HOARE LEA

Arecleoch Windfarm Extension.
Technical Appendix 13.1: Environmental noise assessment.

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Contents.

Overall Summary

Hoare Lea (HL) have been commissioned by SLR Consulting Limited to undertake a noise assessment for the construction and operation of the proposed Arecleoch Windfarm Extension. Noise will be emitted by equipment and vehicles used during construction of the windfarm and by the turbines during operation. The level of noise emitted by the sources and the distance from those sources to the receiver locations are the main factors determining levels of noise at receptor locations.

Construction Noise

Construction noise has been assessed by a desk based study of a potential construction programme and by assuming the windfarm is constructed using standard and common methods. Noise levels have been calculated for receiver locations closest to the areas of work and compared with guideline and baseline values. Construction noise, by its very nature, tends to be temporary and highly variable and therefore much less likely to cause adverse effects. Various mitigation methods have been suggested to reduce the effects of construction noise, the most important of these being suggested restrictions of hours of working. It is concluded that noise generated through construction activities will have a slight effect.

Operational Noise

Operational turbines emit noise from the rotating blades as they pass through the air. This noise can sometimes be described as having a regular 'swish'. The amount of noise emitted tends to vary depending on the wind speed. When there is little wind, the turbine rotors will turn slowly and produce lower noise levels than during high winds when the turbine reaches its maximum output and maximum rotational speed. Background noise levels at nearby properties will also change with wind speed, increasing in level as wind speeds rise due to wind in trees and around buildings, etc.

Noise levels from operation of the turbines have been predicted for those locations around the Site most likely to be affected by noise. Surveys have been performed to establish existing baseline noise levels at a number of these properties, in addition to reference to historical measured data. Noise limits have been derived from data about the existing noise environment following the method stipulated in national planning guidance. Predicted noise levels take full account of the potential combined effect of the noise from the proposed Development along with the operational Arecleoch, Kilgallioch and Mark Hill Windfarms, as well as the consented Chirmorie Windfarm. Other, more distant windfarms were not considered as they do not make an acoustically relevant contribution to cumulative noise levels.

Predicted operational noise levels have been compared to the limit values to demonstrate that turbines of the type and size which would be installed can operate within the limits so derived. It is concluded therefore that operational noise levels from the windfarm will be within levels deemed, by national guidance, to be acceptable for wind energy schemes.

This Summary contains an overview of the noise assessment and its conclusions. No reliance should be placed on the content of this Summary until this report has been read in its entirety.

1. Introduction

1.1.1 This Technical Appendix presents an assessment of the potential construction and operational noise effects of the Arecleoch Windfarm Extension (the proposed Development) on the residents of nearby dwellings. The assessment considers both the construction and operation of the proposed Development. Assessment of the operational noise effects accounts for the cumulative effect of the proposed Development as well as other windfarms nearby. Other windfarms considered were those closest and consisted of: the operational Arecleoch, Kilgallioch and Mark Hill Windfarms, as well as the consented Chirmorie Windfarm. Other, more distant windfarms were not considered because as their potential noise contribution was considered negligible.

1.1.2 Noise and vibration which arises from the construction of a windfarm is a factor which should be taken into account when considering the total effect of the proposed Development. However, in assessing the effects of construction noise, it is accepted that the associated works are of a temporary nature. The main work locations for construction of the turbines are distant from nearest noise sensitive residences and are unlikely to cause significant effects. The construction/upgrading and use of access tracks may, however, occur at lesser separation distances. Assessment of the temporary effects of construction noise is primarily aimed at understanding the need for dedicated management measures and, if so, the types of measures that are required Further details of relevant working practices, traffic routes, and proposed working hours are described in the relevant chapters of the EIA Report.

1.1.3 Once constructed and operating, wind turbines may emit two types of noise. Firstly, aerodynamic noise is a 'broad band' noise, sometimes described as having a characteristic modulation, or 'swish', which is produced by the movement of the rotating blades through the air. Secondly, mechanical noise may emanate from components within the nacelle of a wind turbine. This is a less natural sounding noise which is generally characterised by its tonal content. Traditional sources of mechanical noise comprise gearboxes or generators. Due to the acknowledged lower acceptability of tonal noise in otherwise 'natural' noise settings such as rural areas, modern turbine designs have evolved to minimise mechanical noise radiation from wind turbines. Aerodynamic noise tends to be perceived when the wind speeds are low, although at very low wind speeds the blades do not rotate or rotate very slowly and so, at these wind speeds, negligible aerodynamic noise is generated. In higher winds, aerodynamic noise is generally masked by the normal sound of wind blowing through trees and around buildings. The level of this natural 'masking' noise relative to the level of wind turbine noise determines the subjective audibility of the windfarm. The relationship between wind turbine noise and the naturally occurring masking noise at residential dwellings lying around the proposed Development will therefore generally form the basis of the assessment of the levels of noise against accepted standards.

1.1.4 An overview of environmental noise assessment and a glossary of noise terms are provided in Annex A.

2. Policy and guidance documents

2.1 Planning policy and advice relating to noise

2.1.1 Scottish Planning Policy (SPP)[i] provides advice on how the planning system should manage the process of encouraging, approving and implementing renewable energy proposals including onshore windfarms. Whilst SPP suggests noise impacts are one of the aspects that will need to be considered it provides no specific advice. Planning Advice Note PAN1/2011[ii] provides general advice on the role of the planning system in preventing and limiting the adverse effects of noise without prejudicing investment in enterprise, development and transport. PAN1/2011 provides general advice on a range

of noise related planning matters, including references to noise associated with both construction activities and operational windfarms. In relation to operational noise from windfarms, Paragraph 29 states that:

> *'There are two sources of noise from wind turbines - the mechanical noise from the turbines and the aerodynamic noise from the blades. Mechanical noise is related to engineering design. Aerodynamic noise varies with rotor design and wind speed, and is generally greatest at low speeds. Good acoustical design and siting of turbines is essential to minimise the potential to generate noise. Web based planning advice on renewable technologies for Onshore wind turbines provides advice on 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) published by the former Department of Trade and Industry [DTI] and the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise.'*

2.1.2 The Scottish Government's Online Renewables Planning Advice on Onshore wind turbines[iii] provides further advice on noise, and confirms that the recommendations of 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97)[iv] "*should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments*". The aim of ETSU-R-97 is:

> *'This document describes a framework for the measurement of wind farm noise and gives 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. The suggested noise limits and their reasonableness have been evaluated with regard to regulating the development of wind energy in the public interest. They have been presented in a manner that makes them a suitable basis for noise-related planning conditions or covenants within an agreement between a developer of a wind farm and the local authority.'*

2.1.3 The recommendations contained in ETSU-R-97 provide a robust basis for assessing the noise implications of a windfarm. ETSU-R-97 has become the accepted standard for such developments within the UK. Guidance on good practice on the application of ETSU-R-97 has been provided by the Institute of Acoustics (IOA Good Practice Guide or GPG)[v]. This was subsequently endorsed by the Scottish Government[vi] which advised in the web based planning advice note that this *'should be used by all IOA members and those undertaking assessments to ETSU-R-97',* The methodology of ETSU-R-97 and the IOA GPG has therefore been adopted for the present assessment and is described in greater detail below.

2.1.4 With regard to infrasound and low-frequency noise, the above-referenced online planning advice note, Onshore wind turbines refers to a report for the UK Government which concluded that *'there is no evidence of health effects arising from infrasound or low frequency noise generated by the wind turbines that were tested'.*

2.1.5 PAN1/2011 and the Technical Advice Note[vii] accompanying PAN1/2011 note that construction noise control can be achieved through planning conditions that limit noise from temporary construction-sites, or by means of the Control of Pollution Act (CoPA) 1974[viii]. The CoPA provides two means of controlling construction noise and vibration. Section 60 provides the Local Authority with the power to impose at any time operating conditions on the Site. Section 61 allows the developer to negotiate a prior consent for a set of operating procedures with the Local Authority before commencement of site works.

2.1.6 For detailed guidance on construction noise and its control, the Technical Advice Note refers to British Standard BS 5228[ix] 'Noise control on construction and open sites', Parts 1 to 4 but confirms that the updated version of this standard, published in January 2009 is relevant when used within the planning process. The 2009 version consolidates all previous parts of the standard into BS 5228-1: 2009 (amended 2014)[x] (BS 5228-1) for airborne noise and BS 5228-2: 2009 (amended

2014)[xi] (BS 5228-2) for ground-borne vibration. These updated versions have therefore been adopted as the relevant versions upon which to base this assessment.

2.1.7 BS 5228-1 provides guidance on a range of considerations relating to construction noise including the legislative framework, general control measures, example methods for estimating construction noise levels and example criteria which may be considered when assessing effect significance. Similarly, BS 5228-2 provides general guidance on legislation, prediction, control and assessment criteria for construction vibration.

2.1.8 Planning Advice Note PAN50[xii] "Controlling the Environmental Effects of Surface Mineral Workings" gives guidance on the environmental effects of mineral working. The main document summarises the key issues with regard to various environmental effects relating to surface mineral extraction and processing such as road traffic, blasting, noise, dust, visual intrusion etc. In addition, several annexes to the main document have been published which consider specific aspects in more detail: Annex A, "The Control of Noise at Surface Mineral Workings" and Annex D "The Control of Blasting at Surface Mineral Workings". BS 5228-1 and BS 5228-2 also provide guidance relating to surface mineral extraction including the assessment of noise and vibration effects associated with quarry blasting. BS 6472-2 2008[xiii] gives similar guidance on assessing vibration from blasting associated with mineral extraction.

3. Scope and Methodology

3.1 Methodology for assessing construction noise

3.1.1 Construction works include both moving sources and static sources. The moving sources normally comprise mobile construction plant and Heavy Goods Vehicles (HGVs). The static sources include construction plant temporarily placed at fixed locations and in some instances noise arising from blasting activities where rock is to be worked through.

3.1.2 The analysis of construction noise has been undertaken in accordance with BS 5228-1 which provides methods for predicting construction noise levels on the basis of reference data for the emissions of typical construction plant and activities. These methods include for the calculation of construction traffic along access tracks and haul routes and also for construction activities at fixed locations such as the bases of turbines, site compounds or sub stations.

3.1.3 The BS 5228 calculated levels are then compared with absolute noise limits for temporary construction activities which are commonly regarded as providing an acceptable level of protection from the short-term noise levels associated with construction activities.

3.1.4 Separate consideration is also given to the possible noise impacts of construction related traffic passing to and from the Site along local surrounding roads. In considering potential noise levels associated with construction traffic movement on public roads, reference is made to the accepted UK prediction methodology provided by 'Calculation of Road Traffic Noise'[xiv] (CRTN).

3.1.5 The nature of works and distances involved in the construction of a windfarm are such that the risk of significant effects relating to ground borne vibration are very low (excluding blasting). Occasional momentary vibration can arise when heavy vehicles pass dwellings at very short separation distances, but again this is not sufficient to constitute a risk of significant impacts in this instance. Accordingly, vibration impacts do not warrant detailed assessment and are therefore not discussed further in this assessment.

3.1.6 It is anticipated that some rock extraction from borrow pits by means of blasting operations could be required in some instances. The analysis of the related potential impacts has been made in accordance with PAN50, BS 6472-2 2008 and BS 5228.

3.2 Methodology for assessing windfarm operational noise

3.2.1 The ETSU-R-97 assessment procedure specifies that noise limits should be set relative to existing background noise levels at the nearest properties and that these limits should reflect the variation in both turbine source noise and background noise with wind speed. The wind speed range which should be considered is between the cut-in speed (the speed at which the turbines begin to operate) for the turbines and 12 m/s (43.2 km/h), where all wind speeds are referenced to a ten metre measurement height (refer to Annex F for a discussion of how wind speeds are referenced to ten metre height).

3.2.2 Separate noise limits apply for the day-time and night-time. Day-time limits are chosen to protect a property's external amenity whilst outside their dwellings in garden areas and night-time limits are chosen to prevent sleep disturbance indoors. Absolute lower limits, different for day-time and night-time, are applied where the line of best-fit representation of the measured background noise levels equates to very low levels (< 30 dB(A) to 35 dB(A) for day-time, and < 38 dB(A) during the night).

3.2.3 The day-time noise limit is derived from background noise data measured during the 'quiet periods of the day' defined in ETSU-R-97: these comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). Multiple samples of ten-minute background noise levels using the $L_{A90,10min}$ measurement index are measured contiguously over a wide range of wind speed conditions (a definition of the $L_{A90,10min}$ index is given in Annex A). The measured noise levels are then plotted against the simultaneously measured wind speed data and a 'best-fit' curve is fitted to the data to establish the background noise level as a function of wind speed. The ETSU-R-97 day-time noise limit is then set to the greater of either: a level 5 dB(A) above the best-fit curve to the background noise data over a 0-12 m/s wind speed range or a fixed level in the range 35 dB(A) to 40 dB(A). The precise choice of the fixed lower limit within the range 35 dB(A) to 40 dB(A) depends on a number of factors: the number of noise affected properties, the likely duration and level of exposure and the consequences of the choice on the potential power generating capability of the windfarm.

3.2.4 ETSU-R-97 clearly indicates that the day-time limit is intended to lie within the range from 35 dB(A) to 40 dB(A). Therefore one can conclude that there must be projects where 35 dB(A) is appropriate and conversely, projects where 40 dB(A) is appropriate. Within ETSU-R-97 there is a specific example: *"A single wind turbine causing noise levels of 40 dB(A) at several nearby residences would have less planning merit (...) than 30 wind turbines also causing the same amount of noise at several nearby residences"*. Therefore, where a project offers relatively low power generating potential, the day-time limit should naturally tend towards the lower end of the range, unless the number of noise affected properties and the extent to which those properties would be affected by the higher noise levels is sufficiently low to justify noise limits tending towards the upper end of the range. Conversely, sites with relatively large power generating capacity should naturally justify limits towards the upper end of the range. Given the relatively large energy generating potential of the proposed Development and the scale of cumulative wind development in the area, the limit should be set at the upper end of the 35 dB(A) to 40 dB(A) range. The appropriate choice of value is considered below in this Report.

3.2.5 The night-time noise limit is derived from background noise data measured during the night-time periods (23:00 to 07:00) with no differentiation being made between weekdays and weekends. The ten minute $L_{A90,10min}$ noise levels measured over these night-time periods are again plotted against the concurrent wind speed data and a 'best-fit' correlation is established. As with the day-time limit, the

night-time noise limit is also set as the greater of: a level 5 dB(A) above the best-fit background curve or a fixed level of 43 dB(A). This fixed lower night-time limit of 43 dB(A) was set in ETSU-R-97 on the basis of World Health Organization (WHO) guidance[xv] for the noise inside a bedroom and an assumed difference between outdoor and indoor noise levels with windows open. In the time since ETSU-R-97 was released, the WHO guidelines were revised to suggest a lower internal noise level, but conversely, a higher assumed difference between outdoor and indoor noise levels. Notwithstanding the WHO guideline revisions, the ETSU-R-97 limit remains consistent with current national planning policy guidance with respect to night-time noise levels. In addition, following revision of the night-time WHO criteria, ETSU-R-97 has been incorporated into planning guidance for Wales, England and Scotland and at no point during this process was it felt necessary to revise the guidance within ETSU-R-97 to reflect the change in the WHO guideline internal levels. The advice contained within ETSU-R-97 remains a valid reference on which to continue to base the fixed limit at night.

3.2.6 The exception to the setting of both the day-time and night-time lower fixed limits occurs in instances where a property occupier has a financial involvement in the windfarm development. Where this is the case then the lower fixed portion of the noise limit at that property may be increased to 45 dB(A) during both the day-time and the night-time periods alike.

3.2.7 ETSU-R-97 also offers an alternative simplified assessment methodology:

> *'For single turbines or wind farms with very large separation distances between the turbines and the nearest properties a simplified noise condition may be suitable. We are of the opinion that, if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10m/s at 10m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.'*

3.2.8 The noise limits defined in ETSU-R-97 relate to the total noise occurring at a dwelling due to the combined noise of all operational wind turbines. The assessment will therefore need to consider the combined operational noise of the proposed Development with other windfarms in the area to be satisfied that the combined cumulative noise levels are within the relevant ETSU-R-97 criteria. ETSU-R-97 also requires that the baseline levels on which the noise limits are based do not include a contribution from any existing turbine noise, to prevent unreasonable cumulative increases.

3.2.9 To undertake the assessment of noise effects in accordance with the foregoing methodology the following steps are required:

- specify the number and locations of the wind turbines on all windfarms;
- identify the locations of the nearest, or most noise sensitive, neighbours;
- measure the background noise levels as a function of site wind speed at the nearest neighbours, or at least at a representative sample of the nearest neighbours;
- determine the day-time and night-time noise limits from the measured background noise levels at the nearest neighbours;
- specify the type and noise emission characteristics of the wind turbines;
- calculate the noise immission levels due to the operation of the wind turbines as a function of site wind speed at the nearest neighbours; and
- compare the calculated windfarm noise immission levels with the derived noise limits and assess in the light of planning requirements.

3.2.10 The foregoing steps, as applied to the proposed Development, are set out subsequently in this assessment.

3.2.11 Note that in the above, and subsequently in this assessment, the term 'noise emission' relates to the sound power level actually radiated from each wind turbine, whereas the term 'noise immission' relates to the sound pressure level (the perceived noise) at any receptor location due to the combined operation of all wind turbines on the proposed Development.

3.3 Construction Noise Criteria

3.3.1 BS 5228-1 indicates a number of factors are likely to affect the acceptability of construction noise including site location, existing ambient noise levels, duration of site operations, hours of work, attitude of the Site operator and noise characteristics of the work being undertaken.

3.3.2 BS 5228-1 informative Annex E provides example criteria that may be used to consider the significance of any construction noise effects. The criteria do not represent mandatory limits but rather a set of example approaches intended to reflect the type of methods commonly applied to construction noise. The example methods are presented as a range of possible approaches (both facade and free field noise levels, hourly and day-time averaged noise levels) according to the ambient noise characteristics of the area in question, the type of development under consideration, and the expected hours of construction activity. In broad terms, the example criteria are based on a set of fixed limit values which, if exceeded, may result in a significant effect unless ambient noise levels (i.e. regularly occurring levels without construction) are sufficiently high to provide a degree of masking of construction noise.

3.3.3 Based on the range of guidance values set out in BS 5228 Annex E, and other reference criteria provided by the World Health Organization (WHO) and PAN50 Annex A: The Control of Noise at Surface Mineral Workings (1996), the following significance criteria have been derived. The values have been chosen in recognition of the relatively low ambient noise typically observed in rural environments. The presented criteria have been normalised to free-field day-time noise levels occurring over a time period, T, equal to the duration of a working day on-site. BS 5228-1 Annex E provides varied definitions for the range of day-time working hours which can be grouped for equal consideration. The values presented in Table 1 have been chosen to relate to day-time hours from 07:00 to 19:00 on weekdays, and 07:00 to 13:00 on Saturdays.

Table 1 - Free-field noise criteria against which construction noise effects are assessed

Significance	Condition
Major	Construction noise is greater than 72 dB $L_{Aeq,T}$ for any part of the construction works or exceeds 65 dB $L_{Aeq,T}$ for more than 4 weeks in any 12 month period
Moderate	Construction noise is less than or equal to 65 dB $L_{Aeq,T}$ throughout the construction period, with periods of up to 72dB $L_{Aeq,T}$ lasting not more than 4 weeks in any 12 month period.
Slight	Construction noise is generally less than or equal to 60 dB $L_{Aeq,T}$, with periods of up to 65 dB $L_{Aeq,T}$ lasting not more than 4 weeks in any 12 month period
Negligible	Construction noise is generally less than or equal to 55 dB $L_{Aeq,T}$, with periods of up to 60 dB $L_{Aeq,T}$ lasting not more than 4 weeks in any 12 month period

3.3.4 When considering the impact of short-term changes in traffic, associated with the construction activities, on existing roads in the vicinity of the Project, reference can be made to the criteria set out in the Design Manual for Roads and Bridges (DMRB[xvi]). A classification of magnitudes of changes in the predicted traffic noise level calculated using the CRTN methodology is set out: for short-term changes such as those associated with construction activities, changes of less than 1 dB(A) are considered negligible, 1 to 3 dB(A) is slight, 3 to 5 dB(A) moderate and changes of more than 5 dB(A) constitute a major impact. This classification can be considered in addition to the criteria of Table 1.

3.3.5 Blasting operations can generate airborne pressure waves or "air overpressure". This covers both those pressure waves generated which are in the frequency range of human audibility (approximately 20 Hz to 20 kHz) as well as infrasonic pressure waves (those with a frequency of below 20 Hz), which, although outside the range of human hearing, can sometimes be felt.

3.3.6 Noise from blasting (i.e. pressure waves in the human audible range) is not considered in the same way as noise from other construction activities due to the fact that a large proportion of the energy contained within pressure waves generated by a blast is at frequencies that are below the lower frequency threshold of human hearing, and that the portion of energy contained within the audible range is generally of low frequency and of smaller magnitude than the infrasonic pressure variations.

3.3.7 The relevant guidance documents advise controlling air overpressure (and hence noise from blasting) through the use of good practices during the setting and detonation of charges as opposed to absolute limits on the levels produced, therefore no absolute limits for air overpressure or noise from blasting will be presented in this assessment.

3.3.8 In accordance with the guidance in PAN50 Annex D, ground vibration caused by blasting operations will be considered acceptable if peak particle velocity (PPV) levels, at the nearest sensitive locations, do not exceed 6 mm/s for 95% of all blasts measured over any 6-month period, and no individual blast exceeds a PPV of 12 mm/s.

3.4 Operational Noise Criteria

3.4.1 The acceptable limits for wind turbine operational noise are clearly defined in the ETSU-R-97 document and these limits should not be breached. Consequently, the test applied to operational noise is whether or not the calculated windfarm noise immission levels at nearby noise sensitive properties lie below the noise limits derived in accordance with ETSU-R-97. Depending on the levels of background noise the satisfaction of the ETSU-R-97 derived limits can lead to a situation whereby, at some locations under some wind conditions and for a certain proportion of the time, the windfarm noise may be audible. However, noise levels at the properties in the vicinity of the proposed Development will still be within levels considered acceptable under the ETSU-R-97 assessment method.

3.5 Consultation

3.5.1 Prior to undertaking the background surveys, a summary[xvii] of the proposed monitoring locations and the approach to the assessment of baseline and operational noise levels was forwarded to the Environmental Health Department of South Ayrshire Council (SAC) for comment. This consultation was based on a preliminary project layout which was of a similar form to the layout currently proposed. This led to further consultation with SAC and their appointed noise consultant, ACCON. The proposed approach to the baseline assessment was agreed with ACCON, and is discussed further in the following section. ACCON also made a number of observations and recommendations which were taken into account in the present assessment.

3.5.2 SAC have published a Planning Submission Guidance Note (PSGN) on Wind Turbine Development which sets out information required for the assessment of the noise impacts for wind turbine developments as well as specific guidance. The present report sets out the technical information on noise required in the PSGN. It is noted that the SAC PSGN recommends generic noise limits at the lower end of the range in ETSU-R-97 for day-time periods (although this can be relaxed in the cumulative case) and night-time lower limits lower than those set out in ETSU-R-97. At the same time, ACCON acknowledges that limits at the upper end of the recommended range would be applicable in this case, given the amount of other windfarm developments in the area. In addition, the generic SAC PSGN is not consistent with existing consents for several neighbouring windfarms including the Arecleoch Windfarm, to which the proposed Development forms an extension. It is

therefore concluded that the generic noise limits in the SAC PSGN are not applicable to the proposed Development.

4. Baseline

4.1 General Description

4.1.1 The proposed Development will cover an area extending approximately 4 kilometres north to south and 2 kilometres west to east and is located in an area of relatively low population density. The noise environment in the surrounding area is generally characterised by 'natural' sources, such as wind disturbed vegetation, birds, farm animals. Other sources of noise include intermittent local road and agricultural vehicle movements in the area, as well as noise from existing operating windfarms in the area.

4.2 Details of the Baseline Background Noise Survey

4.3 It was determined during preliminary studies that background noise data was already measured at a number of locations of interest to support the Arecleoch Windfarm application: see Table 2. These locations are also marked on the plan of Figure 13.1. Conducting new measurements at some of these locations would be difficult as they may be clearly influenced by turbine noise, given their relative proximity: this would not be in line with ETSU-R-97. Furthermore, the underlying baseline noise environment (excluding the turbine noise) is expected to be relatively unchanged at these locations, thereby meaning there would be limited use in undertaking new measurements at these properties.

Table 2 – Historical background noise monitoring locations (approximate easting / northing)

No.	Property	Easting	Northing	Mast referenced
1	Chirmorrie	220829	576943	Shiel Hill
2	Laggish	223127	578220	Railway bridge
3	Kilrenzie	217801	583501	Railway bridge
4	Ward of Cairnlea	222658	581609	Railway bridge

4.4 The noise monitoring at the locations of Table 2 was referenced to wind speeds measured at 10 m height above the ground. Therefore, in accordance with good practice, corrections were applied to relate the measurements to wind speeds at a reference representative of the turbines of the proposed Development: see Annex F for details. The resulting original and corrected derived background noise curves are also illustrated in the relevant charts of Annex E.

4.5 To supplement the historical data measured at the properties of Table 2, a total of 5 additional noise monitoring locations were determined in consultation with the Local Authority. These properties are considered representative of the background noise environment for the other residences of interest in and around Barrhill. The five locations are shown on the plan of Figure 13.1 and are listed in

Table 3. The met mast which was used to analyse the measurements is also shown (see Annex F for further details).

Table 3 - Background noise monitoring locations (approximate easting / northing)

No.	Property	Easting	Northing	Mast referenced
1	East Altercannoch	223731	580935	Railway Bridge
2	Brooklyn	223711	581745	Railway Bridge
3	4 Gowland Terrace	223243	582217	Shiel Hill
4	Queensland Caravan Park	221814	583389	Shiel Hill
5	White Cairn	222270	582601	Shiel Hill

4.5.1 Table 4 lists the receptor locations considered in the assessment of operational noise for the proposed Development. Please note that it is not intended to be exhaustive but sufficient to be representative of noise levels typical of those receptors closest to the proposed Development. The results obtained from the survey positions of Tables 2 and 3 have been used to represent the background environment expected to occur at the assessment locations of Table 4. The use of the data is consistent with the guidance provided by ETSU-R-97 and current good practice as set out in the IOA GPG. Locations where such representations have been made, and the source of the representations, are represented in Table 4.

4.5.2 It was determined (based on an earlier iteration of the proposed Development) that a detailed study of the noise effects of the proposed Development at other, more distant receptors would not be required, either because of large separating distance resulting in very low levels being likely (*i.e.* cumulative levels likely below 35 dB L_{A90}, the simplified noise limit in ETSU-R-97) or because the predicted noise from the proposed extension would be relatively negligible (*i.e.* 10 dB lower or more) compared to existing and/or consented sites.

Table 4 - Assessment properties in the vicinity of the windfarm

Property	Easting	Northing	Approximate Distance to Closest Turbine (m)	Closest Development Turbine (ID)	Survey Location
Balkissock	214111	582010	3820	4	Kilrenzie
Bellimore-on-Tig	214900	582900	3100	4	Kilrenzie
Bents Farm*	221176	583628	2670	2	Queensland Caravan Park
Brooklyn	223714	581742	3980	9	Brooklyn
Cairnlea	222470	581788	2780	1	Ward of Cairnlea
Chirmorrie**	220829	576943	2230	13	Chirmorrie
Craigengells	221845	583298	2980	2	Queensland Caravan Park
Dochroyle Cottage	223088	579112	2960	13	Chirmorrie
Dochroyle Farm	223105	579237	2980	13	Chirmorrie

Property	Easting	Northing	Approximate Distance to Closest Turbine (m)	Closest Development Turbine (ID)	Survey Location
Duisk Lodge	222622	582897	3360	1	Queensland Caravan Park
East Altercannoch	223729	580939	3790	9	East Altercannoch
Farden	219373	583713	1860	3	Kilrenzie
Ferngate Cottage	222616	581464	2860	9	Ward of Cairnlea
Glenour***	217250	583100	1130	4	Kilrenzie
Gowlands	223111	582162	3500	1	4 Gowland Terrace
Gowlands Terrace	223203	582210	3600	1	4 Gowland Terrace
Kildonan Courtyard	222366	583156	3300	1	Queensland Caravan Park
Kilrenzie	217794	583411	1220	4	Kilrenzie
Laggish	223141	578208	3130	13	Laggish
Laigh Altercannoch	223820	581599	4030	9	Brooklyn
Queensland Caravan Park	221680	583374	2880	2	Queensland Caravan Park
Scaurhead	222736	582706	3360	1	Queensland Caravan Park
The Craigs	223624	581839	3920	1	Brooklyn
The Manse	223053	582496	3560	1	Queensland Caravan Park
Ward of Cairnlea	222696	581542	2960	1	Ward of Cairnlea
West Altercannoch	223450	581200	3570	9	East Altercannoch
Wheeb	217206	583624	1590	4	Kilrenzie
White Cairn	222238	582574	2870	1	White Cairn

** Bents Farm is financially involved with the proposed Development.

** As part of the consent for the Chirmorie Windfarm, it was agreed that, if that Windfarm is constructed, the Chirmorrie property would become unoccupied.

*** We understand the Glenour property is currently unoccupied and on the register for buildings at risk. It has nevertheless been considered in this assessment.

4.5.3 The background noise monitoring exercise was conducted over a period of around 6 weeks. The equipment used for the survey comprised three Rion NL-31/32 and two Rion NL-52 logging sound level meters. All meters were enclosed in environmental cases with battery power to enable around 2 weeks continuous logging at the required ten-minute averaging periods. Outdoor enhanced windshield systems were used to reduce wind induced noise on the microphones and provide protection from rain. These windshield systems were supplied by the sound level meter manufacturer and maintain the required performance of the whole measurement system when fitted. The

environmental enclosures provided an installed microphone height of approximately 1.2 to 1.5 metres above ground level, consistent with the requirements of ETSU-R-97.

4.5.4 The sound level meters were located in accordance with good practice guidance, never closer than 3.5 metres from the façade of the property and as far away as was practical from obvious atypical localised sources of noise such as running water, trees or boiler flues. Details and photographs of the measurement locations are presented in Annex C.

4.5.5 All measurement systems were calibrated on their deployment on 27/11/2018, during a service visit on 13/12/2019 and upon collection of the equipment on 08/01/2019. No acoustically important (>0.5 dB(A)) drifts in calibration were found to have occurred on any of the systems. A total ETSU-R-97 analysis period of 19 to 40 days was achieved at the different locations, which is in excess of the minimum of one week suggested by ETSU-R-97. The resulting extent of the survey data is compliant with the IOA GPG requirements.

4.5.6 All measurement systems were set to log the $L_{A90,10min}$ and $L_{Aeq,10min}$ noise levels continuously over the deployment period. The internal clocks on the sound level meters were all synchronized with Greenwich Mean Time (GMT) by the use of a Global Positioning System (GPS) receiver. The clock on the met mast from which wind data was subsequently collected for the analysis of the measured background noise as function of wind speed was also set to GMT. Local time (in this case identical to GMT) was used to define day-time and night-time periods in the analysis.

4.6 Measured Background Noise Levels

4.6.1 The ETSU-R-97 assessment method requires noise data to be related to wind speed data at a standardised height of ten metres, with wind speeds either directly measured at a height of ten metres or by calculation from measurement at other heights, the appropriate choice being determined by practitioner judgement and the available data sources. Since the publication of ETSU-R-97, the change in wind speed with increasing height above ground level has been identified as a potential source of variability when carrying out windfarm noise assessments.

4.6.2 The effect of site specific wind shear can be appropriately addressed by implementing the ETSU-R-97 option of deriving ten metre height reference data from measurements made at taller heights. It is this method that has been used for the new measurements at the locations of Table 3 to account for the potential effect of site-specific wind shear. This method is consistent with the preferred method described in the IOA GPG. Wind speeds were measured on two meteorological masts located within the boundary of the Site. Values of wind speed at a standardised height of ten metres were calculated from those measured on the tall mast ("standardised wind speed"). Full details of the calculation method are given in Annex F.

4.6.3 Figures D1 to D4 reproduced at Annex D show the range of wind conditions experienced during the 2018-2019 noise survey period. During the quiet day-time and night-time periods wind speeds of up to 14 m/s were experienced. The wind was observed to be directed from the south west or south-east for the majority of the survey period, the former being consistent with the typical prevailing wind direction for the UK. Few northerly winds were experienced during this survey period.

4.6.4 Figures E1 to E10 of Annex E show the results of the background noise measurements at each of the five locations of Table 3. The background noise data are presented in terms of $L_{A90,10min}$ background noise levels plotted as a function of ten metre height wind speed. Two plots are shown for each location, one for quiet day-time periods and the other for night-time periods, both derived in accordance with ETSU-R-97.

4.6.5 Data from all survey locations were inspected to identify periods which may have been influenced by extraneous noise sources, giving rise to atypical and elevated levels. ETSU-R-97 requires that any data affected by rainfall be excluded from the analysis. A rain gauge was installed at Brooklyn during

the noise survey period; data from this gauge were therefore used to exclude those periods where rain was indicated.

4.6.6 In addition to the impact noise on surrounding vegetation and the sound level meter itself, in some environments rainfall can result in appreciable changes in background sound levels, for example as a result of wet roads which increase tyre noise emissions or dissipating flow noise in water courses and drainage systems. Observations whilst on-site indicated the influence of traffic noise was minimised and therefore a low influence on background sound levels, and thus the possible effect of increased tyre noise from wet roads is not considered relevant to this site. In terms of water flow noise, the influence of water courses was also minimised at the chosen monitoring locations. The monitoring locations were also positioned as far as practically possible from any residential drainage systems to minimise any associated noise influence. Based on the above, rainfall is considered to have a limited effect on background sound levels. Inspection of the data generally tends to support this, given the absence of any identifiable clear data trends that are normally characteristic of a site affected by rain related background sound levels (such as flat clusters of data on the noise versus wind plot, or sharp increases in noise followed by a progressive decrease with time).

4.6.7 The measured background noise data may also have been increased by other extraneous sources or atypical events. The trend of the data when plotted against wind speed was inspected to look for atypical relationships or outliers within the data-set (particularly at low wind speeds) which were excluded. Any data removed from the analysis in this way is detailed in Annex C and indicated on the charts as red circles. The analysis and filtering of the data was therefore undertaken in accordance with current good practice as set out in the IOA GPG.

4.6.8 Although the survey period included the Christmas and New Year period, which may not necessarily be considered typical, a review determined that including these periods in the analysis resulted in lower noise levels and was therefore conservative.

4.6.9 Mark Hill Windfarm is located approximately 2 km to the north of the survey locations. As ETSU-R-97 requires measurements not to be influenced by existing operational windfarms, the potential for the chosen locations to be influenced by the windfarm in northerly winds, in which they would be downwind of this windfarm, was investigated. But the survey period experienced very limited northerly wind conditions, as shown in Annex D. Furthermore, excluding northerly winds did not result in a strong effect, or even to increased noise levels in some cases, and therefore no related exclusions were undertaken. Other operational windfarms to the south or south-east are located more than 4 km south of the measurements locations of Table 3 and were therefore unlikely to have had a clear effect on the measurements.

4.6.10 Following removal of those data points, best-fit lines were generated using a polynomial fit of a maximum of 4th order. These lines of best-fit were then used to derive the noise limits required by ETSU-R-97 that apply during the day-time and night-time periods up to 12 m/s.

4.6.11 The results of the historical baseline measurements at the locations of Table 2 are represented in Figures E11 to E18 of Annex E. In each case, the derived best-fit lines to the previous measurements were corrected using the wind shear corrections detailed in Annex F and determined from long-term measurements at two site masts.

4.6.12 The corresponding ETSU-R-97 noise limits are summarised in Table 5 and Table 6. The noise limits have been set either at the prevailing measured background level plus 5 dB, or at the relevant fixed lower limit, whichever is the greater. The derivation of the relevant fixed lower limit value used for day-time periods (40 dB(A)) is described in a subsequent section.

Table 5 - Day time $L_{A90,T}$ noise limits derived from the baseline noise survey according to ETSU-R-97

Property	Standardised 10 m Wind Speed (m/s)								
	4	5	6	7	8	9	10	11	12
Balkissock	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Bellimore-on-Tig	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Bents Farm	45.0	45.0	45.0	45.0	45.0	45.0	45.4	46.8	48.5
Brooklyn	40.0	40.0	40.0	40.0	40.0	40.8	42.7	44.4	45.9
Cairnlea	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1
Chirmorrie	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Craigengells	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
Dochroyle Cottage	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Dochroyle Farm	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Duisk Lodge	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
East Altercannoch	40.0	40.0	40.0	40.0	40.0	41.2	43.7	45.9	47.9
Farden	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Ferngate Cottage	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1
Glenour	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Gowlands	40.1	40.5	41.2	42.2	43.3	44.6	46.1	47.6	49.2
Gowlands Terrace	40.1	40.5	41.2	42.2	43.3	44.6	46.1	47.6	49.2
Kildonan Courtyard	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
Kilrenzie	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Laggish	40.0	40.0	40.0	40.0	40.0	40.0	41.8	44.0	45.7
Laigh Altercannoch	40.0	40.0	40.0	40.0	40.0	40.8	42.7	44.4	45.9
Queensland Caravan Park	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
Scaurhead	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
The Craigs	40.0	40.0	40.0	40.0	40.0	40.8	42.7	44.4	45.9
The Manse	40.0	40.5	41.1	41.9	42.9	44.0	45.4	46.8	48.5
Ward of Cairnlea	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1
West Altercannoch	40.0	40.0	40.0	40.0	40.0	41.2	43.7	45.9	47.9
Wheeb	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
White Cairn	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.0

Table 6 - Night time $L_{A90,T}$ noise limits derived from the baseline noise survey according to ETSU-R-97

Property	Standardised 10 m Wind Speed (m/s)								
	4	5	6	7	8	9	10	11	12
Balkissock	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Bellimore-on-Tig	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Bents Farm	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.5	47.2
Brooklyn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.7
Cairnlea	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Chirmorrie	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Craigengells	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
Dochroyle Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Property	Standardised 10 m Wind Speed (m/s)								
	4	5	6	7	8	9	10	11	12
Dochroyle Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Duisk Lodge	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
East Altercannoch	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	47.0
Farden	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Ferngate Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Glenour	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Gowlands	43.0	43.0	43.0	43.0	43.2	44.0	45.0	46.3	47.8
Gowlands Terrace	43.0	43.0	43.0	43.0	43.2	44.0	45.0	46.3	47.8
Kildonan Courtyard	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
Kilrenzie	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Laggish	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.1
Laigh Altercannoch	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.7
Queensland Caravan Park	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
Scaurhead	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
The Craigs	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.7
The Manse	43.0	43.0	43.0	43.0	43.0	43.0	44.0	45.5	47.2
Ward of Cairnlea	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
West Altercannoch	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	47.0
Wheeb	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
White Cairn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

5. Predicted Noise Effects

5.1 Predicted Construction Noise Levels

5.1.1 The level of construction noise that occurs at the surrounding properties will be highly dependent on a number of factors such as the final site programme, equipment types used for each process, and the operating conditions that prevail during construction. It is not practically feasible to specify each and every element of the factors that may affect noise levels, therefore it is necessary to make reasonable allowance for the level of noise emissions that may be associated with key phases of the construction.

5.1.2 In order to determine representative emission levels for this study, reference has been made to the scheduled sound power data provided by BS 5228. Based on experience of the types and number of equipment usually associated with the key phases of constructing a windfarm, the scheduled sound power data has been used to deduce the upper sound emission level over the course of a working day. In determining the rating applicable to the working day, it has generally been assumed that the plant will operate for between 75% and 100% of the working day. In many instances, the plant would actually be expected to operate for a reduced percentage, thus resulting in noise levels lower than predicted in this assessment.

5.1.3 To relate the sound power emissions to predicted noise levels at surrounding properties, the prediction methodology outlined in BS 5228 has been adopted. The prediction method accounts for factors including screening and soft ground attenuation. The size of the Site and resulting separation

distances to surrounding properties allows the calculations to be reliably based on positioning all the equipment at a single point within a particular working area (for example, in the case of turbine erection, it is reasonable to assume all associated construction plant is positioned at the base of the turbine under consideration). In applying the BS 5228 methodology, it has been conservatively assumed that there are no screening effects, and that the ground cover is characterised as 50% hard / 50% soft.

5.1.4 Table 7 lists the key construction activities, the associated types of plant normally involved, the expected worst-case sound power level over a working day for each activity, the property which would be closest to the activity for a portion of construction, and the predicted noise level. It must be emphasised that these predictions only relate the noise level occurring during the time when the activity is closest to the referenced property. In many cases, such as turbine erection, the separating distances will be considerably greater for the majority of the construction period and the predictions are therefore the worst-case periods of the construction phase.

Table 7 - Predicted construction noise levels

Task Name	Plant/Equipment	Upper Collective Sound Emission Over Working Day $L_{WA,T}$ dB(A)	Nearest Receiver	Minimum Distance to Nearest Receiver	Predicted Upper Day-Time L_{Aeq}
Upgrade Access Track	excavator / dump trucks / tippers / dozers / vibrating rollers	120	Glenour	1100	48
Construct temporary site compounds	excavator / dump truck / tippers / rollers/ delivery trucks	120	White Cairn	2700	39
Construct site tracks	excavators / dump trucks / tippers / dozers / vibrating rollers	120	Glenour	1000	48
Construct Sub-Station	excavator / concrete truck / delivery truck	110	Cairnlea	2000	32
Construct crane hardstandings	excavators / dump trucks	120	Glenour	1000	48
Construct turbine foundations	Piling Rigs / excavators / tippers / concrete trucks / mobile cranes / water pumps / pneumatic hammers / compressors / vibratory pokers	120	Glenour	1100	48

Task Name	Plant/Equipment	Upper Collective Sound Emission Over Working Day $L_{WA,T}$ dB(A)	Nearest Receiver	Minimum Distance to Nearest Receiver	Predicted Upper Day-Time L_{Aeq}
Excavate and lay site cables	excavators / dump trucks / tractors & cable drum trailers / wacker plates	110	Glenour	1000	38
Erect turbines	cranes / turbine delivery vehicles / artics for crane movement / generators / torque guns	120	Glenour	1100	48
Reinstate crane bases	excavator / dump truck	115	Glenour	1000	43
Reinstate road verges	excavator / dump truck	115	Glenour	1000	43
Lay cable to sub-stations	JCB / saws / hydraulic breaker / dump truck/ tipper / wacker plate / tandem roller / tractor & cable drum trailer / delivery truck	115	Glenour	1000	43
Borrow Pit Quarrying	Primary and secondary stone Crushers / excavators / screening systems / pneumatic breakers / conveyors	125	Arnsheen	850	55
Concrete Batching	Batching Plant	110	White Cairn	2700	29
Forestry felling around turbines and access tracks	Harvesters and forwarders, characterised by saw noise diesel engine noise emissions commonly associated with tractors and excavation noise	115	Glenour	1000	43

5.1.5 Comparing the above predicted noise levels to the range of background noise levels measured around the proposed Development suggests that the noisier construction activities would be audible

at various times throughout the construction phase. However, comparing the predicted worst-case levels of 55 dB L_{Aeq} or lower to the significance criteria of Table 1 indicates that the construction activities of Table 7 will have effects of negligible significance.

5.1.6 The construction working hours proposed for the proposed Development include work between 07:00 to 16:00 on Saturdays and Sundays: work may therefore occur outside the working hours assumed in deriving the criteria of Table 1. However, the predicted activity noise levels do not exceed the criteria of 55 dB L_{Aeq} proposed by SAC for weekend periods in their scoping response. Therefore, the construction activities is considered to represent at most slight impact even considering the proposed weekend work.

5.1.7 There are a number of isolated properties located between 130 and 300 metres from the general access road from the A714 at Wheeb Bridge to the Site. It is expected that very limited works would be required to this existing track as it has been used recently for the existing Arecleoch Windfarm and Kilgallioch Windfarms. Any potential minor repair work that may be required would be very limited in extent and duration such that no significant noise or vibration effects are expected for this aspect of the proposed Development.

5.1.8 In addition to on-site activities, construction traffic passing to and from the Site will also represent a potential source of noise to surrounding properties. The assessment in Chapter 12 of the EIA report for the proposed Development (Access, traffic and transport) has predicted the volume of traffic likely to be generated during the construction. This concluded that the importation of rock material would result in 14 HGV trips per day, or 24 two-way movements, or an average of 2 two-way HGV movements each hour. Tables 12.8 of Chapter 12 was used to ascertain the projected traffic flows for scenarios with and without the Development.

5.1.9 The most sensitive receiver locations in respect of vehicle movements properties such as Arnimean, Burnside or Corwar Farm, located between 130 and 300 metres from the general access road from the A714 at Wheeb Bridge to the Site. Although these properties are relatively isolated some already experience noise from traffic on the A714. Large vehicles can generate noise levels in the order of 108 dB (sound power level) when in motion. However, these types of plant usually pass a receiver location quite quickly. When stationary the same vehicles will be operating in idle which considerably lowers the noise output to the environment. Based on the prediction methodology in BS 5288 and accounting for large vehicles moving at an estimated 35 km per hour, the predicted noise level at those dwellings is of 39 to 41 dB $L_{Aeq,T}$. This represents a negligible effect.

5.1.10 Construction traffic movements on existing local surrounding roads also represent a potential source of noise effects to surrounding properties. The above-referenced projected changes in traffic flow are summarised in Table 8. On this basis, the methodology set out in CRTN has been used to determine the associated maximum total change in the average day time traffic noise level at any given location due to construction of the Development: see Table 9. It should be noted that the traffic volumes of Table 8 are close to or below the minimum flow volume of 1000 vehicles per day that is required by the CRTN methodology to enable reliable predictions. This means that the associate absolute levels of traffic noise, even accounting for the additional construction traffic, are relatively low.

5.1.11 Table 9 indicates a maximum potential increase of 1.2 dB(A) in the day time average noise level during particular phases of the construction programme at locations along the A714 for the route accessing the site from Wheeb Bridge. For the Bents Farm access, the predicted increase is less than 1 dB(A). Based on the criteria set out in the DMRB, the predicted short term change in traffic noise level would correspond to a slight effect.

Table 8 - Projected traffic flows

Access route	Without Development		With Development	
	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles
Wheeb Bridge	618	7.9%	657	10.4%
Bents Farm	1019	4.9%	1104	5.0%

Table 9 - CRTN predicted increase in day time average traffic noise levels ($L_{A10,18hour}$)

Access route	Maximum Change in Traffic Noise Level, dB(A)
Wheeb Bridge	1.2
Bents Farm	0.9

5.1.12 In conclusion, noise from construction activities has been assessed and is predicted to result in a temporary slight effect.

5.2 Construction Noise & Vibration Levels – Blasting

5.2.1 If blasting is employed to quarry the borrow pit at search area 2, there is a potential for this to affect the nearest property. Because of the difficulties in predicting noise and air overpressure resulting from blasting operations, these activities are best controlled following the use of good practice during the setting and detonation of charges, as set out earlier in this report. For the other borrow pit search areas identified, given the separation distances between the location of borrow pits and the nearest noise sensitive receptors (approximately 2 kilometres or more) it is very unlikely that these activities would cause unacceptable residual adverse effects.

5.2.2 The transmission and magnitude of ground vibrations associated with blasting operations at borrow pits are subject to many complex influences including charge type and position, and importantly, the precise nature of the ground conditions (material composition, compaction, discontinuities) at the source, receiver, and at every point along all potential ground transmission paths. Clearly any estimation of such conditions is subject to considerable uncertainty, thus limiting the utility of predictive exercises. Mitigation of potential effects of these activities is best achieved through on-site testing processes carried out in consultation with the Local Authorities, as described earlier in this report.

5.3 Operational Wind Turbine Emissions Data

5.3.1 The exact model of turbine to be used at the Site will be the result of a future tendering process and therefore an indicative turbine model has been assumed for this noise assessment. This operational noise assessment is based upon the noise specification of the Vestas V150 5.6MW wind turbine. 13 turbines have been modelled using the layout as indicated on the map of Figure 13.1 (see Annex B for turbine coordinates). The candidate turbine is a variable speed, pitch regulated machine with a rotor diameter of 150 metres and a hub height of 125 metres.

5.3.2 Due to its variable speed operation, the sound power output of the Vestas V150 5.6MW turbine varies considerably with wind speed, being quieter at the lower wind speeds when the blades are rotating more slowly. Furthermore, in common with many modern turbine models, the turbine blades incorporates serrated trailing edges (STE) technology which reduces noise emissions by around 2 dB(A).

5.3.3 Vestas have supplied specification noise emission data for the Vestas V150 5.6MW turbine. In the absence of specific information about uncertainty allowances in the data, a further correction factor of +2 dB was added to the specification data in line with advice in the IOA GPG. In addition to the overall sound power data, reference has been made to a Vestas spectrum specification document for the unit to derive a representative sound spectrum for the turbine, based on an energetic average of the available information at each octave band. The overall sound power and spectral data are presented in Table 10 and Table 11.

Table 10 - Wind turbine sound power levels used in the noise assessment

Standardised Wind Speed (m/s)	Sound Power Level (dB L_{Aeq})				
	Vestas V150 5.6MW	Gamesa - G80 2MW	Gamesa G114 2.5MW	Gamesa G90 2MW	Gamesa - G87 2MW
4	94.8	97.9	99.5 (+1)*	97.9	98.5
5	98.6	102.7	104.8 (+1)*	102.7	103.6
6	103.0	105.0	108.0 (+1)*	106.6	107.5
7	105.8	105.1	108.0 (+1)*	107.0	108.4
8	106.4	105.1	108.0 (+1)*	107.0	108.4
9	106.9	105.1	108.0 (+1)*	107.0	108.4
10	106.9	105.1	108.0 (+1)*	107.0	108.4
11	106.9	105.1	108.0 (+1)*	107.0	108.4
12	106.9	105.0	108.0 (+1)*	107.0	108.4
Derived from:	*Vestas specification Document no.: 0081-5059 V02, 24/01/2019*	*Gamesa document GD022912-en 16/12/08*	*Gamesa document GD181659-en (25/10/2013)*	*Gamesa document GD080626-en Rev0 12/04/10*	*Gamesa document GD022914-en 12/04/10*

* +1dB Uplift applied to the turbines of the Chirmorie Windfarm

Table 11 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v_{10} = 8 m/s)

Octave Band Centre Frequency (Hz)	A-Weighted Sound Power Level (dB(A))				
	Vestas V150 5.6MW	Gamesa - G80 2MW	Gamesa G114 2.5MW	Gamesa G90 2MW	Gamesa - G87 2MW
63	87.6	81.5	79.2	88.0	87.4
125	95.4	89.4	86.3	95.6	96.3
250	100.2	94.1	91.9	100.6	101.6
500	102.1	95.7	95.0	102.4	101.1
1000	100.9	96.5	94.9	100.2	100.2
2000	96.8	94.9	91.2	95.8	97.2

Octave Band Centre Frequency (Hz)	A-Weighted Sound Power Level (dB(A))				
	Vestas V150 5.6MW	Gamesa - G80 2MW	Gamesa G114 2.5MW	Gamesa G90 2MW	Gamesa - G87 2MW
4000	89.7	88.4	85.4	90.6	90.6
8000	79.6	74.1	74.5	92.2	78.2
Derived from:	*Vestas Document 0079-5099_01, 23/01/2019, 'V150-5.6 MW Third octave noise emission'*	*Derived from test report DEWI S AM 133 / 04 – of 2004/01/15.*	*Gamesa document GD208973-en (09/12/13)*	*Derived from summary test report WT 6432/08*	*Gamesa document GD039994-en dated 15/01/09*

5.3.4 Assessment of cumulative effects from operating Development with other windfarms requires source information for the turbine types similar to that presented in Table 10 and 11 for each windfarm. When considering this, guidance on relevant good practice set out in the IOA GPG was referenced, in addition to a joint expert article on the subject[xviii] and available environmental data.

5.3.5 In summary, for each operational site, noise predictions were based on the actual installed turbine model. For sites which are consented but not built (such as Chirmorie Windfarm), the candidate turbine considered in the planning application for the site was assumed. Consistent with the approach for the proposed Development, for each turbine model, robust noise emission data which includes a margin of uncertainty was first assumed in accordance with IOA GPG guidance: this already represents a robust assumption.

5.3.6 For some adjacent windfarms, noise immission levels are permitted by the site noise limits to be higher than those predicted from turbine emission data alone. No uplift was applied in some cases as the turbine model assumed is predicted to just meet the noise limit at the nearest relevant location(s): it is therefore unlikely that noise emissions from these sites could be higher without resulting in potential excess of their individual consent noise limits. Furthermore, the GPG notes that in cases where there is limited margin between predicted noise levels and the noise limits at a "controlling property", located in relative proximity to a windfarm, this will limit the "headroom" realistically available at other locations situated further away. Additional uplifts considered in this way are indicated in Table 10 above. Addition of an uplift is also considered less relevant for the Arecleoch, Kilgallioch and Mark Hill Windfarms which are under the control of SPR, who would also operate the proposed Development.

- Arecleoch Windfarm: this comprises 60 Gamesa G80 2MW turbines. This windfarm was consented with noise limits based on ETSU-R-97: the greater of either 5 dB above derived background noise levels or a fixed level of 40/43 dB L_{A90} for day/night time periods respectively. The proposed Development represents an extension of this operating windfarm: if consented, both windfarms would effectively operate under a single joint noise limit which would apply to the extended windfarm. There is therefore no need to assume the individual turbines would operate up to their consent limit in isolation.
- Kilgallioch Windfarm: this windfarm includes 96 turbines, most of which are Gamesa G114 2.5MW turbines but with two Gamesa G90-2000 turbines (K21 and K23). This windfarm was also consented with noise limits based on ETSU-R-97: the greater of either 5 dB above derived background noise levels or a fixed level of 40/43 dB L_{A90} for day/night time periods respectively. The windfarm is under the control of SPR and if its noise emissions were significantly greater than assumed based on the standard manufacturer data, it would likely exceed its consent limits at properties such as Pultadie (easting/northing 219230 / 570000). Therefore, no further uplift was applied.
- Chirmorie Windfarm: the site was modelled with 21 Gamesa G114 2.5MW turbines, as assumed at planning stage for the application for the windfarm. The site was consented with a noise limit of no more than 30 dB L_{A90} at neighbouring residential properties, with the exception of Chirmorrie which would be taken out of residential use should the site be constructed. Initial predictions at some of the nearest properties of Table 4 such as Dochroyle Cottage showed that emission levels could be 1 dB higher without exceeding this noise limit and so an uplift of +1dB was applied for this windfarm.
- Mark Hill Windfarm: the site comprises 28 Gamesa G87 2MW turbines. This windfarm was consented with noise limits based on ETSU-R-97: the greater of either 5 dB above derived background noise levels or a fixed level of 40/43 dB L_{A90} for day/night time periods respectively. The assumed emission levels for this turbine model are considered conservative for a number of reasons: they are relatively high compared to other turbines of similar dimensions; analysis of the measured levels at properties in Barrhill in northerly wind directions suggest the predicted levels (illustrated in the charts of Annex E) are conservative; and any additional increase to the assumed emission levels would correspond to a potential excess of the noise limits at properties situated in closer proximity to the turbines such as Balmalloch (Easting/northing 226834/ 584231). Therefore, no further uplift was applied.

5.4 Choice of Windfarm Operational Noise Propagation Model

5.4.1 The ISO 9613-2 model[xix] has been used to calculate the noise immission levels at the selected nearest residential neighbours as advised in the IOA GPG. The model accounts for the attenuation due to geometric spreading, atmospheric absorption, and barrier and ground effects. All attenuation calculations have been made on an octave band basis and therefore account for the sound frequency characteristics of the turbines.

5.4.2 For the purposes of the present assessment, all noise level predictions have been undertaken using a receiver height of four metres above local ground level, mixed ground (G=0.5) and an air absorption based on a temperature of 10°C and 70% relative humidity. A receiver height of four metres will be typical of first floor windows and result in slightly higher predicted noise levels than if a 1.2 to 1.5 metre receiver height were chosen in the ISO 9613 algorithm. The attenuation due to terrain screening accounted for in the calculations has been limited to a maximum of 2 dB(A). In situations of propagation above concave ground, a correction of +3 dB was added. Annex B provides details of the resulting attenuation coefficients for all turbines of the proposed Development.

5.4.3 This method is consistent with the recommendations of the above-referenced Institute of Acoustics Good Practice Guide which provides recommendations on the appropriate approach when predicting wind turbine noise levels. The IOA GPG also allows for directional effects to be taken into account within the noise modelling: under upwind propagation conditions between a given receiver and the windfarm the noise immission level at that receiver can be as much as 10 dB(A) to 15 dB(A) lower than the level predicted using the ISO 9613-2 model. However, predictions have been made assuming downwind propagation from every turbine to every receptor at the same time as a worst-case.

5.5 Predicted Windfarm Operational Noise Immission Levels

5.5.1 Table 12 shows predicted noise immission levels at each of the selected assessment locations for each wind speed from 4 m/s to 12 m/s inclusive. All windfarm noise immission levels in this report are presented in terms of the $L_{A90,T}$ noise indicator in accordance with the recommendations of the ETSU-R-97 report, obtained by subtracting 2 dB(A) from the calculated $L_{Aeq,T}$ noise levels based on the turbine sound power levels presented in Table 10 and Table 11.

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