Borrisbeg Grid Connection

Chapter 11 Noise and Vibration

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11.1 Introduction

This chapter assesses the likely noise and vibration impacts, associated with the Proposed Grid Connection, on noise sensitive locations (typically dwellings) during the construction and operational phases. A detailed description of the Proposed Grid Connection is provided in Chapter 3 of this EIAR.

Each component of the Proposed Grid Connection is assessed in terms of the potential long term operational phase and short-term construction phase noise and vibration impacts.

11.1.1 Statement of Authority

This chapter has been prepared by Miguel Cartuyvels of AWN Consulting Ltd:

Miguel Cartuyvels (Acoustic Consultant) holds a BEng (Hons) in Industrial Engineering and is a member (TechIOA) of the Institute of Acoustics. Miguel previously worked in the construction industry and has worked in the field of acoustics since 2021, where he has contributed to numerous projects related to environmental surveying, noise modelling, and impact assessment for various sectors, including wind energy, industrial, commercial, and residential.

The chapter has been reviewed by Alistair Maclaurin of AWN Consulting Ltd:

Alistair Maclaurin (Senior Acoustic Consultant) holds a BSc in Creative Music and Sound Technology and a Diploma in Acoustics and Noise Control. He is a member of the Institute of Acoustics. Alistair has worked in the field of acoustics since 2012. He has been the lead noise consultant across various sites on major infrastructure projects such as Crossrail and Thames Tideway Tunnel, specialising in construction noise assessment and control. Additionally, he has undertaken various other environmental noise assessments for infrastructure developments and planning reports.

11.1.2 Fundamentals of Acoustics

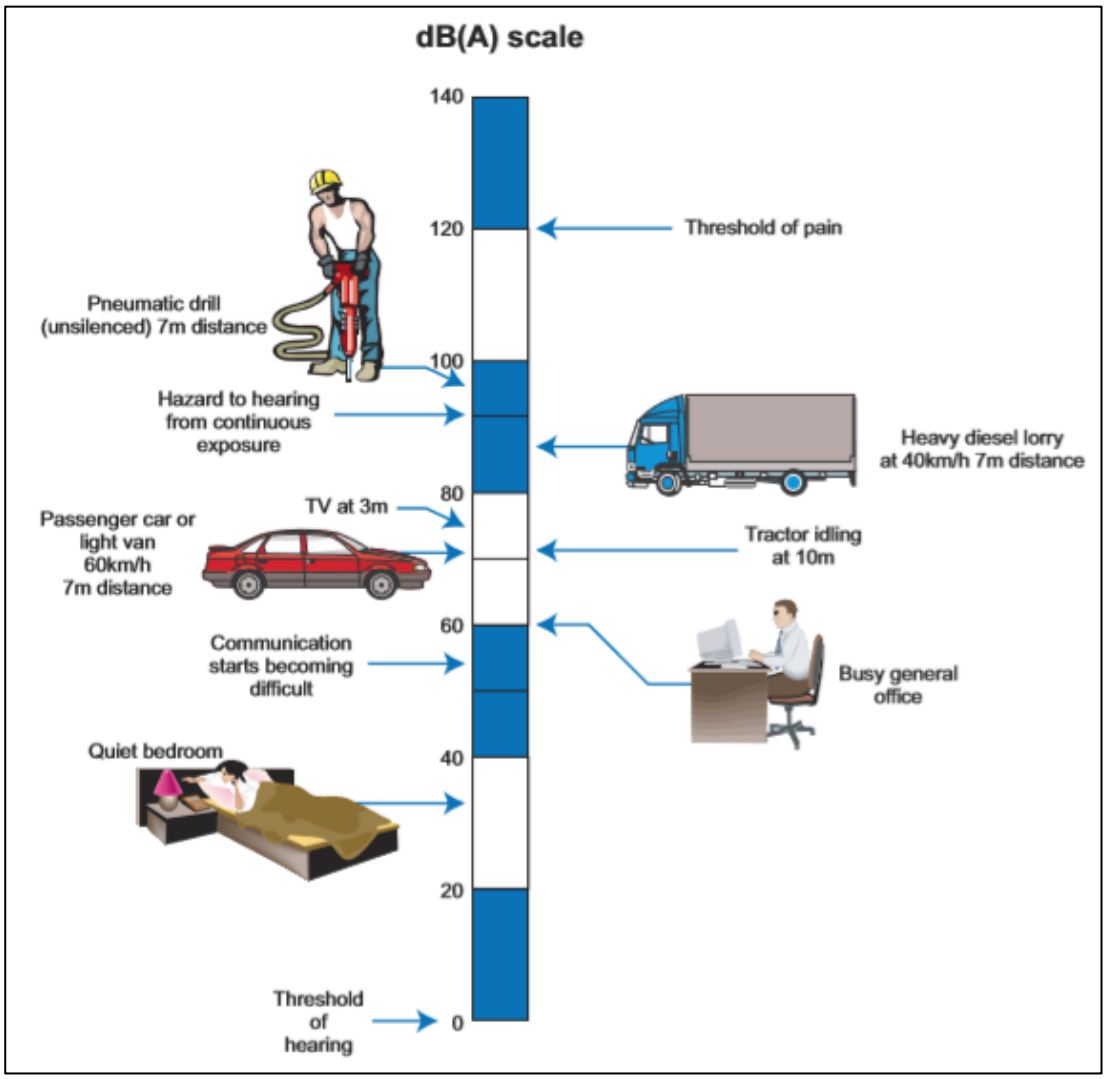
A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure 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 Sound Pressure Levels (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. To rank the SPL of various noise sources, the measured level is adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The ‘A-weighting’ system defined in the international standard, BS ISO 226:2003 Acoustics. Normal Equal-loudness Level Contours has been found to provide the best correlations with human response to perceived loudness. SPL is 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 in Figure 11-1 .

Figure 11-1 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)



For a glossary of terms used in this chapter please refer to Appendix 11-1.

11.2 Assessment Methodology

The assessment of impacts for the Proposed Grid Connection has been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration which are set out below. In addition to these specific guidance documents, the EPA document Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR) (EPA, 2022) were considered when preparing this EIAR chapter.

There are no statutory standards in Ireland relating to noise and vibration limit values for construction works or for environmental noise relating to the operational phase of the Proposed Grid Connection. In the absence of specific statutory Irish guidelines, the assessment has made reference to non-statutory national guidelines, where available, in addition to international standards and guidelines relating to noise and / or vibration impact for environmental sources. These are summarised below:

1. British Standard Institute (BSI) British Standard (BS) 5228-1:2009 +A1 2014 Code of Practice for noise and vibration control of construction and open sites - Part 1: Noise);

2. BS 5228-2:2009+A1:2014 Code of Practice for noise and vibration control of construction and open sites - Part 2: Vibration;
3. BS 7385: 1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration;
4. BS 8233:2014 Guidance on sound insulation and noise reduction for buildings;
5. UK Highways Agency (UKHA) Design Manual for Roads and Bridges (DMRB) LA 111 Sustainability and Environmental Appraisal LA 111 Noise and Vibration Revision 2 (hereafter referred to as DMRB Noise and Vibration) (UKHA 2020);
6. International Organization for Standardization (ISO) 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation;
7. ISO 1996-1:2016 Acoustics - Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedures;
8. ISO 1996-2:2017 - Description, measurement and assessment of environmental noise - Part 2: Determination of sound pressure levels and;
9. The UK Department of Transport Calculation of Road Traffic Noise (hereafter referred to as the CRTN) (UK Department of Transport 1998).

The following outline methodology has been adopted for this assessment:

10. Review of the relevant guidance to identify appropriate criteria for elements of the proposed development.
11. Review noise monitoring survey data to identify the typical existing noise environment in the vicinity of the nearest noise sensitive locations (NSLs).
12. Predict the typical levels of noise emissions at the nearest NSLs for the construction and operational phases.
13. Predict the relative change in noise levels in the environment due to the construction works and the expected increase in road traffic flow associated with the construction and operation of the proposed development.
14. Assess the impact by comparing the calculated levels against the relevant criteria.
15. Where necessary to achieve the relevant criteria, present ameliorative, remedial, or reductive measures to control noise and vibration impacts.
16. Present the predicted impact of the proposed development considering any adopted ameliorative, remedial, or reductive measures.
17. Describe the significance of the residual noise and vibration effects associated with the proposed development.
18. Undertake a cumulative assessment to identify what likely significant effects the proposed development will have on the surrounding environment when considered in combination with relevant permitted, proposed, and constructed projects in the vicinity.

This outline methodology is described in further detail in the following sections.

11.2.1 Assessment Criteria

11.2.1.1 Construction Phase – Noise

There is no published statutory Irish guidance relating to the maximum permissible noise and vibration level that may be generated during the construction phase of a project. Account must be taken of the technical feasibility of the proposed development, the balance between the magnitude of noise and vibration and the duration of the potential exposure, when setting criteria for

construction noise. Local authorities normally control construction activities by imposing limits on the hours of operation and may consider noise and vibration limit values 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 outlined in BS5228-1 calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. Each category has a defined threshold value that, if exceeded (construction noise only), indicates a potential significant noise impact is associated with the construction activities.

Table 11-1 presents the threshold values which, if exceeded, potentially signify a significant effect as recommended by BS 5228-1. The threshold levels relate to construction noise only.

Table 11-1 Threshold of Significant effect at Dwellings

Assessment category and threshold Value Period (L_{Aeq})	Threshold value in decibels (dB)		
	Category A	Category B	Category C
Night-time (23.00 – 07.00)	45	50	55
Evening and Weekends[1]	55	60	65
Daytime (07.00 – 19.00) and Saturdays (07.00-13.00)	65	70	75

Category A: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

Category B: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.

Category C: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are greater than Category A values.

This assessment method is valid for residential NSLs only. For the appropriate period (e.g., daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, the baseline noise surveys presented in Section 11.3 identified daytime ambient noise levels that typically range from 37 to 47 dB $L_{Aeq,T}$ and therefore, for this assessment all NSLs shall be afforded a Category A designation.

Section 11.4.2 presents the construction noise assessment of the Proposed Grid Connection.

11.2.1.1.1 Construction Traffic on Surrounding Roads - Noise

For the assessment of potential noise impacts from construction related traffic along public roads and haul routes it is proposed to adopt guidance from the UK document Design Manual for Roads and Bridges LA 111 Sustainability & Environmental Appraisal. Noise and Vibration Rev 2 (2020).

[1] 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

Table 11-2, taken from Table 13.7 of DMRB Noise and Vibration presents guidance as to the likely impact associated with any change in the background noise level ($L_{Aeq,T}$) at a noise sensitive receiver from construction traffic.

Table 11-2 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019)

Change in Sound Level	Magnitude of Impact
0	No Change
0.1 – 0.9	Negligible
1.0 – 2.9	Minor
3.0 – 4.9	Moderate
>5	Major

The DMRB Noise and Vibration guidance will be used to assess the predicted increases in traffic noise levels on public roads associated with the Proposed Grid Connection and comment on the likely impacts and significance of effects during the construction phase.

11.2.1.1.2 Consideration of Duration When Assessing Effects

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

1. 10 or more days or nights in any 15 consecutive days or nights; or,
2. A total number of days exceeding 40 in any 6 consecutive months.

11.2.1.2 Construction Phase – 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:

1. BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (1993); and
2. BS 5228 – Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (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 such that resonances are excited within structures 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 11-3.

Table 11-3 Recommended Transient Vibration Limits

Allowable vibration velocity (Peak Particle Velocity) at the closest part of any 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

The TII vibration limits are proposed for all construction activities associated with the Proposed Grid Connection; compliance with these limits should ensure that there is little to no risk of even cosmetic damage to buildings.

People are sensitive to vibration stimuli at levels orders of magnitude below those which have the potential to cause any cosmetic damage to buildings. There are no current standards which provide guidance on typical ranges of human response to vibration in terms of PPV for continuous or intermittent vibration sources.

BS5228-2:2009+A1:2014, provides a useful guide relating to the assessment of human response to vibration in terms of the PPV. Whilst the guide values are used to compare typical human response to construction works, they tend to relate closely to general levels of vibration perception from other general sources. Table 11-4 summarises the range of vibration values and the associated potential effects on humans.

Table 11-4 Guidance on Effects of Human Response to PPV Magnitudes

Vibration Level, PPV	Effect
0.140mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies. At lower frequencies people are less sensitive to vibration.
0.3mm/s	Vibration might be just perceptible in residential environments.
1mm/s	It is likely that a vibration level of this magnitude in residential environments will cause complaint.

Vibration typically becomes perceptible at around 0.15 to 0.3 mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single

events or events of short-term duration, particularly during construction projects and when the origin and or the duration of vibration is known. For example, ground breaking can typically be tolerated at vibration levels up to 2.5 mm/s if adequate public relations are in place and timeframes are known. These values refer to the day-time periods only.

During surface construction works (demolition and ground breaking etc.) the vibration limits set within would be perceptible to building occupants and have the potential to cause subjective effects. The level of effect is, however, greatly reduced when the origin and time frame of the works are known and limit values relating to structural integrity are adequately communicated. In this regard, the use of clear communication and information circulars relating to planned works, their duration and vibration monitoring can significantly reduce vibration effects to the neighbouring properties.

11.2.1.3 Operational Phase – Noise

Once constructed and operational, there will be no noise from the underground electrical cable at any NSL and therefore no associated operational noise criteria are presented. Noise during the operational phase will be limited to the operation of the proposed transformer to be installed on site, within the townland of Clonmore. This is discussed in the following section.

11.2.1.3.1 Operational Noise Criteria – Transformer Noise

11.2.1.3.1.1 BS 4142

BS 4142:2014: Methods for rating and assessing industrial and commercial sound is the industry standard method for analysing fixed plant sound emissions to residential receptors. BS 4142 describes methods for rating and assessing sound of an industrial and/or commercial nature. The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

For a BS 4142 assessment it is necessary to compare the measured external background sound level (i.e. the $L_{A90,T}$ level measured in the absence of plant items) to the rating level ($L_{Ar,T}$) of the various plant items, when operational. Where sound emissions are found to be tonal, impulsive, intermittent or to have other sound characteristics that are readily distinctive against the residual acoustic environment, BS 4142 recommends that penalties be applied to the specific level to arrive at the rating level.

The subjective method for applying a penalty for tonal sound characteristics outlined in BS 4142 recommends the application of a 2 dB penalty for a tone which is just perceptible at the receptor, 4 dB where it is clearly perceptible, and 6 dB where it is highly perceptible. In relation to intermittency, BS 4142 recommends that If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied.

The following definitions as discussed in BS 4142 are summarised below:

"Ambient sound level, $L_{Aeq,T}$	*equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at any given time, usually from many sources near and far, at the assessment location over a given time interval, T.*
Residual sound level, $L_{Aeq,T}$	*equivalent continuous A-weighted sound pressure level of the residual sound (i.e. ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not*

	contribute to the ambient sound) at the assessment location over a given time interval, T.
Specific sound level, $L_{Aeq,T}$	*equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, T.*
Rating level, $L_{Ar,T}$	*specific sound level plus any adjustment for the characteristic features of the sound.*
Background sound level, $L_{A90,T}$	*A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting F and quoted to the nearest whole number of decibels."*

To establish an initial estimate of impact, BS 4142 states the following:

> *"Obtain an initial estimate of the impact of the specific sound by subtracting the measured background sound level from the rating level and consider the following:*
>
> *a. Typically, the greater this difference, the greater the magnitude of the impact.*
>
> *b. A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.*
>
> *c. A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.*
>
> *d. The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.*
>
> *Note Adverse impacts include, but are not limited to, annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact."*

BS4142 contains the following pertinent factor that must be considered with respect to the context of the sound, which is relevant to this assessment as the background noise levels are typically low at NSL's during periods of low wind speeds:

> *"The absolute level of sound. For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.*
>
> *Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night."*

11.2.1.3.1.2 EPA NG4

In order to establish whether the noise sensitive locations in the vicinity of the Site would be considered 'low background noise' areas as defined in the Environmental Protection Agency (EPA) publication Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) guidance, the noise levels measured during the environmental noise survey need to satisfy the following criteria:

1. Arithmetic Average of L_{A90} During Daytime Period ≤40 dB L_{A90}, and;
2. Arithmetic Average of L_{A90} During Evening Period ≤35 dB L_{A90}, and;
3. Arithmetic Average of L_{A90} During Night-time Period ≤30 dB L_{A90}.

Table 11-5 outlines the noise emission limit criteria detailed in the NG4 document.

Table 11-5 NG4 Approach for Determining Appropriate Noise Criteria

Scenario	Daytime Noise Criterion, dB $L_{Ar,T}$ (07:00 to 19:00hrs)	Evening Noise Criterion, dB $L_{Ar,T}$ (19:00 to 23:00hrs)	Night Noise Criterion, dB $L_{Aeq,T}$ (23:00 to 07:00hrs)
Areas of Low Background Noise	45	40	35
All other Areas	55	50	45

Based on a review of the measured noise from the background noise survey (Section 11.3.1), the noise sensitive locations in the vicinity of the Site are defined as areas of low background noise as per the NG4 guidance. As the proposed substation will run on a 24-hour basis, the potential impact during night-time periods governs this assessment. A nighttime criterion of 35 dB $L_{Aeq,T}$ is considered appropriate for the operation of the substation. The design must ensure that the noise emissions do not contain audible tones or impulsive characteristics at the nearest noise sensitive locations.

35 dB $L_{Aeq,T}$ is considered a low level of noise. However, it is important to consider the likelihood of adverse noise impacts when assessing noise from fixed plant. The NG4 guidance refers to the assessment method prescribed in BS 4142:2014: *Methods for rating and assessing industrial and commercial sound* that can be used to assess the likelihood of complaints from specific plant noise sources.

In light of the above guidance from EPA's NG4 and BS4142, is it considered that the proposed absolute criterion of 35 dB $L_{Aeq,T}$ at the noise sensitive location for noise from the substation is robust to prevent adverse impacts at NSL's.

11.2.1.4 Operational Phase – Vibration

There will be no vibration emissions from the operation of the Proposed Grid Connection. Consequently, there is no requirement to consider operational vibration emissions further in this assessment. Notwithstanding this, a description of potential effects will be presented as required.

11.2.2 EPA Description of Effects

The significance of effects of the Proposed Grid Connection shall be described in accordance with the EPA guidance document *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), (EPA, 2022)*. Details of the methodology for describing the significance of the effects are provided in Table 1-2 of Chapter 1: Introduction.

11.3 Baseline Environment

11.3.1 Baseline Noise Survey

Reference is made to the background noise survey undertaken at the Site as part of the environmental noise assessment of the Consented Wind Farm to determine baseline noise levels in the receiving environment. The relevant details are discussed in the following sections.

11.3.1.1 Choice of Measurement Locations

The noise monitoring locations were identified by preparing a preliminary noise model contour at an early stage of the assessment. Any noise sensitive location that fell inside the predicted 35 dB L_{A90} noise contour was 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 a site visit and supplemented by reviewing aerial images of the study area and other online sources of information (e.g., Google Earth and OSI Maps).

The selected locations for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 11-6 and Figure 11-2. At location NML1 and NML6 the noise monitoring equipment was moved part-way through the survey period; the locations are identified as ‘a’ and ‘b’ in Table 11-6.

Table 11-6 Noise Measurement Location Coordinates

Location (Ref)	Coordinates – Irish Transverse Mercator (ITM)	
	Easting	Northing
NML-1a (H009)	612,541	675,656
NML-1b (H009)	612,506	675,625
NML-2 (H007)	611,878	673,861
NML-3 (H008)	612,424	673,213
NML-4 (H016)	614,149	674,459
NML-5 (H011)	613,941	676,087
NML-6a (H029)	613,591	677,585
NML-6b (H029)	613,589	677,553

Figure 11-2 Noise measurement locations.

Site visits by survey personnel were carried out during the morning and afternoon time; during these visits, noise sources in this area were noted to be distant traffic movements, activity in and around the properties 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.

11.3.1.2 Measurement Periods

The survey duration was 4 weeks, or until such time that enough data points were captured at each survey locations. Section 2.9.1 of the IOA GPG states:

> *"The duration of a background noise survey is determined only by the need to acquire sufficient valid data over the range of wind speeds (and directions, if relevant). It is unlikely that this requirement can be met in less than 2 weeks."*

An ongoing review of the survey data was conducted at regular intervals to establish when adequate data had been captured. Noise measurements were conducted at each of the monitoring locations over the periods outlined in Table 11-7.

Table 11-7 Measurement Periods

Location	Start Date	End Date
NML-1a	19 January 2023	18 February 2023
NML-1b	23 February 2023	2 March 2023
NML-2	19 January 2023	7 March 2023
NML-3	19 January 2023	23 February 2023
NML-4	19 January 2023	23 February 2023
NML-5	19 January 2023	23 February 2023
NML-6a	19 January 2023	7 February 2023
NML-6b	9 February 2023	23 February 2023

11.3.1.3 Personnel and Instrumentation

AWN Consulting installed and removed the noise monitors at all locations. Battery checks and meter calibrations were carried out part-way through the survey periods. Details of the instrumentation used at the various locations is details in Table 11-8.

Table 11-8 Instrumentation Details

Location	Equipment	Serial Number
NML-1	Rion NL-52	564808
NML-2	Rion NL-52	164427
NML-3	Rion NL-52	575785
NML-4	Rion NL-52	998410
NML-5	Rion NL-52	164426
NML-6	Rion NL-52	764925

Rainfall was monitored and logged using a Texas Instruments TR-525 console and a data logger that was installed on-site for the duration of the surveys. This allows for the identification of periods of rainfall, which allows for the removal of sample periods affected by rainfall from the noise monitoring data sets in line with best practice when calculating the prevailing background noise levels.

11.3.1.4 Procedure

Measurements were conducted at the six locations over the survey periods outlined in Table 11-7. Data samples for all measurements (noise, rainfall, and wind) were logged continuously at 10-minute interval periods for the duration of the survey.

11.3.1.5 Summary of Results

Table 11-9 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 analysis carried out on the data sets in line with guidance contained the IOA GPG and its SGN No. 2 *Data Collection.* A conservative 'envelope', based on the lowest derived background levels at the various wind speeds for both day and night-time is also presented in Table 11-9. Derived noise levels for nighttime period at NML1 were removed as an extraneous water pump was audible and contributed to atypical levels of noise.

Table 11-9 Derived Noise Levels of $L_{A90,10min}$ for Various Wind Speeds

Location	Period	Derived $L_{A90,\ 10\ min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)						
		3	4	5	6	7	8	9
NML-1	Day	32.7	32.8	34.0	35.9	38.1	40.3	42.0
	Night	--	--	--	--	--	--	--
NML-2	Day	35.0	35.9	37.3	39.1	41.4	44.2	47.7
	Night	22.8	24.0	26.5	30.4	35.4	41.0	46.5
NML-3	Day	31.1	31.7	32.9	34.5	36.4	38.8	41.4
	Night	21.0	22.2	24.6	27.9	31.8	36.1	40.5
NML-4	Day	29.1	29.6	30.6	32.0	33.6	35.3	37.2
	Night	21.9	22.8	24.3	26.5	29.2	32.4	35.9
NML-5	Day	27.6	28.8	30.5	32.7	35.2	37.9	40.6
	Night	19.3	20.7	23.3	26.7	30.7	35	39.1
NML-6	Day	31.0	31.7	32.6	33.7	35.1	36.7	38.5
	Night	25.5	26.2	27.4	29.0	31.1	33.5	36.2
Envelope	Day	27.6	28.8	30.5	32.0	33.6	35.3	37.2
	Night	19.3	20.7	23.3	26.5	29.2	32.4	35.9

11.4 Likely Significant Effects and Associated Mitigation Measures

11.4.1 Do-Nothing Scenario

If the Proposed Grid Connection were not to proceed, the existing noise environment in the vicinity of the Proposed Grid Connection will remain largely unchanged. In areas where traffic noise is a significant source, increases in traffic volumes on the road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

If the Proposed Grid Connection were not to proceed, the Consented Wind Farm would not be constructed, therefore the indirect short term construction phase impacts and long term operational phase impacts, (which have been determined to not have significant environmental effects, refer to ACP Planning Reference 318704) , will not occur.

Likewise, the indirect positive contribution the Proposal Grid Connection to meeting National and EU targets for the production and consumption of electricity from renewable resources by 2030 and the reduction of greenhouse gas emissions. The opportunity to generate local employment and investment and to diversify the local economy during the construction and operational phase (albeit limited) would also be lost.

11.4.2 Construction Phase Potential Impacts

The potential impacts of noise and vibration during the construction phase, in addition to the potential impacts from additional vehicular activity on public roads, will be assessed in accordance with best practice guidance as outlined in Section 11.2.1.

A variety of items of plant will be in use for the purposes of site preparation, roads, substation, underground electrical cabling, end masts breaking the existing OH line, 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, however, considering the distances between the construction activities and noise sensitive locations, the risk of significant impacts is considered low. An assessment of the potential construction noise and vibration impacts is presented in the following Sections.

Due to the nature of the construction activities, it is difficult to accurately calculate the magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels at the nearest sensitive receptors 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 the contractor can comply with current best practice guidance to minimise any significant noise and vibration impacts. 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 are expected to be lower than these levels for most of the time at most properties in the vicinity of the Proposed Grid Connection.

There are several elements associated with the construction phase of the Proposed Grid Connection which will include the following:

4. Construction of 110kV substation and temporary construction compound.
5. Underground Electrical Cabling between the proposed onsite 110kV substation and the existing 110kV Ikerrin to Thurles overhead line
6. Construction of end masts to connect the underground cabling to the existing 110kV Ikerrin to Thurles overhead line (OHL)
7. Proposed access and maintenance tracks .

Detailed information is included in Chapter 3: Development Description .

The following sections present an assessment of the main stages of the construction phase that have the potential for associated noise and vibration impacts, all other stages and element are considered not to have significant noise and vibration impacts at NSLs.

11.4.2.1 Noise

There are several elements associated with the construction phase of the Proposed Grid Connection as detailed in Chapter 3 of the EIAR. The indicative noise predictions are presented in outline form to highlight expected noise levels at the nearest noise sensitive receivers and, if necessary, to present mitigation measures that can be utilised to reduce impacts.

The anticipated construction hours are 07:00 – 19:00hrs Monday to Saturday. However, to ensure that optimal use is made of good weather period or at critical periods within the programme, it could be necessary on occasion to work outside of these hours. Any such out of hours working will be agreed in advance with the Local Authority.

11.4.2.1.1 Construction of Substation

During the construction phase, works will take place prior to the installation of electrical equipment. Several indicative sources that would be expected on a site of this nature have been identified and predictions made of the potential noise emissions calculated at the nearest NSLs. The nearest NSL to the proposed substation is situated approximately 148 m southeast (NSL WF EIAR ref. H016) as indicated in Figure 11-3. The assessment is considered worst-case; construction noise levels will be lower at properties located further from the works.

Construction noise levels at various set-back distances from areas of construction works have been calculated to assess the impact at NSLs situated at greater distances from the works.

Figure 11-3 Substation layout in relation to nearest NSLs

Table 11-10 outlines the noise levels associated with the 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-hour assessment period.

Table 11-10 Typical Noise Emission Levels for Typical Construction Activities

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [2]	Predicted Noise Level at 135 m (dB $L_{Aeq,T}$)	Predicted Noise Level at 200 m (dB $L_{Aeq,T}$)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	47	42
Tracked Excavator (C.4.63)	Removing soil and rubble in	77	45	40

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

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [2]	Predicted Noise Level at 135 m (dB $L_{Aeq,T}$)	Predicted Noise Level at 200 m (dB $L_{Aeq,T}$)
	preparation for foundation.			
Excavator Mounted Rock Breaker (C9.12)	Rock breaking	85	53	48
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	52	47
Concrete Mixer Truck and Concrete Pump (C.4.27)	For services, drainage, and landscaping.	75	43	38
Dumper Truck (C.4.4)	Removal of soil	76	44	39
Mobile Telescopic Crane (C.4.39)	Transport of equipment	77	45	40
Vibrating Rollers (D.8.29)	Road surfacing.	77	45	40
Cumulative Predicted Construction Noise Level			57	52

It is predicted that the likely highest potential noise levels due to construction activities associated with preparation works at the substation will be in the order of 57 dB $L_{Aeq,T}$ at the nearest NSL (approximately 135m from the works location), which is associated with breaking activity. All levels are well below the significance threshold of 65 dB $L_{Aeq,T.}$ outlined in Section 11.2.1.1.

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

With respect to the EPA's guidance for description of effects as referenced in Section 11.2.2, the potential worst-case associated effect associated with the construction of the onsite substation at the nearest NSL is expected to be Negative, Slight and Short-Term.

These effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

11.4.2.1.2 Underground Electrical Cabling

Details of the proposed underground electrical cabling are described in Chapter 3, Section 3.2.4.

The associated construction works will occur for short durations at varying distances from Noise Sensitive Locations (NSLs). Review of the grid connection route has identified that the nearest NSLs to the proposed underground cable route, along local roads, are located at approximately 10 m from the nearest point. It is estimated that some 5 no. NSLs are located between 10 m and 20 m from the cabling route across the entire 2km length. The majority of properties set back at distances of 100m or greater from the road. In addition to the proximity of the main construction works, the proposed grid connection route requires undercrossing watercourses for which Horizontal Directional Drilling (HDD) will be used and considered in the assessment notably for the watercourse near NSL H073, approximately 70 m from the watercourse route. **Error! Reference source not found.**Table 11-11 presents outline noise calculations, considering the typical anticipated methods of construction. Calculations have been prepared taking account of the distances to the nearest NSLs and assume that plant items are operating for 66% of the time.

Table 11-11 Indicative noise calculations for construction – Underground Electrical Cabling Route

Plant Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB $L_{Aeq,12hr}$) [3]	Calculated Construction Noise Levels dB $L_{Aeq,12hr}$ at reference distance from works			
		10 m	55 m	100 m	150 m
Tracked Excavator (C.4.64)	75	73	58	53	49
Wheeled Loader (C.2.8)	68	66	51	46	42
HGV (C.6.19)	76	74	59	54	50
HDD (Directional drilling - C.4.96)	77	75	60	55	51
Vibrating Rollers (C.2.40)	73	71	56	51	47
Cumulative Predicted Construction Noise Level		80	65	60	56

The predicted Construction Phase noise levels at the closest sensitive receptors, at distances of 10 – 20 m from works, are above the construction noise criteria set out in Table 11-1. However, proposed works are expected to take a limited amount of time in proximity to a given NSL, i.e. of the order of days. Based on the short duration and linear nature of the works, it can be determined that the levels predicted at 10 m are not significant (see criteria outlined in Section 11.2.1.1.2).

At distances of 55 m and more from areas of works, which is representative of the majority of NSLs in proximity to the proposed underground cabling route, the predicted noise levels associated with the cumulative construction activities is within the relevant noise criteria. For the time that breaking

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

activity were to take place, predicted noise levels are in excess of the criteria and therefore a Negative, Not Significant and Temporary effect is predicted.

With respect to the EPA's guidance for description of effects as referenced in Section 11.2.2, the potential worst-case associated effect at the nearest NSL associated with the underground electrical cabling route construction phase is expected to be Negative, Not Significant and Temporary. As described, construction activity will vary and will not be continuous in nature. A conservative estimation of 66% on-times has been considered. The assessment sets out that the various activities contribute noise levels that, over a standard work day will be above the significance criteria, the noise levels are not predicted to exceed this criteria continuously.

On this basis noise control mitigation measures will be required. These are detailed in Section 11.5.

11.4.2.1.3 Access and Maintenance Tracks

It is proposed to construct new access tracks along the underground grid connection cabling route that will run through some of the agricultural fields. Details are provided in Chapter 4. This activity will occur after the cable is laid and thus the associated noise is assessed as a separate activity. Review of the proposed road layouts has identified the nearest NSLs from the proposed tracks, at their nearest point which is approximately 80m.

Table 11-12 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 11-12 Typical Construction Noise Emission Levels for tracks

Item	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [4]	Calculated Construction Noise Levels dB $L_{Aeq,12hr}$ at reference distance from works			
		10 m	50 m	55 m	100 m
Tracked Excavator (C.4.64)	75	73	59	58	55
HGV Movement (C.2.30)	79	77	63	62	59
Vibrating Rollers (D.8.29)	75	73	59	58	55
Cumulative impact		80	66	65	62

At distances of 55 m and more from areas of works the predicted noise levels associated with the cumulative construction activities is within the relevant noise criteria. The closest receptor location is approximately 80m distance to the new tracks where it is predicted that the construction noise will be 62 dB which is within the adopted criteria.

With respect to the EPA's guidance for description of effects as referenced in Section 11.2.2, the potential worst-case associated effect at the nearest NSL associated with the access and

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

maintenance tracks routes construction phase is expected to be Negative, Not Significant to Slight and Temporary.

11.4.2.1.4 Construction Traffic

Based on the data presented in the Material Assets chapter the increases in traffic along the haul routes are all lower than 25%. It should be noted that a doubling of traffic volume typically results in a 3 dB increase in noise level and an increase of 25% in traffic volume would be required for a 1 dB increase in noise level. Hence, in this instance the majority of routes will experience a change in noise level of less than 1 dB, which is considered negligible in accordance with the criteria in Table 11-2 and the effect can be described as imperceptible.

Along the LS7039 there is a predicted increase in traffic volume of 63% which would results in an increase of approximately 2 dB. This would correspond to a minor increase in noise levels in accordance with the criteria in Table 11-2 with an effect described as negative, slight and temporary impact. It should be noted that the total vehicles on the route will remain low, and hence the associated noise level with the route will also remain low.

11.4.2.2 Vibration

During any required ground-breaking, there is potential for vibration to propagate through the ground. Empirical data for this activity is not provided in the BS 5228- 2:2009+A1:2014 standard, however the likely levels of vibration from this activity is expected to be significantly below the vibration criteria for building damage on experience from other sites. AWN Consulting have previously conducted vibration measurements under controlled conditions, during trial construction works on a sample site where concrete slab breaking was carried out. The trial construction works consisted of the use of the following plant and equipment when measured at various distances:

8. 3 tonne hydraulic breaker on small CAT tracked excavator
9. 6 tonne hydraulic breaker on large Liebherr tracked excavator

Vibration measurements were conducted during various staged activities and at various distances. Peak vibration levels during staged activities using the 3 Tonne Breaker ranged from 0.48 to 0.25 PPV (mm/s) at distances of 10 to 50 m respectively from the breaking activities. Using a 6 Tonne Breaker, measured vibration levels ranged between 1.49 to 0.24 PPV (mm/s) at distances of 10 to 50 m respectively.

The range of values recorded provides some context in relation typical ranges of vibration generated by construction breaking activity likely associated with the Proposed Grid Connection. The range of vibration magnitudes indicate vibration levels at the closest sensitive properties noted above, will be below the limits set out in Table 11-3 and will therefore avoid any cosmetic damage to buildings.

With respect to human sensitivities, there is potential for vibration to be perceptible at the nearest buildings adjacent to the cable route for the time that ground-breaking activity is taking place. Depending on machinery used, with reference to Table 11-4, there is potential for vibration levels to be above the level whereby vibration has a higher probability to cause complaint, during periods ground-breaking activity occurring within 20m of a sensitive location.

Notwithstanding the above, any construction activities undertaken on the Site will be required to operate below the recommended vibration criteria set out in Table 11-3 during all activities. Further discussion on mitigation measures during this phase are discussed in the next section.

11.4.3 Operational Phase Potential Impacts

The following sections present an assessment of the expected noise and vibration impacts associated with the operational phases of the Proposed Grid Connection with respect to the assessment criteria that have been presented in Section 11.2.1.

11.4.3.1 Noise

11.4.3.1.1 Underground Electrical Cabling Route

Once constructed and operational, there will be no noise from the underground electrical cabling at any NSL and therefore no specific mitigation measures will be required.

With respect to the EPA's guidance for description of effects as referenced in Section 11.2.2; the underground electrical cable, once constructed, will not generate noise during the operational phase. The associated effect is Neutral, Imperceptible and permanent.

11.4.3.1.2 Transformer Noise

The proposed 110kV substation will be situated within the townland of Clonmore. As part of the substation, the transformer installed will be operational on a continuous basis. The noise emission level associated with such transformers is the order of 92 dB(A) L_w. At the nearest receptor distance (NSL WF EIAR ref. H016), the predicted noise level is approximately 33 dBA $L_{Aeq.}$

The noise levels are within the proposed criteria set out in Section 11.2.1.3 for all receivers and therefore no specific mitigation measures will be required. At all receptors further from the transformer the noise level will be lower as a result of attenuation of noise over distance.

With respect to the EPA's guidance for description of effects as referenced in Section 11.2.2, the potential effects at the nearest NSL associated with the operation of the substation is expected to be Negative, Not Significant and permanent.

11.5 Mitigation Measures

11.5.1 Construction Phase Mitigation

For most of the construction phase the recommended construction noise thresholds are not expected to be exceeded, however when works associated with underground electrical cabling are ongoing close to roadside NSLs, predicted noise levels will exceed the relevant noise criteria. Therefore, mitigation measures are proposed below and in the accompanying Appendix 3-2 Construction Environment Management Plan (CEMP) for this potential impact

The contractor undertaking the construction works will be required to undertake noise abatement measures where necessary and comply with the recommendations of BS5228-1:2009+A1:2014.

It is proposed that various practices be adopted during construction as required, including the following:

1. selection of quieter plant;
2. noise control at source;
3. liaison with the public, and;
4. project programme.

Detailed comment is offered on these items in the following paragraphs. Noise control measures that will be considered include the selection of quiet plant, enclosures and screens around noise sources and limiting the hours of work.

11.5.1.1 Selection of Quieter Plant

The potential for any item of plant to generate noise will be assessed prior to the item being brought onto the Site. The least noisy item should be selected wherever possible. Should a particular item of plant already on the Site be found to generate high noise levels, the first action will be to identify whether or not said item can be replaced with a quieter alternative.

11.5.1.2 Noise Control at Source

If replacing a noisy item of plant is not a viable or practical option, consideration will be given to noise control “at source”. This refers to the modification of an item of plant or the application of improved sound reduction methods in consultation with the supplier. For example, resonance effects in panel work or cover plates can be reduced through stiffening or application of damping compounds; rattling and grinding noises can often be controlled by fixing resilient materials in between the surfaces in contact.

Referring to the potential noise generating sources for the works under consideration, the following best practice migration measures will be considered:

1. The lifting of bulky items, dropping and loading of materials will be restricted to normal working hours.
2. Mobile plant will be switched off when not in use and not left idling.
3. For concrete mixers, control measures will be employed during cleaning to ensure no impulsive hammering is undertaken at the mixer drum.
4. For all materials handling ensure that materials are not dropped from excessive heights, lining drops chutes and dump trucks with resilient materials.
5. Demountable enclosures can also be used to screen operatives using hand tools and will be moved around site as necessary.
6. All items of plant will be subject to regular maintenance. Such maintenance can prevent unnecessary increases in plant noise and can serve to prolong the effectiveness of noise control measures.

11.5.1.3 Liaison with the Public

A designated environmental liaison officer should be appointed to site during construction works. Any noise complaints should be logged and followed up in a prompt fashion by the liaison officer. In addition, where a particularly noisy construction activity is planned or other works with the potential to generate high levels of noise, or where noisy works are expected to operate outside of normal working hours etc., the liaison officer will inform the nearest noise sensitive locations of the time and expected duration of the noisy works.

11.5.1.4 Project Programme

The phasing programme will be arranged so as to control the amount of disturbance in noise and vibration sensitive areas at times that are considered of greatest sensitivity. The majority of

construction works will be rolling in nature, i.e. works will take place in a given location and will move on to the next location after approximately 1 no. day, over a 31 day construction period for the underground grid connection cabling route. In this way, potential noise impacts on nearby NSLs are limited to days instead of weeks.

11.5.2 Operational Phase Mitigation

Once operational, the Proposed Grid Connection will not have any significant impacts. The underground electrical cable will not emit noise. Any noise emissions associated with the proposed transformer to be installed at the proposed substation at NSLs will not be significant and is predicted to be well within the criteria set out in Section 11.2.1.3, therefore, no mitigation measures are required.

11.6 Description of Residual Effects

11.6.1 Construction Phase

11.6.1.1 Proposed Substation

With respect to the EPA's criteria for description of effects, in terms of the construction and decommissioning activities, the overall associated residual effects at the nearest noise sensitive locations are described below.

The predicted residual noise and vibration effect associated with this element of the construction phase is described as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

11.6.1.2 Underground Electrical Cabling

With respect to the EPA's criteria for description of effects, in terms of the construction activities, the overall associated residual effects at the nearest noise sensitive locations are described below.

The predicted residual noise and vibration effect associated with this element of the construction phase is described as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

11.6.1.3 Access Tracks

With respect to the EPA's criteria for description of effects, in terms of the construction activities, the overall associated residual effects at the nearest noise sensitive locations are described below.

The predicted residual noise and vibration effect associated with this element of the construction phase is described as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

11.6.1.4 Construction Traffic

With respect to the EPA's criteria for description of effects, in terms of the construction activities, the overall associated residual effects at the nearest noise sensitive locations are described below.

The predicted residual noise and vibration effect associated with this element of the construction phase is described as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant - Slight	Temporary

11.6.2 Operational Phase

The residual impacts associated with the Proposed Grid Connection are not predicted to increase the existing noise levels at any NSL.

With respect to the EPA's criteria for description of effects, in terms of the operation of Proposed Grid Connection, the potential worst-case associated residual effects at the nearest noise sensitive locations associated with the various elements of the Proposed Grid Connection are described below.

11.6.2.1 Underground Electrical Cabling

The underground electrical cable, once constructed, will not generate noise during the operational phase. The associated residual effect is therefore summarised as follows:

Quality	*Significance*	*Duration*
Neutral	Imperceptible	Permanent

11.6.2.2 Transformer Noise

The associated residual effect from the operation of the proposed transformer at the Proposed on site 110kV substation at the nearest NSL is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant	Permanent

11.7 Cumulative Impacts

11.7.1 Construction Phase

The potential for impact between the Proposed Grid Connection with the Consented Wind Farm, other proposed or consented wind projects within the surrounding landscape, and other relevant non-wind projects (existing, permitted or proposed) has been carried out with the purpose of identifying what potential noise and vibration effects will occur due to the Proposed Grid Connection as well as the interactions between these factors, when considered cumulatively and in combination with relevant existing, permitted or proposed projects and plans in the vicinity of the Site. Please see Chapter 15 for Interactions and Cumulative Effects for the detailed cumulative assessment methodology. Please refer to Appendix 15-1 for a comprehensive listing of the considered cumulative and in combination with relevant existing, permitted or proposed projects and plans in the vicinity of the Site.

With the exception of, potentially, the underground electrical cabling, the associated noise levels at nearby NSLs from the proposed construction activities are at a level that will not result in any cumulative noise and vibration impacts that would result in any significant effect.

For construction of the underground electrical cabling there is a slight potential for cumulative impacts if other construction activities were to occur in the immediate vicinity, as the nearest NSLs are in proximity to the proposed works. The Contractor will adopt the mitigation measures outlined in Section 11.5 and Appendix 3-2 CEMP as appropriate to minimise potential impacts. The risk of any significant cumulative effect is low.

The noise and vibration effects associated with cumulative impacts for the construction phase of the Proposed Grid Connection should grid construction works and other construction activities from proposed developments adjacent to the Site as listed in Appendix 15-1, be undertaken at the same time are described as Negative, Moderate to Significant and Temporary. However, as the Contractor will ensure adjacent construction works are not undertaken simultaneously, the noise and vibration effects associated with cumulative impacts for the construction phase of the Proposed Grid Connection are described as Slight to Moderate Significance and Temporary.

11.7.2 Operational Phase

The operational noise from the Proposed Grid Connection is limited to noise associated with the proposed transformer to be installed at the proposed substation. The predicted noise level at the nearest noise sensitive location is 33 dB L_{Aeq}, this level of noise is relatively low.

The Site is located adjacent to the Consented Wind Farm; however, the guidelines and criteria associated for wind turbine noise and noise from fixed plant are distinct. It is not appropriate undertake a cumulative assessment of wind turbine noise and noise from this Site as the assessment parameters and criteria differ.

There are no other industrial noise sources of fixed mechanical and electrical plant in the vicinity of the nearest NSLs to the proposed substation that are expected to cause any cumulative noise impacts.

11.8 References

1. EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports May 2022 (EPA, 2022)
2. Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document Guidelines for the Treatment of Noise and Vibration in National Road Schemes (NRA, 2004)
3. BS 5228: 2009 & A1 2014 – Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise.
4. BS 5228: 2014 & A1 2014 – Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2: Vibration.
5. BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (1993)
6. ISO 1996: 2017: Acoustics — Description, measurement and assessment of environmental noise.
7. BS 8233:2014 Guidance on Sound Insulation and Noise Reduction for Buildings
8. WHO Guidelines for Community Noise (1999)
9. ISO 1996: 2017 – Acoustics Description, Measurement and Assessment of Environmental Noise.
10. ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996)
11. Design Manual for Roads and Bridges LA 111 Sustainability & Environmental Appraisal. Noise and Vibration Rev 2 (2020).