13. NOISE AND VIBRATION

13.1 Introduction

13.1.1 Background and Objectives

This chapter of the EIAR describes the assessment undertaken of the potential noise and vibration impacts associated with the proposed Lyrenacarriga Wind Farm (the 'Proposed Development'). The Proposed Development comprises up to 17 wind turbines with a maximum overall ground level blade tip height of up to 150 metres above the top of the foundation. A full description of the Proposed Development is provided in Chapter 4 of this EIAR.

There are 80 noise sensitive locations (NSLs) within 1.2 km of the proposed turbine locations. Further details and Grid Reference locations for all NSLs are provided in Section 13.3.1.1.1 below. The nearest NSL is a landowner dwelling located approximately 700 m to the nearest proposed turbine location (i.e. Location H61 from proposed turbine T6). The next nearest NSLs are H11 and H40, which are located approximately 705 m to the nearest proposed turbine locations at T12 and T5 respectively. For a list of turbine locations please see Section 13.3.1.1.1 below.

Noise impact assessments have been prepared for both the operational phase and the construction phase of the Proposed Development to the nearest 80 NSLs. To inform this assessment, background noise levels have been measured at several representative NSLs in the vicinity of the site to assess the potential impacts associated with the operation of the Proposed Development. Cork County Council, Waterford County Council and the Health Service Executive were consulted as part of the EIAR scoping exercise, for further details please see Section 2.6 of Chapter 2.

13.1.2 Statement of Authority

This chapter of the EIAR has been prepared by the following staff of AWN Consulting Ltd:

Dr. Aoife Kelly

Dr. Aoife Kelly (Acoustic Consultant) holds a BSc (Hons) in Environmental Health, a Diploma in Acoustics and Noise Control, a PhD in Occupational Noise and is a member of the Institute of Acoustics. Aoife has specialised in acoustics since 2014 and has broad experience in the area of wind farm noise monitoring. She has extensive knowledge and experience in environmental and occupational noise surveying and environmental acoustics, including windfarm commissioning and noise nuisance complaints.

Dermot Blunnie

Dermot Blunnie (Senior Acoustic Consultant) holds a BEng (Hons) in Sound Engineering, MSc in Applied Acoustics and has completed the Institute of Acoustics (IOA) Diploma in Acoustics and Noise Control. He has been working in the field of acoustics since 2008 and is a member of the Institute of Engineers Ireland (MIEI) and the Institute of Acoustics (MIOA). He has extensive knowledge and experience in relation to commissioning noise monitoring and impact assessment of wind farms as well as a detailed knowledge of acoustic standards and proprietary noise modelling software packages. He has commissioned noise surveys and completed noise impact assessments for numerous wind farm projects within Ireland.

13.2 Fundamentals of Acoustics

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of SPL is 0 dB (for the threshold of hearing) to 120 dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10 dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3 dB.

The frequency of sound is the rate at which a sound wave oscillates is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250 Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The 'A-weighting' system is defined in the international standard BS EN 61672-1:2013 *Electroacoustics. Sound Level Meters. Specifications.* BS ISO 226:2003 *Acoustics - Normal Equal-loudness Level Contours* has been found to provide the best correlations with human response to perceived loudness. SPLs measured using 'A-weighting' are expressed in terms of dB(A).

An indication of the level of some common sounds on the dB(A) scale is presented below in Figure 13-1.

Commonly used statistical parameters used to describe noise levels in this chapter are as follows:

$L_{Aeq,T}$ This is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period (T).

L_{AF90} Refers to those A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude the intermittent features of traffic and is used to estimate a background level. Measured using the "Fast" time weighting.

For a glossary of acoustic terms used in this chapter please refer to Appendix 13-1.

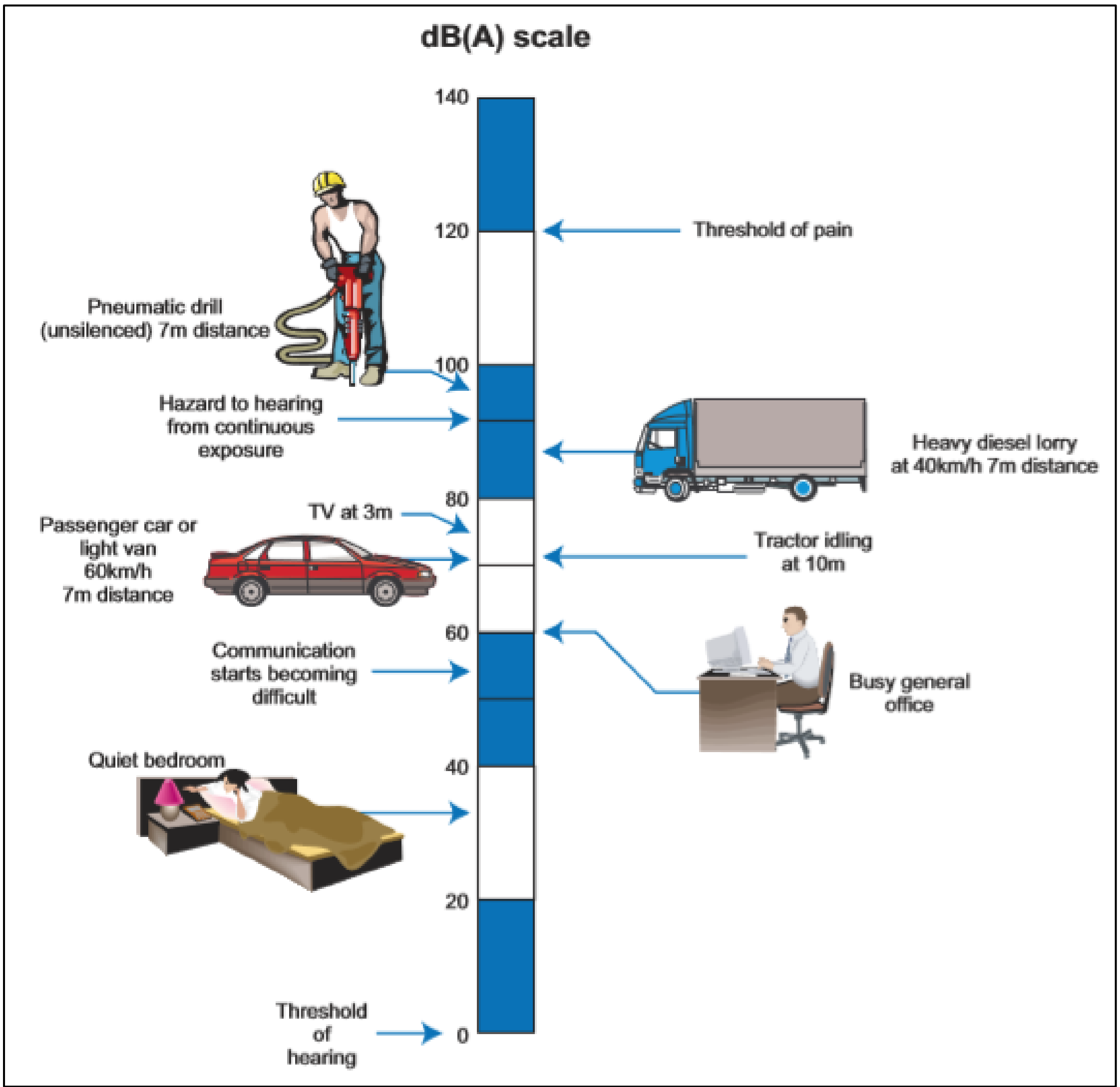

Figure 13-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

13.3 Methodology

The assessment of impacts has been undertaken with reference to the most appropriate guidance documents relating to noise and vibration for both the operational and construction phases of the Proposed Development, which are set out within the relevant sections of this chapter.

In addition to the specific guidance documents as discussed above, the following guidelines were considered and consulted for the purposes of preparing this chapter:

- EPA *Guidelines on the Information to be contained in Environmental Impact Statements*, (EPA, 2002);
- EPA *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements)*, (EPA, 2003);
- EPA *Advice Notes for Preparing Environmental Impact Statements*, (Draft, September 2015); and
- EPA *Guidelines on the Information to be contained in Environmental Impact Assessment Reports Draft August 2017 (EPA, 2017).*

The methodology adopted for this noise impact assessment is summarised as follows:

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction and operational phases;
- Characterise the receiving noise and vibration environment;
- Characterise the Proposed Development;
- Predict the noise and vibration impact and cumulative impacts associated with the Proposed Development, and;
- Evaluate the potential noise and vibration impacts and effects.
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the Proposed Development; and
- Describe the significance of the residual noise and vibration effects associated with the Proposed Development.

13.3.1 Noise Model

A series of computer-based prediction models have been prepared to quantify the noise level associated with the operation of the Proposed Development. This section discusses the methodology for the noise modelling process.

13.3.1.1 Noise Modelling Software

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, DGMR iNoise Enterprise, calculates noise levels in accordance with *ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, (ISO, 1996). The iNoise software fully conforms with the recommendations of the quality standard *ISO/TR 17534-3:2015 Acoustics – Software for the calculation of sound outdoors – Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1.*

iNoise is a proprietary noise calculation package for computing noise levels and propagation of noise sources. iNoise calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated considering a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of A-weighted sound power levels (L_{WA});
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400 m).

13.3.1.1.1 *Input Data and Assumptions*

The calculation settings, input data and any assumptions made in the assessment are described in the following sections. The assumption for the noise propagation is conducted for ‘typical worst-case’ downwind conditions, which are, spherical noise propagation, a ground factor of G = 0.5; atmospheric conditions of 70 per cent relative humidity and 10 degrees Celsius; +3 dB for a concave ground correction (not applicable in this instance) -2 dB for topological screening of a turbine. A typical worst-case prediction assumes that all properties are downwind of all turbines at all times, which is unlikely to happen in practice.

Additional information relating to the noise model inputs and calculation settings is provided in Appendix 13-2.

NSLs Details

Table 13-1 presents the co-ordinates of the 80 noise sensitive locations (NSLs) being considered in this assessment.

Table 13-1 NSL Co-ordinates Within 1.2 km of Proposed Turbine Locations

NSL Ref.	Co-ordinates (ITM)		NSL Ref.	Co-ordinates (ITM)	
	Easting	Northing		Easting	Northing
H01	598514	588721	H41	602629	585772
H02	598645	588003	H42	602655	586333
H03	598651	587842	H43	602690	585993
H04	598656	588404	H44	602718	585838
H05	598687	587517	H45	602726	585900
H06	598850	587409	H46	602730	586270
H07	598894	588985	H47	602738	585979
H08	598998	586888	H48	603003	584835
H09	599326	586507	H49	603022	584761
H10	599748	586235	H50	603085	584339
H11	600379	588814	H51	603114	588174
H12	600493	588853	H52	603170	584219
H13	600562	589306	H53	603997	584136
H14	600549	586316	H54	604076	584274
H15	600654	589321	H55	604113	588564
H16	600822	586555	H56	604119	584398
H17	601046	587710	H57	604305	588638
H18	601073	587560	H58	604428	588706
H19	601077	587501	H59	604493	584864
H20	601175	587859	H60	604511	584867
H21	601232	587219	H61	604594	585857
H22	601260	587175	H62	604600	588586
H23	601282	587503	H63	604654	588453
H24	601306	588360	H64	604701	585856
H25	601370	588387	H65	604897	587449
H26	601546	588343	H66	604792	588210

NSL Ref.	Co-ordinates (ITM)		NSL Ref.	Co-ordinates (ITM)	
	Easting	Northing		Easting	Northing
H27	601556	586585	H67	604818	587518
H28	601596	586485	H68	604854	585817
H29	601655	586422	H69	604957	587397
H30	601777	585912	H70	605008	586923
H31	601850	585882	H71	605266	586328
H32	602048	587698	H72	605282	586432
H33	602152	586803	H73	605377	586748
H34	602198	585676	H74	600571	589162
H35	602210	587575	H75	605310	586260
H36	602379	587837	H76	600578	586492
H37	602444	587867	H77	599077	586273
H38	602475	587884	H78	599077	586274
H39	602605	586363	H79	598876	587308
H40	602608	586548	H80	605293	586234

Turbine Details

Table 13-2 details the co-ordinates of the 17 proposed turbines that are being considered in this assessment.

Table 13-2 Proposed Lyrenacarriga Turbine Co-ordinates

Turbine Ref.	Co-ordinates (ITM)	
	Easting	Northing
T01	603992	587718
T02	603109	587386
T03	603575	587412
T04	603876	587091
T05	603176	586974
T06	604338	586514
T07	603959	586377
T08	603869	585916
T09	603486	585581
T10	603622	585230
T11	603482	586139
T12	599804	588402
T13	599365	588089
T14	599702	587808
T15	600078	587585
T16	599590	587320
T17	600260	587156

For the purposes of this assessment, the turbine type assumed for the development site is the Nordex N117/3600 non-serrated edge turbine. The turbine is a pitch regulated upwind turbine with a three-blade rotor. For the purposes of this noise impact assessment, predictions have assumed the source of noise at a hub height of 91 m. Each wind turbine is secured to a circular-shaped reinforced concrete foundation.

While the noise profiles of the Nordex N117/3600[1] wind turbine has been used for the purposes of this noise impact assessment, the actual turbine to be installed on the site will be the subject of a competitive tender process and could include turbines not amongst the turbine models currently available. The turbine eventually selected for installation on site will not give rise to noise levels of greater significance than that used for the purposes of this assessment, to ensure the findings of this assessment remain valid. Any references to the Nordex turbines in this assessment must be considered in the context of the above and should not be construed as meaning it is the only hub height, blade diameter, make or model of wind turbine that could be used on the site. It is therefore an indicative candidate turbine.

Table 13-3 details the noise spectra used for noise modelling purposes for the proposed Lyrenacarriga Wind Farm development. As outlined further in Section 13.4.2.1.1, appropriate guidance is couched in terms of a L_{A90} criterion.

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[1] *Nordex Technical Report – F008-256-A17-EN Revision 00, 2018-06-07 Nordex N117/3600 Third Octave Sound Power Levels. Data has been corrected from hub height to a standardised 10 m above ground wind speed for an assumed hub height of 91 m. This manufacturer's data has been used, including details of noise spectra. The detailed noise spectra are not presented here for commercial reasons and associated non-disclosure agreements with the manufacturer.*

The provided wind turbine sound power data is referenced in terms of the L_{Aeq} parameter. Best practice guidance contained within the *Institute of Acoustics Good Practice Guide* (IoA GPG) states that "L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB". Therefore, in accordance with best practice guidance, a 2 dB reduction has been applied to the predicted results in this assessment to represent L_{A90} levels.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a +2 dB uncertainty factor has been added to all noise emission values in line with guidance for wind turbine noise assessment contained in the IOA GPG.

Table 13-3 L_{wa} Spectra Used for Prediction Model – Lyrenacarriga Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	72.7	80.2	87.5	89.0	87.8	85.7	78.7	71.0	94.0
4	73.6	80.5	87.4	89.1	90.5	90.4	84.1	69.2	96.0
5	80.3	87.5	91.7	93.4	96.0	96.1	92.1	79.2	101.5
6	83.8	90.1	94.8	96.9	99.1	98.8	94.9	82.7	104.5
≥7	84.6	90.9	94.7	96.8	99.7	99.7	95.4	83.3	105.0

Best practice specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described in ETSU-R-97, and is related to the level by which any tonal components exceed audibility. For this assessment a tonal penalty has not been included within the predicted noise levels. A warranty will be provided by the manufacturers of the selected turbine to ensure that the noise output will not require a tonal noise correction under ETSU-R-97 best practice guidance.

A review of existing, proposed and permitted wind turbine developments in the wider study has been undertaken in accordance with the guidance contained in the IOA GPG. The nearest wind turbine from another site to the boundary of the Proposed Development is located at a distance of 11.5 km. As per Section 5.1.5 the IOA GPG

> *"In such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary."*

A cumulative wind turbine assessment has not been carried out for the Proposed Development as the contributions from the other wind farm turbines are more than 10 dB below the lowest noise limit.

13.4 Guidance Documents and Assessment Criteria

The following sections review best practice guidance that is commonly adopted in relation to developments such as the one under consideration here.

13.4.1 Construction Phase

13.4.1.1 Construction Noise

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities normally control construction activities by imposing limits on the hours of operation and may consider noise limits at their discretion.

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the British Standard 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*

The approach adopted here calls for the designation of a NSL into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded (construction noise only), indicates a potential significant noise impact is associated with the construction activities.

Table 13-4 sets out the values which, when exceeded, potentially signify a significant effect at the facades of residential receptors as recommended by BS 5228 – 1. These levels relate to construction noise only.

Table 13-4 Example Threshold of Potential Significant Effect at Dwellings

Assessment category and threshold value period (T)	Threshold values, $L_{Aeq,T}$ dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings and weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 – 13:00hrs)	65	70	75

Note A Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.
Note B Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.
Note C Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.
Note D 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

The following assessment method is only valid for residential properties.

For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, with the rural nature of the site, properties near the development have daytime ambient noise levels that typically range from 40 to 50 dB $L_{Aeq,1hr}$. Therefore, all properties will be afforded a Category A designation.

See Section 13.6.2 for the detailed assessment in relation to this site. If the specific construction noise level exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to have occurred.

13.4.1.2 Additional Vehicular Activity on Public Roads

For the assessment of potential noise impacts from construction related traffic along public roads and haul routes it is proposed to adopt guidance from Design Manual for Roads and Bridges (DMRB), Highways England, Transport Scotland, The Welsh Government and The Department of Infrastructure 2019.

Table 13-5, taken from Section 13.17 of DMRB presents guidance as to the likely impact associated with any change in the background noise level ($L_{Aeq,T}$) at a noise sensitive receiver as a result of construction traffic.

Section 3.19 of DMRB states that construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

- 10 or more days or nights in any 15 consecutive days or nights;
- A total number of days exceeding 40 in any 6 consecutive months.

Table 13-5 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019)

Change in Sound Level	Magnitude of Impact
<1.0	Negligible
1.0 – 2.9	Minor
3.0 – 4.9	Moderate
5+	Major

The DMRB guidance outlined will be used to assess the predicted increases in traffic levels on public roads associated with the Proposed Development and comment on the likely impacts during the construction phase.

13.4.1.3 Construction Vibration

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. With respect to this development, the range of relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:

- BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration (BSI, 1993); and
- BS 5228 – Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (BSI, 2009+A1:2014).

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15 mm/s at low frequencies rising to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 15 mm/s for transient vibration at frequencies below 15 Hz and 20 mm/s at frequencies above than 15 Hz. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is generated the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document Guidelines for the Treatment of Noise and Vibration in National Road Schemes (NRA, 2004) also contains information on the permissible construction vibration levels during the construction phase as shown in Table 13-6.

Table 13-6 Allowable Transient Vibration at Properties

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of		
Less than 10Hz	10 to 50Hz	50 to 100Hz (and above)
8 mm/s	12.5 mm/s	20 mm/s

13.4.2 Operational Phase

13.4.2.1 Noise

The noise assessment summarised in the following sections has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document *"Wind Energy Development Guidelines"* published by the Department of the Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication *"The Assessment and Rating of Noise from Wind Farms"* (1996). The ETSU document has been used to supplement the guidance contained within the *"Wind Energy Development Guidelines"* publication where necessary.

13.4.2.1.1 Wind Energy Development Guidelines

Section 5.6 of the Wind Energy Development Guidelines published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to wind farm developments.

The following extracts from this document should be considered:

> "*An appropriate balance must be achieved between power generation and noise impact.*"

While this comment is noted it should be stated that the Guidelines give no specific advice in relation to what constitutes an 'appropriate balance'. In the absence of this, guidance will be taken from alternative and appropriate publications.

The following definition in relation to NSLs is of note:

> "*In the case of wind energy development, a noise sensitive location includes any occupied house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational importance. Noise limits should apply only to those areas frequently used for relaxation of activities for which a quiet environment is highly desirable. Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed.*"

As will be seen from the calculations presented later in this chapter the various issues identified in this extract have been incorporated into our assessment. Note the noise limits are defined in terms of the $L_{A90,10min}$ parameter.

> "*In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5 dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours.*"

This represents the commonly adopted daytime noise criterion curve in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

> "*However, in very quiet areas, the use of a margin of 5 dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection*

and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the $L_{A90,\ 10min}$ of the wind energy development be limited to an absolute level within the range of 35 – 40 dB(A)."

The ETSU-R-97 guidance allows for a higher level of turbine noise operation at properties that have an involvement in the development, both as a higher fixed level of 45 dB L_{A90} and/or a higher level above the prevailing background noise level. In line with the guidance a lower threshold of 45 dB $L_{A90,10min}$ is applicable to NSLs involved in the proposed development (H61 and H64).

In relation to night-time periods the following guidance is given:

"*A fixed limit of 43dB(A) will protect sleep inside properties during the night.*"

Note again, this limit is defined in terms of the $L_{A90,10min}$ parameter. This represents the commonly adopted night-time lower limit noise criterion curve in relation to wind farm developments.

In summary, the Wind Energy Development Guidelines outlines the following guidance to identify appropriate wind turbine noise criteria curves at NSLs:

- An appropriate absolute limit level for quiet daytime environments of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night-time periods.

While the caveat of an increase of 5 dB above background for night-time operation is not explicit within the current guidance it is commonly applied in noise assessments prepared and is detailed in numerous examples of planning conditions issued by local authorities and An Bord Pleanála. Therefore, a night-time 5 dB above background allowance has also been adopted for this assessment.

This set of criteria has been chosen as it is in line with the intent of the relevant Irish guidance and is comparable to noise planning conditions applied to similar sites previously granted planning permission by An Bord Pleanála. The proposed operational noise criteria curves for wind turbine noise at various NSLs are presented in Section 13.6.3.3.

13.4.2.1.2 The Assessment and Rating of Noise from Wind Farms – ETSU-R-97

As stated previously the core of the noise guidance contained within the Wind Energy Development Guidelines guidance document is based on the 1996 ETSU publication *The Assessment and Rating of Noise from Wind Farms* (ETSU-R-97).

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. ETSU-R-97 considers that absolute noise limits, applied at all wind speeds, are not suited to wind turbine developments, and recommends that noise limits should be set relative to the existing background noise levels at NSLs. A critical aspect of the noise assessment of wind energy proposals relates to the identification of prevailing background noise levels through on-site noise surveys.

ETSU-R-97 states on page 58, "*…absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question…*". Therefore, the noise contribution from all wind turbine development in the area should be included in the assessment.

13.4.2.1.3 *Institute of Acoustics Good Practice Guide*

The guidance contained within the institute of Acoustics (IoA) document, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013) (IOA GPG), and Supplementary Guidance Notes are considered to represent best practice, and have been adopted for this assessment. The IOA GPG states, that at a minimum continuous background noise monitoring should be carried out at the nearest NSLs, for typically a two-week period, and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e. $L_{A90,10min}$) should be related to wind speed measurements that are collected at the site of the wind turbine development. best-fitting polynomial curve is applied to these data sets, to derive background noise levels at various wind speeds to establish the appropriate day-time and night-time noise criterion curves.

Noise emissions associated with the wind turbine can be predicted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (1996). This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate noise criteria.

Where noise predictions indicate that reductions in noise emissions are required in order to satisfy any adopted criteria, consideration can be given to detailed downwind analysis and operating turbines in low noise mode, which is typically offered by modern wind turbine units.

Reference has been made to the IoA GPG for guidance on the methodology for the background noise survey and operation impact assessment for wind turbine noise.

13.4.2.1.4 *Future Potential Guidance Change*

In December 2019, the Draft Revised Wind Energy Development Guidelines December 2019 were published for consultation and therefore have yet to be finalised. Therefore, in line with best practice, the assessment presented in the EIAR is based on the current guidance outlined in Section 5.6 of the Wind Energy Development Guidelines for Planning Authorities.

13.4.2.1.5 *World Health Organisation (WHO) Noise Guidelines for the European Region*

The WHO Environmental Noise Guidelines for the European Region (2018) provide guidance on protecting human health from exposure to environmental noise. They set health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise.

Recommendations are rated as either 'strong' or 'conditional'. A strong recommendation, "*can be adopted as policy in most situations"* whereas a conditional recommendation, *"requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply"*.

The objective of the WHO *Environmental Noise Guidelines for the European Region* 2018 is to provide recommendations for protecting human health from exposure to environmental noise from transportation, wind farm and leisure sources of noise. The guidelines present recommendations for each noise source type in terms of L_{den} and L_{night} levels above which there is risk of adverse health risks.

In relation to wind turbine noise, the WHO Guideline Development Group (GDG) state the following:

> "*For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den}, as wind turbine noise above this level is associated with adverse health effects.*
>
> *No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.*
>
> *To reduce health effects, the GDG conditionally recommends that policymakers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another."*

The quality of evidence used for the WHO research is stated as being 'Low', the recommendations are therefore **conditional**. A conditional recommendation, before it becomes folded into any legislative context, would require substantial debate of stakeholders (such as, but not limited to the Public, government bodies, wind farm developers and operators as well as turbine manufacturers). A conditional recommendation is based on low quality evidence that this chosen noise level is effective. There is potential increased uncertainty due to the parameter used by the WHO for assessment of exposure (i.e. L_{den}), which it is acknowledged may be a poor characterisation of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes, as stated below.

> "*Even though correlations between noise indicators tend to be high (especially between L_{Aeq}-like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in L_{den} is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes…*
>
> *…Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region."*

It is therefore considered that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) if applied, as target noise criteria for an existing or proposed wind turbine development in Ireland, should be done with caution. The L_{den} criteria has been adopted as part of this assessment, this is based upon the review set out above and the conclusion that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

13.4.2.2 Special Characteristics of Turbine Noise

13.4.2.2.1 *Infrasound/Low Frequency Noise*

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200 Hz whereas Infrasound is typically described as sound at frequencies below 20 Hz. In relation to Infrasound, the following extract from the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)* (EPA, 2011) is noted here:

> *"There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. This was a prominent feature of passive yaw "downwind" turbines where the blades were positioned downwind of the tower which resulted in a characteristic "thump" as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e. the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature."*

With respect to infrasonic noise levels below the hearing threshold, the World Health Organisation (WHO) document *Community Noise* (WHO, 1995) has stated that:

> *"There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects."*

In 2010, the UK Health Protection Agency published a report entitled *Health Effects of Exposure to Ultrasound and Infrasound, Report of the independent Advisory Group on Non-ionising Radiation.* The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

> *"Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*
>
> *For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects."*

The UK Institute of Acoustics Bulletin in March 2009 included a statement of agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed on behalf of community groups campaigning against wind farm developments (IAO JS2009). The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern. In relation to the issue of infrasound, the article states the following:

> *"Infrasound is the term generally used to describe sound at frequencies below 20 Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from*

> *wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.*
>
> *Sounds at frequencies from about 20 Hz to 200 Hz are conventionally referred to as low-frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view."*

The article concludes that:

> *"from examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, generally has adverse effects on wind farm neighbours".*

A report released in January 2013 by the South Australian Environment Protection Authority namely, *Infrasound levels near windfarms and in other environments* (EPA, 2013)[2] found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

The study included several houses in rural and urban areas, both adjacent to and away from a wind farm, and measured the levels of infrasound with the wind farms operating and switched off.

There were no noticeable differences in the levels of infrasound under all these different conditions. In fact, the lowest levels of infrasound were recorded at one of the houses closest to a wind farm, whereas the highest levels were found in an urban office building.

The EPA's study concluded that the level of infrasound at houses near wind turbines was no greater than in other urban and rural environments, and stated that:

> *"The contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment."*

A German report[3], titled "*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*" presents the details of a measurement project which ran from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016 and concluded the following in relation to infrasound from wind turbines:

> "*The measured infrasound levels (G levels) at a distance of approx. 150 m from the turbine were between 55 and 80 dB(G) with the turbine running. With the turbine switched off, they were between 50 and 75 dB(G). At distances of 650 to 700 m, the G levels were between 55 and 75 dB(G) with the turbine switched on as well as off.*"
>
> "*For the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013 Draft)*[4]"

---

2 *EPA South Australia, 2013, Wind farms* *https://www.epa.sa.gov.au/files/477912_infrasound.pdf*

3 *Report available at* *https://www4.lubw.baden-wuerttemberg.de/servlet/is/262445/low-frequency_noise_incl_infrasound.pdf?command=downloadContent&filename=low-frequency_noise_incl_infrasound.pdf*

4 *DIN 45680:2013-09 – Draft "Measurement and Assessment of Low-frequency Noise Immissions" November 2013*

> "*The results of this measurement project comply with the results of similar investigations on a national and international level.*"

13.4.2.2.2 Amplitude Modulation

In the context of this assessment, amplitude modulation (AM) is defined in the IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (IOA, 2016) as:

> "*Periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency (BPF) of the turbine rotor(s).*"

It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

- 'Normal' AM, and;
- 'Other' AM (sometimes referred to 'Excessive' AM).

In both cases, the result is a regular fluctuation in amplitude at the Blade Passing Frequency (BPF) of the wind turbine blades (the rate at which the blades of the turbine pass a fixed point). For a three-bladed turbine rotating at 20 rpm, this equates to a modulation frequency of 1 Hz.

'Normal' AM

An observer at ground level close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from the observer.

This effect is reduced for an observer on or close to the turbine axis, and therefore would not generally be expected to be significant at typical separation distances, at least on relatively level sites.

The RenewableUK AM project (RenewableUK, 2013) has coined the term 'normal' AM (NAM) for this inherent characteristic of wind turbine noise, which has long been recognised and was discussed in ETSU-R-97 in 1996.

'Other' AM

In some cases AM is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies.

On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including wind speed and direction.

It was proposed in the RenewableUK 2013 study that the fundamental cause of this type of AM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency.

Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade.

The RenewableUK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

Frequency of Occurrence of AM

Research by Salford University commissioned by the Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report *Research into Aerodynamic Modulation of Wind Turbine Noise* (2007). The broad conclusions of this report were that aerodynamic modulation was only considered to be an issue at 4, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the 4 sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7 and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

It should be noted that AM is associated with wind turbine operation and it is not possible to predict an occurrence of AM at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is the exception rather than the rule.

Renewable UK Research Document states the following in relation to matter:

Page 68 Module F	"even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."
Page 6 Module F	"It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months."
Page 61 Module F	"There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed."

Assessment of AM

Research and Guidance in the area is ongoing with recent publications being issued by the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) (The Reference Method). The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response or propose any limits for AM. The purpose of the group is simply to use existing research to develop a Reference Methodology for the measurement and rating of amplitude modulation.

The definition of any limits of acceptability for AM, or consideration of how such limits might be incorporated into a wind farm planning condition, is outside the scope of the AMWG's work.. There has been no adoption of endorsement of an AM 'penalty' scheme by any government. The IOA GPG states in section 7.2.1 "The evidence in relation to "Excess" or "Other" Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM." Therefore, it is best practice not to provide a condition for AM.

13.4.2.3 Comments on Human Health Impacts

13.4.2.3.1 *The National Health & Medical Research Council*

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a comprehensive independent assessment of the scientific evidence on wind farms and human health, the findings are contained in the NHMRC Information Paper: *Evidence on Wind Farms and Human Health* 2015, this report concluded:

> *"After careful consideration and deliberation, NHMRC concluded that there is no consistent evidence that wind farms cause adverse health effects in humans. This finding reflects the results and limitations of the direct evidence and also takes into account the relevant available parallel evidence on whether or not similar noise exposure from sources other than wind farms causes health effects"*

13.4.2.3.2 *Health Canada*

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014[5]. The study was initiated in 2012 specifically to gather new data on wind farms and health. The study considered physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality. More than 4,000 hours of wind turbine noise measurements were collected and a total of 1,238 households participated.

No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses. Additionally, the study's results did not support a link between wind turbine noise and stress, or sleep quality (self-reported or measured). However, an association was found between increased levels of wind turbine noise and individuals reporting of being annoyed.

13.4.2.3.3 *New South Wales Health Department*

In 2012, the New South Wales (NSW) Health Department provided written advice to the NSW Government that stated existing studies on wind farms and health issues had been examined and no known causal link could be established.

NSW Health officials stated that fears that wind turbines make people sick are 'not scientifically valid'. The officials wrote that there was no evidence for 'wind turbine syndrome', a collection of ailments including sleeplessness, headaches and high blood pressure that some people believe are caused by the noise of spinning blades.

13.4.2.3.4 *The Australian Medical Association*

The Australian Medical Association put out a position statement, *Wind Farms and Health* 2014[6]. The statement said:

> *"The available Australian and international evidence does not support the view that the infrasound or low frequency sound generated by wind farms, as they are currently regulated in Australia, causes adverse health effects on populations residing in their vicinity. The infrasound and low frequency sound generated by modern wind farms in Australia is well*

---

5 *Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at https://www.canada.ca/en/health-canada/services/environmental-workplace-health/noise/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html*

6 *Australian Medical Association, 2014, Wind farms and health. Available at https://ama.com.au/position-statement/wind-farms-and-health-2014*

below the level where known health effects occur, and there is no accepted physiological mechanism where sub-audible infrasound could cause health effects."

13.4.2.3.5 Journal of Occupational and Environmental Medicine

The review titled, *Wind Turbines and Health: A Critical Review of the Scientific Literature* was published in the Journal of Occupational and Environmental Medicine, 2014. An independent review of the literature was undertaken by the he Department of Biological Engineering of the Massachusetts Institute of Technology (MIT). The review took into consideration health effects such as stress, annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines. The study found that:

"No clear or consistent association is seen between noise from wind turbines and any reported disease or other indicator of harm to human health."

The report concluded that living near wind farms does not result in the worsening of the quality of life in that region.

13.4.2.3.6 Summary

The peer reviewed research outlined in the preceding sections supports that there are no negative health effects on people with long term exposure to wind turbine noise. Please refer to Chapter 5 of the EIAR for further details of potential health impacts associated with the Proposed Development.

13.4.2.4 Vibration

A recent report published in Germany by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016, "*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*", Conducted vibration measurements study for an operational Nordex N117/2400 wind turbine. The report concluded that at distances of less than 300 m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

Considering the distances from nearest NSLs to any of the proposed turbines the level of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the Proposed Development.

13.4.2.5 EPA Description of Effects

The significance of effects of the Proposed Development shall be described in accordance with the EPA guidance document *Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), Draft, August 2017*. Details of the methodology for describing the significance of the effects are provided in Chapter 1: Section 1.7.2 of this EIAR: Introduction.

The effects associated with the Proposed Development are described with respect to the EPA guidance in the relevant sections of this chapter.

13.5 Receiving Environment

This stage of the assessment was to determine typical background noise levels at representative NSLs surrounding the development site. The background noise survey was conducted through installing unattended sound level meters at six representative locations in the surrounding area.

All measurement data collected during the background noise surveys has been carried out in accordance with ETSU-R-97, IOA GPG and accompanying, Supplementary Guidance Note 1: Data Collection (2014).

13.5.1 Choice of Unattended Measurement Locations

The noise monitoring locations were identified by preparing a preliminary noise model contour at an early stage of the assessment. Any locations that fell inside the predicted 35 dB L_{A90} noise contour were considered for noise monitoring in line with current best practice guidance outlined in the IoA GPG. The selection of the noise monitoring locations was informed by site visits and supplemented by reviewing of aerial images of the study area and other online sources of information (e.g. Google Earth).

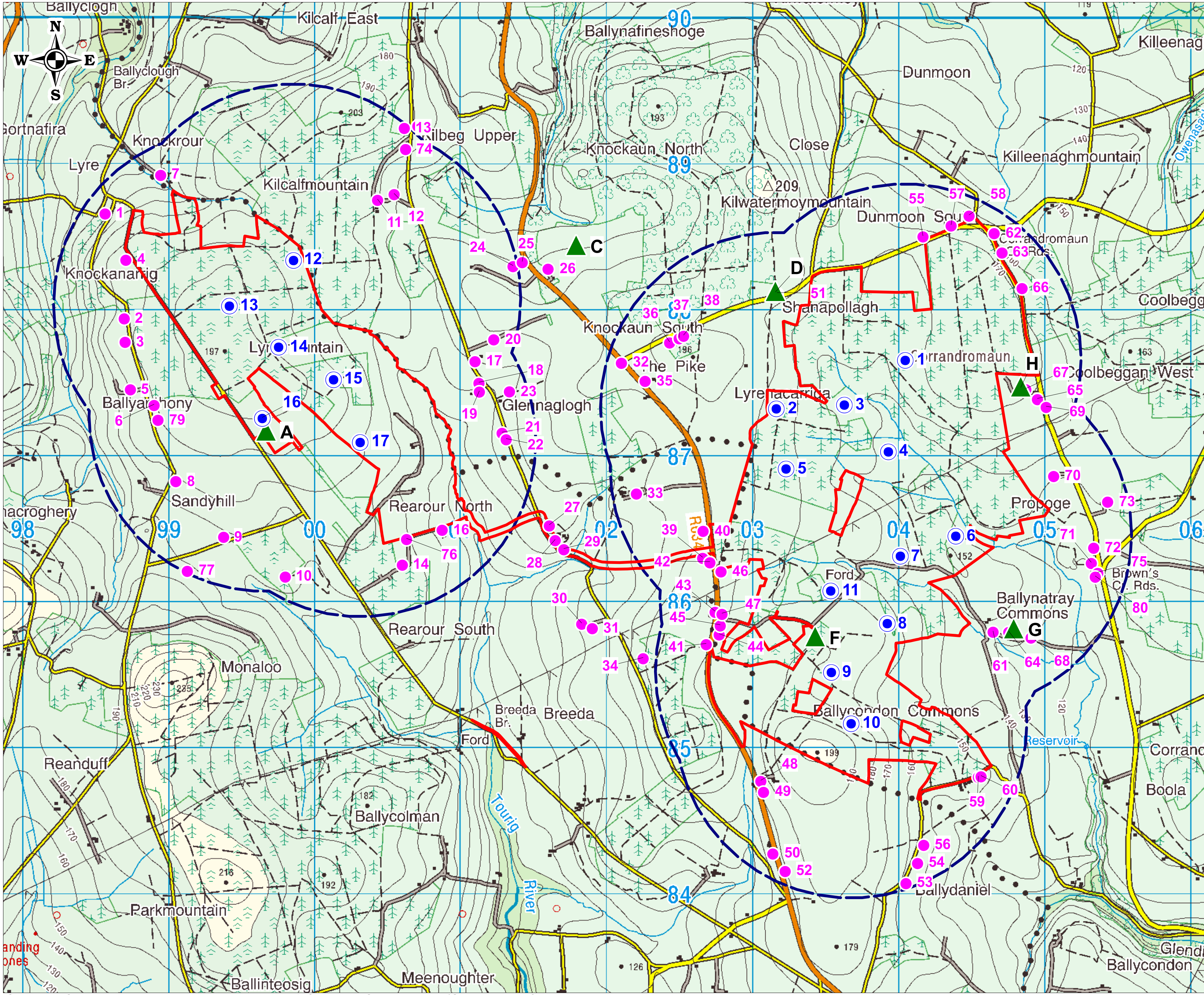
The selected locations for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 13-7 and illustrated in Figure 13-2.

Table 13-7 Measurement Location Coordinates

Location	Coordinates – Irish Grid (ITM)	
	Easting	Northing
A (H08 Proxy)	599,616	587,223
C (H26 Proxy)	601,739	588,494
D (H51)	603,103	588,179
F (H45 Proxy)	603,376	585,815
G (H64)	604,735	585,869
H (H67)	604,783	587,525

Please note Locations B and E were earlier monitoring locations considered but ultimately not used, due to access reasons. Significant noise sources in this area were noted to be distant traffic movements, activity in and around the residences and wind generated noise from local foliage and other typical anthropogenic sources typically found in such rural settings.

There were no perceptible sources of vibration noted at any of the survey locations.



Map Legend

- Site Location
- Proposed Turbine Location
- Distance from Turbines: 1.2 km
- House Location (NSL)
- Noise Monitoring Location

MAP TITLE: **Noise Monitoring Locations**

PROJECT TITLE: **Lyrenacarriga Wind Farm**

MAP NO.:	Figure 13-2		
DRAWING BY:	L Meehan	CHECKED BY:	M Watson
SCALE:	1:35,000	DATE:	09-12-2020
OS SHEET NO.:	2008		

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Plate 13-1 to Plate 13-6 illustrate the installed noise monitoring kits.

The noise meter at Location A was positioned on a proxy location, close to the proposed position of T16, as access to any nearby occupied properties could not be obtained. Owing to practical constraints on site it was not possible to install the SLM in the open field. The SLM was positioned approximately 15 m north of the farmyard shed, 90 m from the local road and 1.5 m above the low-level vegetation in the immediate area. Wind-generated noise from low level vegetation was unlikely to affect the measurement levels.

This proxy location was considered suitable for properties located to the west of the proposed windfarm owing to the quiet background environment noted in the area. Based on inspection and observation at the time of installation, it was deemed that there were no other suitable noise-sensitive locations, in the vicinity of any selected location and close to a dwelling, where background noise levels would be expected to be consistently lower than the levels at the selected position.

Plate 13-1 Location A (H08 Proxy)

Location C was positioned approx. 230 m further from the R634 road than H26 dwelling located 100 m from R634 (dwelling not visible in figure), as access to any nearby occupied properties could not be obtained. The noise meter was positioned along the low-level hedgerow between two fields owing to the practical constraints on site *i.e.* cows grazing on arable lands. Wind-generated noise from low level vegetation was unlikely to affect the measurement levels.

The background noise levels at Location C were expected to be lower than those experienced at the dwelling owing to the increased distance from the R634 road traffic noise. There were no other significant noise sources noted in the environment and therefore the measurement location was deemed to be an appropriate proxy location for H26.

Plate 13-2 Location C (H26 Proxy)

Location D was located at the rear of the garden, set back 30 m from the dwelling to the south, in order to secure it from the resident's dog. Location D was also considered an appropriate proxy location for properties located to the north east of the proposed windfarm owing to the quiet background environment noted in the area.

Plate 13-3 Location D (H51)

The noise meter at Location F was positioned on a proxy location, close to the proposed positions of T9/T11, due to access issues in the area. The SLM was positioned up a hill, approximately 500 m east of the dwellings (H41, H43, H44, H45, H47) along the R634. Small conifer trees were in proximity to the SLM, but as access to any nearby occupied properties could not be obtained; this was the only permissible position for the SLM, which allowed for the infrequent passing of farm equipment during the monitoring period. The conifers were considered to contribute low levels of wind-borne foliage noise at moderate wind-speeds.

This proxy location was considered suitable for properties located to the south of the proposed windfarm owing to the influence of road traffic noise noted in the area, albeit the background noise levels at Location F were expected to be lower than those experienced at the dwellings in the area due to the increased distance from the road.

Plate 13-4 Location F (H45 Proxy)

There are no photographs available for the installation at Location G as the photograph image file was subsequently corrupted and could not be recovered. The SLM was positioned in line with the dwelling garage at H64, used to minimise the influence of the milking parlour to the west of the dwelling (approximately 150 m). The images below indicate where the SLM was positioned at the property.

Plate 13-5 Location G (H64) (Source: Google Maps)

At Location H, the noise meter was located in a field close to the house (at a distance of approximately 30 m further from the local road than dwelling).

Plate 13-6 Location H (H67)

13.5.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the periods outlined in Table 13-8.

Table 13-8 Measurement Periods

Location	Start Date	End Date
A (H08 Proxy)	4th September 2018	5th October 2018
C (H26 Proxy)	8th August 2018	1st September 2018
D (H51)	8th August 2018	5th October 2018
F (H45 Proxy)	8th August 2018	30th August 2018
G (H64)	8th August 2018	19th September 2018
H (H67)	4th September 2018	5th October 2018

A range of wind speed and variety of weather conditions were encountered over the survey periods in question. Figure 13-3 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the survey period detailed in Table 13-8.

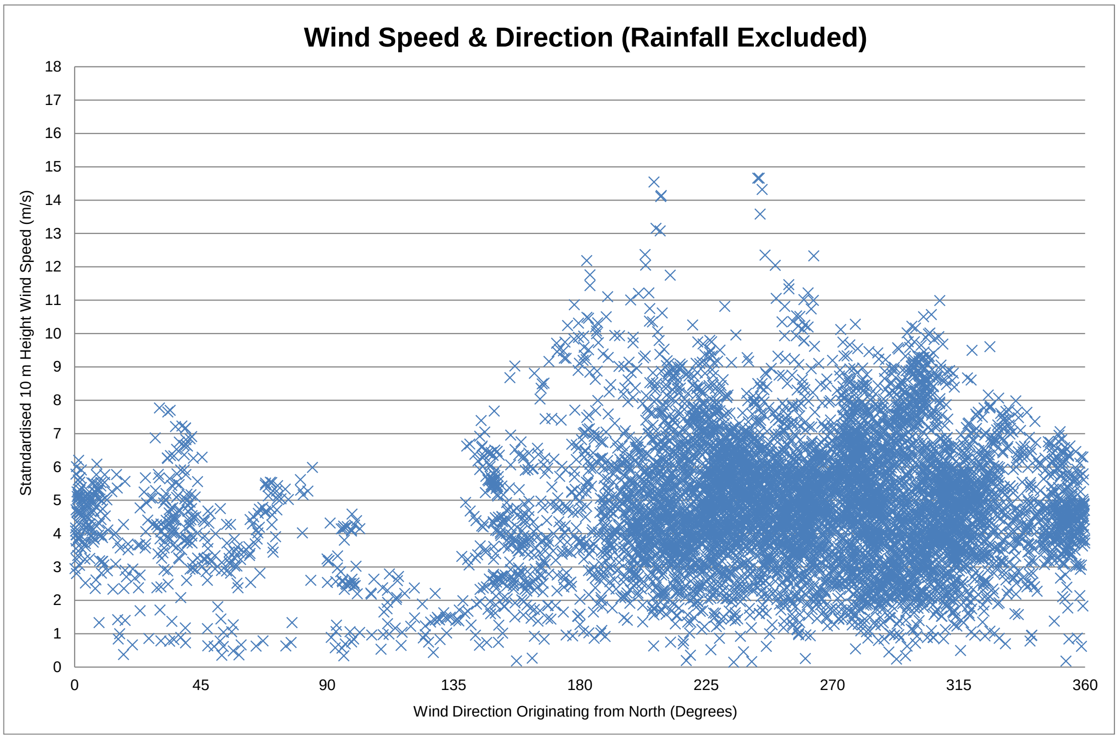


Figure 13-3 Distributions of Wind Speeds and Directions Over the Survey Period (8 August to 5 October 2018)

13.5.3 Personnel and Instrumentation

AWN Consulting installed and removed the noise monitors at all locations. The noise monitors consisted of a Class 1 SLM instrument and Rion WS-15 Outdoor Microphone Protection System. Battery checks and meter calibrations were carried out halfway through the survey periods. The following instrumentation was used at the various locations:

Table 13-9 Instrumentation Details

Location	Equipment	Serial Number
A (H08 Proxy)	Rion – NL-52	186667
C (H26 Proxy)	Rion – NL-52	186667
D (H51)	Rion – NL-52	575785
F (H45 Proxy)	Rion – NL-52	186669
G (H64)	Rion – NL-52	575802
H (H67)	Rion – NL-52	186669

Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. All drifts were below 0.2 dB. Relevant calibration certificates are presented in Appendix 13.3.

Rain fall was monitored and logged using a Texas Instruments TR-525 console and a data logger that was installed on-site at Location F between 8 August to 4 September 2018 (603376, 585815) and at Location D between 4 September to 5 October 2018 (603106, 588172). This allows for the identification of periods of rain fall to allow for the removal sample periods affect by rainfall from the noise monitoring data sets in line with best practice when calculating the prevailing background noise levels.

Wind data was measured using LIDAR equipment located within the site of the Proposed Development and was supplied to AWN for data analysis.

13.5.4 Procedure

Measurements were conducted at six locations over the survey periods outlined in Table 13-8. Data samples for all measurements (noise, rainfall and wind) were logged continuously at 10-minute interval periods for the duration of the survey.

Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site. Description of the observed noise environment at each of the monitoring locations is presented below. $L_{Aeq,10min}$ and $L_{A90,10min}$ parameters were measured in this instance.

13.5.5 Consideration of Wind Shear

Wind shear is defined as the increase of wind speed with height above ground. As part of a robust wind farm noise assessment due consideration should be given to the issue of wind shear. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in the IoA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed.

Wind speed measurements at 80 m and 60 m heights have been converted to a height of 91 m *(i.e.* the assumed hub height for this assessment) in accordance with preferred Method B of the IOA GPG. The calculated hub height wind speeds were then converted to standardised 10 metre height wind speed.

The IoA GPG presents the following equations in relation to the derivation of a standardised wind speed at 10 m above ground level:

Shear Exponent Profile:

$$U = U_{ref}\left[\frac{H}{H_{ref}}\right]^m$$

Where:

U Calculated wind speed

U_{ref} Measured hub height wind speed.

H Height at which the wind speed will be calculated.

H_{ref} Height at which the wind speed was measured.

m shear exponent = $\log(U/U_{ref})/\log(H/H_{ref})$

The Calculated hub height wind speeds have been standardised to 10 m height using the following equation:

Roughness Length Shear Profile:

$$U_1 = U_2\frac{\ln(H_1/z)}{\ln(H_2/z)}$$

Where:

H_1 The height of the wind speed to be calculated (10m)

H_2 The height of the measured or calculated hub height wind speed.

U_1 The wind speed to be calculated.

U_2 The measured or calculated hub height wind speed.

z The roughness length.

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10 m height in the IEC 61400-11:2003 standard, regardless of what the actual roughness length seen on a site may have been. This 'normalisation' procedure was adopted for comparability between test results for different turbines.

Any reference to wind speed in the following sections of this chapter should be understood to be the 10 m height standardised wind speed reference unless otherwise stated.

13.5.6 Analysis of Background Noise Data

The data sets have been filtered to remove outliers such as the dawn chorus and the influence of other atypical noise sources. An example of atypical sources would be short isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues, operation of gardening equipment etc. In addition, sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been screened form the data sets. Please see Appendix 13-4 for filtering of data sets. The assessment methods outlined above are in line with the guidance contained in ETSU-R-97, IoA *GPG* and the IOA GPG SGNs.

The results presented in the following sections refer to the noise data collated during 'quiet periods' of the day and night as defined in ETSU-R-97. These periods are defined as follows:

- Daytime Amenity hours are:
  - all evenings from 18:00 to 23:00 hrs;
  - Saturday afternoons from 13:00 to 18:00 hrs, and;
  - all day Sunday from 07:00 to 18:00 hrs.
- Night-time hours are 23:00 to 07:00 hrs.

13.5.7 Background Noise Levels

The following sections present an overview and results of the noise monitoring data obtained from the background noise survey in accordance with the methodology discussed above. Observations made on site during installation, interim visits and collection are presented below for each monitoring location. Site visits were carried out during the morning and afternoon time and therefore no observations were made during night time periods. Due to the noise floor of the instrumentation, the data collated and displayed in the graphs in the following section do not display any data below the Rion noise floor (15 dB).

13.5.7.1 Location A (H08 Proxy)

13.5.7.1.1 Daytime Quiet Periods

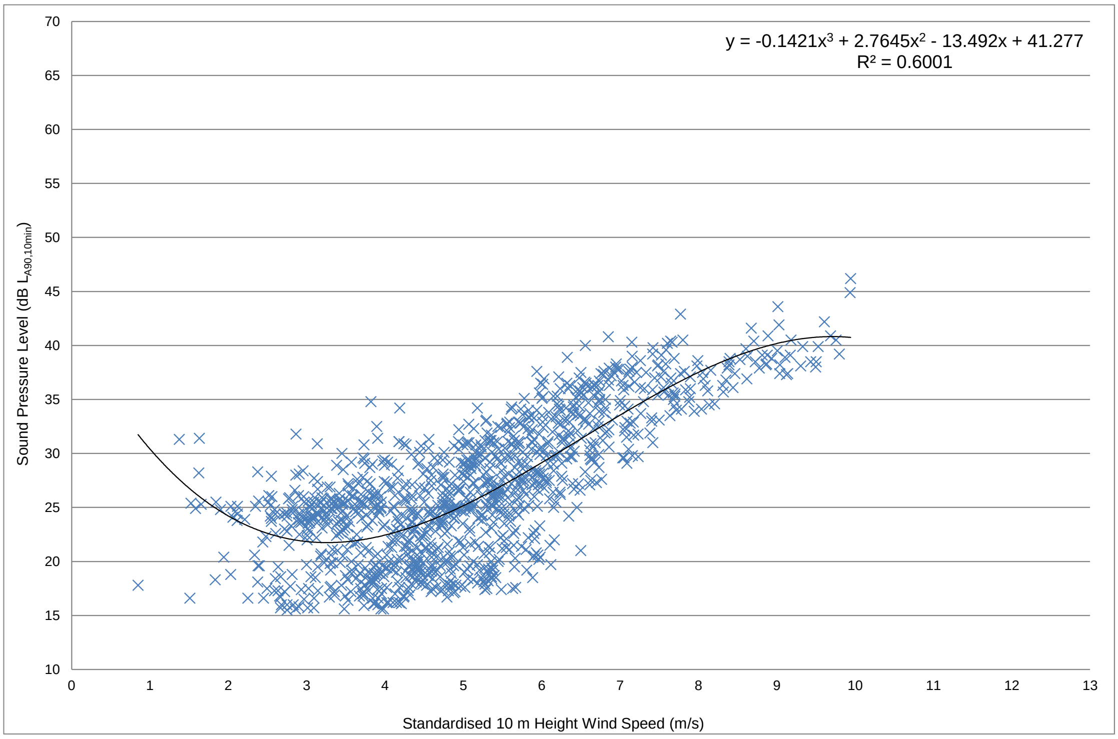


Figure 13-4 Location A (H08 Proxy) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

13.5.7.1.2 Night-time Quiet Periods

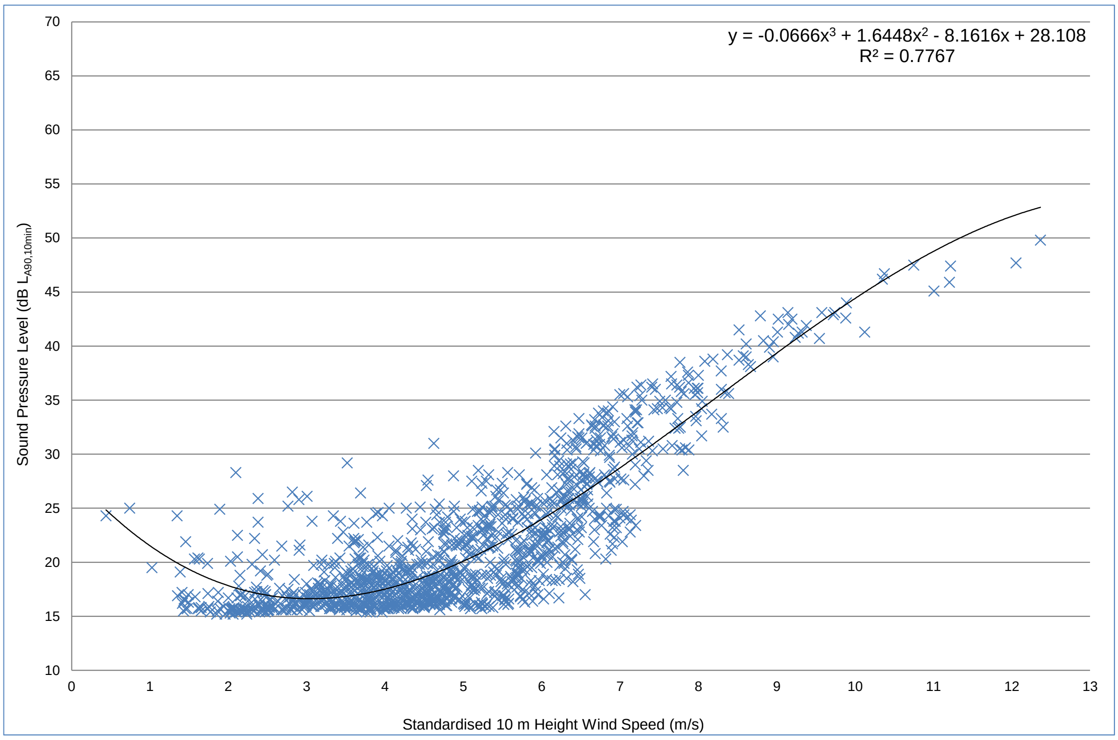


Figure 13-5 Location A (H08 Proxy) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night -time

13.5.7.2 Location C (H26)

13.5.7.2.1 Daytime Quiet Periods

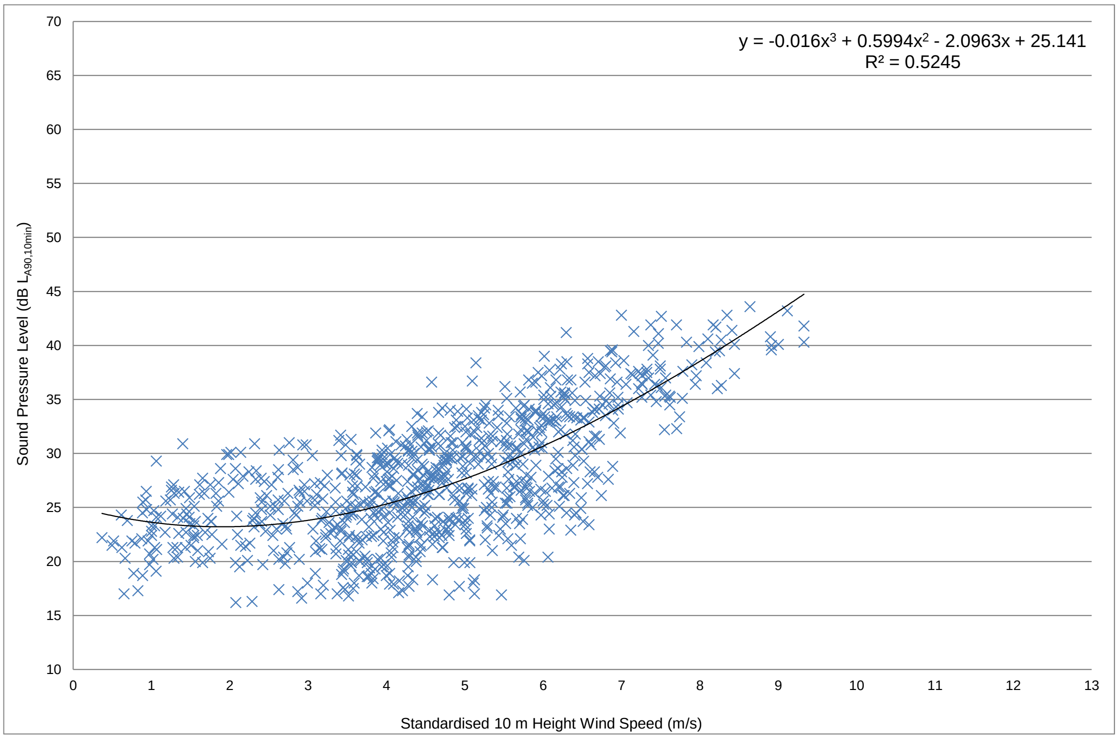


Figure 13-6 Location C (H26) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

13.5.7.2.2 Night-time Quiet Periods

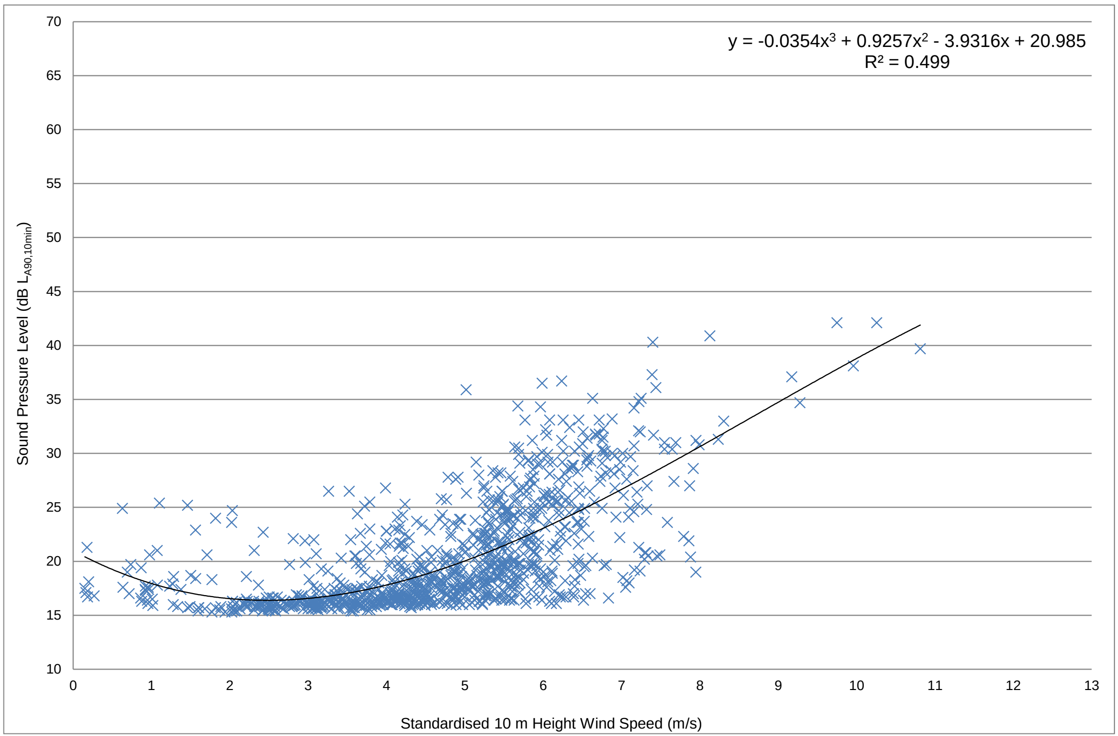


Figure 13-7 Location C (H26) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night -time

13.5.7.3 Location D (H51)

13.5.7.3.1 Daytime Quiet Periods

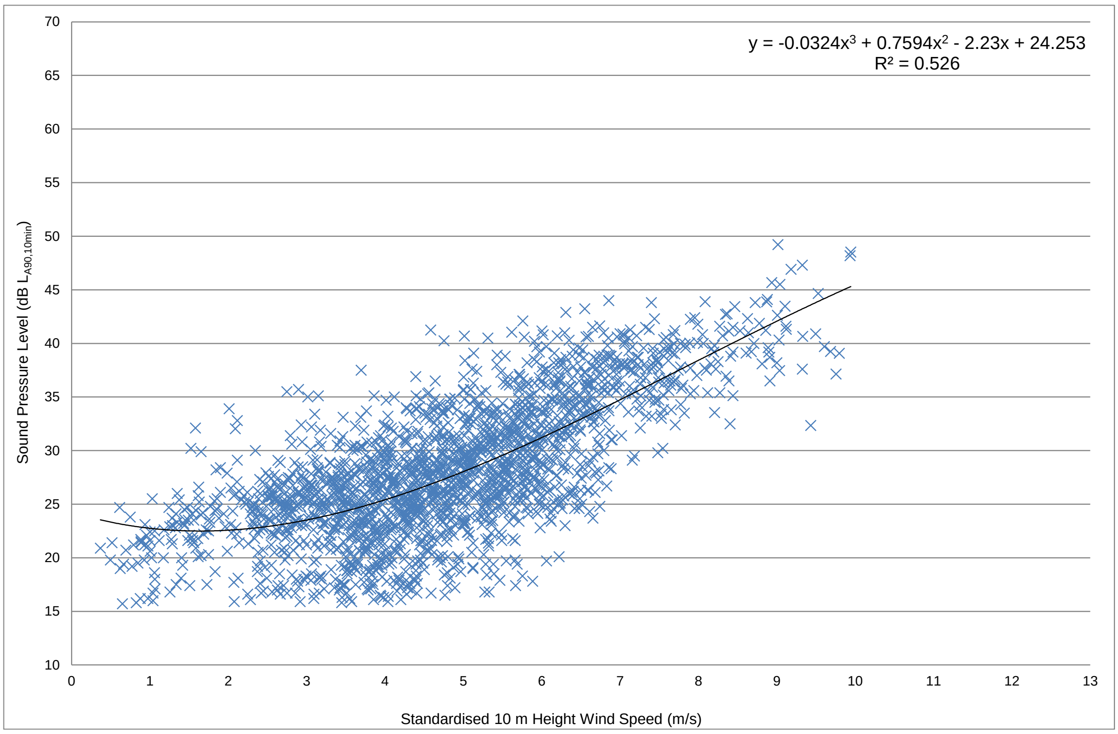


Figure 13-8 Location D (H51) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

13.5.7.3.2 Night-time Quiet Periods

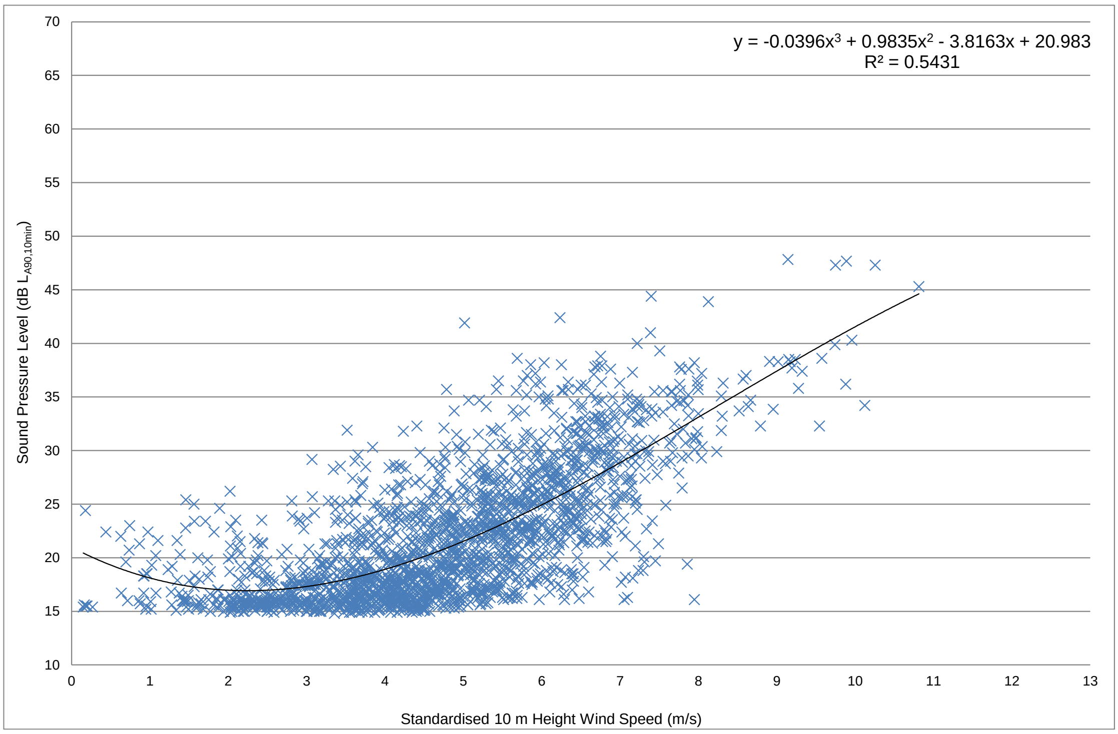


Figure 13-9 Location D (H51) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

13.5.7.4 Location F (H45 Proxy)

13.5.7.4.1 Daytime Quiet Periods

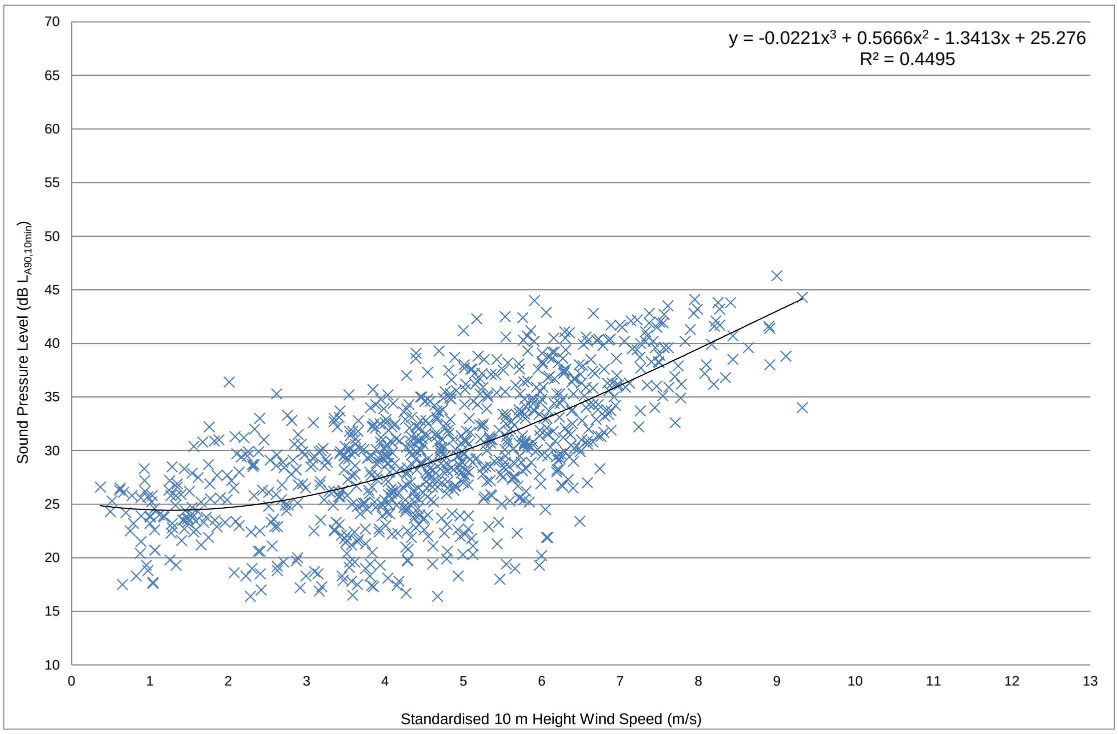


Figure 13-10 Location F (H45 Proxy) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

13.5.7.4.2 Night-time Quiet Periods

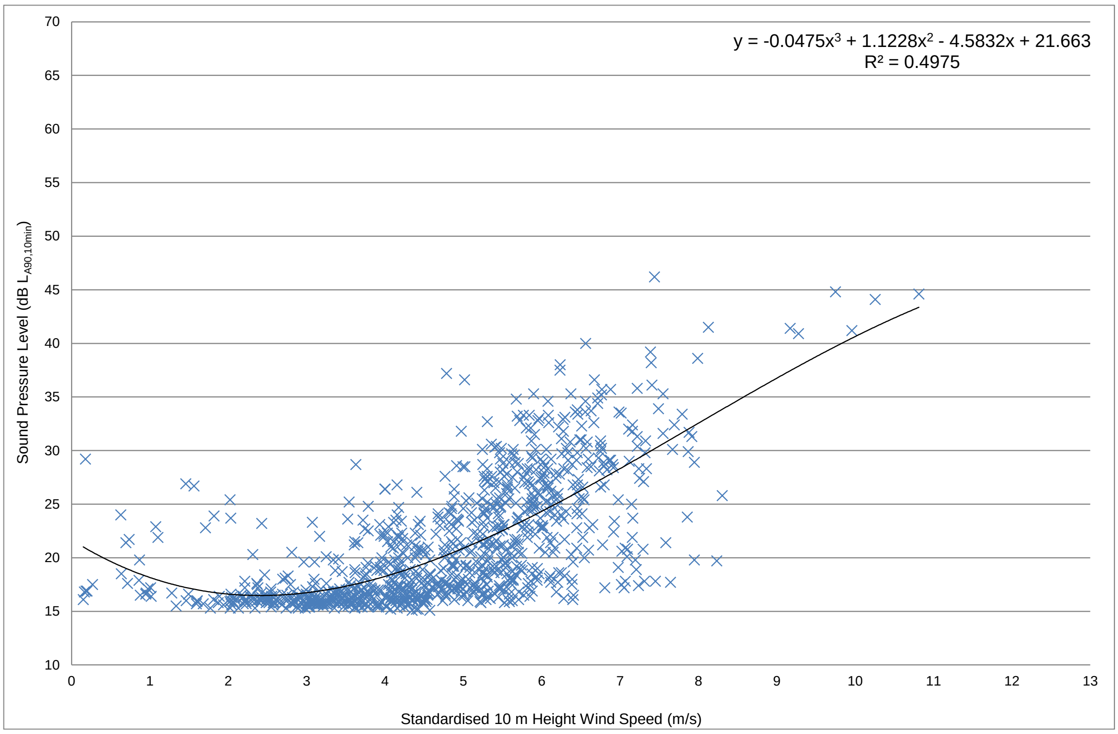


Figure 13-11 Location F (H45 Proxy) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

13.5.7.5 Location G (H64)

13.5.7.5.1 Daytime Quiet Periods

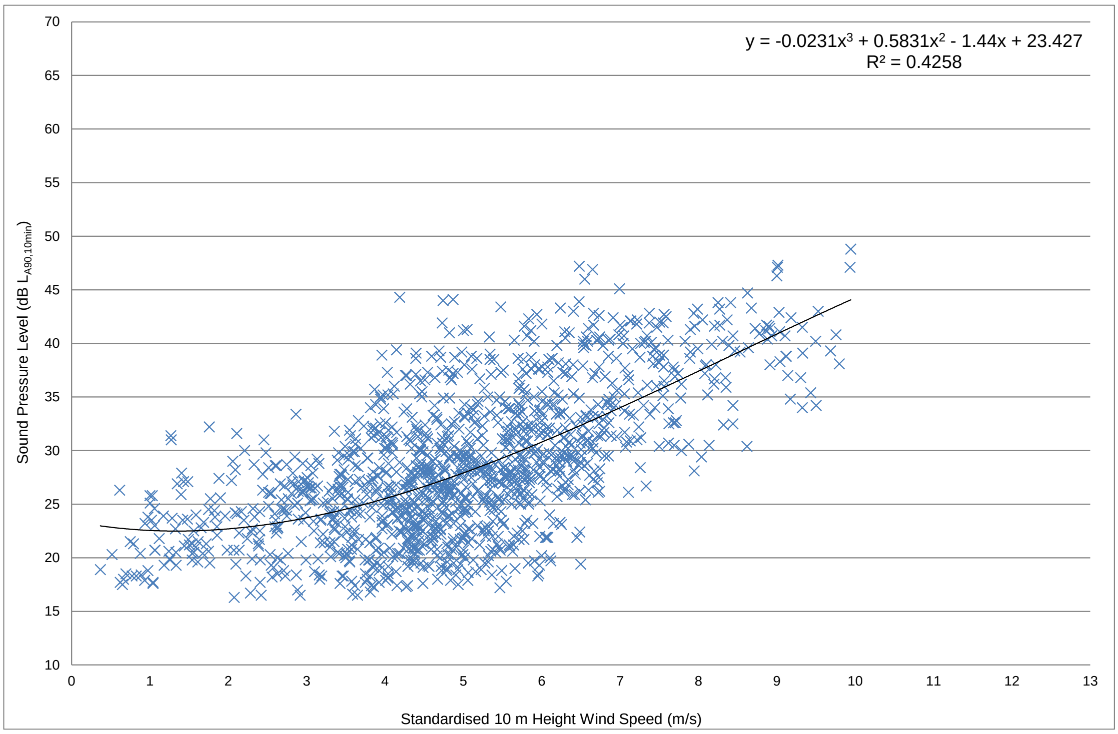


Figure 13-12 Location G (H64) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

13.5.7.5.2 Night-time Quiet Periods

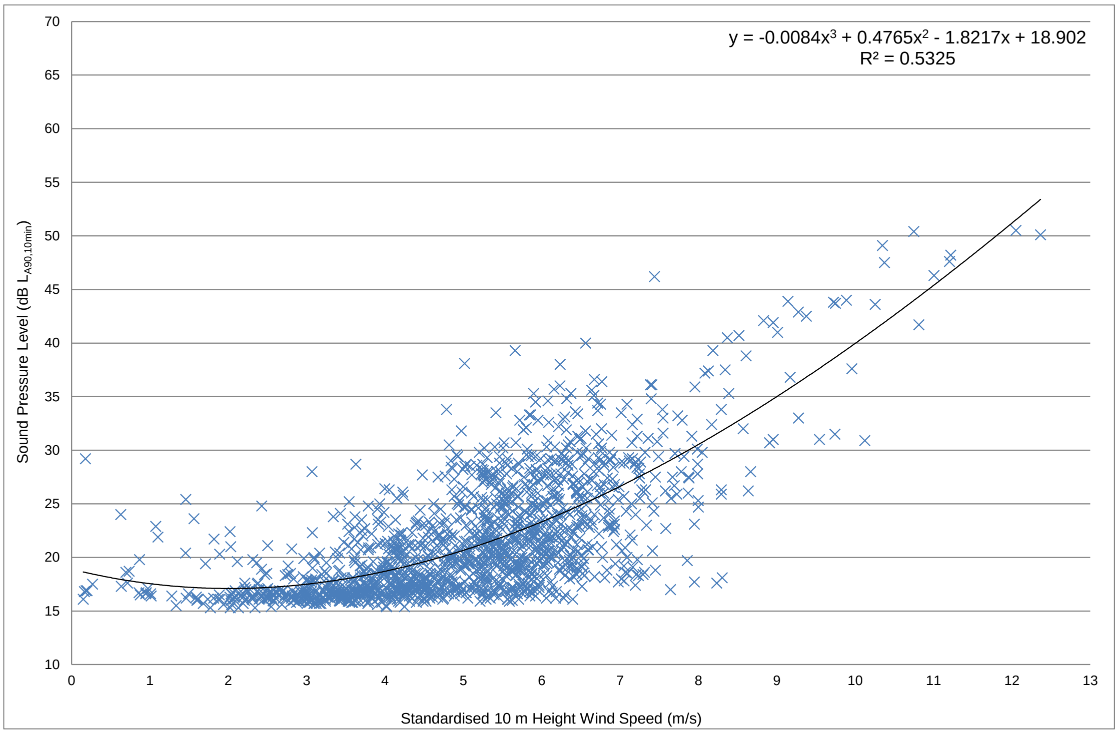


Figure 13-13 Location G (H64) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

13.5.7.6 Location H (H67)

13.5.7.6.1 *Daytime Quiet Periods*

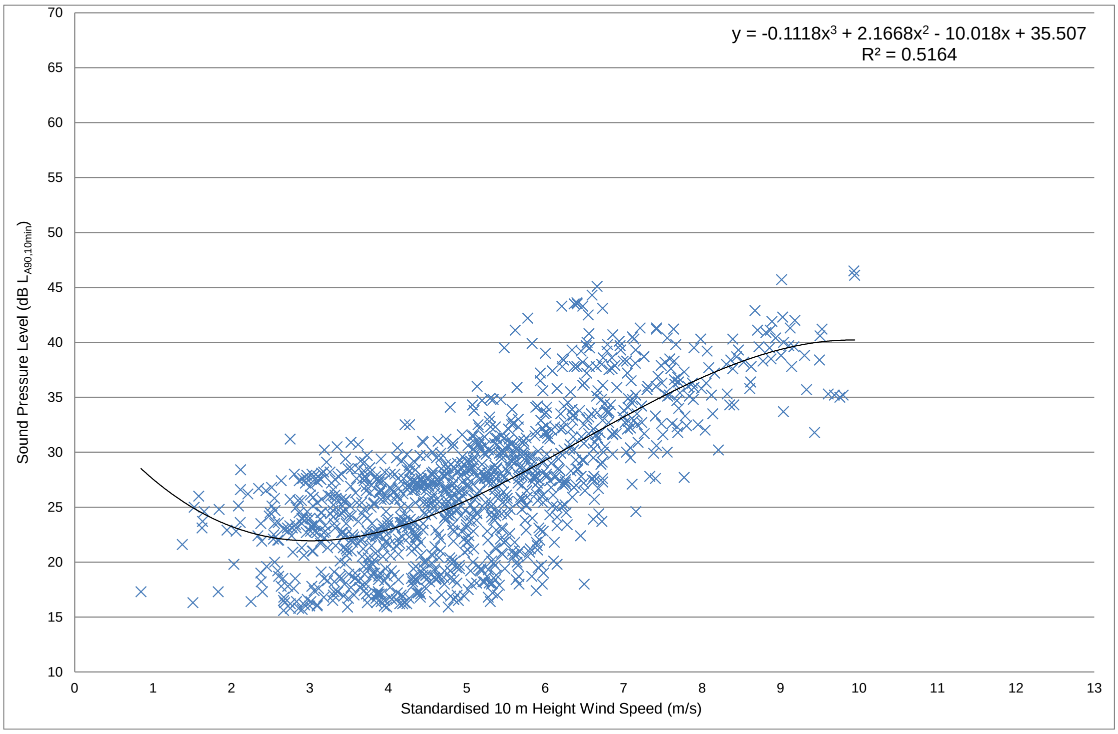


Figure 13-14 Location H (H67) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

13.5.7.6.2 *Night-time Quiet Periods*

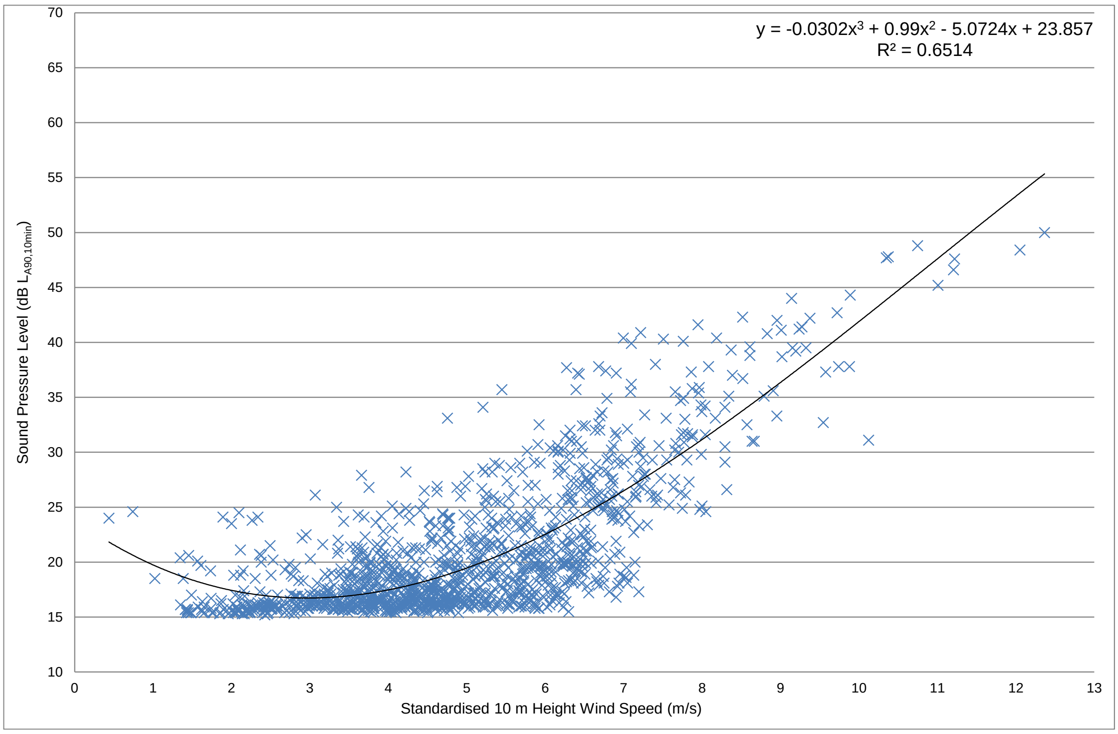


Figure 13-15 Location H (H67) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

13.5.7.7 Summary

Table 13-10 presents the various derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime quiet periods and night-time periods. These levels have been derived using regression analysis carried out on the data sets in line with guidance contained the IoA GPG and the *Supplementary Guidance Note (SGN) No. 2 Data Processing & Derivation of ETSU-R-97 Background Curves.*

Table 13-10 Derived Noise Levels of $L_{A90,10min}$ for Various Wind Speeds

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A (H08 Proxy)	Day	21.8	22.4	25.2	29.2	33.6	37.5	40.2	40.7
	Night	16.6	17.5	20.1	24.0	28.7	34.0	39.3	44.4
C (H26 Proxy)	Day	23.8	25.3	27.6	30.7	34.3	38.5	43.2	–
	Night	16.6	17.8	20.0	23.1	26.7	30.7	34.8	38.8
D (H51)	Day	23.5	25.4	28.0	31.2	34.7	38.4	42.1	–
	Night	17.3	18.9	21.5	24.9	28.9	33.1	37.4	41.6
F (H45 Proxy)	Day	25.8	27.6	30.0	32.9	36.1	39.5	43.0	–
	Night	16.7	18.3	20.9	24.3	28.3	32.5	36.7	–
G (H64)	Day	23.7	25.5	27.9	30.8	34.0	37.4	40.9	44.2
	Night	17.5	18.7	20.7	23.3	26.6	30.5	35.0	39.9
H (H67)	Day	21.9	22.9	25.6	29.3	33.2	36.8	39.4	40.2
	Night	16.7	17.5	19.5	22.5	26.5	31.2	36.4	41.9

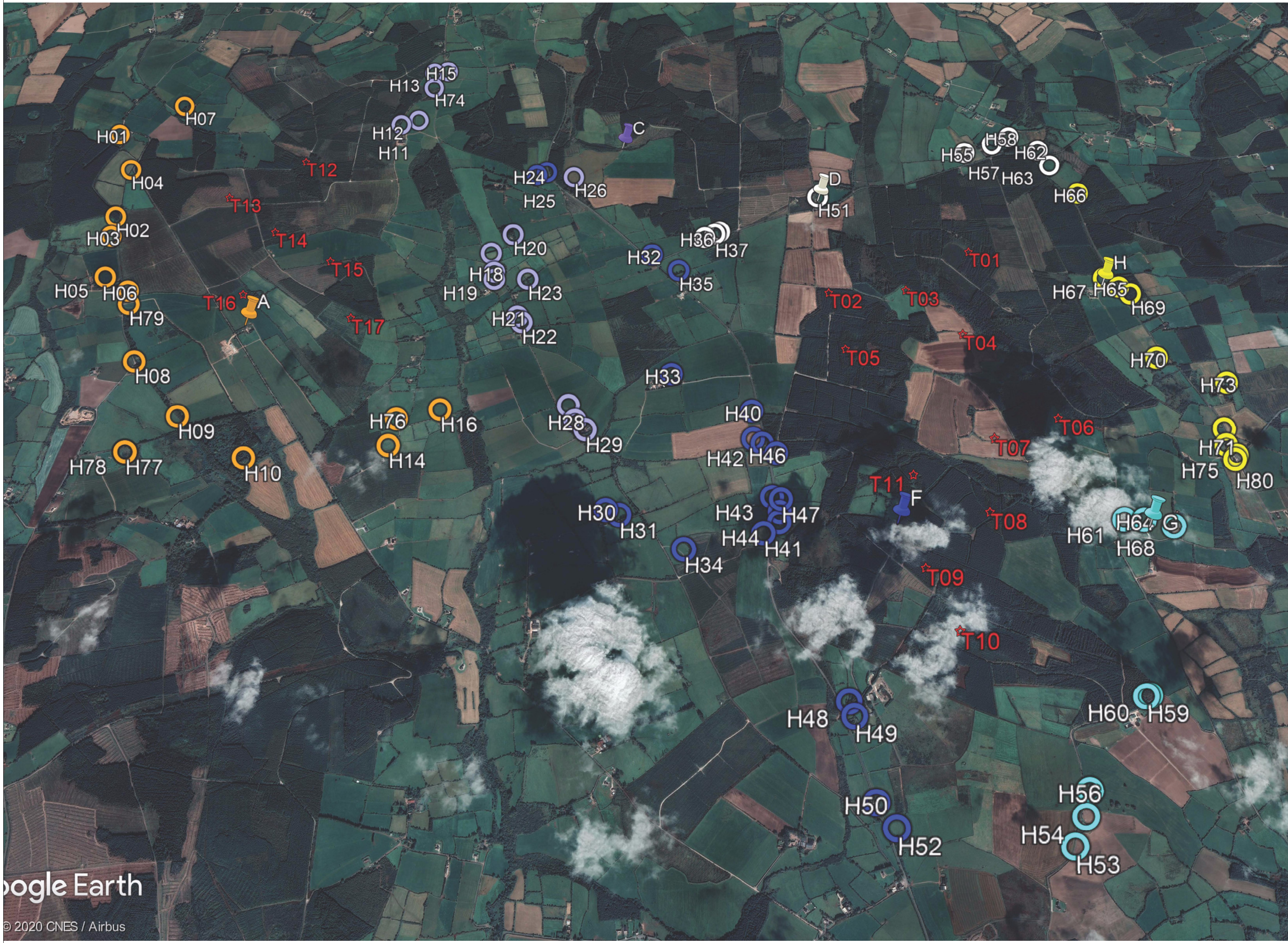
The background noise data shall be used to derive appropriate noise limits for each of the NSLs. In a situation where measurements have been conducted near another receiver, the background noise levels measured nearby have been deemed representative for establishing appropriate noise limits. It is worth noting that the noise levels at varying wind speeds are comparable at the different locations, which indicates that the proxy locations chosen are acting as representative survey locations for dwellings in the area where access could not be obtained.

Table 13-11 presents the assigned NSLs relative to the representative background noise levels. The noise criteria curves for this assessment will be based on the assigned background noise levels at each of these NSLs.

Table 13-11 Background Noise Levels and Representative Receiver Locations

Representative Background Noise Levels	NSL
Location A (Proxy location near T16)	H01, H02, H03, H04, H05, H06, H07, H08, H09, H10, H14, H16, H76, H77, H78, H79
Location C (Proxy location for H26)	H11, H12, H13, H15, H17, H18, H19, H20, H21, H22, H23, H27, H28, H29, H74
Location D (H51)	H36, H37, H38, H55, H57, H58, H62, H63
Location F (Proxy location for H45)	H24, H25, H30, H31, H32, H33, H34, H35, H39, H40, H41, H42, H43, H44, H46, H47, H48, H49, H50, H52
Location G (H64)	H53, H54, H56, H59, H60, H61, H68
Location H (H67)	H65, H66, H69, H70, H71, H72, H73, H75, H80

Figure 13-16 displays the assigned NSLs, each colour coded to indicate the background noise level measurement representative of the NSL.



N
W E
S

MAP TITLE:
Assigned NSLs

PROJECT TITLE:
Lyrenacarriga Wind Farm

MAP NO.: **Figure 13-16**

DRAWING BY: **L Meehan**	CHECKED BY: **M Watson**
SCALE: **1:40,000**	DATE: **09-12-2020**
OS SHEET NO.: **2008**	

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13.6 Likely Significant Effects and Associated Mitigation Measures

13.6.1 Do-Nothing Scenario

If the development is not progressed the existing noise environment in the vicinity of the site and noise sensitive receivers will remain largely unchanged.

13.6.2 Construction Phase

A variety of items of plant will be in use for the purposes of site preparation, construction of turbines, roads, substation and other site works. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for generation of significant levels of noise. These are discussed in the following Sections.

Owing to the nature of the construction activities it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels at the nearest sensitive receptor using guidance set out in BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*

The predicted noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. It should also be noted that the predicted "worst case" levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for most of the time at most properties in the vicinity of the proposed development.

13.6.2.1 General Construction – Turbines and Hardstanding

13.6.2.1.1 Noise

As the construction programme has been established in outline form, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels using guidance set out in *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*

Turbine foundation works are anticipated at a distance of some 700 m from the nearest NSL and landowner (H61). The next nearest NSLs are H40 and H11, which are located approximately 705 m to the nearest proposed turbine locations at T5 and T12 respectively. Several indicative sources that would be expected on a site of this nature have been identified and noise predictions of their potential impacts prepared to nearby houses. The assessment is representative of a worst-case, construction noise levels will be lower at properties located further from the works.

Table 13-12 outlines the noise levels associated with typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009. Calculations have assumed an on-time of 66% for each item of plant i.e. 8-hours over a 12 hours assessment period.

Table 13-12 Typical Construction Noise Emission Levels

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10 m Distance (dB $L_{Aeq,T}$) [7]	Predicted Noise Level at 700 m (dB $L_{Aeq,T}$)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	32
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	30
Piling Operations (C.12.14)	Standard pile driving.	88	41
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	34
Dewatering Pumps (D.7.70)	If required.	80	33
JCB (D.8.13)	For services, drainage and landscaping.	82	35
Vibrating Rollers (D.8.29)	Road surfacing.	77	30
Total Construction Noise (cumulative for all activities)			**44**

At the nearest NSL, the predicted noise levels from construction activities are in the range of 30 to 41 dB $L_{Aeq,T}$ with a total worst-case construction level of the order of 44 dB $L_{Aeq,T}$. In all instances the predicted noise levels at the nearest NSLs are below the appropriate criteria outlined in Table 13-4 (Category A - 65 dB $L_{Aeq,T}$ during daytime periods).

This assessment is considered representative of worst-case and construction noise levels will be lower at properties located further than 700 m from the works.

There are no items of plant that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in

7 *All plant noise levels are derived from BS 5228: Part 1*

Table 13-12 and this finding is valid should all items of plant operate simultaneously.

It is concluded that there are no significant noise impacts associated with the construction of the turbine hardstands and met mast therefore no specific mitigation measures are required.

13.6.2.1.1 Vibration

Owing to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

13.6.2.2 Construction of Internal Roads and Upgrade of Existing Roads

It is proposed to upgrade existing internal roads, construct new internal roads and temporary roads to access selected borrow pit areas as part of the development. It is also proposed to carry out surfacing works to widen the existing junction on the R634 regional road at Lombard's crossroads (approximately 4.9 km south east of the proposed wind farm site), and to construct a new section of 300m access road across a greenfield site near Breeda Bridge, to facilitate turbine delivery. The proposed works on the turbine delivery route are described in detail in Section 4.4.3 of Chapter 4.

Review of the proposed wind farm road layout has identified that the nearest NSL to any point along the proposed wind farm roads is 30 m to location H46 (602730 E, 586270N).

Review of the proposed turbine delivery route has identified that the nearest residential NSL to the proposed surfacing works location at Lombard's Crossroads is at 15 metres distance (606990 E, 581070 N)

All other locations are at greater distances with the majority at significantly greater distances. The full description of the proposed new and upgraded roads is outlined in Chapter 4 of the EIAR.

13.6.2.2.1 *Noise*

Table 13-13 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 66% for each item of plant.

Table 13-13 Typical Construction Noise Emission Levels

Item (BS 5228 Ref.)	Plant Noise Level at 10 m Distance (dB $L_{Aeq,T}$) [8]	Highest Predicted Noise Level at Stated Distance from Edge of Works (dB $L_{Aeq,T}$)		
		15 m Lombard's Crossroads	30 m H46	55 m H42
HGV Movement (C.2.30)	79	72	65	60
Mini Tracked Excavator with Rock Breaker (C5.2)	83	75	68	63
Vibrating Rollers (D.8.29)	77	70	63	58
Total Construction Noise (cumulative for all activities)		**78**	**71**	**65**

[8] *All plant noise levels are derived from BS 5228: Part 1*

The proposed surfacing works on the R634 regional road, at Lombard's crossroads, are within 15 m of a residential property to the north east. The predicted noise level from the construction activities are 78 dB $L_{Aeq,T}$, which is 13 dB above the significant threshold of 65 dB $L_{Aeq,1hr}$. . It should be noted that the surfacing works at this location wil be limited and short term in nature. ,1hr.

At the nearest NSL (H46) to the proposed wind farm site road works, the predicted noise levels from construction activities are of the order of 71 dB $L_{Aeq,T}$, which is 6 dB above the significance threshold of 65 dB L_{Aeq}.

Given the variations of on-site activities, the number of plant items operating at any one time and the location of upgrading road works only operating along the closest boundaries for a limited duration of the overall development, the calculated noise levels presented are considered to present a worst-case scenario.

The next nearest property to the proposed windfarm site road works is H42 (602655 E, 586333 N), which is 55 m distance from the works. At this location, the predicted noise levels are in the range of 58-63 dB $L_{Aeq,T}$, with a total worst-case construction level at the significance threshold level of 65 dB $L_{Aeq,1hr}$.

Where a NSL is within 55 m of works, detailed consideration to potential construction noise impacts is required and appropriate mitigation measures implemented in order to manage associated impacts. Typical mitigation measures that will be employed are outlined in the mitigation section of this document (Section 13.6.2 below) with further guidance contained within the BS 5228 standards. It should be noted that these works will progress along the route and it is envisioned that works would be carried out and completed in the vicinity of a property in 2 to 3 days.

The proposed new section of access road south of Breeda Bridge is located 80m from the nearest NSL (601354 E, 585114N), at which the worst-case construction noise level is below the significance threshold level of 65 dB $L_{Aeq,1hr}$.

In summary, for the majority of NSLs, the construction works will be negative, slight and temporary. At H46 the construction works will have a temporary significant negative impact. Mitigation measures will be in place to reduce this impact, please see Section 13.6.2.8 below.

13.6.2.2.2 *Vibration*

Owing to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

13.6.2.3 Borrow Pits

To inform this aspect of the proposal a comparative noise assessment has been prepared and is outlined in the following paragraphs. Two situations have been considered as follows:

- Scenario A Blasting operation[9]
- Scenario B Rock breaking operation

In terms of these activities please note the following:

- A mobile crusher will operate on site for both options.

---

9 *Note that blasting may be required at some turbine base locations. If this is the case the mitigation measures detailed in the relevant section of this chapter will be applicable to these activities. The assessment presented here for borrow pit activities will be comparable to those expected in relation to works associated with turbine foundations.*

- In Scenario B that two rock breakers will be in use on site during daytime periods for an estimated three-month period.
- For the purposes of this assessment we have assumed the plant is working in the vicinity of the potential borrow pits location indicated in Table 13-14.
- Table 13-13 outlines the assumed noise levels for the plant items as extracted from *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*
- If the blasting option is undertaken it is estimated that some 8 to 12 blasts will be required over a 4-week period. It is expected that no more than 1 blast would occur in a single working day.

Table 13-14 Proposed Borrow Pit Locations

Borrow Pit ID	Co-ordinates	
	Easting	Northing
BOR 1	599,514	588,128
BOR 2	599,513	587,856
BOR 3	604,024	587,559

Table 13-15 Typical Plant Noise Levels

Item	BS 5228 Ref:	dB Lw Levels per Octave Band (Hz)								dB(A)
		63	125	250	500	1k	2k	4k	8k	
Crusher	Table C1.14	121	114	107	109	103	99	94	87	110
Rock Breaker	Table C9.11	119	117	113	117	115	115	112	108	121

A construction noise model has been prepared to consider the expected noise emissions from the proposed construction works for the two scenarios outlined above A percentage on-time of 66% has been assumed for the noise calculations. The predicted levels are detailed in Table 13-16 at the ten closest NSLs to the two borrow pits to the west of the development.

Table 13-16 Typical Plant Noise Levels Borrow Pits to West

Borrow Pit 1 and Borrow Pit 2			
Loc.	Predicted Construction Noise Level $L_{Aeq,1hr}$		Diff. dB(A)
	Scenario		
	A	B	
H11	40	53	-13
H06	38	52	-14
H79	38	52	-14
H02	38	51	-13
H03	38	51	-13
H05	37	51	-14
H04	37	50	-13
H12	37	50	-13
H07	36	49	-13
H08	35	49	-14

The predicted levels are detailed in Table 13-17 at the ten closest NSLs to the one borrow pit to the east of the development.

Table 13-17 Typical Plant Noise Levels Borrow Pits to East

Borrow Pit 3			
Loc.	Predicted Construction Noise Level $L_{Aeq,1hr}$ Scenario A	Predicted Construction Noise Level $L_{Aeq,1hr}$ Scenario B	Diff. dB(A)
H67	41	53	-12
H65	40	52	-12
H66	38	49	-11
H55	37	50	-13
H69	37	50	-13
H51	35	48	-13
H63	35	47	-12
H70	34	48	-14
H57	34	47	-13
H62	34	46	-12

Review of the data contained in Table 13-16 and Table 13-17 confirms the following:

- Predicted construction noise levels for both Scenario A (34 to 41 dB(A)) and B (46 to 53 dB(A)) at all borrow pits are well within the best practice construction noise criteria outlined in Table 13-4. It is assumed that construction works at the borrow pits will only occur during daytime periods only (07:00 to 23:00hrs).
- The blasting proposal results in lower levels of construction noise since the use of the rock breaking plant is not required in this instance. Predicted noise levels are lower at all assessed locations for Scenario A.
- It is accepted that the individual blast events will be audible at some locations. Blast events will be designed and controlled such that the best practice noise and vibration limit values outlined in the mitigation section of this chapter are not exceeded.

13.6.2.4 Substation

The proposed substation location is shown in Figure 4.1 in Chapter 4 of the EIAR, and is located approximately 270 m to the north of T6. The noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with the construction of the Substation at the nearest NSL.

The nearest NSL to the substation site is at approximately 450 m. Assuming the same construction activities as outlined in Section 13.6.2.1.1 it is predicted that the likely worst-case potential cumulative noise levels at either location from construction activities associated with the substation will be in the order of 49 dB $L_{Aeq,T}$ at Location H70. This level of noise is significantly below the construction noise criterion outlined in Table 13-4.

It is concluded that there will be no significant noise impacts associated with the construction of the substation and therefore no specific mitigation measures will be required.

13.6.2.5 Collector Cabling Construction

It is proposed to connect the two clusters of turbines via underground cabling located within agricultural land and the public road corridor. The collector cabling route measures approximately 3.3 km. The collector cable route passes from within the site boundary, across private lands, along a short section of public road, again to cross private lands and return to within the site boundary.

Connection to the National Grid from the proposed wind farm will be via an onsite connection from the proposed substation to the existing 110 kV overhead line which traverses the site. The full description of the proposed grid connection arrangements for the Proposed Development is presented in Chapter 4 of the EIAR.

The collector cabling route will involve Underground Cabling (UGC), and as a result a worst-case scenario of UGC being laid at nearest NSLs has been assumed.

Construction activities will be carried out during normal daytime working hours (i.e. weekdays 0700 – 1900hrs and Saturdays 0700 – 1300hrs).

Table 13-18 outlines the noise levels associated with typical construction noise sources assessed with the proposed works for the substation, which at a worst-case (UGC) are likely to be 10 m to the nearest NSL (H39). Also presented in the table are the calculated noise levels at varying distances which reflect the next nearest NSLs (presented in parentheses).

Table 13-18 Indicative Noise Levels from Construction Plant at Nearest NSL from the Cabling Works

Item (BS 5228 Ref.)	Highest Predicted Plant Noise Level [10] (dB $L_{Aeq,T}$)				
	10 m Distance (H39)	16 m Distance (H28)	21 m Distance (H29, H42)	43 m Distance (H27, H46)	155 m Distance (H40)
Mini Excavator with Hydraulic Breaker (C5.2)	79	74	71	63	49
Wheeled loader (C2.28)	72	67	64	56	42
Tracked excavator (C2.8)	66	61	58	50	36
Dozer (C2.13)	74	69	66	58	44
Dump truck (C2.30)	75	70	67	59	45
Road Roller (C2.30)	71	66	63	55	41
HGV Movements (20 per hour)	55	50	47	39	25
Total Construction Noise	82	77	74	67	53

10 *All plant noise levels are derived from BS 5228: Part 1*

At the five nearest NSLs, the predicted cumulative noise levels from construction activities are of the range of 67-82 dB $L_{Aeq,T}$, which are above the significance threshold of 65 dB $L_{Aeq,1hr}$. Given the variations of grid connection activities, the number of plant items operating at any one time and the location of upgrading road works only operating along the closest boundaries for a limited duration of the overall development, the calculated noise levels presented are considered to present a worst-case scenario. As these works will progress along the route the worst-case predicted impacts will reduce. It is envisioned that they would be at the closest position to the nearest NSLs for no more than 2 to 3 days. The next nearest property is H40, which is 155 m distance from the works. At this location, the predicted noise levels are in the order of 53 dB $L_{Aeq,T}$.

Where a NSL is within 50 m of works, detailed consideration to potential construction noise impacts will be required and appropriate mitigation measures implemented in order to manage associated impacts. Typical mitigation measures that will be employed are outlined in the mitigation section of this document with further guidance contained within the BS 5228 standards. It should be noted that these works will progress along the route and it is envisioned that works would be carried out and completed in the vicinity of a property in 2 to 3 days.

13.6.2.6 Construction Traffic

This section has been prepared in order to review potential noise impacts associated with construction traffic on the local road network. The traffic information presented in Chapter 15 has been used to inform the assessment here. The following situations are commented upon here:

- Stage 1a – Site Preparation – Concrete Pouring
- Stage 1b – Site Preparation & Ground Works
- Stage 2a – Extended Artic Deliveries
- Stage 2b – Turbine Delivery

Table 13-19 Assumptions for Construction Traffic Noise Assessment

Route	Stage	Traffic Units	%HGV
1. N25 Waterford	Existing	13,954	6.3
	1a	14,434	7.3
	1b	14,094	6.3
	2a	14,134	6.3
	2b	14,049	6.3
2. N25 Midleton	Existing	9,970	6.3
	1a	10,450	7.7
	1b	10,110	6.3
	2a	10,150	6.3
	2b	10,065	6.3
3. R634 Youghal	Existing	2,603	4.1
	1a	3,083	9.2
	1b	2,743	4.2
	2a	2,783	4.3
	2b	2,698	4.2
4. R634 - Site Access	Existing	1,640	4.1
	1a	2,120	11.7
	1b	1,780	4.3
	2a	1,820	4.5
	2b	1,735	4.3

Route	Stage	Traffic Units	%HGV
5. L7806 - Site Access	Existing	1,150	4.1
	1a	1,630	14.3
	1b	1,290	4.4
	2a	1,330	4.6
	2b	1,245	4.3
6. L2003 - Site Access	Existing	1,150	4.1
	1a	1,630	14.3
	1b	1,290	4.4
	2a	1,230	3.8
	2b	1,245	4.3

Based on the assumptions presented above changes in noise level based on the existing flows have been estimated and is presented in Table 13-20.

Table 13-20 Estimated Changes in Traffic Noise Levels

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
1a – Site Preparation – Concrete Pouring	1	+0.5	17
	2	+0.7	17
	3	+2.7	17
	4	+3.8	11
	5	+4.7	6
	6	+4.7	11
1b – Site Preparation and Ground Works	1	+0.0	365
	2	+0.1	365
	3	+0.3	365
	4	+0.5	237
	5	+0.6	128
	6	+0.6	237
2a – Extended Artic Deliveries (large turbine components)	1	+0.0	31
	2	+0.1	NA
	3	+0.3	31
	4	+0.5	20
	5	+0.7	11
	6	+0.1	20
2b – Other Deliveries (small turbine components)	1	+0.0	17
	2	+0.0	NA
	3	+0.2	17
	4	+0.3	11

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
	5	+0.5	6
	6	+0.5	11

With the exception of Stage 1a on Routes 4, 5, and 6, the predicted increases in traffic noise levels during each of the construction stages of the proposed development are less than 3 dB along all routes. With reference to the criteria set out in Section 13.4.1.2 the potential impacts are negligible to minor. With reference to the DMRB criteria, the increase calculated for Stage 1a on Routes 4, 5 and 6 is potentially moderate however, the estimated durations of the corresponding phases are only 11 days, 6 days and 11 days respectively. No additional mitigation measures are proposed.

It is concluded that there will be no significant noise impacts associated with the additional traffic generated during the construction phase of the proposed development and therefore no specific mitigation measures will be required.

13.6.2.7 Construction Phase General Mitigation Measures

Regarding construction activities, reference will be made to BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*, which offers detailed guidance on the control of noise & vibration from demolition and construction activities. It is proposed that various practices be adopted during construction, including:

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- establishing channels of communication between the contractor/developer, Local Authorities and residents;
- appointing a site representative responsible for matters relating to noise and vibration;
- monitoring typical levels of noise and vibration during critical periods and at sensitive locations;
- Keeping site access roads even to mitigate the potential for vibration from lorries.

Furthermore, a variety of practicable noise control measures will be employed. These include:

- Selection of plant with low inherent potential for generation of noise and/ or vibration;
- Placing of noisy / vibratory plant as far away from sensitive properties as permitted by site constraints, and;
- Regular maintenance and servicing of plant items.

13.6.2.8 Construction Phase Mitigation Measures – Noise

The contract documents will clearly specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.* The following list of measures will be employed, where necessary, to ensure compliance with the relevant construction noise criteria:

- No plant used on site will be permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.

- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate outside of general construction hours will be surrounded by an acoustic enclosure or portable screen.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Table 13-4 using methods outlined in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs weekdays and between 7:00hrs and 14:00hrs on Saturdays. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, rotor/tower deliveries) it could occasionally be necessary to work outside of these hours.

Where rock breaking is employed in relation to the proposed borrow pit location, the following are examples of measures that will be employed, where necessary, to mitigate noise emissions from these activities:

- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency.
- Ensure all leaks in air lines are sealed.
- Use a dampened bit to eliminate ringing.
- Erect acoustic screen between compressor or generator and noise sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.
- Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

Air overpressure from a blast is difficult to control, however, because of its variability much can be done to reduce the effect. A reduction in the amount of primer cord used, together with the adequate burial of any that is above the ground, can give dramatic reduction to air overpressure intensities especially in the audible frequency range. Most complaints are likely to be received from an area downwind of the blast site, and therefore, if air blast complaints are a continual problem, it would be advisable to postpone blasting during unfavourable weather conditions if possible. As air blast intensity is a function of total charge weight, then a reduction in the total amount of explosives used can also reduce the air overpressure value.

Further guidance will be obtained from the recommendations contained within BS 5228: Part 1 and the European Communities (Construction Plant and Equipment) (Permissible Noise Levels) Regulations 1988 in relation to blasting operations.

The methods used to minimise impacts will consist of the following:

- Restriction of hours within which blasting can be conducted (e.g. 09:00 – 18:00hrs).
- Notification to nearby residents before blasting starts (e.g. 24-hour written notification).
- The firing of blasts at similar times to reduce the ‘startle’ effect.
- On-going circulars informing people of the progress of the works.
- The implementation of an onsite documented complaints procedure.
- The use of independent monitoring by external parties for verification of results.
- Trial blasts in less sensitive areas to assist in blast designs and identify potential zones of influence.

13.6.2.9 Construction Phase Mitigation Measures – Vibration

It is recommended that vibration from construction activities will be limited to the values set out in Table 13-6. It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage these limits may need to be reduced by up to 50%.

Considering the large distances between locations where piling may take place and the nearest NSLs, no significant impact will be experienced. Therefore, no mitigation measures are proposed for piling operations.

Specific to blasting the following mitigation measures will be employed to control the impact during blasts:

- Trial blasts may be undertaken to obtain scaled distance analysis;
- Ensuring appropriate burden to avoid over or under confinement of the charge;
- Accurate setting out and drilling;
- Appropriate charging;
- Appropriate stemming with appropriate material such as sized gravel or stone chipping;
- Delay detonation to ensure small maximum instantaneous charges;
- Decked charges and in-hole delays;
- Blast monitoring to enable adjustment of subsequent charges;
- Good blast design to maximise efficiency and reduce vibration;
- Avoid using exposed detonating cord on the surface.

13.6.3 Operational Phase

13.6.3.1 Wind Turbine Noise Criteria Curves

With respect to the relevant guidance documents outlined in Section 13.4.2.1. The following noise criteria curves have been identified for the Proposed Development. The criteria curves have been derived following a detailed review of the background noise data conducted at the nearest NSLs.

It is proposed to adopt a daytime threshold of 40 dB $L_{A90,10\text{-}min}$ for low noise environments where the background noise is less than 30 dB(A). This follows a review of the prevailing background noise levels and is considered appropriate in light of the following:

- The EPA document 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)' proposes a daytime noise criterion of 45 dB(A) in 'areas of low background noise'. The proposed lower threshold here is 5 dB more stringent than this level.
- It is reiterated that the 2006 *Wind Energy Development Guidelines* states that "*An appropriate balance must be achieved between power generation and noise impact.*"

Based on a review of other national guidance in relation to acceptable noise levels in areas of low background noise it is considered that the criteria adopted as part of this assessment are robust.

Following comparison of the previously presented guidance the proposed operational limits in $L_{A90,10min}$ for the Proposed Development are:

- 40 dB $L_{A90,10min}$ for quiet daytime environments of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher),

- 45 dB $L_{A90,10min}$ for landowner daytime environments or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night time periods.

Table 13-21 outlines the derived noise criteria curves based on the information contained within Table 13-10.

Table 13-21 Noise Criteria Curves

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A (H08 Proxy)	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Night	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
C (H26 Proxy)	Day	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
D (H51)	Day	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
F (H45 Proxy)	Day	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
G (H64)	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
H (H67)	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9

13.6.3.2 Turbine Noise Assessment

The noise levels for the proposed site has been calculated for all noise sensitive receivers identified within 1.2 km of the proposed turbines.

A worst-case assessment has been completed assuming all noise locations are downwind of all turbines at the same time. The predicted levels have been compared against the adopted noise criteria curves as detailed in Table 13-21. Table 13-22 presents the details of the exercise at all 80 NSLs considered as part of this assessment.

Table 13-22 Review of the Predicted Turbine Noise Levels against Relevant Criteria

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
H001	Predicted	23.0	23.8	28.8	32.0	32.3	32.3	32.3	32.3
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H002	Predicted	28.3	29.3	34.3	37.5	37.8	37.8	37.8	37.8
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H003	Predicted	28.3	29.3	34.3	37.4	37.8	37.8	37.8	37.8
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H004	Predicted	27.5	28.4	33.5	36.6	36.9	36.9	36.9	36.9
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H005	Predicted	28.0	29.0	34.0	37.2	37.5	37.5	37.5	37.5
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H006	Predicted	29.3	30.4	35.4	38.5	38.9	38.9	38.9	38.9
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H007	Predicted	25.7	26.5	31.5	34.7	35.0	35.0	35.0	35.0
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H008	Predicted	28.2	29.2	34.2	37.4	37.7	37.7	37.7	37.7
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H009	Predicted	27.2	28.1	33.1	36.3	36.6	36.6	36.6	36.6
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H010	Predicted	26.1	26.9	31.9	35.1	35.4	35.4	35.4	35.4
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H011	Predicted	28.3	29.2	34.2	37.4	37.7	37.7	37.7	37.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H012	Predicted	27.2	28.1	33.1	36.3	36.6	36.6	36.6	36.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H013	Predicted	24.1	24.8	29.8	33.0	33.2	33.2	33.2	33.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H014	Predicted	26.5	27.3	32.3	35.5	35.7	35.7	35.7	35.7
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H015	Predicted	23.7	24.4	29.3	32.5	32.8	32.8	32.8	32.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H016	Predicted	27.1	27.9	32.9	36.1	36.4	36.4	36.4	36.4
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H017	Predicted	27.8	28.6	33.6	36.8	37.0	37.0	37.0	37.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H018	Predicted	27.7	28.6	33.6	36.7	37.0	37.0	37.0	37.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H019	Predicted	27.7	28.6	33.5	36.7	37.0	37.0	37.0	37.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H020	Predicted	26.7	27.5	32.4	35.6	35.9	35.9	35.9	35.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H021	Predicted	26.7	27.5	32.4	35.6	35.9	35.9	35.9	35.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H022	Predicted	26.6	27.4	32.3	35.5	35.8	35.8	35.8	35.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H023	Predicted	26.3	27.1	32.0	35.2	35.5	35.5	35.5	35.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H024	Predicted	25.0	25.6	30.6	33.7	34.0	34.0	34.0	34.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H025	Predicted	24.7	25.3	30.3	33.5	33.7	33.7	33.7	33.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H026	Predicted	24.3	24.9	29.9	33.1	33.3	33.3	33.3	33.3
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H027	Predicted	25.3	26.0	30.9	34.1	34.3	34.3	34.3	34.3
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H028	Predicted	25.2	25.8	30.8	34.0	34.2	34.2	34.2	34.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H029	Predicted	25.1	25.7	30.7	33.9	34.1	34.1	34.1	34.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H030	Predicted	24.2	24.8	29.7	32.9	33.2	33.2	33.2	33.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H031	Predicted	24.4	25.0	29.9	33.1	33.4	33.4	33.4	33.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H032	Predicted	26.5	27.1	32.1	35.3	35.6	35.6	35.6	35.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H033	Predicted	27.6	28.3	33.3	36.5	36.8	36.8	36.8	36.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H034	Predicted	26.1	26.8	31.8	34.9	35.2	35.2	35.2	35.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H035	Predicted	27.6	28.4	33.4	36.5	36.8	36.8	36.8	36.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H036	Predicted	27.8	28.6	33.6	36.8	37.1	37.1	37.1	37.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H037	Predicted	28.1	28.9	33.9	37.1	37.4	37.4	37.4	37.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H038	Predicted	28.2	29.0	34.0	37.2	37.5	37.5	37.5	37.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H039	Predicted	29.9	30.8	35.8	38.9	39.2	39.2	39.2	39.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H040	Predicted	30.4	31.3	36.3	39.5	39.8	39.8	39.8	39.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H041	Predicted	29.2	30.0	35.0	38.2	38.5	38.5	38.5	38.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H042	Predicted	30.2	31.1	36.1	39.3	39.6	39.6	39.6	39.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H043	Predicted	30.0	30.9	35.9	39.0	39.4	39.4	39.4	39.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H044	Predicted	30.0	30.9	35.9	39.1	39.4	39.4	39.4	39.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H045	Predicted	30.1	31.1	36.1	39.2	39.6	39.6	39.6	39.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H046	Predicted	30.6	31.6	36.6	39.8	40.1	40.1	40.1	40.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H047	Predicted	30.3	31.3	36.3	39.5	39.8	39.8	39.8	39.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H048	Predicted	27.9	29.0	34.0	37.1	37.5	37.5	37.5	37.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H049	Predicted	27.5	28.5	33.5	36.6	37.0	37.0	37.0	37.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H050	Predicted	24.8	25.5	30.5	33.7	34.0	34.0	34.0	34.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H051	Predicted	29.3	30.3	35.3	38.5	38.8	38.8	38.8	38.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H052	Predicted	24.1	24.9	29.9	33.0	33.3	33.3	33.3	33.3
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.0	48.0
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	–	–	–	–	–	–	–	–
H053	Predicted	24.0	24.8	29.7	32.9	33.2	33.2	33.2	33.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H054	Predicted	24.9	25.6	30.6	33.8	34.0	34.0	34.0	34.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H055	Predicted	26.9	27.7	32.7	35.9	36.2	36.2	36.2	36.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H056	Predicted	25.7	26.5	31.4	34.6	34.9	34.9	34.9	34.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H057	Predicted	25.8	26.5	31.5	34.7	35.0	35.0	35.0	35.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H058	Predicted	22.8	23.6	28.6	31.7	32.0	32.0	32.0	32.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H059	Predicted	27.0	27.8	32.8	36.0	36.2	36.2	36.2	36.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H060	Predicted	26.9	27.7	32.7	35.9	36.1	36.1	36.1	36.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H061	Predicted	31.1	32.2	37.2	40.3	40.7	40.7	40.7	40.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H062	Predicted	22.9	23.7	28.7	31.9	32.2	32.2	32.2	32.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6
	Night-time Excess	–	–	–	–	–	–	–	–
H063	Predicted	24.7	25.5	30.5	33.7	34.0	34.0	34.0	34.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	47.1	47.1
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.6

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Excess	–	–	–	–	–	–	–	–
H064	Predicted	30.2	31.2	36.2	39.4	39.7	39.7	39.7	39.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H065	Predicted	28.2	29.0	34.0	37.2	37.5	37.5	37.5	37.5
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H066	Predicted	26.2	27.0	32.0	35.2	35.5	35.5	35.5	35.5
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H067	Predicted	28.6	29.5	34.5	37.7	38.0	38.0	38.0	38.0
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H068	Predicted	28.8	29.7	34.7	37.9	38.2	38.2	38.2	38.2

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	45.9	49.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9
	Night-time Excess	–	–	–	–	–	–	–	–
H069	Predicted	27.9	28.7	33.7	36.9	37.2	37.2	37.2	37.2
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H070	Predicted	28.7	29.6	34.6	37.8	38.1	38.1	38.1	38.1
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H071	Predicted	26.9	27.7	32.6	35.8	36.1	36.1	36.1	36.1
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H072	Predicted	26.8	27.6	32.6	35.8	36.1	36.1	36.1	36.1
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H073	Predicted	26.0	26.8	31.7	34.9	35.2	35.2	35.2	35.2
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H074	Predicted	24.9	25.6	30.6	33.8	34.1	34.1	34.1	34.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0	45.0	48.2	48.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
	Night-time Excess	–	–	–	–	–	–	–	–
H075	Predicted	26.5	27.2	32.2	35.4	35.6	35.6	35.6	35.6
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–
H076	Predicted	27.8	28.7	33.7	36.9	37.2	37.2	37.2	37.2
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–

Name	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
H077	Predicted	24.6	25.3	30.3	33.4	33.7	33.7	33.7	33.7
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H078	Predicted	24.6	25.3	30.3	33.5	33.7	33.7	33.7	33.7
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H079	Predicted	29.3	30.3	35.3	38.5	38.8	38.8	38.8	38.8
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.2	45.7
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	44.3	49.4
	Night-time Excess	–	–	–	–	–	–	–	–
H080	Predicted	26.5	27.3	32.3	35.5	35.7	35.7	35.7	35.7
	Daytime Criterion	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.2
	Daytime Excess	–	–	–	–	–	–	–	–
	Night-time Criterion	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.9
	Night-time Excess	–	–	–	–	–	–	–	–

A noise contour for standard mode operation rated power wind speed (i.e. highest noise emission) has been presented in Appendix 13-5.

The predicted operational noise levels at various wind speeds have been compared against the noise criteria curves outlined in Table 13-21. The predicted omni-directional noise levels for all turbines operating in standard mode are below the day and night-time criteria in all cases.

Assuming the implementation of the above turbine type or similar sound power level, it is not considered that a significant effect is associated with the operation of this development, since the predicted noise levels associated with the proposed development will be within the relevant best practice noise criteria curves for wind farms. As previously discussed, the following guidance is relevant for this assessment, "*Wind Energy Development Guidelines*" published by the Department of the Environment, Heritage and Local Government in 2006 and in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "*The Assessment and Rating of Noise from Wind Farms*" (1996).

While noise levels at low wind speeds will increase due to the development, the predicted levels will remain low, albeit a new source of noise will be introduced into the soundscape.

13.6.3.3 Site Roads

Considering that there is no significant traffic expected on site roads during the operational phase and the significant distances (>300 m) from any site road to the nearest NSL; there are no noise and vibration impacts anticipated from site roads during the operational phase.

13.6.3.4 Substation

As previously stated, the proposed substation location is to the north of T6 and is approximately 450 m to the nearest NSL (H70). The proposed substation location is indicated in Table 13-23 below.

Table 13-23 Proposed Substation Location

Substation	Irish Grid Co-ordinates	
	Eastings	Northing
Substation location	604,349	586,897

As part of the development the substation will be typically operational 24/7. The noise emission level associated with a typical substation that would support a development of this nature is the order of 93 dB(A) L_w as detailed in Figure 13-17.

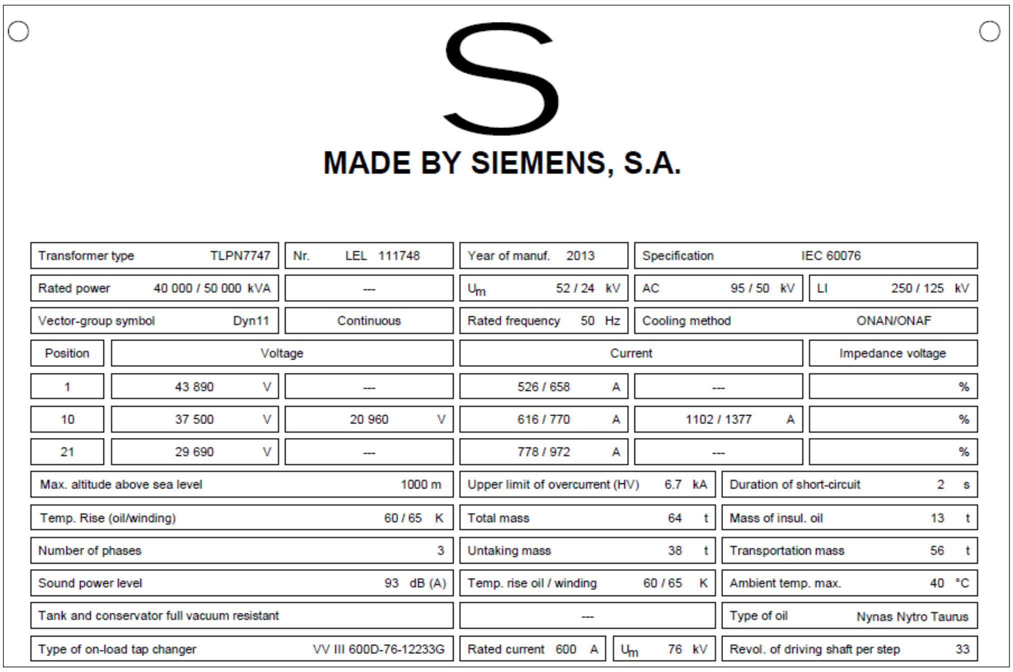

Figure 13-17 Statement of L_w for Typical Sub Station Used for Assessment

An iteration of the noise model has been developed to consider the expected noise level from the plant at the nearest NSLs to the proposed substation. Prediction calculations for substation noise have been conducted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation, 1996.*The predicted noise levels at the closest ten receivers are presented in Table 13-24.

Table 13-24 Predicted Substation Noise Levels

House ID	Height (m)	Predicted $L_{Aeq,T}$ dB
H70	4	29
H69	4	26
H65	4	26
H67	4	25
H73	4	24
H72	4	23
H71	4	23
H75	4	22
H80	4	22
H61 (Landowner) H64 (Landowner)	4	22

The worst case predicted level is expected to be the order of 22-29 dB (A) at the nearest NSLs to the substation. These noise levels will be in line with or less than prevailing background noise levels. At other locations the predicted level is 20 dB(A) or less. The prediction levels are worst-case as they do not take account of screening associated with the local environment or from buildings associated with the substations. Noise from the operation of a substation will not have any significant cumulative impact on the overall noise levels associated with the operation of the Proposed Development at any NSL.

Comment on Noise from Battery Storage Compound

There is a battery storage compound proposed to be located within the footprint of the substation. Full details of the proposed battery storage compound are outlined in Chapter 4 of the EIAR.

The contribution of noise emissions associated with the operation of the battery storage compound will not give rise to an increase in the total noise emissions for the proposed substation as outlined above. Therefore, the impact assessment presented here for the operation of the substation is representative of the cumulative noise emissions of the substation and proposed battery storage compound.

13.6.3.5 Operational Phase Mitigation Measures

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 13.7.3 of this Chapter. The findings of the assessment confirmed that the predicted operational noise levels will be within the relevant best practice noise criteria curves for wind farms at all but one NSL, which is a landowner dwelling. Therefore, no mitigation measures are required.

If alternative turbine technologies are considered for the site an updated noise assessment will be prepared to confirm that the noise emissions associated with them will comply with the noise criteria curves as per best practice guidance outlined in Section 13.4.2.1.1 and/or the relevant operational criteria associated with the grant of planning for the Proposed Development. If necessary suitable curtailment strategies will be designed and implemented for alternative technologies to ensure compliance with the relevant noise criteria curves, should detailed assessment conclude that this is necessary.

In the unlikely event that an issue with low frequency noise is associated with the Proposed Development, it is recommended that an appropriate detailed investigation be undertaken. Due consideration should be given to guidance on conducting such an investigation which is outlined in Appendix VI of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4) (EPA, 2016). This guidance is based on the threshold values outlined in the Salford University document *Procedure for the assessment of low frequency noise complaints*, Revision 1, December 2011.

13.6.3.5.1 *Monitoring*

One post commissioning noise monitoring survey is recommended to ensure compliance with any noise conditions applied to the development. In the unlikely instance that an exceedance of these noise criteria is identified, the assessment guidance outlined in the noise conditions, ESTU-R-97, IoA GPG and *Supplementary Guidance Note 5: Post Completion Measurements (July 2014)* will be followed and relevant corrective actions will be taken, if required. For example, implementation of noise operational modes resulting in curtailment of turbine operation can be implemented for specific turbines in specific wind conditions to ensure predicted noise levels are within the relevant planning conditions. Such curtailment can be applied using the wind farm LiDAR system and is a standard technology available to wind farm operators.

13.6.4 Decommissioning Phase

In relation to the decommissioning phase, similar overall noise levels as those calculated for the construction phase would be expected, as similar tools and equipment will be used.

13.6.4.1 Decommissioning Phase Mitigation

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development, i.e. as per Section 13.7.2.

13.7 Description of Likely Significant Effects

13.7.1 Do-Nothing Scenario

If development were not to proceed then the existing noise environment will remain largely unchanged considering the existing and permitted wind turbine developments in the area. In areas where traffic noise is a significant source in the noise environment, increases in traffic volumes on the local road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

13.7.2 Construction and Decommissioning Phases

During the construction phase of the project there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive properties and the fact that the construction phase of the development is temporary in nature, it is expected that the various noise sources will not be excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration effect is kept to a minimum.

With respect to the EPA's criteria for description of effects, in terms of these construction activities, the potential worst-case associated effects at the nearest NSLs associated with the various elements of the construction phase are described below.

13.7.2.1 General Construction – Turbines and Hardstanding

The predicted construction noise and vibration effects associated with on-site construction activities are short-term and slight and is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Slight	Short-term

13.7.2.2 Internal Roads Construction and Existing Road Upgrades

The predicted worst-case noise and vibration effects associated with proposed construction operations at NSLs are summarised as follows:

Quality	*Significance*	*Duration*
Negative	Significant	Temporary

The above effects should be considered in terms that the effect is variable and that this assessment considers two locations with the greatest potential impact.

At all other NSLs, the following effect is associated with the internal construction of roads:

Quality	*Significance*	*Duration*
Negative	Slight	Temporary

13.7.2.3 Borrow Pit Activity

The predicted worst-case noise and vibration effects associated with proposed borrow pit construction at NSLs are summarised as follows:

Quality	*Significance*	*Duration*
Negative	Slight	Temporary

13.7.2.4 Substation Construction

The predicted worst-case noise and vibration effects associated with proposed substation construction at NSLs are summarised as follows:

Quality	*Significance*	*Duration*
Negative	Moderate	Temporary

13.7.2.5 Collector Cabling Construction

The predicted worst-case noise and vibration effects associated with proposed grid connection construction at NSLs are summarised as follows:

Quality	*Significance*	*Duration*
Negative	Moderate	Temporary

The above effects should be considered in terms that the effect is variable and that this assessment considers six locations with the greatest potential impact.

At all other NSLs, the following effect is associated with the internal construction of roads:

Quality	*Significance*	*Duration*
Negative	Slight	Temporary

13.7.2.6 Construction Traffic

The potential worst-case effects at the nearest NSLs associated with the additional traffic generated during the construction phase of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Not significant	Temporary

13.7.3 Operational Phase

13.7.3.1 Noise

13.7.3.1.1 *Wind Turbine Noise*

The predicted noise levels associated with the Proposed Development will be within best practice noise criteria curves recommended in Irish guidance '*Wind Energy Development Guidelines for Planning Authorities* it is not considered that a significant effect is associated with the development.

While noise levels at low wind speeds will increase due to the development and specifically the operation of the turbines, the predicted levels will remain low, albeit new sources of noise will be introduced into the soundscape.

With respect to the EPA's criteria for description of effects, in terms of the operational phase, the potential worst-case associated residual effects at the nearest NSLs associated with the various elements of the operational phases are described below.

The predicted residual operational turbine noise effects are summarised as follows at the closest NSLs to the site:

Quality	*Significance*	*Duration*
Negative	Moderate	Long-tern

The above effect should be considered in terms that the effect is variable and that this assessment considers periods of the greatest potential effect.

For most of the locations assessed here the effect of the operational turbines are as follows:

Quality	*Significance*	*Duration*
Negative	Slight	Long-tern

13.7.3.1.2 *Substation Noise*

The associated effect from the day to day operation of the substation is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Not significant	Long-term

13.7.3.2 Vibration

There are no expected sources of vibration associated with the operational phase of the Proposed Development. In relation to of vibration the associated effect is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Imperceptible	Long Term

13.7.4 Cumulative Effects

A review of existing, proposed and permitted wind turbine developments in the wider study has been undertaken in accordance with the guidance contained in the IOA GPG. The nearest wind turbine, from another site to the boundary of the Proposed Development, is located at a distance of 11.5 km. A cumulative wind turbine assessment has not been carried out for the Proposed Development as the contributions from the other wind farm turbines are more than 10 dB below the lowest noise limit .

This assessment has considered the potential cumulative impacts of the Proposed Development in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 13.4.2.1.

13.8 Difficulties Encountered

The siting of noise measurement equipment in line with the IOA GPG was difficult due to access issues in the area *e.g.* reluctance of residents to participate in the background noise survey or those who did participate preferring if the equipment was not visible to the public. As a result, professional judgement was made to choose suitable proxy locations at properties and lands that were agreeable to participate in the background noise survey. While none of the measurement locations were within 20m of dwellings, as per the IOG GPG the monitoring locations were deemed representative of *"typical 'low' levels likely to be experienced in the vicinity of a dwelling (or group of dwellings if the measurements are intended to be applied to more than one dwelling)."*

As per the IOA GPG, due to access issues:

> *"The overriding consideration is that it can reasonably be claimed, from inspection and observation, that there are no other suitable noise-sensitive locations, in the vicinity of any selected location and close to a dwelling, where background noise levels would be expected to be consistently lower than the levels at the selected position. This is a matter of judgment: the objective is to measure 'typical' or 'indicative' not 'absolute lowest' levels of background noise (which could only be determined by extended measurements at a large number of locations over a long period which is neither necessary nor practicable)."*

As noted in SGN 2:

> *The choice of survey positions is often an area of dispute between those proposing a wind turbine development and those opposing it: with claims made that background noise levels at the selected locations are higher than at other positions for which the actual measurement position is a proxy, which leads to higher noise limits and therefore disadvantages local residents.*

All proxy measurement locations used in this project are considered typical of the lowest background noise levels, as all are sited further from the dominant noise sources *e.g.* road traffic noise, than the other NSLs in the area. This is a worst-case scenario for the wind farm operator as the criteria is based on the lowest background noise levels, and conversely is the best case scenario for the NSLs in the area.