17. NOISE IMPACT ASSESSMENT

17.1 Summary

17.1.1 This noise chapter assesses the noise impact of the proposed increase in tip height for the consented Limekiln Wind Farm (the 'Revised Consented Development'). Cumulative operational impacts including the proposed Limekiln Wind Farm Extension and other wind farms in the vicinity are also considered. Operational noise predictions have been carried out assuming the same turbines are installed at Limekiln Wind Farm and Limekiln Wind Farm Extension.

17.1.2 Predicted operational noise levels from the proposed Revised Consented Development, and from the combined effect of the Revised Consented Development and Limekiln Wind Extension Farm, have been compared with the noise limits applied to the Consented Development. The cumulative noise impact, including other consented wind farms in the vicinity, has been considered by comparing the predicted noise levels with other relevant noise limits.

17.1.3 Predicted operational noise levels from the proposed Revised Consented Development assuming turbines with an increased tip height meet the noise limits that apply to the Consented Development. In addition, predicted operational noise levels from the combined effect of Revised Consented Development and Limekiln Wind Farm Extension meet the noise limits that apply to the Consented Development. No significant further cumulative noise impacts, when combined with other wind farm sites, are predicted.

17.1.4 Noise from construction has been scoped out of detailed assessment, however, such noise has been considered with reference to BS5288:2009, *Noise and Vibration Control on Construction and Open Sites*. Noise from construction and decommissioning activities would be significantly below the adopted daytime noise limit of 65 dB L_{Aeq} that applies to construction activities of duration of greater than one month, and therefore no significant construction noise impacts are predicted.

17.1.5 Noise from vehicle accessing the site during the construction phase has been assessed, as requested by The Highland Council, by calculating the increase in noise along the access routes relative to the future baseline traffic flow during the construction phase. The predicted increases were below 1 dB and therefore no significant impacts are expected.

17.2 Summary of Conclusions – Previous Applications

Technical Topic	2012 ES (24 Turbine Layout – tip heights 126m and 139m)	2016 ES (24 Turbine Layout – tip heights 126m and 139m)	2017 SI (21 Turbine Layout – tip heights 126m and 139m)	2021 Section 36C Application (21 Turbine layout with 149.9 m tip heights, plus amended tracks)
Noise	Operational noise levels were below the noise limits derived according to ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, and it was concluded that the proposed Limekiln Wind Farm would have no significant effects in relation to operational noise. Noise form construction met the criteria set out in BS 5228:2009, *Code of practice for noise and vibration control on construction and open sites*, and therefore no significant construction noise effects were predicted. Predicted increases in road traffic noise during the construction phase were below 3 dB and therefore no significant effects were envisaged	Operational noise levels were below the noise limits derived according to ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, and it was concluded that the proposed Limekiln Wind Farm would have no significant effects in relation to operational noise. Noise form construction met the criteria set out in BS 5228:2009, *Code of practice for noise and vibration control on construction and open sites*, and therefore no significant construction noise effects were predicted. Predicted increases in road traffic noise during the construction phase were below 3 dB and therefore no significant effects were envisaged	Operational noise levels were below fixed noise limits (based on limits suggested by The Highland Council) of 35 dB L_{A90} and 38 dB L_{A90} during the day and night periods respectively. Predicted cumulative noise levels also met these limits. Noise from construction (including construction traffic) was not assessed in the 2017 SI as the impacts were not considered to have materially changed as a result of the Revised Layout.	Operational noise levels meet the noise limits applied to the Consented Development, and also meet the relevant ETSU-R-97 noise limits both in isolation and cumulatively with other wind farm developments in the vicinity. Noise from construction activities was scoped out and will be below the relevant noise limits suggested by BS 5229:2009 +A1:2014, and therefore no significant effects are expected. Predicted increases in road traffic noise during the construction are below 1 dB and therefore no significant effects are predicted.

17.3 Introduction

17.3.1 This chapter contains an assessment of the operation of the Revised Consented Development, which is a proposed tip height increase of the consented Limekiln Wind Farm (the 'Consented Development'). The assessment has been undertaken by the Hayes McKenzie Partnership Ltd.

17.3.2 The assessment has been performed with reference to ETSU-R-97 *The Assessment and Rating of Noise from Wind Farms* (ETSU-R-97) and the guidance contained within the Institute of Acoustics (IOA) document, *A Good Practice Guide* (GPG) *to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*, which is endorsed by Scottish Government.

17.3.3 A primary assessment has been undertaken by comparing predicted operational noise levels with the noise limits that were set for the Consented Development, which were set with reference to ETSU-R-97 but modified by The Highland Council to apply a lower limiting value at night than prescribed by ETSU-R-97.

17.3.4 In addition to the primary assessment, two cumulative noise impact assessments have been undertaken. Firstly, an assessment has been carried out for the combined operation of the Revised Consented Development and the proposed Limekiln Wind Farm Extension, and secondly, a further cumulative assessment has been undertaken by reviewing predicted operational noise levels from all wind farms in the vicinity that may contribute to received noise at the nearest residential properties to the Revised Consented Development.

17.3.5 Construction and decommissioning noise on-site should normally be assessed with reference to BS 5228:2009, *Code of practice for noise and vibration control on construction and open sites*. In this case, noise from construction and decommissioning has been scoped out of the EIA as noise from such activities will be sufficiently distant from residential receptors, or of such short term duration, such that the relevant limits set out in BS 5228 will be met.

17.3.6 Noise from vehicle accessing the site during the construction phase has been assessed, as requested by The Highland Council, by calculating the increase in noise along the access routes relative to the future baseline traffic flow during the construction phase.

17.4 Statement of Competency

17.4.1 The noise assessment has been undertaken by Hayes McKenzie Partnership Ltd who have worked on over 1000 proposed, consented or existing wind farm sites, particularly in the UK and the Irish Republic but also in the rest of Europe, Australia, New Zealand, Canada and the USA, and who have provided evidence for around 100 UK public inquiries together with other hearings and in court. Hayes McKenzie is also UKAS accredited to ISO/IEC 17025:2005 for its acoustic emission testing of wind turbines according to IEC 61400-11.

17.4.2 All consultants are associate or corporate members of the UK Institute of Acoustics (IOA). The company is a member of the UK Association of Noise

Consultants (ANC) and a Sponsor Member of the UK Institute of Acoustics. All work is carried out in line with recognised industry standards, and best practice recommendations of the IOA and ANC.

17.5 Policy and Guidance

Planning Advice Note PAN1/2011, Planning and Noise

17.5.1 PAN1/2011 identifies two sources of noise from wind turbines; mechanical noise and aerodynamic noise. It states that "*good acoustical design and siting of turbines is essential to minimise the potential to generate noise*" (Scottish Government 2011). It refers to the "*web-based planning advice*" (Scottish Government 2011) on renewables technologies for onshore wind turbines.

Scottish Government 2014, Web Based Planning Advice, Onshore Wind Turbines

17.5.2 The web-based planning advice on onshore wind turbines re-iterates the sources of noise as "*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*" (Scottish Government 2014) and that "*there has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design*" (Scottish Government 2014). It states that "the Report, "*The Assessment and Rating of Noise from Wind Farms*" *(Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available*" (Scottish Government 2014). It notes that "*this gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions*" (Scottish Government 2014).

17.5.3 The advice introduces the Institute of Acoustics (IOA) A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics, 2013), and states that "*The Scottish Government accepts that the guide represents current industry good practice*" (Scottish Government 2014).

17.5.4 The accompanying Technical Advice Note (Scottish Government, 2011) to PAN1/2011, Assessment of Noise, lists BS 5228, Noise and Vibration Control on

Construction and Open Sites (British Standards Institution, 2014). as being applicable for Environmental Impact Assessment (EIA) and planning purposes.

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

17.5.5 ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (ETSU-R-97), presents the recommendations of the Working Group on Noise from Wind Turbines, set up in 1993 by the Department of Trade and Industry (DTI) as a result of difficulties experienced in applying the noise guidelines existing at the time to wind farm noise assessments. The group comprised independent experts on wind turbine noise, wind farm developers, DTI personnel and local authority Environmental Health Officers. In September 1996 the Working Group published its findings by way of report ETSU-R-97. This document describes a framework for the measurement of wind farm noise and contains suggested noise limits, which were derived with reference to existing standards and guidance relating to noise emission from various sources.

17.5.6 ETSU-R-97 recommends that, although noise limits should be set relative to existing background and should reflect the variation of both turbine and background noise with wind speed; this can imply very low noise limits in particularly quiet areas, in which case, "*it is not necessary to use a margin above background in such low-noise environments. This would be unduly restrictive on developments which are recognised as having wider global benefits. Such low limits are, in any event, not necessary in order to offer a reasonable degree of protection to the wind farm neighbour*" (DTI 1996).

17.5.7 For day-time periods, the noise limit is 35 dB – 40 dB L_{A90} or 5 dB(A) above the 'quiet day-time hours' prevailing background noise, whichever is the greater. The actual value within the 35 dB – 40 dB(A) range depends on the number of dwellings in the vicinity; the impact of the limit on the number of kWh generated; and the duration of the level of exposure.

17.5.8 For night-time periods the noise limit is 43 dB L_{A90} or 5 dB(A) above the prevailing night-time hours background noise, whichever is the greater. The 43 dB(A) lower limit is based on an internal sleep disturbance criteria of 35 dB(A) with an allowance of 10 dB(A) for attenuation through an open window and 2 dB(A) subtracted to account for the use of L_{A90} rather the L_{Aeq}.

17.5.9 Where predicted noise levels are low at the nearest residential properties a simplified noise limit can be applied, such that noise is restricted to the minimum ETSU-R-97 level of 35 dB L_{A90} for wind speeds up to 10 m/s at 10 m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

17.5.10 It is stated that the $L_{A90,10min}$ noise descriptor should be adopted for both background and wind farm noise levels and that, for the wind farm noise, this is likely to be between 1.5 dB and 2.5 dB less than the L_{Aeq} measured over the same period. The $L_{Aeq,t}$ is the equivalent continuous 'A' weighted sound pressure level occurring over the measurement period 't'. It is often used as a description of the average ambient noise level. Use of the L_{A90} descriptor for wind farm

noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

17.5.11 ETSU-R-97 also specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described and is related to the level by which any tonal components exceed the threshold of audibility.

17.5.12 With regard to multiple wind farms in a given area, ETSU-R-97 specifies that the absolute noise limits and margins above background should relate to the cumulative impact of all wind turbines in the area contributing to the noise received at the properties in question. Existing wind farms should therefore be included in cumulative predictions of noise level for proposed wind turbines and not considered as part of the prevailing background noise.

A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise

17.5.13 In May 2013, the Institute of Acoustics (IOA) published A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (GPG), as referred to in the Web Based Planning Advice. This was subsequently endorsed by the Secretary of State for Energy and Climate Change and by the Scottish Ministers. The publication of the GPG followed a review of current practice (Department of Energy and Climate Change, 2011) carried out for the Department of Energy and Climate Change (DECC) and an IOA discussion document (Institute of Acoustics, 2012) which preceded the GPG.

17.5.14 The GPG includes sections on Context; Background Data Collection; Data Analysis and Noise Limit Derivation; Noise Predictions; Cumulative Issues; Reporting; and Other Matters including Planning Conditions, Amplitude Modulation, Post Completion Measurements and Supplementary Guidance Notes. The Context section states that the guide "*presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine development above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published*" (IOA 2013). It adds that "*the noise limits in ETSU-R-97 have not been examined as these are a matter for Government*" (IOA 2013).

17.5.15 As well as expanding on and, in some areas, clarifying issues which are already referred to in ETSU-R-97, additional guidance is provided on noise prediction and a preferred methodology for dealing with wind shear. The guidance within the GPG has been considered and generally followed for this assessment.

The Highland Council Noise Limits

17.5.16 It should be noted that The Highland Council have provided guidance on their own recommended wind farm noise limits which depart from the ETSU-R-97 noise limits. They specify night time and daytime noise lower limiting values of 38 and 35 dB L_{A90} respectively, thereby setting the night-time lower limiting value at 5 dB below that specified by ETSU-R-97, and setting the daytime noise

limit at the lowest end of the range of lower and upper daytime lower limiting values range specified by ETSU-R-97.

17.5.17 It is noted that the noise limits applied to the Consented Development are similarly set at 38 and 35 dB L_{A90} for the night time and daytime respectively.

Cumulative Noise

17.5.18 Section 5.1 of the IOA GPG deals with cumulative noise, and re-iterates the position set out in ETSU-R-97 that "*absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question*" (IOA 2013).

17.5.19 The IOA GPG defines when a cumulative noise assessment is necessary and states that, "*if the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary*" (IOA 2013). This is because if the predicted noise is more than 10 dB below that already existing (or the applicable noise limit) its contribution to the overall noise level is negligible.

Other Potential Operational Wind Farm Noise Impacts

Tonal Noise

17.5.20 If tonal noise is associated with a sound source it is generally then more noticeable, and in line with other noise guidance that penalises noise which is tonal, a penalty is added to wind turbine noise if there is tonal noise which is audible at residential properties. In this case, it has been assumed that there would be no tonal noise associated with the operation of the wind farm which would give rise to a tonal penalty as set out in ETSU-R-97. A penalty is usually included within the planning conditions for wind farms that can be used to ensure that noise levels, including a tonal penalty, do not exceed acceptable levels in practice.

Low Frequency and Infrasound

17.5.21 Work carried out in 2006 to investigate the extent of low frequency and infrasonic noise from three UK wind farms (Department of Trade and Industry, 2006) concluded that "*the common cause of complaints associated with noise at all three wind farms is not associated with low frequency noise, but is the audible modulation of the aerodynamic noise, especially at night*" (DTI 2006). It is therefore considered that low frequency and infrasound can be scoped out of the assessment, but modulation of aerodynamic noise is considered in more detail below.

Amplitude Modulation

17.5.22 The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic

modulation (AM). This effect is identified within ETSU-R-97 where it is envisaged that *"… modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine…"* (DTI 1996) and that at distances further from the turbine where there are *"… more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)"* (DTI 1996). There have been instances where the levels of AM are higher than this, which results in the noise being perceived as more intrusive (in the same way as tonal content makes the noise more intrusive).

17.5.23 The Government released a Wind Turbine AM Review (Department of Energy and Climate Change, 2016) report in October 2016 (although the Phase 2 report is dated August 2016). Phase 1 of the report sets out its approach and methodology, and the Phase 2 report includes a literature review, its research into human response to AM, and recommends how excessive AM might be controlled through the use of a planning condition. The report includes recommendations on how AM should be addressed when quantified according to the recommendations of an IOA Amplitude Modulation Working Group (AMWG) document, A Method for Rating Amplitude Modulation in Wind Turbine Noise (Institute of Acoustics, 2016).

17.5.24 The AM Review reports recommend a two-tier approach whereby the first tier would be to seek a reduction in the depth and/or occurrence of AM with a rating level (according to the IOA AMWG method) ≥3 dB. Whether remedial action is required depends on the prevalence of any complaints, and how often AM rating levels ≥3 dB occur. The second tier is that if AM is deemed to be a significant issue, and, if nothing can be done to reduce the level of AM, then a penalty scheme is proposed whereby a penalty ranging from 3 dB (for a rating level of 3 dB) up to a maximum of 5 dB (for a rating level of 10 dB and above) should be added to the measured level before measured levels are compared with the relevant noise limits.

17.5.25 It should be noted that most wind farms operate without significant AM, and that it is not possible to predict the likely occurrence of AM, but, like tonal noise, AM could be covered by a suitably worded planning condition.

Construction Noise

17.5.26 The Scottish Government's Technical Advice Note, *Assessment of Noise*, states that, for planning purposes, construction noise should be assessed according to BS 5228, *Noise and Vibration Control on Construction and Open Sites*. The standard provides example criteria for the assessment of the significance of construction noise effects and a method for the prediction of noise levels from construction activities. Two example methods are provided for assessing significance.

17.5.27 The first is based on the use of criteria defined in Department of the Environment Advisory Leaflet (AL) 72, *Noise Control On Building Sites* (Department of the Environment, 1969) which sets a fixed limit of 70 dB(A) in rural suburban and urban areas away from main roads and traffic. Noise levels

are generally taken as façade L_{Aeq} values with free-field levels taken to be 3 dB lower, giving an equivalent noise criterion of 67 dB L_{Aeq}.

17.5.28 The second is based on noise change, with a 5 dB increase in overall noise considered to be significant. However, when existing noise levels are low, such as at this site, and construction activities continue for more than one month, minimum criteria are applicable. These are 45 dB, 55 dB and 65 dB L_{Aeq}, for night-time (23:00-07:00), evening and weekends, and daytime (07:00-19:00) including Saturdays (07:00-13:00) respectively.

17.5.29 Construction traffic noise is typically assessed by calculating the predicted increase in noise levels generated by road traffic associated with the development, or where there is currently very little traffic, against the criteria for construction noise set out in BS 5228. Where the predicted increase is less than 1 dB then no impacts are predicted, and if the impact is between 1 and 3 dB a negligible impact is predicted.

17.6 Consultation

17.6.1 The Highland Council provided a response to the scoping document which included noise at paragraphs 3.49 to 3.61 covering both operational and construction noise.

Operational Noise

17.6.2 The Council's response specified that the operational noise assessment should be carried out according to ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, and the associated Good Practice Guide published by the Institute of Acoustics.

17.6.3 It was noted that the Limekiln Wind Farm Extension proposal was assessed against the fixed 35 dB L_{A90} noise limit and that a simplified cumulative noise condition was preferred that would apply to the combined effect of Limekiln Wind Farm and Limekiln Wind Farm Extension, and that the assessment should demonstrate compliance with such a condition.

17.6.4 In respect of cumulative noise, it is stated that the assessment should take into account predicted and consented noise levels from other developments, and describes the information to be reported.

17.6.5 The response then gives details on noise exposure, background noise measurements, and amplitude modulation. In this case, it is proposed that the existing noise limits that apply to Limekiln Wind Farm are applied to the Revised Consented Development (including it operating cumulatively with the proposed Limekiln Wind Farm Extension) such that no additional noise exposure is predicted over that already consented. No new baseline noise measurements have been undertaken as the application has been assessed against its consented noise limits.

17.6.6 It is noted that amplitude modulation (AM) is not controlled by an agreed noise condition, but that where significant AM effects occur, that this would be investigated in terms of the Statutory Nuisance provisions of the Environmental Protection Act 1990. In this respect it is likely that any AM investigation would be carried out using the best practice guidance available at the time of any complaint.

Construction Noise

17.6.7 In respect of construction noise, the scoping response states that '*given the location, construction noise at the turbines sites is unlikely to be an issues* [sic] *at any noise sensitive properties, however, consideration will need to be given to construction traffic*'.

17.6.8 The scoping response sets out that a construction noise assessment would be required where audible construction noise that is carried outside of normal daytime construction hours, and for short and long term activities are likely to exceed specified criteria.

17.6.9 In this case, noise from construction activities are not expected to exceed the defined criteria and therefore construction noise has been scoped out of the assessment. During the construction phase, the best practicable means will be employed to control noise arising from construction activities at residential receptor locations.

17.6.10 As noise from construction traffic was specifically mentioned by The Highland Council, predictions have been undertaken with reference to the Traffic and Transport chapter to ascertain the increase in noise from construction vehicles accessing the site during the construction phase.

17.7 Noise Impact Assessment Criteria

Existing Noise Limits for Limekiln Wind Farm

17.7.1 The Consented Development has noise limits set at neighbouring properties in the June 2019 consent notice. Planning condition 35 sets out these limits and the methodology by which complaints about noise are assessed. The noise limits applicable to neighbouring properties are 35 dB L_{A90} during the daytime and 38 dB L_{A90} during the night time.

Operational Noise Impact Assessment Criteria

17.7.2 The operational noise impact assessment has been carried out for the nearest residential properties to the proposed development. If the relevant noise limits are met at the nearest properties then they will be met at more distant properties. The combined effect of the Revised Consented Development and the

proposed Limekiln Wind Farm Extension has been assessed against the noise limits applicable to the Consented Development.

17.7.3 In this case, because the Revised Consented Development will be operated by the same operator as the Proposed Limekiln Wind Farm Extension and the two would be effectively operated as a single wind farm site, the noise limit for the Consented Development can be applied via planning conditions as a cumulative noise limit to the combined effect of the Revised Consented Development and Limekiln Wind Farm Extension. It is noted that the draft planning conditions for the Limekiln Wind Farm Extension apply the same limits as applied to the Consented Development to the combined effect of the Consented Development and Limekiln Wind Farm Extension.

17.7.4 The noise limits set for the Consented Development are set at levels that are similar to those specified by ETSU-R-97, and therefore still appropriate for application to this development. It should be noted that, for the Consented Development, the daytime limit is set at the lowest of the daytime permitted noise limit range which is usually the greater of 35-40 dB L_{A90} or plus 5 dB above background. The night limit is set at 5 dB below the ETSU-R-97 lower limiting value of 43 dB L_{A90}.

17.7.5 Despite the operational noise assessment for the Revised Consented Development (and the combination of the Revised Consented Development with the proposed Limekiln Wind Farm Extension) being assessed against the Consented Development noise limits, a further cumulative noise assessment has also been carried out that takes into account all wind farms in the vicinity that may contribute to received noise at the nearest residential properties to the Revised Consented Development.

17.8 Predictions

Operational Noise Prediction Methodology

17.8.1 Operational noise predictions have been carried out in line with the recommendations of the IOA GPG using ISO 9613-2 *Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation*. The calculation method is set out in full in Appendix 17.1.

17.8.2 The same turbine model would be installed at the Revised Consented Development and at Limekiln Wind Farm Extension, as it is intended that both wind farms would be constructed at the same time and maintained by the same operator. Although the Vestas V117 is the candidate turbine, the Nordex N133 has also been considered as the worst-case scenario. Operational noise predictions have therefore been carried out assuming either Vestas V117 4.2 MW or Nordex N133 4.8 MW turbines at both sites.

17.8.3 These noise predictions have been carried out for the maximum sound power and octave band levels detailed in Table 17.1 and Table 17.2. For the Vestas V117, the sound power level variation with wind speed has been calculated from the manufacturer's sound power level data presented relative to hub height

wind speed, standardised to 10 m height[1] with integer values calculated using linear interpolation. The manufacturer provides data for the Nordex N133 for a hub height of 83 m which has been used here.

Table 17.1 Sound Power Levels (dB L_{WA})

Turbine Make & Model	Hub (m)	Standardised 10 m height Wind Speed (m/s)								
		2	3	4	5	6	7	8	9	>10
Vestas V117 4.2 MW STE	91.4	94.2	95.1	98.0	102.2	106.0	108.0	108.0	108.0	108.0
Nordex N133 4.8 MW	83	-	96.5	97.7	103.2	107.4	108.0	108.0	108.0	108.0

17.8.4 The overall sound power levels have had an appropriate amount of uncertainty added, according to the data available, in line with the IOA GPG. In this case 2 dB has been added to the sound power levels for each turbine as this data is provided by the turbine manufacturers and is likely to be warranted in practice, and the data shown in Table 17.1 includes this uncertainty.

17.8.5 The octave band spectra assumed for each turbine type, normalised to the required sound power level at each integer wind speed, as taken from the manufacturer's documentation, is provided at Table 17.2 below.

Table 17.2 Octave Band Spectra (dB L_{WA})

Turbine Make and Model	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
V117 4.2 MW STE	88.3	95.5	100.3	102.6	102.4	99.7	94.5	86.8
N133 4.8 MW	88.0	95.1	99.9	102.3	102.9	100.4	92.9	80.6

Operational Noise Prediction Results

Noise Predictions for the Revised Consented Development

17.8.6 The nearest residential receptors to the Revised Consented Development were identified, and predicted noise levels have been calculated the Revised Consented Development operating at its maximum noise output for each turbine shown at Table 17.1 under downwind propagation conditions.

17.8.7 Table 17.3 shows the results of the predictions for Vestas V117 turbines and Table 17.4 shows the results of the predictions for Nordex N133 turbines, together with the margins between the predicted noise levels and day and night noise limits. The results area also shown graphically as noise contour plots at Figure 17.1 and 17.2 for the Vestas V117 and Nordex N133 turbines respectively. It should be noted that at lower wind speeds, when the turbines

[1] Hub height wind speed corrected to 10 m using a logarithmic wind shear profile and a ground roughness length of 0.05 m.

are not operating at their maximum noise output, and for propagation conditions other than downwind, operational noise levels would be lower.

Table 17.3 Predicted Noise Levels for the Revised Consented Development for Vestas V117 turbines

Location	Easting	Northing	Noise Level (dB L_{A90})		
			Revised Consented Development	35 dB L_{A90} day limit met by	38 dB L_{A90} night limit met by
Achins	295877	964090	30	5	8
Reay	296167	964440	29	6	9
Borlum House	297199	964065	32	3	6
Milton	297861	964470	31	4	7
Loanscorribest	298508	964010	33	2	5
Achunabust	299559	964415	30	5	8
Water Plant Houses	300551	964205	30	5	8
Rathlin	301008	964000	29	6	9
Shebster	301405	963875	29	6	9
Shepherds Cottage	303367	960288	27	8	11
Broubster Cottage	301975	961907	31	4	7
Achreregan	302077	962120	30	5	8

Table 17.4 Predicted Noise Levels for the Revised Consented Development for Nordex N133 turbines

Location	Easting	Northing	Predicted Noise Level (dB L_{A90})		
			Revised Consented Development	35 dB L_{A90} day limit met by	38 dB L_{A90} night limit met by
Achins	295877	964090	30	5	8
Reay	296167	964440	29	6	9
Borlum House	297199	964065	32	3	6
Milton	297861	964470	31	4	7
Loanscorribest	298508	964010	33	2	5
Achunabust	299559	964415	30	5	8
Water Plant Houses	300551	964205	29	6	9
Rathlin	301008	964000	29	6	9
Shebster	301405	963875	29	6	9
Shepherds Cottage	303367	960288	27	8	11
Broubster Cottage	301975	961907	30	5	8
Achreregan	302077	962120	30	5	8

17.8.8 The operational noise prediction results presented in Table 17.3 and Table 17.4 show that operational noise levels from the Revised Consented Development are below the Consented Development day and night noise limits of 35 and 38 dB L_{A90} by at least 2 and 5 dB respectively.

Cumulative prediction results for Limekiln Wind Farm and Limekiln Wind Farm Extension

The cumulative operational noise prediction results of the Revised Consented Development and the proposed Limekiln Wind Farm Extension are presented in Table 17.5 and

17.8.9 Table 17.6 for the Vestas and Nordex turbines respectively, assuming the turbines are operating at their maximum noise output shown in Table 17.1. It should be noted that the cumulative predicted noise levels are calculated prior to rounding to the nearest decibel.

Table 17.5 Predicted Noise Levels for the Revised Consented Development and the Proposed Limekiln Wind Farm Extension for Vestas V117 turbines at both sites

Location	Easting	Northing	Predicted Noise Level (dB L_{A90})		
			Revised Consented Development	Proposed Extension Development	Cumulative
Achins	295877	964090	30	21	30
Reay	296167	964440	29	21	30
Borlum House	297199	964065	32	25	33
Milton	297861	964470	31	25	32
Loanscorribest	298508	964010	33	28	34
Achunabust	299559	964415	30	27	32
Water Plant Houses	300551	964205	30	27	32
Rathlin	301008	964000	29	27	31
Shebster	301405	963875	29	27	31
Shepherds Cottage	303367	960288	27	25	29
Broubster Cottage	301975	961907	31	30	33
Achreregan	302077	962120	30	29	33

Table 17.6 Predicted Noise Levels for the Revised Consented Development and the Proposed Limekiln Wind Farm Extension for Nordex N133 turbines at both sites

Location	Easting	Northing	Predicted Noise Level (dB L_{A90})		
			Revised Consented Development	Proposed Extension Development	Cumulative
Achins	295877	964090	30	21	30
Reay	296167	964440	29	21	30
Borlum House	297199	964065	32	24	32
Milton	297861	964470	31	25	32
Loanscorribest	298508	964010	33	28	34
Achunabust	299559	964415	30	27	32
Water Plant Houses	300551	964205	29	27	31
Rathlin	301008	964000	29	27	31
Shebster	301405	963875	29	26	31
Shepherds Cottage	303367	960288	27	24	29
Broubster Cottage	301975	961907	30	30	33
Achreregan	302077	962120	30	29	32

17.8.10 **Figure 17.1** and **Figure 17.2** show the results as noise contours for the Revised Consented Development cumulatively with the proposed Limekiln Wind Farm Extension for the two proposed turbine types.

The operational noise prediction results presented at **Figure 17.1** and **Figure 17.2**, and in Table 17.5 and

17.8.11 Table 17.6 show that operational noise levels from the combined effect of the Revised Consented Development and the proposed Limekiln Wind Farm Extension are below the Consented Development day and night noise limits of 35 and 38 dB L_{A90} by at least 1 and 4 dB respectively.

Further Cumulative Noise Predictions

17.8.12 The results of the predictions show that the Revised Consented Development and proposed Limekiln Wind Farm Extension can be operated together within the noise limits for the Consented Development. The Consented Development is already permitted to operate up to these limits, and if both the Consented Development and the Revised Consented Development can operate within these limits then a detailed cumulative assessment, including other wind farm sites, may not be required.

17.8.13 In this case, an additional cumulative assessment that considers all wind farms in the vicinity that may contribute to noise at the nearest residential receptor locations has been undertaken. There are two nearby wind farms with predicted noise levels above 25 dB L_{A90} at some of the properties included in Table 17.5 above, and therefore a detailed cumulative assessment has been undertaken for completeness that includes these wind farms. The two wind farms included in the cumulative assessment is the operational Baillie Wind Farm (to the north east of the Revised Consented Development) and the proposed Drum Hollistan 2 Wind Farm (located to the north west of the Revised Consented Development).

17.8.14 The noise limits set for Baillie Wind Farm contained in its decision notice are set at the greater of 35 dB L_{A90} or plus 5 dB above the quiet daytime background noise level during the daytime, or the greater of 43 dB L_{A90} or plus 5 dB above the background noise level at night. The lower limiting value during both day and night periods increases to 45 dB L_{A90} where the occupiers of a house is a stakeholder in the development.

17.8.15 The source sound power levels for these two additional cumulative sites is detailed in Table 17.7 below. Nordex N90 HS wind turbines have been installed at Baillie Wind Farm, and the Enercon E115 wind turbine is the selected candidate turbine for EIA purposes for Drum Hollistan 2 Wind Farm.

Table 17.7 Sound Power Levels for Additional Cumulative Schemes (dB L_{WA})

Turbine Model	Hub (m)	Standardised 10 m height Wind Speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Nordex N90 HS	70	95.5	99.4	102.6	105.9	107.0	107.4	107.5	107.5	107.5	107.5
Enercon E115	67	85.2	93.5	98.4	102.4	104.8	105.5	106.3	106.5	106.5	106.5

17.8.16 The overall sound power levels have had an appropriate amount of uncertainty added, depending on the data supplied or available in line with the IOA GPG. In this case 2 dB has been added to the sound power levels for each turbine as this data is provided by the turbine manufacturers and is likely to be warranted

in practice, and the data shown in Table 17.7 and Table 17.8 include this uncertainty.

17.8.17 The octave band spectra assumed for each turbine, has been normalised to the required sound power level at each integer wind speed, taken from the manufacturer's documentation and is provided in Table 17.8 below.

Table 17.8 Octave Band Spectra for Additional Cumulative Schemes (dB L_{WA})

Turbine Make and Model	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Nordex N90 HS	92.7	96.8	101.2	101.6	100.1	99.0	95.0	87.4
Enercon E115	87.4	93.0	95.9	98.5	100.3	101.4	98.0	88.1

17.8.18 The results of the cumulative predictions can be seen in

17.8.19 Table 17.9 below. It should be noted that the results of the predictions presented here assume downwind noise propagation in all directions, and this cannot occur in practice. Where there are properties between the wind farms, they cannot be downwind of both simultaneously. These cumulative noise predictions assume the use of the Vestas V117 turbines at the Revised Consented Development and at Limekiln Wind Farm Extension.

Table 17.9 Cumulative Predicted Noise Levels for 10 m/s standardised 10 m height wind speed

Location	Predicted Noise Level (dB L_{A90})				
	Limekiln Wind Farm	Limekiln Wind Farm Extension	Baillie Wind Farm	Drum Hollistan 2 Wind Farm	Cumulative Predicted Noise Level
Achins	30	21	24	27	33
Reay	29	21	25	26	32
Borlum House	32	25	27	23	34
Milton	31	25	29	20	34
Loanscorribest	33	28	30	19	36
Achunabust	30	27	33	16	36
Water Plant Houses	30	27	37	14	38
Rathlin	29	27	38	14	39
Shebster	29	27	39	13	40
Shepherds Cottage	27	25	28	10	32
Broubster Cottage	31	30	32	12	36
Achreregan	30	29	33	12	36

17.8.20 The results presented at

17.8.21 Table 17.9 above indicate that there are 7 noise sensitive receptors near to the Revised Consented Development where cumulative predicted noise levels are above the lowest noise limit applied to the Consented Development of 35 dB L_{A90}. There are only two properties where predicted cumulative noise levels are above the night noise limit of 38 dB L_{A90} applied to the Consented Development, but all predicted noise levels meet the ETSU-R-97 daytime lower limiting value of 40 dB L_{A90} and night lower limiting value of 43 dB L_{A90}.

For the 7 locations described above, the predicted additional contribution from the proposed Revised Consented Development and Limekiln Wind Farm Extension compared to the predicted noise from the operational Baillie Wind Farm are shown in

17.8.22 Table 17.10. It should be noted that Drum Hollistan 2 Wind Farm has been excluded from further cumulative analysis as it is not consented, and its potential contribution to these 7 locations is negligible as the predicted noise levels are below 20 dB L_{A90}. It should be noted that the predicted increases are calculated prior to rounding.

Table 17.10 Cumulative Predicted Increases due to Revised Consented Development

Location	Predicted Noise Level (dB L_{A90})			Predicted Increase (dB)	
	Cumulative Predicted Noise Level (excluding Limekiln Wind Farm Extension)	Cumulative Predicted Noise Level (including Limekiln Wind Farm Extension)	Predicted Noise Level from Baillie Wind Farm	Additional due to Revised Consented Development	Additional due to Revised Consented Development & Limekiln Wind Farm Extension
Loanscorribest	35	36	30	5	6
Achunabust	35	36	33	2	3
Water Plant Houses	37	38	37	1	1
Rathlin	39	39	38	1	1
Shebster	40	40	39	0	1
Broubster Cottage	35	36	32	2	3
Achreregan	35	36	33	2	3

The results of the cumulative noise predictions shown in

17.8.23 Table 17.10 indicate that there are 4 locations where the Revised Consented Development adds more than 1 dB to existing operational noise such that there is the potential for significant cumulative noise effects. Where the predicted increase is 1 dB or less, then the cumulative noise impact is not considered to be significant.

17.8.24 For the 4 locations described above where the Revised Consented Development or the combined operation of the Revised Consented Development and Limekiln Wind Farm Extension increase cumulative operational noise levels by more than 1 dB, the maximum predicted cumulative noise level is 36 dB L_{A90} which is 1 dB above the daytime noise limit applied to the Consented Development, and 2 dB below the night noise limit applied to the Consented Development. The cumulative noise assessment assumes downwind propagation in all directions which clearly cannot occur in practice, and therefore in practice cumulative operational noise levels are likely to be lower than predicted here for the majority of the time.

17.8.25 In addition, for these 4 locations, predicted cumulative operational noise levels from the combined operation of the Revised Consented Development acting together with the operational Baillie Wind Farm (i.e. excluding the potential contribution from Limekiln Wind Farm Extension) meet the lowest noise limit of 35 dB L_{A90} applied to the Consented Development.

17.8.26 It should be noted that the combined operation of the Revised Consented Development and Limekiln Wind Farm Extension would remain within the noise limits that were already applied to the Consented Development. In addition, the agreed noise limits for Limekiln Wind Farm Extension specify a cumulative noise limit that applies to the combined noise from Limekiln Wind Farm and Limekiln Wind Farm Extension. It is envisaged that the same limits would apply to the Revised Consented Development such that the noise limits for both sites apply to the combined operation.

17.9 Assessment of Impacts

Revised Consented Development Operating Alongside the Proposed Limekiln Wind Farm Extension

17.9.1 It can be seen at that predicted noise levels from the combined operation of the Revised Consented Development and the proposed Limekiln Wind Farm Extension are below the daytime noise limit applied to the Consented Development by at least 1 dB, and are at least 4 dB below the night limit applied. It should be noted that at lower wind speeds, when the wind turbine sound power levels are lower, operational noise levels would be lower and there would be greater margin to the limits.

17.9.2 As noted at paragraph 17.7.4 above, the noise limits applied to the Consented Development accord with the limits specified by ETSU-R-97 and are therefore appropriate for application to this development. It is envisaged that the noise limits applied to the Consented Development would be applied to the cumulative operational noise from the Revised Consented Development and the proposed

Limekiln Wind Farm Extension, and it is noted that this has been proposed at the Limekiln Wind Farm Extension Public Inquiry.

Cumulative Operational Noise Assessment

17.9.3 Although it has been shown that the Revised Consented Development can operate within the noise limits already imposed on the Consented Development, a further cumulative assessment has been carried out for completeness.

17.9.4 It should be noted that, because operational noise levels from the combined effect of the Revised Consented Development and the proposed Limekiln Wind Farm Extension meet the limits already imposed on the Consented Development, no increase in noise levels over that already consented is predicted.

17.9.5 The further cumulative assessment showed that either the Revised Consented Development did not contribute significantly (i.e. 1 dB or less) to noise from other wind farms, or that any cumulative increases in relation to the lowest applicable noise limit (i.e. 35 dB L_{A90}) were not significant (i.e. 1 dB or less).

Assessment of Consented Noise Levels

17.9.6 The Highland Council scoping response requires that the cumulative noise assessment considers neighbouring wind farm developments operating at their consented noise limit levels rather than at their predicted noise levels so that the theoretical situation of all sites operating at their limits can be considered. In this case the noise limits for the operational Baillie Wind Farm specified in the planning conditions state that:

> *At wind speeds not exceeding 12 metres per second, as measured or calculated at a height of 10 metres above ground level (at the location of the meteorological mast shown at location easting 302610 northing 965639 on the approved layout plan) the wind turbine noise level at any house or other Noise Sensitive Premises shall not exceed-*
>
> *(a) during night hours, 43 dB LA90,10min, or the night hours LA90,10min background noise level plus 5 dB(A), whichever is the greater;*
>
> *(b) during quiet waking hours, 35 dB LA90,10min or the quiet waking hours LA90,10min background noise level plus 5 dB(A), whichever is the greater; and*
>
> *(c) at all times 45 dB, LA90,1Omin or the (day/night as appropriate) hours LA90, 10min background noise level plus 5 dB(A), whichever is the higher in respect of any house where the occupier is a stakeholder in the development*

17.9.7 The predicted operational noise levels at the three residential receptor locations to the south-west of the operational Baillie Wind Farm, based on the source assumptions described in section 17.8, are shown at Table 17.11 below.

Table 17.11 Baillie Wind Farm Predicted Noise Levels at 10 m/s

Location ID	Easting	Northing	Predicted Noise Level (dB L_{A90})
Location 1	301775	963986	41
Location 2	301993	963991	42
Location 3	302458	964040	44

17.9.8 Predicted operational noise levels based on the assumptions for Baillie Wind Farm in section 17.8 indicate that at the nearest residential receptor locations to Baillie Wind Farm, predicted noise levels are likely to be very close to the consented noise limits. Therefore, it is unlikely for operational noise levels in practice to be higher than assumed here without causing an exceedance of the limits. It is therefore considered very unlikely that operational noise levels at the nearest receptor locations to the Revised Consented Development would be higher in practice than assumed for this assessment, and therefore no additional significant impacts are predicted assuming that Baillie Wind Farm is operating at its consented noise limits rather than at its predicted noise level. In addition it should be noted that the properties affected by both Limekiln Wind Farm and Baillie Wind Farm cannot be downwind of both site simultaneously.

Construction Traffic Predictions and Assessment

As requested by The Highland Council, an assessment of noise arising from construction traffic accessing the site during the construction phase has been carried out. Predictions have been undertaken based on the increases in road traffic detailed at Table 7.7 and Table 7.9 of the Traffic and Transport Assessment Chapter. The results of the predictions are detailed below at

17.9.9 Table 17.12.

Table 17.12 Road Traffic Predicted Increase in Noise Levels

Location	Existing Baseline Traffic Flow		Baseline + Construction Traffic Flow		Baseline + Construction Traffic Flow	Assessment of Impact
	Total Traffic Flow	Total HGV	Total Traffic Flow	Total HGV		
A9 Between Thurso and Scrabster Harbour	3369	109 (3%)	3426	111 (3%)	**0.1 dB(A)**	**No Impact**
A9 South of Thurso (near Sordale)	3549	292 (8%)	3635	323 (9%)	**0.3 dB(A)**	**No Impact**
A9 Thurso, east of River Thurso	14675	361 (2%)	15009	393 (3%)	**0.2 dB(A)**	**No Impact**
A9 Thurso, west of River Thurso	3388	206 (6%)	3531	236 (7%)	**0.3 dB(A)**	**No Impact**
A836 Between Thurso and the site access	2427	68 (3%)	2570	95 (4%)	**0.5 dB(A)**	**No Impact**

17.9.10 The results show that no noise impacts at receptor locations from vehicular traffic accessing the site are predicted as the increase in road traffic noise during the construction phase of the development is below 1 dB.

17.10 Mitigation

Operational Mitigation

17.10.1 No specific operational mitigation is required as the relevant noise limits are met. It should be noted that noise reduced modes of operation are generally available for wind turbines of the scale proposed here that allow noise levels to be reduced by restricting the rotational speed of the machines. This mitigation could be employed if any noise issues arise that would require mitigation to be implemented.

17.11 Conclusions

17.11.1 Operational noise from the Revised Consented Development has been assessed by comparing operational noise levels from the Revised Consented Development both acting alone and acting together with the proposed Limekiln Wind Farm Extension against the noise limits applied to the Consented Development. The results of the assessment show that, both the Revised Consented Development

acting alone, and the combined effect of the Revised Consented Development with the proposed Limekiln Wind Farm Extension meet these limits.

17.11.2 Although the Consented Development is already permitted to operate up to the noise limits against which the combined effect of the Revised Consented Development with the proposed Limekiln Wind Farm Extension have been assessed, a further cumulative noise assessment was carried out for completeness. This showed that there were no significant cumulative noise impacts from the operation of the Proposed and Consented Developments with other nearby consented wind farm projects, although cumulative noise levels at 4 locations could be 1 dB above the lowest noise limit that would apply, but still within normal ETSU-R-97 noise limits.

17.11.3 Construction traffic noise has been assessed by calculating the predicted increase in noise levels generated by road traffic associated with the development. No significant noise impacts at receptor locations from vehicular traffic accessing the site are predicted as the increase in road traffic noise during the construction phase of the development is below 1 dB.

Comparison with the Consented Development

17.11.4 It is proposed that the same noise limits that were applied to the Consented Development are applied to the Revised Consented Development, but modified to apply to the cumulative noise from the Revised Consented Development acting together with the proposed Limekiln Extension Wind Farm. In this way, it will be ensured that, operational noise from the combined operation of the Revised Consented Development with the proposed Limekiln Extension Wind Farm remain within the noise limits for the Consented Development. The Revised Consented Development therefore will result in no increases in potential operational noise above that already consented.