Technical Report

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Project

Barnsley BSF
Wind Turbine Noise
Revised Assessment
Shafton School

Prepared for

P Mills
Barnsley Partnership for Learning
Barnsley Digital Media Centre
County Way
Barnsley
S70 2JW

By

Trevor Hickman *BSc MSc PhD MIOA*

Sound Research Laboratories Limited
Specialist Consultants: Acoustics – BREEAM – Fire – Air leakage

Head Office & Laboratory:
Holbrook House, Little Waldingfield, Sudbury, Suffolk CO10 0TH
Tel: +44(0)1787 247595 Fax: +44(0)1787 248420
e-mail:srl@soundresearch.co.uk

Summary

Surveys have been done to help assess the impact of noise from the proposed wind turbine installation at Shafton School on neighbouring dwellings. Surveys are reported of the measurement of background noise levels at different times of day and of the measurement of the variation of background noise with wind speed. The measurements have been assessed following the method recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

We conclude that at the closest dwellings, the ETSU criteria will be met at all wind speeds for a turbine located on the southern boundary.





Trevor Hickman
For and on behalf of
Sound Research Laboratories Limited
Tel: 01787 247595
Email: trevor.hickman@soundresearch.co.uk

Nick Swainston

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1. Introduction

As part of the second phase of the BSF development for Barnsley, it is proposed to erect one or more wind turbines at each of the schools in the scheme. In seeking planning approval for this, it is necessary to have assessed the acceptability of noise from the wind turbines affecting the nearby residents. This report considers the noise impact from the operation of one wind turbine at Shafton School.

2. Proposed Wind Turbine Installation

As part of the redevelopment of Shafton School it is proposed to erect one wind turbine on the school playing fields. It would be located close to the southern site boundary, as indicated on the plan in Appendix 1. To the south and east of the turbine site are small groups of dwellings on or just off Engine Lane, at distances of between 220 and 380m. To the west are dwellings along Lindrick Close, Sunningdale Drive and a few properties at the end of George Street. These are at distances of more than 400m from the turbine site. To the north of the site will be the school itself with dwellings beyond it on the far side of the main Collier Road more than 500m distant.

The type of wind turbine proposed is the WES 18/80, with the turbine hub installed at 34 metres above ground level. The specifications for this turbine shows that it cuts in at a hub wind speed of 2.7 m/s and cuts out at 25 m/s.

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3. Assessment Methodology

The method of assessing noise impact on-site follows that recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

The wind turbine noise level, expressed as L_{A90}, is predicted at the most affected dwelling(s). If appropriate a tonal correction is made. These predictions are based on measurements done by an independent test organisation of noise output as a function of wind speed. In this case the measurements were done by ECN Solar & Wind Energy to IEC-61400-11. This is the same standard as BS EN 61400 Part 11. The ECN report is of measurements on a Lagerwey 18/80 wind turbine which is the same as the WES 18/80, WES having taken over the design.

The background noise level, also expressed as $L_{A90\text{-}10min}$, is measured at the dwelling(s). This must be done at different times and at wind speeds over the range at which the wind turbine is expected to operate, because the background noise level will vary with wind speed. The wind speed as a 10 minute average is measured simultaneously, at the recommended reference height of 10 metres above ground level, at a location representative of the proposed wind turbine siting. The corresponding wind speed at hub height of the proposed turbine is calculated by adjusting the measured speeds according to the equation given in the ETSU report.

The predicted wind turbine noise level is then compared with both

- fixed noise level criteria
- the background noise level as a function of wind speed

The corrected wind turbine noise is considered acceptable outside dwellings if it is no greater than:

- 35dB $L_{A90\text{-}10min}$ during the daytime
- 43dB $L_{A90\text{-}10min}$ during the night-time

  or

- the background $L_{A90\text{-}10min}$ +5dB at any time

  whichever is the higher.

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4. Wind Turbine Noise Levels

The measured and declared sound power levels at 8m/s, wind speed at 10m height with hub at 40m, for the WES 18/80 are 93 and 95 dBA (L_{wA}). The measured frequency spectrum shows tonal noise at 400Hz, so I have included a correction of +5dBA.

The trend line is given by

$$L_{Aeq} = 0.7235u + 86.415$$

where u is the wind speed at 10m height, and the range of wind speeds from which this was derived is 4 to 8 m/s.

The Working Party guidelines use the L_{A90} of the turbine noise as the index for assessment, using the relationship $L_{A90} = L_{Aeq}$-2dB. They recommend assessment is done up to an average wind speed of 12m/s (at 10m height). They also recommend that the wind speed at the hub height (u_h) is calculated from the averaged wind speed at the reference height (u_{10}) of 10 metres using the relationship:

$u_h/u_{10} = \ln(\frac{h}{z_o})/\ln(\frac{10}{z_o})$ where z_o is the roughness factor of the local ground cover. Examples of roughness factor that they give indicate a suitable value for this area to be of the order of z_o = 0.01.

5. Background Noise Measurement

Ambient noise levels (L_{A90} and L_{Aeq}) were measured at different times of day and under different conditions as follows:

i) During the middle of the night-time with no or low wind (below the speed at which the turbines would operate)

ii) During the late evening, as being representative of the quietest time of day, with no or low wind

iii) On at least two different days under different wind conditions. Measurements were done on different days in order to monitor a spread of wind speed within the range 3 to 12m/s

iv) During the middle of the day under no or low wind conditions.

The measurements were located close to residential properties that were thought most likely to be affected by wind turbine noise. These were :

- Dwellings off Engine Lane to the south of the site
- The farmhouse on Engine Lane to the east of the site
- The rear of dwellings in Sunningdale Drive and the end of George Street. As there was no access directly to the rear of these dwellings, measurements were taken at the western boundary of the site.

These locations are shown on the plan in Appendix 1. Also shown is the location of the wind monitor, which was on a mast at 10 metres above ground level. During the surveys during windy conditions ((iii) above), average wind speed measurements were made every 10 minutes to correspond with the 10 minute background noise level (L_{A90}) measurements.

The equipment used to make the measurements and other survey details are given in Appendix 2. The large spherical B&K windshield was used to prevent noise generated at the windshield invalidating the results. It is less affected than other commercially available windshields.

The results are tabulated in Appendix 3. Measurements of L_{Aeq} are included for information although not used in this assessment.

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6. Assessment

The measured relationship between background noise and average wind speed (measured at 10m height) is plotted for locations 1, 2 and 4 on figures 1 to 6 in Appendix 4. See Appendix 1 for the location of the turbine site.

Linear and geometric regression (trend) lines have been calculated and superimposed on figures 1, 3, 5 and 2, 4, 6 respectively, together with the 'goodness' of fit (R^2). At moderate wind speeds the trend line goes below the measured 'no wind' background. In these circumstances the wind generated noise is not affecting the overall background level, so any such data points are not included in the regression analysis.

The predicted turbine noise at the nearest residence is also superimposed on the plots. This calculation is based on the trend line equations, given in section 4, and the wind speed adjusted to a height of 34m.

Under low to moderate wind conditions the wind was considered not to be affecting the background noise levels. The background noise levels during the daytime, at the time of day when wind noise was monitored, generally ranged from 45 to 50 dBL_{A90}. L_{A90} levels measured during high wind noise surveys were all higher than this, which indicates that they were dependent on the wind rather than other noise sources in the locality.

The plot of background noise versus wind speed shows a good correlation at location 1 ($R>0.8$) and very good ($R>0.9$) at location 3 which is midway between locations 2 and 4. There is insignificant difference between the linear and geometric regression curves over the range measured. As the wind speed drops, one would theoretically expect the wind generated noise to fall to nothing ($-\infty$dBA) at zero wind speed, so a geometric fit would be better. However, other sources will determine the background noise level well before this point is reached.

With no or very low wind the lowest background (L_{A90}) levels measured were as follows:

		Location 1	Location 2
Daytime (evening)	dB L_{A90}	37	40
Nightime	dBL_{A90}	27	31

At location 4, where we did not gain access, we estimate that the quietest background levels during evening and night-time would be 35 and 25 dBL_{A90} respectively. At these times the L_{A90} at locations 1 and 2 was caused by distant traffic noise, generally from the north, not traffic on the nearby roads, and could be heard all around the site. Location 4 is not sheltered from this direction and would have similar background during evening and night-time.

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Taking the residential locations in turn:

Location 1 - Daytime

- Lowest background is 37 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 42 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 42 dBL_{A90}, which it would reach at a wind speed of 9m/s at the reference height of 10m above ground level.
- At this wind speed of 9m/s (10m), the background noise (+5 dB) would be 55 dBL_{A90}, considerably greater than the turbine noise level.
- At higher wind speeds the background noise will certainly be greater than the turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 1 – Night-time

- Lowest background is 27 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 32 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of more than 9m/s at the reference height of 10m above ground level.
- At this wind speed of more than 9m/s (10m), the background noise (+5dB) would be >55 dBL_{A90}, considerably greater than the turbine noise level.
- At higher wind speeds the predicted background noise will certainly be greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Therefore, at location 1 the data show that the ETSU criteria would be met at all appropriate wind speeds by an installation of a turbine as proposed at the south of the site.

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Location 2 – Daytime

- Lowest background is 40 dBL_{A90}
- Criterion for turbine noise is higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 45 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 45 dBL_{A90}, which it would reach at a wind speed of well above 9m/s at the reference height of 10m above ground level.
- At this wind speed of well above 9m/s (10m), the background noise (+5dB) would be >55 dBL_{A90}, considerably greater than the turbine noise level.
- At higher wind speeds the background noise will certainly be greater than the predicted turbine noise. Therefore, the turbine noise would be below the criteria of background level + 5 dB.

Location 2 – Night-time

- Lowest background is 31 dBL_{A90}
- Criterion for turbine noise higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 36 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which it would reach at a wind speed of about 7.5m/s at the reference height of 10m above ground level.
- At this wind speed of about 7.5m/s (10m), the background noise (+5dB) would be >50 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the predicted background noise will certainly be greater than the predicted turbine noise. Therefore, the turbine noise would be below the criterion of background level + 5 dB.

Therefore, at location 2 the data show, that the ETSU criteria would be met at all appropriate wind speeds by an installation of one turbine as proposed at the south of the site.

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Location 4 - Daytime

- Lowest background is 35 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 40 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 40 dBL_{A90}, which it would reach at a wind speed of more than 9m/s at the reference height of 10m above ground level.
- At this wind speed of more than 9m/s (10m), the background noise (+5 dB) would be about 55 dBL_{A90}, much greater than the turbine noise level.
- At higher wind speeds the background noise will certainly be greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 4 – Night-time

- Lowest background is 25 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 30 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which it would not be expected to reach at a wind speed less than 12 m/s at the reference height of 10m above ground level.
- At this wind speed of 12m/s (10m), the background noise (+5dB) would be >55 dBL_{A90}, much greater than the turbine noise level.

Therefore, at location 4 the data show that the ETSU criteria would be met at all appropriate wind speeds by an installation of a turbine as proposed at the south of the site.

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7. Conclusions

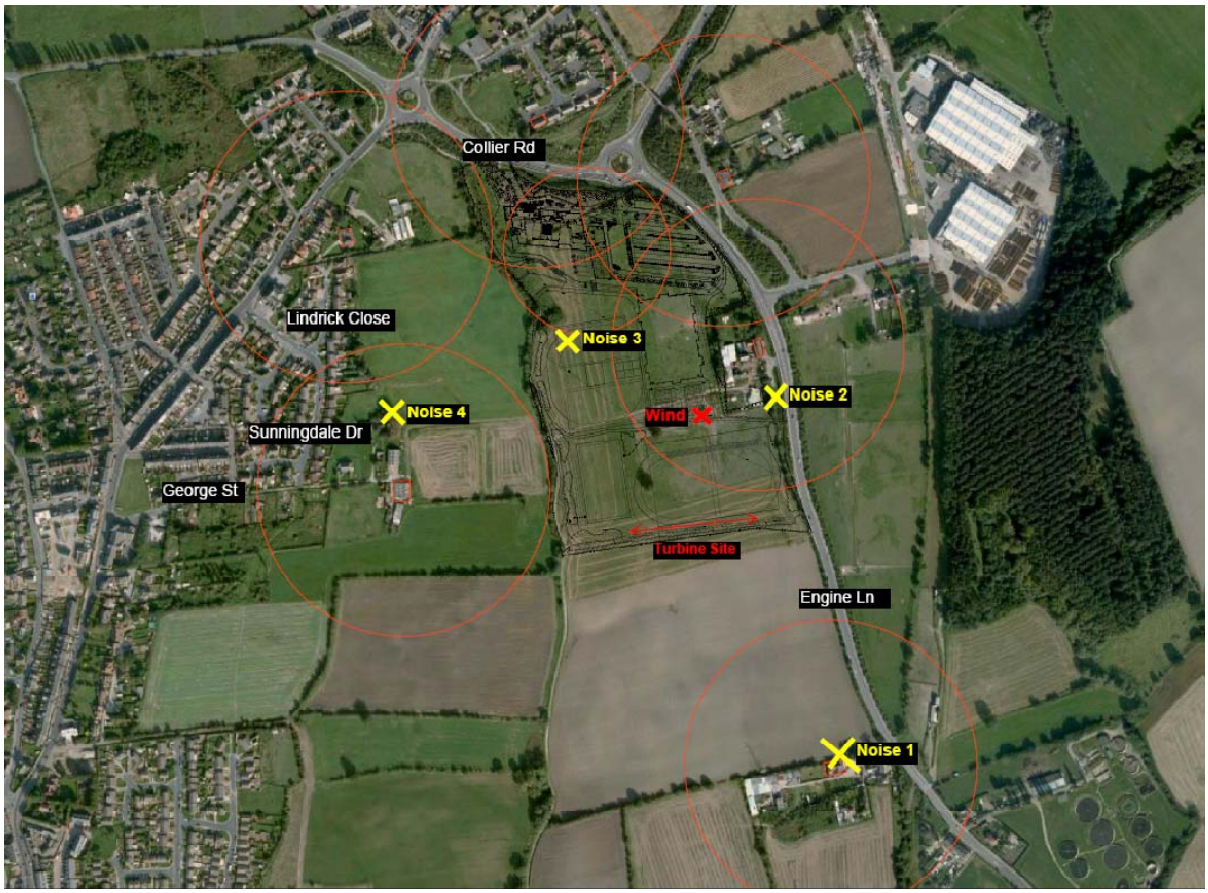
The measured data indicate that the ETSU criteria for the acceptability of wind turbine noise are likely to be met at all speeds for both daytime and night-time with one turbine at the location proposed.

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Appendix 1

Plan showing Measurement and Predictions



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Appendix 2

Survey Details

A1. Location of Surveys

Shafton, Barnsley. For measurement positions see Appendix 1

A2. Dates & Type of Surveys

26 & 27 October 2009 – Day/Evening/Night-time, no/low wind
23 November 2009 – Daytime – low to moderate wind
24 November 2009 – Daytime, moderate to high wind

A3. Personnel Present During Surveys

Mark Hinds- 26 & 27 October, 23 & 24 November
Mark Graham – 23 & 24 November

A4. Instrumentation

Bruel & Kjaer
Type 2250 Sound Level Meter, S/N 2559287
Type 4189 Microphone, S/N 2556367
Type 4231 Sound Level Calibrator, S/N 2482655
Type 2270 Sound Level Meter, S/N 2623080
Type 4189 Microphone, S/N 2638475
Type 4231 Sound Level Calibrator, S/N 2665089

Davis
Type Vantage Pro 2 6152UK Weather Station, S/N A90708N037

A5. Calibration Procedure

Before and after the survey the sound level measurement apparatus was check calibrated to an accuracy of $\pm$0.3 dB using the type 4231 Sound Level Calibrator.

A.6 Survey Procedure

Ambient noise levels and average wind speed were monitored at various positions around the site as shown in Appendix 1. The measurements are tabulated in Appendix 3, and explanations of the parameters used are listed in Appendix 5.

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Appendix 3

Survey Results at Shafton School

Measured Ambient Noise Levels (dB re $2x10^{-5}$ Pa)

Evening/Night – Low Wind

Date Position	Time	L_{A90}	L_{Aeq}	Comments
26.10.09				
1	21:00	40	52	
2	21:15	49	59	Barking Dog
1	21:27	38	52	
2	21:40	42	60	Barking Dog
1	21:56	37	53	
2	22:10	40	58	
1	22:28	42	53	
2	22:43	44	58	
27.10.09				
1	01:57	28	41	
2	02:11	31	48	
1	02:28	27	42	
2	02:42	32	45	
1	02:59	29	43	
2	03:13	32	46	
1	03:30	28	36	
2	03:44	32	48	

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Daytime, Low Wind

Date Position	Time	L_{A90}	L_{Aeq}	Comments
26.10.09				
1	11:41	53	59	Barking Dog – Continually
2	11:58	47	63	
1	12:12	49	58	Barking Dog
2	12:28	55	65	Tractor Nearby
1	12:42	49	58	Barking Dog
2	12:55	48	63	
1	13:08	48	58	
2	13:22	47	62	
1	13:36	47	58	
2	13:49	49	63	
1	14:03	51	59	
2	14:17	54	64	Tractor Nearby
1	14:32	50	58	
2	14:46	48	62	
23.11.09				
3	11:55	46	51	
3	12:10	45	49	
3	12:20	44	49	
3	12:30	44	47	

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Daytime - Moderate Wind

Date Position	Time	L_{A90}	L_{Aeq}	Wind speed m/s@10m	Comments
23.11.09					
3	12:40	45	48	4.0	
	12:50	47	49	3.6	
1	13:10	49	54	4.9	
	13:20	50	54	4.9	
	13:30	49	53	4.9	
	13:40	48	53	4.9	
3	14:00	48	50	5.4	
	14:10	48	51	5.8	
	14:20	48	50	4.9	
	14:30	48	52	6.3	
	14:40	48	50	5.8	
	14:50	48	62	5.4	Helicopter
1	15:10	51	55	6.3	
	15:20	51	55	6.7	
	15:30	51	54	6.3	
	15:40	50	53	5.8	
	15.50	51	54	63	

Note: Under moderate wind conditions distant road traffic noise was at too high a level for the effect of wind speed to be measured. These readings were not used in the analysis.

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Daytime - High Wind

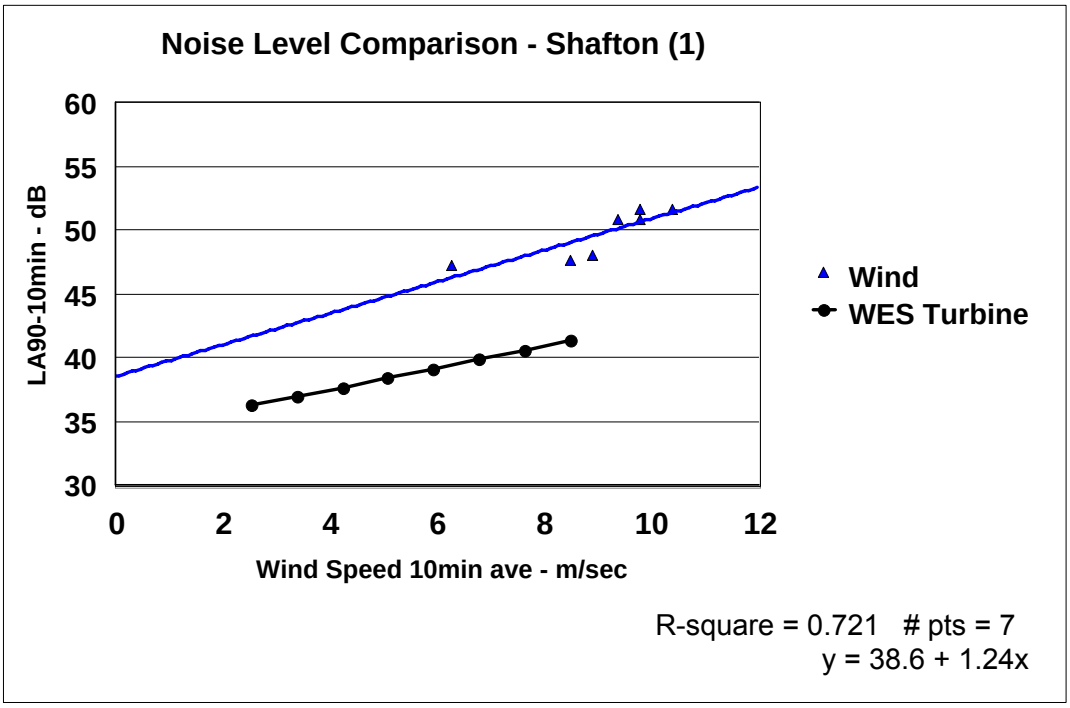
Date Position	Time	L_{A90}	L_{Aeq}	Wind speed m/s@10m	Comments
24.11.09					
3	13:10	50	57	10.3	
	13:20	50	57	9.8	
	13:30	49	56	8.9	
	14:10	54	63	11.2	
	14:20	50	58	9.4	
	14:30	50	56	9.4	
	14:40	50	57	9.4	
	14:50	49	55	8.9	
	15:00	50	59	9.4	
	15:10	50	55	9.4	
	15:20	50	55	9.4	
1	15:40	51	56	9.8	
	15:50	52	55	9.8	
	16:00	51	55	9.4	
	16:10	52	57	10.4	
	17:40	48	54	8.9	
	17:50	48	54	8.5	
3	18:05	48	51	8.9	
	18:15	47	50	8	
	18:25	46	49	6.7	
	18:35	46	49	6.7	
1	18:50	47	57	6.3	

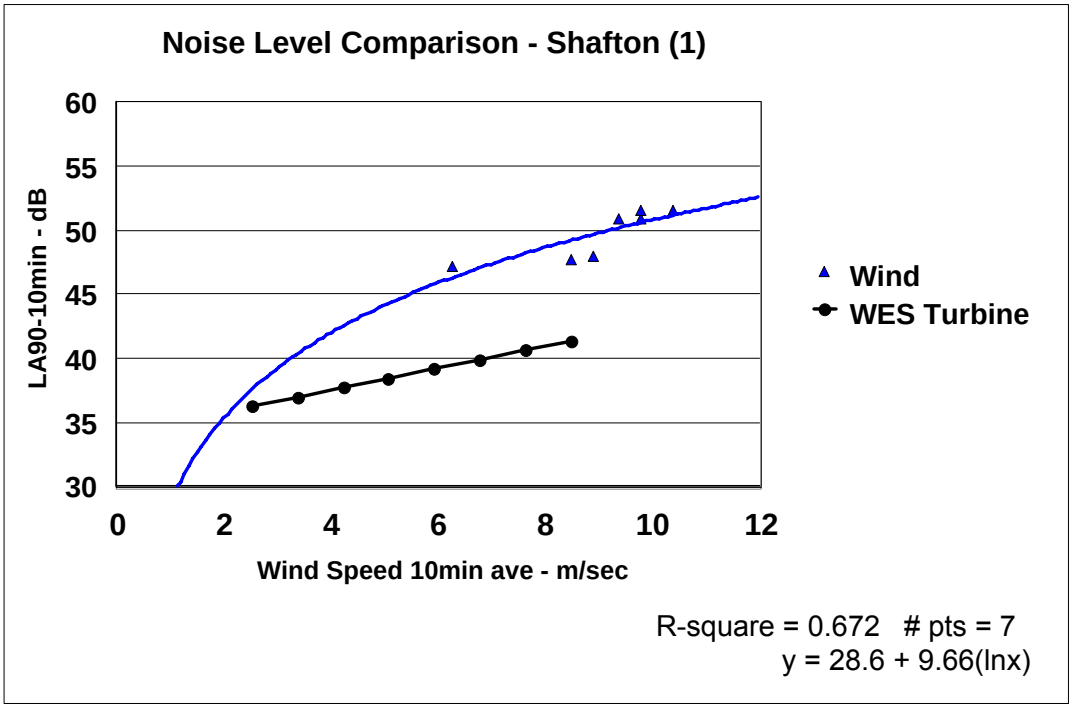
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Appendix 4

Assessment Results

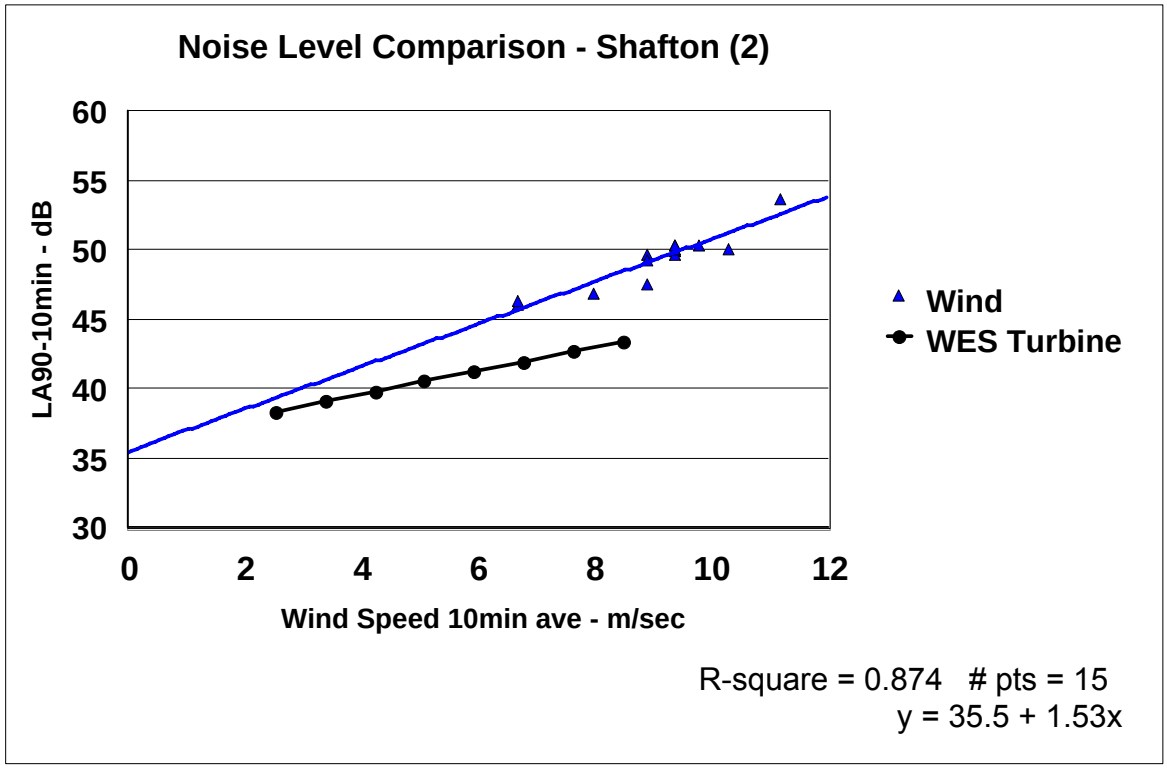
Figures 1 & 2 – Location 1

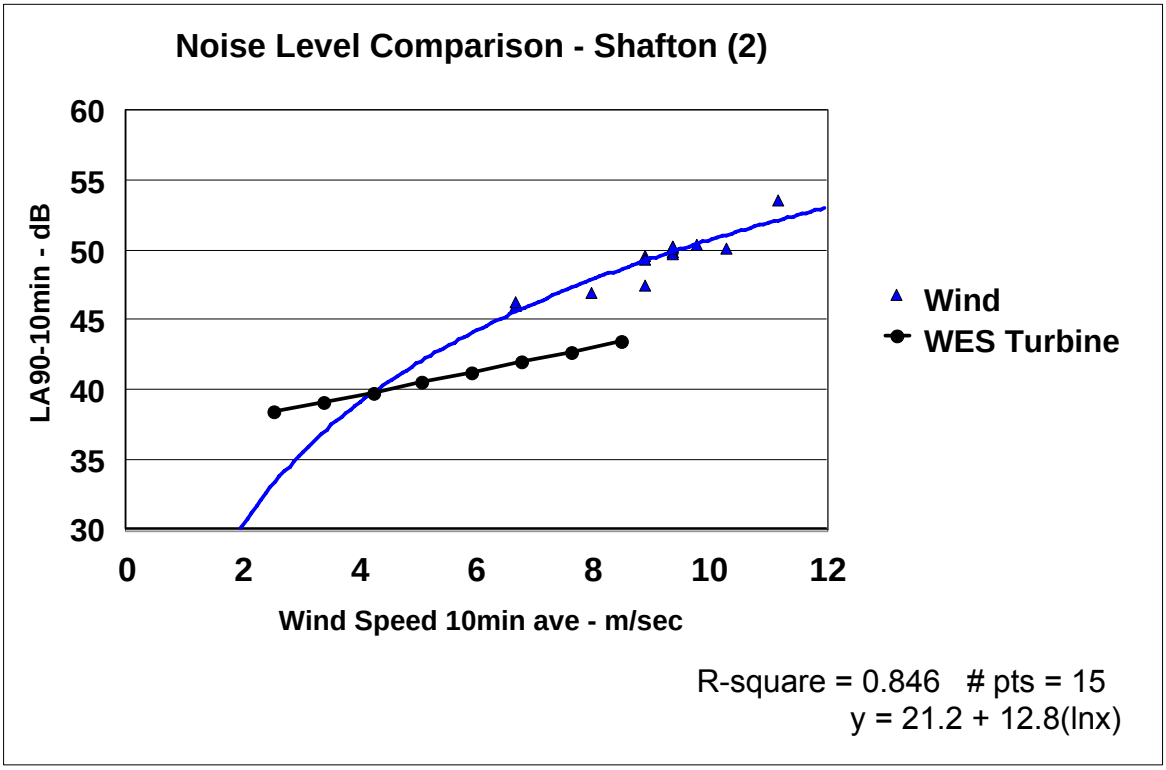




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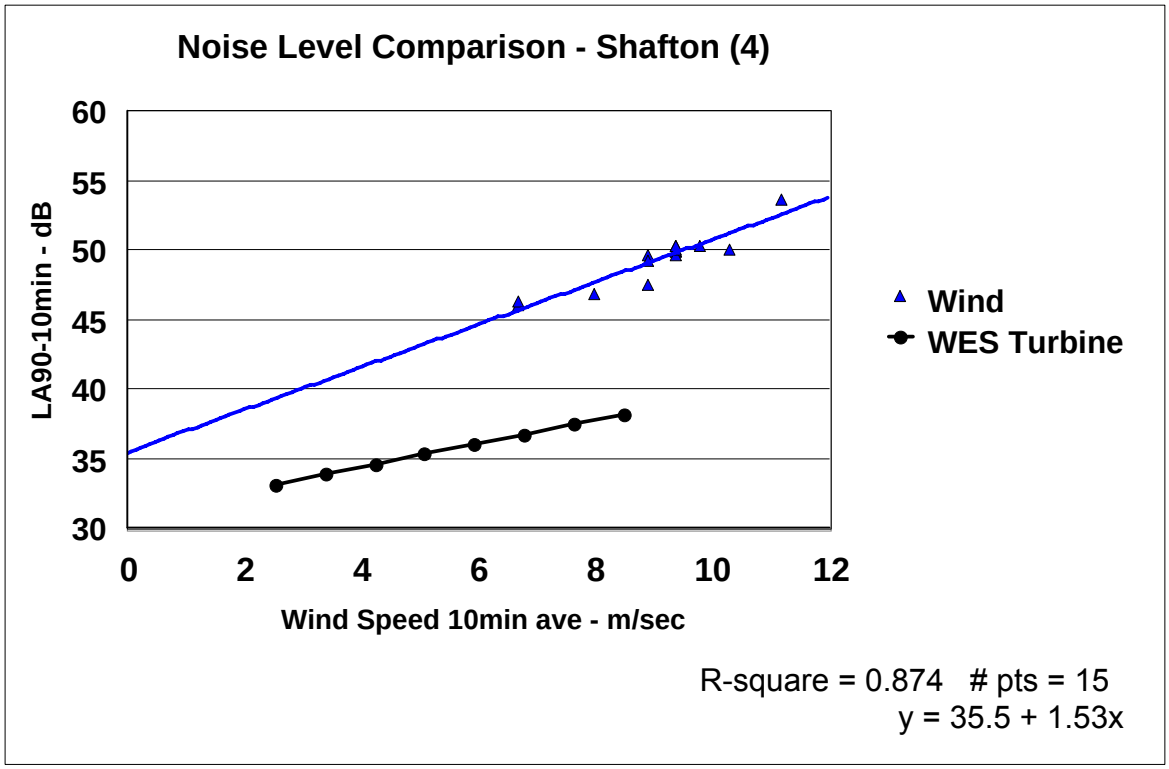
Figures 3 & 4 – Location 2

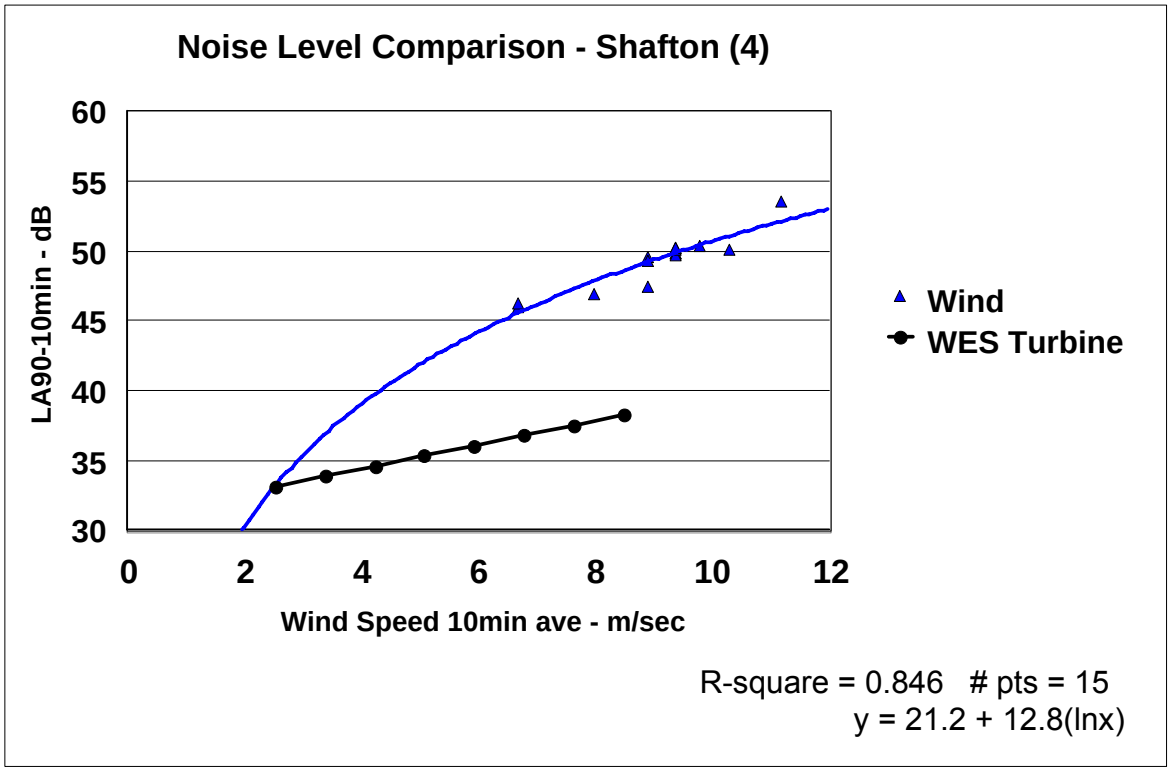




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Figures 5 & 6 –- Location 4





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Appendix 5

Noise Measurement Parameter Definitions

L_{A90} - The "A" weighted sound pressure level that is exceeded for 90% of the measurement period. It is commonly used as the "Background Noise Level".

L_{Aeq} - The "A" weighted equivalent continuous sound pressure level. A representation of a continuous sound level containing the same amount of sound energy as the measured varying noise, over the measurement period. It can be considered as the "average" noise level.

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S R L

Sound Research Laboratories Limited
Registered Address:
Holbrook House
Little Waldingfield
Sudbury
Suffolk
CO10 0TH

Registered Number: 907694 England
Tel: 01787 247595
Fax: 01787 248420
Website: www.soundresearch.co.uk
e.mail: srl@soundresearch.co.uk

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London Office:
70 Cowcross Street
London
EC1M 6EJ
Tel: 0207 251 3585
Fax: 0207 336 8880

Altrincham Office:
Lynnfield House
Church Street
Altrincham, Cheshire WA14 4DZ
Tel: 0161 929 5585
Fax: 0161 929 5582

Wessex Office:
Hartham Park
Corsham
Wiltshire, SN13 0RP
Tel: 01249 700205

Dubai Office (representative):
Sound Research Laboratories Consulting FZC
P.O. Box 10559
Rakfz, RAK, UAE
Tel: 00971 4 3470047
Fax 00971 4 3470824

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