Unexplained Low Frequency Noise

Note: Technical papers distinguish infrasound (below 20 Hz) from low frequency noise (20-200 Hz), since 20 Hz is the lowest sound frequency considered by "experts" to be audible to humans.

I have used the term Low Frequency Noise (LFN) in this document to refer to all sound frequencies below 200 Hz since I do not know what spectrum of low sound frequencies my wife is capable of hearing.

Executive Summary:

On behalf of my wife and other people who are sensitive to LFN, I am writing these notes based on recorded and anecdotal observations made over a 3½ year period.

My wife and other people started hearing an unexplained intermittent low frequency noise (LFN) the autumn/ winter of 2006 – at about the same time a wind farm was commissioned nearly 25 miles SE of our home. Prior to this time they never heard any unexplained LFN.

Our hypothesis is that that the audible LFN is emitted by one or more wind farms. Even though we live a considerable distance (10 miles +) from the nearest wind farm - and are out of sight of any wind farms - the LFN can occasionally cause a minor adverse affect my wife's health when it is particularly loud.

Even though we do not yet have sufficient data to conclusively prove our hypothesis, with wind farms encroaching ever closer to our quiet rural home, I am concerned about the adverse effects the LFN will have on my wife's physical and emotional health in the not too distant future - if (or when) my hypothesis proves to be true.

As wind turbines continue to get larger and larger, the low frequency (LF) spectrum of noise emitted by wind turbines becomes lower and lower. The use of A-weighted noise measurements, under current ETSU-R-97 noise assessment guidelines for wind farm developments, disregards most of the LFN spectrum emitted by wind turbines. The current regulations make it extremely difficult (if not nearly impossible), for people severely affected by wind farm noise, to get adequate protection from noise regulations governing wind farms.

Another effect of LFN, not covered by noise measuring procedures in ETSU-R-97, is that of resonance - the walls of an enclosed space are capable of

resonating low frequency sounds (much like the sound box of a musical instrument) - with the lowest resonant frequency being dependant on the dimensions of the room. This resonance appears to amplify LFN levels indoors. Again ETSU-R-97 procedures to not take this phenomenon into account.

Therefore, people sensitive to LFN have no legal protection from the adverse affects of LFN emitted by wind farms due to inadequacies of the ETSU-R-97 guidelines.

Because of the lack of legal protection offered to LFN hearers by ETSU-R-97 I have serious concerns for the health and well being of my wife, and others, in the not too distant future. I have therefore concluded that I have no option but to put my hypothesis into the public domain now in the hope that my hypothesis will be subject to independent scientific testing.

Background:

When my wife started hearing an unexplained intermittent low frequency noise (LFN) in our home in the winter of 2006, she though the noise came from airplanes since we live under a busy transatlantic flight path. Apart from the occasional distant tractor or other large agricultural machine there is no known source of LFN anywhere near our home.

My wife also started hearing the LFN over an extensive area around our home which she would not hear the LFN while driving - only when I stopped the car. Prior to this time she never heard any unexplained LFN. Several months later we discovered that other people were also hearing unexplained LFN and told us it was not produced by aircraft. One of the LFN hearers used to drive around at all hours "looking for the bugger operating the big machine".

We live 200 m above sea level in a very rural location at the end of a long track (0.9 miles) and have no grid electricity. There any no pylons nearby which could produce electrical noise pollution. The nearest main road is about 6 miles away and the nearest town is about 8 miles away, and there is no heavy industry which could produce the LFN.

Two years after first hearing the unexplained LFN it was suggested by Jane Davis, whose family was driven from their home by noise emitted from a neighbouring wind farm, that the LFN noise my wife was hearing may be produced by a wind farm. Until then we had not considered any wind farm as a potential source for the unexplained LFN.

The LFN hearers we knew of all started hearing it in the autumn of 2006. This coincided with the commissioning of Ffynnon Oer Wind Farm, owned by RWE, in the autumn of 2006 – perhaps this correlation is just a coincidence, I don't yet know. I was astonished at the possible correlation however, because that wind farm is nearly 25 miles from our home and not visible behind the distant mountains.

Further observations over the next 3½ years suggested that the above mentioned wind farm could be a possible emission source of the unexplained LFN. More recently we made observations which suggest that at least one other wind farm (perhaps Alltwallis may also be emitting LFN.

Nearest Known Operating Wind Farms in order of start up dates:

Wind Farm	Distance from home (miles)	Start up date
Bryn Titli	34	Jul 1994
Rheidiol	31	Jan1997
Mynydd Gorddu	34	Apr 1998
Parc Cynog	24	Feb 2001
Blaenbowi	18	Jul 2002
Llangwyryfon	38	Feb 2004
? Near Tregaron	c. 24	2004 or earlier
Cefn Croes	33	Jun 2005
Fynnon Oer	25	Jun 2006
Alltwallis	10	Nov 2009

Data Recording Methodology:

I must stress at the outset that the data recording methodology was not conducted in a robust scientific manner due to lack of funds and equipment available to us. Internet research, together with recorded and anecdotal observations made over a 3½ year period - from 01 Jan 2009 to 26 June 2012, were used to draw up and add weight to our hypothesis.

1) A digitally recorded noise log was initially kept for 8 months – from 01 Jan to 23 Aug 2009 – when the LFN was particularly prevalent. A graph of comparative noise levels was plotted against time – see Appendix 1. No daily wind speed or wind direction was recorded during this time period. We did observe, however, that the LFN was loudest during certain atmospheric

conditions associated with stable high pressure systems – i.e. when a light wind blew from a SE direction, and the air close to ground level was quite still. According to Moller and Pedersen:

> "Under certain atmospheric conditions, e.g., temperature inversion, the noise may be more annoying and - in particular the low-frequency part - propagate much further than usually assumed. More knowledge is needed on such phenomena and their occurrences" (2)

A sound recording was taken inside our home in June 2009 by a scientific officer from the Public Health Dept of the local council using a 01dB Solo Metrovib meter. This meter can record noise levels as low as 1 dB in the frequency spectrum 10 Hz to 20 kHz). It also has a small LCD display, showing bars for different frequency bands pulsating up & down in real time while the noise is being recorded. The pulsating bars displayed the loudest recorded noise in the low frequency spectrum on the LCD display, and correlated directly with the LFN my wife was hearing during the recording. It was the first time she had seen any real evidence of the LFN she had been hearing for the previous 2½ years. The scientific officer told us the low frequencies measured were too low to be generated by road traffic.

I was given a digital copy of the recorded data as a CSV test file which I imported into in a computer spreadsheet to summarise the recorded noise. It is **not** data post-processed using proprietary noise analysis software. A graph of noise level readings (Minimum, Maximum and Average dB) in 1/3rd octave frequency bands, from 10-20,000 Hz was plotted – see Appendix 2. This proves the presence of LFN in our home during the time the recording was made.

For a period of over 2 years (Sept 2009 to mid May 2012), when the wind blew frequently between the SW, NW, N & NE, my wife rarely heard any LFN. If it was present it was very intermittent and infrequently audible. No noise log was kept during this time period.

When the LFN started bothering my wife again during a stable high pressure system, the noise log was continued again from 17 May 2012. This time we started recording wind direction and wind speed data. The wind data was obtained online from the nearest available weather station. (1)

A copy of this Noise Log is included in Appendix 3 to show the range of data and information being gathered. A graph of this data, showing comparative noise levels against time, is included in Appendix 4.

Observations and Hypothesis:

1) The LFN is real – not psychosomatic – its presence has been recorded. When my wife went away for a week in 2009 she heard no LFN at all.
2) The LFN is most probably airborne – my wife can hear LFN in the car when the engine is turned off. The air filled tyres on the car would dampen any ground borne vibrations.
3) The LFN appears to make house walls and car body resonate, amplifying the LFN - opening a door or window reduces intensity of the LFN in both house and car (4). The LFN is not normally audible outdoors unless it is particularly loud. (See Conclusion 4 below).
4) The loudness of the LFN heard by my wife appears to be dependant on wind direction & atmospheric conditions – a very light SE wind under a stable high pressure system. Still air close to ground level appears to be the most significant contributing factor to propagation of particularly loud LFN. Efficient transmission of LFN in a stable atmosphere, when there is little or no wind at ground level, has been documented by experts. (2)
5) Until very recently, all loud LFN was heard by my wife when the wind blew from a SE direction under atmospheric conditions described above in Observation 4.
6) On 28 May 2012 my wife heard extremely loud LFN when the wind was blowing from the W (Alltwallis Wind Farm is less than 10 miles away in that direction). As yet I cannot yet prove a correlation.

Effects on Health

Occurrences of LFN have had the following effects on my wife's health:

1) Makes my wife tired and irritable when LFN is loud.
2) Makes her tense with teeth clenched when LFN is loud.
3) Interferes with her quality of sleep when LFN is loud.

When the LFN is at a low level my wife has learned to tolerate the intrusive noise to some degree. She would rather not have to listen to it and, most of the time, drowns the LFN out by plugging an MP3 player into her ears. She has even resorted leaving the radio turned on constantly during the night to drown out any LFN that may disturb her. Before resorting to this tactic she used to have trouble getting to sleep when the LFN was loud.

I hate to think what effects long term exposure to LFN, whatever the source may be, will have on my wife's health if more wind turbines are erected closer to our home.

Legal Protection for People Sensitive to LFN

The ETSU-R-97 noise measurement guidelines only measure noise using an A-weighted meter which ignores a significant component of any LFN which may be present.

ETSU-R-97 therefore appears to offer no legal protection from disturbing noise pollution for a significant minority of people who are sensitive to LFN.

Since wind turbines also produce low frequency noise and infrasound (2), this recording methodology has an effect of reducing the measured sound level.

> At 100 Hz, an A-weighting filter reduces sound measurement by a factor of 1000 [30 dB]. At 31 Hz, an A-weighting filter reduces sound measurement by a factor of 10,000 [40 dB].) (3)

People from a minority background and from religious minorities have legal protection against racial discrimination. However, people who are sensitive to LFN through no fault of their own, have no legal protection whatsoever against noise emissions from wind farm developments. This is a form of discrimination from my way of thinking.

Dr Nina Pierpont (USA), Dr Amanda Harry from Cornwall (6) and others have investigated unexplained health problems in people who live near wind farms. Most (if not all) of the people studied were previously healthy.

Despite observations of ill health experienced by people, pets and stock worldwide, the wind farm industry continues to claim that there is no evidence of wind farm noise(s) causing ill health in some people. That is because no robust scientific studies have been conducted to my knowledge.

The vestibular system (organs of motion, position and balance) located in the inner ear are very sensitive to LFN and can respond rapidly and alarmingly in some people who have visited a wind farm. Even though LFN may not be audible it can still have an adverse effect on the health of some people. (3)

According to Pierpont (2009), people who are especially susceptible to WTS include those who have:

- pre-existing migraine disorder,
- motion sensitivity (prone to travel sickness),
- inner ear damage (pre-existing tinnitus, hearing loss, or industrial noise exposure)

Recent studies show a substantial proportion of the population - 6% for males, 18% for females of all human populations studied so far. (3)

Why is LFN Louder in the House than Outside?

According to Bellhouse, resonance occurs in enclosed or partially open spaces. When the wavelength of a sound is twice the longest dimensions of a room, the condition for lowest frequency resonance occurs. (4)

From the $c = \lambda \times f$ relationship, (where c = speed of sound in air [340 m/sec], λ = wavelength, and f = frequency), the lowest resonating frequency in our living room (5.5m deep x 6.3 m wide), is between 27 and 31 Hz. My wife can hear these frequencies clearly. The calculations can be seen in Appendix 5.

> If the LFN is loud, when we open the door, "it lets the noise out" as my wife describes the sensation. The level of LFN diminishes and often disappears if it is not too loud in the first place.

These observations appear to support Bellhouse's description of enclosed space resonance and the phenomenon of Helmholtz resonance - where a partially enclosed space resonates at a lower frequency than an enclosed space - e.g. like blowing across the top of an empty bottle. (4)

Noise Measurements in Environmental Statements

ES documents produced by wind farm developers only include A-weighted noise measurements which filters out low frequency noise – the lower the frequency, the more exponential the filtering out of noise.

Since wind turbines also produce low frequency noise and infrasound, this recording methodology has an effect of reducing the sound level measured. (3)

> At 100 Hz, an A-weighting filter reduces sound measurement by a factor of 1000 [30 dB]. At 31 Hz, an A-weighting filter reduces sound measurement by a factor of 10,000 [40 dB].) (3)

From what I have read in the EIS noise predictions in EIS documents don't appear to take into account resonance frequencies that can be generated in houses and other enclosed spaces.

In summary, the sound recording methodology employed by wind farm developers appears to be a cheap trick to reduce or eliminate noise levels in the low frequency spectrum. (3)

Conclusions

All the testimonies in the "Wind Turbine Syndrome Guide" (3), and on numerous internet blogs and web sites world wide provide an increasing number of first hand accounts detailing the terrible experiences of a significant number of people living near wind farms. These accounts suggest that large wind turbines may be contributing to ill health in people, pets and stock. Even without conclusive scientific proof, a moratorium on further wind farm development should be imposed until in depth independent research can prove otherwise.

However, despite the presence of mounting numbers of bad personal experiences from people living near wind farms, Renewables UK continue to claim that "There are no direct health effects from noise at the level of noise generated by wind turbines." (5)

The observations my wife and I have made over the last 3½ years have made us hypothesise that modern larger wind turbines emit LFN which, can travel significant distances (at least 25-30 miles) from the source of emission.

ETSU-R-97 regulations allow for an attenuation indoors of 10 dBA through an open window, making an assumption that an indoor environment will be significantly quieter compared with an adjacent outside environment.

Our own observation suggest that at least some houses may resonate LFN, making the indoor environment louder than outside for people who are sensitive to LFN. The ETSU-R-97 procedures offer no legal protection from LFN pollution since all noise measurements are taken outside using A-weighted meters, effectively ignoring the LF component of wind farm noise. (3)

If the phenomena of LFN and LF resonance we have observed are widespread, where can we move to so that my wife doesn't have to put up with regular intrusive bombardment by LFN?

There is already another wind farm being constructed on Mynydd Betws, which will be larger and a lot closer to our home than Ffynnon Oer Wind Farm. My wife is dreading that wind farm coming on line. What is the price of good health and a reasonably quiet environment for people who are very sensitive to LFN?

Based on the experiences of my wife and other LFN hearers, I would describe people who are sensitive to low frequency noise and as being the "canaries in the coal mine" –they are giving us all an early warning of increasing noise problems, possibly associated with wind farms.

As wind farms continue to proliferate over an increasingly wider area, more people are likely to suffer from health problems associated with low frequency noise from larger and larger wind turbines. The potential financial costs of dealing with noise induced health problems could put a huge burden on the NHS in the future.

I can only conclude that the wind industry noise "experts" either:

- know much less than they think they do about LFN - how far it can be emitted from its source and how it could be amplified within enclosed spaces at considerable distances from its source(s);
- or they are very economical with the information they regurgitate.

It's about time rigorous independent scientific studies are carried out, incorporating experts of different disciplines, to ascertain if there is a correlation between ill health suffered by people living near wind farms and wind turbine noise (including infrasound).

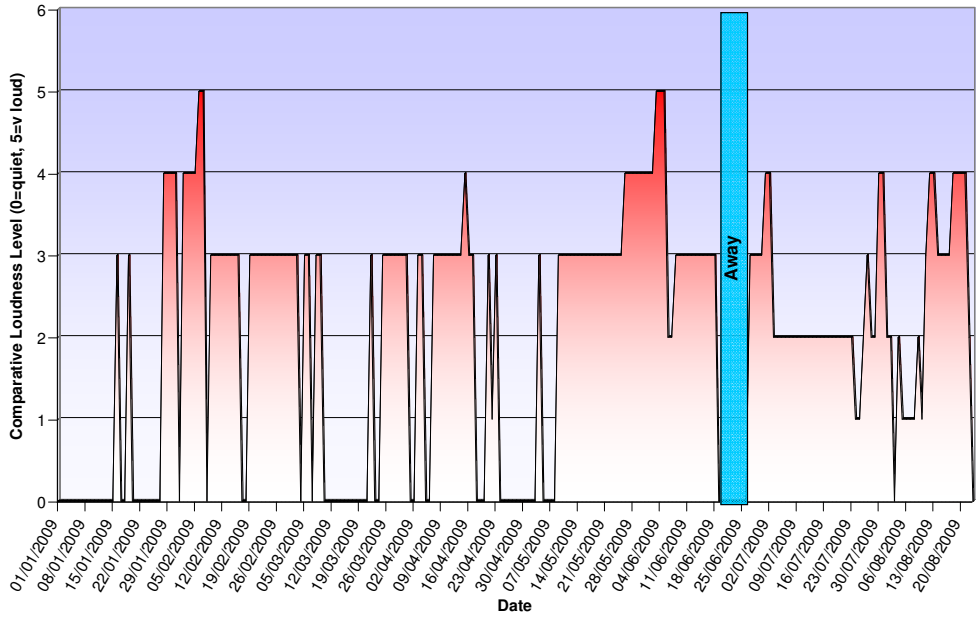
Numerous residents living in the shadow of Alltwallis Wind Farm are continuing to suffer from noise emitted from that wind farm. This is despite a "rigorous" noise assessment submitted by the developer in their EIS which concluded that noise emitted by the wind farm would not breach statutory guidelines.

It only goes to demonstrate that Noise Assessments submitted by wind farm developers as part of their EIS should be considered not fit for purpose until developers and their "experts" can offer adequate protection to people from wind farm induced noise pollution.

Appendicies:

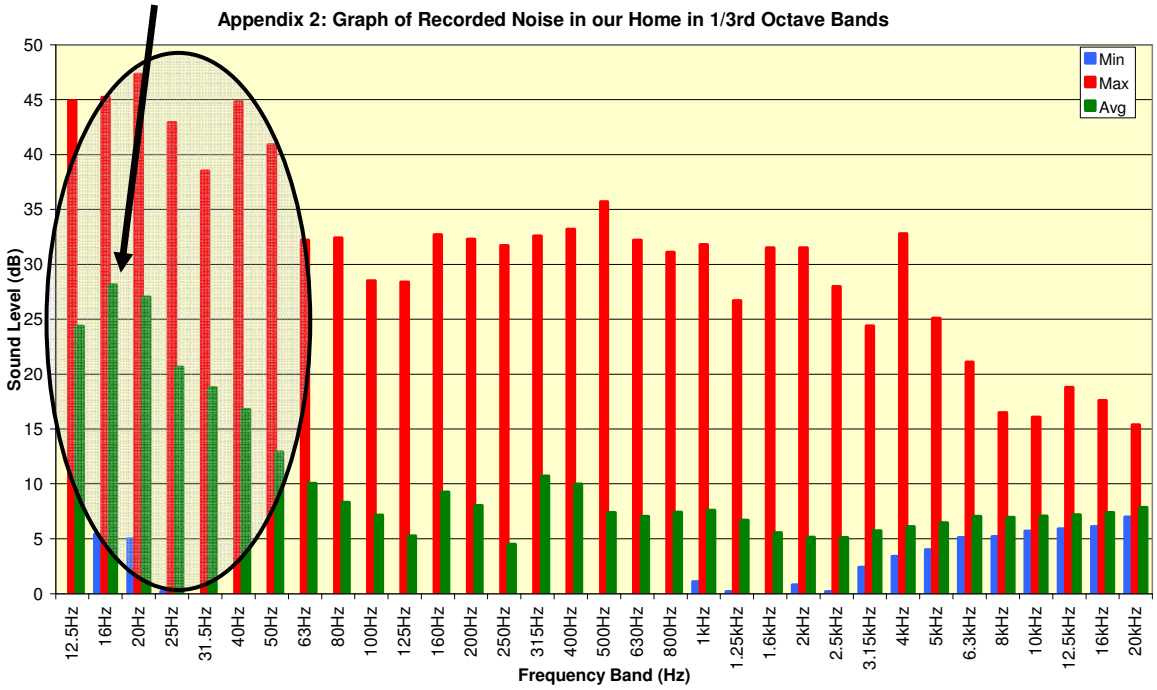
Appendix 1:	Noise Intensity Log (2009)
Appendix 2:	Graph of Recorded Noise in our Home in 1/3rd Octave Bands
Appendix 3:	Recent Noise Log (2012)
Appendix 4:	Noise Intensity Log (2012)
Appendix 5:	Resonance Calculations for Living Room

Appendix 1: Noise Intensity Log 2009



What's causing this low frequency noise?

Appendix 2: Graph of Recorded Noise in our Home in 1/3rd Octave Bands



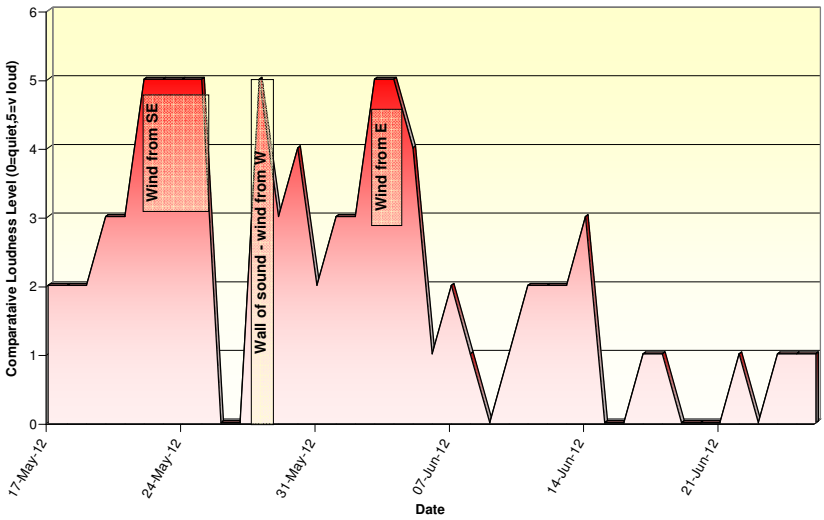
Appendix 3: Recent Noise Log

Date	Noise heard? (0=No;1=Yes)	Noise Level (1=Quiet, 5=V loud)	Comments on loudness	Mean Sea Level Pressure hPa	Wind Dir Deg	Wind direction daily avg	Wind direction Min	Wind direction max	Wind direction Avg	Mean Wind Speed Km/h	Weather
16/5/12				1026	289	WNW				14	**Noise log started on 17-05-2012**
17/5/12	1	2		1015	96	E	45	45	0	13	Sunny with cloudy spells
18/5/12	1	2		1004	55	NE	45	45	0	19	Sunny with cloudy spells
19/5/12	1	2		1009	64	ENE	45	45	0	10	Sunny with cloudy spells
20/5/12	1	3		1011	63	ENE	315	315	0	18	Sunny with cloudy spells
21/5/12	1	3		1011	307	NW	315	315	0	11	Sunny with cloudy spells
22/5/12	1	5	Heard v loud noise outdoors	1017	287	WNW	135	135	0	18	Sunny, warm
23/5/12	1	5	Heard v loud noise outdoors	1024	289	WNW	135	135	0	19	Sunny, warm
24/5/12	1	5	Heard v loud noise outdoors	1026	29	NNE	135	135	0	11	Sunny, hot
25/5/12	1	5	Heard v loud noise outdoors	1022	66	ENE	90	90	0	21	Sunny, hot
26/5/12	0	0		1018	75	ENE	90	90	0	31	Sunny, hot
27/5/12	0	0		1018	5	N	90	135	32	19	Sunny, hot, windy from late morning
28/5/12	1	5	V loud in still morning air	1019	257	WSW	270	270	270	10	sunny. Solid wall of sound. Noise abated after wind picked up
29/5/12	1	3	Louder in still morning air	1018	279	W	270	292.5	281	13	sunny.Quite loud. Noise decreaded after wind picked up a little bit
30/5/12	1	4	Louder in still morning air	1018	306	NW	270	270	270	13	Sunny w/ cloudy spells. Light wind
31/5/12	1	2	constant noise all day	1020	277	W	247.5	270	259	21	damp showers
1/6/12	1	3	constant noise all day	1019	280	W	270	292.5	281	16	dull with brighter spells mostly dry
2/6/12	1	3	constant noise all day	1012	86	E	90	135	113	11	cloudy with bright and sunny spells.
3/6/12	1	5	V loud during day; quiet after change in wind direction	1005	271	W	67.5	90	79	16	cloudy, dull and wet all day, clearing in late evening
4/6/12	1	5	V loud most of day; quieter in evening	1015	49	NE	22.5	45	34	18	cloudy with bright and sunny spells.
5/6/12	1	4	Loud in morning. Not audible in evening	1011	162	SSE	202.5	225	214	14	cloudy dull and light rain all day.
6/6/12	1	1	Very quiet most of day, louder in evening	1001	252	WSW	202.5	225	214	16	cloudy with bright and sunny spells & scattered showers

Appendix 3: Recent Noise Log (cont'd)

Date	Noise heard? (0=No;1=Yes)	Noise Level (1=Quiet, 5=V loud)	Comments on loudness	Mean Sea Level Pressure hPa	Wind Dir Deg	Wind direction daily avg	Wind direction Min	Wind direction max	Wind direction Avg	Mean Wind Speed Km/h	Weather
7/6/12	1	2	Moderately quiet, fading to nothing later in the day	992	154	SSE	112.5	202.5	158	23	cloudy dull and wet with rare sunny spells in late afternoon
8/6/12	1	1	Very quiet, out most of day	996	257	WSW	247.5	270	259	39	Cloudy dull & wet with dry & bright spells later
9/6/12	0	0	No noise heard today	1010	279	W	180	270	225	27	Sunny with scatterd cloud
10/6/12	1	1	Barely audible, but present	1008	60	ENE	270	450	360	8	Sunny spells & showers later
11/6/12	1	2	Louder than yesterday	1005	344	NNW	0	135	68	10	Cloudy w/ bright & occ sunny spells w/ showers
12/6/12	1	2	Similar to yesterday	1010	64	ENE	90	247.5	169	8	Cloudy w/ bright & occ sunny spells w/ showers later
13/6/12	1	2	Similar to yesterday	1015	128	SE	112.5	180	146	13	Sunny w/ cloudy spells. Showers later
14/6/12	1	3	moderately loud, fading away later	1012	115	ESE	112.5	135	124	21	Cloudy with rare sunny spells. Showers later
15/6/12	0	0	out a lot of the day	1004	192	SSW	135	202.5	169	21	Cloudy & dull with frequent heavy showers. Bright spells later
16/6/12	0	0	Wonderful, no noise today	1005	230	SW	202.5	202.5	203	24	Wet and windy all day, dryer later on
17/6/12	1	1	noise very quiet this evening	1016	273	W	225	270	248	21	Sunny spells & dry
18/6/12	1	1	quiet noises in kitchen & bathroom this morning	1017	251	WSW	22.5	202.5	113	6	Sunny with showers in evening
19/6/12	0	0	no noticeable noises all day	1019	237	WSW	202.5	225	214	13	cloudy with good sunny spells & showers
20/6/12	0	0	no noticeable noises all day	1015	92	E	45	157.5	101	11	sunny & warm w/ scattered cloud. Clouding over late afternoon
21/6/12	0	0	no noticeable noises all day	1005	308	NW	157.5	225	191	19	cloudy w/ bright spells. Dull & wet later.
22/6/12	1	1	quiet noises all day	1010	258	NNE	247.5	270	259	31	dull & wet becoming bright w/ occ sunny spells
23/6/12	0	0	no noticeable noises all day	1018	253	WSW	202.5	270	236	26	cloudy w/ bright & sunny spells. Dull & wet later.
24/6/12	1	1	heard occasionally	1014	248	WSW	225	270	248	20	cloudy becoming sunny w/ scattered cloud & rare light showers
25/6/12	1	1	a tiny bit in early morning	1018	240	WNW	202.5	405	304	13	sunny w/ cloudy spells
26/6/12	1	1	a tiny bit in early morning	1019	146	SE	90	202.5	146	16	

Appendix 4: Noise Intensity Log 2012



Appendix 5 Resonance Calculations for Living Room

Room dimensions:	
W	D
m	m
6.3	5.5

Basic formula for calculating relationships of speed, wavelength and frequency of sound waves (5)

$c = \Lambda \times f$

where,

c=	340	m/s	(Speed of sound in air)
Λ =	wavelength		
f =	frequency		

resonating frequency of an enclosed space, the wavelength of the sound wave is double the length (or depth) of the space. (5) To calculate the

Room depth Resonance calculation:		
f =	c / (D x 2)	
Room length	5.5	M
c =	340	m/s
Lowest Resonating frequency =	**30.9**	**Hz**

Room width Resonance calculation:		
f =	c / (W x 2)	
Room width	6.3	m
c =	340	m/s
Lowest Resonating frequency =	**27.0**	**Hz**

References:

1) Historical weather data link (24 hour historical data):
   http://uk.weather.com/weather/almanacHourly-Llandeilo-UKXX1208?day=1
2) "Low Frequency Noise from Large Wind Turbines" by Henrik Moller and Christian Sejersted Pedersen (Section of Acoustics, Aalborg University 2010):
   http://docs.wind-watch.org/Moller-Pedersen-Low-frequence-noise-large-wind-turbines.pdf
3) Your Guide to Wind Turbine Syndrome … a roadmap to this complicated subject by Calvin Luther Martin, Ph.D. (July 2010)
   http://www.windturbinesyndrome.com/img/WTSguide.pdf
4) Low Frequency Noise And Infrasound From Wind Turbine Generators: A Literature Review" (George Bellhouse, 2004)
   http://www.apere.org/manager/docnum/doc/doc1283_eoliennes.fiche102.pdf
5) Renewables UK BWEA Briefing Sheet: "Low Frequency Noise and Wind Turbines"
   http://www.bwea.com/pdf/briefings/lfn_summary.pdf
6) Dr Amanda Harry
   http://docs.wind-watch.org/wtnoise_health_2007_a_harry.pdf