12 Acoustic Assessment

12.1 Introduction

12.1.1 This chapter considers the likely significant acoustic effects associated with the construction, operation and decommissioning of the proposed Longcroft Wind Farm (hereafter referred to as the proposed development) on residents of nearby properties. The specific objectives of the chapter are to:

- describe the current baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects;
- describe the mitigation measures proposed to address the likely significant effects; and
- assess the residual effects remaining following the implementation of mitigation measures.

12.1.2 This assessment has been undertaken by Renewable Energy Systems Ltd (RES) (hereafter referred to as the applicant), with two in-house Members of the Institute of Acoustics involved in its production. The applicant has undertaken acoustic impact assessments in every single one of its UK wind farm development applications since 2000. The applicant has also carried out noise assessments and reported to several local planning authorities on operational wind energy projects, including taking measurements on newly constructed wind farms to ensure compliance with planning conditions.

12.1.3 The chapter author is Artem Khodov, a Member of the Institute of Acoustics with six years of experience in acoustics. The chapter reviewer is Jeremy Bass, a Member of the Institute of Acoustics with over 30 years of experience in wind farm development and acoustic assessments.

12.1.4 Additionally, the applicant has been project co-ordinator for several Joule[1] projects, leading European research into wind turbine noise, was involved in producing the guideline 'The Assessment and Rating of Noise from Wind Farms'[2] for the DTI in 1996, acted as peer reviewer for the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'[3], and contributed to the RenewableUK work on Amplitude Modulation[4]. Selected publications include:

- 'Wind Turbine Measurements for Noise Source Identification', ETSU W/13/003914/00.REP, 1999, Dr P Dunbabin, RES et al;
- 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU W/13/00385/REP, 2000 Dr J Bass, RES;
- 'Aerodynamic Noise Reduction for Variable Speed Turbines', ETSU/W/45/00504/REP, 2000, Dr P Dunbabin, RES;
- 'Fundamental research in amplitude modulation - a project by RenewableUK', Dr J Bass et al, Fourth International Meeting on Wind Turbine Noise, Rome, April 2011;
- 'Investigation of the 'Den Brook' Amplitude Modulation methodology for wind turbine noise', Dr J Bass, Acoustics Bulletin Vol 36 No 6 November/December 2011;
- 'How does noise influence the design of a wind farm?', Dr M Cassidy, Fifth International Conference on Wind Turbine Noise, Denver, 2013;
- 'Propagation of Noise from Wind Farms According to the Good Practice Guide', A Birchby, Sixth International Conference on Wind Turbine Noise, Glasgow, 2015; and
- 'A Method for Rating Amplitude Modulation in Wind Turbine Noise', Institute of Acoustics Noise Working Group, August 2016.

12.1.5 The chapter is supported by:

- Figure 12.1 – Predicted Sound Footprint;
- Technical Appendix 12.1 - Assessment of Energy Storage Facility;
- Technical Appendix 12.2 – Issues Scoped Out of Wind Farm Noise Assessment;
- Technical Appendix 12.3 – Calculating Standardised Wind Speed;
- Technical Appendix 11.4 – Background Sound Survey Photos;
- Technical Appendix 11.5 – Instrumentation Records;
- Technical Appendix 11.6 – Charts;

[1] DGXII European Commission funded projects in the field of Research and Technological Development in non-nuclear energy

[2] 'The Assessment and Rating of Noise from Wind Farms', The Working Group on Noise from Wind Turbines, ETSU Report for the DTI, ETSU-R-97, September 1996. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

[3] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise', Institute of Acoustics, May 2013. Available at: https://www.ioa.org.uk/publications/wind-turbine-noise

[4] 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects', RenewableUK, December 2013. Available at: http://usir.salford.ac.uk/id/eprint/33475/

- Technical Appendix 11.7 – Suggested Planning Conditions.

12.1.6 Figure and Technical Appendices are referenced in the text where relevant.

12.2 Legislation, Policy and Guidance

Operational Noise

12.2.1 In the context of other sources of environmental noise, the noise levels produced by wind turbines are generally low and have greater dependence upon wind speed. The combination of these two factors implies that a degree of masking would often be provided by background noise.

12.2.2 As described by Scottish Government Planning Advice for Onshore Wind Turbines[5]:

“Technically, there are two quite distinct types of noise sources within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design.”

12.2.3 Within Scotland, noise is defined within the planning context by ‘Planning Advice Note 1/2011: Planning and Noise’[6]. This Planning Advice Note provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The Planning Advice Note 1/2011 states that:

“Good acoustical design and siting of turbines is essential to minimise the potential to generate noise.”

12.2.4 Planning Advice Note 1/2011 refers to the use of the Department of Trade and Industry’s ‘The Assessment and Rating of Noise from Wind Farms’ (ETSU-R-97), noting that further guidance is provided in the web-based planning advice on renewable technologies for onshore wind turbines[7]. In relation to noise from wind farms the web-based renewables advice states:

“ ‘The Assessment and Rating of Noise from Wind Farms’ provides a framework for the measurement of wind farm noise, noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments…until such time as new guidance is produced”., until such time as an update is available.”

12.2.5 It is therefore considered that the use of ETSU-R-97, as criteria for assessment of wind farm noise, fulfils the requirements of Planning Advice Note 1/2011.

12.2.6 The methodology described in ETSU-R-97 was developed by a working group comprised of a cross-section of interested persons including, amongst others, environmental health officers, wind farm operators and independent acoustic experts.

12.2.7 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that arise through the development of renewable energy resources. The principle of balancing development needs against protection of amenity may be considered common to any type of noise control guidance.

12.2.8 The basic aim of ETSU-R-97, in arriving at the recommendations contained within the report, is the intention to provide:

“Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities.”

12.2.9 An article published in the Institute of Acoustics (IoA) Bulletin Vol. 34 No. 2, March/April 2009[8], recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97, such as in relation to wind shear or noise propagation modelling. Whilst this article does not represent formal legislation or guidance it was authored by a group of independent acousticians experienced in wind farm noise issues who have undertaken work on behalf of wind farm developers, local planning authorities and third parties and as such is a good indicator of best practice techniques. The assessment presented herein adopts the recommendations made within this article.

12.2.10 A Good Practice Guide (GPG) to the application of ETSU-R-97 for the assessment and rating of wind turbine noise[9], issued by the Institute of Acoustics (IoA) in May 2013 and endorsed by the Northern Ireland Executive, along with the governments in England, Scotland and Wales, provides guidance on all aspects of the use of ETSU-R-97 and reaffirms the recommendations of the Acoustics Bulletin article with regard to propagation modelling and wind shear. The assessment presented herein adopts the recommendations of the GPG.

[5] ‘Onshore wind turbines: planning advice’, Scottish Government, May 2014. Available at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

[6] ‘Planning Advice Note 1/2011: Planning and Noise’, Scottish Government, March 2011. Available at: https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/

[7] Scottish Government (2022). Onshore wind: Policy Statement. Scottish Government. Available at: https://www.gov.scot/publications/onshore-wind-policy-statement-2022/

[8] ‘Prediction and Assessment of Wind Turbine Noise’, Bowdler et al, Acoustics Bulletin Vol 34 No 2 March/April 2009

[9] ‘A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Notes’, Institute of Acoustics, July & September 2014. Available at https://www.ioa.org.uk/publications/wind-turbine-noise

12.2.11 Supplementary guidance notes were published by the IoA in July and September 2014, and these provide further details on specific areas of the IoA GPG. The assessment presented herein adopts the recommendations made within these supplementary guidance notes.

12.2.12 ETSU-R-97 has been applied at the vast majority of wind farms currently operating in the UK and provides a robust basis for assessing the noise impact of a wind farm when used in accordance with the IoA GPG. It is the only relevant guidance referenced in Scottish Planning Policy (2014) for rating and assessing operational wind farm noise. Based on planning policy and guidance, as outlined above, a wind farm which can operate within noise limits derived according to ETSU-R-97 shall be considered acceptable. This approach has been agreed with Scottish Borders Council.

Construction Noise

12.2.13 In the web based Scottish Government technical advice on construction noise assessment in 'Appendix 1: Legislative Background, Technical Standards and Codes of Practice'[10] it is stated that:

"However, under Environmental Impact Assessments and for planning purposes i.e. not in regard to the Control of Pollution Act 1974, the 2009 version of BS 5228 is applicable."

12.2.14 Given that BS 5228-1:2009 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'[11] is identified as being the appropriate source of guidance on appropriate methods for minimising noise from construction activities, it is adopted herein.

12.2.15 The Control of Pollution Act 1974 provides information on the need for ensuring that the best practicable means are employed to minimise noise[12].

12.2.16 BS 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration'[13], provides a method for predicting vibration levels which has been adopted in this assessment.

12.2.17 BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration'[14] has been used to set criteria for satisfactory magnitudes of vibration at nearby residential properties to ensure compliance with respect to human response.

12.3 Consultation

12.3.1 Details of the consultation undertaken are outlined in **Table 12.1**.

Table 12.1: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
Energy Consents Unit	08/03/23	Scoping report submitted (ECU reference ECU00004774), detailing proposed assessment methodology.
Energy Consents Unit	22/06/23	Scoping response that noise assessment should be carried out in line with the legislation and standards outlined in the scoping report.
Scottish Borders Council	02/06/2023	RES report (04728-5642993-01) "Planned Acoustic Assessment at the Proposed Longcroft Wind farm sent to Scottish Borders Council for environmental health department to review. Report details proposed assessment methodology along with suggested background noise survey locations. The email with the report also included proposed dates when the survey would start and invitation for the EHO to attend, if they wish to do so.
Scottish Borders Council	05/06/2023	Email from the Planning Officer confirming receipt of the report, and passing it on to the Environmental Health team.
Scottish Borders Council	12/06/2023	Email to the Planning Officer confirming proposed date of equipment installation.
Scottish Borders Council	13/06/2023	Response from Planning Officer, relaying the confirmation from the Environmental Health that they have no objections or concerns in relation to the proposed methodology.
Scottish Borders Council	30/06/2023	RES report "Background Sound Survey Locations for the Acoustic Assessment of the Proposed Longcroft Wind Farm" sent to EHO providing details of installed survey locations.
Scottish Borders Council	03/07/2023	Email from the Planning Officer confirming receipt of the report, and forwarding it to the Environmental Health team

[10] 'Assessment of noise: technical advice note', Scottish Government, March 2011. Available at: http://www.gov.scot/publications/technical-advice-note-assessment-noise/

[11] 'Code of Practice for Noise and vibration control on construction and open sites - Part 1: Noise', British Standards Institution, BS 5228-1:2009

[12] 'Control of Pollution Act', published by Her Majesty's Stationary Office, July 1974. Available at: https://www.legislation.gov.uk/ukpga/1974/40

[13] 'Code of Practice for Noise and vibration control on construction and open sites - Part 2: Vibration', British Standards Institution, BS 5228-2:2009

[14] 'Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration', BS 6472-2:2008

12.4 Methodology

Scope of Assessment

12.4.1 Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities. The effect of noise, both in the construction and operational phase, is therefore a material consideration in the determination of planning applications.

Operation

12.4.2 To ensure adequate assessment of the potential impacts of the operational noise from the proposed development the following steps have been taken, in accordance with relevant guidance detailed above:

- The baseline noise conditions at each of the nearest residential properties to the proposed development are established by way of representative background sound surveys;
- The noise levels at the nearest residential properties from the operation of the proposed development are predicted using a sound propagation model considering: the locations of the wind turbines; the intervening terrain; and the likely noise emission characteristics of the wind turbines;
- The acoustic assessment criteria are derived appropriately; and
- The evaluation of the acoustic impact is undertaken by comparing the predicted noise levels with the assessment criteria. Significant effects would be identified if the predicted noise levels exceed limits derived in accordance with ETSU-R-97. Significant effects would not be expected should the predicted noise levels be less or equal than the ETSU-R-97 limit.

12.4.3 Aerodynamic and mechanical noise are scoped into the operational noise assessment. The main focus of the assessment of operational noise presented here is based on the most relevant type of noise emission for modern wind turbines: aerodynamic noise, which is broadband in nature. Mechanical noise, which can be tonal in nature, is also considered albeit less relevant to modern wind turbines whose improved design has led to significant reductions in mechanical noise. Implicitly incorporated within this assessment is the normal character of the noise associated with wind turbines (commonly referred to as 'blade swish') and consideration of a range of noise frequencies, including low frequencies.

12.4.4 An acoustic assessment considering the operation of the proposed battery energy storage system (BESS), is also scoped in and can be found in **Technical Appendix 12.1**.

12.4.5 Low frequency content of the noise from wind farms shall be considered through the use of octave band specific noise emission and propagation modelling, however it is considered that specific and targeted assessment on low frequency content of noise emissions from the proposed development is unjustified. Details for scoping out low frequency noise from the operational noise assessment, as well as infrasound, sleep disturbance, vibration, amplitude modulation and wind turbine syndrome can be found in **Technical Appendix 12.2**.

12.4.6 A summary of the findings of a comprehensive study into wind turbine noise and associated health effects can be found in **Technical Appendix 12.2.**

Construction

12.4.7 The construction of wind turbines, ancillary electrical equipment, compounds and the corresponding access tracks typically occurs at very large distances from neighbouring residential properties. The resultant noise and vibration, which would be temporary in nature, is only very rarely cause for concern in terms of the potential for disturbing the inhabitants of neighbouring residential properties. Whilst the noise associated with the construction of these aspects may well be audible to people residing in the area, the levels would be below established noise limits and planning requirements in this respect. Nevertheless, typical mitigation measures, including the use of 'best practicable means' would be incorporated into the construction practices for the proposed development with a view to reducing noise levels where possible and practical. As a result, this aspect is discussed in generalised terms with reference to standard noise limiting requirements; typical working practices; hours of work, and standard mitigation measures in this respect. A detailed assessment has not been undertaken and a similar rationale can be applied for noise impacts associated with decommissioning of the proposed development.

12.4.8 Construction relating to the provision of access to the site, including the upgrade of public roads and their use thereof, may well occur at locations near to residential properties. As a result, and in instances where this is likely to occur, consideration of enhanced mitigation measures which would be reasonably possible to implement, have been discussed. In any event, typical noise limiting requirements would apply and the contractor undertaking the works would be responsible for potential issues and taking appropriate and reasonable steps to address these should they occur. As a result, this aspect is also discussed in generalised terms and a detailed assessment has not been undertaken as this would require a detailed construction plan to provide confidence in the results, which is not available at this time. However, certain details as to construction practices would be provided within a Construction Environmental Management Plan (CEMP), with reference to potential noise and vibration impacts, where necessary. An outline CEMP has been provided in **Technical Appendix 3.1**.

12.4.9 Noise and vibration associated with the movement of additional vehicles, including heavy goods vehicles (HGVs) along public roads and access routes may well be noticeable to residents adjacent to these. However, this would essentially only result in a minor increase in the average noise levels from existing public roads, with the most noticeable noise and perceptible vibration effects resulting from the sporadic and increased number of HGV pass-bys at residential properties along the access routes, with resulting levels for individual events being similar to that created by existing HGV movements.

12.4.10 In order to release materials at proposed borrow-pit locations, the use of specifically designed explosives may be used, this is also known as blasting. The resultant noise, vibration and air overpressure from blasting cannot be reliably predicted. However, these aspects may well be perceptible to neighbouring residents. The vibration generated by each blast would be well below levels that would be expected to cause damage to the nearest housing and/or structures nearby. As a result, the impacts resulting from blasting is not considered in any detail other than the provision of discussion as to the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planned blasting activities.

Decommissioning

12.4.11 Whilst noise would also arise during decommissioning of the proposed development (through wind turbine deconstruction and breaking of the exposed part of the concrete bases) this is not discussed separately as noise levels resulting from it are expected to be lower than those during construction due to the number and type of activities involved.

Baseline Characterisation

12.4.12 Similar to other assessments of acoustic impacts (most notably BS 4142[15], which ETSU-R-97 identifies as forming the basis of its recommendations), the ETSU-R-97 methodology requires the comparison of predicted noise levels due to wind turbine emissions (which vary with hub height wind speed) with noise limits based upon the noise levels already existing under those same conditions (i.e. the baseline conditions).

12.4.13 Since background sound levels depend upon wind speed, as indeed do wind turbine noise emissions, it is important when making reference measurements to put them in that context. Thus, the assessment of background sound levels requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the site rather than at the residential properties, since it is this wind speed that would subsequently govern the proposed development’s noise generation. Often the residential properties themselves will be sheltered from the wind and may consequently have relatively low background sound levels.

12.4.14 To establish the baseline conditions, sound level meters and associated apparatus are set-up to record the required acoustic information at a selection of the nearest residential properties geographically spread around the proposed development and which are likely to be representative of other residential properties in the locale.

12.4.15 Wind speed and direction are recorded as 10-minute averages for the same period as for the sound measurements, and are synchronised with the acoustic data to allow correlations to be established. The wind speed that is adopted for use is the same wind speed as that which drives the wind turbine noise levels.

12.4.16 The adoption of this wind speed was recommended within the IoA GPG. The methodology used to calculate standardised 10m wind speed is described in **Technical Appendix 12.3.**

[15] ‘Method for Rating Industrial Noise affecting Mixed Residential and Industrial Areas’, British Standards Institution, 1997

12.4.17 Prior to establishing the baseline conditions the acoustic data is filtered as follows:

- For each background sound measurement location, the measured noise data is divided into two sets, as specified by ETSU-R-97 and shown in **Table 12.2**:

Table 12.2: Definition of Time-of-Day Periods

Time of Day	Definition
Quiet daytime	08:00 - 23:00 every day 13:00 - 18:00 Saturday 07:00 - 18:00 Sunday
Night-time	23:00 - 07:00 every day

- Rainfall affected data is systematically removed from the acoustic data set. To facilitate this, a rain gauge is deployed to record 10-minute rainfall data and identify potentially affected acoustic data. Both the 10-minute period containing the bucket tip and the preceding 10-minute period are removed from the dataset as recommended in the IoA GPG to account for the time it takes for the rain gauge tipping bucket to fill.
- Periods of measured background noise data thought to be affected by extraneous, i.e. non-typical, noise sources are identified and removed from the data set. Whilst some ‘extraneous’ data may actually be real, it tends to bias any trend lines upwards so its removal is adopted as a conservative measure.
- In practice this means close inspection of the measured background noise levels, comparison with concurrent data measured at nearby locations and consideration of both directional and temporal variation.

Modelling Noise Propagation

12.4.18 Whilst there are several sound propagation models available, the ISO 9613 Part 2 model has been used[16], this being identified as most appropriate for use in such rural sites[17]. The specific interpretation of the ISO 9613 Part 2 propagation methodology recommended in the aforementioned IoA Bulletin and the subsequent IoA GPG has been employed.

12.4.19 To make noise predictions it is assumed that:

- the wind turbines have the Sound Power Level (SWL) specified in this report;
- each wind turbine can be modelled as a point source at hub-height; and
- each residential property is assigned a reference height to simulate the presence of an observer.

12.4.20 The sound propagation model takes account of attenuation due to geometric spreading and atmospheric absorption. The assumed temperature and relative humidity are 10˚C and 70% respectively, as recommended in the IoA Bulletin and IoA GPG. Ground effects are also taken into account by the propagation model with a ground factor of 0.5 and a receiver height of 4m used as recommended in the IoA Bulletin and IoA GPG.

12.4.21 The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions[16]. Therefore, barrier attenuation according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the residential property in question and any part of the wind turbine, 2dB attenuation has been assumed as recommended in the IoA Bulletin and the IoA GPG.

12.4.22 Additionally, verification studies have also shown that ISO 9613 Part 2 tends to slightly underestimate noise levels at nearby dwellings in certain exceptional cases, notably in a valley type environment where the ground drops off between source and receiver. In these instances, an addition of 3dB(A) has been applied to the resulting overall a weighted noise level as recommended by the IoA GPG.

12.4.23 To generate the ground cross sections between each wind turbine and each dwelling necessary for reliable propagation modelling, ground contours at 5m intervals for the area of interest have been generated from 50m grid resolution digital terrain data.

12.4.24 The predicted noise levels are calculated as L_{Aeq} noise levels and changed to the L_{A90} descriptor (to allow comparisons to be made) by subtraction of 2dB, as specified by ETSU-R-97.

12.4.25 It has been shown by measurement-based verification studies that the ISO 9613 Part 2 model tends to slightly overestimate noise levels at nearby dwellings[16]. Examples of additional conservative assumptions modelled are:

- properties are assumed to be downwind of all noise sources simultaneously and at all times. In reality, this is not the case and additional attenuation would be expected when a property is upwind or crosswind of the proposed wind turbines;
- although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as ‘mixed’, i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the IoA Bulletin and IoA GPG;

[16] ‘Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation’, International Organisation for Standardisation, ISO 9613-2:1996

[17] ‘A Critical Appraisal of Wind Farm Noise Propagation’, ETSU Report W/13/00385/REP, January 2000

- receiver heights are modelled at 4m above local ground level, which equates roughly to first floor window level, as recommended by the IoA Bulletin and IoA GPG. This results in a predicted noise level anything up to 2dB(A) higher than at the typical human ear height of 1.2m - 1.8m;
- trees and other non-terrain shielding effects have not been considered;
- an allowance for measurement uncertainty has been included in the sound power levels for the presented candidate wind turbine.

12.5 Acoustic Impact Criteria

Operational Noise Impact

12.5.1 Sound is measured in decibels (dB) which is a measure of the sound pressure level, i.e. the magnitude of the pressure variations in the air. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear.

12.5.2 ETSU-R-97 seeks to protect the internal and external amenity of wind farm neighbours by defining acceptable limits for operational noise from wind turbines. The test applied to operational noise is whether or not the noise levels produced by the combined operation of the wind turbines comply with noise limits derived in accordance with ETSU-R-97 at nearby residential properties.

12.5.3 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also provides a simplified methodology:

"if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10m/s at 10m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary".

12.5.4 In the detailed methodology, ETSU-R-97 states that different limits should be applied during daytime and night-time periods. The daytime limits, derived from the background noise levels measured during quiet daytime periods, are intended to preserve outdoor amenity, while the night-time limits are intended to prevent sleep disturbance. The general principle is that the noise limits should be based on existing background sound levels, except for very low background sound levels, in which case a fixed limit may be applied. The suggested limits are given in **Table 12.3** below, where L_B is the background $L_{A90,10min}$ and is a function of wind speed. During daytime periods and at low background sound levels, a lower fixed limit of 35-40dB(A) is applicable. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced, and the duration and level of exposure.

Table 12.3: Permissible Noise Level Criteria

Time of Day	Definition
Quiet daytime	35-40 dB(A) for L_B less than 30-35 dB(A) L_B + 5 dB, for L_B greater than 30-35 dB(A)
Night-time	43 dB(A) for L_B less than 38 dB(A) L_B + 5 dB, for L_B greater than 38 dB(A)

12.5.5 Note that a higher noise level is permissible during the night than during the day as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB for attenuation through an open window.

12.5.6 The wind speeds at which the acoustic impact is considered are less than or equal to $12ms^{-1}$ at a height of 10m and are likely to be the acoustically critical wind speeds. Above these wind speeds, as stated in ETSU-R-97, reliable measurements of background and wind turbine noise are difficult to make. However, if a wind farm meets the acoustic criteria at the wind speeds presented, it is most unlikely that it would cause any greater loss of amenity at higher wind speeds due to increasing background sound levels masking wind farm generated sound.

12.5.7 It is important to note that, since reactions to noise are subjective, it is not possible to guarantee that a given development would not result in any adverse comment with regard to noise as the response to any given noise will vary from person to person. Consequently, standards and guidance that relate to environmental noise are typically presented in terms of criteria that would be expected to be considered acceptable by the majority of the population.

Construction Noise Impact

12.5.8 Construction noise is discussed with reference to Annex E of BS 5228-1:2009 which provides guidance on setting environmental noise targets. Several methods of assessing the significance of noise levels are presented in Annex E and the most applicable to the construction of the proposed development is the ABC method.

12.5.9 The ABC method sets threshold noise levels for construction noise for specific periods based on the pre-existing ambient noise levels, subject to average lower Category A limiting values of 65, 55 and 45dB L_{Aeq} for daytime (07:00 - 19:00 weekdays and Saturdays 07:00 - 13:00), evenings and weekends (19:00 - 23:00 weekdays, 13:00 - 23:00 Saturdays and 07:00 - 23:00 Sundays) and night-time (23:00 - 07:00) periods respectively, for instances where existing ambient noise levels are relatively low, which is the case here.

12.5.10 BS 5228-2:2009 provides guidance on the assessment of vibration due to blasting. A scaled distance graph is shown in Figure E.1 within Annex E which provides an indication of likely vibration magnitudes at various distances. This Figure can be used to determine the level of vibration which would not be expected to be exceeded in 95% of blasts for a given distance and charge size.

12.5.11 BS 6472-2:2008 details the maximum satisfactory magnitudes for vibration measured on a firm surface outside buildings with respect to human response. For up to three blast vibration events per day, the generally accepted maximum satisfactory magnitude at residential premises during daytime periods (08:00 – 18:00 Monday to Friday and 08:00 – 13:00 on Saturdays), is a peak particle velocity (ppv) of 6.0 to 10.0 $mm.s^{-1}$. In practice, the lower satisfactory magnitude should be used with the higher magnitude being justified on a case-by-case basis.

12.5.12 Where it is considered that the levels of construction noise and vibration, including that from blasting, can meet the relevant limits for each aspect or that appropriate controls or mitigation can be put in place, the resultant impact is considered not significant.

12.6 Baseline

12.6.1 The proposed development is located approximately 8.5km[18] north-east of Lauder, in the Scottish Borders. The surrounding area is predominantly rural in nature and used for grazing sheep, as well as grouse shooting with the A68 and A697 to the west of the site. The operational Fallago Rig Wind Farm sits adjacent, north-east of the site. The general noise character is typical of a rural environment with sound from farm machinery, sheep, cattle, and birds, rustle of trees and sound of nearby streams, with the occasional overhead aircraft.

12.6.2 Background sound measurements were undertaken at three residential property locations (4 Longcroft Cottages, Soonhope Bothy and The Howe) in accordance with ETSU-R-97. These three locations are detailed in **Table 12.4.**

Table 12.4 - Background Sound Survey Details

House Name	Measurement Period		
	Start	End	Duration (days)
4 Longcroft Cottages	21/06/2023	03/08/2023	44
Soonhope Bothy	21/06/2023	03/08/2023	44
The Howe	21/06/2023	03/08/2023	44

12.6.3 The background sound monitoring equipment was housed in weather-proof enclosures and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.2 - 1.5m above ground and equipped with all-weather wind shields which also provide an element of water resistance.

12.6.4 The proprietary wind shields used are designed to reduce the effects of wind-generated noise at the microphone and accord with the recommendations of the IoA GPG in that they are the appropriate size and, in combination with the microphone, are certified by the manufacturer as meeting Type 1 / Class 1 precision standards.

12.6.5 Sound levels are monitored continuously, and summary statistics stored every 10 minutes in the internal memory of each meter. The relevant statistic measured is the $L_{A90,10min}$ (The A-weighted sound pressure level exceeded for 90% of the 10-minute interval).

12.6.6 The sound level meters were placed away from reflecting walls and vegetation. Photos of the equipment, in situ, may be seen in **Technical Appendix 12.4.** The apparatus were calibrated before and after the survey period and the maximum detected calibration drift was 0.2dB, which is within the required range recommended in the IoA GPG. All instrumentation has been subject to laboratory calibration traceable to national standards within the last 24 months, as recommended in the IoA GPG. Details are provided in **Technical Appendix 12.5.**

12.6.7 **Chart 12.6.1** (see **Technical Appendix 12.6** for all charts) shows the measured wind rose over the background sound survey period, as measured by a LiDAR (Light Detection and Ranging) located on-site.

12.6.8 A LiDAR is a remote sensing device that measures conditions in the atmosphere by using pulses from a LASER by applying the principle of the Doppler Effect, detecting the movement of air in the atmospheric boundary layer to measure wind speed and direction. LiDAR provides measurements at several heights, and this enables wind speed data to be obtained that describe the wind profile across a range of heights.

[18] This distance is given to the approximate centre point of the site.

12.6.9 LIDAR has been successfully tested, by independent third parties using suitable test sites, against conventional anemometry[19,20]. From the technical reports, these tests have demonstrated that, over a range of relevant heights, the accuracy of the LIDAR is comparable to that of the conventional anemometry.

12.6.10 For illustrative purposes, Chart 12.6.2 shows the predicted wind rose using mesoscale modelling over an extended period (one calendar year). As previously discussed, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the wind turbines. Chart 12.6.2 therefore may aid the reader as to the likelihood of over-estimation due to this factor.

12.6.11 The acoustic data has been cross-referenced with rainfall data measured at the site using a rain gauge. Any acoustic data identified as having been affected by rainfall has been removed from the analysis as shown in **Charts 12.6.3 to 12.6.8**.

12.6.12 Short-term periods of increased noise levels considered to be atypical have been removed from the datasets. The excluded data is shown in **Charts 12.6.3 to 12.6.8**.

12.6.13 **Charts 12.6.3 to 12.6.5** show $L_{A90,10min}$ correlated against wind speed for quiet daytime periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

12.6.14 **Charts 12.6.6 to 12.6.8** show $L_{A90,10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

12.6.15 **Table 12.5** and **Table 12.6** detail the $L_{A90,10min}$ background noise levels calculated from the derived 'best fit' lines, as described above. They are provided as sound pressure levels in dB referenced to 20 micro Pascals (see Glossary for further detail):

Table 12.5 - Quiet Daytime Noise Levels (dB(A) re 20μPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
4 Longcroft Cottages	30.7	30.7	30.7	31.1	32.0	33.3	34.9	37.0	39.2	41.7	44.3	44.3
Soonhope Bothy	32.0	32.5	33.0	33.6	34.2	34.9	35.8	36.9	38.1	39.5	41.2	41.2
The Howe	25.7	25.7	26.1	27.0	28.5	30.3	32.5	34.9	37.6	40.4	43.3	43.3

Table 12.6 - Night-time Noise Levels (dB(A) re 20 μPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
4 Longcroft Cottages	26.5	26.5	27.4	28.2	28.9	29.6	30.4	31.5	32.9	34.6	34.6	34.6
Soonhope Bothy	31.9	31.9	32.3	32.4	32.4	32.4	32.8	33.7	35.4	37.9	37.9	37.9
The Howe	26.6	26.6	27.4	28.1	28.7	29.3	30.1	31.3	32.8	32.8	32.8	32.8

Future Baseline

12.6.16 The baseline conditions would not be expected to change under the "do nothing" scenario i.e. in the event that the proposed development does not go ahead.

12.7 Assessment of Potential Effects

Operational Effects

Noise Propagation Modelling

12.7.1 The locations of the proposed wind turbines are provided in **Table 12.7** and shown in **Figure 12.1**. All coordinates are according to Ordnance Survey of Great Britain, 1936 (EPSG code 27700).

Table 12.7: Location of Proposed Wind Turbines

Wind Turbine	Co-ordinates		Wind Turbine	Co-ordinates		Wind Turbine	Co-ordinates	
	X (m)	Y (m)		X (m)	Y (m)		X (m)	Y (m)
T1	354167	654601	T8	356429	656886	T15	355148	656448
T2	355077	654904	T9	356059	657276	T16	354396	656398
T3	355506	655349	T10	356612	657632	T17	353724	656312
T4	355019	655655	T11	357010	658361	T18	353893	655663
T5	355688	655868	T12	356390	658096	T19	353392	655261
T6	356323	656104	T13	355614	657800			
T7	355898	656509	T14	355275	657314			

[19] "Evaluation of WINDCUBE", Albers et al, Deutsche WindGuard Consulting GmbH, Report PP 08007, 16 March 2008

[20] "Verification test for three WindCubeTM WLS7 LiDARs at the Høvsøre test site", Gottschall et al, DTU Report Risø-R-1732, May 2010

12.7.2 The locations of the nearest residential properties to the wind turbines have been determined by inspection of relevant maps and through site visits. The study area has been determined in accordance with guidance provided in IoA GPG. More residential properties may have been identified but have not been considered critical to this acoustic assessment or may be adequately represented by another residential property. The locations considered are listed in **Table 12.8** and are also shown in **Figure 12.1.**

12.7.3 The distances from each residential property to the nearest wind turbine are given in **Table 12.8**. It can be seen that the minimum house-to-wind turbine separation is 1,192 m to H315 (The Howe).

Table 12.8: Location of Residential Properties and Distances to Nearest Proposed Wind Turbine

House ID	House Name	Co-ordinates		Distance (m)	Nearest Wind Turbine
		X (m)	Y (m)		
H32	Burncastle Farm Bothy	354250	651473	3129	T1
H34	Earnscleugh	354281	651535	3068	T1
H40	1 Lylestane Farm Cottages	352480	651638	3410	T1
H41	Lylestane Farmhouse	352634	651701	3280	T1
H42	Murrayswalls Lylestane	352682	651721	3241	T1
H43	Lylestane Farm	352599	651722	3278	T1
H44	Steading House	352630	651728	3258	T1
H49	4 Wiselawmill Steading	351469	651832	3866	T1
H50	Wiselawmill Farm House	351441	651838	3882	T1
H52	Burncastle Lodge	354434	651852	2762	T1
H53	1 Wiselawmill Steading	351435	651854	3874	T1
H54	3 Wiselawmill Steading	351466	651859	3849	T1
H55	Wiselawmill Steading	351453	651861	3857	T1
H56	2 Wiselawmill Steading	351449	651864	3857	T1
H60	Woodrigdean	352205	652276	3042	T1
H61	Riverside Cleekhimin	352168	652294	3053	T1
H62	Cleekimin House	352168	652294	3053	T1
H66	Braidshawrigg	358096	652813	3625	T3
H67	Addinston Bungalow	352059	653029	2600	T19
H68	Addinston Lodge	352145	653063	2527	T19
H69	Addinston	351995	653162	2522	T19
H70	Glencroft	351043	653191	3131	T19
H72	Boghall	351083	653203	3093	T19
H73	Glencroft	351071	653216	3094	T19
H74	1 Addinston Farm Cottage	352127	653217	2404	T19
H75	2 Addinston Farm Cottage	352134	653231	2388	T19
H76	3 Addinston Farm Cottage	352129	653244	2380	T19
H77	4 Addinston Farm Cottage	352127	653251	2375	T19
H78	Carfrae Lea	351047	653253	3088	T19
H81	Finchlea	351034	653281	3079	T19
H84	Thimble Ha	350904	653307	3164	T19
H105	The Grange	350894	653372	3132	T19
H116	Mill View	350914	653393	3104	T19
H137	Carfraemill	350839	653419	3148	T19
H142	Burnden	350904	653423	3094	T19
H171	Westhope	350840	653467	3120	T19
H216	Leader House	350859	653520	3074	T19
H219	The Camping & Caravanning Club	350947	653522	3001	T19
H236	Corner House	350900	653560	3018	T19
H238	Carfraemill	350886	653562	3028	T19
H243	Carfraemill House	350910	653599	2987	T19
H246	The Shed	350923	653610	2970	T19
H249	Vre House	350843	653622	3031	T19
H251	Mid House	350910	653642	2964	T19
H258	North Corner House	350918	653686	2933	T19
H260	4 Longcroft Farm Cottages	353020	653728	1442	T1
H261	3 Longcroft Farm Cottages	353012	653735	1444	T1
H262	2 Longcroft Farm Cottages	352976	653774	1450	T1
H263	1 Longcroft Farm Cottages	352966	653783	1453	T1
H265	Longcroft Farm	352926	653944	1397	T19
H267	Soonhope Bothy	352794	654159	1254	T19
H268	Soonhope House	352765	654215	1220	T19
H278	1 Carfrae Farm Cottages	350064	655057	3335	T19
H279	Hillhouse Farmhouse	350585	655077	2813	T19

House ID	House Name	Co-ordinates		Distance (m)	Nearest Wind Turbine
		X (m)	Y (m)		
H280	Hillhouse Farm	350585	655077	2813	T19
H281	Milkmans Cottage Carfrae Farm	350112	655081	3285	T19
H282	Carfrae	350154	655101	3242	T19
H283	Carfrae Farming Co	350153	655103	3243	T19
H284	2 Hillhouse Farm Cottages	350570	655127	2825	T19
H285	1 Hillhouse Farm Cottages	350562	655133	2833	T19
H286	The Caravan	350171	655148	3223	T19
H287	Carfrae Farm Steading Cottage	350171	655148	3223	T19
H288	3 Hillhouse Farm Cottages	350597	655151	2797	T19
H289	Little Highfield	350604	655157	2790	T19
H290	Sparrow Castle	349657	655265	3735	T19
H291	Vineleaf Cottage	349973	655267	3419	T19
H292	2 Carfrae Farm Cottages	350016	655276	3376	T19
H293	3 Carfrae Farm Cottages	350051	655278	3341	T19
H294	4 Carfrae Farm Cottages	350061	655279	3331	T19
H295	Headshaw Bungalow	349073	655280	4319	T19
H296	5 Carfrae Farm Cottages	350069	655280	3323	T19
H297	6 Carfrae Farm Cottages	350077	655281	3315	T19
H298	Headshaw Farm	349041	655287	4351	T19
H299	Bridge Cottage	349088	655351	4305	T19
H300	Well Cottage	349148	655354	4245	T19
H301	New Fairnieleas Oxton	350151	656165	3365	T19
H302	Fairnieleas Hillhouse	349852	656769	3848	T19
H303	Tollishill	352055	657034	1818	T17
H304	Dodcleugh	352032	657039	1842	T17
H305	Tollishill Farmhouse	351849	657889	2450	T17
H306	Shepherds Cottage Tollishill	351843	657922	2476	T17
H307	Tollishill Farm	351860	657933	2470	T17
H308	Kelphope Bungalow	351222	658127	3091	T17
H309	Plover Cottage	351231	658326	3205	T17
H310	Kelphope Farm	351291	658366	3184	T17
H311	Kelphope Bothey	351197	658392	3273	T17
H315	The Howe	353768	657503	1192	T17

12.7.4 Although not finalised, the candidate wind turbine type used for the purposes of the acoustic assessment of the proposed development is the Siemens-Gamesa SG 6.6-170 6.6MW machine. This report uses the acoustic data from the manufacturer's performance specification for this machine for all analysis[21]. The manufacturer has identified these values as warranted although no independent test reports are available to indicate whether any margin has been incorporated. A 2dB allowance for uncertainty has therefore been added to the warranted levels as a conservative measure as recommended by the IoA GPG. Details used in this analysis are as follows:

- hub height of 135 m;
- a rotor diameter of 170 m;
- sound power levels, L_{WA}, for standardised 10m height wind speeds (v_{10}) as shown in **Table 12.9;**
- octave band sound power level data, at the wind speeds where it is available, as shown in **Table 12.10**; and
- tonal emission characteristics such that no clearly audible tones are present at any wind speed.

[21] 'Product Customer Documentation, Developer package, SG 6.6-170' Document ref D2830475/018, Siemens Gamesa Renewable Energy, 2022

Table 12.9 – A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Siemens-Gamesa SG 6.6-170 6.6MW Wind Turbine , including 2dB uncertainty

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	135 m Hub Height
1	95.2
2	95.2
3	95.2
4	100.4
5	105.1
6	107.9
7	108.0
8	108.0
9	108.0
10	108.0
11	108.0
12	107.0

Table 12.10 - Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at Standardised 10m Height Wind Speeds for the Siemens-Gamesa SG 6.6-170 6.6MW Wind Turbine

Octave Band (Hz)	$8ms^{-1}$
63	88.5
125	95.4
250	98.1
500	99.9
1000	103.8
2000	101.9
4000	95.3
8000	85.0

Predictions of Noise Levels at Residential Properties

12.7.5 **Table 12.11** shows the predicted noise immission levels at the nearest residential properties at each wind speed considered, calculated from the operation of the proposed development. The property with the highest predicted noise immission level of 36.4 dB(A) is H315 (The Howe).

12.7.6 **Figure 12.1** shows an isobel (i.e. noise contour) plot for the proposed development at a 10m height wind speed of $8ms^{-1}$. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 12.11: Predicted Noise Levels At Nearby Residential Properties, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H32	11.5	11.5	11.5	16.7	21.4	24.2	24.3	24.3	24.3	24.3	24.3	23.3
H34	11.7	11.7	11.7	16.9	21.6	24.4	24.5	24.5	24.5	24.5	24.5	23.5
H40	11.2	11.2	11.2	16.4	21.1	23.9	24.0	24.0	24.0	24.0	24.0	23.0
H41	11.2	11.2	11.2	16.4	21.1	23.9	24.0	24.0	24.0	24.0	24.0	23.0
H42	11.3	11.3	11.3	16.5	21.2	24.0	24.1	24.1	24.1	24.1	24.1	23.1
H43	11.3	11.3	11.3	16.5	21.2	24.0	24.1	24.1	24.1	24.1	24.1	23.1
H44	11.3	11.3	11.3	16.5	21.2	24.0	24.1	24.1	24.1	24.1	24.1	23.1
H49	11.3	11.3	11.3	16.5	21.2	24.0	24.1	24.1	24.1	24.1	24.1	23.1
H50	11.8	11.8	11.8	17.0	21.7	24.5	24.6	24.6	24.6	24.6	24.6	23.6
H52	12.2	12.2	12.2	17.4	22.1	24.9	25.0	25.0	25.0	25.0	25.0	24.0
H53	11.8	11.8	11.8	17.0	21.7	24.5	24.6	24.6	24.6	24.6	24.6	23.6
H54	11.4	11.4	11.4	16.6	21.3	24.1	24.2	24.2	24.2	24.2	24.2	23.2
H55	11.9	11.9	11.9	17.1	21.8	24.6	24.7	24.7	24.7	24.7	24.7	23.7
H56	11.9	11.9	11.9	17.1	21.8	24.6	24.7	24.7	24.7	24.7	24.7	23.7
H60	13.1	13.1	13.1	18.3	23.0	25.8	25.9	25.9	25.9	25.9	25.9	24.9
H61	13.1	13.1	13.1	18.3	23.0	25.8	25.9	25.9	25.9	25.9	25.9	24.9
H62	13.1	13.1	13.1	18.3	23.0	25.8	25.9	25.9	25.9	25.9	25.9	24.9
H66	13.2	13.2	13.2	18.4	23.1	25.9	26.0	26.0	26.0	26.0	26.0	25.0
H67	16.2	16.2	16.2	21.4	26.1	28.9	29.0	29.0	29.0	29.0	29.0	28.0
H68	16.7	16.7	16.7	21.9	26.6	29.4	29.5	29.5	29.5	29.5	29.5	28.5
H69	16.3	16.3	16.3	21.5	26.2	29.0	29.1	29.1	29.1	29.1	29.1	28.1
H70	10.6	10.6	10.6	15.8	20.5	23.3	23.4	23.4	23.4	23.4	23.4	22.4
H72	10.7	10.7	10.7	15.9	20.6	23.4	23.5	23.5	23.5	23.5	23.5	22.5
H73	10.7	10.7	10.7	15.9	20.6	23.4	23.5	23.5	23.5	23.5	23.5	22.5
H74	17.1	17.1	17.1	22.3	27.0	29.8	29.9	29.9	29.9	29.9	29.9	28.9
H75	17.2	17.2	17.2	22.4	27.1	29.9	30.0	30.0	30.0	30.0	30.0	29.0
H76	17.2	17.2	17.2	22.4	27.1	29.9	30.0	30.0	30.0	30.0	30.0	29.0
H77	17.2	17.2	17.2	22.4	27.1	29.9	30.0	30.0	30.0	30.0	30.0	29.0
H78	10.7	10.7	10.7	15.9	20.6	23.4	23.5	23.5	23.5	23.5	23.5	22.5
H81	10.7	10.7	10.7	15.9	20.6	23.4	23.5	23.5	23.5	23.5	23.5	22.5
H84	10.9	10.9	10.9	16.1	20.8	23.6	23.7	23.7	23.7	23.7	23.7	22.7

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H105	11.0	11.0	11.0	16.2	20.9	23.7	23.8	23.8	23.8	23.8	23.8	22.8
H116	10.6	10.6	10.6	15.8	20.5	23.3	23.4	23.4	23.4	23.4	23.4	22.4
H137	11.2	11.2	11.2	16.4	21.1	23.9	24.0	24.0	24.0	24.0	24.0	23.0
H142	10.6	10.6	10.6	15.8	20.5	23.3	23.4	23.4	23.4	23.4	23.4	22.4
H171	11.0	11.0	11.0	16.2	20.9	23.7	23.8	23.8	23.8	23.8	23.8	22.8
H216	11.1	11.1	11.1	16.3	21.0	23.8	23.9	23.9	23.9	23.9	23.9	22.9
H219	10.9	10.9	10.9	16.1	20.8	23.6	23.7	23.7	23.7	23.7	23.7	22.7
H236	10.9	10.9	10.9	16.1	20.8	23.6	23.7	23.7	23.7	23.7	23.7	22.7
H238	10.8	10.8	10.8	16.0	20.7	23.5	23.6	23.6	23.6	23.6	23.6	22.6
H243	10.9	10.9	10.9	16.1	20.8	23.6	23.7	23.7	23.7	23.7	23.7	22.7
H246	11.0	11.0	11.0	16.2	20.9	23.7	23.8	23.8	23.8	23.8	23.8	22.8
H249	11.5	11.5	11.5	16.7	21.4	24.2	24.3	24.3	24.3	24.3	24.3	23.3
H251	11.3	11.3	11.3	16.5	21.2	24.0	24.1	24.1	24.1	24.1	24.1	23.1
H258	11.4	11.4	11.4	16.6	21.3	24.1	24.2	24.2	24.2	24.2	24.2	23.2
H260	20.0	20.0	20.0	25.2	29.9	32.7	32.8	32.8	32.8	32.8	32.8	31.8
H261	20.0	20.0	20.0	25.2	29.9	32.7	32.8	32.8	32.8	32.8	32.8	31.8
H262	20.0	20.0	20.0	25.2	29.9	32.7	32.8	32.8	32.8	32.8	32.8	31.8
H263	19.9	19.9	19.9	25.1	29.8	32.6	32.7	32.7	32.7	32.7	32.7	31.7
H265	20.5	20.5	20.5	25.7	30.4	33.2	33.3	33.3	33.3	33.3	33.3	32.3
H267	20.8	20.8	20.8	26.0	30.7	33.5	33.6	33.6	33.6	33.6	33.6	32.6
H268	21.0	21.0	21.0	26.2	30.9	33.7	33.8	33.8	33.8	33.8	33.8	32.8
H278	12.5	12.5	12.5	17.7	22.4	25.2	25.3	25.3	25.3	25.3	25.3	24.3
H279	12.9	12.9	12.9	18.1	22.8	25.6	25.7	25.7	25.7	25.7	25.7	24.7
H280	12.9	12.9	12.9	18.1	22.8	25.6	25.7	25.7	25.7	25.7	25.7	24.7
H281	12.7	12.7	12.7	17.9	22.6	25.4	25.5	25.5	25.5	25.5	25.5	24.5
H282	12.8	12.8	12.8	18.0	22.7	25.5	25.6	25.6	25.6	25.6	25.6	24.6
H283	12.8	12.8	12.8	18.0	22.7	25.5	25.6	25.6	25.6	25.6	25.6	24.6
H284	13.2	13.2	13.2	18.4	23.1	25.9	26.0	26.0	26.0	26.0	26.0	25.0
H285	13.2	13.2	13.2	18.4	23.1	25.9	26.0	26.0	26.0	26.0	26.0	25.0
H286	12.8	12.8	12.8	18.0	22.7	25.5	25.6	25.6	25.6	25.6	25.6	24.6
H287	12.8	12.8	12.8	18.0	22.7	25.5	25.6	25.6	25.6	25.6	25.6	24.6
H288	13.1	13.1	13.1	18.3	23.0	25.8	25.9	25.9	25.9	25.9	25.9	24.9
H289	13.2	13.2	13.2	18.4	23.1	25.9	26.0	26.0	26.0	26.0	26.0	25.0
H290	12.8	12.8	12.8	18.0	22.7	25.5	25.6	25.6	25.6	25.6	25.6	24.6
H291	11.8	11.8	11.8	17.0	21.7	24.5	24.6	24.6	24.6	24.6	24.6	23.6
H292	11.7	11.7	11.7	16.9	21.6	24.4	24.5	24.5	24.5	24.5	24.5	23.5
H293	11.9	11.9	11.9	17.1	21.8	24.6	24.7	24.7	24.7	24.7	24.7	23.7
H294	12.0	12.0	12.0	17.2	21.9	24.7	24.8	24.8	24.8	24.8	24.8	23.8
H295	11.9	11.9	11.9	17.1	21.8	24.6	24.7	24.7	24.7	24.7	24.7	23.7
H296	12.0	12.0	12.0	17.2	21.9	24.7	24.8	24.8	24.8	24.8	24.8	23.8
H297	12.1	12.1	12.1	17.3	22.0	24.8	24.9	24.9	24.9	24.9	24.9	23.9
H298	11.9	11.9	11.9	17.1	21.8	24.6	24.7	24.7	24.7	24.7	24.7	23.7
H299	12.2	12.2	12.2	17.4	22.1	24.9	25.0	25.0	25.0	25.0	25.0	24.0
H300	12.1	12.1	12.1	17.3	22.0	24.8	24.9	24.9	24.9	24.9	24.9	23.9
H301	12.7	12.7	12.7	17.9	22.6	25.4	25.5	25.5	25.5	25.5	25.5	24.5
H302	13.8	13.8	13.8	19.0	23.7	26.5	26.6	26.6	26.6	26.6	26.6	25.6
H303	16.9	16.9	16.9	22.1	26.8	29.6	29.7	29.7	29.7	29.7	29.7	28.7
H304	16.7	16.7	16.7	21.9	26.6	29.4	29.5	29.5	29.5	29.5	29.5	28.5
H305	17.4	17.4	17.4	22.6	27.3	30.1	30.2	30.2	30.2	30.2	30.2	29.2
H306	18.3	18.3	18.3	23.5	28.2	31.0	31.1	31.1	31.1	31.1	31.1	30.1
H307	18.2	18.2	18.2	23.4	28.1	30.9	31.0	31.0	31.0	31.0	31.0	30.0
H308	12.7	12.7	12.7	17.9	22.6	25.4	25.5	25.5	25.5	25.5	25.5	24.5
H309	12.5	12.5	12.5	17.7	22.4	25.2	25.3	25.3	25.3	25.3	25.3	24.3
H310	12.7	12.7	12.7	17.9	22.6	25.4	25.5	25.5	25.5	25.5	25.5	24.5
H311	12.4	12.4	12.4	17.6	22.3	25.1	25.2	25.2	25.2	25.2	25.2	24.2
H315	23.6	23.6	23.6	28.8	33.5	36.3	36.4	36.4	36.4	36.4	36.4	35.4

12.7.7 Noise levels at 87 of the 88 nearest residential properties are below 35dB(A), indicating that the noise immission levels would be regarded as acceptable and the resident's amenity as receiving 'sufficient protection' without further assessment requiring to be undertaken.

12.7.8 There is one property (H315) that have predicted noise levels greater than this simplified noise criteria as indicated in **Table 12.11**. Therefore the 'full' acoustic assessment need only be considered at this property.

12.7.9 In addition, a full acoustic assessment has been undertaken for the group of seven residential properties located to the south-west of the site (namely H260, H261, H262, H263, H265, H267 & H268), as they are next nearest to the proposed development.

Acoustic Acceptance Criteria

12.7.10 As stated previously, during daytime periods and at low background noise levels, a lower fixed limit of 35-40dB(A) is applicable with the exact value dependent upon a number of factors: the number of noise affected residential properties; the potential impact on the power output of the proposed development and the likely duration and level of exposure. Through consideration of these factors, the applicant has adopted a 37.5dB(A) level. The justification being:

- Number of noise affected residential properties: one of the considered residential properties is predicted to experience noise levels of greater than 35dB(A). This is a small number of properties in relation to the scale of the proposed development which would generate significant social, economic and environmental benefits suggesting a limit towards the middle of the range would be appropriate;
- Potential impact on the power output of the proposed development: The rated power would be approximately 125MW should the wind turbine type considered in the acoustic assessment be installed, large in comparison with other wind farm developments in Scotland, suggesting that a lower limit towards the middle, or upper end, of the range would be appropriate. A lower limit towards the lower end of the range would limit the power output of the proposed development; and
- The likely duration and level of exposure: The amount of the time that noise levels of greater than 35dB(A) are predicted is limited to periods of sufficiently high wind speed. Noise levels would also be reduced when properties are not located downwind of the wind turbines. Again, this does not suggest a high impact such that a lower limit in the middle of the range would be appropriate.

12.7.11 A 43dB(A) lower limit has been adopted at night in accordance with ETSU-R-97. The resulting criteria are shown in **Table 12.12.**

Table 12.12: Permissible Noise Level Criteria

Time of Day	Permissible Noise Level
Daytime	37.5dB(A) for L_B less than 32.5dB(A) L_B + 5dB, for L_B greater than 32.5dB(A)
Night-time	43dB(A) for L_B less than 38dB(A) L_B + 5dB, for L_B greater than 38dB(A)

Calculation of Acceptable Noise Limits from Baseline Conditions

12.7.12 The 'best-fit' lines of **Technical Appendix 12.6 Charts 12.6.3-16.6.8** have been used to calculate the acceptable noise limits at the background noise measurement locations in line with the permissible noise level criteria set out in **Table 12.12. Table 12.13** shows the proposed daytime noise limits and **Table 12.14** the night-time noise limits.

Table 12.13 - Recommended Daytime Noise Limits (dB(A) re 20 μPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
4 Longcroft Farm Cottages	37.5	37.5	37.5	37.5	37.5	38.3	39.9	42.0	44.2	46.7	49.3	49.3
Soonhope Bothy	37.5	37.5	38.0	38.6	39.2	39.9	40.8	41.9	43.1	44.5	46.2	46.2
The Howe	37.5	37.5	37.5	37.5	37.5	37.5	37.5	39.9	42.6	45.4	48.3	48.3

Table 11.14 - Recommended Night-time Noise Limits (dB(A) re 20 μPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
4 Longcroft Farm Cottages	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Soonhope Bothy	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
The Howe	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

12.7.13 The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey results inferred to be representative for each property are shown in **Table 12.15**.

12.7.14 The specific choice of noise survey chosen has been made considering the distance to the nearest survey location and the likelihood of experiencing a broadly similar exposure as the survey.

Table 12.15 - Assumed Representative Background Noise Survey Locations

House ID	House Name	Survey Location
H260	4 Longcroft Farm Cottages	4 Longcroft Farm Cottages
H261	3 Longcroft Farm Cottages	4 Longcroft Farm Cottages
H262	2 Longcroft Farm Cottages	4 Longcroft Farm Cottages
H263	1 Longcroft Farm Cottages	4 Longcroft Farm Cottages
H265	Longcroft Farm	4 Longcroft Farm Cottages
H267	Soonhope Bothy	Soonhope Bothy
H268	Soonhope House	Soonhope Bothy
H315	The Howe	The Howe

Acoustic Assessment

12.7.15 **Table 12.16** shows a comparison of the predicted noise levels with the proposed daytime noise limits for each residential property where the full assessment procedure is being applied. The predicted noise levels at $1ms^{-1}$ and $2ms^{-1}$ have been assumed as equal to $3ms^{-1}$ as a conservative measure as noise levels at these wind speeds would typically be less. The term ΔL is used to denote the difference between the predicted wind farm noise level and the proposed limit. A negative value indicates that the predicted noise level is within the limit. **Table 12.17** shows a comparison with the proposed night-time noise limits.

12.7.16 Noise levels at all locations are within the daytime noise limits at all wind speeds considered with a minimum margin of -1.2 dB(A). Noise levels at all locations are within the night-time noise limits at all wind speeds considered with a minimum margin of -6.6 dB(A).

Table 12.16 - Comparison of Predicted Noise Levels and Daytime Noise Limits - (dB(A) re 20 μPa)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H260	20.0	37.5	-17.5	20.0	37.5	-17.5	20.0	37.5	-17.5	25.2	37.5	-12.3	29.9	37.5	-7.6	32.7	38.3	-5.6	32.8	39.9	-7.1	32.8	42.0	-9.2	32.8	44.2	-11.4	32.8	46.7	-13.9	32.8	49.3	-16.5	31.8	49.3	-17.5
H261	20.0	37.5	-17.5	20.0	37.5	-17.5	20.0	37.5	-17.5	25.2	37.5	-12.3	29.9	37.5	-7.6	32.7	38.3	-5.6	32.8	39.9	-7.1	32.8	42.0	-9.2	32.8	44.2	-11.4	32.8	46.7	-13.9	32.8	49.3	-16.5	31.8	49.3	-17.5
H262	20.0	37.5	-17.5	20.0	37.5	-17.5	20.0	37.5	-17.5	25.2	37.5	-12.3	29.9	37.5	-7.6	32.7	38.3	-5.6	32.8	39.9	-7.1	32.8	42.0	-9.2	32.8	44.2	-11.4	32.8	46.7	-13.9	32.8	49.3	-16.5	31.8	49.3	-17.5
H263	19.9	37.5	-17.6	19.9	37.5	-17.6	19.9	37.5	-17.6	25.1	37.5	-12.4	29.8	37.5	-7.7	32.6	38.3	-5.7	32.7	39.9	-7.2	32.7	42.0	-9.3	32.7	44.2	-11.5	32.7	46.7	-14.0	32.7	49.3	-16.6	31.7	49.3	-17.6
H265	20.5	37.5	-17.0	20.5	37.5	-17.0	20.5	37.5	-17.0	25.7	37.5	-11.8	30.4	37.5	-7.1	33.2	38.3	-5.1	33.3	39.9	-6.6	33.3	42.0	-8.7	33.3	44.2	-10.9	33.3	46.7	-13.4	33.3	49.3	-16.0	32.3	49.3	-17.0
H267	20.8	37.5	-16.7	20.8	37.5	-16.7	20.8	38.0	-17.2	26.0	38.6	-12.6	30.7	39.2	-8.5	33.5	39.9	-6.4	33.6	40.8	-7.2	33.6	41.9	-8.3	33.6	43.1	-9.5	33.6	44.5	-10.9	33.6	46.2	-12.6	32.6	46.2	-13.6
H268	21.0	37.5	-16.5	21.0	37.5	-16.5	21.0	38.0	-17.0	26.2	38.6	-12.4	30.9	39.2	-8.3	33.7	39.9	-6.2	33.8	40.8	-7.0	33.8	41.9	-8.1	33.8	43.1	-9.3	33.8	44.5	-10.7	33.8	46.2	-12.4	32.8	46.2	-13.4
H315	23.6	37.5	-13.9	23.6	37.5	-13.9	23.6	37.5	-13.9	28.8	37.5	-8.7	33.5	37.5	-4.0	36.3	37.5	-1.2	36.4	37.5	-1.1	36.4	39.9	-3.5	36.4	42.6	-6.2	36.4	45.4	-9.0	36.4	48.3	-11.9	35.4	48.3	-12.9

Table 12.17 - Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H260	20.0	43.0	-23.0	20.0	43.0	-23.0	20.0	43.0	-23.0	25.2	43.0	-17.8	29.9	43.0	-13.1	32.7	43.0	-10.3	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	31.8	43.0	-11.2
H261	20.0	43.0	-23.0	20.0	43.0	-23.0	20.0	43.0	-23.0	25.2	43.0	-17.8	29.9	43.0	-13.1	32.7	43.0	-10.3	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	31.8	43.0	-11.2
H262	20.0	43.0	-23.0	20.0	43.0	-23.0	20.0	43.0	-23.0	25.2	43.0	-17.8	29.9	43.0	-13.1	32.7	43.0	-10.3	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	32.8	43.0	-10.2	31.8	43.0	-11.2
H263	19.9	43.0	-23.1	19.9	43.0	-23.1	19.9	43.0	-23.1	25.1	43.0	-17.9	29.8	43.0	-13.2	32.6	43.0	-10.4	32.7	43.0	-10.3	32.7	43.0	-10.3	32.7	43.0	-10.3	32.7	43.0	-10.3	32.7	43.0	-10.3	31.7	43.0	-11.3
H265	20.5	43.0	-22.5	20.5	43.0	-22.5	20.5	43.0	-22.5	25.7	43.0	-17.3	30.4	43.0	-12.6	33.2	43.0	-9.8	33.3	43.0	-9.7	33.3	43.0	-9.7	33.3	43.0	-9.7	33.3	43.0	-9.7	33.3	43.0	-9.7	32.3	43.0	-10.7
H267	20.8	43.0	-22.2	20.8	43.0	-22.2	20.8	43.0	-22.2	26.0	43.0	-17.0	30.7	43.0	-12.3	33.5	43.0	-9.5	33.6	43.0	-9.4	33.6	43.0	-9.4	33.6	43.0	-9.4	33.6	43.0	-9.4	33.6	43.0	-9.4	32.6	43.0	-10.4
H268	21.0	43.0	-22.0	21.0	43.0	-22.0	21.0	43.0	-22.0	26.2	43.0	-16.8	30.9	43.0	-12.1	33.7	43.0	-9.3	33.8	43.0	-9.2	33.8	43.0	-9.2	33.8	43.0	-9.2	33.8	43.0	-9.2	33.8	43.0	-9.2	32.8	43.0	-10.2
H315	23.6	43.0	-19.4	23.6	43.0	-19.4	23.6	43.0	-19.4	28.8	43.0	-14.2	33.5	43.0	-9.5	36.3	43.0	-6.7	36.4	43.0	-6.6	36.4	43.0	-6.6	36.4	43.0	-6.6	36.4	43.0	-6.6	36.4	43.0	-6.6	35.4	43.0	-7.6

The term L_p is used to denote the predicted noise level due to the operation of the proposed development

The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit

Construction and Decommissioning Effects

12.7.17 Primary activities creating noise during the construction period include the construction of the wind turbine bases, the erection of the wind turbines, the excavation of trenches for cables, and the construction of associated hardstands, access tracks and compounds. Noise from vehicles on public roads and access tracks would also arise due to the delivery of wind turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

12.7.18 The exact methodology and timing of construction activities have not yet been defined and a reliable assessment of expected construction noise levels is not possible as a result. However, as discussed in **Section 12.4**, works expected to be undertaken at or around the proposed wind turbine locations would occur at distances that are unlikely result in noise levels that would breach typical criteria at neighbouring residential properties in this regard.

12.7.19 The access route for the proposed development is expected to pass reasonably close to some residential properties and with some upgrade works to existing access tracks and public roads also expected to occur in close proximity to these residential properties. In these instances, the level of noise generated by construction works could be close to the limits defined as part of the 'ABC method' discussed earlier. As a result, typical construction noise mitigation measures are provided in **Section 12.8** which aim to minimise noise as far as reasonably practicable and/or reasonable.

12.7.20 The movement of additional vehicles, including heavy goods vehicles (HGVs), along public roads and access routes may well be noticeable to residents adjacent to these in terms of the noise and vibration generated by them. The resultant impacts on public roads, that are already well used by local traffic and existing HGV movements, would be relatively minor in terms of the increase in average noise levels resulting from the additional vehicles on the public roads. However, the individual events may well be noticeable to residents, with resulting levels for individual events being similar to that created by existing HGV movements. The resultant noise levels on parts of the route that are less well used by existing traffic would be noticeable to residents located along the route. However, the resultant noise and vibration levels from vehicles passing the dwellings would be unlikely to breach the adopted construction noise limits and accepted vibration thresholds.

12.7.21 The noise associated with blasting at 'borrow pit' locations may well be audible to neighbouring residents. However, the level of noise, overpressure and vibration generated by each blast would be well below levels that would be expected to cause damage to the nearest housing and/or structures. **Section 12.8** provides details as to standard mitigation measures to be incorporated into the blasting processes and may also be included within the CEMP.

12.8 Mitigation

Operational Noise

12.8.1 One of the key constraints and considerations in designing the layout of the wind turbines was the minimisation of potential noise impacts at the nearest residential receptors. As such the wind turbine layout was designed to ensure that there is an adequate separation distance between any of the proposed turbines and the nearest residential property.

12.8.2 Due to this consideration of the noise impacts in the design of the proposed development, by embedding mitigation measures in the wind turbine layout, when a conservative candidate machine is modelled this meets the noise limits derived in accordance with ETSU-R-97.

12.8.3 If planning permission is granted for the proposed development, planning conditions can be proposed to provide a degree of protection to nearby residents in the form of limits relating to noise level and tonality.

12.8.4 **Technical Appendix 12.7** contains a set of draft planning conditions relating to noise that the applicant considers appropriate.

Construction and Decommissioning Noise

12.8.5 For all activities, measures would be taken to reduce noise levels with due regard to practicality and cost as per the concept of 'best practicable means' as defined in Section 72 of the Control of Pollution Act 1974.

12.8.6 BS 5228-1:2009 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority is recommended along with steps to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on public roads and dust generation, would also be controlled through construction practices adopted on-site and managed via a Construction and Environmental Management Plan (CEMP).

12.8.7 Furthermore, the following noise mitigation options could be implemented where appropriate:

- Consideration would be given to noise emissions when selecting plant and equipment to be used on-site;
- All equipment should be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources would be sited as far away as reasonably possible from residential properties and where necessary and appropriate, acoustic barriers could be used to screen them; and
- The movement of vehicles to and from the proposed development would be controlled and employees instructed to ensure compliance with the noise control measures adopted.
- Site operations would be limited to 07:00-19:00 Monday to Saturday except during wind turbine /erection and commissioning or during periods of emergency work.

12.8.8 Should it be considered necessary to reduce noise levels further to adhere to the more stringent target level for Saturdays 13:00-19:00, the following mitigation measures would be considered:

- Reduce the number of construction activities occurring simultaneously;
- Restrict the distance of construction activity from nearby properties during these times; &
- Reduce construction traffic as appropriate.

12.8.9 There are many strategies to reduce construction noise by the limitation of activities that would result in predicted noise levels being lower than the specified targets. Any such measures should be considered adequate and the mitigation adopted should not be limited to the proposed measures.

12.8.10 With specific regard to blasting, it is proposed that the following mitigation measures are implemented:

- Good practice on blasting, as recommended by Planning Advice Note (PAN) 50 'Controlling the environmental effects of surface mineral workings'[22] shall be followed;
- The vibration and air overpressure reduction methods outlined in Section 8.6.9.2 of BS 5228-2:2009 shall be adhered to where appropriate;
- Advance warning shall be given to nearby residents;
- Blasting should only occur between the hours of 08:00-18:00 on Mondays-Fridays or between the hours of 08:00-13:00 on Saturdays; and
- No more than three blasts per day should occur.

12.8.11 Depending upon the charge sizes required it may be prudent to perform trial blasts with smaller amounts of explosive and measure vibration magnitudes at various distances to more accurately determine how vibration propagates at the proposed development.

12.8.12 As with operational noise, if planning permission is granted for the proposed wind farm, planning conditions can be proposed so that appropriate noise mitigation measures and construction practices are included within a CEMP.

12.9 Assessment of Residual Effects

Operational

12.9.1 The acoustic assessment demonstrates that predicted noise levels at residential properties do not exceed the derived noise limits. This should not be interpreted to mean that wind farm operational noise would be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable under ETSU-R-97 and associated guidance.

Construction

12.9.2 Noise and vibration during the construction and decommissioning of the proposed development may well be audible and/or perceptible to people residing in the area, but the levels would be below established noise limits and planning requirements in this respect due to the large distances between the site and the surrounding residential properties. Where construction noise relating to the provision of access to the site, including the upgrade of public roads and their use thereof, is expected to occur in close proximity to residential properties, enhanced mitigation measures would be adopted to reduce noise and vibration where necessary. The impacts resulting from blasting at borrow pits are only considered in terms of the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planned blasting activities, with no significant impacts being expected.

[22] 'Planning Advice Note 50: Controlling the environmental effects of surface mineral workings', Scottish Government, October 1996. Available at: https://www.gov.scot/publications/planning-advice-note-pan-50-controlling-environmental-effects-surface-mineral/

12.10 Assessment of Cumulative Effects

12.10.1 Cumulative noise impact from nearby wind farms that are operational, consented or in planning has been considered.

12.10.2 The operational Fallago Rig Wind Farm is located north-east from the proposed development. The proposed Dunside Wind Farm (ECU ref:ECU00003436) is located east of Fallago Rig Wind Farm.

12.10.3 At the time the acoustic assessment was undertaken no other operational, consented wind farms or wind farms in planning, that are close enough to the proposed development to create potential for cumulative effect on nearby properties were identified.

12.10.4 An investigation of nearby residential properties has been undertaken and no properties have been identified that may have cumulative impact on them from both wind farms.

12.10.5 As a result, no other wind farms have been considered in a cumulative operational or construction noise impact assessment.

12.11 Summary

12.11.1 The acoustic impact for the operation of the proposed development on nearby residential properties has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication 'The Assessment and Rating of Noise from Wind Farms', otherwise known as ETSU-R-97, and Institute of Acoustics Good Practice Guide (IoA GPG), as recommended for use by relevant planning policy.

12.11.2 To establish baseline conditions, background sound surveys were carried out at three nearby properties and the measured background sound levels used to determine appropriate noise limits, as specified by ETSU-R-97 and the IoA GPG.

12.11.3 Operational noise levels were predicted using the recommended noise propagation model. The predicted noise levels for the proposed development are within the derived noise limits at all considered wind speeds. The proposed development therefore complies with the relevant guidance on wind farm noise and the impact on the amenity of all nearby residential properties would be regarded as acceptable.

12.11.4 Construction noise has been discussed with reference to BS 5228 and it has been determined that on-site construction noise levels are highly unlikely to exceed typical limiting noise criteria at nearby residential properties although appropriate mitigation measures will be adopted as a matter of due course. The access route for the proposed development is expected to pass reasonably close to residential properties and with some upgrade works to existing access tracks and public roads potentially occurring in close proximity to some of these residential properties. In these instances, the level of noise generated by construction works could be close to typical limits for relatively brief periods. As a result, typical and enhanced construction noise mitigation measures are provided within the chapter which aim to minimise noise as far as reasonably practicable and/or reasonable.

12.11.5 Vibration and air overpressure due to blasting are not expected to have a significant impact on nearby residents should the mitigation measures described within the chapter be adopted.

12.11.6 The potential impact of the proposed development, along with the mitigation proposed and any residual impact, is summarised in **Table 12.18**.

Table 12.18: Summary of Potential Impacts, Mitigation and Residual Impacts

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/ Residual Impact
Operation			
Potential impact on residential amenity due to operational noise	The proposed development operating in isolation and cumulatively with other existing operational and proposed wind farm developments meet the limiting requirements of ETSU-R-97. As a result, no mitigation is required.	Not applicable	Not significant
Construction and Decommissioning			
Potential for noise and vibration to be created during general construction activities and by construction traffic	Due regard for 'best practicable means' (defined by Section 72 of the Control of Pollution Act 1974). A range of noise mitigation measures are proposed for the construction phase in accordance with measures outlined in BS 5228-1:2009. Site operations to be limited to 07:00 – 19:00 Mondays to Saturdays (except during wind turbine delivery/erection and	Noise mitigation measures would be implemented as part of the CEMP which would be required to be agreed as a condition of consent.	Not significant

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/ Residual Impact
	commissioning/periods of emergency work). Additional noise mitigation measures are proposed to reduce the acoustic impact of construction further during Saturdays 13:00-19:00. Good practice on blasting shall be followed along with guidance on blast frequency and timing.		

Glossary of Terms

Word	Definition
A-weighting	A frequency-response function providing good correlation with the sensitivity of the human ear.
Broadband Noise	Noise which covers a wide range of frequencies (see Frequency).
Decibel dB(A)	The decibel (dB) is a logarithmic unit used in acoustics to quantify sound levels relative to a 0dB reference (e.g. a sound pressure level of $2*10^{-5}$ Pa). The 'A' signifies A-weighting.
Equivalent Continuous Sound Level (L_{eq})	The equivalent continuous sound level is a notional steady noise level, which over a given time would provide the same energy as the intermittent noise.
Frequency	Refers to how quickly the air vibrates, or how close the sound waves are to each other and is measured in cycles per second, or Hertz (Hz). The lowest frequency audible to humans is 20Hz and the highest is 20,000Hz. The human ear is most sensitive to the 1kHz, 2kHz and 4kHz octave bands and much less sensitive at lower audible frequencies.
Frequency Spectrum	Description of the sound pressure level of a source as a function of frequency.
Percentile Sound Level (L_{90})	Sound pressure level exceeded for 90% of the time for any given time interval. For example, $L_{(A)90,10min}$ means the A-weighted level that is exceeded for 90% of a ten-minute interval. This indicates the noise levels during quieter periods, or the background noise level. It represents the lower estimate of the prevailing noise level and is useful for excluding such effects as aircraft or dogs barking on background noise levels.
Noise Emission	The noise energy emitted by a source (e.g. a wind turbine).
Noise Immission	The sound pressure level detected at a given location (e.g. nearest dwelling).
Octave Band	Range of frequencies between one frequency ($f_0*2^{-1/2}$) and a second frequency ($f_0*2^{+1/2}$). The quoted centre frequency of the octave band is f_0.
Sound Power Level	Sound power level is the acoustic power radiated from a sound source and is independent of the surroundings. It is a logarithmic measure in comparison to a reference level (10^{-12} watts).
Sound Pressure Level	A logarithmic measure of the effective sound pressure of a sound relative to a reference value which is for minimum audible field conditions ($20*10^{-6}$Pa).
Third Octave Band	The range of frequencies between one frequency ($f_0*2^{-1/6}$) and a second frequency equal to ($f_0*2^{+1/6}$). The quoted centre frequency of the third octave band is f_0.
Tonal Noise	A noise that contains a noticeable or discrete, continuous note and includes noises such as hums, hisses, screeches.