Hayes McKenzie
Consultants in Acoustics

Herds Hill Wind Farm

Environmental Noise Impact Assessment

Report HM: 3709_R01_EXT4

24 November 2023

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1. INTRODUCTION

1.1 This report describes the environmental noise impacts associated with the proposed three turbine wind farm at Herd's Hill, south of Kirkconnel, Dumfries and Galloway.

1.2 Construction noise impacts have been scoped out of detailed assessment due to the large separation distances between construction activities and noise sensitive receptors. However, the relevant guidance is discussed and the noise limits that would apply during the construction phase are set out.

1.3 The operational noise impact assessment has been undertaken by comparing predicted operational noise levels for a candidate turbine, with relevant noise limits. The assessment takes into account the guidance set out in ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms,* and the Institute of Acoustics document, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise.*

1.4 A cumulative operational noise impact assessment, incorporating approved, operational, and applied for wind farms in the vicinity has also been undertaken by comparing predicted cumulative operational noise levels, with relevant noise limits.

2. POLICY AND GUIDANCE

National Panning Framework 4

2.1 National Planning Framework 4 (February 2023) sets out the Scottish Government's overarching ambitions with regards to national planning. Policy 11 states that development proposals for all forms of renewable, low-carbon and zero emissions technologies will be supported, but that noise effects on communities should be assessed. Policy 23 states that development proposals that are likely to raise unacceptable noise issues will not be supported.

Planning Advice Note PAN1/2011, Planning and Noise

2.2 PAN1/2011[1] 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*". It refers to the 'web based planning advice' on renewables technologies for onshore wind turbines.

2.3 The associated technical advice note to PAN1/2011 confirms that construction noise should be assessed using BS 5228 Noise and Vibration control on construction and open sites.

BS 5228 Noise and Vibration control on construction and open sites

2.4 BS5228[2] 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.

2.5 The relevant noise limits for construction activities continuing for more than one month are 45, 55 and 65 dB LAeq, for night-time (23:00-07:00), evening and weekends, and daytime (07:00-19:00) including Saturdays (07:00-13:00) respectively . These are the limits against which noise from construction activities are assessed. Noise from construction activities is usually controlled and minimised through a construction and environmental management plan (CEMP) which would be prepared at the time of construction. This would also cover short term construction noise impacts from activities such as track construction which may be required in the vicinity of residential receptors.

2.6 In this case as construction activities are generally distant from noise sensitive receptors, detailed assessment has been scoped out as it is anticipated that the relevant noise limits set out above will be met in practice, and therefore no significant noise construction effects are predicted.

Onshore Wind Policy Statement 2022

2.7 The Scottish Government's Onshore Wind Policy Statement (OWPS) 2022 sets out the Government's ambition to deploy 20 GW of onshore wind by 2030. OWPS section 3.7 relates to noise and refers to ETSU-R-97 and states that all applicants are required to follow the framework set out within it supplemented by the guidance in the Institute of Acoustics (IOA) document; *A Good Practice Guide to the Application of ETSU-R-97 for the*

1 The Scottish Government, 2011. March. Planning Advice Note PAN1/2011, Planning and Noise.

2 BS 5228 + A1, Code of Practice for Noise and Vibration Control on Construction and Open Sites, BSI, 2009 + 2014

Assessment and Rating of Wind Turbine Noise (GPG).

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

2.8 ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, 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.

2.9 ETSU-R-97 recommends that, although noise limits should be set relative to existing background noise 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*.'

2.10 For day-time periods, the noise limit is 35-40 dB L_{A90} or 5 dB(A) above the 'quiet day-time hours'[3] prevailing background noise, whichever is the greater. The actual value within the 35-40 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.

2.11 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 criterion 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}.

2.12 Residential properties where the occupier has financial involvement with the wind farm are allowed higher 'financially involved' noise limits where the lower fixed limits (for both the day-time and night-time) are increased to 45 dB L_{A90}.

2.13 Where predicted noise levels are low at the nearest residential properties a simplified noise

[3] 1800-2300 on weekdays, 1300-2300 on Saturdays and 0700-2300 on Sundays

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 when measured at 10 m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

2.14 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 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.

2.15 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.

2.16 Regarding 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

2.17 In May 2013, the IOA published *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*. The publication of the Good Practice Guide (GPG) followed a review of current practice carried out for the Department of Energy and Climate Change (DECC) and an IOA discussion document which preceded the GPG.

2.18 The GPG includes sections on Context; Background Noise 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*'. It adds that '*the noise limits in ETSU-R-97 have not been examined as these are a matter for Government*'.

2.19 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 followed for this assessment.

Other Issues Arising

Tonal Noise

2.20 As discussed at Paragraph 2.15, ETSU-R-97 specifies that, in line with other noise guidance, a penalty should be added to measured or predicted wind turbine noise levels if there is tonal noise above a certain level which is audible at residential properties. In this assessment, it has been assumed that there would be no tonal noise associated with the operation of the wind farm which would give rise to such a penalty as most modern turbines operate without significant tonal noise. A penalty is usually included with the planning conditions for wind farms requiring a tonal penalty to be added to measured noise levels, where required, before comparing them with the noise limits.

Low Frequency and Infrasound

2.21 Low frequency sound is typically defined as sound in the audible hearing frequency range of 20 Hz up to about 200 Hz. Infra-sound is noise occurring at frequencies below that at which sound is normally audible, i.e. at less than about 20 Hz, due to the significantly reduced sensitivity of the ear at such frequencies. In this frequency range, for sound to be perceptible, it must be at very high amplitude, which is not the case for wind turbine noise.

2.22 Noise from wind turbines is not inherently low-frequency and it is typically broad-band in nature; close to a wind turbine the dominant frequencies are usually in the 250 to 2000 Hz range. As the distance from a wind farm site increases, the noise level decreases as a result of the spreading out of the sound energy and also due to air absorption which increases with increasing frequency. This means that, although the energy across the whole frequency range is reduced, higher frequencies are reduced more than lower frequencies with the effect that, as distance from the site increases, the ratio of low to high frequencies also increases. This effect may be observed with road traffic noise or natural sources, such as the sea, where higher frequency components are diminished relative to lower frequency components at long distances.

2.23 Work carried out in 2006 by Hayes McKenzie for the UK Department of Trade and Industry to investigate the extent of low frequency and infrasonic noise from three UK wind farms 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*'. It is therefore considered that low frequency noise can be scoped out of the assessment.

2.24 In November 2016 a study into low frequency and infrasound was published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Wuerttemberg, Germany that contained a comprehensive review of low frequency and infrasound from wind turbines and evaluated such noise in relation to other sources. The results state that '*the infrasound level in the vicinity of wind turbines is – at distances between 120 m and 300 m – well below the threshold of what humans perceive'* and that '*at a distance of 700 m from the wind turbines, it was observed by means of measurements that when the turbine is switched on, the measured infrasound level did not increase or only increased to a limited extent. The infrasound was generated mainly by the wind and not by the turbines'*.

2.25 The report concludes that 'Infrasound is caused by a large number of different natural and technical sources. It is an everyday part of our environment that can be found everywhere. Wind turbines make no considerable contribution to it. The infrasound level generated by them lie clearly below the limits of human perception. There is no scientifically proven evidence of adverse effects in this level range'. It is therefore considered that infrasound can be scoped out of the assessment.

Amplitude Modulation

2.26 The variation in noise level associated with wind 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 or Amplitude/ 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...'* 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)'*. There have been instances where level of AM rates 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).

2.27 The Department of Energy & Climate Change commissioned a Wind Turbine AM Review report that was published in two phases: Phase 1 in September 2015 and Phase 2 in October 2016 (although the Phase 2 report is dated August 2016). Phase 1 of the report sets out the approach and methodology to the review and research, and the Phase 2 report includes a literature review, 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 a separate Institute of Acoustics (IOA) working group document, A Method for Rating Amplitude Modulation in Wind Turbine Noise (August 2016).

2.28 The AM Review reports recommend a two-tier approach whereby the first tier seeks a reduction in the depth and/or occurrence of AM with a rating level (according to the IOA Amplitude Modulation Working Group 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 has been 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) could be added to the measured level before measured levels are compared with the relevant noise limits.

2.29 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. The IOA GPG, states that '*the evidence in relation to "Excess" or "other" Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM*'. There is no current accepted standard planning condition to deal with AM and it can still be controlled through statutory nuisance powers, although it is possible to control such noise with an appropriately worded planning condition if necessary.

3. NOISE LIMITS AND SIGNIFICANCE CRITERIA

Construction Noise

3.1 Although noise from construction activities has been scoped out of the assessment, the relevant noise limits are set out at Table 1 below, and it is anticipated that these are the limits that would apply to construction activities with a duration of more than one month. It is considered that no significant noise impacts will arise if these noise limits are met.

Table 1 – Construction Noise Limits

Time Period	Limit (dB $L_{Aeq,t}$)
Weekday daytime (07:00-19:00) and Saturday morning (07:00-13:00)	65
Evenings (19:00-23:00) and weekends (Saturday 13:00-19:00 and Sunday (07:00-19:00)	55
Night time (23:00-07:00)	45

Operational Noise

3.2 Operation noise from the proposed development in isolation has been assessed against the ETSU-R-97 simplified limit of 35 dB L_{A90} at wind speeds of up to 10m/s at standardised 10m height. The exception to this is at properties that are inhabited by residents that are financially involved with the proposed development, where the financially involved limit of 45 dB L_{A90} applies.

Cumulative Operational Noise

3.3 There are several consented wind farms in the vicinity of the proposed development. As noted at paragraph 2.16 the ETSU-R-97 noise limits apply to noise from all wind farm developments in the vicinity. The cumulative noise limits applied in the Sanquhar II Wind Farm planning conditions (Energy Consents Unit reference number ECU00001801) are set at the greater of 40 dB L_{A90} and 43 dB L_{A90} during the day and night-time respectively. Therefore, the lowest applicable limit for cumulative operational noise is 40 dB L_{A90}, and the relevant noise limits for cumulative operational noise are therefore the greater of 5 dB above background subject to lower limiting values of 40, 43, and 45 dB L_{A90} for the daytime, night-time, and at financially involved properties respectively.

3.4 The following methodology has therefore been applied to assess the cumulative operational noise impacts:

- Where predicted levels from the proposed development acting alone are below 30 dB L_{A90}, properties will be scoped out of the cumulative assessment. This is because the predicted noise impact from the proposed development is 10 dB or more below the cumulative noise limit and therefore its contribution can be considered to be negligible and not significant.

- Where predicted levels form the proposed development acting alone are below 35 dB L_{A90} for properties financially involved in either the proposed development or a neighbouring scheme, properties will be scoped out of the cumulative assessment. This is because the predicted noise impact from the proposed development is 10 dB or more below the financially involved cumulative limit and therefore its contribution can be considered to be negligible and not significant.

- Where predicted operational noise levels from the proposed development are above 30 dB L_{A90}, cumulative operational noise levels are assessed against a limit of 40 dB L_{A90} at locations that are not financially involved with the proposed development and 45 dB L_{A90} at properties that are financially involved with the proposed development.

3.5 A summary table setting out the noise impact assessment criteria and significance of the impact is set out at Table 2 below. It should be noted that only the daytime noise limit has been used as the basis of the cumulative assessment as the cumulative night-time noise limit is higher, and therefore if the daytime cumulative limits are met then it can be inferred that the night-time limits will also be met.

Table 2 – Operational Noise Limits

Limit (dB L_{A90})	Significance
Predicted operational noise levels from proposed development acting alone equal to or below 30 dB L_{A90}	Negligible (and no further assessment required)
Predicted operational noise levels from proposed development acting alone equal to or below 35 dB L_{A90}	Not significant (subject to cumulative noise effects)
Predicted cumulative operational noise levels equal to or below 40 dB L_{A90}	Not significant
Predicted operational noise levels from proposed development acting alone equal to or below 35 dB L_{A90} where a property is financially involved with the proposed development or neighbouring scheme	Negligible (and no further assessment required)
Predicted operational noise levels from proposed development acting alone equal to or below 45 dB L_{A90} where a property is financially involved with the proposed development or neighbouring scheme	Not significant (subject to cumulative noise effects)
Predicted cumulative operational noise levels equal to or below 45 dB L_{A90} where a property is financially involved with the proposed development or neighbouring scheme	Not significant

4. OPERATIONAL NOISE PREDICTIONS

4.1 Operational noise predictions have been carried out using International Standard ISO 9613, Acoustics - Attenuation of Sound during Propagation Outdoors (International Organization for Standardization, 1996). The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long-term overall averages. When the wind is blowing in the opposite direction, noise levels may be significantly lower, especially if there is any shielding between the site and the houses. Only the ‘worst case’ downwind short-term predictions are carried out here, such that the long-term average predicted noise levels would be lower.

4.2 The GPG suggests that ISO 9613-2 can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions, provided that the appropriate choice of input parameters are made. The prediction methodology is described in Appendix A.

Wind Turbine Sound Power Levels

4.3 The candidate wind turbine is a Vestas V112 3.45MW machine with a hub height of 93 m. The sound power levels at hub height for the V112 were supplied by the manufacturer. These values have been used to calculate the sound power levels at standardised 10 m height wind speeds and are shown at Table 3 below. An uncertainty value of 2 dB has been added to the sound power level data for the turbine and is included within the following tables.

Table 3 – Wind Turbine Sound Power Levels (dB L_{WA})

Turbine make and model	Standardised 10 m height wind speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Vestas V112 3.45 MW	96.1	98.7	103.2	107.0	108.7	108.7	108.7	108.7	108.7	108.7

4.4 The corresponding octave band noise data, taken from manufacturers documentation for the Vestas turbine is shown at Table 4 below for each wind speed.

Table 4 – Wind Turbine Octave Band Levels (dB L_{Aeq})

Standardised 10 m height wind speed (m/s)	Octave band centre frequency (Hz)								Overall
	63	125	250	500	1000	2000	4000	8000	
3	76.9	85.0	88.9	90.1	90.6	87.8	82.3	66.8	96.1
4	78.5	86.7	91.0	92.7	93.7	90.2	85.4	71.4	98.7
5	83.0	91.2	95.5	97.2	98.2	94.7	89.8	75.9	103.2
6	86.6	94.9	99.3	101.0	102.0	98.4	93.6	79.7	107.0
7	87.8	96.1	100.7	102.7	103.9	100.0	95.5	82.5	108.7
8	88.2	96.6	100.9	102.7	103.8	100.2	95.4	81.7	108.7
9	89.2	97.6	101.5	102.7	103.2	100.3	94.8	79.3	108.7
10	89.9	98.4	101.9	102.7	102.6	100.4	94.3	77.5	108.7
11	90.4	99.0	102.1	102.7	102.3	100.4	94.0	76.2	108.7
12	90.7	99.5	102.3	102.7	101.9	100.3	93.7	75.0	108.7

Operational Noise Prediction Results

4.5 Operational noise predictions have been carried out for a number of residential receptor locations representative of the nearest noise sensitive receptors. A number of potential receptors in the vicinity of the proposed development (listed at Table 5 below) are derelict and not inhabitable and have therefore been scoped out of the assessment.

Table 5 – Properties Scoped Out

Location	Grid references	
	Easting	Northing
Corserig	272093	610456
Glenmaddie	274220	607203
Glenglass	270875	606394
Bank Cottage	270578	606421

4.6 The operational noise prediction results for each scoped in noise sensitive receptor location are shown at Table 6 below. An FI in brackets after the property name indicates that the property is financially involved in the proposed development.

Table 6 – Predicted operational noise levels as they vary with wind speed (dB L_{A90})

Location	Grid references		Standardised 10 m height wind speed (m/s)									
	Easting	Northing	3	4	5	6	7	8	9	10	11	12
Drumbuie (FI)	274679	610872	14	16	20	24	26	26	26	27	27	27
Birknowe (FI)	273991	609923	20	23	27	31	32	33	33	33	33	33
Glengape (FI)	273569	609508	25	28	32	36	38	38	38	38	38	38
Euchan Cottage	275703	608154	12	14	19	22	24	24	24	25	25	25
Barmoor Cottages (FI)	275709	609351	13	16	20	24	26	26	26	26	26	27
Old Barr	276266	608532	12	14	18	22	24	24	24	25	25	25
Barr	276530	609379	11	13	17	21	22	23	23	23	24	24
Connelbush	275875	610492	11	13	18	22	23	23	24	24	24	25
Drumbuie Cottage	274885	610878	13	15	20	24	25	25	26	26	26	26
Greystone Avenue	273811	611005	15	17	22	26	27	27	28	28	28	28
Euchan Filter Station House*	272964	607108	21	24	28	32	34	34	34	34	34	34

* Financially involved with Whiteside Wind Farm

4.7 Operational predicted noise levels for a wind speed of 10 m/s are shown as noise contours at Figure 1 appended to this report. Also shown on the noise contour plot are the nearest noise sensitive receptors considered in this assessment. The figure includes topographical corrections (barrier and concave valley) in line with the guidance contained in the GPG.

5. OPERATIONAL NOISE ASSESSMENT

5.1 Predicted operational noise levels have been compared with the noise limit described in section 3 above (i.e. 35 dB L_{A90} or 45 dB L_{A90} at financially involved properties), at the locations listed at Table 6 above.

5.2 The noise assessment results are shown at Table 7 below for each location. A positive number indicates the margin below the relevant limit.

Table 7 – Operational Noise Assessment margin to limits (dB)

Location	Limit (dB L_{A90})	Standardised 10 m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Drumbuie (FI)	45	31	29	25	21	19	19	19	18	18	18
Birknowe (FI)	45	25	23	18	14	13	13	12	12	12	12
Glengape (FI)	45	20	17	13	9	7	7	7	7	7	7
Euchan Cottage	35	23	21	17	13	11	11	11	10	10	10
Barmoor Cottages (FI)	45	32	29	25	21	20	19	19	19	19	18
Old Barr	35	23	21	17	13	11	11	11	11	10	10
Barr	35	25	22	18	14	13	12	12	12	11	11
Connelbush	35	24	22	17	13	12	12	11	11	11	11
Drumbuie Cottage	35	22	20	15	12	10	10	9	9	9	9
Greystone Avenue	35	20	18	13	9	8	8	7	7	7	7
Euchan Filter Station House*	35	14	11	7	3	1	1	1	1	1	1

* Financially involved with Whiteside Wind Farm

5.3 The results of the assessment indicate that the ETSU-R-97 simplified noise limit of 35 dB L_{A90} is met at all noise sensitive receptor locations, and the 45 dB L_{A90} limit is met at all financially involved properties.

5.4 All other noise sensitive locations are further from the proposed turbine than the locations assessed here, and therefore as the relevant noise limits are met at the nearest locations, the relevant noise limits will also be met at more distant locations where operational noise levels will be lower.

5.5 Furthermore, all properties bar Glengape and Euchan Filter Station House have predicted levels from the proposed development below 30 dB L_{A90} (or 35 dB L_{A90} for financially involved properties). These properties have therefore been scoped out of the cumulative assessment as predicted operational noise levels from the proposed development are 10 dB or more below the cumulative noise limit and therefore the contribution from the proposed development is considered to be negligible.

5.6 Euchan Filter Station House is understood to be financially involved with the Whiteside Wind Farm. The predicted levels from the proposed development here are below 35 dB L_{A90} and therefore the property has been scoped out of the cumulative assessment as predicted operational noise levels are 10 dB or more below the financially involved cumulative noise limit and therefore the contribution from the proposed development is considered to be negligible.

6. CUMULATIVE OPERATIONAL NOISE PREDICTIONS

6.1 As discussed in Section 5 cumulative operational noise levels are considered to be not significant where the relevant cumulative noise limit is met by 10 dB or more. There is only one noise sensitive property that is required to be included in the cumulative operational noise impact assessment; Glengape (which is financially involved with the proposed development).

6.2 The following wind farms were considered for inclusion within the cumulative assessment.

- Cloud Hill; 11 Vestas V150 turbines with a hub height of 102.5 m
- Euchanhead; 21 Vestas V150 turbines with a hub height of 155 m
- Hare Hill; 20 Vestas V47 turbines with a hub height of 39 m
- Hare Hill Extension; 35 G52 turbines with hub heights of 45/55/65 m
- Lorg; 15 Vestas V162 turbines with a hub height of 119 m
- Sandy Knowe; 24 Vestas V112 turbines with a hub height of 76 m
- Sandy Knowe Extension; 6 Vestas V112 turbines with a hub height of 94 m
- Sanquhar; 9 Vestas V112 turbines with a hub height of 74 m
- Sanquhar II; 42 Enercon E138 EP3 turbines with a hub height of 125 m hubs, and 2 Enercon E115 EP3 turbines with a hub height of 94 m
- Twenty Shilling Hill; 9 Nordex N100 turbines with a hub height of 75 m
- Whiteside; 10 GE103 turbines with a hub height of 69.7 m

6.3 Initial predictions for each wind farm acting alone, indicated that only Cloud Hill, Sandy Knowe, Sanquhar and Sanquhar II were producing levels greater than 25 dB L_{A90} at Glengape. Predicted operational noise levels from Whiteside Hill were also below 25 dB L_{A90} but given its proximity was included to ensure a conservative assessment. The remaining schemes have been scoped out of the cumulative assessment on the basis that they have a negligible impact on the overall cumulative levels. Figure 2 shows the location of the turbines that have been included in the cumulative operational noise predictions.

6.4 The wind turbine models for the cumulative schemes modelled are presented in Table 8, along with their relevant hub heights. The coordinates of the turbines used can be found in Appendix B. The sound power levels are shown at Table 8 below. An uncertainty value of 2 dB has been added to the sound power level data for the turbine and is included within the following tables.

Table 8 – Wind Turbine Sound Power Levels (dB L_{WA})

Turbine make and model	Hub Height (m)	Standardised 10 m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Vestas V150 5.6 MW	102.5	94.5	98.2	102.5	105.5	106.2	106.9	106.9	106.9	106.9	106.9
Vestas V112 3.6 MW	76.0	95.5	97.4	101.5	105.4	107.4	107.6	107.6	107.6	107.6	107.6
Vestas V112 3.6 MW	74.0	95.5	97.4	101.5	105.3	107.4	107.6	107.6	107.6	107.6	107.6
Enercon E138 EP3 4 MW	125.0	95.8	101.7	103.1	104.1	104.7	105.3	106.0	106.0	106.0	106.0
Enercon E115 EP3 4 MW	94.0	90.4	95.8	100.7	104.7	106.7	107.3	108.0	108.0	108.0	108.0
GE103	69.7	-	95.3	99.1	102.7	106.4	107.0	107.0	107.0	107.0	107.0

6.5 The corresponding octave band noise data, taken from manufacturers documentation, and which is normalised to the required sound power level at each integer wind speed, is shown at Table 9 below, for the V112, E138, E115 and GE103 turbines. The V150 octave band noise data for each wind speed is presented in Table 10.

Table 9 – Wind Turbine Octave Band Levels (dB L_{Aeq})

Turbine make and model	Octave band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Vestas V112 3.6 MW	95.0	98.9	98.8	101.1	101.9	99.2	93.7	77.3
Enercon E138 EP3 4 MW	89.8	95.7	98.4	100.4	100.2	97.8	89.3	68.5
Enercon E115 EP3 4 MW	91.3	97.2	100.2	102.4	102.3	100.1	92.6	75.7

Turbine make and model	Octave band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
GE 103	88.1	95.7	98.2	99.6	101.2	101.3	95.0	75.6

Table 10 – Octave Band Levels (dB LAeq) for the Vestas V150 5.6 MW Turbine

Standardised 10 m height wind speed (m/s)	Octave band centre frequency (Hz)								Overall
	63	125	250	500	1000	2000	4000	8000	
3	75.6	83.2	87.9	89.7	88.5	84.3	77.2	67.0	94.5
4	79.2	86.9	91.6	93.4	92.2	88.0	80.9	70.8	98.2
5	83.5	91.2	95.9	97.7	96.5	92.4	85.3	75.2	102.5
6	86.2	94.0	98.8	100.7	99.6	95.4	88.4	78.2	105.5
7	86.7	94.6	99.4	101.3	100.3	96.1	89.0	78.8	106.2
8	87.9	95.6	100.3	102.1	100.9	96.8	89.8	79.8	106.9
9	88.2	95.7	100.2	102.0	100.9	96.9	90.1	80.4	106.9
10	88.0	95.5	100.1	102.0	101.0	97.1	90.5	81.0	106.9
11	87.7	95.2	99.9	101.9	101.1	97.4	91.0	81.8	106.9
12	87.2	94.9	99.7	101.9	101.2	97.7	91.5	82.4	106.9

Cumulative Operational Noise Prediction Results

6.6 The cumulative operational noise prediction results are shown at Table 11 below.

Table 11 – Predicted cumulative operational noise levels as they vary with wind speed (dB L_{A90})

Location	Grid references		Standardised 10 m height wind speed (m/s)									
	Easting	Northing	3	4	5	6	7	8	9	10	11	12
Glengape (FI)	273569	609508	27	30	34	38	40	40	40	40	40	40

6.7 Operational predicted noise levels for a wind speed of 10 m/s are shown as noise contours at Figure 3 appended to this report. The figure includes topographical corrections (barrier and concave valley) in line with the guidance contained in the GPG.

7. CUMULATIVE OPERATIONAL NOISE ASSESSMENT

7.1 Predicted cumulative operational noise levels at Glengape have been compared with the proposed financially involved noise limit described in Section 3 above (i.e. 45 dB L_{A90}).

7.2 The noise assessment results are shown at Table 12 below. A positive number indicates the margin below the relevant limit.

Table 12 – Cumulative operational noise assessment margin to derived limits (dB)

Location	**Limit (dB L_{A90})**	**Standardised 10 m height wind speed (m/s)**									
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Glengape (FI)	45	18	15	11	7	5	5	5	5	5	5

7.3 The results of the assessment indicate that the financially involved noise limit of 45 dB L_{A90} is met at Glengape and therefore the cumulative operational noise impact is considered to be not significant.

7.4 As discussed above, predicted operational noise levels at all other noise sensitive receptor locations are 10 dB or more below the relevant cumulative noise limit, and therefore no significant cumulative noise impacts are predicted at any other noise sensitive receptor.

8. CONCLUSIONS

8.1 An operational noise assessment for the proposed Herd's Hill Wind Farm has been carried out in line with national policy, which refers to ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms,* and the Institute of Acoustics, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Noise from Wind Turbines.*

8.2 Predicted operational noise levels for the proposed development acting in isolation were compared with the ETSU-R-97 simplified noise limit of 35 dB L_{A90} and the financially involved limit of 45 dB L_{A90}, and the results indicate that the relevant noise limit will be met at all noise sensitive receptors in the vicinity of the development.

8.3 A cumulative operational noise impact assessment was carried out at all receptors where predicted operational noise levels from the proposed development acting in isolative were within 10 dB of the relevant cumulative noise limits. In this case, there was only one noise sensitive receptor location that was required to be included in the cumulative noise impact assessment. The results of the cumulative noise impact assessment indicates that the relevant cumulative noise limits are met.

8.4 Noise will also arise during the construction phase of the development. However, construction noise was scoped out of detailed assessment due to the large separation distances between construction activities and noise sensitive receptors. The relevant noise limits that would apply during the construction phase of the development are set out within this report.

Appendix A

Noise Prediction Methodology

Noise Prediction Methodology

A.1. The ISO 9613-2 standard is used for predicting sound pressure level for downwind propagation by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

Predicted Octave Band Noise Level $= L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$

A.2. These factors are discussed in detail below together with additional terms for taking concave valleys and wind direction into account where required. The predicted octave band levels from each turbine are summed together to give the overall 'A' weighted predicted sound level.

L_W - Source Sound Power Level

A.3. The sound power level of a noise source is normally expressed in dB re: 1pW. Noise predictions are based on sound power levels detailed in the main body of the report.

A.4. The octave band noise spectra used for the predictions have been taken from the technical specifications of the turbine with the results shown in the main body of the report.

D – Directivity Factor

A.5. The directivity factor allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is measured in a down wind direction, corresponding to the worst case propagation conditions considered here and needs no further adjustment.

A_{geo} – Geometrical Divergence

A.6. The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in an attenuation depending on distance according to:

$$A_{geo} = 20 \times \log(d) + 11$$

where d = distance from the turbine

A.7. The wind turbine may be considered as a point source beyond distances corresponding to one rotor diameter.

A_{atm} - Atmospheric Absorption

A.8. Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation depends on distance according to:

$A_{atm} = d \times \alpha$

where d = distance from the turbine

α = atmospheric absorption coefficient in dB/m

A.9. Values of 'α' from ISO 9613 Part 1[4] corresponding to a temperature of 10ºC and a relative humidity of 70%, the values specified in the UK Institute of Acoustics, A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbines Noise (IOA GPG), which give relatively low levels of atmospheric attenuation and correspondingly worst case noise predictions, as given below.

Frequency dependent atmospheric absorption coefficients

Octave Band Centre Frequency (Hz)	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Atmospheric Absorption Coefficient (dB/m)	0.000122	0.000411	0.00104	0.00193	0.0037	0.00966	0.0328	0.117

A_{gr} - Ground Effect

A.10. Ground effect is the interference of sound reflected by the ground with the sound propagating directly from source to receiver. The prediction of ground effects are inherently complex and depend on the source height, receiver height, propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable G which varies between 0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The IOA GPG states that where wind turbine source noise data includes a suitable allowance for uncertainty, a ground factor of G = 0.5 and a receptor height of 4m should be used.

4 ISO 9613-1, Acoustics - Attenuation of sound during propagation outdoors, Part 1: Method of calculation of the attenuation of sound by atmospheric absorption, International Organization for Standardization, 1992

A_{bar} - Barrier Attenuation

A.11. The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under down wind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU[5] concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of sight between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of sight. In this case no topographical shielding has been included in the predictions, as there are no significant topographical barriers.

A_{misc} – Miscellaneous Other Effects

A.12. ISO 9613 includes effects of propagation through foliage, industrial plants and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

Concave Ground Profile

A.13. Sound propagation across a concave ground profile, for example valleys or where the ground falls away significantly between the turbine and the receptor, incurs an additional correction of +3 dB(A) to the overall A-weighted noise levels. This correction is implemented in order to take account of the reduced ground effects and, under some rare circumstances, the potential for multiple reflection paths caused by the concave profile.

A.14. A condition is recommended in the IOA GPG for indicating where this correction should be applied:

$$h_m \geq 1.5 \times \left(\frac{\text{abs}(h_s - h_r)}{2}\right)$$

where h_m is the mean height above ground along the direct path between the source and the receptor, h_s is the absolute source height above ground level and h_r is the absolute receptor height above ground level.

A.15. Whilst this condition is useful at highlighting where the ground profile beneath a source – receptor path may be concave, it is inherently non-robust and can produce false positives.

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5 ETSU W/13/00385/REP, A Critical Appraisal of Wind Farm Noise Propagation, DTI 2000

It should therefore be used in conjunction with a visual assessment of the ground profile when determining whether a correction should be applied.

A.16. Table 13 below shows the calculated barrier and concave ground corrections applied for the Proposed Development.

Table 13 – Proposed Development Barrier and Concave Ground Corrections

Property	T1	T2	T3
Drumbuie (FI)	0	0	0
Birknowe (FI)	0	0	0
Glengape (FI)	0	0	0
Euchan Cottage	-2	-2	-2
Barmoor Cottages (FI)	0	0	0
Old Barr	0	0	0
Barr	0	0	0
Connelbush	0	0	0
Drumbuie Cottage	0	0	0
Greystone Avenue	0	0	0
Euchan Filter Station House	-2	0	-2

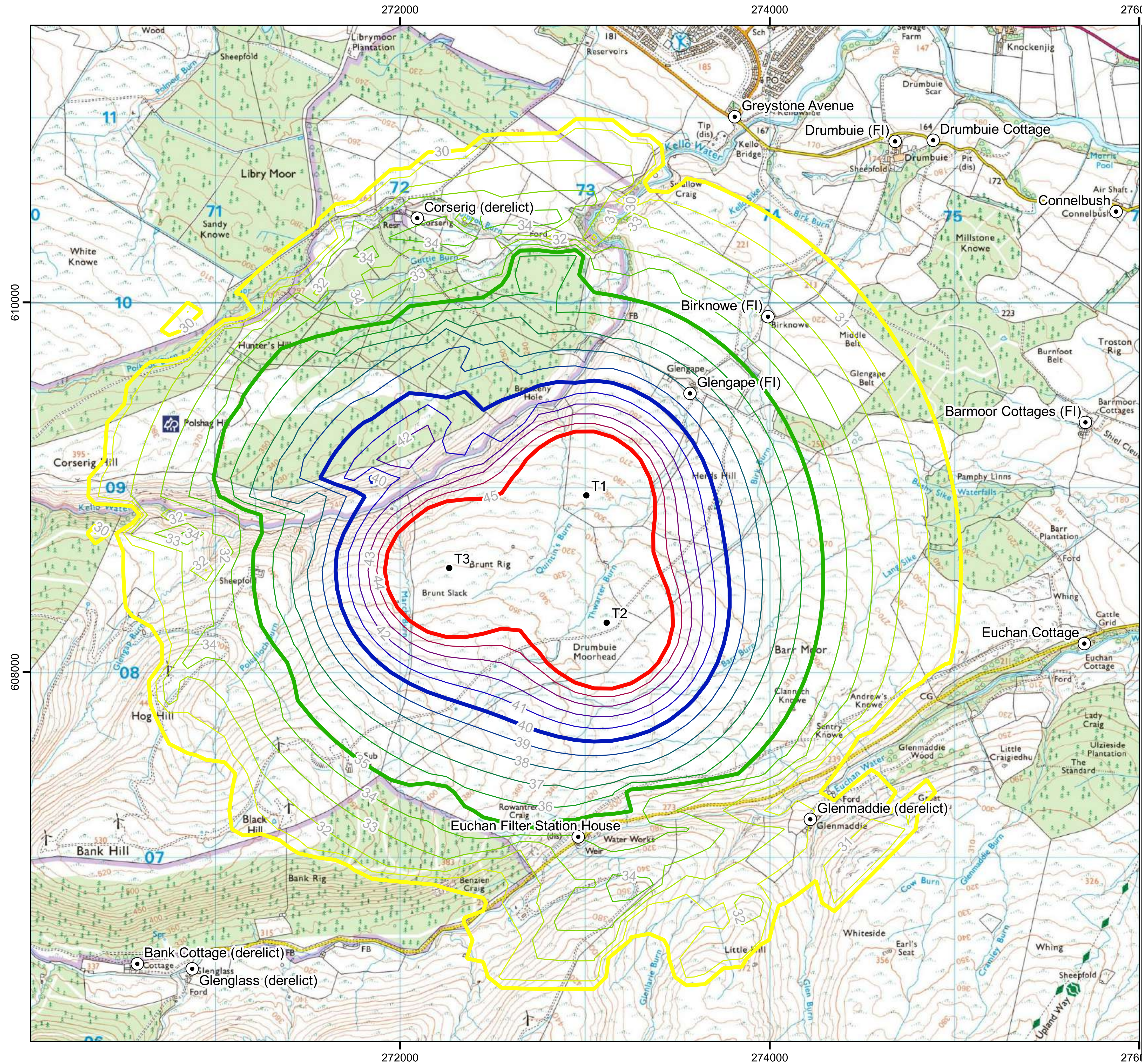
Appendix B

Turbine Locations

Table B.1 – Turbine Locations

Wind Farm	Turbine ID	Easting	Northing	Hub Height
Herds Hill	T1	273008	608956	93
Herds Hill	T2	273118	608267	93
Herds Hill	T3	272266	608563	93
Cloud Hill	CH1	272659	604834	102.5
Cloud Hill	CH2	273175	604921	102.5
Cloud Hill	CH3	273092	605665	102.5
Cloud Hill	CH4	273373	605389	102.5
Cloud Hill	CH5	273730	605207	102.5
Cloud Hill	CH6	274245	605360	102.5
Cloud Hill	CH7	273845	605862	102.5
Cloud Hill	CH8	274884	605633	102.5
Cloud Hill	CH9	274544	605909	102.5
Cloud Hill	CH10	274504	606359	102.5
Cloud Hill	CH11	273559	606172	102.5
Sandy Knowe	SK1	269572	611396	76
Sandy Knowe	SK2	269201	611337	76
Sandy Knowe	SK3	269055	611108	76
Sandy Knowe	SK4	268892	610887	76
Sandy Knowe	SK5	269030	610590	76
Sandy Knowe	SK6	268807	610399	76
Sandy Knowe	SK7	268720	610143	76
Sandy Knowe	SK8	268627	609893	76
Sandy Knowe	SK9	269488	611065	76
Sandy Knowe	SK10	269408	610668	76
Sandy Knowe	SK11	269198	610102	76
Sandy Knowe	SK12	269050	609876	76
Sandy Knowe	SK13	269913	610787	76
Sandy Knowe	SK14	269962	610498	76
Sandy Knowe	SK15	269724	610136	76
Sandy Knowe	SK16	269685	609866	76
Sandy Knowe	SK17	270428	610753	76
Sandy Knowe	SK18	270382	610471	76
Sandy Knowe	SK19	270402	610182	76
Sandy Knowe	SK20	270151	610007	76
Sandy Knowe	SK21	270187	609664	76
Sandy Knowe	SK22	270579	609876	76
Sandy Knowe	SK23	270830	610051	76
Sandy Knowe	SK24	270764	610503	76
Sanquhar	S1	271343	607571	74
Sanquhar	S2	269085	607945	74
Sanquhar	S3	268760	607612	74
Sanquhar	S4	271398	607240	74
Sanquhar	S5	270967	607108	74
Sanquhar	S6	270476	607158	74
Sanquhar	S7	270745	607985	74
Sanquhar	S8	270086	607069	74
Sanquhar	S9	269714	607527	74
Sanquhar II	SII1	269049	607171	125
Sanquhar II	SII2	268288	607015	125
Sanquhar II	SII3	267673	606542	125
Sanquhar II	SII4	267437	605867	125
Sanquhar II	SII5	266682	605196	125
Sanquhar II	SII6	266119	604768	125
Sanquhar II	SII7	265660	604150	125
Sanquhar II	SII8	265306	604543	125
Sanquhar II	SII9	264993	604941	125
Sanquhar II	SII10	264947	605469	125
Sanquhar II	SII11	266055	603373	125
Sanquhar II	SII12	266769	603637	125

Sanquhar II	SII13	267282	603469	125
Sanquhar II	SII14	267993	604117	125
Sanquhar II	SII15	268463	604679	125
Sanquhar II	SII16	268566	603463	125
Sanquhar II	SII17	268793	604105	125
Sanquhar II	SII18	269493	603801	125
Sanquhar II	SII19	270312	603852	125
Sanquhar II	SII20	270823	603554	125
Sanquhar II	SII21	269912	601914	125
Sanquhar II	SII22	270398	601312	125
Sanquhar II	SII23	270767	600999	125
Sanquhar II	SII24	271405	600887	125
Sanquhar II	SII25	272015	600451	125
Sanquhar II	SII26	272602	600916	125
Sanquhar II	SII27	272622	600262	125
Sanquhar II	SII28	273200	600051	125
Sanquhar II	SII29	273949	599815	125
Sanquhar II	SII30	274648	599339	125
Sanquhar II	SII31	270939	601845	125
Sanquhar II	SII32	271536	602350	125
Sanquhar II	SII33	271853	601945	125
Sanquhar II	SII34	272117	602837	125
Sanquhar II	SII35	272772	603135	125
Sanquhar II	SII36	273344	603022	125
Sanquhar II	SII37	272466	602391	125
Sanquhar II	SII38	272850	602033	125
Sanquhar II	SII39	273291	601732	125
Sanquhar II	SII40	273929	601996	125
Sanquhar II	SII41	273733	601390	125
Sanquhar II	SII42	274058	601025	125
Sanquhar II	SII43	271644	608084	94
Sanquhar II	SII44	271979	607680	94
Whiteside	W1	270905	604899	69.7
Whiteside	W2	271047	604579	69.7
Whiteside	W3	271528	604749	69.7
Whiteside	W4	271748	605145	69.7
Whiteside	W5	271764	605490	69.7
Whiteside	W6	270979	605290	69.7
Whiteside	W7	271920	604847	69.7
Whiteside	W8	272351	605270	69.7
Whiteside	W9	272494	605657	69.7
Whiteside	W10	272692	606090	69.7



Project:

3709 Herds Hill Wind Farm

Title:
Figure 01: Predicted Operational Noise Levels - Proposed Development Only - Vestas V112 3.45MW, non-STE, at 10 m/s

Key

- Receptor Locations
- Herds Hill Turbine Locations

Predicted Noise Levels (dB LA90)
(intermediate lines at 1 dB spacing)

- 30
- 35
- 40
- 45
- 50

Scale @ A3: 1:21,237.359325
Coordinate System: British National Grid

N

0 1 km

Date: 24-11-23	Prepared by: ERG	Checked by: RES
Ref: 3709_F01	EXT3	

Drawing by:
Hayes McKenzie Partnership Ltd.
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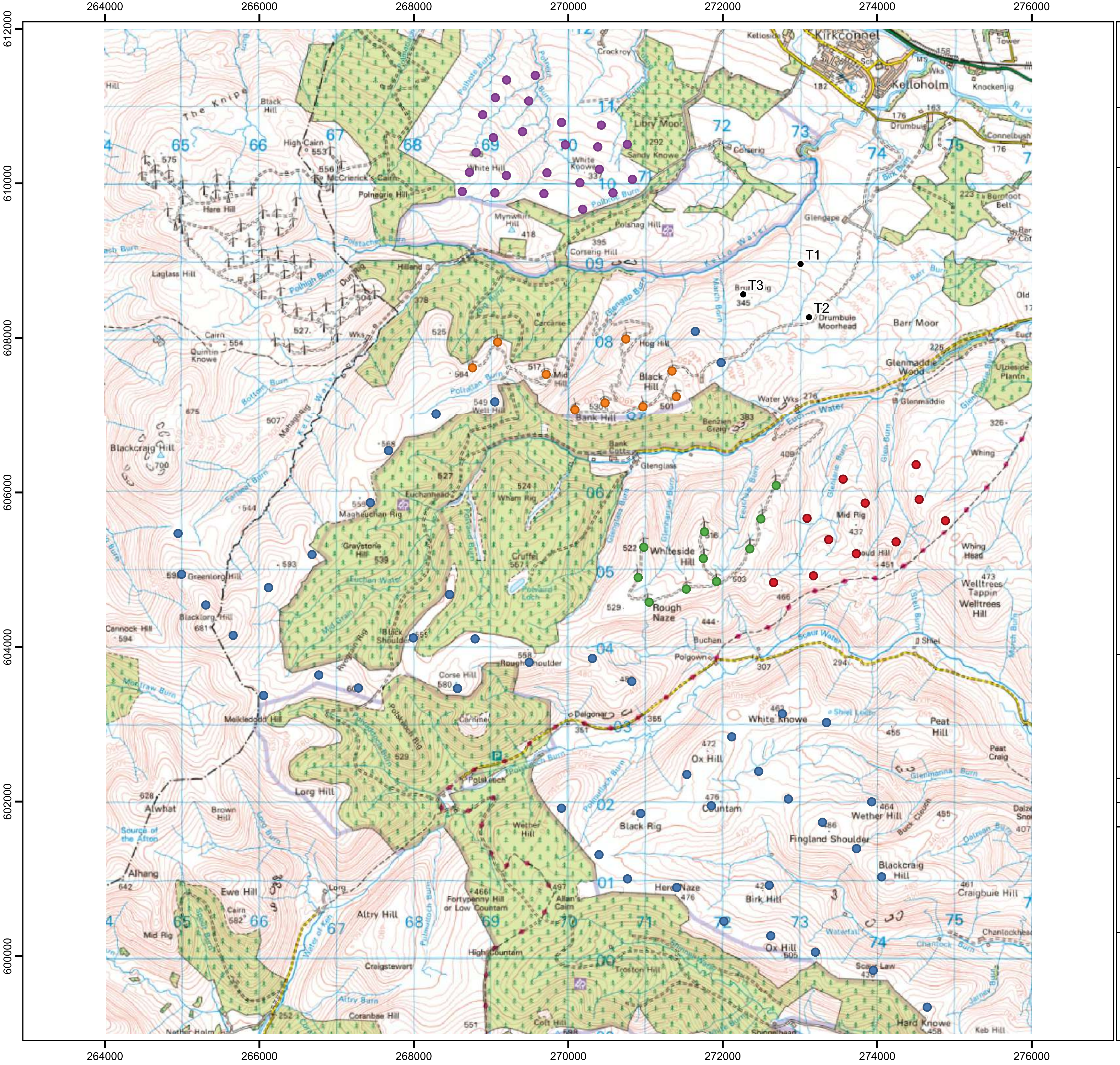

Project:

3709 Herds Hill Wind Farm

Title:
Figure 02: Cumulative Wind Farms - Turbine Locations Scoped In

Key

- Herds Hill Turbine Locations
- Cloud Hill Turbine Locations
- Sandy Knowe Turbine Locations
- Sanquhar Turbine Locations
- Sanquhar II Turbine Locations
- Whiteside Turbine Locations

Scale @ A3: 1:50,000.035396

Coordinate System: British National Grid

N

0 1 km

Date: 24-11-23	Prepared by: ERG	Checked by: RES
Ref: 3709_F03	EXT3	

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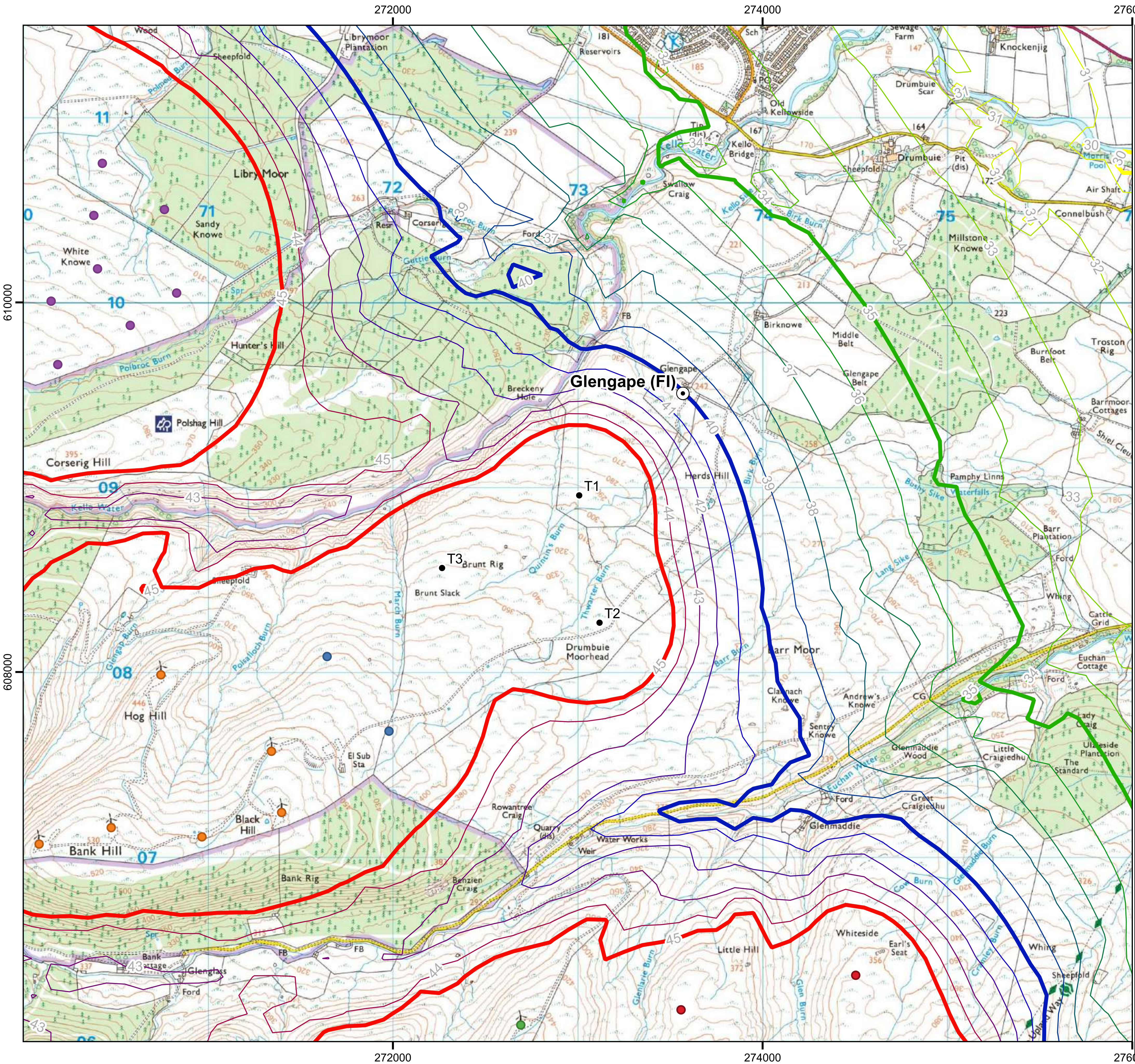

Project:

3709 Herds Hill Wind Farm

Title:
Figure 03: Predicted Cumulative Operational Noise Levels at 10 m/s

Key

- Receptor Locations
- Herds Hill Turbine Locations
- Cloud Hill Turbine Locations
- Sandy Knowe Turbine Locations
- Sanquhar Turbine Locations
- Sanquhar II Turbine Locations
- Whiteside Turbine Locations

Predicted Noise Levels (dB LA90)
(intermediate lines at 1 dB spacing)

- 30
- 35
- 40
- 45
- 50

Scale @ A3: 1:21,237.359325
Coordinate System: British National Grid

0 1 km

N

Date: 24-11-23	Prepared by: ERG	Checked by: RES
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