Section 11
NOISE

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11.1 Introduction

11.1.1 Hayes McKenzie Partnership Limited (HMPL) have undertaken an assessment of the potential noise levels resulting from the introduction of the proposed Scoop Hill Windfarm, located in Dumfries & Galloway, on behalf of Community Windpower Limited (CWL).

11.1.2 The operational assessment has been carried out according to the recommendations of ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, and the best practice guidance published by the Institute of Acoustics, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (GPG) and its associated Supplementary Guidance documents. These documents are referred to within web-based planning guidance provided by the Scottish Government.

11.1.3 Noise limits for properties neighbouring the Proposed Development have been derived from data obtained during a survey of background noise levels at several dwellings neighbouring the development combined with corresponding on-site wind speed information in accordance with ETSU-R-97, as refined by the GPG.

11.1.4 Predictions of the noise levels associated with the operation of the Proposed Development, based on the installation of Enercon E138 4.2MW wind turbines, have been compared with the noise limits derived as discussed above.

11.1.5 A discussion of the potential impacts relating to the construction of the Development, including from possible blasting within the proposed borrow pits, is provided in terms of relevant guidance; BS5228 Code of Practice for Noise and Vibration Control on Construction & Open Sites. However, a detailed assessment is not provided here as the relative distances from turbine construction activities and neighbouring properties will mean that potential noise levels will be well within typical limits in this regard.

11.2 Legislation, Policy & Guidelines

PAN1/2011, Planning and Noise

11.2.1 Planning Advice Note PAN1/2011 (Scottish Government 2011) identifies two sources of noise from wind turbines; mechanical and aerodynamic. 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 renewable technologies for onshore wind turbines.

11.2.2 The accompanying Technical Advice Note to PAN1/2011, Assessment of Noise, lists BS5228, Noise and Vibration Control on Construction and Open Sites (see Paragraphs 11.2.19 to 11.2.21) as being applicable for Environmental Impact Assessment (EIA) and planning purposes.

Web Based Planning Advice, Onshore Wind Turbines

11.2.3 The web based planning advice on onshore wind turbines (Scottish Government, 2014) states that the sources of noise are *"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"* and that *"there has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design"*. 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"*. 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"*.

11.2.4 It 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 (GPG), and states that *"the Scottish Government accepts that the guide represents current industry good practice"*.

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

11.2.5 ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (DTI, 1996), 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.

11.2.6 ETSU-R-97 recommends that 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, and it states that *"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"*.

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

11.2.8 For night-time periods the noise limit is 43 dB L_{A90} or 5 dB above the prevailing night-time hours background noise, whichever is the greater. The 43 dB L_{A90} lower limit is based on a sleep disturbance criteria of 35 dB(A) with an allowance of 10 dB for attenuation through an open window and 2 dB subtracted to account for the use of L_{A90} rather the L_{Aeq} (see Paragraph 11.2.12).

11.2.9 Where the occupier of a property has some financial involvement with the proposal, the day and night-time lower noise limits are increased to 45 dB L_{A90} and consideration can be given to increasing the permissible margin above background. These limits are applicable up to a wind speed of 12 m/s measured at 10 m height on the site.

11.2.10 Quiet day-time periods are defined as evenings from 18:00-23:00 plus Saturday afternoons from 13:00-18:00 and Sundays from 07:00-18:00. Night-time is defined as 23:00-07:00. The prevailing background noise level is set by calculation of a best fit curve through values of background noise plotted against wind speed as measured during the appropriate time period with background noise measured in terms of $L_{A90,t}$. The $L_{A90,t}$ is the noise level which is exceeded for 90% of the measurement period 't'. It is recommended that at least 1 weeks' worth of measurements are required.

11.2.11 Where predicted noise levels are low at the nearest residential properties, a simplified noise limit can be applied, such that noise is restricted to a 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.

11.2.12 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 noise level. Use of the L_{A90} descriptor, the level exceeded for 90% of the measurement period, for wind farm noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

11.2.13 ETSU-R-97 also specifies that a penalty should be added to the predicted noise levels, where any audible tone is present. The level of this penalty, as shown on page 10 of the executive summary, is described and varies according to the level by which any tonal components exceed audibility.

11.2.14 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 effect of all wind turbines in the area contributing to the overall turbine noise received at the properties in question. Existing wind farms should therefore not be considered as part of prevailing background noise level and noise limits should be compared with cumulative predictions for proposed wind turbines operating in combination with existing sites.

A Good Practice Guide to the Application of ETSU-R-97

11.2.15 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 (IoA, 2013). This was subsequently endorsed by the Scottish Government. 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, 2011) and an IoA discussion document which preceded the GPG (IoA, 2012).

11.2.16 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"*. It adds that *"the noise limits in ETSU-R-97 have not been examined as these are a matter for Government"*.

11.2.17 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.

BS 8233 Guidance on Sound Insulation and Noise Reduction for Buildings

11.2.18 British Standard (BS) 8233 (BSI, 2014) advises the use of ETSU-R-97 when assessing wind farm noise impact and states that reliable estimates of wind farm noise levels can be made by implementing the procedures set forth in the IOA GPG. It draws particular attention to the issues of amplitude modulation (AM); however, it goes on to state that such adverse effects cannot be predicted at the planning stage.

BS 5228 Code of Practice for Noise and Vibration Control on Construction and Open Sites

11.2.19 BS 5228:2009 + A1:2014 (BSI, 2009 + 2014) 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.

11.2.20 The first is based on the use of criteria defined in Department of the Environment Advisory Leaflet (AL) 72, Noise Control On Building Sites (DoE, 1976), 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}.

11.2.21 The second is based on noise change but applies minimum criteria of 45, 55 and 65 dB L_{Aeq} for night-time (23:00-07:00), evening and weekends (19:00-23:00 weekdays, 13:00-23:00 Saturdays and 07:00-23:00 Sundays), and daytime (07:00-19:00) including Saturdays (07:00-13:00) respectively. These limits are applicable when existing noise levels are relatively low, which they are at the Proposed Development, and have a duration of one month or more. It should be noted that the time period to which each limit applies also defines the time averaging period for the calculated L_{Aeq}.

Blade Swish (Amplitude Modulation of Aerodynamic Noise)

11.2.22 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) and is an inherent feature of wind turbine noise. This affect 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)'*.

11.2.23 It has been noted that complaints to planning authorities regarding wind farm noise in the UK, where they have occurred, have often been specifically concerned with amplitude modulation. This is also apparent from ETSU-R-97, where it is noted that *'it is the regular variation of the noise with time that, in some circumstances, enables the listener to distinguish the noise of the turbines from the surrounding noise'*. The modulation of noise may affect perceived annoyance for sounds with the same overall sound pressure level.

11.2.24 RenewableUK (RUK), the main renewable energy trade association in the UK, completed research into the causes and subjective effects of AM (RUK, 2013) following various reports of increased levels of AM being experienced at dwellings neighbouring some wind turbine sites. This concluded that the predominant cause is likely to be from individual blades going in and out of stall as they pass through regions of higher wind speed at the top of their rotation under high wind shear conditions. Subjective tests carried out by Salford University, using loudness matching techniques, demonstrated the extent to which higher levels of modulation depth result in increased perceived loudness.

11.2.25 This resulted in the inclusion of a mechanism to assess and regulate AM effects in the standard form of a potential planning condition (RUK, 2013), which could be applied to wind farm developments in the same way as that included in the IoA GPG. The IoA reviewed this mechanism and released a discussion document (IoA, 2015) which reviews several different methods for rating amplitude modulation in wind turbine noise and subsequently released a recommended method (IOA, 2016) by which to characterise the peak to trough level in any given 10 minute period.

11.2.26 Although this document provides a definitive approach to the quantification of amplitude modulation, it does not provide any comment on what could be defined as an unacceptable level of AM nor any kind of penalty scheme, such as for tonal content, by which the overall turbine noise level should be corrected to account for its presence. This has subsequently been covered by a Department of Energy & Climate Change (DECC) commissioned project looking at human response to the amplitude modulated component of wind turbine noise (DECC, 2016).

11.2.27 The combination of these two documents provides both a method of quantification of the level of amplitude modulation over a given 10-minute period and the appropriate penalty to apply where necessary. This is in addition to any penalty for tonal noise.

11.2.28 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 can be covered by a suitably worded planning condition. One proposed wording for such a condition can be seen in an article jointly authored by a number of consultants working in the area in the November/December 2017 issue of the Institute of Acoustics' Acoustics Bulletin magazine (McKenzie et al., 2017).

11.2.29 Currently, AM is typically addressed in response to any complaints via a measurement scheme that refers to emerging best practice in this regard. There are no standard or agreed methods by which to predict, with any certainty, the likelihood of amplitude modulation occurring at a level requiring a penalty at a particular development, only some indicators such as relatively high wind shear conditions under certain circumstances or particular turbine designs and/or dimensions for example.

Wind Shear

11.2.30 Wind shear, or more specifically vertical wind shear, is the rate at which wind speed increases with height above ground level. This has particular significance to wind turbine noise assessment where background noise measurements are referenced to measurements of wind speed at 10 metres height, which is suggested as appropriate by ETSU-R-97, but which is not representative of wind at hub-height, which is what affects the noise generated by the turbines.

11.2.31 The preferred method of accounting for wind shear in noise assessments is by referencing background noise measurements to hub height wind speed. Hub height wind speed may be determined directly by using a tall mast or remote sensing technology (i.e. LiDAR or SoDAR) or indirectly from measurements at a number of heights below hub height in order to calculate the hub height wind speed during the background noise survey period, as described in the GPG referred to in Paragraphs 11.2.15 to 11.2.17. The hub height wind speeds are then converted to 'standardised 10 m wind speeds', assuming reference ground roughness conditions as used by turbine manufacturers when specifying turbine sound power levels.

Tonal Noise

11.2.32 ETSU-R-97 notes that, where complaints had been made over noise from windfarms existing at the time the report was written, the tonal character of the noise from machinery in the nacelle had been the feature that had caused greatest annoyance. The recommendation was, therefore, that any assessment carried out should include a correction to the predicted noise levels according to the level of any tonal components in the noise. A specific tonal assessment methodology is described in the report which is based on the well-established Joint Nordic Method for the Evaluation of Tones in Broadband Noise (DMoE, 1984) which has now been superseded by a revised version (Pederson et al., 1999) although this revision makes no substantive difference to the ETSU-R-97 methodology. A scale of corrections for tonal noise is included where the penalty is increased as the tone level increases above audibility to a maximum of 5 dB. The necessity of minimising tonal components in the noise output from the turbines is well understood by the turbine manufacturers and a guarantee should always be sought that any tonal noise will be below that requiring a penalty under the ETSU-R-97 scheme.

Infra-sound

11.2.33 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 has to be of very high amplitude and it is generally considered that when such sounds are perceptible then they can cause considerable annoyance.

11.2.34 Wind turbines have been cited by some as producers of infra-sound. This has, however, been due to the high levels of such noise, as well as audible low frequency thumping noise, occurring on older 'downwind' turbines of which many were installed in the USA prior to the large scale take up of wind power production in the UK. Downwind turbines are configured with the blades downwind of the tower such that the blades pass through the wake left in the wind stream by the tower resulting in a regular audible thump, with infra-sonic components, each time a blade passes the tower. Virtually all modern larger turbines are of the upwind design; that is with the blades upwind of the tower, such that this effect is eliminated.

11.2.35 A study into low frequency noise from wind farms (ETSU/DTI, 2006) concluded that *"infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Even assuming that the most sensitive members of the population have a hearing threshold which is 12 dB lower than the median hearing threshold, measured infrasound levels are well below this criterion"*. It goes on to state that, based on information from the World Health Organisation, *"there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects"* and that *"it may therefore be concluded that infrasound associated with modern wind turbines is not a source which may be injurious to the health of a wind farm neighbour"*.

11.2.36 A considerable amount of research has been conducted in regard to the levels of infrasound that wind turbines emit (ETSU/DTI, 1997) (Styles et al., 2005) (Turnball et al., 2012). All reliable evidence suggests that at typical residential distances (e.g. at 500 m or more), the levels of infrasound from a wind farm are significantly below accepted thresholds of perception. Even when measured in close proximity to a wind turbine, the measured levels of infrasound are still below accepted thresholds of perception. This suggests that infrasound is not an issue for neighbours in the vicinity of wind turbines.

Low Frequency Noise

11.2.37 Noise from modern wind turbines is essentially broad band in nature in that it contains similar amounts of noise energy in all frequency bands from low to high frequency. As distance from a windfarm 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 sound 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 is not specific to wind turbines and 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. At such distances, where residential properties are typically located in relation to wind farm developments, the overall noise level is so low, such that any bias in the frequency spectrum is insignificant.

Vibration

11.2.38 The ETSU study referenced at Paragraph 11.2.36 (ETSU/DTI, 1997) found that vibration from wind turbines, as measured at 100 m from the nearest machine, was well below the criteria recommended for human exposure in critical working areas such as precision laboratories (BSI, 2008). At greater distances from turbines vibration levels are even lower. This has been confirmed by the Keele University study (Styles et al., 2005), which showed vibration levels of around 10^{-8} $m.s^{-2}$ at a distance of 2.4 km from the Dun Law Windfarm site under high wind conditions, orders of magnitude lower than the criteria referred to above which specify levels in the region of 0.005 $m.s^{-2}$.

Audibility

11.2.39 The potential audibility of noise from proposed wind turbines depends to a large extent on the amount by which the predicted turbine noise level exceeds the noise from other sources (the baseline or background noise level) and the presence of any acoustical 'features' which distinguish it. Such other noise may be steady and unchanging, but is more likely to be continuously variable depending on the time of day and other factors including, particularly in rural areas, wind speed.

11.2.40 The results of baseline noise measurements carried out for the Proposed Development are expressed in terms of the level exceeded for 90 % of each 10-minute interval which are shown plotted against wind speed on the background noise data analysis charts. The potential audibility of wind turbine noise from the Proposed Development, for the quiet day-time and night-time hours and for worst case downwind propagation from the site towards the various measurement locations, can be determined by comparing the relevant predicted turbine noise with the corresponding measured background noise level for each 10 minute measurement period. Where predicted noise levels are around the same level as the background noise this suggests that the noise source may be just audible, with perceived audibility increasing with margin above background and also when taking into account any significant acoustic features such as tonality or amplitude modulation. Similarly, where predicted noise levels are lower than the existing background noise levels, audibility decreases correspondingly as it reduces.

Sleep Disturbance

11.2.41 The potential for sleep disturbance depends on the average and maximum levels of noise in sleeping areas during the night-time period. The night-time noise limits in ETSU-R-97 aim to protect against sleep disturbance by limiting the amount of turbine noise external to dwellings assuming a worst case of inhabitants sleeping with the windows open for ventilation. The internal noise levels in such circumstances can be calculated by assuming a 10-15 dB reduction in noise from outside to inside. The World Health Organisation (WHO) published recommendations in 1999 to the effect that average night-time noise levels in sleeping areas should not exceed 30 dB L_{Aeq} (WHO, 1999). Although this figure relates to overall noise level in sleeping areas, the potential for sleep disturbance specifically from turbine noise, for worst case downwind propagation with windows open, can be evaluated for each dwelling by subtracting 10-15 dB from the predicted turbine noise level and comparing with this criterion, after also adding 2 dB to convert the predicted turbine noise level to an L_{Aeq} value.

11.2.42 It should be noted that guidance from the WHO on night noise levels, in the form of the Night Noise Guidelines for Europe (WHO, 2009), recommends that the population is not exposed to average external night-time noise levels, over a whole year, of more than 40 dB L_{Aeq}. This average yearly noise level will depend on the variation in wind speed, wind direction and noise from other sources over each year period.

11.2.43 Further to the above, the latest guidance from the WHO (WHO, 2018) conditionally recommends that turbine noise should not exceed an L_{den} of 45 dB. L_{den} is the average noise level over one year, where noise during evening and night-time periods is penalised with a 5 and 10 dB correction respectively. Although compliance can be shown through predictions, it would be almost impossible to establish compliance with this limit through measurements at residential locations.

11.2.44 It should also be noted that potential difficulty in getting to sleep, either at the start of the night or once awoken by other sources, may be more related to audibility indoors under specific circumstances (see Paragraph 11.2.39) than by average noise level.

11.3 Consultation

11.3.1 Dumfries & Galloway Council (D&GC) environmental department were consulted on the proposed approach to background noise monitoring, the general methodology for the assessment, the level of construction noise assessment to be provided and the operational noise limits that are to be put forward in terms of the impacts associated with the Development.

11.3.2 A number of locations were proposed as suitable for monitoring as part of the consultation. However, as the correspondence with D&GC indicated may be the case, the specific monitoring locations listed within the correspondence have changed and various assumptions have been made where either access to undertake monitoring at certain properties was not granted or a particular property was deemed not suitable for the purposes of the exercise.

11.4 Assessment Methodology & Significance Criteria

Assessment Methodology

11.4.1 The assessment of the noise levels associated with the Proposed Development have been undertaken in accordance with ETSU-R-97 and the GPG for (i.e. via the comparison of derived noise limits with predicted operational noise levels at neighbouring dwellings over a range of wind speeds). There are no other wind farms in the vicinity of the Proposed Development that would result in combined cumulative noise effects of any relevance.

11.4.2 Table 11.1 shows the co-ordinates of the assessment locations used to represent residential properties, as considered within this chapter, and the corresponding location from which background noise information is available to represent each one (or group). The background noise data used to represent locations where specific information is not available are prescribed on a basis which is considered to be conservative i.e. using the measurement location corresponding to that which has the lowest derived prevailing background noise levels for the majority of the time (see Section 11.5).

11.4.3 The assessment locations are named based on Ordnance Survey markings on relevant maps and may not represent the specific names of some dwellings in reality. Furthermore, some of the locations represent small groups of residences. A location representative of a property that is considered to be financially involved (FI) with the development and an indication of the corresponding background noise assumptions and corresponding limits (see Paragraphs 11.2.7 to 11.2.9) are also marked accordingly. The buildings known as Craigfield and Old Garwarsheilds are derelict and Old Braefield will not be occupied for the life of the wind farm. As a result, these locations are not referred to any further.

Table 11.1 Assessment Locations & Applied Background/Baseline Noise Levels

Name	Easting	Northing	Representative Background Monitoring Location
Craigbeck Hope	313760	603615	Dryfe Lodge
Newbigging	311085	598452	Newbigging
Kilbrook (FI)	311663	597160	Kilbrook
Leithenhall Cottages (FI)	312918	596850	Dryfe Lodge
Leithenhall Farm (FI)	312963	596706	Dryfe Lodge
Kirkhill Farm (FI)	313489	596266	Dryfe Lodge
Kirkhill Cottages	313506	595955	2 Kirkhill Cottages
Laverhay (FI)	313966	598272	Dryfe Lodge
Laverhay Cottage (FI)	313964	598291	Dryfe Lodge
Laverhay Farm (FI)	314009	598093	Dryfe Lodge
Crowgill (FI)	313948	597684	Crowgill
Milne (FI)	313851	597220	Dryfe Lodge
Kirncleugh	314150	594432	Dryfe Lodge
Waterhead of Dryfe	318886	594313	Dryfe Lodge
Dryfe Lodge	318426	593651	Dryfe Lodge
Waterhead Cottage	318695	593928	Dryfe Lodge
Sandyford Cottage	320407	593787	Dryfe Lodge
Kilburn	320576	596006	Kilburn
Finniegill (FI)	317100	598238	Finniegill
Wood Cottage (FI)	317220	597921	Finniegill

11.4.4 Construction noise (including forestry felling) has been discussed in general terms and with due regard to typical guidance on this matter.

Noise Prediction Methodology

11.4.5 Noise predictions have been carried out using International Standard ISO 9613, Acoustics - Attenuation of Sound During Propagation Outdoors. The propagation model described in Part 2 of this standard (ISO, 1996) provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long-term overall averages. In this case only the former has been considered except where otherwise indicated.

11.4.6 The ISO propagation model calculates the predicted sound pressure level 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:

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

11.4.7 These factors are discussed in detail below. The predicted octave band levels are summed together to give the overall 'A' weighted predicted sound level.

11.4.8 The turbine co-ordinates used for the assessment have been provided by CWL and are shown at Table 11.2 below for reference.

Table 11.2 Turbine Co-ordinates

ID	Easting	Northing	Hub	ID	Easting	Northing	Hub	ID	Easting	Northing	Hub
T1	312672	599050	125	T26	316244	599891	175	T51	316911	595207	125
T2	312672	598423	125	T27	316568	599470	175	T52	317338	596114	125
T3	312652	597748	125	T28	316881	599000	175	T53	317696	595735	125
T4	313097	599735	125	T29	315440	599190	125	T54	317676	595186	125
T5	313425	599236	125	T30	314623	599026	125	T55	318365	595445	125
T6	313363	598636	125	T31	315812	598811	175	T56	319311	595318	125
T7	313348	597956	125	T32	314970	598596	125	T57	319126	595951	125
T8	312593	600275	125	T33	315350	598114	125	T58	318347	596321	125
T9	312907	600876	105	T34	315450	597585	125	T59	318973	597234	125
T10	313214	601536	105	T35	314823	597078	125	T60	319318	596764	125
T11	313826	601870	105	T36	315442	596819	125	T61	319883	595184	125
T12	313887	601268	125	T37	314855	596296	125	T62	320057	594684	125
T13	313790	600764	125	T38	314784	595558	125	T63	317992	596829	125
T14	313656	600308	125	T39	315411	596015	125	T64	318419	597447	175
T15	314429	602335	105	T40	315974	596530	125	T65	318298	597974	175
T16	314745	601897	150	T41	315904	595769	125	T66	318053	598453	175
T17	316349	602807	125	T42	315574	595224	125	T67	318172	599198	175
T18	316345	602256	125	T43	316081	595222	125	T68	317984	599770	175
T19	316541	601754	175	T44	316113	598034	175	T69	317962	600559	175
T20	315887	601440	175	T45	316153	597268	125	T70	317743	601134	175
T21	316221	601040	175	T46	316703	597917	175	T71	317265	600588	175
T22	316515	600596	175	T47	316847	597220	125	T72	317140	601105	175
T23	315285	600882	175	T48	317624	597413	175	T73	317453	601823	150
T24	315709	600129	175	T49	316485	596382	125	T74	317382	602590	125
T25	314961	599964	125	T50	316566	595771	125	T75	317142	603165	125

L_W - Source Sound Power Level

11.4.9 The sound power level of a noise source is normally expressed in dB re:1pW. Noise predictions for the proposed Scoop Hill turbines are based on the sound power levels for the Enercon E138 4.2MW turbine with a hub-height of 125 m and with serrated trailing edges (STEs) installed on the blades, as provided by the turbine manufacturer.

11.4.10 In reality, the proposed turbine hub-heights will range from around 105 to 175 m depending on the specific turbine location/number, with the majority of 125 m hub-height turbines being located closest to and having the dominant impact on the majority of neighbouring receptors. As a result, the difference in relative hub-heights will not have a substantive effect on the predicted noise level and assessment herein, especially in instances where lower fixed noise limits (not set relative to background noise) apply at neighbouring dwellings for some wind speeds and at some locations. The reference wind speed becomes less relevant under these circumstances; the comparative maximum overall turbine level with the respective lower limiting value is generally the key matter. It is considered that the approach taken here provides a robust basis for assessment despite any perceived discrepancies/difficulties in determining the wind speed reference for the assessment.

11.4.11 The sound power levels for the turbine model are taken from specification documents provided by the manufacturer with 2 dB added to account for uncertainty. As such, the assumed sound power levels are likely to be comparable to a declared sound power level i.e. derived according to the methodology detailed within IEC 61400-14 (IEC, 2005).

11.4.12 The provided source noise data is referenced to wind speeds experienced at the hub-height of the turbine. As a result, the data has been converted to reference standardised 10 m height wind speeds in accordance with procedures defined within IEC-61400-11 (IEC, 2012).

11.4.13 Table 11.3 provides the overall source noise levels used for the noise predictions, including for the uncertainty, and taking into account the conversion from hub-height to standardised wind speeds explained above.

Table 11.3 Turbine Source Sound Power Levels, dB L_{WA}

Turbine	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
E138 4.2MW Mode 0 125 m	98.6	102.1	105.2	106.2	107.1	108.0	108.0	108.0	108.0	108.0

11.4.14 The octave band noise spectrums used for the noise predictions are shown at Table 11.4. The data for the E138 turbine is also based on the information obtained from Enercon, normalised to the maximum sound power level for the unrestricted mode of operation shown in Table 11.3.

Table 11.4 Octave Band Noise Spectra, dB L_{WA}

Turbine	Overall dB L_{WA}	Octave Band Centre Frequency (Hz)							
		63	125	250	500	1k	2k	4k	8k
E138 4MW Mode 0	108.0	89.5	95.2	98.1	100.5	102.1	102.8	97.8	81.9

11.4.15 The predictions provided assume that the wind turbine noise contains no audible tones. Where tones are present, a correction is added to the measured or predicted noise level before comparison with the limits. The audibility of any tones can be assessed by comparing the narrow band level of such tones with the masking level contained in a band of frequencies around the tone called the critical band. The ETSU-R-97 noise limits require a tone correction to be applied to any derived turbine noise levels resulting from noise measurements of the operational turbines which depends on the amount by which the tone exceeds the audibility threshold. A warranty will be sought from the supplier of the turbines to be installed at the site to help to ensure that no tonal penalty would be required in practice.

D - Directivity Factor

11.4.16 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 the case of wind turbines, the sound power level is measured in a downwind direction, corresponding to the worst-case propagation conditions considered here and needs no further adjustment except as covered by wind direction effects (as discussed below).

A_{geo} - Geometrical Divergence

11.4.17 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 x log(d) + 11

where, d = distance from the turbine

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

A_{atm} - Atmospheric Absorption

11.4.19 The atmospheric absorption accounts for the frequency dependant linear attenuation with distance over the frequency spectrum according to:

A_{atm} = d x α

where, α = the atmospheric absorption coefficient for the relevant frequency band

11.4.20 Published values of ‘α’ from ISO9613 Part 1 (ISO, 1992) have been used, corresponding to a temperature of 10ºC and a relative humidity of 70%, which give relatively low levels of atmospheric attenuation, as given at Table 11.5. This provides a conservative basis for assessment.

Table 11.5 Atmospheric Absorption Coefficients

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.0010	0.0019	0.0037	0.0097	0.0328	0.1170

A_{gr} - Ground Effect

11.4.21 Ground effect is the interference of sound reflected by the ground interfering 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 and any sites with low porosity) and 1 for ‘soft’ ground (includes ground covered by grass, trees or other vegetation). The GPG recommends that the use of G = 0.5 and a receptor height of 4 m in rural areas are appropriate assumptions for the determination of noise emission levels at receptor locations downwind of wind turbines, provided that an appropriate margin for uncertainty has been included within the source levels for the proposed turbine. Accordingly, predictions provided here are based on G = 0.5 with a receptor height of 4 m.

A_{bar} - Barrier Attenuation

11.4.22 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 downwind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU (DTI, 2000), concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of site 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 site. The effect of barrier attenuation, including the effects of increased distance from the turbine to surrounding dwellings as a result of the surrounding topography as compared with a 'flat-earth' model, has been included within the prediction model.

11.4.23 The potential attenuation of noise due to the topography of the site has been determined through the inclusion of a terrain map within the prediction model. The resultant attenuation due to the topographical barriers has been calculated using VDI 2720 Noise Control by Barriers Outdoors (VDI, 1997). The relevant inputs, C_1, C_2 and C_3, account for the proportional attenuation effects associated with line of sight between the source and receiver, the relative path difference and the presence of any localised reflections near the barrier respectively. These factors have been calibrated, minimising the overall effect of each such that the resultant attenuation due to topography at neighbouring residences is limited to approximately 2 dB where there is clearly no line of site between a turbine and the receptor, 5 dB in situations where there is a significant topographical barrier between a particular turbine and a receptor and 10 dB in exceptional situations where receptors are located relatively close to particularly large barriers such as tall cliff faces that obstruct any view from the wind farm site.

A_{misc} - Miscellaneous Other Effects

11.4.24 ISO 9613 includes effects of propagation through foliage and industrial plants as additional attenuation effects. The attenuation due to foliage has not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

Concave Ground Profile

11.4.25 Studies have shown that sound propagation across a valley or 'concave ground profile' can result in noise levels which are higher than predicted due to a reduced ground effect and/or the focussing effect of the ground shape. Calculating the precise effect of this phenomenon is particularly difficult. However, a simplified approach to allow for it has been suggested in the GPG. Paragraph 4.3.9 in the GPG states that *'A further correction of +3 dB (or +1.5 dB if using G=0.0) should be added to the calculated overall A-weighted noise level for propagation "across a valley", i.e. a concave ground profile, or where the ground falls away significantly, between the turbine and the receiver location. The following criterion of application is recommended:*

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

where, h_m is the mean height above the ground of the direct line of sight from the receiver to the source (as defined in ISO 9613-2, Figure 3), and h_s and h_r are the heights above local ground level of the source and receiver respectively.'

11.4.26 The GPG states that *'Care needs to be exercised when evaluating this condition, as small changes in distances and height may trigger (or not) the criterion when the actual situation has not changed significantly'*. It is also evident that the criterion may also be triggered in situations where there is more than one valley between a particular source and receiver, where, in reality, the stated causes of the 'concave ground profile' effect could not occur.

11.4.27 The topography between the turbines and surroundings considered here has been incorporated into the noise model. A 3 dB correction has been applied in all instances where the above criterion is fulfilled, except where there is no line-of-sight between a turbine and a relevant location (i.e. one of the possible instances where the criterion may be triggered but the stated effect could not occur in practice).

Significance Criteria

11.4.28 There are no formal significance criteria for assessing noise from wind farms. However, for the purposes of this assessment, the noise impact is considered to be not significant if the limits discussed at Paragraphs 11.2.7 to 11.2.9 are met and significant if not.

11.4.29 Construction noise is assessed against an adopted daytime criterion of 65 dB L_{Aeq} and the impact is therefore judged to be not significant if this criterion is met (see Paragraphs 11.2.19 to 11.2.21).

11.5 Baseline Conditions

11.5.1 A background noise survey was carried out, as the first stage of the assessment procedure. A total of seven dwelling locations were chosen based on the turbine layout considered here.

11.5.2 The survey was undertaken over the period from 18th March to the 7th April 2020.

Noise Measurement Locations

11.5.3 A description of each of the monitoring locations is provided below. Photos of each may be provided on request.

Crowgill

11.5.4 This dwelling is located to the southwest of the Proposed Development. The noise monitoring equipment was placed near a poly tunnel to the northeast of the dwelling and approximately 2 m from a small shed. Noise sources noted during installation and removal of the equipment included birdsong, water noise, occasional traffic and slight creaking from the nearby shed.

Newbigging

11.5.5 This property is located directly to the west of the Proposed Development. The monitoring equipment was installed to the north of the dwelling, within the front garden. Noise sources noted during installation and removal of the equipment included traffic on the M74, occasional local traffic, birdsong and wind in the trees and surrounding foliage.

Kilbrook

11.5.6 This property is located to the southwest of the Proposed Development. Noise monitoring equipment was placed on the lawn to the front of the property. Noise sources that were audible during installation and removal of the equipment included rooks, traffic on the M74, occasional local traffic, birdsong and wind in the trees.

2 Kirkhill Cottages

11.5.7 This property is also located to the southwest of the Proposed Development. The equipment was placed within the garden to the rear of the dwelling in a position that minimised water noise from a nearby stream. Audible noise during installation and removal of the equipment included water flow from a brook to the south of the dwelling, wind in the trees and birdsong.

Dryfe Lodge

11.5.8 This group of 3 properties is located to the south of the Proposed Development. The equipment was placed in the front garden of one of the properties, away from a river passing to the west. Noise sources that were audible during installation and removal of the kit were birdsong, very occasional traffic, wind in the trees and water noise from the river running to the west of the dwellings.

Kilburn

11.5.9 This property is located to the southeast side of the Proposed Development. The equipment was placed in the back garden. Water noise from the nearby reservoir dominated the noise environment with birdsong and wind in the trees also being audible during installation and removal of the noise monitoring equipment.

Finniegill

11.5.10 This dwelling is located to the centre of the Proposed Development. The noise monitoring equipment was placed within the garden to the north of the dwelling. Noise sources that were audible during installation and removal of the equipment included birdsong, wind in the trees, occasional aircraft overhead and water noise from a stream running to the east of the house.

Instrumentation

11.5.11 The background/baseline noise measurements were made with Larson Davis model LD-820 Sound Level Meters fitted with 1/2" microphones which comply with the Type 1 standard in IEC 651-1:1979 (IEC, 1979). The microphones were fitted with 45 mm radius foam ball windshields surrounded by 125 mm radius secondary windshields of 40 mm thickness, based on recommended design specifications within ETSU W/13/00386/REP, Noise Measurements in Windy Conditions (ETSU/DTI, 1996), and mounted on tripods at a height of approximately 1.2 to 1.5 metres height. Pre-calibration and post calibration checks were carried out using Brüel & Kjær acoustic calibrators (s/n 3022368 & 2218188).

11.5.12 Concurrent onsite wind data was obtained from an existing meteorological mast with cup anemometers installed at 81, 60 and 40 m height and a wind vane installed at a height of approximately 80 m.

11.5.13 Pluvimate rain gauges were installed at Kilbrook & Dryfe Lodge in order to provide an indication of when it rained at all monitoring locations.

Measurement Procedure

11.5.14 The meters were programmed to measure a number of statistical noise indices, including the L_{A90}, together with the maximum and minimum levels and the L_{Aeq} over consecutive 10-minute intervals. The equipment was synchronised to a Global Positioning System (GPS) time signal and the results were automatically stored at the end of each interval.

11.5.15 Calibration of the noise measurement equipment was carried out before the monitoring commenced and was checked at the end. A change of no more than 0.2 dB was noted at any of the measurement locations, which is within normal tolerances.

11.5.16 Wind shear has been addressed by relating background noise measurements to 125 m height wind speed (the hub height of the dominant turbines, see Paragraph 11.4.10), determined from the wind speed measured at 81 and 60 m height above ground level and based on instantaneous wind shear exponent, α, for each period, as derived from the expression:

$$\frac{V_1}{V_2} = \left(\frac{h_1}{h_2}\right)^{\alpha},$$

where, h_1 and h_2 are the respective heights at which wind speeds V_1 and V_2 were measured.

11.5.17 This derived hub height wind speed has been corrected to 'standardised' 10 m height wind speed using the same methodology as is used by manufacturers to quantify sound power level data as required by IEC 61400-11 (IEC, 2012) and as detailed within the GPG, i.e.:

$$V_{10} = V_h \left(\frac{\ln\left(\frac{10}{z_0}\right)}{\ln\left(\frac{h_h}{z_0}\right)} \right),$$

where, V_{10} and V_h are the 'standardised' 10m height and hub height (h_h) wind speeds respectively, and z_0 is the reference ground roughness length (=0.05 m). In this way, it is ensured that the comparisons of predicted turbine noise level, background level and the corresponding noise limits are made on a like-for-like basis.

11.5.18 Rainfall data was taken from the installed rain gauges, which both logged rainfall in 10-minute intervals, time synchronised to a GPS time signal. This allows for corresponding data, where noise levels may be affected by the presence of rainfall, to be removed from the analysis.

Results of Measurements

11.5.19 The noise, wind and rain data collected during the measurement campaign have been analysed in accordance with the requirements of ETSU-R-97, as refined by the GPG.

11.5.20 Prevailing background noise levels during the night-time and quiet daytime hours have been derived by plotting the measured L_{A90} background noise levels against the standardised 10 m height wind speeds as described within ETSU-R-97 and the GPG and shown within Appendix 11.1 (Figures 1 to 14) for the quiet daytime and night night-time periods defined within ETSU-R-97.

11.5.21 Any 10 minute period where rainfall was recorded at either of the measurement locations is shown with dark blue circles and has been removed from the derivation of the prevailing background noise levels from the data collected at all the measurement locations. Other atypical or extraneous noise levels have also been removed from the analysis at some locations and these are identified with green circles.

11.5.22 All data has been referenced to local tame i.e. taking into account the change from GMT to BST at 01:00 on the 29th March 2020. Data collected between hours of 05:00 & 07:00 at all locations has been removed from the analysis (red circles) as this represents times where dawn chorus and/or traffic can influence the results during the night-time.

11.5.23 Second and third order lines of best fit have been calculated through the respective night-time and daytime background noise data for each time period to give the prevailing background noise levels over a range of wind speeds at each measurement location, as required for the derivation of the ETSU-R-97 limits. Table 11.6 shows these in tabular form. Where background noise levels appear to increase with decreasing wind speeds, this is considered to be an anomaly of the analysis and the lowest derived level for any given wind speed has been used to represent the background noise level in such instances.

Table 11.6 Prevailing Background Noise Levels, dB L_{A90}

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Night-time										
Crowgill	31.2	31.2	31.3	31.6	32.2	33.0	33.9	35.1	36.5	38.1
Newbigging	36.4	36.4	36.4	36.4	36.8	37.5	38.6	40.1	41.9	44.1
Kilbrook	35.9	35.9	35.9	35.9	36.2	36.9	38.1	39.6	41.6	44.0
2 Kirkhill Cottages	37.5	37.5	37.5	37.6	37.7	38.0	38.3	38.8	39.4	40.1
Dryfe Lodge	25.4	25.4	25.8	26.4	27.4	28.6	30.2	32.1	34.3	36.9
Kilburn	31.5	31.5	31.7	32.0	32.6	33.3	34.2	35.3	36.6	38.0
Finniegill	29.0	29.1	29.5	30.2	31.2	32.5	34.2	36.1	38.4	41.0
Quiet Daytime										
Crowgill	31.4	31.5	32.0	32.9	34.0	35.3	36.7	38.3	39.9	41.4
Newbigging	37.7	37.7	37.9	38.5	39.5	40.7	42.1	43.6	45.1	46.5
Kilbrook	38.1	38.1	38.1	38.5	39.5	40.9	42.7	44.9	47.4	50.2
2 Kirkhill Cottages	38.2	38.2	38.2	38.2	38.3	38.7	39.6	41.1	43.4	46.7
Dryfe Lodge	27.7	28.6	29.4	30.2	31.2	32.4	34.0	36.2	38.9	42.5
Kilburn	32.3	32.3	32.8	33.5	34.6	35.9	37.6	39.4	41.5	43.8
Finniegill	30.1	30.2	30.9	31.9	33.1	34.6	36.0	37.3	38.3	39.0

11.5.24 Table 11.7 shows the resultant and corresponding night-time & upper daytime and noise limits for each of the relevant measurement locations (see Paragraphs 11.2.7 & 11.2.8).

11.5.25 The Proposed Development has a very large generating capacity with a relatively small number of dwellings neighbouring the site and with the majority of these residences being located upwind of the site in the prevailing wind direction, it reduces any potential exposure to noise. As a result, and in-line with the recommendations of ETSU-R-97 (see Paragraph 11.2.7), the upper daytime noise limit has been adopted for this project in the instances where neighbouring dwellings do not have a financial involvement with the development.

Table 11.7 Noise Limits, dB L_{A90}

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Night-time										
Crowgill	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1
Newbigging	43.0	43.0	43.0	43.0	43.0	43.0	43.6	45.1	46.9	49.1
Kilbrook	43.0	43.0	43.0	43.0	43.0	43.0	43.1	44.6	46.6	49.0
2 Kirkhill Cottages	43.0	43.0	43.0	43.0	43.0	43.0	43.3	43.8	44.4	45.1
Dryfe Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Kilburn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Finniegill	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	46.0
Daytime										
Crowgill	40.0	40.0	40.0	40.0	40.0	40.3	41.7	43.3	44.9	46.4
Newbigging	42.7	42.7	42.9	43.5	44.5	45.7	47.1	48.6	50.1	51.5
Kilbrook	43.1	43.1	43.1	43.5	44.5	45.9	47.7	49.9	52.4	55.2
2 Kirkhill Cottages	43.2	43.2	43.2	43.2	43.3	43.7	44.6	46.1	48.4	51.7
Dryfe Lodge	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Kilburn	40.0	40.0	40.0	40.0	40.0	40.9	42.6	44.4	46.5	48.8
Finniegill	40.0	40.0	40.0	40.0	40.0	40.0	41.0	42.3	43.3	44.0

11.5.26 The derived prevailing background noise levels and corresponding noise limits have been applied to these and the remaining assessment locations as detailed at Table 11.1. Where a property is expected to have a financial involvement (FI) with the scheme, the lower limiting night-time and daytime values have been increased to 45 dB L_{A90}, as prescribed within ETSU-R-97 (see Paragraph 11.2.9). The resultant limits are shown at Table 11.8 below.

Table 11.8 Noise Limits, dB L_{A90}

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Night-time										
Craigbeck Hope	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Newbigging	43.0	43.0	43.0	43.0	43.0	43.0	43.6	45.1	46.9	49.1
Kilbrook (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.6	49.0
Leithenhall Cottages (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Leithenhall Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Kirkhill Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Kirkhill Cottages	43.0	43.0	43.0	43.0	43.0	43.0	43.3	43.8	44.4	45.1
Laverhay (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Laverhay Cottage (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Laverhay Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Crowgill (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Milne (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Kirncleugh	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Waterhead of Dryfe	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Dryfe Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Waterhead Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Sandyford Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Kilburn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Finniegill (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.0
Wood Cottage (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.0
Old Garwaldshiels (Derelict)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Daytime										
Craigbeck Hope	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Newbigging	42.7	42.7	42.9	43.5	44.5	45.7	47.1	48.6	50.1	51.5
Kilbrook (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	52.4	55.2
Leithenhall Cottages (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Leithenhall Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Kirkhill Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Kirkhill Cottages	43.2	43.2	43.2	43.2	43.3	43.7	44.6	46.1	48.4	51.7
Laverhay (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Laverhay Cottage (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Laverhay Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Crowgill (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.4
Milne (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Kirncleugh	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.5
Waterhead of Dryfe	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Dryfe Lodge	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Waterhead Cottage	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Sandyford Cottage	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.9	47.5
Kilburn	40.0	40.0	40.0	40.0	40.0	40.9	42.6	44.4	46.5	48.8
Finniegill (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Wood Cottage (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0

11.6 Potential Effects

Operational Noise

11.6.1 Appendix 11.2 provides a comparison of the predicted operational turbine noise levels with the applied noise limits assuming that all the dwellings considered here are downwind of all turbines simultaneously and that the turbines are operating unrestricted (including for all relevant corrections in terms of concave ground and barrier effects etc.). Appendix 11.3 shows the corresponding contour plot of the noise levels resulting from the Proposed Development for the wind speeds where operational noise levels from the proposed turbines are at their maximum.

11.6.2 The predicted turbine noise L_{Aeq} has been adjusted by subtracting 2 dB to give the equivalent L_{A90} as suggested in ETSU-R-97 and reaffirmed within the GPG. Table 11.9 shows the predicted noise levels associated with the Proposed Development over a range of standardised 10 m height wind speeds for reference.

11.6.3 A comparison of the levels shown at Table 11.9 with the limits at Table 11.8 (as provided within Appendix 11.3) shows that predicted levels of operational noise are below the prescribed ETSU-R-97 criteria.

11.6.4 Further to the above, as discussed at Paragraph 11.4.10, the predicted turbine noise levels and relevant noise limits are referenced to standardised 10 m height wind speeds derived from a 125 m height. In reality, the proposed turbine hub-heights will range from around 105 to 175 m height depending on the specific turbine location/number, with the majority of 125 m hub-height turbines being located closest to the majority of neighbouring receptors. As a result, the difference in hub-heights will not have a substantive effect on the predicted noise level. Where lower fixed noise limits (not set relative to background noise) apply at neighbouring dwellings for relevant wind speeds, the hub-height reference wind speed therefore becomes less relevant under these circumstances and the maximum overall turbine level in comparison with the respective derived ETSU-R-97 lower limiting value is the key issue. It is considered that the approach taken here provides a robust basis for assessment despite the difficulties in defining the appropriate wind speed reference height.

11.6.5 As a result of the above, operational noise is considered not significant (see Paragraph 11.4.28).

Table 11.9 Predicted Scoop Hill Turbine Noise Levels, dB L_{A90}

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Craigbeck Hope	25.3	28.8	31.9	32.9	33.8	34.7	34.7	34.7	34.7	34.7
Newbigging	26.7	30.2	33.3	34.3	35.2	36.1	36.1	36.1	36.1	36.1
Kilbrook (FI)	27.9	31.4	34.5	35.5	36.4	37.3	37.3	37.3	37.3	37.3
Leithenhall Cottages (FI)	29.1	32.6	35.7	36.7	37.6	38.5	38.5	38.5	38.5	38.5
Leithenhall Farm (FI)	28.7	32.2	35.3	36.3	37.2	38.1	38.1	38.1	38.1	38.1
Kirkhill Farm (FI)	29.6	33.1	36.2	37.2	38.1	39.0	39.0	39.0	39.0	39.0
Kirkhill Cottages	28.6	32.1	35.2	36.2	37.1	38.0	38.0	38.0	38.0	38.0
Laverhay (FI)	34.6	38.1	41.2	42.2	43.1	44.0	44.0	44.0	44.0	44.0
Laverhay Cottage (FI)	34.6	38.1	41.2	42.2	43.1	44.0	44.0	44.0	44.0	44.0
Laverhay Farm (FI)	34.6	38.1	41.2	42.2	43.1	44.0	44.0	44.0	44.0	44.0
Crowgill (FI)	34.0	37.5	40.6	41.6	42.5	43.4	43.4	43.4	43.4	43.4
Milne (FI)	32.3	35.8	38.9	39.9	40.8	41.7	41.7	41.7	41.7	41.7
Kirncleugh	26.4	29.9	33.0	34.0	34.9	35.8	35.8	35.8	35.8	35.8
Waterhead of Dryfe	29.0	32.5	35.6	36.6	37.5	38.4	38.4	38.4	38.4	38.4
Dryfe Lodge	25.8	29.3	32.4	33.4	34.3	35.2	35.2	35.2	35.2	35.2
Waterhead Cottage	27.0	30.5	33.6	34.6	35.5	36.4	36.4	36.4	36.4	36.4
Sandyford Cottage	26.4	29.9	33.0	34.0	34.9	35.8	35.8	35.8	35.8	35.8
Kilburn	28.1	31.6	34.7	35.7	36.6	37.5	37.5	37.5	37.5	37.5
Finniegill (FI)	34.8	38.3	41.4	42.4	43.3	44.2	44.2	44.2	44.2	44.2
Wood Cottage (FI)	35.2	38.7	41.8	42.8	43.7	44.6	44.6	44.6	44.6	44.6

Construction Noise

11.6.6 The construction of the proposed turbines will occur at distances that are highly unlikely to breach typical construction noise limits prescribed within relevant guidance such as BS 5228 Code of Practice for Noise and Vibration Control on Construction & Open Sites (see Paragraphs 11.2.19 to 11.2.21). This combined with the temporary nature of the works means that a detailed assessment of the construction noise impacts is not considered necessary. Furthermore, it is not expected that upgrades to local roads and provision of additional tracks relating to construction would occur in close proximity to neighbouring dwellings. As a result, this aspect of the Proposed Development is considered not significant (see Paragraph 11.4.29).

11.6.7 If required, an additional construction noise impact may be from blasting associated with stone extraction from borrow pits in order to obtain materials for the construction of turbine bases and access roads. This type of noise does not typically fall within the assessment of normal construction noise because of the extremely high amplitude and impulsive nature of the waveform. It is very likely that blasting noise could be heard at nearby residential locations, but a construction noise assessment would average noise levels across the day and is therefore not applicable to use for the assessment of blasting noise impacts. Mitigation to reduce the noise impact from blasting activities is set out in Section 11.7.

11.6.8 Where highways upgrades and cabling between the site and grid connection is carried out close to residential properties, there may be temporary short-term noise impacts, with the level of impact dependant on the specific work required. It is likely, however, that noisy activities near residential properties will generally continue for less than one month, and therefore this short-term noise impact can be considered to be not significant.

11.7 Cumulative Assessment

Operational Noise

11.7.1 There are no cumulative operational impacts expected at this time. As a result, this aspect is considered to be not significant.

Construction Noise

11.7.2 There are no cumulative effects expected in respect of construction noise. As a result, this is considered not significant.

11.8 Mitigation

Operational Noise

11.8.1 The site has been designed such that predicted noise levels associated with the operation of the Proposed Development are expected to meet the requirements of ETSU-R-97 with all turbines operating unrestricted. As a result, no mitigation measures are prescribed here.

11.8.2 No significant residual operational effects are predicted as operational noise levels meet the relevant derived noise limits.

Construction Noise

11.8.3 Noise during construction works would be controlled by generally restricting works to standard working hours and exclude Sundays, unless specifically agreed otherwise.

11.8.4 BS 5228 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authorities would be required along with providing information to residents on intended activities.

11.8.5 The construction works on-site would be carried out in accordance with:

- relevant EU Directives and UK Statutory Instruments that limit noise emissions from a variety of construction plant;
- the guidance set out in PAN1/2011 and BS 5228: 2009; and
- Section 61 of the Control of Pollution Act 1974 and Section 80 of the Environmental Protection Act.

11.8.6 There are no residential properties within 1 km of any road improvements and therefore construction noise from this activity is highly unlikely to be significant.

11.8.7 A noise control plan would be produced that includes:

- procedures for ensuring compliance with statutory or other identified noise control limits;
- procedures for minimising noise from construction related traffic on the existing road network;
- procedures for ensuring that all works are carried out in accordance with the principle of "Best Practicable Means" as defined in the Control of Pollution Act 1974; and
- general induction training for site operatives, and specific training for staff having responsibility for particular aspects of controlling noise from the site.

11.8.8 In terms of the blasting, if required for the Proposed Development, the most appropriate mechanism is for a pre-blasting noise management programme to be prepared which would identify the most sensitive receptors that could be potentially affected by blasting noise. The programme would contain details of the proposed frequency of blasting, and proposed monitoring procedures. The operator would inform the nearest residents of the proposed times of blasting and of any deviation from this programme in advance of the operations. The programme would also contain contact details which would be provided to local residents should concerns arise regarding construction and blasting activities. In addition, each blast will be designed carefully to maximise its efficiency and to reduce the transmission of noise.

11.8.9 Operational noise would ultimately be controlled via planning conditions which set out noise limits for the Proposed Development.

11.9 Residual Effects

Operational Noise

11.9.1 No significant residual operational effects are expected as operational noise levels meet the relevant derived noise limits without mitigation/curtailment applied to the turbines, although it is entirely possible that noise from the Proposed Development may be audible at receptor locations at times (see Paragraphs 11.2.39 & 11.2.40). However, noise levels will meet planning guidelines in this regard.

11.9.2 Operational noise would, in practice, be controlled via planning conditions which set out noise limits for the Proposed Development.

Construction Noise

11.9.3 No significant residual construction effects are expected as construction noise levels will be below the adopted noise limit, although it is possible that noise from construction activities could be audible at receptor locations at times.

11.10 Summary

11.10.1 A noise assessment was carried out in order to determine whether the site meets typical planning requirements in respect of operational noise from wind turbines. The assessment takes in to account the methodologies set out within ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996) and the Institute of Acoustic document, A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise.

11.10.2 Background/baseline noise measurements were undertaken at a selection of seven locations surrounding the Proposed Development. The results of the survey have been used to derive appropriate noise limits which have been applied at all the potentially affected dwellings surrounding the site.

11.10.3 The results of the operational noise assessment indicate that turbine noise levels meet the relevant noise limits and no specific mitigation is required. The noise impact is, therefore, determined to be not significant.

11.10.4 Construction noise levels at neighbouring dwellings are expected to meet typical requirements in this regard and no specific mitigation measures are considered to be required other than that deemed necessary under normal best practice requirements.

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Appendix 11.1: Data Analysis

Figure 11.1.1

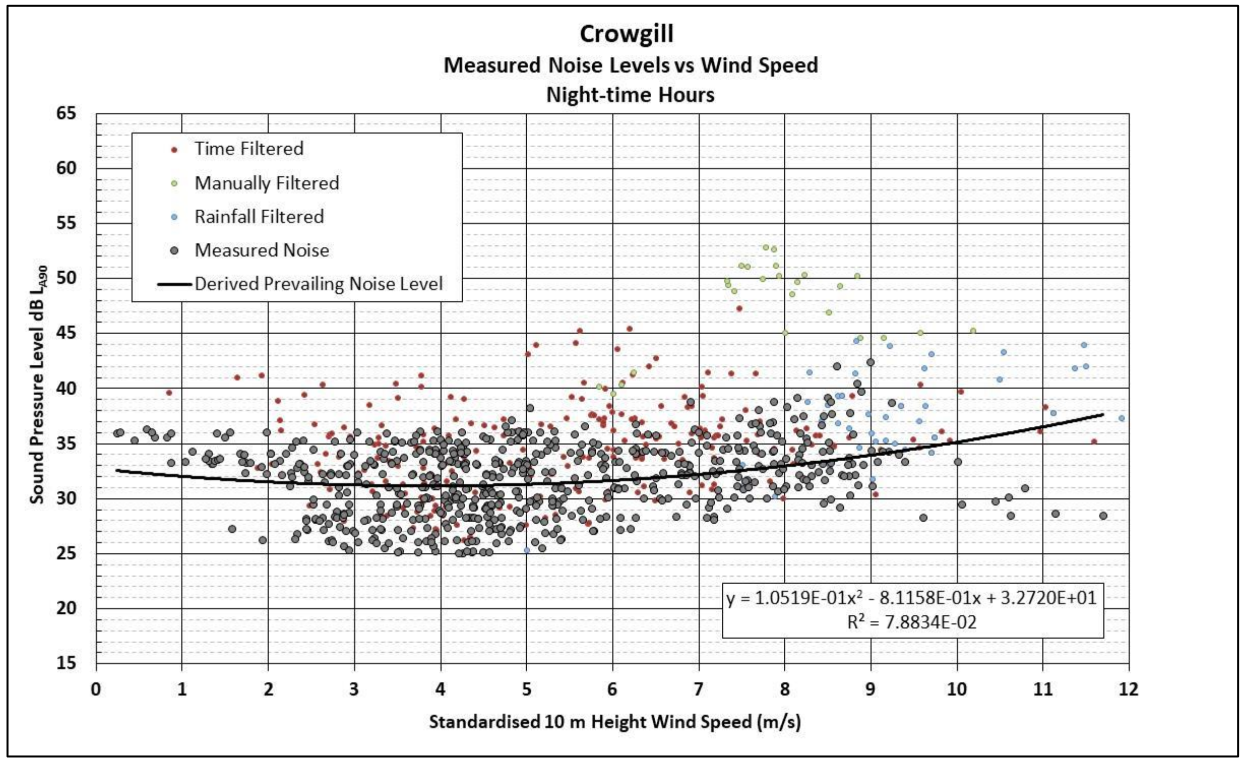
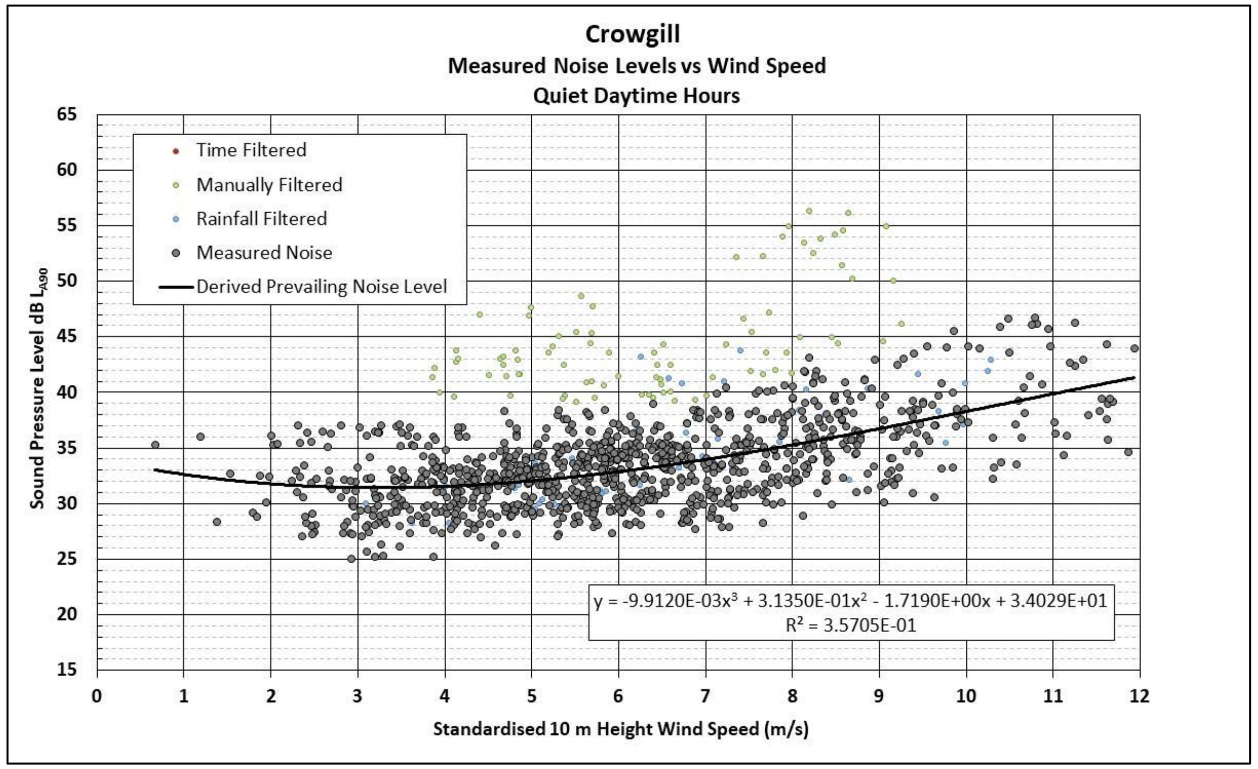


Figure 11.1.2



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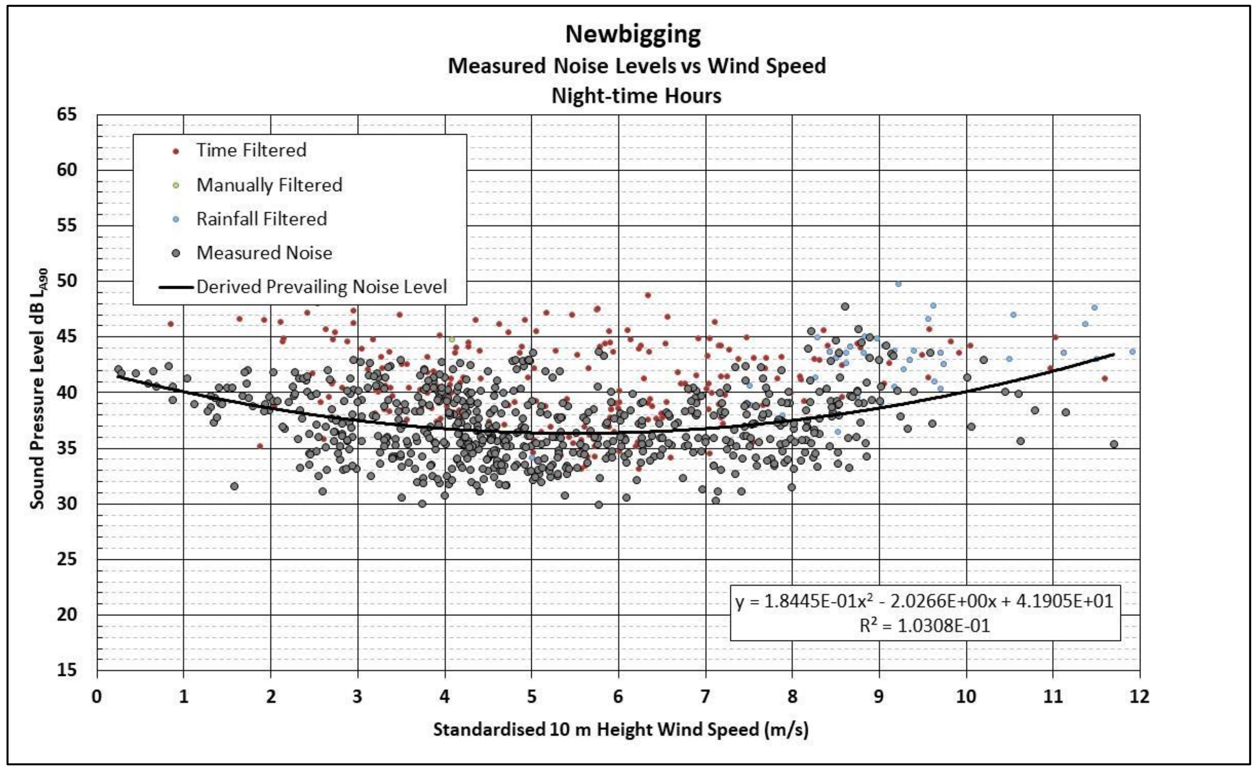

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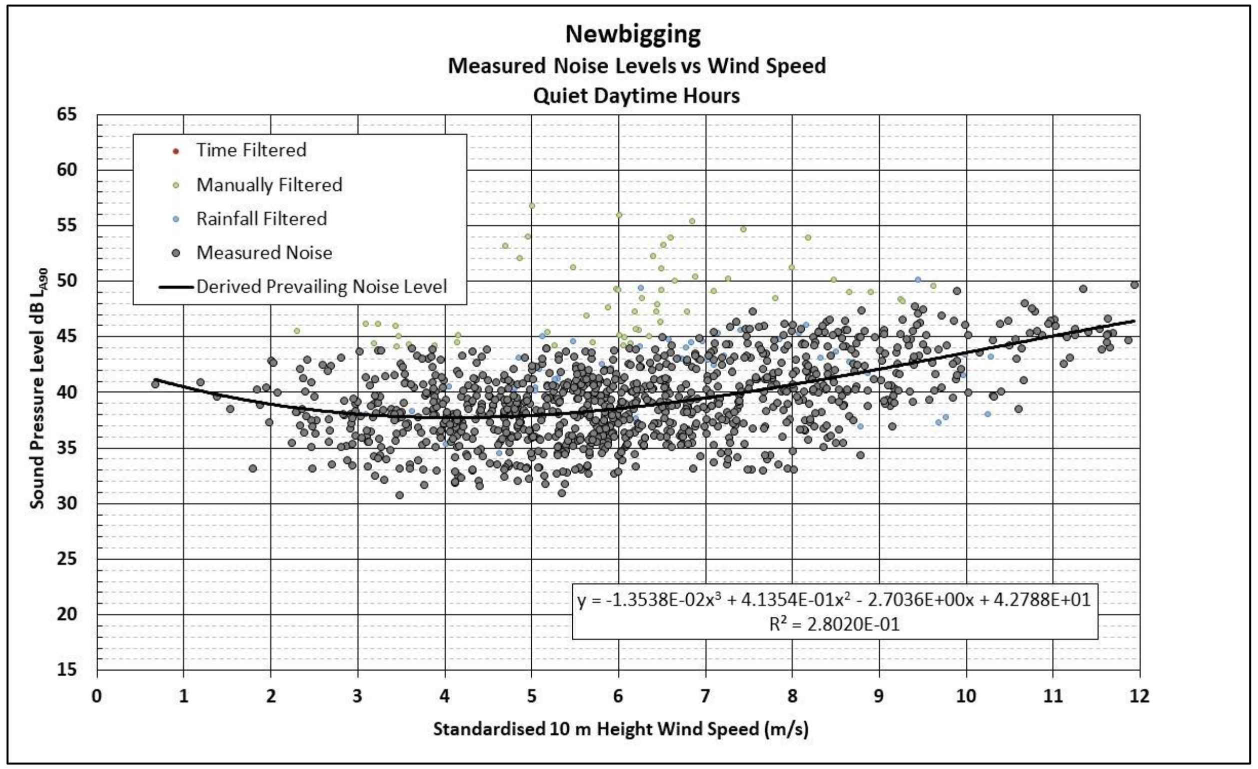

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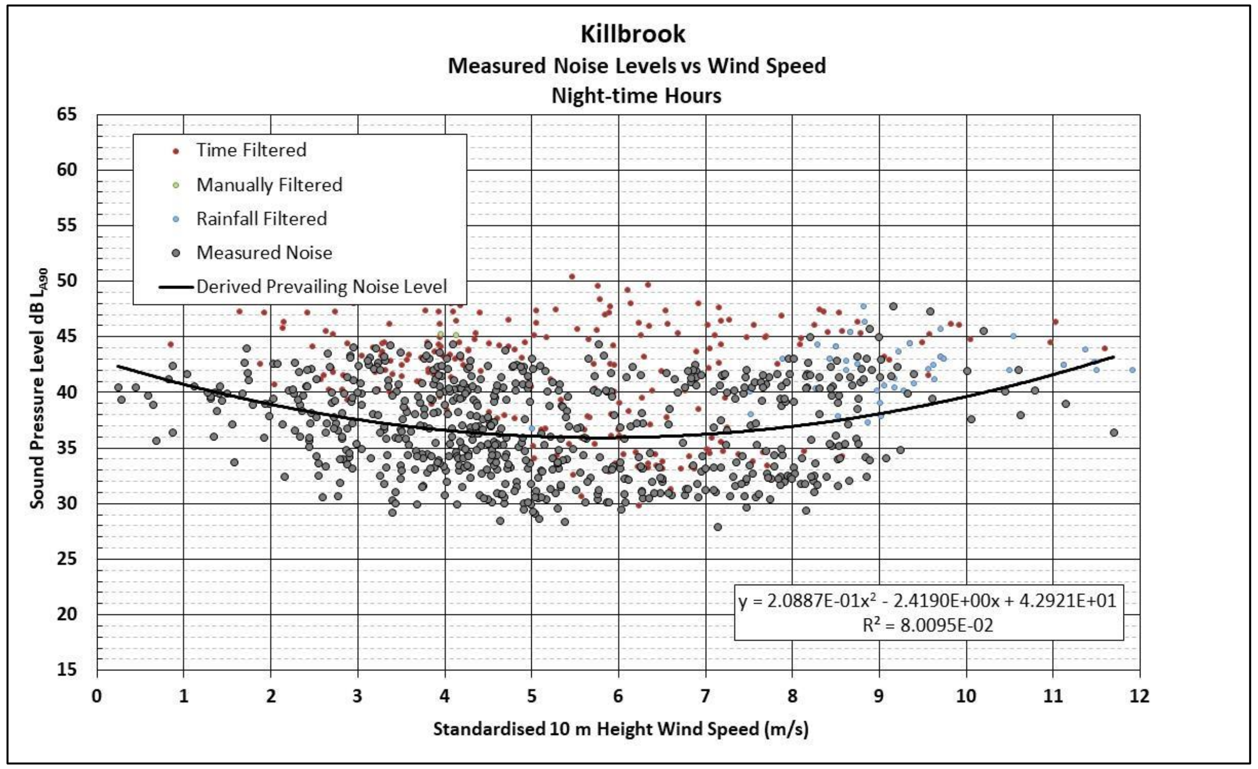

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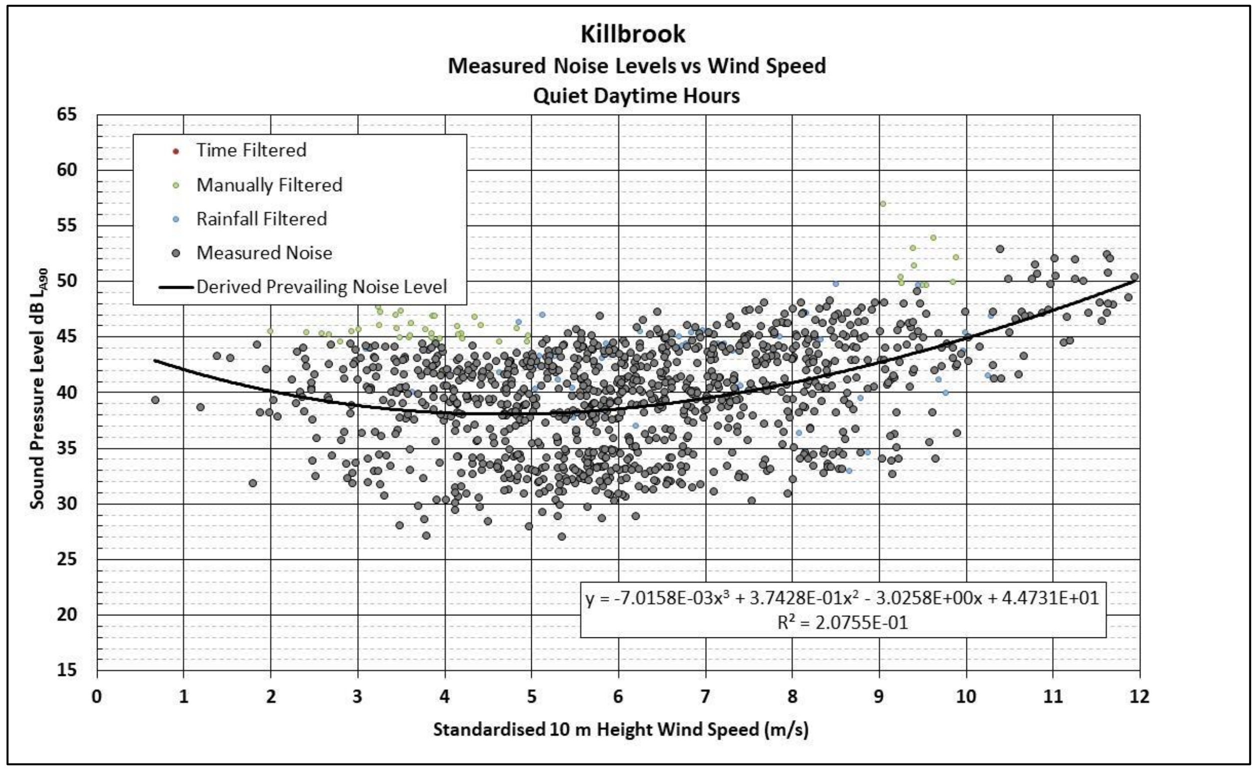

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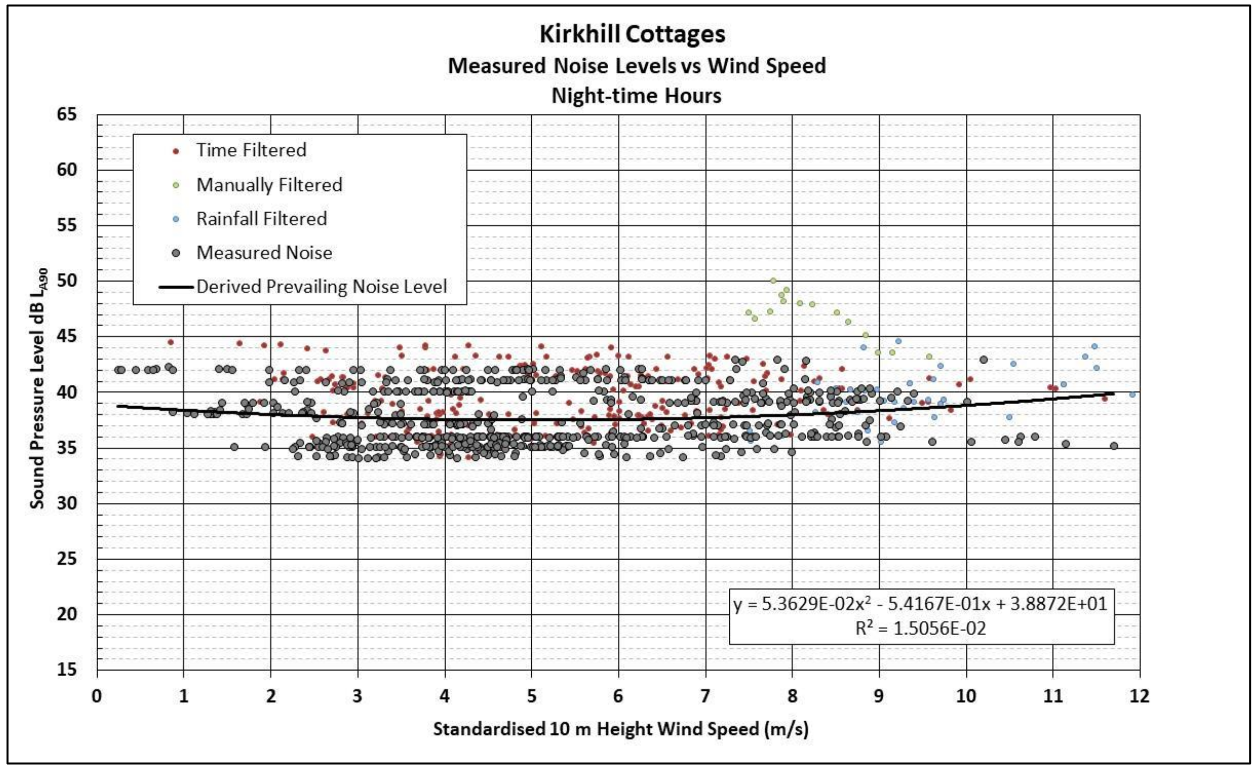

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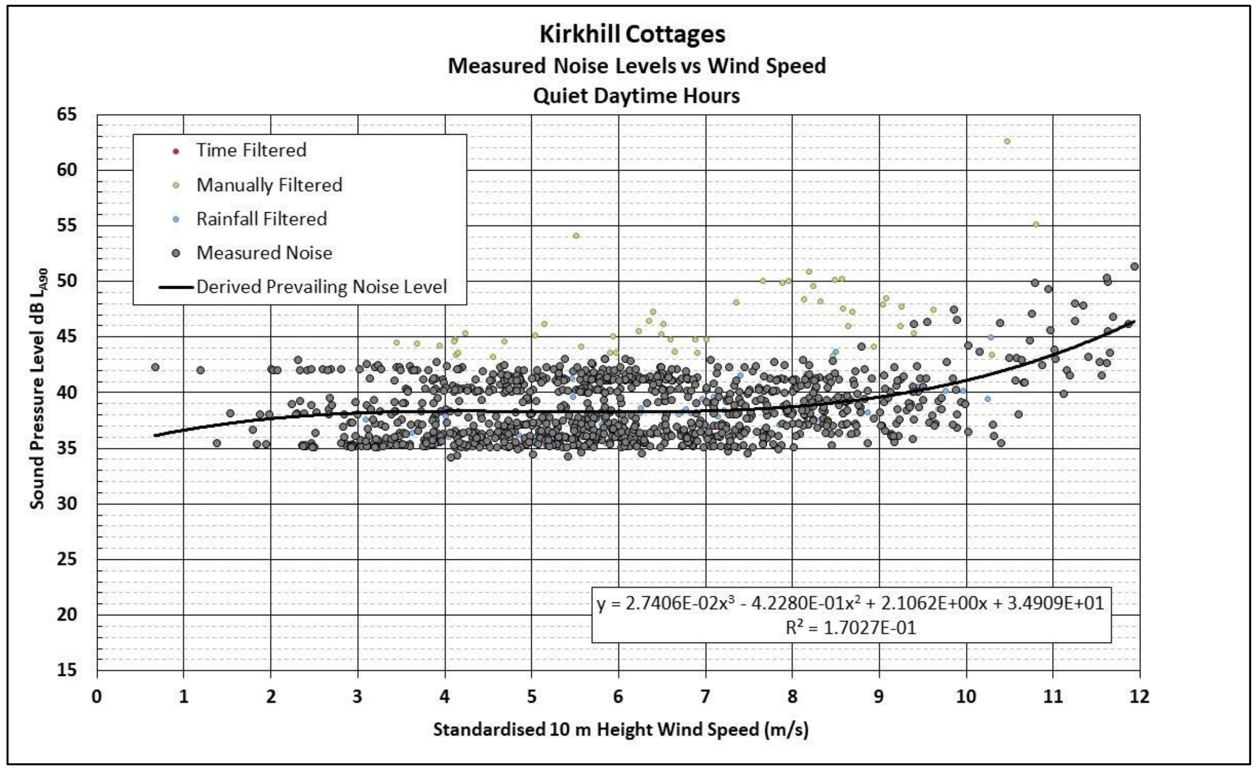

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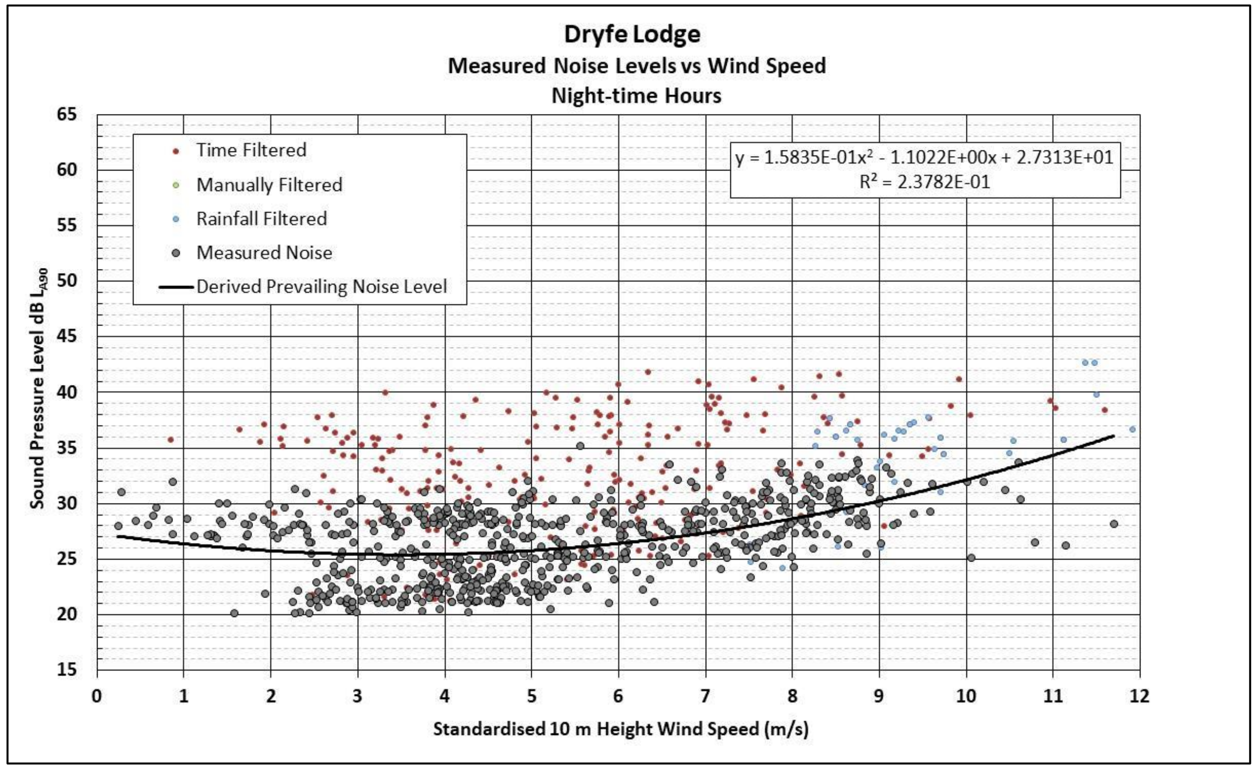

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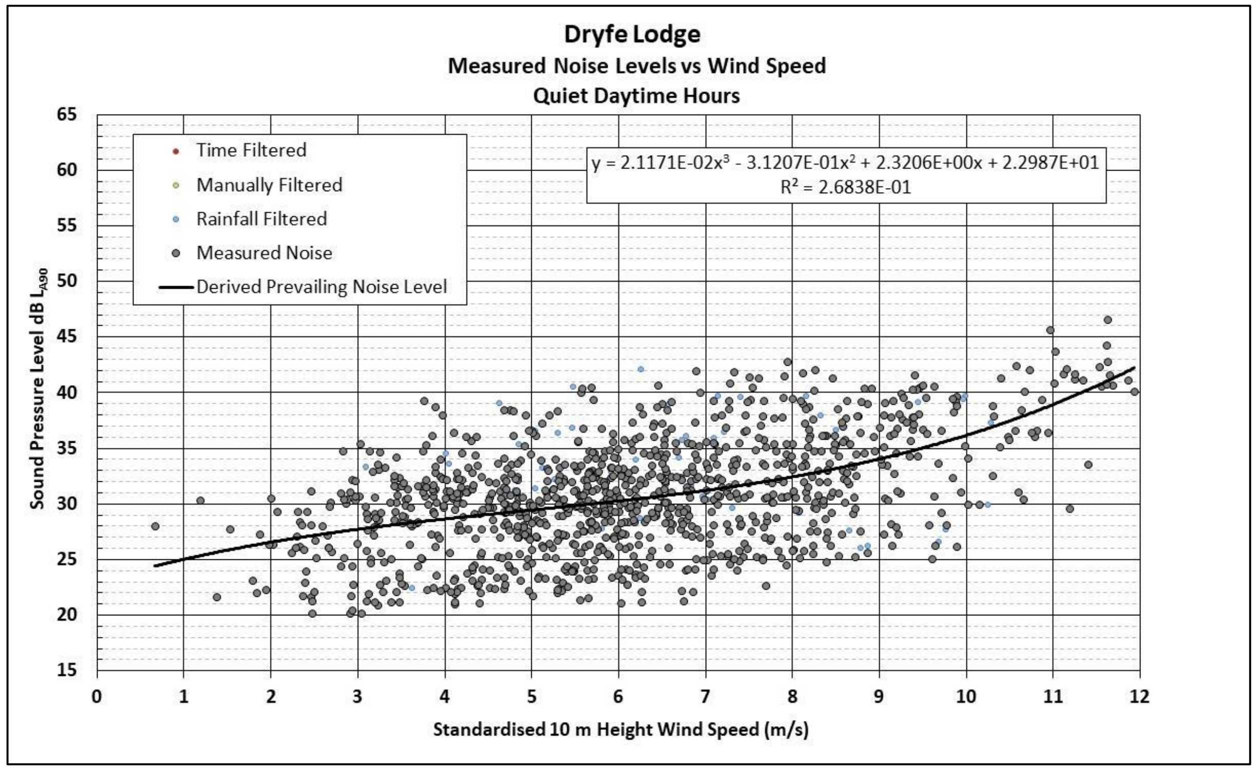

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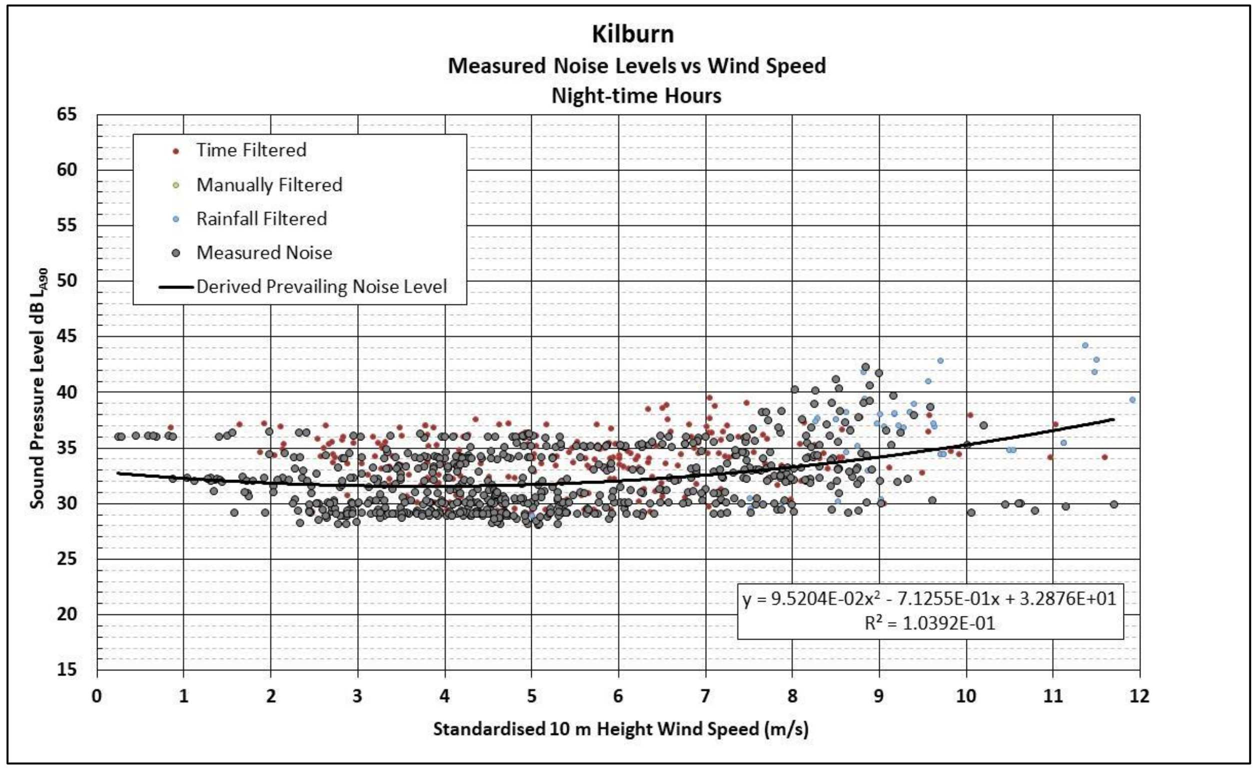

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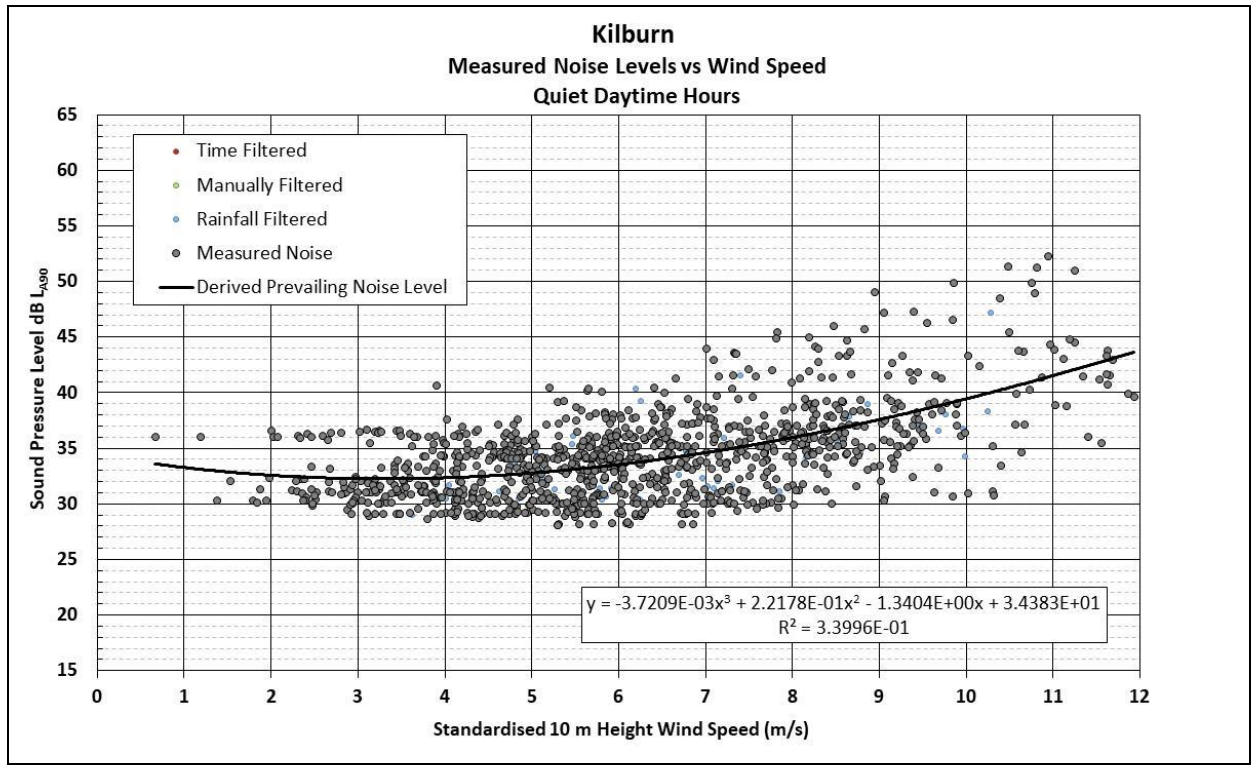

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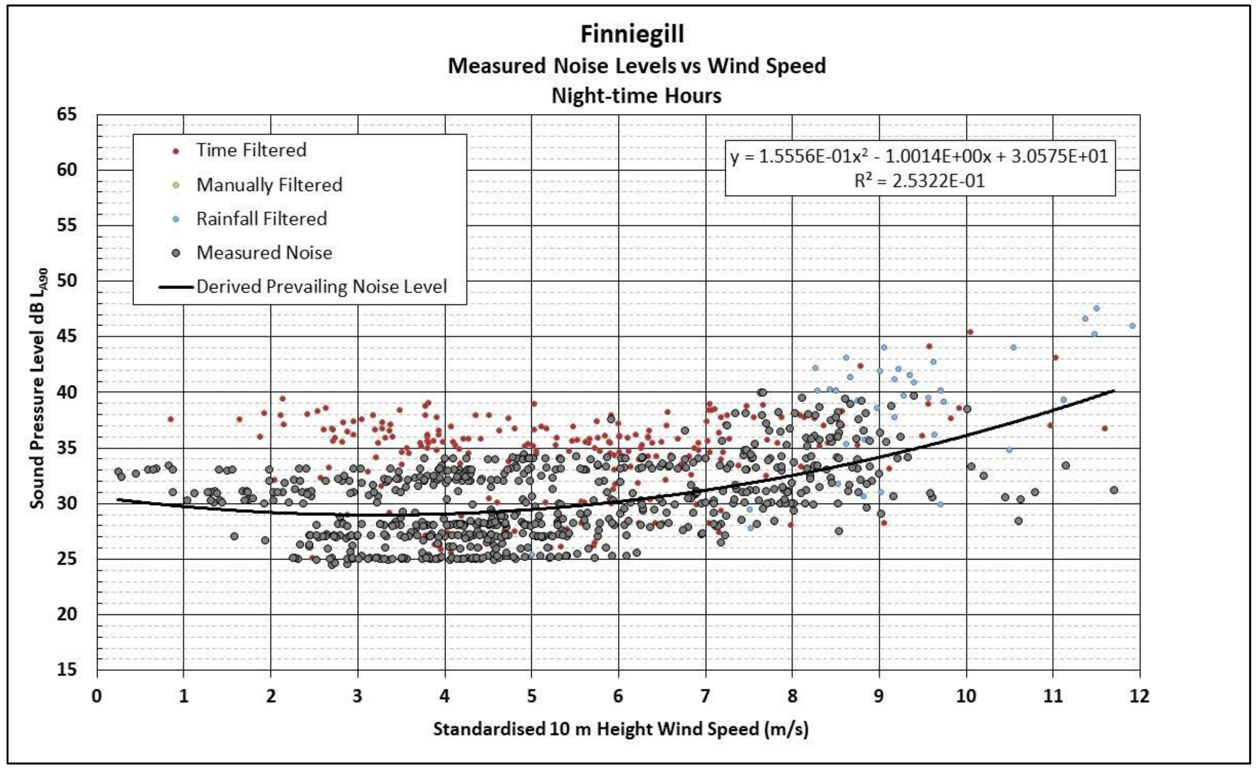

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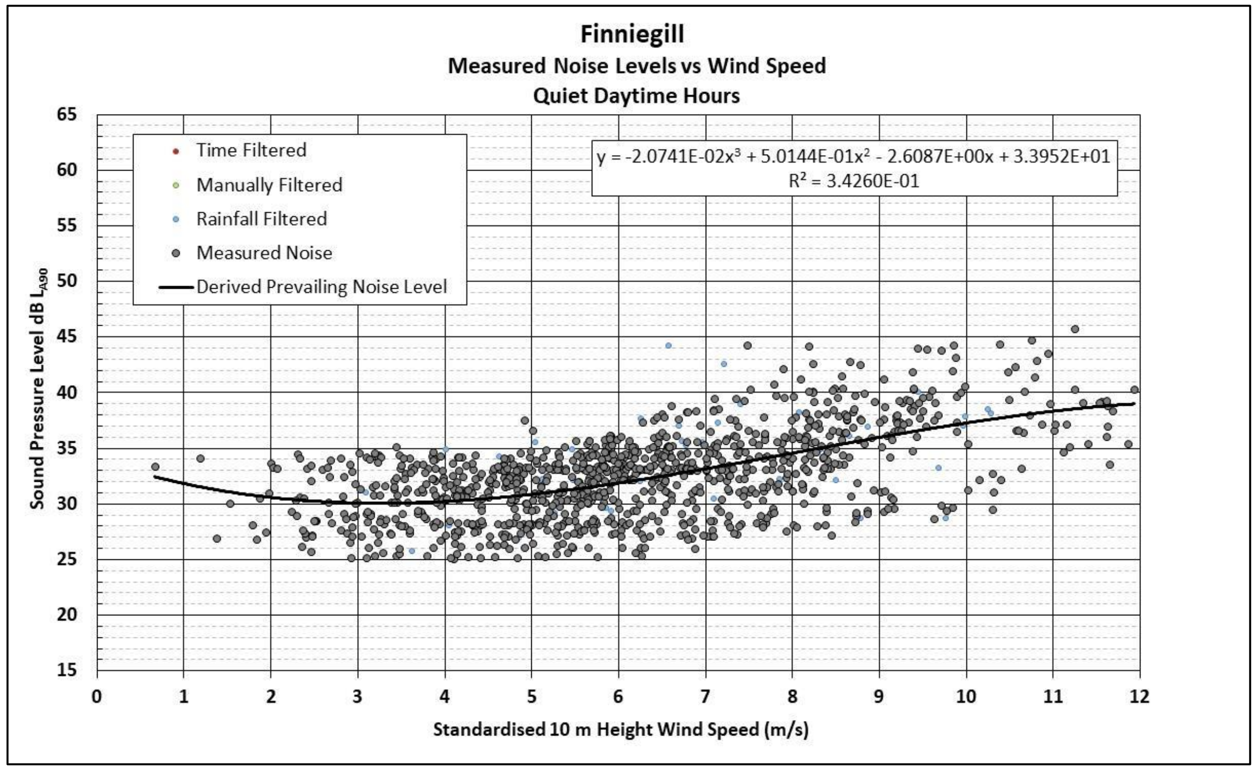
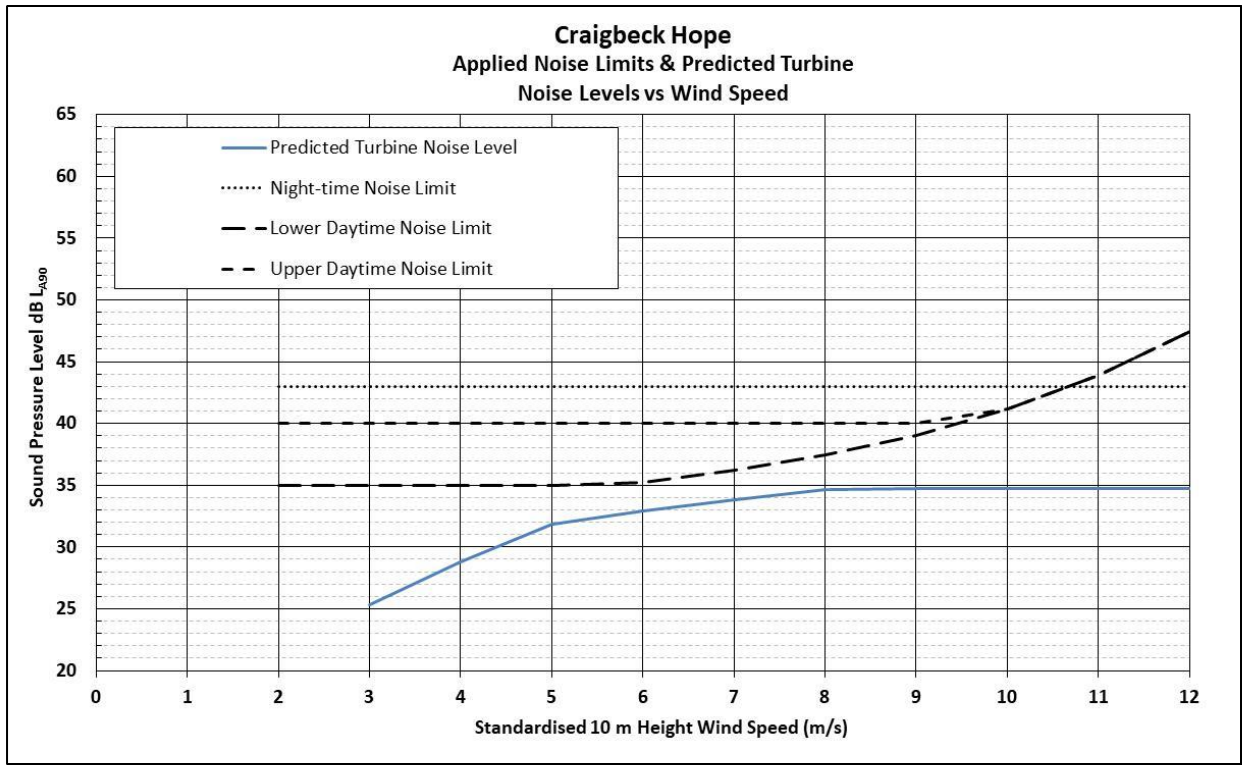


Appendix 11.2: Noise Impact Assessment Charts

Figure 11.2.1



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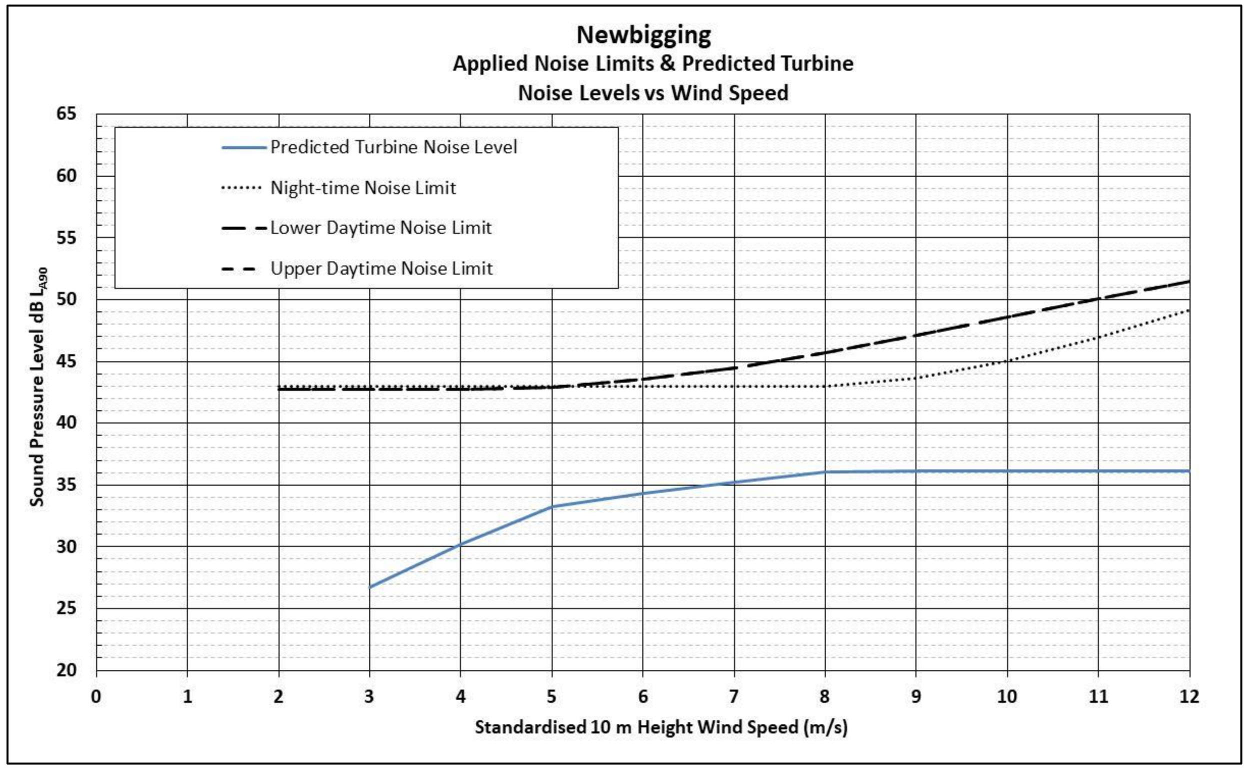

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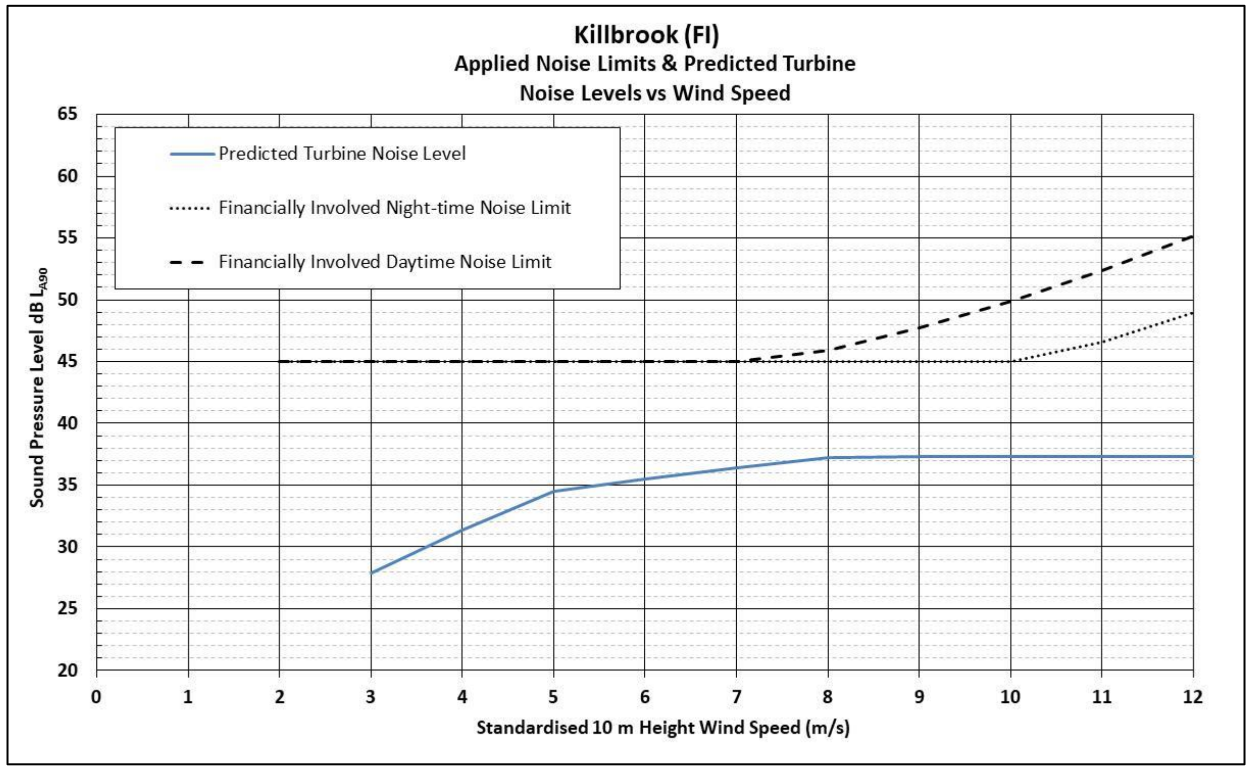

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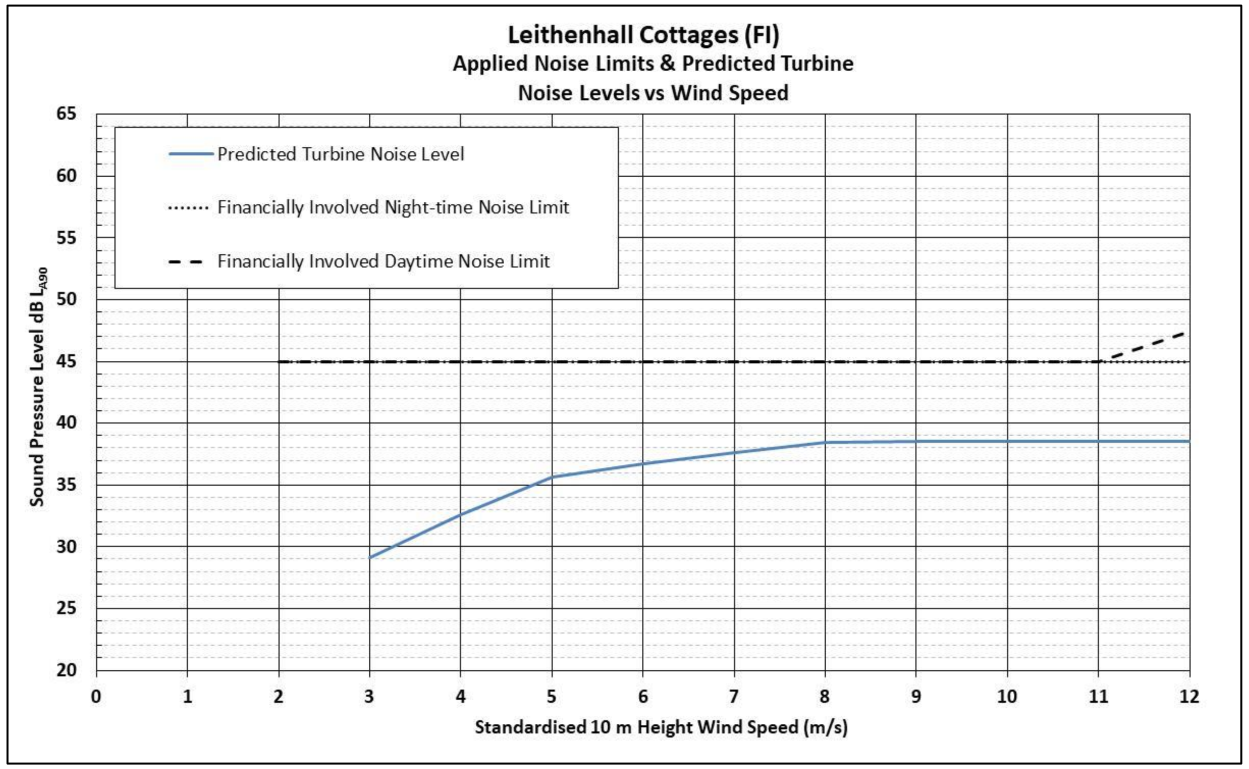

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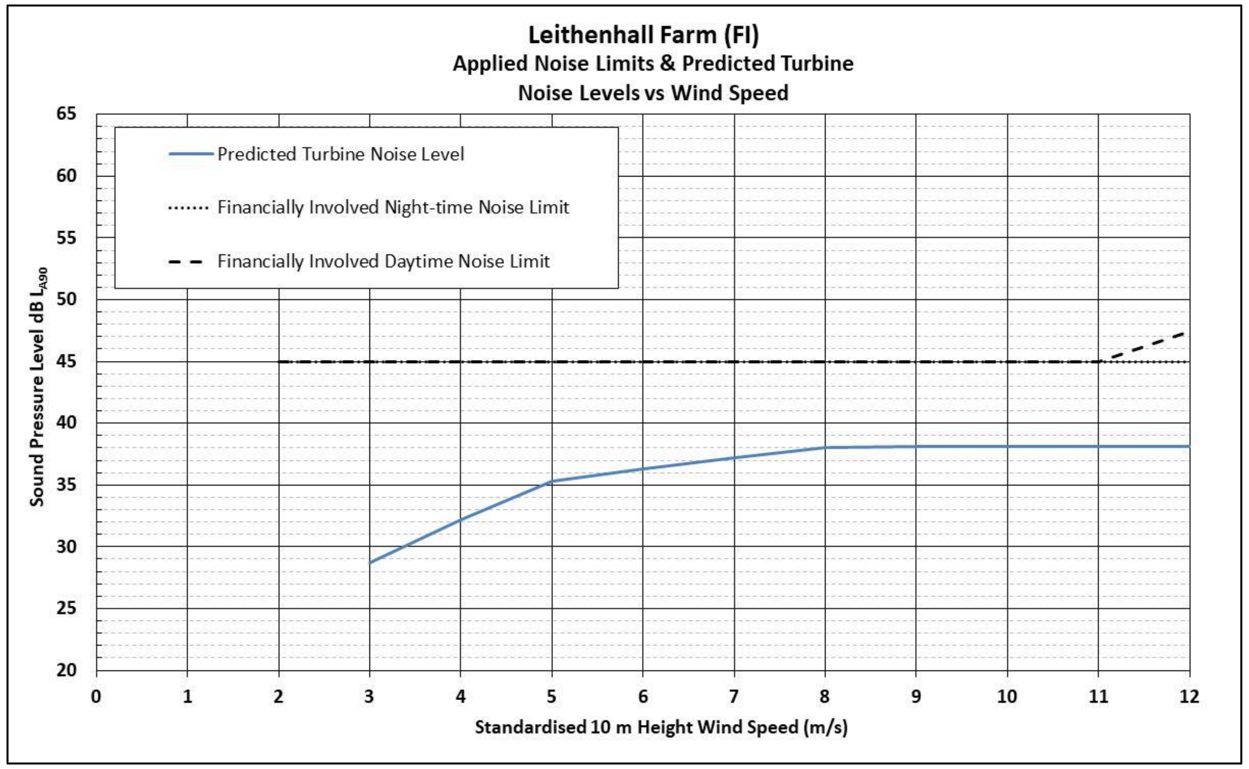

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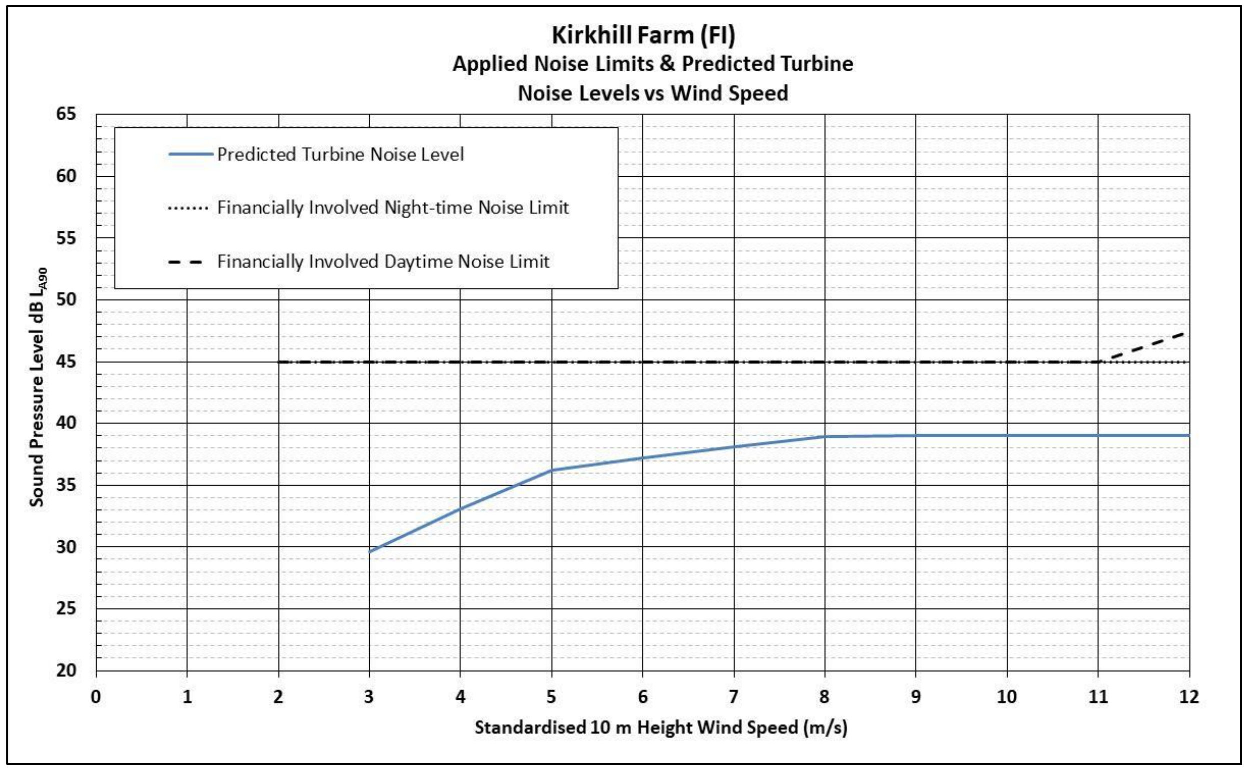

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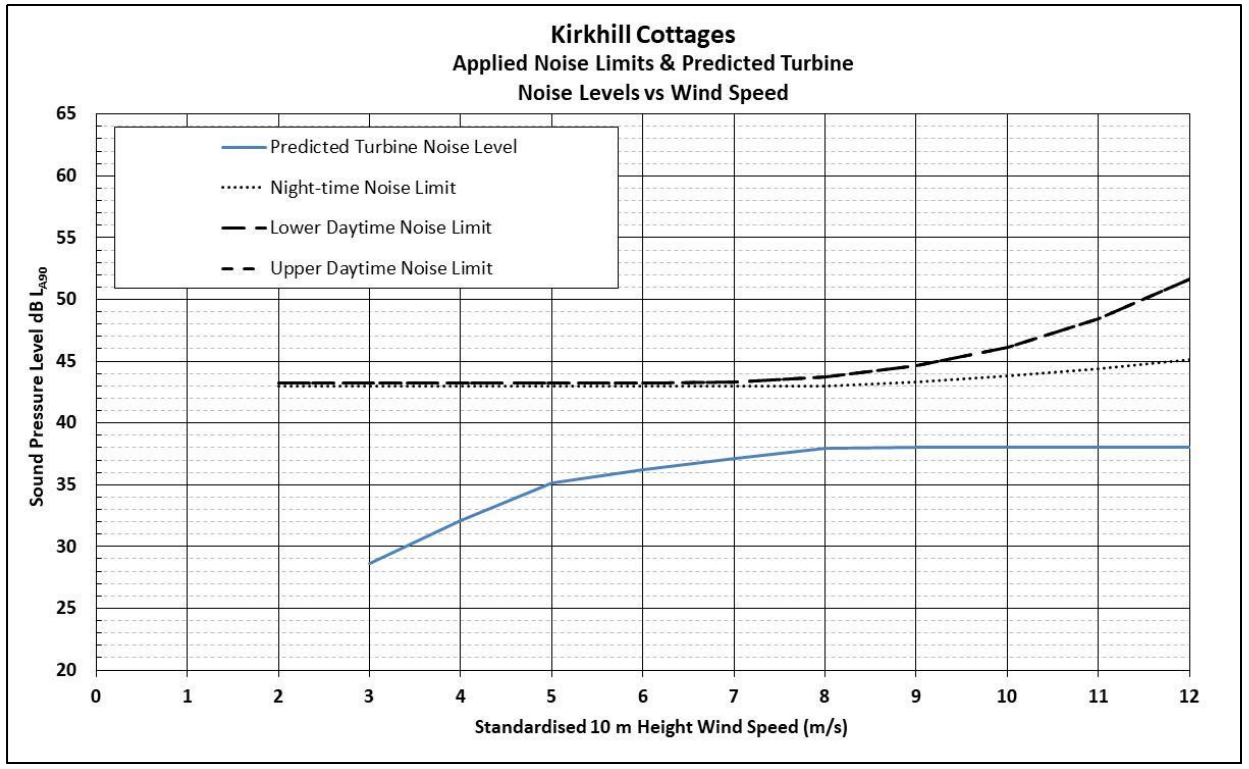

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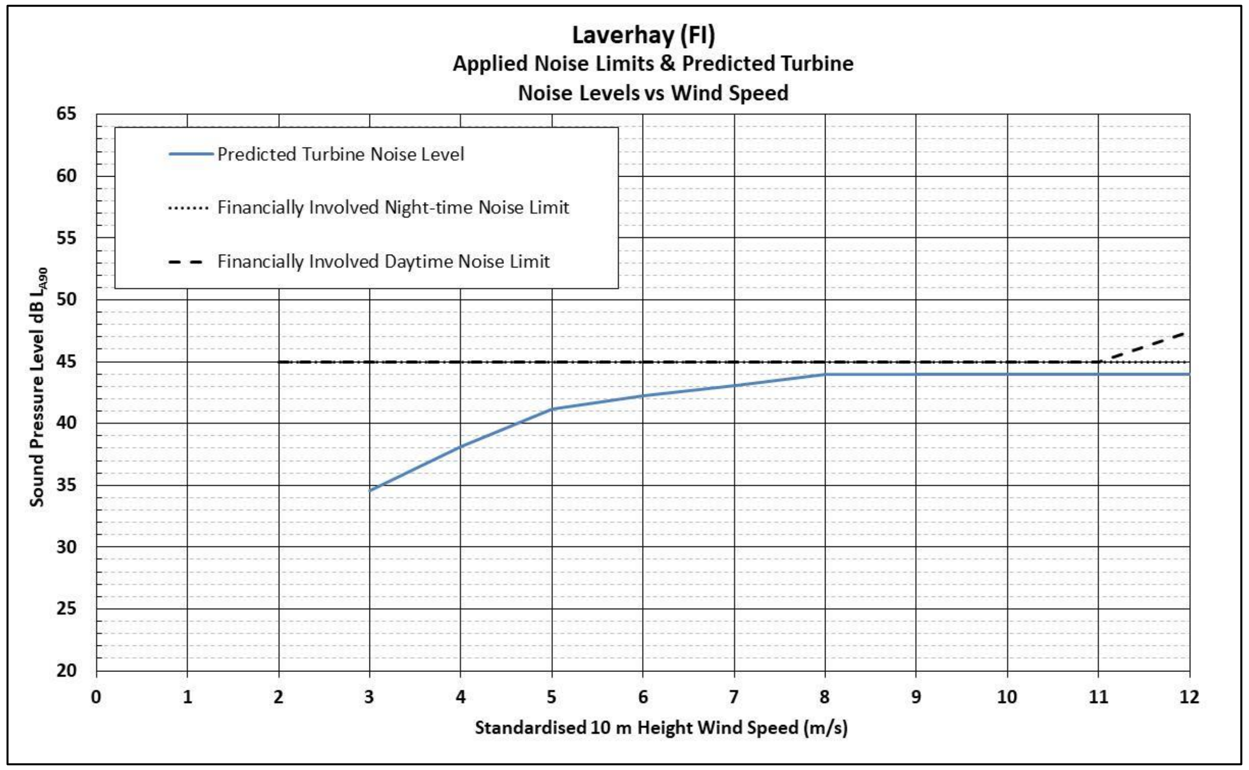

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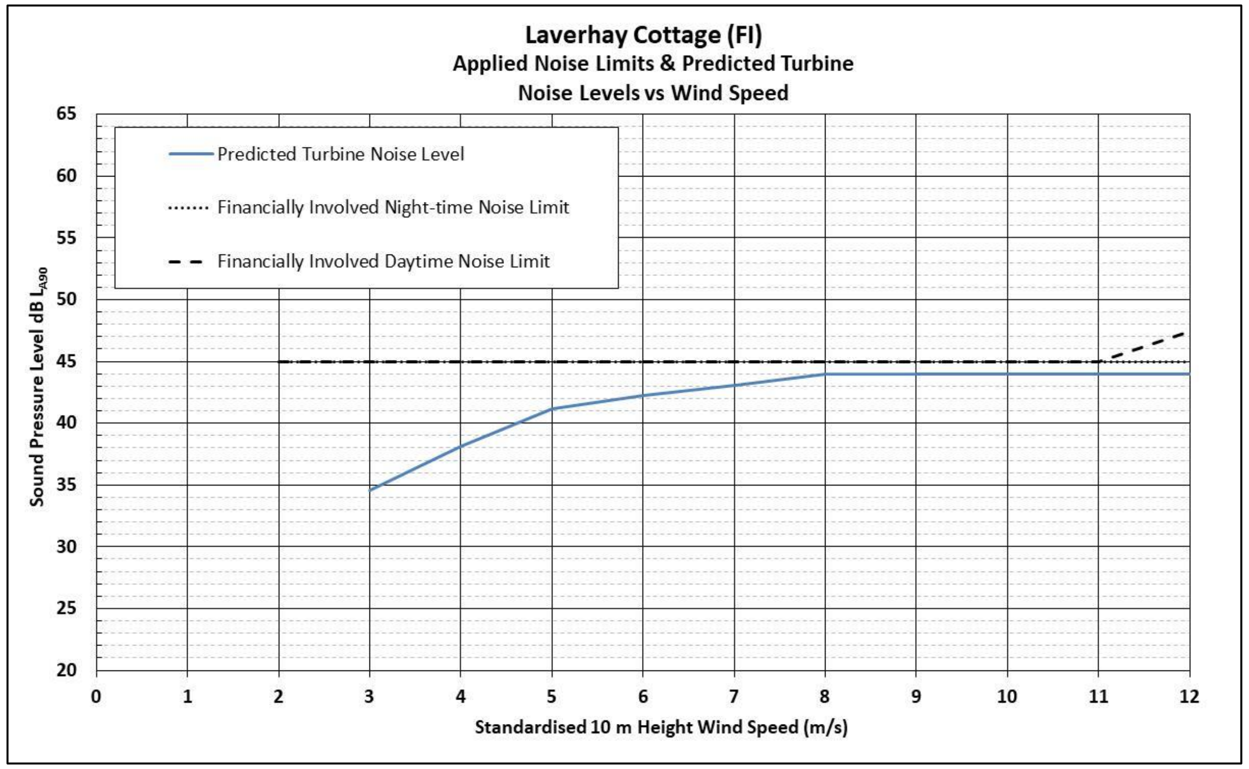

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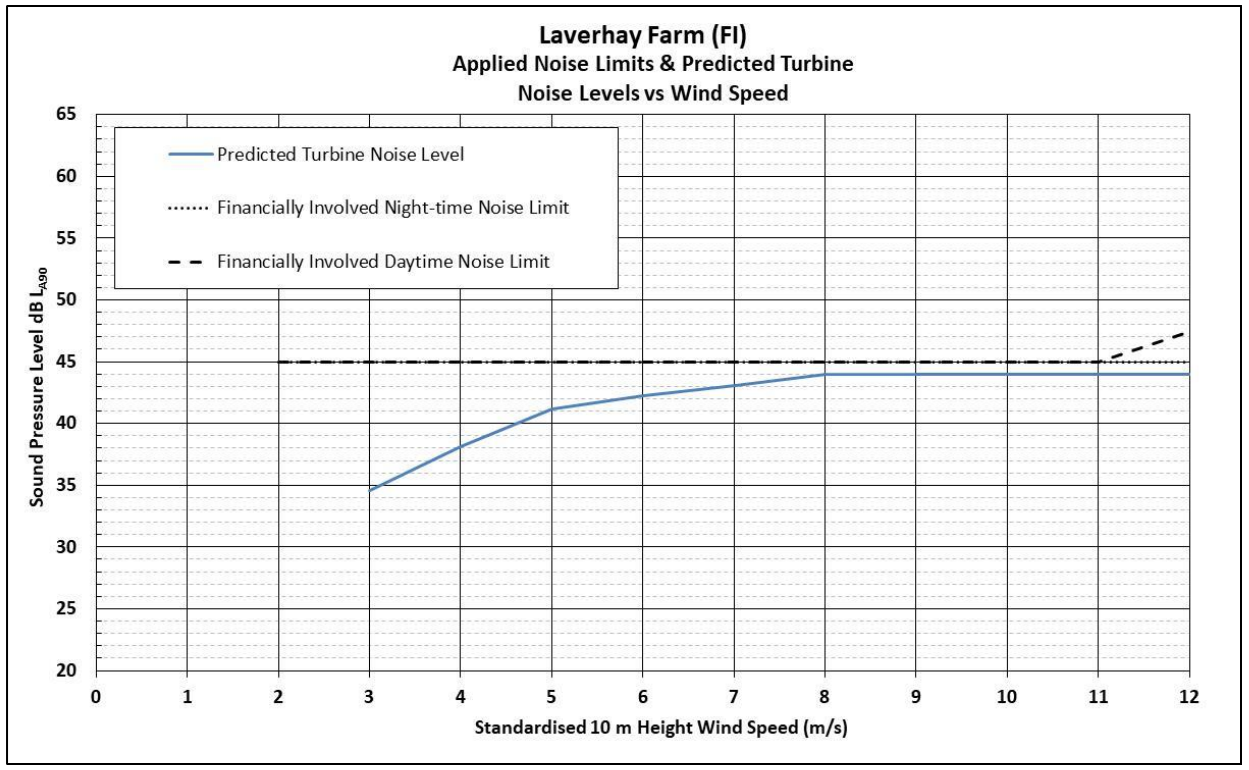

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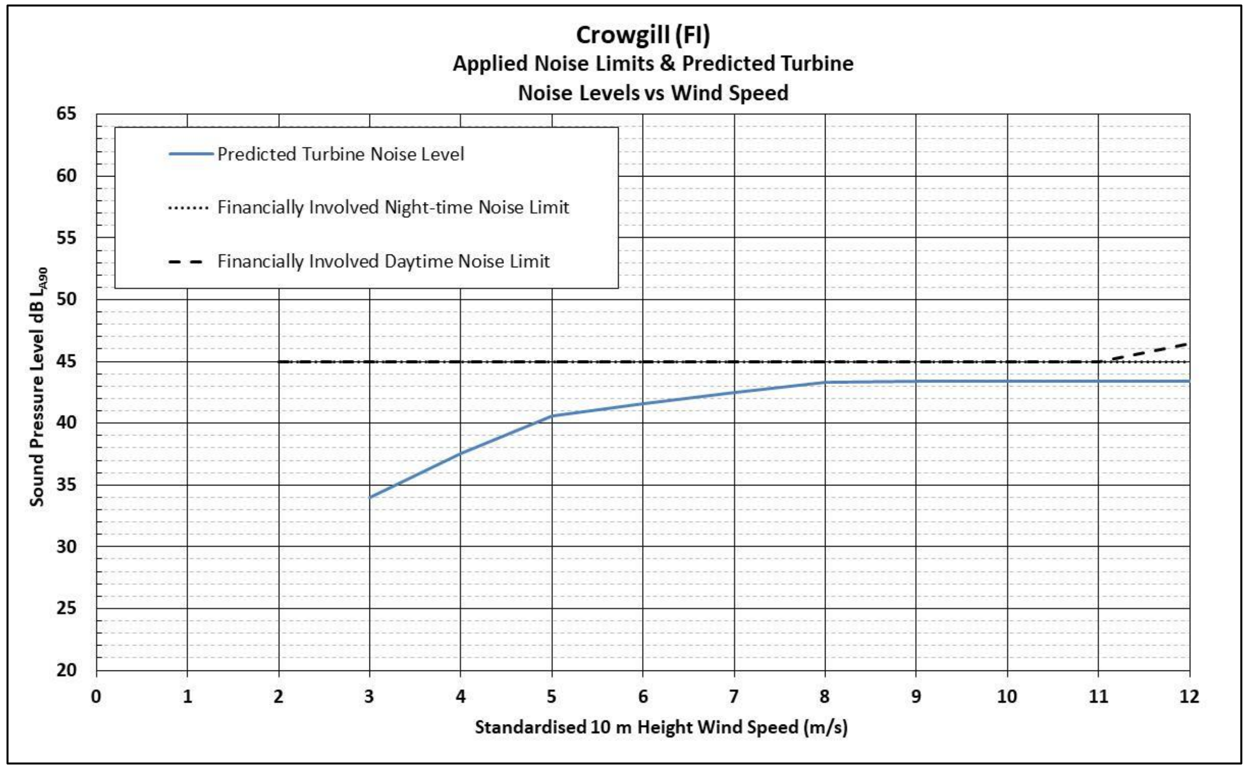

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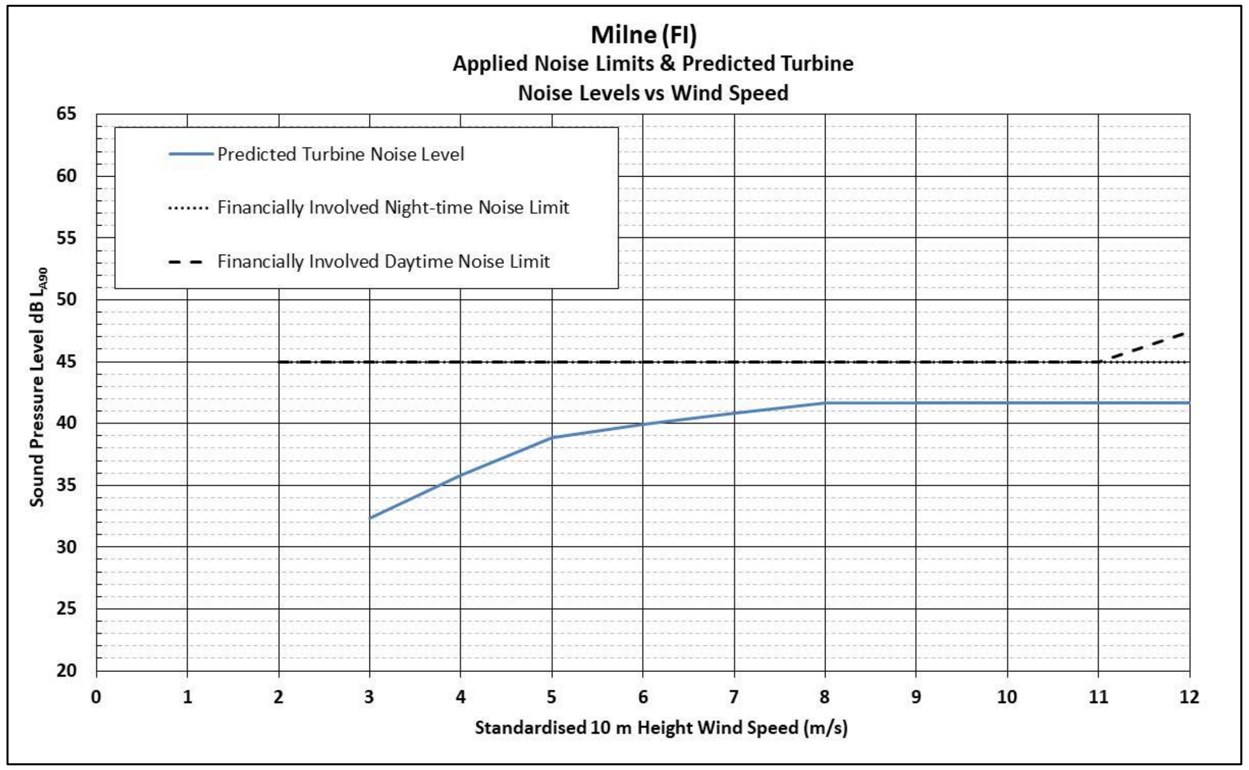

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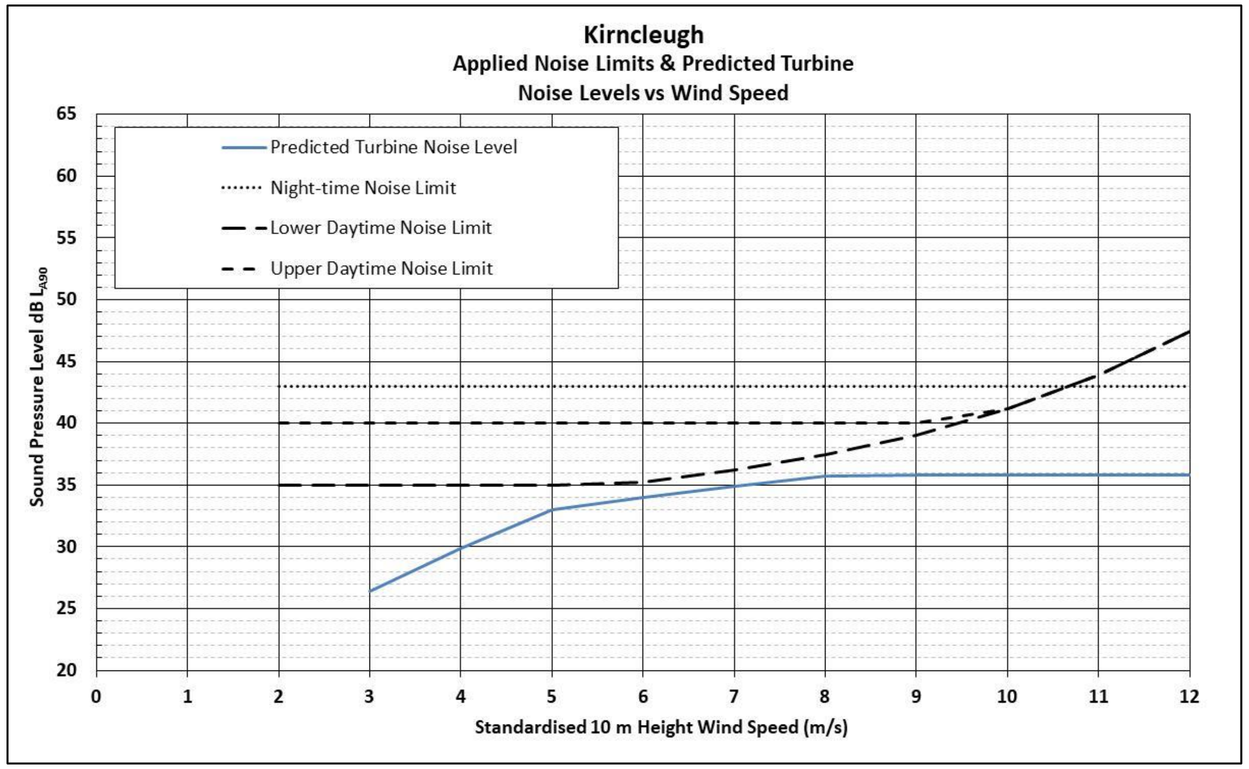

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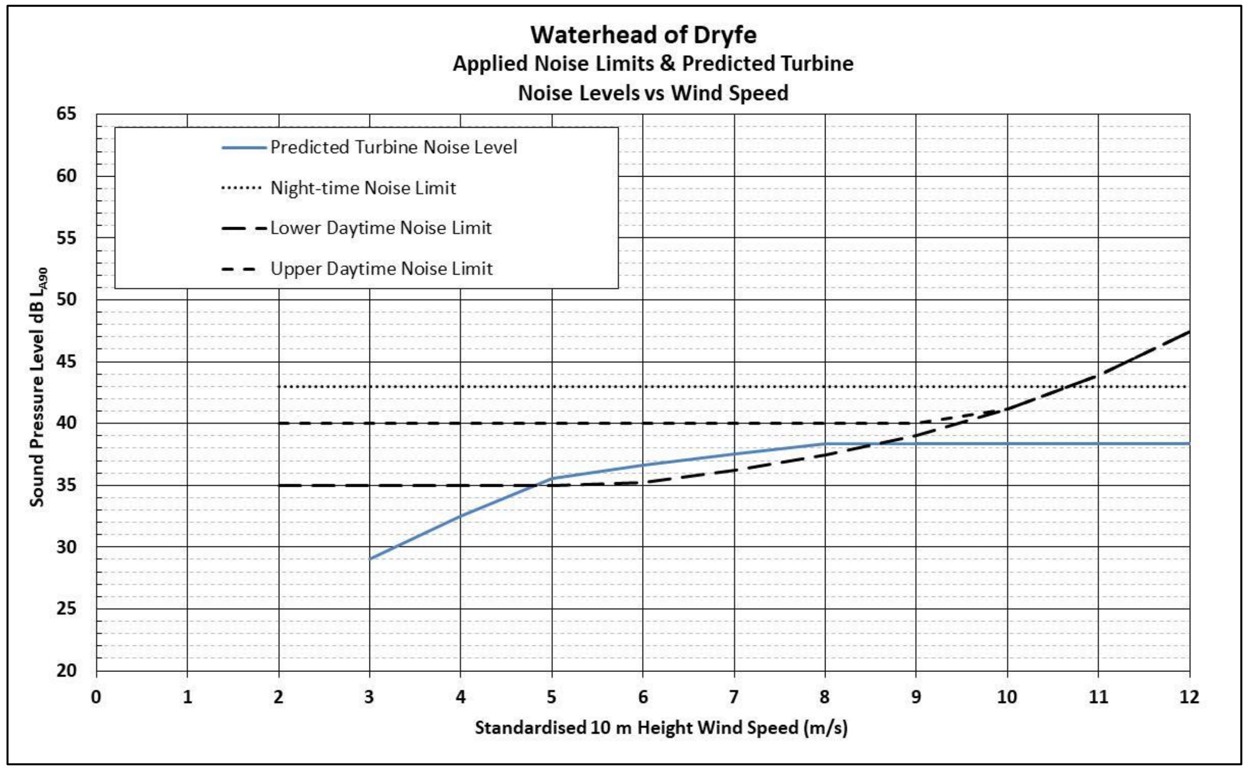


Figure 11.2.15

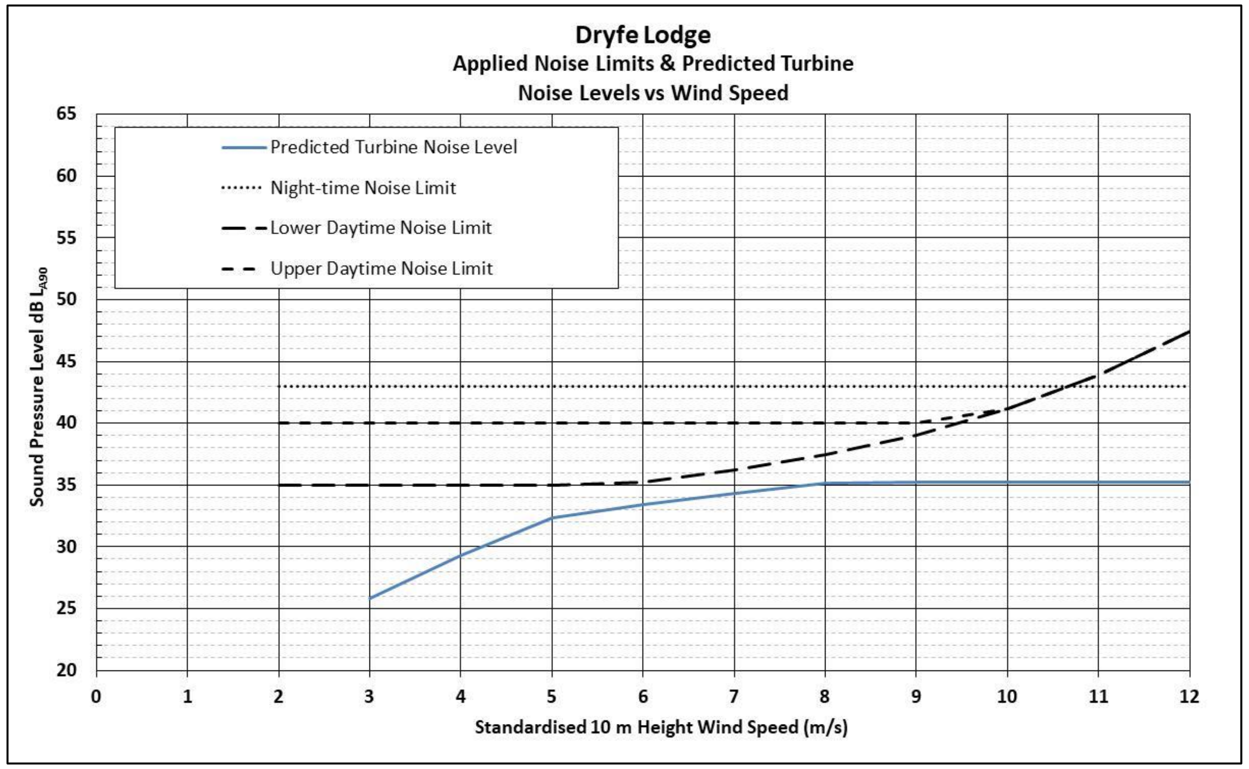


Figure 11.2.16

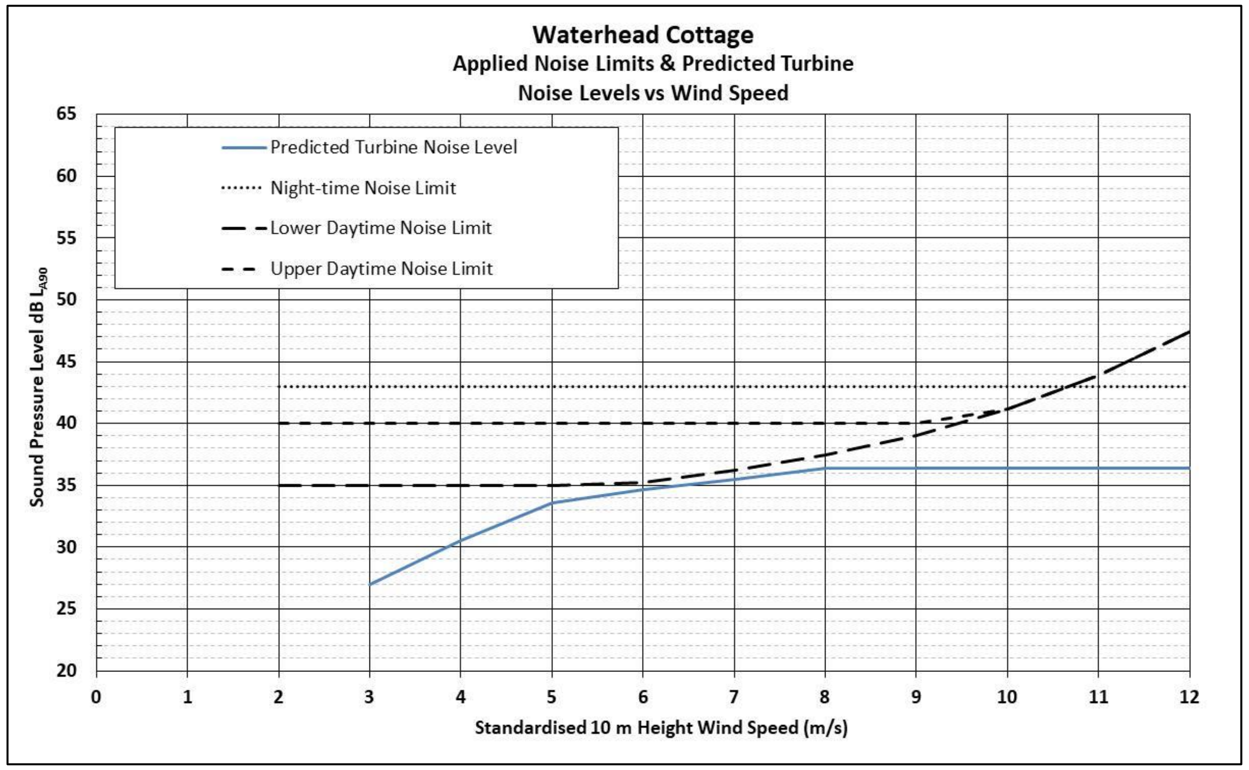


Figure 11.2.17

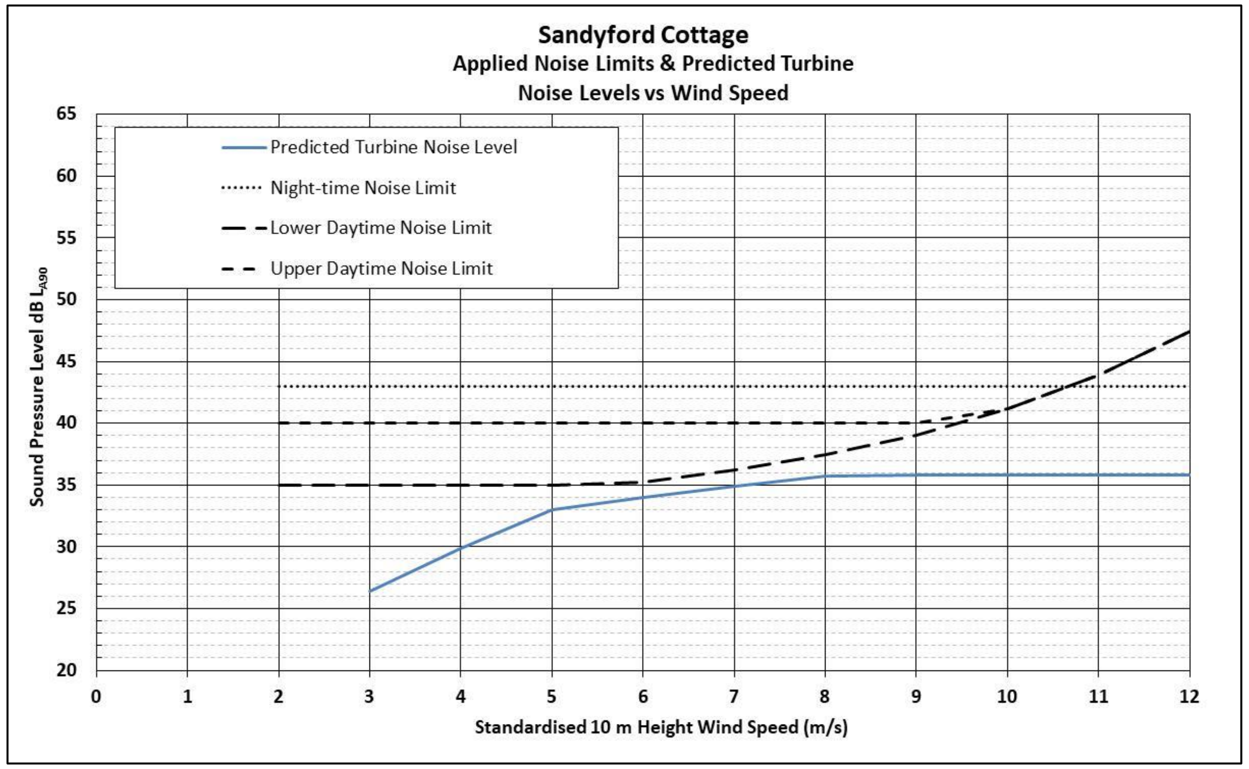


Figure 11.2.18

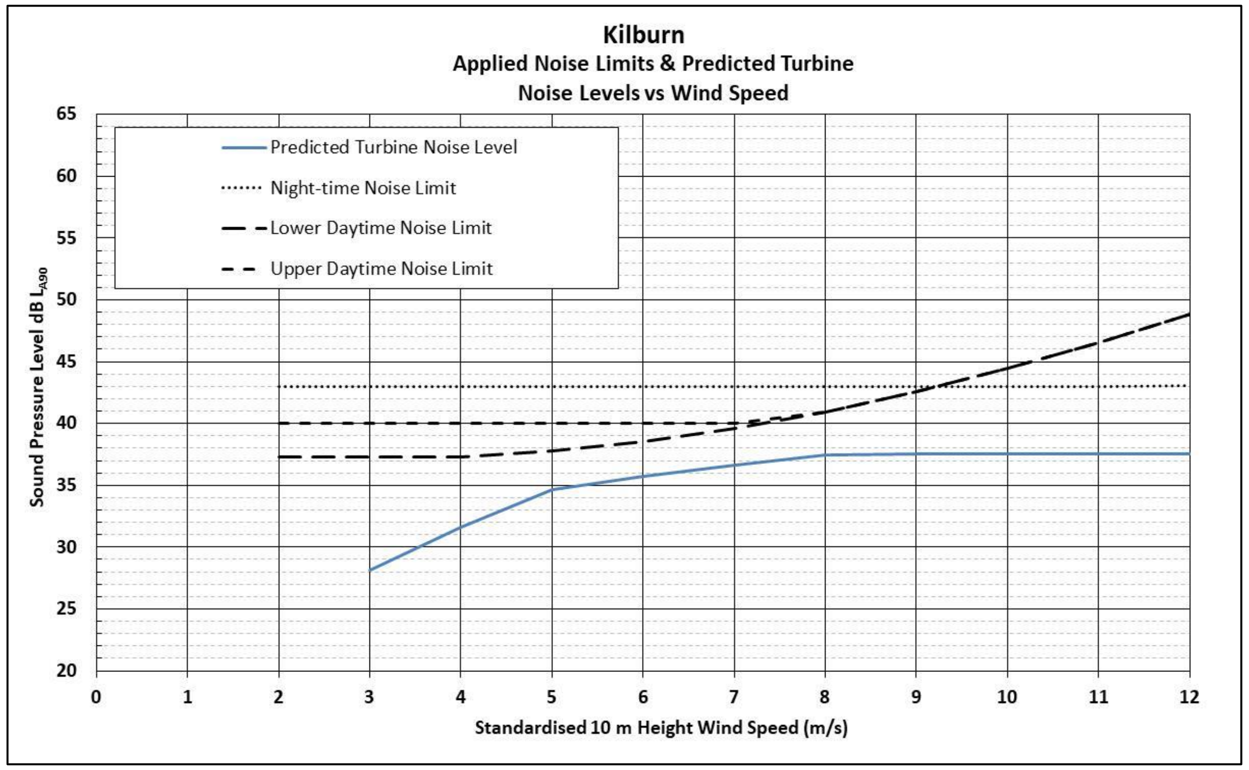


Figure 11.2.19

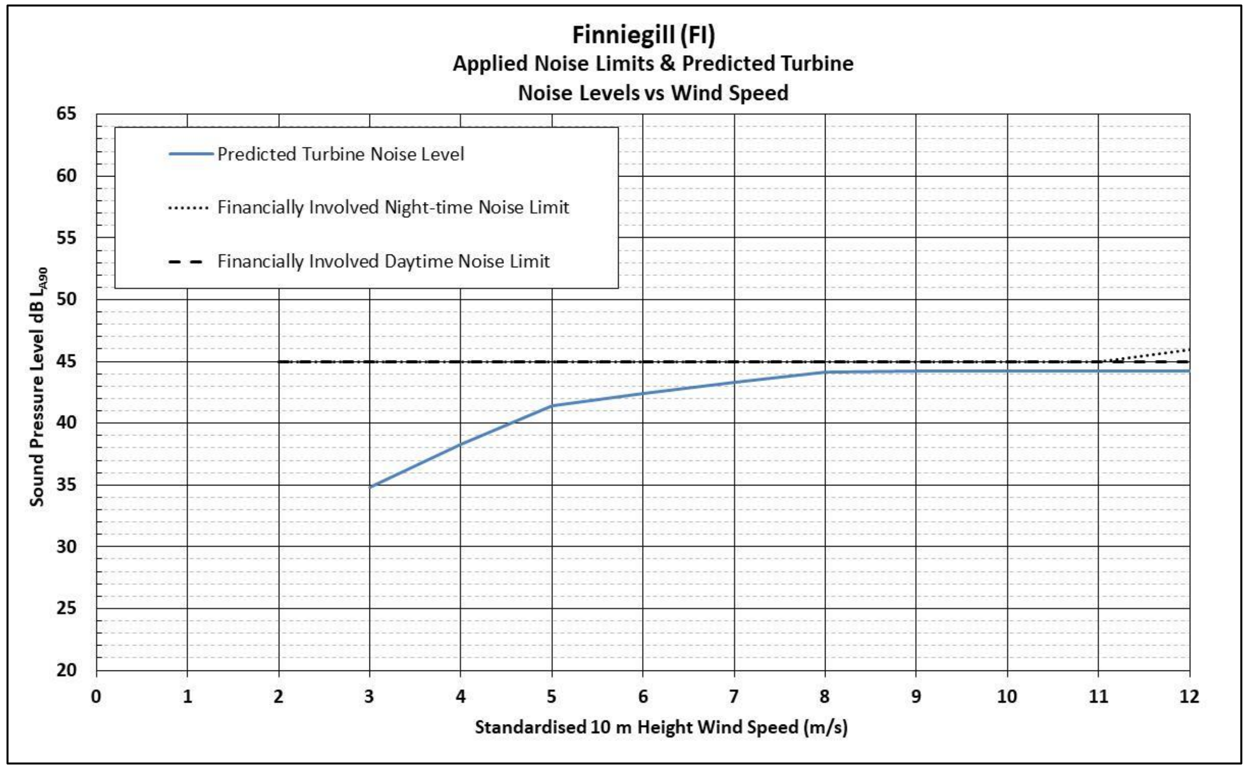
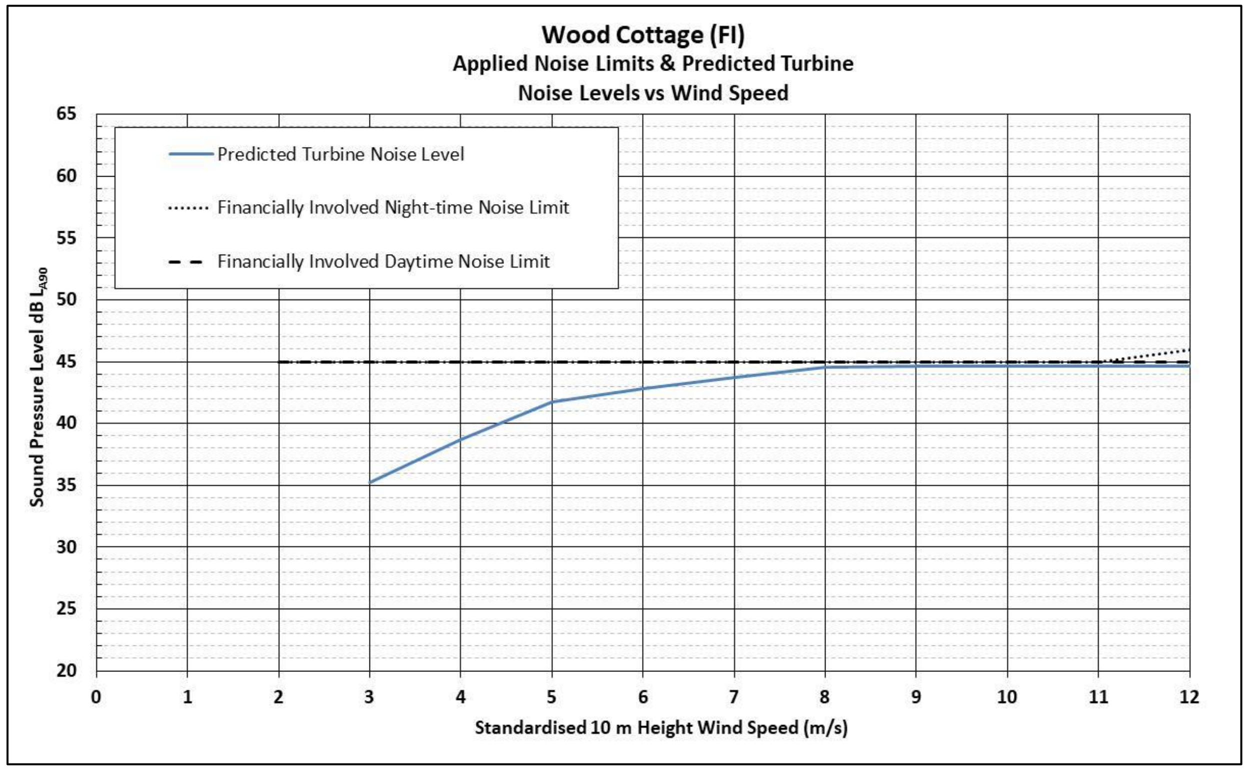


Figure 11.2.20



Appendix 11.3: Noise Contour Plot

Figure 11.3.1