APPENDIX 13.1 – NOISE PREDICTION METHODOLOGY

1. CONTENTS

1.1 This technical appendix sets out the details of the noise modelling predictions for both construction and operational calculations. The relevant section contents are provided in Table 13.1-1.

Table 13.1-1 – Contents

Section Title	Subtitle	Contents
Construction Noise Predictions	Construction of Access Tracks	
Operational Noise Predictions	Details of Cumulative Windfarms	Sound Power Levels
		Turbine Co-ordinates
	Noise Predictions Methodology	Overview
		ISO 9613
	Corrections for Ground Profile and Barriers	
References		

2. CONSTRUCTION NOISE PREDICTIONS

Construction of Access Tracks

2.1 Construction noise calculations are undertaken for the construction of the access track. A set of indicative plant items have been assumed for these works. The calculations are based upon the distance to the closest noise-sensitive receptor, which is 170 m at the closest approach to construction working areas. For most of the access track construction, works will be at greater distances than these.

2.2 Calculations are undertaken based on the methods set out in BS 5228 (BSI, 2014). Sound power or sound pressure levels of plant items are identified in octave bands from 63 Hz to 8000 Hz. In this case the sound power levels are identified and are presented in Table 13.1-2.

Table 13.1-2 – Assumed Indicative Construction Plant Items and Sound Power Levels, dB

Name and BS 5228 Reference	Number of Items	Octave band centre frequency (Hz)								Total A-weighted Level
		63	125	250	500	1000	2000	4000	8000	
Asphalt Paver (+tipper lorry) C.5-32	1	115	112	109	108	107	104	102	93	112
Dozer C.5-12	1	108	106	99	98	102	96	93	89	105
Dump Truck C.9-16	1	114	117	116	116	114	111	104	98	119
Tracked Excavator 27kW C.5-35	1	110	100	99	97	97	98	89	82	103
Vibratory Compacter (Asphalt) C.5-29	1	104	106	102	105	105	105	101	98	111
Wheeled Backhoe Loader C.2-8	1	102	94	92	92	91	88	87	78	96

2.3 Sound power levels are converted to sound pressure levels at a distance of 10 m, by subtracting a 28 dB correction factor.

2.4 The sound level transmission loss over distance is calculated on the basis of 100% acoustically hard ground (e.g. concrete, water) and 100% acoustically soft ground (e.g. grass), based on the following respective formulae:

Transmissions Loss for Hard Ground = $20 \times \log(d_2 / d_1)$

Transmission Loss for Soft Ground = $25 \times \log(d_2 / d_1)$

where d_1 is the source sound level reference distance (10 m); and

d_2 is the distance between source and receiver (170 m).

2.5 A linear interpolation is applied based on an assumed proportion of hard ground between source and receiver, which in this case is 50%. The transmission loss is then subtracted from the sound levels.

2.6 Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation depends on temperature and relative humidity of the air and is frequency dependent, with greater attenuation at higher frequencies. The attenuation depends on distance on a dB per metre basis for each frequency band.

2.7 Atmospheric absorption coefficient values are given in Table 13.1-3, corresponding to an assumed temperature of 10 ºC and a relative humidity of 70 %.

Table 13.1-3 – Frequency-dependent atmospheric absorption coefficients

Octave band centre frequency (Hz) Atmospheric Absorption	Octave band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Absorption coefficient, dB/m	0.000122	0.000411	0.00104	0.00193	0.0037	0.00966	0.0328	0.117

2.8 For each item of equipment, the atmospheric absorption is calculated for each frequency band and, alongside the sound pressure conversion facto and the distance transmission loss, are subtracted from the relevant specified sound levels for each frequency band, and are then summed together to calculate the total A-weighted sound pressure level at the receiver location.

2.9 An on-time correction is then applied on the basis of:

On-time correction = 10 × log(T / Tr)

where T is the duration that the equipment will be operating in a given reference time period; and

T_r is the reference time period.

2.10 The total sound pressure levels for all plant items is then logarithmically added together to give the total calculated sound pressure level, which in this case is 62 dB.

3. OPERATIONAL NOISE PREDICTIONS

Details of Cumulative Windfarms

3.1 This section sets out the turbine sound power level and turbine co-ordinate data assumed for other wind farms that have been included in the cumulative operational noise assessment detailed in the noise chapter.

Sound Power Levels

3.2 The sound power levels assumed for each site included in the cumulative predictions are set out below. Each set of data includes the relevant uncertainty (+2 dB) in line with the recommendations of the IOA GPG.

3.3 The wind farms included in the cumulative assessment, along with the installed or proposed turbine model, are set out in Table 13.1-4.

Table 13.1-4 – Cumulative Windfarm Turbines

Windfarm	Status	Turbine Make and Model	Hub Height (m)	Number of Turbines
Dalswinton Wind Farm	Operational	Senvion MM82	69	15
Harestanes Windfarm	Operational	Siemens Gamesa G87 II	78	42
		Siemens Gamesa G87 CS	78	25
		Siemens Gamesa G80	67	1
Harestanes South Wind Farm Extension	Proposed	Siemens Gamesa STW 5.0-145	125	8
Minnygap Wind Farm	Operational	Nordex N100/2500	80	10

3.4 The sound power levels for each turbine type are shown in Table 13.1-5 to Table 13.1-10 by octave band frequency (63 Hz to 8000 Hz) against wind speed standardised to 10 m height (3 m/s to 12 m/s).

Table 13.1-5 – Senvion MM82 –80 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m height wind speed, m/s	Octave band centre frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	74.3	80.1	84.8	85.5	83.5	81.9	74.6	60.5	90.7
4	79.7	85.5	90.2	90.9	88.9	87.3	80.0	65.9	96.1
5	84.2	90.2	95.0	96.7	95.7	91.4	84.6	70.8	101.6
6	87.3	93.5	98.2	100.4	99.6	95.0	89.9	76.6	105.3
7	87.9	94.2	98.9	101.1	100.3	95.7	90.9	77.6	105.9
8	88.4	94.3	98.3	100.8	100.6	96.3	91.7	78.4	106.0
9	87.9	94.1	98.3	100.8	100.7	96.5	92.2	78.7	106.0
10	88.6	94.2	97.8	100.5	100.7	97.1	93.3	78.9	106.0
11	88.8	94.3	97.7	100.4	100.7	97.2	93.5	78.9	106.0
12	88.8	94.3	97.7	100.4	100.7	97.2	93.5	78.9	106.0

3.5 Sound power levels for the Senvion MM82 are taken from *Harestanes South Windfarm Extension Environmental Impact Assessment (EIA) Report Chapter 9: Noise*[1] and converted using standard wind speed gradient model from the specified 80 m hub height to a 69 m hub height model installed at Dalswinton Wind Farm.

[1] Referenced to Senvion technical document entitled: Power curve & sound power level, MM82 [2050kW/50/60Hz], document IF: SWT-2.5-WT.PC.02-B-F-EN

Table 13.11-6 – Siemens Gamesa G87 II – 78 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m Height Wind Speed, m/s	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	79.6	86.1	91.3	93.7	92.7	88.3	80.3	67.1	98.4
4	79.6	86.1	91.3	93.7	92.7	88.3	80.3	67.1	98.4
5	84.5	91.0	96.2	98.6	97.6	93.2	85.2	72.0	103.2
6	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.2
7	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3
8	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3
9	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3
10	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3
11	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3
12	87.5	94.0	99.2	101.6	100.6	96.2	88.2	75.0	106.3

3.6 Sound power levels for the Siemens Gamesa G87 II are taken from *Harestanes South Windfarm Extension EIA Report Chapter 9: Noise*[2].

Table 13.1-7 – Siemens Gamesa G87 CS – 78 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m Height Wind Speed, m/s	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	76.0	82.5	87.7	90.1	89.1	84.7	76.7	63.5	94.8
4	80.5	87.0	92.2	94.6	93.6	89.2	81.2	68.0	99.2
5	85.3	91.8	97.0	99.4	98.4	94.0	86.0	72.8	104.0
6	89.2	95.7	100.9	103.3	102.3	97.9	89.9	76.7	107.9
7	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4
8	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4
9	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4
10	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4
11	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4
12	89.6	96.1	101.3	103.7	102.7	98.3	90.3	77.1	108.4

3.7 Sound power levels for the Siemens Gamesa G87 CS are taken from *Harestanes South Windfarm Extension EIA Report Chapter 9: Noise*[2].

[2] Referenced to Gamesa technical document entitled: Noise emissions analysis for G8X wind turbines, document code: GD027805-en Rev. 4 dated 26/04/10

Table 13.1-8 – Siemens Gamesa G80 – 67 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m Height Wind Speed, m/s	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	77.6	84.8	89.8	92.4	91.8	88.4	82.3	72.5	97.4
4	77.6	84.8	89.8	92.4	91.8	88.4	82.3	72.5	97.4
5	81.9	89.1	94.1	96.7	96.1	92.7	86.6	76.8	101.7
6	84.8	92.0	97.0	99.6	99.0	95.6	89.5	79.7	104.6
7	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1
8	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1
9	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1
10	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1
11	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1
12	85.3	92.5	97.5	100.1	99.5	96.1	90.0	80.2	105.1

3.8 Sound power levels for the Siemens Gamesa G80 are taken from *Harestanes South Windfarm Extension EIA Report Chapter 9: Noise*[2] and converted using standard wind speed gradient model from the specified 80 m hub height to a 67 m hub height model installed at Harestanes Windfarm.

Table 13.1-9 – Siemens Gamesa STW 5.0-145 – 125 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m Height Wind Speed, m/s	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	83.4	89.0	92.5	93.5	95.3	94.9	88.7	75.2	100.9
4	83.4	89.0	92.5	93.5	95.3	94.9	88.7	75.2	100.9
5	88.4	94.0	97.5	98.5	100.3	99.9	93.7	80.2	105.9
6	92.6	98.2	101.7	102.7	104.5	104.1	97.9	84.4	110.1
7	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3
8	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3
9	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3
10	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3
11	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3
12	93.8	99.4	102.9	103.9	105.7	105.3	99.1	85.6	111.3

3.9 Sound power levels for the Siemens Gamesa STW 5.0-145 are taken from *Harestanes*

South Windfarm EIA Report Chapter 9: Noise[3].

Table 13.1-10 – Nordex N100/2500 – 80 m Hub Turbine Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m Height wind pseed, m/s	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1000	2000	4000	8000	
3	80.9	86.3	91.8	93.5	93.5	89.6	80.3	69.1	98.8
4	83.0	89.5	94.8	96.0	94.1	90.7	82.3	72.2	100.8
5	85.3	90.5	96.0	97.9	98.0	93.0	85.7	72.6	103.1
6	86.2	92.4	99.7	101.8	100.6	95.7	91.6	82.8	106.4
7	89.5	94.9	101.7	103.1	100.9	96.2	94.8	86.9	107.8
8	89.1	94.8	101.6	103.4	101.5	96.9	95.2	87.2	108.0
9	89.1	94.8	101.6	103.4	101.5	96.9	95.2	87.2	108.0
10	89.1	94.8	101.6	103.4	101.5	96.9	95.2	87.2	108.0
11	89.1	94.8	101.6	103.4	101.5	96.9	95.2	87.2	108.0
12	89.1	94.8	101.6	103.4	101.5	96.9	95.2	87.2	108.0

3.10 Sound power levels for the Nordex N100/2500 are taken from *Harestanes South Windfarm Extension EIA Report Chapter 9: Noise*[4].

Turbine Co-ordinates

Table 13.1-11 – Dalswinton Wind FarmTurbine Co-ordinates

Turbine ID	Easting	Northing	Hub Height (m)
D1	293572	588811	69
D2	293901	588777	69
D3	294185	588729	69
D4	294468	588502	69
D5	293737	589252	69
D6	294074	589241	69
D7	294356	589104	69
D8	294592	588772	69
D9	293888	589559	69
D10	294228	589536	69
D11	294608	589405	69
D12	294794	589061	69

[3] Referenced to Siemens Gamesa technical document entitled: SG 5.0-145 Noise Emission Analysis, document code: GD411363-en Rev. 2, dated 30/06/19
[4] Referenced to Nordex technical document entitled: Sale document, Noise levels, Nordex N100/2500, document number: F008_228_A03_EN Rev. -4, dated 10/04/2014

Turbine ID	Easting	Northing	Hub Height (m)
D13	294315	589833	69
D14	294644	589770	69
D15	294965	589371	69

Table 13.1-12 – Harestanes Windfarm Turbine Co-ordinates

Turbine ID	Easting	Northing	Hub Height (m)
H01	300630	599980	78
H02	300968	599820	78
H03	301267	599591	78
H04	301551	599347	78
H05	300312	599505	78
H06	300628	599289	78
H07	300933	599050	78
H08	301474	598541	78
H09	301787	598183	78
H10	302004	597900	78
H11	300070	598911	78
H12	300381	598686	78
H13	300674	598441	78
H14	300945	598183	78
H15	301189	597917	78
H16	301498	597523	78
H17	301699	597222	78
H18	300044	598150	78
H19	300324	597903	78
H20	300584	597646	78
H21	300823	597373	78
H24	300205	597128	78
H25	301119	596962	78
H26	301880	596910	78
H27	299498	596956	78
H28	299782	596657	78
H29	300414	596867	78
H30	301302	596654	78
H31	300616	596566	78
H32	300857	596208	78
H33	301550	596101	78
H34	301835	595897	78
H35	299036	596525	78

Turbine ID	Easting	Northing	Hub Height (m)
H36	299979	596398	78
H38	300645	595809	78
H40	299278	596256	78
H41	298986	595618	78
H42	299164	595302	78
H43	300107	595304	78
H44	301039	595653	78
H45	301478	595413	78
H46	301787	595191	78
H47	300473	595202	78
H48	300810	594980	78
H49	302072	594947	78
H50	302323	594676	78
H51	301206	594838	78
H52	301511	594606	78
H53	299647	594733	78
H54	300066	594666	78
H55	300468	594528	78
H56	300818	594340	78
H57	301778	594346	78
H58	302010	594060	78
H59	301379	593846	78
H60	301122	594109	78
H61	299493	594111	78
H62	299958	594043	78
H63	300346	593888	78
H64	300663	593676	78
H65	301593	593551	78
H66	300921	593411	78
H67	301126	593099	78
H89	299240	593463	78
H90	299746	593447	78
H91	300133	593282	78
H92	300415	593035	78
H95	301213	598801	67

Table 13.1-13 – Harestanes South Windfarm Extension Turbine Co-ordinates

Turbine ID	Easting	Northing	Hub Height (m)
HS1	300147	592473	125

Turbine ID	Easting	Northing	Hub Height (m)
HS2	300726	592539	125
HS3	301281	592104	125
HS4	301841	593217	125
HS5	302348	592685	125
HS6	302391	593393	125
HS7	302667	593967	125
HS8	303049	593567	125

Table 13.1-14 – Minnygap Wind Farm Turbine Co-ordinates

Turbine ID	Easting	Northing	Hub Height (m)
M1	302363	597326	80
M2	302592	597044	80
M3	302842	596742	80
M4	303009	596427	80
M5	303159	596096	80
M6	302193	596692	80
M7	302410	596374	80
M8	302601	596029	80
M9	302776	595651	80
M10	303329	595777	80

Noise Predictions Methodology

Overview

3.11 The noise prediction methodology is based on guidance in ESTU-R-97 *The Assessment and Rating of Noise from Wind Farms* and the UK Institute of Acoustics (IOA) document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbines Noise* (GPG). These documents detail the assessment and calculation approach for wind farm noise, and advocate for the use of ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* as the basis for the noise predictions, with some specific assumptions and adjustments.

ISO 9613

3.12 The ISO 9613 standard is used for predicting sound pressure level for downwind propagation by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors. These are set out in ISO 9613-2 General method of calculation according to the following relevant parameters:

Predicted Octave Band Noise Level = $L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$

3.13 These factors are discussed in detail below together with an additional term for taking wind direction into account where required. The predicted octave band levels from each turbine are summed together to give the overall 'A' weighted predicted sound level.

L_w – Source Sound Power Level

3.14 The sound power level of a noise source is normally expressed in dB re: 1 pW. Noise predictions are based on sound power levels detailed in the noise chapter.

3.15 The octave band noise spectra used for the predictions have been taken from the technical specifications of the turbine with the results shown in the noise chapter.

D – Directivity Factor

3.16 The directivity factor allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is measured in a down wind direction, corresponding to the worst-case propagation conditions considered here and needs no further adjustment.

A_{geo} – Geometrical Divergence

3.17 The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in an attenuation depending on distance according to:

$$A_{geo} = 20 \times \log(d) + 11$$

where d = distance from the turbine.

3.18 The wind turbine may be considered as a point source beyond distances corresponding to one rotor diameter.

A_{atm} – Atmospheric Absorption

3.19 Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation depends on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with greater attenuation at higher frequencies. The attenuation depends on distance according to:

$$\mathbf{A_{atm} = d \times \alpha}$$

where d = distance from the turbine, and

α = atmospheric absorption coefficient in dB/m.

3.20 Values of 'α' from ISO 9613 Part 1 *Calculation of the absorption of sound by the atmosphere*, as given in Table 13.1-15, correspond to a temperature of 10 ºC and a relative humidity of 70 %, the values specified in the IOA GPG. These values give relatively low levels of atmospheric attenuation and correspondingly worst-case noise predictions.

Table 13.1-15 – Frequency-dependent atmospheric absorption coefficients

Octave Band Centre Frequency (Hz) Atmospheric Absorption	**Octave Band Centre Frequency (Hz)**							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Coefficient (α, dB/m)	0.000122	0.000411	0.00104	0.00193	0.0037	0.00966	0.0328	0.117

A_{gr} – Ground Effect

3.21 Ground effect is the interference of sound reflected by the ground with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable G which varies between 0.0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1.0 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The IOA GPG states that where wind turbine source noise data includes a suitable allowance for uncertainty, a ground factor of G = 0.5 and a receptor height of 4 m should be used.

A_{bar} – Barrier Attenuation

3.22 The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under down wind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU-R-97 concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of sight between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of sight. In this case a correction of 2 dB has been applied where there is no line of sight between the source and the receiver.

A_{misc} – Miscellaneous Other Effects

3.23 ISO 9613 includes effects of propagation through foliage, industrial plants and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

Corrections for Ground Profile and Barriers

3.24 Sound propagation across a concave ground profile, for example valleys or where the ground falls away significantly between the turbine and the receptor, incurs an additional correction of +3 dB(A) to the overall A-weighted noise levels. This correction is calculated in order to take account of the reduced ground effects and, under some rare circumstances, the potential for multiple reflection paths caused by the concave profile.

3.25 A computer programme is used to generate the ground profiles beneath each source-to-receptor path. From these plots it is possible to determine where a correction is appropriate, based upon guidance set out in the IOA GPG.

3.26 A mathematical condition is recommended in the IOA GPG for indicating where this correction should be applied:

$$h_m \geq 1.5 \times \left(\frac{abs(h_s - h_r)}{2}\right)$$

where h_m is the mean height above ground along the direct path between the source and the receptor,
h_s is the absolute source height above ground level, and
h_r is the absolute receptor height above ground level.

3.27 Whilst this condition is useful at highlighting where the ground profile beneath a source-to-receptor path may be concave, it is inherently non-robust and can produce false positives. It should therefore be used in conjunction with a visual assessment of the ground profile when determining whether a correction should be applied.

3.28 In one instance, between T2 and R8, the condition was met. However, upon review, it was concluded that ground effects were likely to be normal and there was a low risk of multiple reflection paths increasing noise levels. This was based on the absolute distance of over 1.8 km between turbine and receptor, and the substantial relatively flat terrain between the receptor and the point approximately 500 m from the turbine. No correction has therefore been applied in this case.

3.29 The ground profile correction factors used in the assessment are set out in Table 13.1-16 to Table 13.1-20 for each identified windfarm turbine and for each assessed receptor location. The receptor ID values are used in the tables, comprising:

- R1 Glencorse;
- R2 Glenfine Farm;
- R3 3 Gubhill (April Cottage) ;
- R4 4 Gubhill (Pine Cottage) ;
- R5 Burnfoot;
- R6 Larchview Cottage;
- R7 Glenview;
- R8 Gubhill Farm;
- R9 Windyhill;
- R10 Knockenshang;
- R11 Glenbrae;
- R12 Glenmaid;
- R13 Whitestanes;
- R14 Shaws;
- R15 Ae Village, comprising 66 residential properties; and
- NR1 Ae Primary School.

Table 13.1-16 – Ground Profile and Barrier Corrections for the proposed Development

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
T1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	-2	0	0	0	-2	0	0	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T7	0	0	-2	-2	-2	0	0	0	-2	0	0	0	0	0	0	0
T8	0	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	0
T9	0	0	-2	-2	-2	-2	-2	0	-2	0	0	-2	0	0	0	0
T10	0	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	0
T11	0	0	-2	-2	-2	-2	-2	0	-2	0	0	-2	0	0	0	0
T12	0	0	-2	-2	-2	0	0	0	-2	0	0	0	0	0	0	0

Table 13.1-17 – Ground Profile and Barrier Corrections for Dalswinton Windfarm

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
D1	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-2	-2
D2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-2	-2

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
D3	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D4	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D5	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-2	-2
D6	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D7	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D8	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D9	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-2	-2
D10	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D11	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D12	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D13	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D14	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
D15	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

Table 13.1-18 – Ground Profile and Barrier Corrections for Harestanes Windfarm

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
H1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H3	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
H4	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H5	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H6	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2
H7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H8	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H9	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H10	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H11	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H12	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H13	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H14	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H15	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H16	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H17	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H18	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H19	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H20	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H21	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H24	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H25	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H26	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H27	-2	0	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
H28	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	-2
H29	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H30	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H31	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H32	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H33	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H34	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H35	0	0	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H36	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2
H38	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H40	0	0	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H41	0	0	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H42	0	0	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	-2
H43	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H44	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H45	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H46	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H47	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H48	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H49	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H50	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H51	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**NR1**
H52	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H53	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H54	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
H55	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H56	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H57	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H58	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H59	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H60	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H61	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	-2
H62	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2
H63	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	0	-2	0	-2	-2
H64	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	0	-2	-2
H65	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H66	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H67	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H89	0	0	-2	-2	-2	-2	-2	-2	0	-2	0	0	0	0	-2	-2
H90	-2	0	-2	-2	-2	-2	-2	-2	0	-2	0	0	0	0	-2	-2
H91	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	0	0	0	0	-2	-2
H92	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
H95	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

Table 13.1-19 – Ground Profile and Barrier Corrections for Harestanes South Windfarm Extension

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
HS1	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	0	-2	-2
HS2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	0	-2	-2
HS3	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	0	0	0	-2	-2
HS4	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
HS5	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
HS6	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
HS7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
HS8	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

Table 13.1-20 – Ground Profile and Barrier Corrections for Harestanes South Windfarm Extension

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
M1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
M2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
M3	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
M4	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
M5	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
M6	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
M7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

Turbine	Correction Factor by Noise-Sensitive Receptor, dB(A)															
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	NR1
M8	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
M9	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2
M10	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2

4. REFERENCES

- British Standards Institute (2014). BS 5228:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites – Part 1: Noise. BSI.
- Institute of Acoustics (May 2013). A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. IOA.
- International Organization for Standardization (1993). ISO 9613-1, Acoustics - Attenuation of sound during propagation outdoors, Part 1: Calculation of the absorption of sound by the atmosphere. ISO.
- International Organization for Standardization (2024). ISO 9613-2, Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: Engineering method for the prediction of sound pressure levels outdoors. ISO.
- ETSU-R-97 (1996). The Assessment and Rating of Noise from Wind Farms. MM for the DTI.