APPENDIX D.2

NOISE IMPACT MODELLING

ESB Wind Development Ltd

Grousemount Wind Farm

Turbine noise modelling

00840-004-R

Version 5

28 August 2015

prevailing
wind farm analysis

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Release history		
Version	Date	Notes
1	27 March 2015	Original release
2	23 July 2015	Updated noise limits and dwelling locations
3	29 July 2015	Updated text, single modelling scenario and noise constraint scheme
4	18 August 2015	Updated noise limits and revised noise constraint schemes
5	28 August 2015	Updated text

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1 Introduction

ESB Wind Development Ltd (ESB-WD) has commissioned Prevailing to undertake an assessment of the turbine noise emission at the Grousemount Wind Farm in Co. Kerry, Ireland.

Noise limits for surrounding dwellings have been supplied by ESB-WD. Prevailing has undertaken noise modelling of the Grousemount and neighbouring wind farms in order to derive a curtailment strategy for the Grousemount Wind Farm. The noise modelling undertaken as part of this analysis has been undertaken according to industry best practice methods.

1.1 Site description

The Grousemount site comprises 38 turbines located in complex terrain. The ground cover across the project is typical of upland moor, comprising of low-lying vegetation. The proposed wind farm and the noise sensitive dwellings are shown in Figure 1.1.

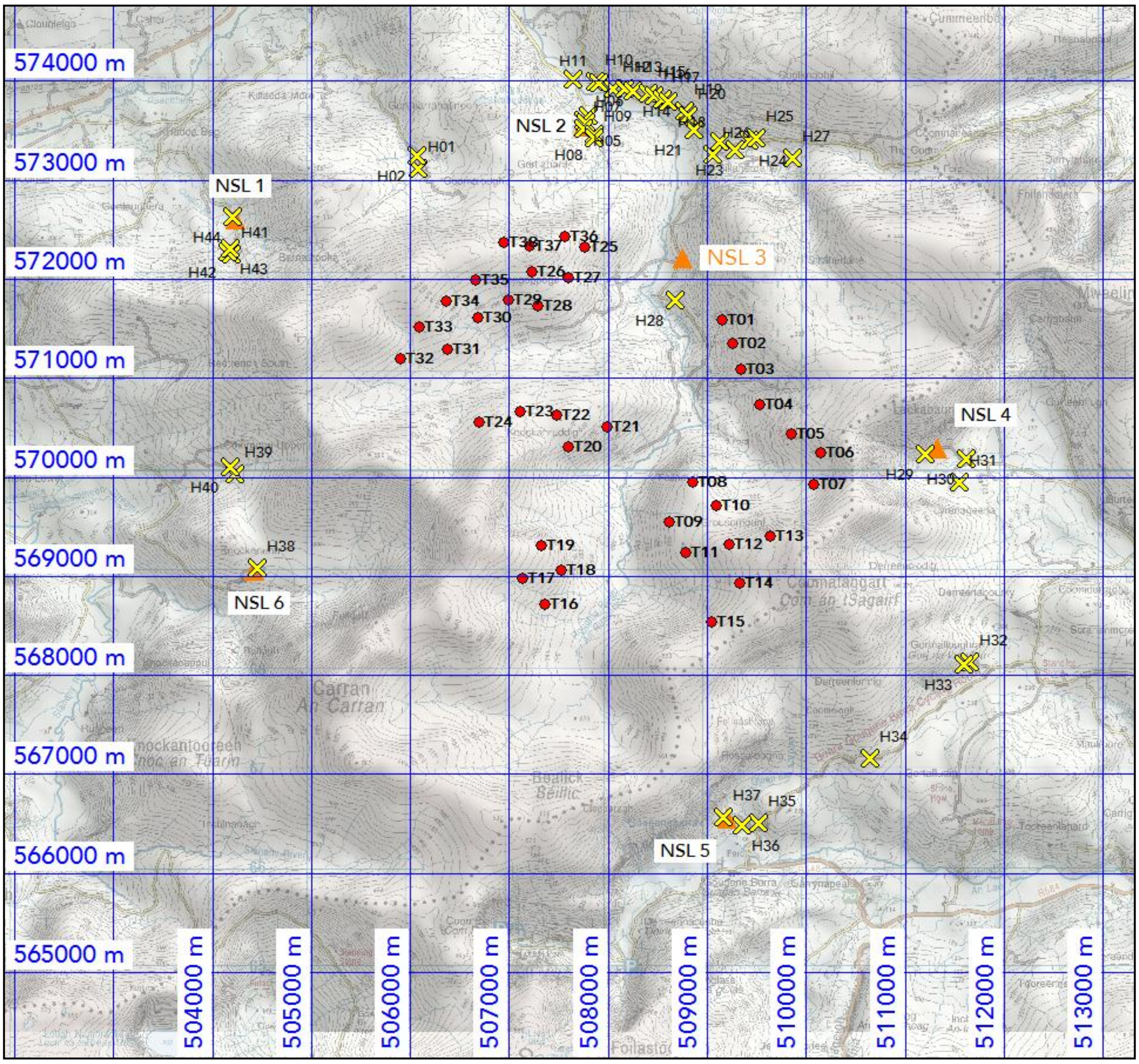
Turbine and dwelling coordinates have been provided by ESB-WD and are presented in Appendix A.

1.2 Wind farm configuration

The following wind farm configuration has been analysed in this report:

Turbines	Turbine model	Number of turbines	Maximum sound power level [dB]	Hub height [m]
T01 to T06	Siemens SWT-2.3-93	6	105.4	63.3
T07 to T38	Vestas V112-3.3 MW	32	105.8	69.0

Table 1.1 Wind farm configuration



Legend

Proposed Grousemount Wind Farm turbine

Third party dwelling

Noise measurement location

Notes

- Coordinate system is ITM Irenet95 Datum.

Figure 1.1 Grousemount Wind Farm layout and dwelling locations

1.3 Neighbouring wind farms

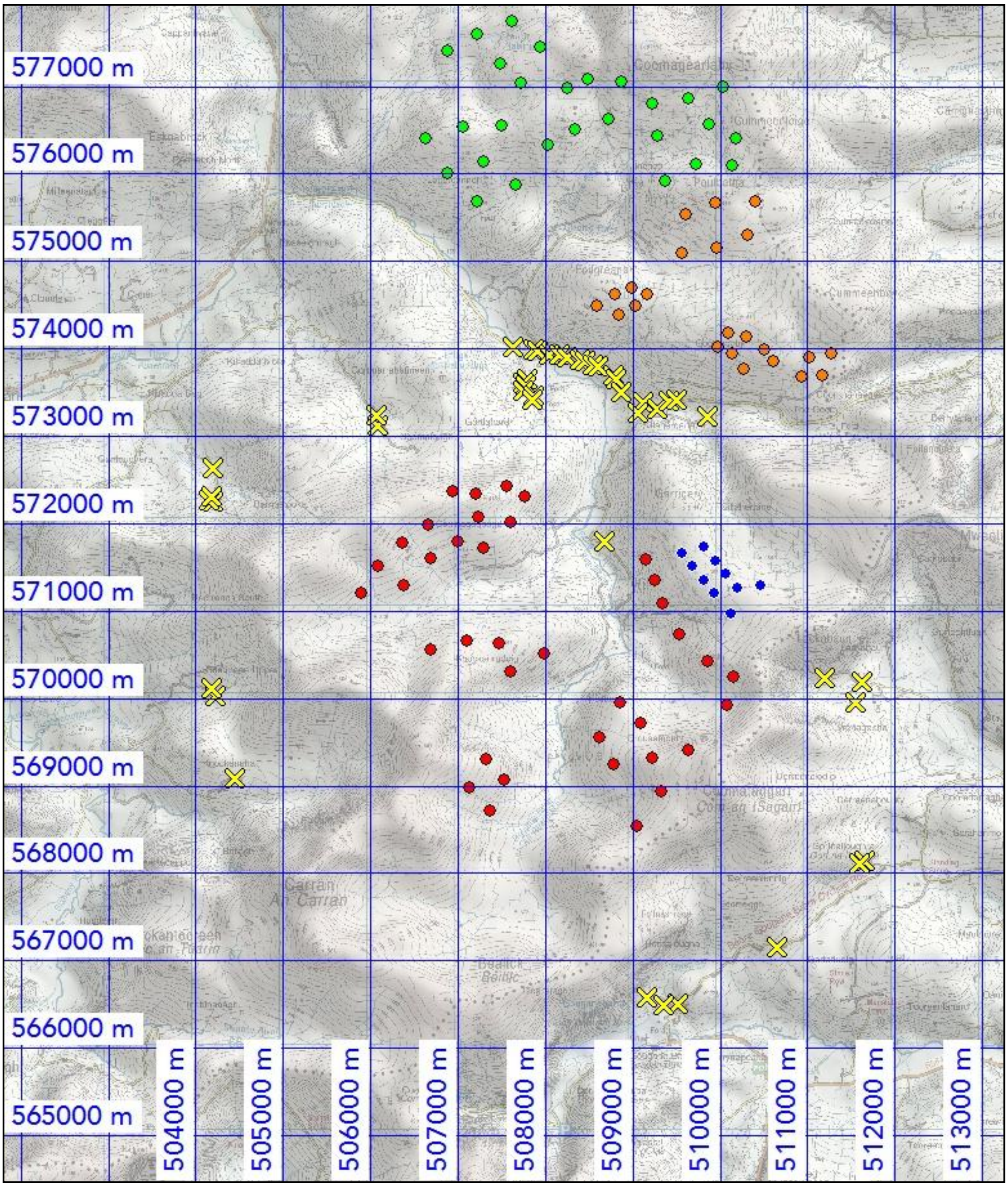
Existing or planned wind farms in the vicinity of the site can have an effect on the energy yield and noise impact of the proposed wind farm.

There are a number of operational wind farms in the vicinity of the site. A summary of the neighbouring wind farms is presented in Table 1.2 and their locations are shown in Figure 1.2.

The cumulative effect of both the noise from the Grousemount Wind Farm as well as the noise from the neighbouring wind farms has been considered in this analysis.

Wind Farm	Status	Turbine model	Number of turbines	Hub height [m]
Coomagearlahy	Operational	Vestas V90 3MW	15	80.0
Coomagearlahy (Inchincoosh)	Operational	Nordex N90/2500	6	80.0
Coomagearlahy (Lettercannon)	Operational	Nordex N90/2500	7	80.0
Glanlee	Operational	Vestas V90 3MW, Vestas V52 850kW	23	80.0, 60.0
Sillahertane	Operational	Vestas V52 850kW	10	55.0

Table 1.2 Summary of neighbouring wind farms



Legend

- Proposed Grousemount Wind Farm turbine
- Operational Glanlee Wind Farm turbine
- Third party dwelling
- Operational Sillhertane Wind Farm turbine
- Operational Coomagearlahy Wind Farm turbine

Notes

- Coordinate system is Irish Transverse Mercator, Irenet95 Datum.

Figure 1.2 Neighbouring wind farm layouts

2 Noise modelling

Prevailing has conducted noise modelling of the Grousemount Wind Farm. The sections below detail the noise limits considered in this analysis, modelling methods used and predicted headroom.

2.1 Noise limits

ESB-WD has supplied assumed noise limits for surrounding dwellings based on background noise measurements conducted by AWN Consulting[1]. Where necessary the noise measurements were subjected to a filtering process by AWN Consulting to remove noise from existing turbines. The filtering process was conducted in accordance with the IoA Guidelines.

The receptor and noise measurement locations are presented in Figure 1.1 and dwelling coordinates are presented in Appendix A.

The dwellings, adopted measurement locations and associated noise limits are shown in Table 2.1.

Dwelling	Measurement location	Noise limit per wind speed [dB(A)] (L_{90})									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H1 – H27	NSL2	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
H28	NSL3	45.0	45.0	45.0	45.0	45.0	45.0	45.3	46.0	46.7	47.4
H29 - H31	NSL4	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1
H32 – H37	NSL5	45.0	45.0	45.0	45.0	45.0	45.0	45.4	47.2	48.6	49.8
H38 – H40	NSL6	45.0	45.0	45.0	45.0	45.0	45.7	47.9	49.9	52.0	54.2
H41 – H44	NSL1	45.0	45.0	45.0	45.0	45.2	45.8	46.6	47.5	48.6	49.5

Table 2.1 Noise limits – Daytime (07:00 – 22:59)

Dwelling	Measurement location	Noise limit per wind speed [dB(A)] (L_{90})									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H1 – H27	NSL2	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H28	NSL3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H29 - H31	NSL4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H32 – H37	NSL5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H38 – H40	NSL6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H41 – H44	NSL1	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Table 2.2 Noise limits – Night time (23:00 – 06:59)

[1] 14_8169NR02a (Grousemount Wind Farm Baseline Report)_Includes Noise Limits_ISSUED 13082015.pdf

2.2 Noise modelling

There are a number of neighbouring wind farms operating in close proximity to the proposed Grousemount Wind Farm, therefore cumulative noise levels have been considered in this analysis.

Prevailing has carried out noise modelling based on the following:

- Noise modelling in accordance with ETSU-R-97, ISO-9613-2, and Institute of Acoustics guidance on wind farm specific propagation modelling. A detailed description of the noise propagation model applied is provided in Appendix A.
- Noise simulations have been carried out at each integer 10 m standard height wind speed, and at each 1° direction resolution.
- An uncertainty of 2 dB has been attributed to the sound power levels for both the Grousemount Wind Farm turbines and the operational neighbouring turbines.

2.3 Results

The calculated headroom at the dwellings is shown in Table 2.3 and Table 2.4 for the daytime and night time cases. The presented values are for the full noise mode operation of the Grousemount and existing turbines. Negative headroom is a breach of the noise limits.

From Table 2.3, minor exceedance of the assumed daytime noise limits is observed at Dwelling H28 for the Grousemount and existing turbines.

From Table 2.4, exceedance of the assumed night time noise limits is observed at eleven dwellings at a number of wind speeds.

In Section 3, two noise constraint schemes has been derived by Prevailing to minimise exceedance of the assumed daytime or night time noise limits at all dwellings.

Dwelling	Headroom per wind speed									
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H01	14.9	12.8	9.5	6.2	4.4	4.0	4.2	4.3	4.3	4.3
H02	15.3	13.2	10.0	6.6	4.8	4.4	4.6	4.7	4.7	4.7
H03	12.8	12.0	10.2	6.4	4.4	3.9	4.2	4.6	4.9	4.9
H04	11.1	10.4	8.7	4.8	2.7	2.3	2.6	3.1	3.4	3.4
H05	11.0	10.3	8.5	4.7	2.6	2.1	2.4	3.0	3.2	3.2
H06	11.0	10.2	8.4	4.6	2.5	2.0	2.3	2.9	3.1	3.1
H07	11.0	10.2	8.3	4.5	2.4	1.9	2.3	2.8	3.0	3.0
H08	10.8	10.1	8.2	4.4	2.4	1.9	2.2	2.7	3.0	3.0
H09	10.8	10.1	8.1	4.3	2.2	1.8	2.1	2.6	2.8	2.8
H10	11.9	11.2	9.5	5.7	3.6	3.2	3.4	4.0	4.3	4.3
H11	11.7	11.0	9.4	5.6	3.5	3.0	3.3	3.9	4.2	4.2
H12	11.1	10.6	9.1	5.2	3.1	2.6	2.9	3.5	3.9	3.9
H13	10.5	10.1	8.8	4.8	2.7	2.2	2.5	3.2	3.6	3.6
H14	10.2	9.9	8.8	4.8	2.6	2.1	2.4	3.2	3.6	3.6
H15	9.6	9.5	8.7	4.6	2.4	1.8	2.1	3.0	3.4	3.4
H16	9.5	9.3	8.6	4.4	2.2	1.7	1.9	2.8	3.3	3.3
H17	9.3	9.2	8.6	4.4	2.2	1.6	1.9	2.8	3.3	3.3
H18	9.3	9.2	8.5	4.4	2.1	1.6	1.9	2.8	3.3	3.3
H19	9.7	9.6	8.5	4.6	2.5	2.0	2.2	2.9	3.3	3.3
H20	10.1	10.0	8.7	4.8	2.8	2.2	2.5	3.2	3.5	3.5
H21	11.2	11.0	9.4	5.6	3.6	3.1	3.4	3.9	4.2	4.2
H22	10.8	10.7	9.8	5.9	3.7	3.1	3.4	4.3	4.5	4.5
H23	10.6	10.5	9.7	5.6	3.4	2.9	3.2	4.1	4.5	4.5
H24	10.2	10.0	9.4	5.3	3.0	2.5	2.8	3.7	4.1	4.1
H25	9.6	9.5	8.9	4.7	2.5	1.9	2.3	3.2	3.7	3.7
H26	11.1	11.0	9.6	5.9	3.9	3.3	3.7	4.2	4.4	4.4
H27	8.5	8.4	7.9	3.7	1.4	0.9	1.2	2.2	2.7	2.7
H28	10.4	9.5	5.3	1.4	-0.5	-0.8	-0.3	0.4	1.2	1.9
H29	20.7	19.1	15.4	11.5	9.6	9.3	9.5	9.6	9.7	10.8
H30	22.9	21.3	17.9	14.2	12.3	12.0	12.1	12.3	12.4	13.5
H31	21.5	20.1	17.2	13.3	11.4	11.1	11.3	11.5	11.7	12.8
H32	24.0	22.5	19.9	16.4	14.4	14.0	14.6	16.7	18.2	19.4
H33	23.9	22.4	19.8	16.2	14.3	13.9	14.5	16.5	18.1	19.3
H34	25.6	22.8	19.5	16.3	14.6	14.3	14.8	16.7	18.1	19.3
H35	27.9	25.2	22.0	18.8	17.1	16.8	17.3	19.2	20.7	21.9
H36	28.6	25.9	22.7	19.5	17.8	17.5	18.0	19.9	21.3	22.5
H37	28.4	25.7	22.5	19.3	17.6	17.2	17.8	19.7	21.1	22.3
H38	26.2	23.4	20.2	17.2	15.5	15.9	18.1	20.2	22.3	24.5
H39	25.3	22.3	19.1	16.1	14.4	14.8	17.1	19.2	21.3	23.5
H40	25.2	22.3	19.0	16.0	14.3	14.7	17.0	19.1	21.2	23.4
H41	22.5	20.3	17.1	13.9	12.4	12.5	13.3	14.3	15.4	16.3
H42	22.8	20.5	17.3	14.1	12.6	12.7	13.5	14.5	15.6	16.5
H43	23.1	20.6	17.3	14.2	12.7	12.8	13.6	14.5	15.6	16.5
H44	23.1	20.7	17.4	14.3	12.8	12.9	13.7	14.6	15.7	16.6

Table 2.3 Predicted headroom at surrounding dwellings – Grousemount and existing wind farms – Daytime case

Dwelling	Headroom per wind speed									
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H01	12.9	10.8	7.5	4.2	2.4	2.0	2.2	2.3	2.3	2.3
H02	13.3	11.2	8.0	4.6	2.8	2.4	2.6	2.7	2.7	2.7
H03	10.8	10.0	8.2	4.4	2.4	1.9	2.2	2.6	2.9	2.9
H04	9.1	8.4	6.7	2.8	0.7	0.3	0.6	1.1	1.4	1.4
H05	9.0	8.3	6.5	2.7	0.6	0.1	0.4	1.0	1.2	1.2
H06	9.0	8.2	6.4	2.6	0.5	0.0	0.3	0.9	1.1	1.1
H07	9.0	8.2	6.3	2.5	0.4	-0.1	0.3	0.8	1.0	1.0
H08	8.8	8.1	6.2	2.4	0.4	-0.1	0.2	0.7	1.0	1.0
H09	8.8	8.1	6.1	2.3	0.2	-0.2	0.1	0.6	0.8	0.8
H10	9.9	9.2	7.5	3.7	1.6	1.2	1.4	2.0	2.3	2.3
H11	9.7	9.0	7.4	3.6	1.5	1.0	1.3	1.9	2.2	2.2
H12	9.1	8.6	7.1	3.2	1.1	0.6	0.9	1.5	1.9	1.9
H13	8.5	8.1	6.8	2.8	0.7	0.2	0.5	1.2	1.6	1.6
H14	8.2	7.9	6.8	2.8	0.6	0.1	0.4	1.2	1.6	1.6
H15	7.6	7.5	6.7	2.6	0.4	-0.2	0.1	1.0	1.4	1.4
H16	7.5	7.3	6.6	2.4	0.2	-0.4	-0.1	0.8	1.3	1.3
H17	7.3	7.2	6.6	2.4	0.1	-0.4	-0.1	0.8	1.3	1.3
H18	7.3	7.2	6.5	2.4	0.1	-0.4	-0.1	0.8	1.3	1.3
H19	7.7	7.6	6.5	2.6	0.5	0.0	0.2	0.9	1.3	1.3
H20	8.1	8.0	6.7	2.8	0.8	0.2	0.5	1.2	1.5	1.5
H21	9.2	9.0	7.4	3.6	1.6	1.1	1.4	1.9	2.2	2.2
H22	8.8	8.7	7.8	3.9	1.7	1.1	1.4	2.3	2.5	2.5
H23	8.6	8.5	7.7	3.6	1.4	0.9	1.2	2.1	2.5	2.5
H24	8.2	8.0	7.4	3.3	1.0	0.5	0.8	1.7	2.1	2.1
H25	7.6	7.5	6.9	2.7	0.5	-0.1	0.3	1.2	1.7	1.7
H26	9.1	9.0	7.6	3.9	1.9	1.3	1.7	2.2	2.4	2.4
H27	6.5	6.4	5.9	1.7	-0.6	-1.1	-0.8	0.2	0.7	0.7
H28	8.4	7.5	3.3	-0.6	-2.5	-2.8	-2.6	-2.6	-2.6	-2.6
H29	18.7	17.1	13.4	9.5	7.6	7.3	7.5	7.6	7.7	7.7
H30	20.9	19.3	15.9	12.2	10.3	10.0	10.1	10.3	10.4	10.4
H31	19.5	18.1	15.2	11.3	9.4	9.1	9.3	9.5	9.7	9.7
H32	22.0	20.5	17.9	14.4	12.4	12.0	12.2	12.5	12.6	12.6
H33	21.9	20.4	17.8	14.2	12.3	11.9	12.1	12.3	12.5	12.5
H34	23.6	20.8	17.5	14.3	12.6	12.3	12.4	12.5	12.5	12.5
H35	25.9	23.2	20.0	16.8	15.1	14.8	14.9	15.0	15.1	15.1
H36	26.6	23.9	20.7	17.5	15.8	15.5	15.6	15.7	15.7	15.7
H37	26.4	23.7	20.5	17.3	15.6	15.2	15.4	15.5	15.5	15.5
H38	24.2	21.4	18.2	15.2	13.5	13.2	13.2	13.3	13.3	13.3
H39	23.3	20.3	17.1	14.1	12.4	12.1	12.2	12.3	12.3	12.3
H40	23.2	20.3	17.0	14.0	12.3	12.0	12.1	12.2	12.2	12.2
H41	20.5	18.3	15.1	11.9	10.2	9.7	9.7	9.8	9.8	9.8
H42	20.8	18.5	15.3	12.1	10.4	9.9	9.9	10.0	10.0	10.0
H43	21.1	18.6	15.3	12.2	10.5	10.0	10.0	10.0	10.0	10.0
H44	21.1	18.7	15.4	12.3	10.6	10.1	10.1	10.1	10.1	10.1

Table 2.4 Predicted headroom at surrounding dwellings – Grousemount and existing wind farms – Night time case

3 Noise constraint scheme

Noise levels are predicted to exceed the assumed night and daytime noise limits when the proposed Grousemount Wind Farm and existing wind farm turbines are operating in full power mode.

Two constraint schemes have been derived for the Grousemount Wind Farm, such that:

- Daytime noise limits are not exceeded at any wind speed, in any wind direction, at any receptor;
- Night time breaches are minimised at any wind speed, in any wind direction, at any receptor;
- Each turbine operates within the capabilities as stated by the manufacturer and as interpreted by Prevailing. It has been assumed that turbines are capable of effectively immediate switching between modes;
- Energy production is maximised as far as possible within the above constraints.

(i) Day time curtailment

The derived daytime constraint scheme involves operating Turbines T1 and T2 in noise-reduced modes at some wind speeds and in some direction sectors. The calculated headroom at the dwellings following implementation of the daytime noise constraint scheme for the Grousemount Wind Farm is shown in Table 3.1.

(ii) Night time curtailment

The derived night time constraint scheme involves shutting down or operating Turbines T1, T2, T3, T4, T25, T26, T27, T28, T36, T37 and T38 of the Grousemount Wind Farm in noise-reduced modes at some wind speeds and in some direction sectors.

The calculated headroom at the dwellings following implementation of the night time noise constraint scheme for the Grousemount Wind Farm is shown in Table 3.2.

In the derivation of the night time noise constraint scheme for the Grousemount Wind Farm, Prevailing has ensured that any additional exceedance at the dwellings is minimised as far as possible.

(iii) Energy loss due to curtailment

The derived noise constraint schemes results in a loss in energy yield of 0.9 % at Grousemount Wind Farm.

Dwelling	Headroom per wind speed [dB]									
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H01	14.9	12.8	9.5	6.2	4.4	4.0	4.1	4.2	4.3	4.3
H02	15.3	13.2	9.9	6.6	4.8	4.4	4.6	4.7	4.7	4.7
H03	12.8	12.0	10.2	6.4	4.4	3.9	4.2	4.6	4.9	4.9
H04	11.0	10.3	8.6	4.8	2.7	2.2	2.6	3.1	3.4	3.4
H05	11.0	10.3	8.4	4.6	2.6	2.1	2.4	2.9	3.2	3.2
H06	10.9	10.2	8.4	4.5	2.5	2.0	2.3	2.9	3.1	3.1
H07	11.0	10.2	8.3	4.4	2.4	1.9	2.3	2.8	3.0	3.0
H08	10.8	10.1	8.2	4.4	2.4	1.9	2.2	2.7	3.0	3.0
H09	10.8	10.1	8.1	4.3	2.2	1.8	2.1	2.5	2.8	2.8
H10	11.9	11.2	9.5	5.7	3.6	3.2	3.5	4.0	4.3	4.3
H11	11.7	11.0	9.4	5.6	3.5	3.0	3.3	3.9	4.2	4.2
H12	11.1	10.5	9.1	5.1	3.1	2.6	2.9	3.5	3.8	3.8
H13	10.4	10.0	8.8	4.8	2.7	2.2	2.5	3.2	3.5	3.5
H14	10.2	9.9	8.8	4.8	2.6	2.1	2.4	3.1	3.5	3.5
H15	9.6	9.4	8.7	4.5	2.3	1.8	2.1	2.9	3.4	3.4
H16	9.4	9.3	8.6	4.4	2.2	1.6	1.9	2.8	3.3	3.3
H17	9.3	9.2	8.6	4.4	2.1	1.6	1.9	2.8	3.2	3.2
H18	9.3	9.2	8.5	4.3	2.1	1.6	1.8	2.8	3.2	3.2
H19	9.7	9.6	8.5	4.6	2.5	1.9	2.2	2.9	3.3	3.3
H20	10.1	10.0	8.7	4.8	2.8	2.2	2.5	3.2	3.5	3.5
H21	11.1	11.0	9.4	5.6	3.6	3.1	3.4	3.9	4.2	4.2
H22	10.8	10.7	9.8	5.9	3.7	3.1	3.4	4.3	4.5	4.5
H23	10.6	10.5	9.7	5.6	3.4	2.8	3.2	4.0	4.4	4.4
H24	10.1	10.0	9.4	5.2	3.0	2.4	2.8	3.7	4.1	4.1
H25	9.6	9.5	8.9	4.7	2.5	1.9	2.2	3.2	3.7	3.7
H26	11.1	10.9	9.6	5.9	3.9	3.3	3.6	4.2	4.4	4.4
H27	8.5	8.4	7.9	3.7	1.4	0.9	1.2	2.2	2.7	2.7
H28	10.4	9.6	5.4	1.5	0.2	0.0	0.5	0.5	1.2	1.9
H29	20.7	19.1	15.4	11.5	9.6	9.3	9.5	9.6	9.7	10.8
H30	22.9	21.2	17.9	14.2	12.3	12.0	12.1	12.3	12.4	13.5
H31	21.4	20.1	17.1	13.2	11.2	10.9	11.1	11.4	11.5	12.6
H32	24.0	22.5	19.9	16.4	14.5	14.0	14.6	16.7	18.2	19.4
H33	23.9	22.4	19.8	16.2	14.3	13.9	14.5	16.5	18.1	19.3
H34	25.6	22.8	19.5	16.3	14.6	14.3	14.8	16.7	18.1	19.3
H35	27.9	25.2	22.0	18.8	17.1	16.8	17.3	19.2	20.7	21.9
H36	28.6	25.9	22.7	19.5	17.8	17.5	18.0	19.9	21.3	22.5
H37	28.4	25.7	22.5	19.3	17.6	17.2	17.8	19.7	21.1	22.3
H38	26.2	23.4	20.2	17.2	15.5	15.9	18.1	20.2	22.3	24.5
H39	25.3	22.3	19.1	16.1	14.4	14.8	17.1	19.2	21.3	23.5
H40	25.2	22.2	19.0	16.0	14.3	14.7	17.0	19.1	21.2	23.4
H41	22.5	20.3	17.1	13.9	12.4	12.5	13.3	14.3	15.4	16.3
H42	22.8	20.5	17.3	14.1	12.6	12.7	13.5	14.5	15.6	16.5
H43	23.1	20.6	17.3	14.2	12.7	12.8	13.6	14.5	15.6	16.5
H44	23.1	20.7	17.4	14.3	12.8	12.9	13.7	14.6	15.7	16.6

Table 3.1 Predicted headroom at surrounding dwellings – Grousemount and existing wind farms – Grousemount noise constraint scheme applied – Daytime case

Dwelling	Headroom per wind speed [dB]									
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H01	12.9	10.8	7.5	4.2	2.5	2.3	2.3	2.3	2.3	2.3
H02	13.3	11.2	7.9	4.6	2.9	2.7	2.7	2.7	2.8	2.8
H03	10.8	10.0	8.2	4.4	2.5	2.1	2.3	2.7	3.0	3.0
H04	9.0	8.3	6.6	2.8	0.8	0.5	0.7	1.2	1.5	1.5
H05	9.0	8.3	6.4	2.6	0.7	0.3	0.5	1.0	1.3	1.3
H06	8.9	8.2	6.4	2.5	0.6	0.3	0.5	1.0	1.2	1.2
H07	9.0	8.2	6.3	2.4	0.5	0.2	0.4	0.9	1.1	1.1
H08	8.8	8.1	6.2	2.4	0.5	0.2	0.3	0.8	1.1	1.1
H09	8.8	8.1	6.1	2.3	0.4	0.1	0.2	0.7	0.9	0.9
H10	9.9	9.2	7.5	3.7	1.8	1.3	1.6	2.1	2.4	2.4
H11	9.7	9.0	7.4	3.6	1.6	1.2	1.5	2.0	2.3	2.3
H12	9.1	8.5	7.1	3.1	1.2	0.9	1.0	1.6	1.9	1.9
H13	8.4	8.0	6.8	2.8	0.8	0.5	0.6	1.3	1.7	1.7
H14	8.2	7.9	6.8	2.8	0.8	0.4	0.5	1.3	1.7	1.7
H15	7.6	7.4	6.7	2.5	0.5	0.1	0.3	1.0	1.5	1.5
H16	7.4	7.3	6.6	2.4	0.5	-0.1	0.2	0.9	1.4	1.4
H17	7.3	7.2	6.6	2.4	0.4	-0.2	0.1	0.9	1.4	1.4
H18	7.3	7.2	6.5	2.3	0.3	-0.3	0.0	0.8	1.3	1.3
H19	7.7	7.6	6.5	2.6	0.7	0.1	0.4	1.2	1.5	1.5
H20	8.1	8.0	6.7	2.8	1.1	0.5	0.8	1.5	1.8	1.8
H21	9.1	9.0	7.4	3.6	2.1	1.5	1.8	2.4	2.5	2.5
H22	8.8	8.7	7.8	3.9	1.8	1.2	1.6	2.3	2.8	2.8
H23	8.6	8.5	7.7	3.6	1.6	1.0	1.4	2.1	2.6	2.6
H24	8.1	8.0	7.4	3.2	1.2	0.6	0.9	1.7	2.2	2.2
H25	7.6	7.5	6.9	2.7	0.6	0.0	0.4	1.2	1.7	1.7
H26	9.1	8.9	7.6	3.9	2.1	1.5	1.9	2.5	2.7	2.7
H27	6.5	6.4	5.9	1.7	-0.4	-1.0	-0.6	0.3	0.8	0.8
H28	8.4	7.5	3.4	0.0	0.2	0.0	0.1	0.0	0.0	0.0
H29	18.7	17.1	13.4	9.5	7.7	7.4	7.6	7.7	7.7	7.7
H30	20.9	19.2	15.9	12.2	10.4	10.1	10.2	10.4	10.4	10.4
H31	19.4	18.1	15.1	11.2	9.3	9.0	9.2	9.4	9.5	9.5
H32	22.0	20.5	17.9	14.4	12.5	12.1	12.3	12.5	12.6	12.6
H33	21.9	20.4	17.8	14.2	12.4	12.0	12.1	12.4	12.5	12.5
H34	23.6	20.8	17.5	14.3	12.7	12.4	12.5	12.6	12.6	12.6
H35	25.9	23.2	20.0	16.8	15.2	14.9	15.0	15.1	15.1	15.1
H36	26.6	23.9	20.7	17.5	15.9	15.6	15.7	15.7	15.8	15.8
H37	26.4	23.7	20.5	17.3	15.6	15.3	15.5	15.5	15.5	15.5
H38	24.2	21.4	18.2	15.2	13.6	13.3	13.3	13.3	13.3	13.3
H39	23.3	20.3	17.1	14.1	12.4	12.2	12.2	12.3	12.3	12.3
H40	23.2	20.2	17.0	14.0	12.4	12.1	12.1	12.2	12.2	12.2
H41	20.5	18.3	15.1	11.9	10.2	9.8	9.7	9.8	9.8	9.8
H42	20.8	18.5	15.3	12.1	10.4	10.0	9.9	10.0	10.0	10.0
H43	21.1	18.6	15.3	12.2	10.5	10.1	10.0	10.0	10.0	10.0
H44	21.1	18.7	15.4	12.3	10.6	10.2	10.1	10.1	10.1	10.1

Table 3.2 Predicted headroom at surrounding dwellings – Grousemount and existing wind farms – Grousemount noise constraint scheme applied – Night time case

Appendix A: Noise modelling

prevailing
wind farm analysis

A Noise modelling

A1 Site coordinates

The coordinate system for all listed coordinates is ITM Irenet95 Datum.

Turbine	Easting [m]	Northing [m]	Elevation [m.a.s.l.]	Turbine	Easting [m]	Northing [m]	Elevation [m.a.s.l.]
T1	509157	571590	311	T20	507610	570305	369
T2	509263	571347	331	T21	507993	570504	350
T3	509351	571082	320	T22	507484	570624	395
T4	509543	570736	306	T23	507117	570663	391
T5	509861	570428	386	T24	506701	570550	403
T6	510154	570247	408	T25	507777	572315	332
T7	510088	569922	374	T26	507244	572069	385
T8	508860	569948	391	T27	507606	572006	346
T9	508625	569548	378	T28	507297	571721	345
T10	509105	569709	391	T29	507006	571788	355
T11	508796	569240	401	T30	506691	571605	349
T12	509230	569320	452	T31	506386	571287	345
T13	509651	569402	485	T32	505904	571196	369
T14	509338	568932	466	T33	506096	571517	391
T15	509055	568536	455	T34	506367	571771	392
T16	507371	568711	405	T35	506663	571988	392
T17	507145	568973	459	T36	507568	572430	363
T18	507539	569063	409	T37	507217	572337	394
T19	507329	569308	457	T38	506956	572364	393

Appendix Table A.1 Turbine coordinates

A2 Dwelling locations

Dwelling coordinates have been supplied by the client.

Dwelling	Easting	Northing
H01	506088	573111
H02	506076	573243
H03	507648	574012
H04	507809	573648
H05	507762	573607
H06	507783	573575
H07	507765	573518
H08	507873	573459
H09	507868	573418
H10	507876	573992
H11	507914	573978
H12	508057	573922
H13	508176	573927
H14	508258	573903
H15	508410	573871
H16	508473	573853
H17	508561	573816
H18	508615	573789
H19	508784	573697
H20	508815	573644
H21	508881	573503
H22	509135	573383
H23	509292	573306
H24	509429	573394
H25	509509	573420
H26	509067	573260
H27	509871	573222
H28	508680	571790
H29	511214	570233
H30	511633	570189
H31	511554	569948
H32	511665	568135
H33	511605	568104
H34	510655	567153
H35	509524	566501
H36	509358	566482
H37	509178	566571
H38	504466	569076
H39	504238	570031
H40	504194	570106
H41	504201	572253
H42	504168	572271
H43	504189	572313
H44	504208	572627

Appendix Table A.2 Dwelling coordinates

A3 Noise modelling

(i) Noise propagation model

The noise modelling has been carried out in accordance with the ISO 9613-2 standard. The equivalent continuous downwind octave-band sound pressure level at a receiver location, $L_{fT}(DW)$, the downwind noise level, is calculated using the follow equation:

$$L_{fT}(DW) = L_W + D_C - A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$

Where

L_W is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt.

D_C is the directivity factor. The complex terrain directivity factors from the Institute of Acoustics bulletin[2] have been applied.

A_{div} is the attenuation due to geometric divergence and is dependent on the distance from the source to the receiver. It is calculated as follows:

$$A_{div} = [20\, ln(d) + 11]$$

Where d is the distance from the source to the receiver in metres.

A_{atm} is the attenuation due to atmospheric absorption. The following standard values are used at 10°C and at a relative humidity of 70%:

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.0011	0.0023	0.0041	0.0087	0.0264	0.0937

A_{gr} is the attenuation due to the ground effect. Prevailing normally assumes 0.5 for mixed ground. A receptor height of 4 m is used.

A_{bar} is the attenuation due to a barrier. The Institute of Acoustics bulletin guidance on appropriate terrain blockage attenuation factors have been applied.

A_{misc} is the attenuation due to miscellaneous other effects. A negative attenuation (increase in noise level) is included to account for the typical uncertainty in the sound output values of the turbines. This uncertainty value depends on the turbine model.

(i) Correction for propagation across a valley

As stated in the IOA guidance document[2] a further +3 dB correction to the noise level is applied for propagation across a valley, where the ground falls away significantly between the turbine and the receiver location. The following criterion is used to determine whether a valley is present:

$$h_m \geq 1.5 \times (abs(h_s - h_r)/2)$$

Where

h_m is the mean height above the ground of the direct line of sight from the receiver to the source.

h_s is height above ground level of the source.

h_r is height above ground level of the receiver.

(ii) Standard 10 m wind speed conversion

Conversion between hub height and standard 10 m height wind speeds is carried out in accordance with IEC 61400-11. A logarithmic boundary layer model, with 0.05 m roughness, is assumed.

[2] IOA Good Practice Guide to the Application of ETSU-R-97 for the assessment and rating of wind turbine noise, May 2013.