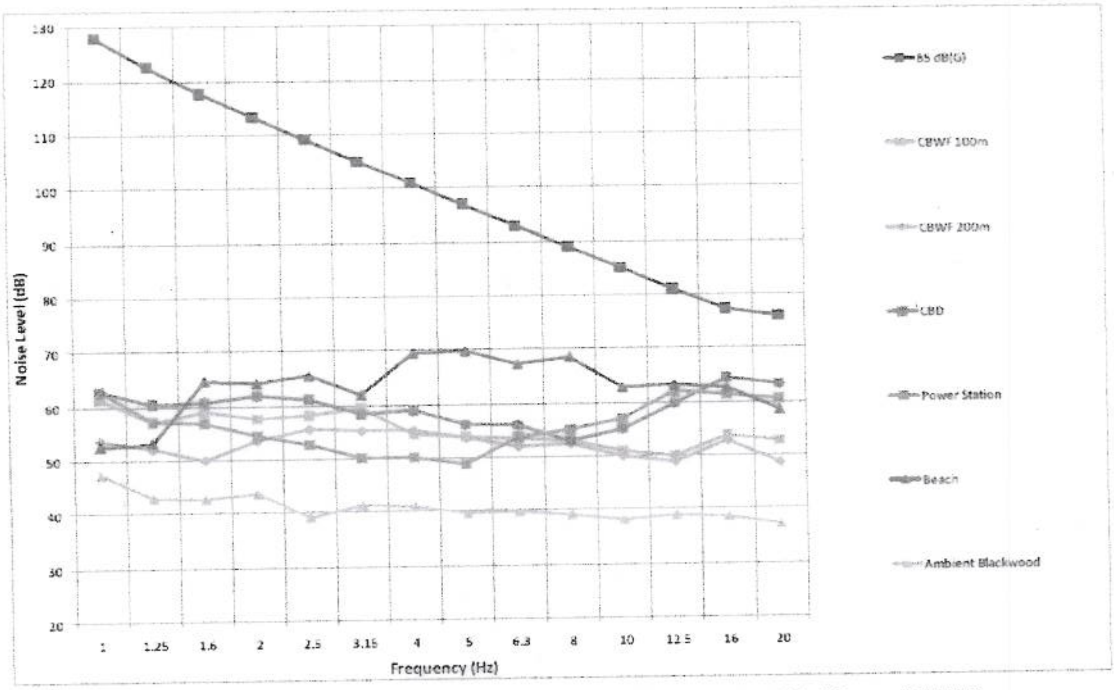


Figure 12 - Summary of Measurements Cape Bridgewater Wind Farm (CBWF)

Source: Sonus Pty Ltd, *Infrasound Measurements from Wind Farms and Other Sources*, Prepared for: Pacific Hydro Pty Ltd, November 2010.

The assessment undertaken by Sonus, demonstrates that infrasound from wind farms is at a very low level and is not perceptible to humans. Noise at just 100 m to 200 m from a wind turbine is less than that experienced at a beach and also less than in a central business district. Furthermore, the levels recorded at residences with more than a 300 m separation from a working turbine are significantly lower again, to the point that they approach ambient levels. We are not aware of infrasound from any of these other similar and moderate sources being linked to human health.

[5] Sonus Pty Ltd, *Infrasound Measurements from Wind Farms and Other Sources*, Prepared for: Pacific Hydro Pty Ltd, November 2010.

Dept Health and ageing Australia Govt
Weighting C is used when Low Frequency is a problem
Submission from Sonus

We hear and respond to some frequencies more acutely than others, so that sound measurements are often filtered to reflect this sensitivity. The most common example, the 'A-weighting', focuses on the mid- and high-range frequencies we hear and gives less emphasis to low frequencies to which our hearing is less sensitive. A 'C-weighting' is often used to measure sources where low frequencies are a problem.

As noise is emitted from a source it spreads in the air and its level decreases as the distance from the source increases (see Figure 2). This 'attenuation' is due to several factors:

- the distribution of acoustic energy over a geometrically expanding area within increasing distance
- noise screening by barriers between noise sources and receivers
- sound absorption by the air
- sound absorption by the ground.

Other factors influencing noise propagation include wind, temperature gradients and humidity (WHO, 1990). These are important factors to consider when determining noise impacts on the community.

Basics of noise measurement

When interpreting acoustical data it is important to recognise that not all metrics are directly comparable and different metrics are often used for different classifications or types of noise having varying characteristics.

A knowledge of sound, noise and human response leads to a selection of noise measurement equipment and various noise descriptors, frequency and time weightings in an attempt to describe and replicate human responses to sound and its impact. A number of different noise descriptors are commonly used to quantify the noise environment and are described below.

$L_{Aeq,T}$ or the equivalent continuous A-weighted sound pressure level measured over a time period T – that level of constant noise equivalent to the varying noise level occurring over a measurement period T, often termed the energy-average noise level. Time periods can vary from 1 minute to 24 hours and include:

- $L_{Aeq,\,1\,min}$ previously used in recommending design sound levels for building interiors, for example, AS 2107
- $L_{Aeq,\,15\,min}$ commonly used in compliance assessment of industrial noise
- $L_{Aeq,\,1\,hr}$ used in setting acceptable planning noise criteria for development

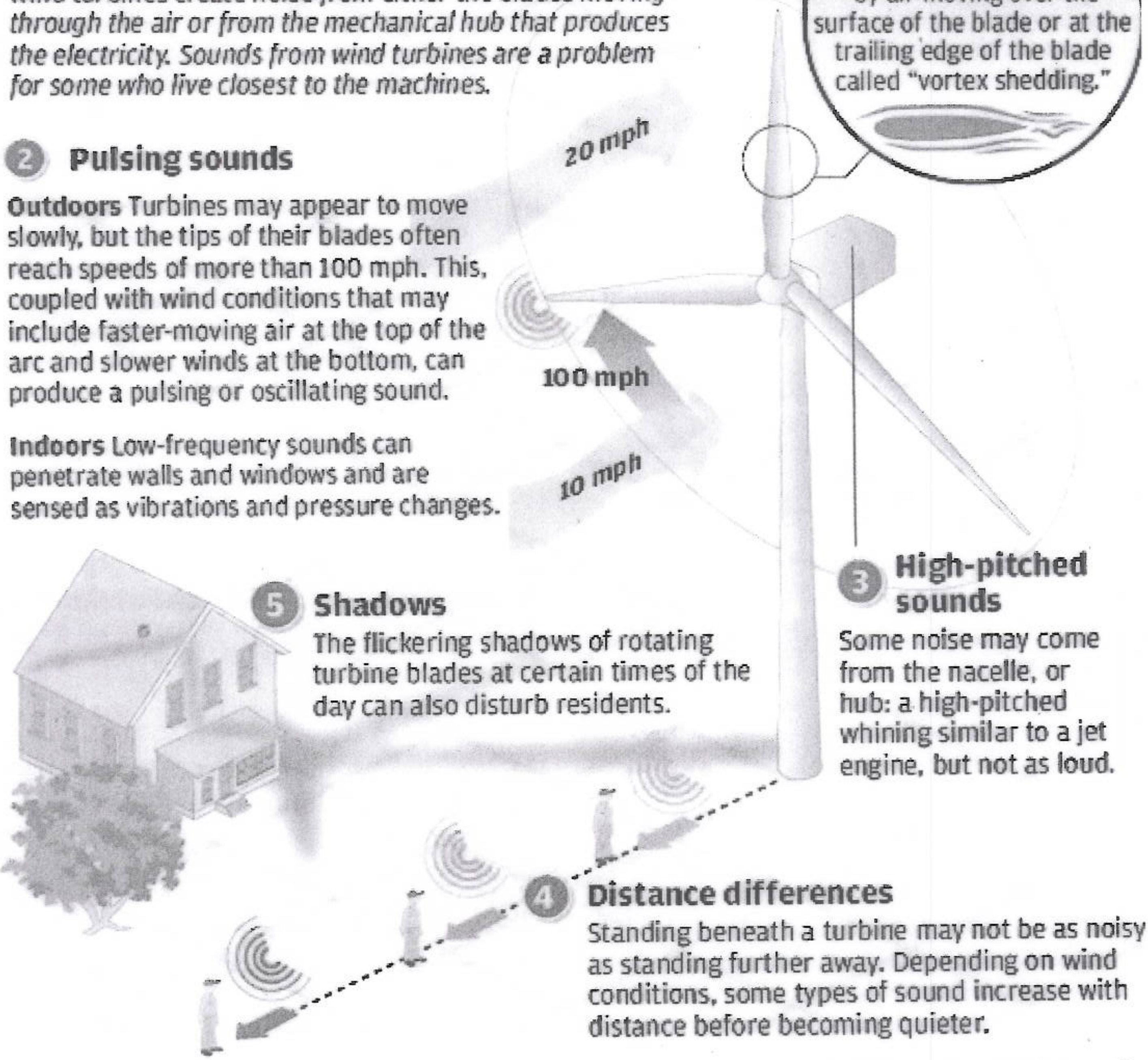
Table 1. Subjective effect of changes in sound pressure level

Change in sound level (dB)	Change in power		Change in apparent loudness
	Decrease	Increase	
3	1/2	2	Just perceptible
5	1/3	3	Clearly noticeable
10	1/10	10	Half or twice as loud
20	1/100	100	Much quieter or louder

(Source: Bies & Hansen, 1996)

Sound pollution from wind turbines

Wind turbines create noise from either the blades moving through the air or from the mechanical hub that produces the electricity. Sounds from wind turbines are a problem for some who live closest to the machines.



1 Air-foil turbulence

Sound is generated by air moving over the surface of the blade or at the trailing edge of the blade called "vortex shedding."

2 Pulsing sounds

Outdoors Turbines may appear to move slowly, but the tips of their blades often reach speeds of more than 100 mph. This, coupled with wind conditions that may include faster-moving air at the top of the arc and slower winds at the bottom, can produce a pulsing or oscillating sound.

Indoors Low-frequency sounds can penetrate walls and windows and are sensed as vibrations and pressure changes.

3 High-pitched sounds

Some noise may come from the nacelle, or hub: a high-pitched whining similar to a jet engine, but not as loud.

4 Distance differences

Standing beneath a turbine may not be as noisy as standing further away. Depending on wind conditions, some types of sound increase with distance before becoming quieter.

5 Shadows

The flickering shadows of rotating turbine blades at certain times of the day can also disturb residents.

Source: American and Canadian Wind Energy Associations

MARK BOSWELL - Minneapolis Star Tribu

the abdomen 4–8Hertz. A study examining the chronic effects of low frequency vibration and subsequent psychological and physiological consequence are reported in Table 1 (Rasmussen: Cited in Harry. In fact, the weight of opinion supports the claim that low frequency noise is produced by wind turbines, with the displacement of air by the blades and the turbulence around the blade surface the likely cause. These low frequencies can produce a seismic characteristic leading to those in the proximity of wind turbines to complain not only of audible noise but also noise that they can feel. Low frequency sounds modulate the perception of other audible frequencies and can be sensed as a vibration of the chest or throat. Residents neighbouring wind turbines in the USA have described:

> "... distressing sensation of having to breathe in sync with the rhythmic thumps of the turbine blades, especially at night when trying to sleep."

Casella, reporting on the effects of low frequency turbine noise, makes the observation that, compared to medium and high frequencies, low frequency levels decay slowly with distance, are less attenuated by conventionally designed structures, cause certain building material to vibrate and can sometimes resonate with rooms, undergoing amplification thereby. The relationship between low frequency wind turbine noise and building type creates an interesting proposition in which the low frequency sound may be louder inside the house than out. As the engineering experts attest:

> "Modern home construction techniques used for most wood frame homes result in walls and roofs that cannot block wind turbine low frequencies from penetrating into the interior....When low frequency sound is present outside homes and other occupied structures; it is often more likely to be an indoor problem than an outdoor one. This is very true for wind turbine sounds."

Table 1: psychological and physiological sequelae resulting from low frequency vibration.

Frequency of vibration	Symptoms
4–9 Hz	Feelings of discomfort
5–7 Hz	Chest pains
10–18 Hz	Urge to urinate
13–20 Hz	Head Aches

Summary

In summary:

- Sound is what we hear; noise is unwanted sound.
- Sound, be it unwanted or wanted, influences not only the way we think and behave, but also our physiological systems including cardiovascular and gastrointestinal activities, and hormone secretion.

The prediction at the house of Noel and Janine Dean was 37 - 40 dB.

To comply with New Zealand Standard Requirements the predicted sound level at any house near a wind farm should not exceed 40 dB with an allowance of

3 dB

to take into account inaccuracy in the prediction.

If Special Audible Characteristics are present (as indicated by a swooshing sound from the turbines) an extra

5 dB

should be allowed for.

To comply with New Zealand Standard Requirements the prediction at the house of Noel and Janine Dean should have been less than 32 dB.

Please note: This prediction **does not** take into account allowances for hub height, blade length, spacing, vortex shedding and weather conditions including air stability and topography, these factors could produce up to 10dB of extra sound.

The noise predictions do not tell the whole story, however. Meteorological conditions, wind turbine spacing and associated wake and turbulence effects, vortex effects, turbine synchronicity, tower height, blade length, and power settings all contribute to sound levels heard or perceived at residences. In addition to this the method of prediction has what is known as "uncertainty". That is, the predicted values are given as a range, ± 3 dB(A) at 1000 metres for the most common prediction method with the predicted value being the "middle" of the range. The uncertainty increases with distance and the effect of two or more turbines operating in phase with a light/strong breeze blowing towards a residence. A variation of 6 to 7 dB(A) can be expected under such adverse conditions. This is explained in more detail later in this Report.

The noise predictions in Plate 3 are not a single line or a single number but, in fact, a range of sound levels from 33 to 39 dB(A) at H41 as shown in **Plate 4.**

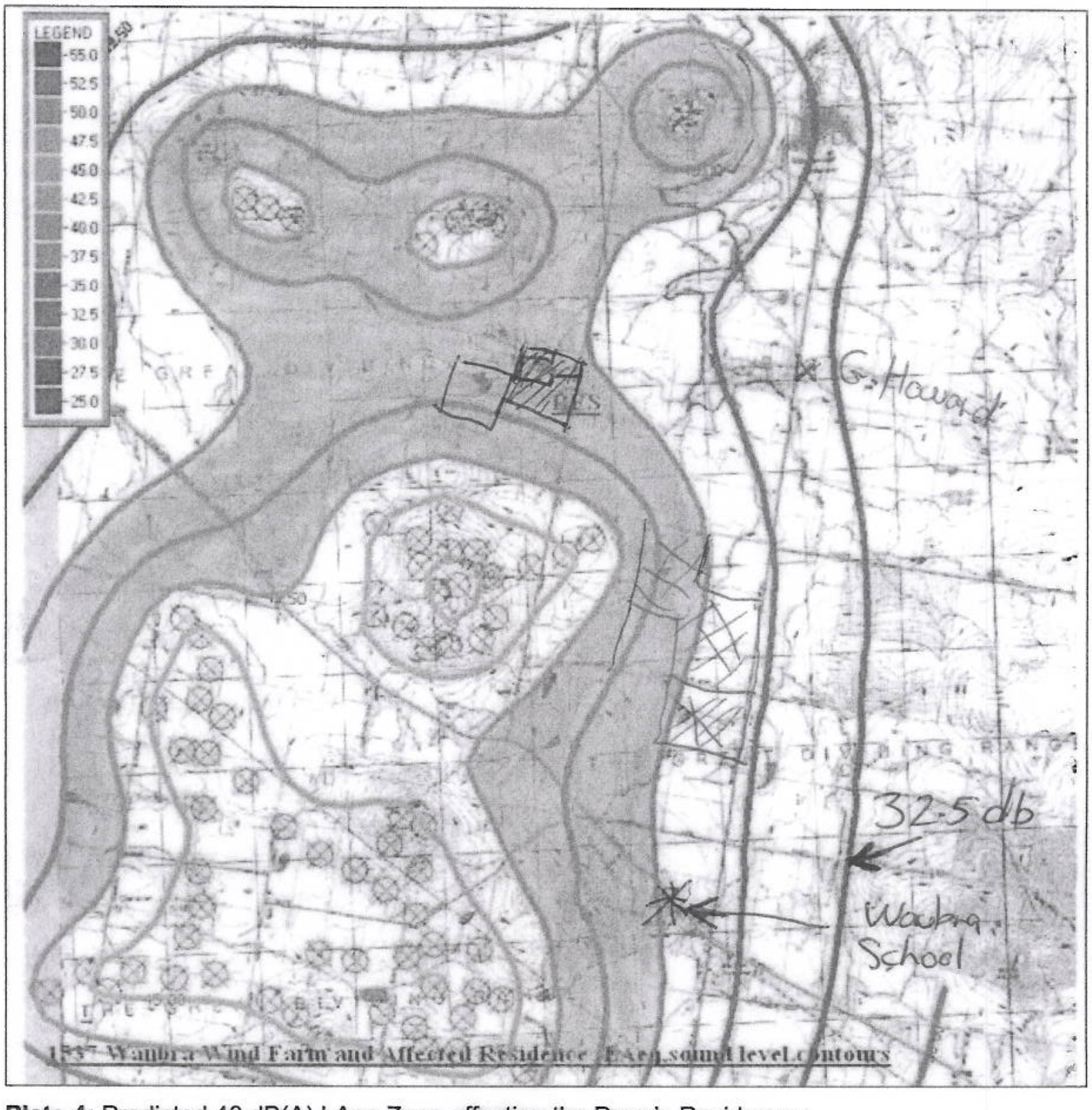
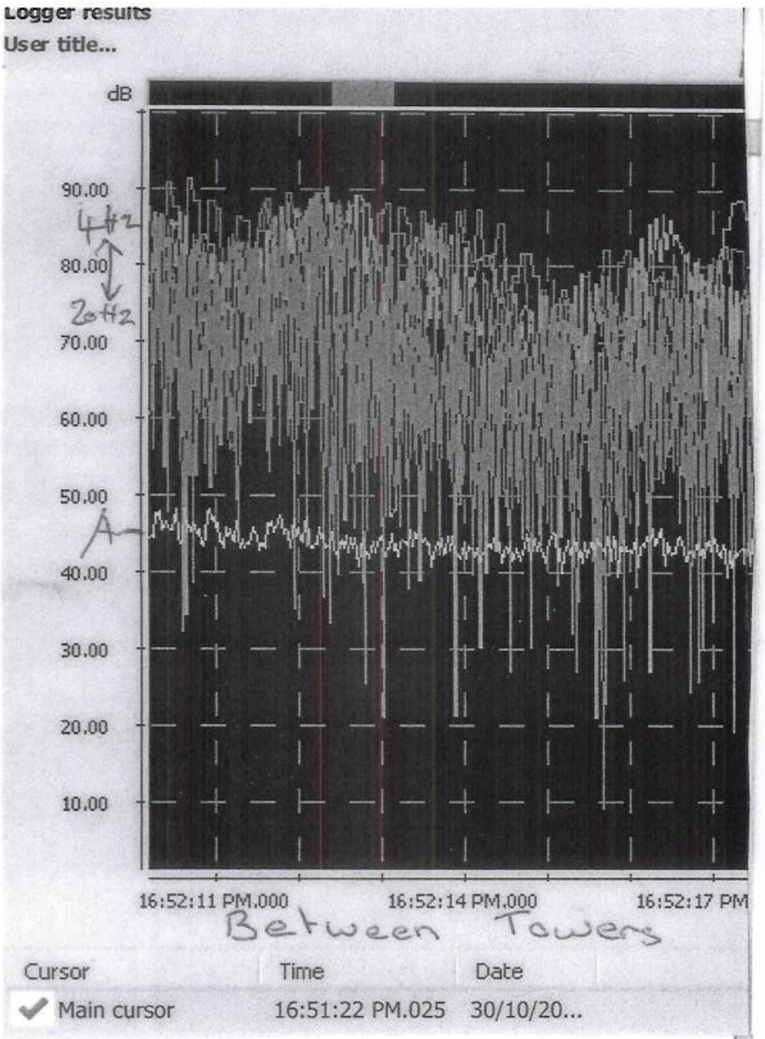
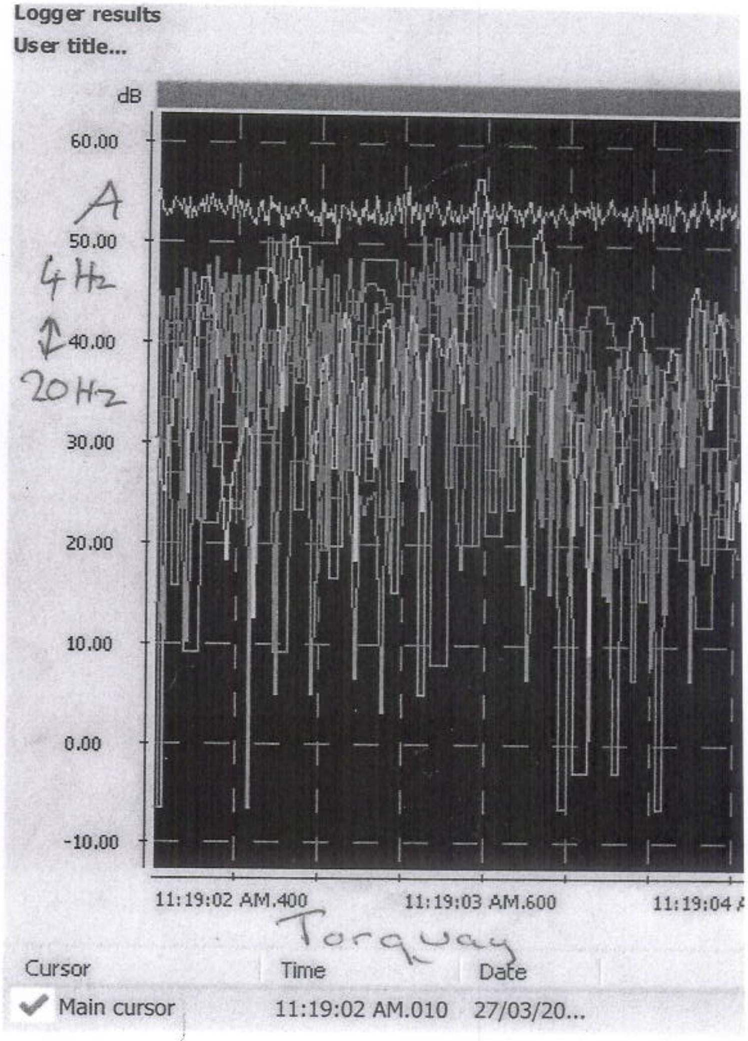


Plate 4: Predicted 40 dB(A) LAeq Zone affecting the Dean's Residences

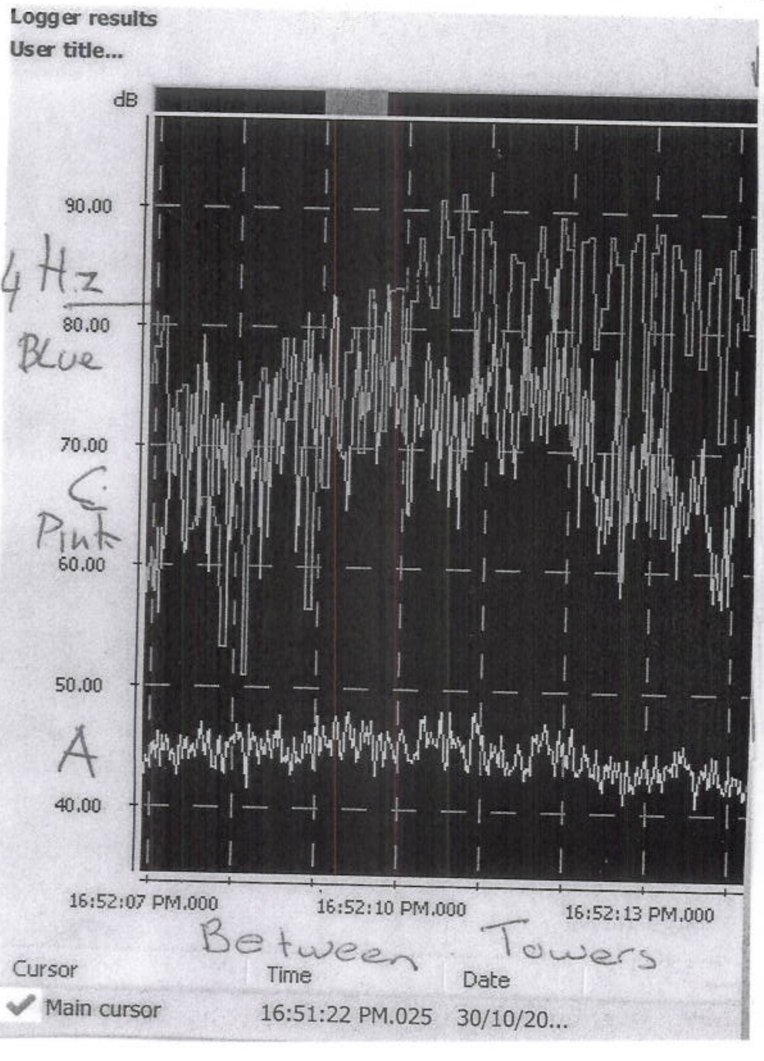
Note: the orange coloured zone is the area affected by 40 dB(A) LAeq based on the standard prediction assumptions given in the ISO9613-2 standard.

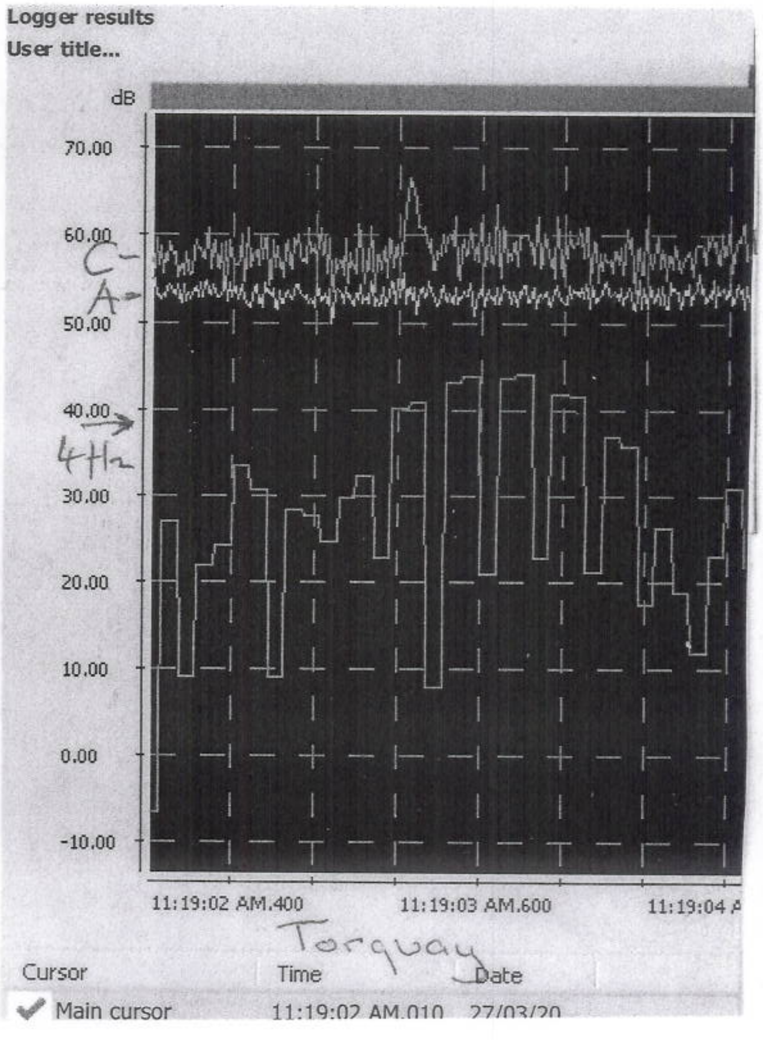


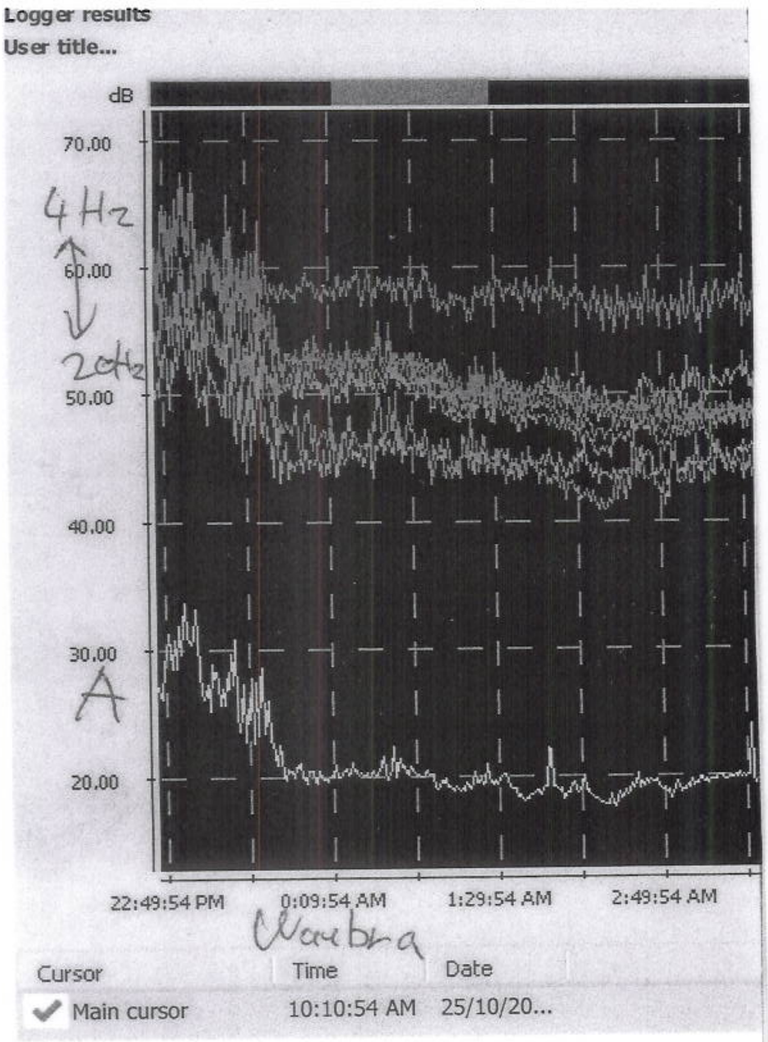
112 Towers at 300mts.



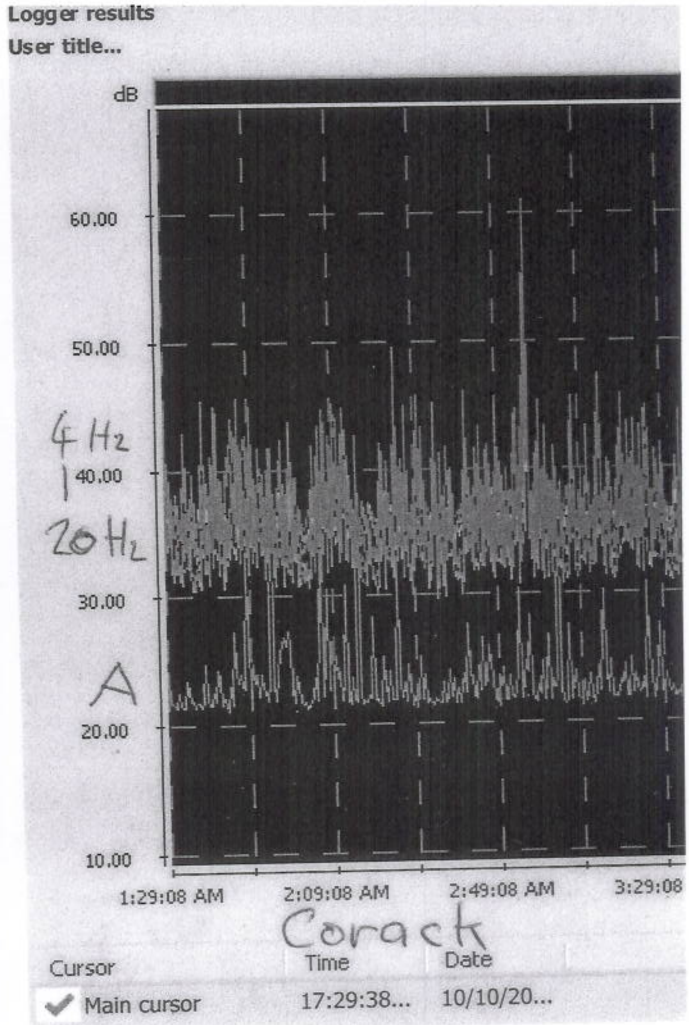
434 300 mts from Beach.







93 Stud Farm Rd House



45 Corack House