HOARE LEA

Knockcronal Wind Farm.
Baseline noise assessment.

REVISION 5 – 26 OCTOBER 2020

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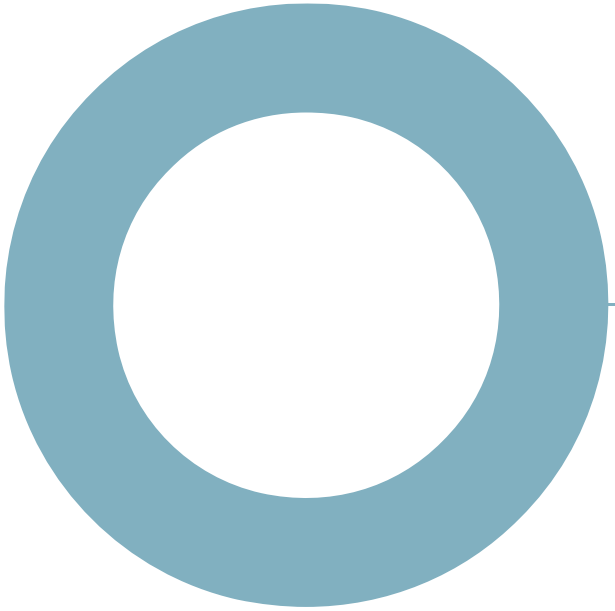

Audit sheet.

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1. Introduction & Background

1.1 This report presents an assessment of the baseline background noise levels around the site of the proposed Knockcronal Windfarm (the 'Proposed Development') at a number of nearby noise sensitive receptor locations. Baseline survey locations were originally proposed for assessment of noise from the previous Linfairn Windfarm, which was withdrawn. The turbine development area of the Proposed Development is similar to that of the Linfairn scheme.

2. Planning Policy and Advice Relating to Noise

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

2.2 The recommendations contained in ETSU-R-97 provide a robust basis for assessing the noise implications of a wind farm. Guidance on good practice on the application of ETSU-R-97 has been provided by the Institute of Acoustics (IOA Good Practice Guide or GPG)[iii]. This was subsequently endorsed by the Scottish Government[iv] which advised in the web-based planning advice note [i] that this *'should be used by all IOA members and those undertaking assessments to ETSU-R-97',* The methodology of ETSU-R-97 and the IOA GPG has therefore been adopted for the present assessment.

3. Methodology

3.1 The ETSU-R-97 assessment procedure specifies that noise limits should be set relative to existing background noise levels at the nearest properties and that these limits should reflect the variation in both turbine source noise and background noise with wind speed. The wind speed range which should be considered for the noise assessment is between the cut-in speed (the speed at which the turbines begin to operate) for the turbines and 12 m/s (43.2 km/h), where all wind speeds are referenced to a ten metre measurement height (refer to Annex F for a discussion of how wind speeds are referenced to ten metre height). The IOA GPG clarified that where wind farms are to be constructed using pitch regulated variable speed turbines (the majority of currently available turbines are of this type) baseline noise surveys need to cover a sub-set of this range (IOA GPG Para 2.9.3): *"between cut-in wind speed and the wind speed corresponding to its maximum sound power level",* which is typically for ten metre wind speeds of around 8 m/s to 9 m/s.

3.2 Separate noise limits apply for the day-time and night-time. The ETSU-R-97 day-time noise limits are derived from background noise data measured during the 'quiet periods of the day' defined in ETSU-R-97: these comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). The night-time noise limit is derived from background noise data measured during the night-time periods (23:00 to 07:00) with no differentiation being made between weekdays and weekends.

3.3 Multiple samples of ten-minute background noise levels using the $L_{A90,10min}$ measurement index are measured contiguously over a wide range of wind speed conditions (a definition of the $L_{A90,10min}$ index is given in Annex A). Measured noise levels are then plotted against the simultaneously measured wind speed and a 'best-fit' curve is fitted to the data to establish the background noise level as a function of wind speed. Data during quiet day-time and night-time are plotted separately.

4. Consultation

4.1 Prior to undertaking the background survey, a protocol for monitoring at six proposed locations (see Table 1) was forwarded to the Environmental Health Department of South Ayrshire Council (SAC) for comment (included in full as Annex F). SAC's noise consultants ACCON UK Ltd responded to the consultation and agreed the procedure and locations suggested. ACCON suggested monitoring rain at two locations rather than one proposed, which was agreed (discussed further below).

4.2 Subsequent to this consultation, it was not possible to gain permission to monitor at Tallaminnoch, the most south-easterly location that had been proposed. Staff from ACCON attended site during installation of the monitoring equipment and attended a joint visit to view Tallaminnoch from the roadside. During the second interim visit to site, an additional monitoring position was added at Tairlaw Toll House, data from which may be suitable to represent Tallaminnoch (discussed further below). The locations installed were chosen to be representative for the purpose of an ETSU-R-97 assessment. The agreed noise monitoring locations are shown on the plan in Annex B. Further information about the equipment used and pictures of the survey locations are presented in Annex C.

5. Baseline Background Noise Survey

5.1 A total of six noise monitoring locations were proposed in the noise protocol as being representative of the background noise environment for the nearest residences to the Proposed Development for the purposes of an ETSU-R-97 assessment. The locations are shown on the plan in Annex B and listed in Table 1. As discussed above, access to Tallaminnoch was not possible and an additional monitoring position was added at Tairlaw Toll House during the first interim visit. The chosen measurement position at Tairlaw Toll House was more shielded from the water flow noise than at Tairlaw Toll Cottage and therefore chosen as representative of Tallaminnoch (in the absence of direct access).

Table 1 – Original proposed background noise monitoring locations and the final locations surveys (approximate easting / northing)

No.	Property	Easting	Northing
1	Glenalla Farm	234709	600152
2	Knockskae	237279	601396
3	Linfairn Farm	238159	601207
4	Genoch Cottage	239049	600791
5	Tairlaw Toll Cottage	239762	599541
6*	Tallaminnoch	240021	598257
7#	Tairlaw Toll House	239830	599542

* *Originally proposed as a survey location but access could not be obtained.*

\# *Additional survey location more shielded from water flow noise to better represent Tallaminnoch*

5.2 The list of survey locations is not intended to be exhaustive but sufficient to be representative of noise levels typical of those receptors closest to the Proposed Development. This approach is consistent with the guidance provided by ETSU-R-97 and current good practice as set out in the IOA GPG.

5.3 The background noise monitoring exercise was conducted over a period from 14th Nov 2017 (28th Nov 2017 at Tairlaw Toll House) to 26th Jan 2018, with data covering a period of just under seven weeks as a minimum at any survey location. The equipment used for the survey comprised three Rion NL-52, one Rion NL-32 and one Rion NL-31 logging sound level meters. All meters were enclosed in

environmental cases with battery power to enable approximately 14 days continuous logging at the required ten minute averaging periods. Outdoor enhanced windshield systems were used to reduce wind induced noise on the microphones and provide protection from rain. These windshield systems were supplied by the sound level meter manufacturer and maintain the required performance of the whole measurement system when fitted. The environmental enclosures provided an installed microphone height of approximately 1.2 to 1.5 metres above ground level, consistent with the requirements of ETSU-R-97.

5.4 The sound level meters were located on the wind farm side of the property in question where possible, never closer than 3.5 metres from the façade of the property and as far away as was practical from obvious atypical localised sources of noise such as running water, trees or boiler flues. Details and photographs of the measurement locations are presented in Annex C. Locations were agreed with ACCON during the joint site visit when equipment were installed[1].

5.5 All measurement systems were calibrated on their deployment on 14th Nov 2017 (28th Nov for Tairlaw Toll House), during interim service visits and upon collection of the equipment on the 26th Jan 2018. No acoustically important (>0.5 dB) drifts in calibration were found to have occurred on any of the systems. This equates to a total ETSU-R-97 analysis period of at least 48 days for each location, which is in excess of the minimum of one week suggested by ETSU-R-97 and is consistent with IOA GPG requirements.

5.6 All measurement systems were set to log the $L_{A90,10min}$ and $L_{Aeq,10min}$ noise levels continuously over the deployment period. The internal clocks on the sound level meters were all synchronized with Greenwich Mean Time (GMT) by the use of a Global Positioning System (GPS) receiver. The clock on the LIDAR and SODAR sensor systems, from which wind data was subsequently collected for the analysis of the measured background noise as function of wind speed, was also set to GMT. Some corrections to these clocks were necessary for one sound level meter and one rain logger for the first period of data (details provided in Table B2 and Table B4 of Annex B) but did not preclude use of these data once appropriate time corrections were applied.

6. Measured Background Noise Levels

6.1 The ETSU-R-97 assessment method requires noise data to be related to wind speed data at a height of ten metres, with wind speeds either directly measured at a height of ten metres or by calculation from measurement at other heights, the appropriate choice being determined by practitioner judgement and the available data sources. Since the publication of ETSU-R-97, the change in wind speed with increasing height above ground level has been identified as a potential source of variability when carrying out wind farm noise assessments. The effect of site specific wind shear can be appropriately addressed by implementing the ETSU-R-97 option of deriving ten metre height reference data from measurements made at taller heights. It is this method that has been used in the noise assessment for the Proposed Development to account for the potential effects of site-specific wind shear. This method is consistent with the preferred methods described in the IOA GPG.

6.2 Wind speeds were measured on a LIDAR (23rd Nov 2017 to 10th Jan 2018) and then SODAR (11th Jan 2018 to 25th Jan 2018) wind sensing instruments, located within the boundary of the Proposed Development (at approximate OSGB 238149, 600032). Values of wind speed at a standardised height of ten metres were calculated from those measured on these instruments based on a hub height of

[1] The measurement position for the subsequent installation at Tairlaw Toll House was agreed by e-mail (Steve Summers of ACCON UK to Mark Jiggins of Hoare Lea, Wed 29/11/2017).

132[2] metres, considered the tallest hub height which may be used for the site. Full details of the calculation method are given in Annex E.

6.3 Figures C1 to C12 reproduced at Annex C show the range of wind conditions experienced during the noise survey period. During the quiet day-time and night-time periods wind speeds of up to 14 m/s were experienced. The wind was observed to cover a wide range of wind directions, with higher wind speeds more common from south east through to westerly directions, generally typical of wind directions for the UK.

6.4 Figures D1 to D12 of Annex D show the results of the background noise measurements at each of the six locations. The background noise data are presented in terms of $L_{A90,10min}$ background noise levels plotted as a function of ten metre height wind speed. Two plots are shown for each location, one for quiet day-time periods and the other for night-time periods, both derived in accordance with ETSU-R-97. The IOA GPG suggests as a guideline, there should be at least 200 valid data points for each of the quiet day-time and nigh-time periods in the wind speed range required (up to approximately 8 m/s) and no fewer than 5 valid data points in any 1 m/s wind speed 'bin' within this range. These requirements have been met at all survey locations during both quiet day-time and night-time periods

6.5 Data from all survey locations were inspected to identify periods which may have been influenced by extraneous noise sources, giving rise to atypical and elevated levels. ETSU-R-97 requires that any data affected by rainfall be excluded from the analysis. Two rain logging systems were installed, one at Glenalla Farm and one at Genoch Cottage. Data from these were used to exclude those periods where rain was indicated. Rain data gathered at Glenalla Farm were used for exclusions at Glenalla Farm, whilst rain data gathered at Genoch Cottage were used for exclusions for the other survey locations, which were closest to this position.

6.6 In addition to the impact noise on surrounding vegetation and the sound level meter itself, in some environments rainfall can result in appreciable changes in background sound levels, for example as a result of wet roads which increase tyre noise emissions or dissipating flow noise in water courses and drainage systems. Observations whilst on-site indicated traffic noise to be a negligible influence on background sound levels, and thus the possible effect of increased tyre noise from wet roads is not considered relevant to this site. In terms of water flow noise, the site is generally characterised as having numerous water courses in the area, many of which were heard during site visits. The monitoring locations were positioned as far as practical from audible source of water flow, however for some locations, water flow noise had a very clear influence due to its proximity (Tairlaw Toll Cottage for example). Periods affected by atypical levels of elevated background following rainfall were excluded as by excluded all ten minute periods where rain was indicated and for six hours following indication of rainfall.

6.7 The measured background noise data may also have been increased by other extraneous sources or atypical events. Time-histories of the noise levels at each survey location were therefore inspected to look for any atypical relationships when compared to the wind speeds present during that time. Any elevated levels found in this way were excluded. The trend of the data when plotted against wind speed was also inspected to look for atypical relationships or outliers within the data-set (particularly at low wind speeds) which were excluded. Any data removed from the analysis in this way is indicated on the charts as red circles. The analysis and filtering of the data was therefore undertaken in accordance with current good practice as set out in the IOA GPG.

6.8 Following removal of those data points, best-fit lines were generated using a polynomial fit of a maximum of 4th order. These lines of best-fit then define the baseline background noise levels for the

2 Should a hub height be used which is lower than 132 metres, an assessment using ETSU R 97 noise limits derived from these background noise levels would be precautionary.

purposes of deriving noise limits in accordance with ETSU-R-97 and that would apply during the day-time and night-time periods up to 12 m/s. Tabular values of these background noise levels at integer wind speeds are shown in Tables 3 and 3 for each of the survey locations and for day-time and night-time periods.

6.9 Dersalloch Windfarm was operating during the noise survey and may potentially have influenced measured noise levels. The resident at Knockskae informed us that they had heard wind turbine noise from Dersalloch under downwind conditions. Dersalloch is approximately 3.7 km from Knockskae. Dersalloch Windfarm was not heard during any of the site visits however downwind conditions would generally be with wind directions from approximately 30 to 80 degrees and are less common in the UK. In order to consider whether this may have influenced the survey results, additional data-filters were applied to data from Knockskae, to exclude wind directions from 30 to 80 degrees which would put Knockskae downwind of Dersalloch Windfarm. Figures D13 and D14 of Annex D show that excluded data tend to be present for lower wind speeds and this filtering did not have an acoustically significant effect on the position of the best-fit lines during both day-time and night-time periods. It is concluded that operation of Dersalloch Windfarm during the noise survey did not influence the survey results and these additional filters are not necessary.

Table 2 – Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during quiet day-time periods.

Property	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	29.0	28.7	28.6	28.9	29.6	30.7	32.1	33.7	35.6	37.5	39.2	40.7
Knockskae	25.8	26.5	26.8	27.0	27.4	28.2	29.3	30.8	32.5	34.4	36.0	37.1
Linfairn Farm	30.1	29.6	30.0	30.9	32.0	33.4	34.7	35.9	37.1	38.2	39.3	40.6
Genoch Cottage	34.5	34.3	34.4	34.7	35.2	35.8	36.5	37.2	38.1	39.2	40.6	42.5
Tairlaw Toll Cottage	40.7	39.9	39.6	39.9	40.4	41.3	42.3	43.4	44.5	45.6	46.6	47.5
Tairlaw Toll House	35.0	35.0	35.0	35.2	35.6	36.4	37.6	39.0	40.8	42.7	44.6	46.2

Table 3 – Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during night-time periods.

Property	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	26.6	28.4	29.4	29.9	30.4	30.9	31.7	32.9	34.5	36.3	38.2	40.0
Knockskae	24.3	26.5	27.4	27.6	27.8	28.3	29.4	31.0	33.1	35.4	37.2	38.1
Linfairn Farm	25.4	28.1	30.1	31.6	32.7	33.5	34.1	34.7	35.3	36.2	37.5	39.2
Genoch Cottage	32.5	33.7	34.6	35.4	36.0	36.3	36.5	36.6	36.9	37.5	38.8	40.9
Tairlaw Toll Cottage	38.5	40.5	41.3	41.3	41.2	41.0	41.2	41.9	43.0	44.6	46.4	48.2
Tairlaw Toll House	32.9	34.7	35.5	35.7	35.8	36.0	36.7	37.8	39.4	41.4	43.7	46.0

6.10 Comparing the survey results from Tairlaw Toll Cottage and Tairlaw Toll House indicates that in general water flow noise is around 5 dB(A) lower at low wind speeds to the rear of Tairlaw Toll House than at the side of Tairlaw Toll Cottage. Background noise levels at Tairlaw Toll House at lower wind speeds are similar to those obtained at Genoch Cottage, but increase as wind speeds increase at a slightly greater rate. This greater rate change with wind speed may be indicative of increased exposure of Tairlaw Toll House to the wind, being at approximately 100 metres higher elevation than Genoch Cottage. Tallaminnoch is at a similar elevation (~265 m above datum) to Tairlaw Toll House (~235 m above datum) and might therefore be expected to have similar exposure to the wind. Tallaminnoch

does not have water flow noise present to the extent found at Tairlaw Toll Cottage but may be reasonably represented by Tairlaw Toll House data.

6.11 Alternative representation of baseline at Tallaminnoch would be to use data surveyed at locations in the valley of Girvan Water but these locations are more sheltered from the wind, being generally at lower elevation above datum than Tallaminnoch. It is proposed that data measured at location Tairlaw Toll House is suitably representative of background noise levels at Tallaminnoch. It is also proposed that data from Tairlaw Toll House is used to represent Tairlaw Toll Cottage, on the basis that data obtained at Tairlaw Toll House has less influence from the water flow.

7. Conclusions

7.1 This report has presented an assessment of baseline background noise levels at six nearby receptor locations agreed with the local council in the area surrounding the proposed Knockcronal Windfarm, completed in accordance with an agreed measurement protocol and in accordance with ETSU-R-97 and best practice in consultation with South Ayrshire Council and their consultants ACCON UK.

8. References

i Scottish Government, Online Renewables Planning Advice, Onshore Wind Turbines (http://www.gov.scot/Resource/0045/00451413.pdf). Updated May 28, 2014.

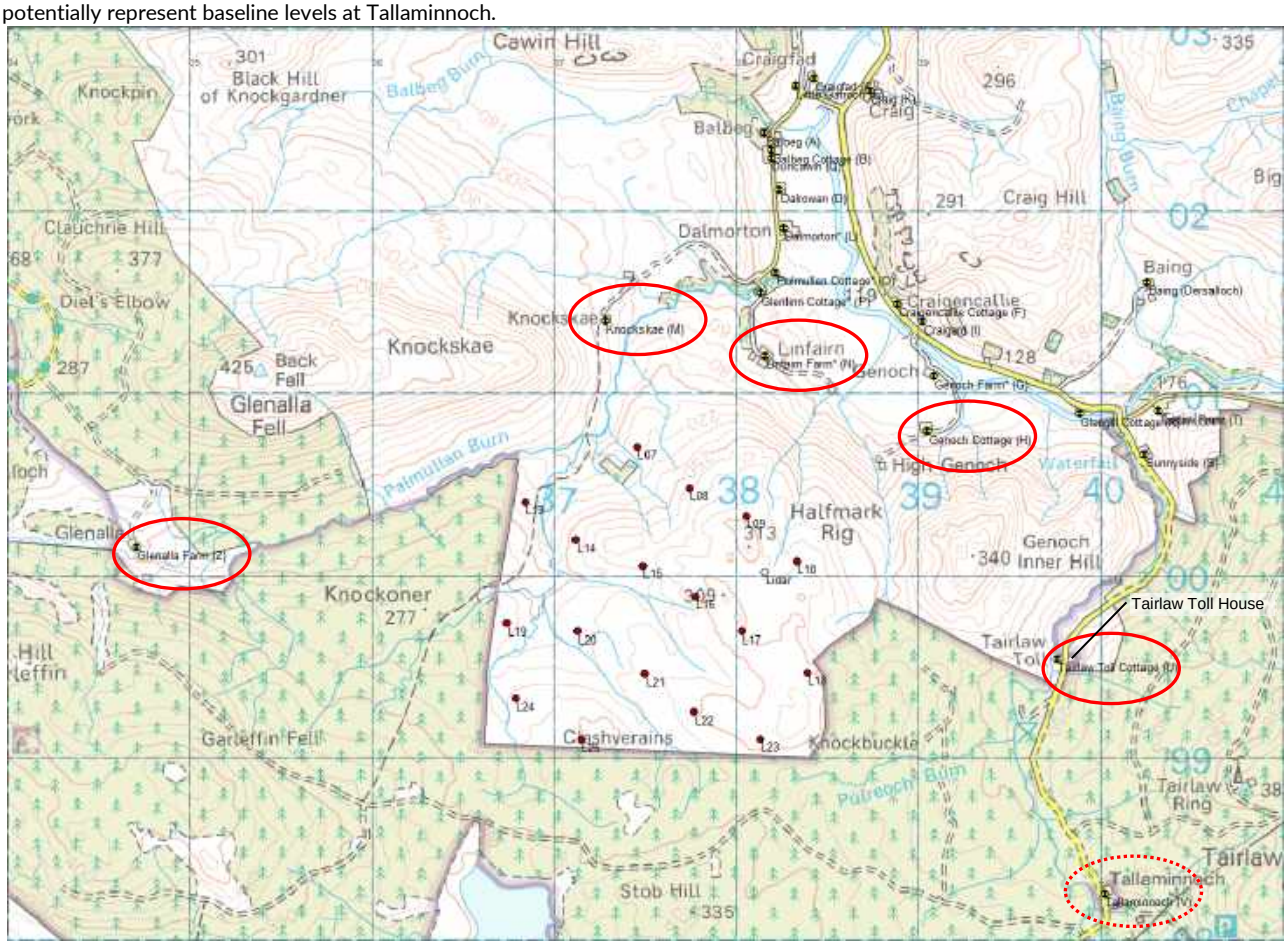
ii ETSU-R-97, the Assessment and Rating of Noise from Wind Farms, Final ETSU-R-97 Report for the Department of Trade & Industry. The Working Group on Noise from Wind Turbines, 1997.

iii A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, M. Cand, R. Davis, C. Jordan, M. Hayes, R. Perkins, Institute of Acoustics, May 2013.

iv Letter from John Swinney MSP, Scottish Government, 29/05/2013

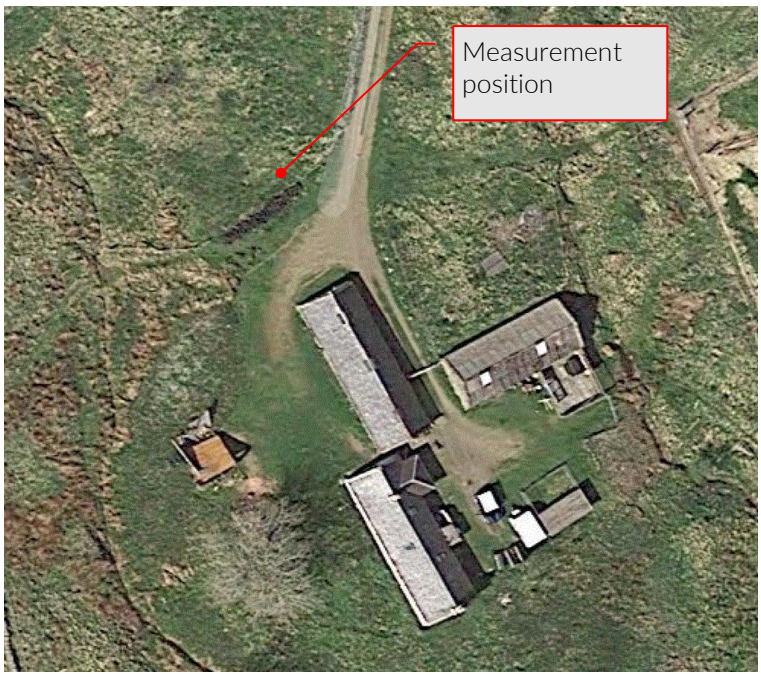
Annex A - Location Map

Figure A1 - Map showing the background noise monitoring locations in the baseline assessment protocol (red outlines), as well as the layout of turbines on the original Linfairn Wind Farm. The final list of survey locations did not include Tallaminnoch (access could not be obtained) and an additional survey position was added at Tairlaw Toll House (opposite side of the road and to the east of Tairlaw Toll Cottage) to potentially represent baseline levels at Tallaminnoch.



Annex B – Noise Monitoring Information Sheets

Table B1 – Information on the measurement location, equipment and noise data at Glenalla Farm.

Measurement Location Name	Glenalla Farm
Measurement Location Description	 A location was chosen at the end of the barns in a fenced field due to concern by the resident about their dogs attacking the equipment and also to get furthest from the boiler flue which was firing whilst setting up the equipment and was very apparent near the house and much reduced but just audible at the measurement position. Water flow noise was a source heard all around the property due to the number of different burns nearby. Wind in the trees, birdsong and distant aircraft were heard during visits. SLM Location: 234678, 600229 (acc. 6 m) - rain logger also installed

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-52	00331833	15/08/2017
Microphone	Rion UC-59	04900	15/08/2017
Pre-amplifier	Rion NH-25	21784	15/08/2017
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	n/a (single range)		
Rain Logger	Campbell CR200X	10463	n/a
Rain Bucket	Davis 7852	HLA-05	n/a

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	2017/11/14 15:40:00	2017/11/28 14:30:00	94.0	94.0	0.0	No significant drift
2	2017/11/28 14:50:00	2017/12/12 13:20:00	94.0	94.0	0.0	No significant drift
3	2017/12/12 13:30:00	2018/01/04 13:50:00	94.0	94.0	0.0	No significant drift
4	2018/01/04 14:10:00	2018/01/26 13:10:00	94.0	94.0	0.0	No significant drift

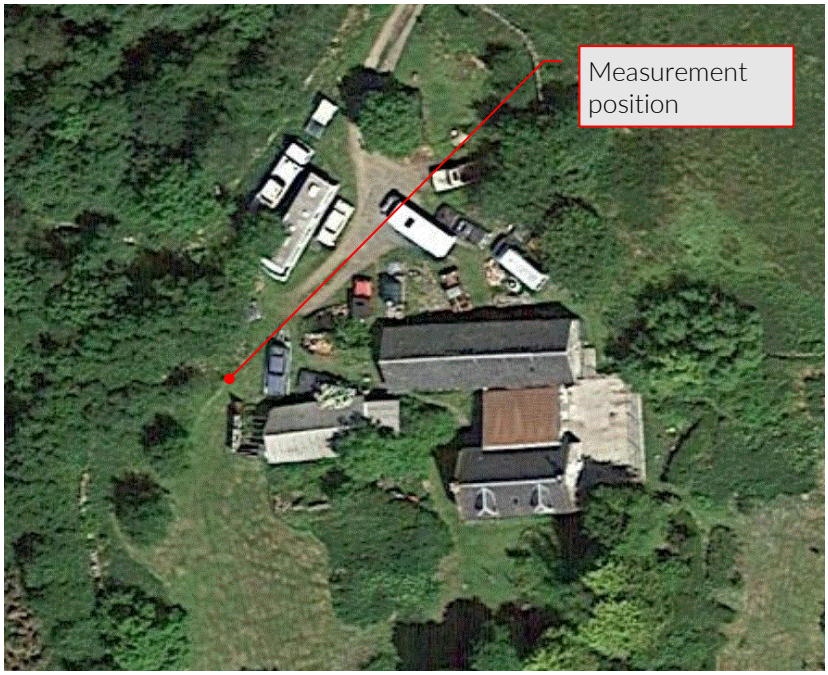
Data Exclusions
Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded. Data-points above 40 dB(A) which were below 7.5 m/s during day-time periods and below 8.5 m/s during night-time periods

Figure B1 View of the monitoring location at Glenalla Farm looking approximately south

Figure B2 View of the monitoring location at Glenalla Farm looking approximately west.

Figure B3 View of the monitoring location at Glenalla Farm looking approximately east

Table B2 – Information on the measurement location, equipment and noise data at Knockskae.

Measurement Location Name	Knockskae
Measurement Location Description	 Time spent to find an appropriate location which was least influenced by water flow noise which was apparent to the rear (southern) garden area of the house. Also to the rear of the house was a heating flue so avoided that area. The chosen area was on the track leading to the rear garden to the side of the outbuildings. At this position water flow noise was least apparent. Weather conditions during setup were relatively calm wind speeds and quiet, a distant aircraft and some wind in the trees heard. Resident mentioned being able to hear Dersalloch when downwind of that site but this was not heard during any of the visits. Wind in trees, distant aircraft and birdsong were heard during visits. SLM Location: 237258, 601401 (acc. 8 m)

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-52	00632045	16/08/2017
Microphone	Rion UC-59	05212	16/08/2017
Pre-amplifier	Rion NH-25	32073	16/08/2017
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	n/a (single range)		

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	2017/11/14 14:10:00	2017/11/28 13:10:00	94.0	93.9	0.1	No significant drift
2	2017/11/28 13:30:00	2017/12/12 11:40:00	94.0	94.0	0.0	No significant drift
3	2017/12/12 12:00:00	2017/12/30 05:30:00	94.0	94.0	0.0	No significant drift
4	2018/01/04 13:10:00	2018/01/23 00:10:00	94.0	94.0	0.0	No significant drift

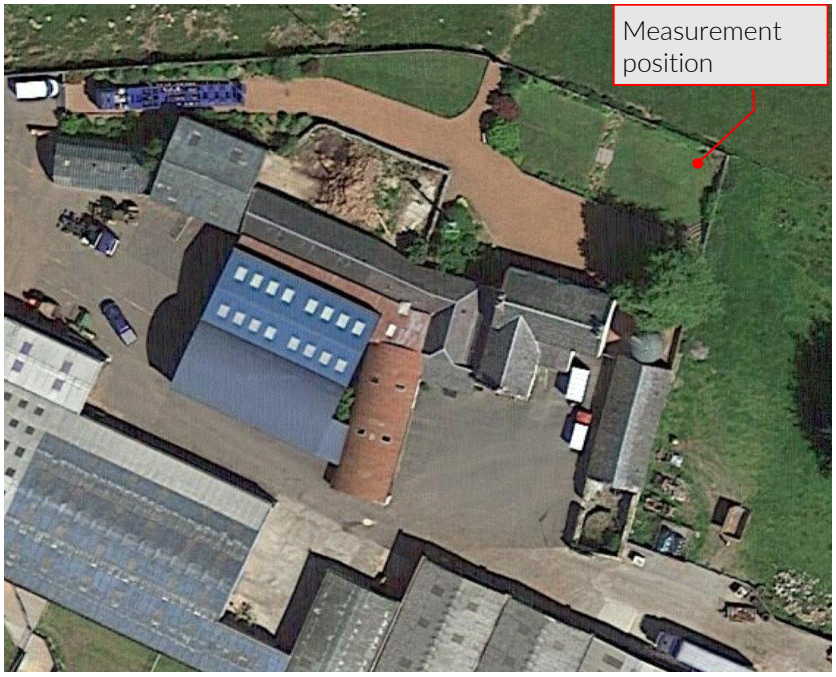
Data Exclusions
The first period of data from the sound level meter was acquired with the SLM clock set to year 2014 not 2017 but with the month, day and time all correct: this was corrected during processing of the data. Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded. Data-points above 40 dB(A) and below 6.0 m/s during both day-time and night-time periods.

Figure B4 View of the monitoring location at Knockskae looking approximately north east.

Figure B5 View of the monitoring location at Knockskae looking approximately east.

Figure B6 View of the monitoring location at Knockskae looking approximately south.

Table B3 – Information on the measurement location, equipment and noise data at Linfairn Farm.

Measurement Location Name	Linfairn Farm
Measurement Location Description	 Positioned at the corner of the garden at the point furthest from the central heating flue. This is in the garden of the house away from the farmyard areas. During installation the wind conditions were calm with some wind in the trees and birdsong heard, a tractor in the barn started part way through the install. Road traffic noise on road through the valley, wind in the conifer by house, sheep, birdsong, dog barking, distant aircraft, occasional distant road traffic noise as well as distant water flow noise from the valley were heard during visits. SLM Location: 238185, 601223 (acc. 5 m)

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-32	01172484	12/06/2017
Microphone	Rion UC-53A	313611	12/06/2017
Pre-amplifier	Rion NH-21	25573	12/06/2017
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	n/a (single range)		

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	2017/11/14 12:10:00	2017/11/28 13:50:00	94.0	93.9	0.1	No significant drift
2	2017/11/28 14:09:59	2017/12/12 12:09:59	94.0	94.0	0.0	No significant drift
3	2017/12/12 12:29:59	2018/01/01 03:49:59	94.0	94.1	0.1	No significant drift
4	SLM failed to store data	SLM failed to store data	94.0	94.0	0.0	No significant drift

Data Exclusions
Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded. Data-points above 50 dB(A) and below 12 m/s and above 40 dB(A) and below 5 m/s during day-time periods

Figure B7 View of the monitoring location at Linfairn Farm looking approximately north west.

Figure B8 View of the monitoring location at Linfairn Farm looking approximately east.

Figure B9 View of the monitoring location at Linfairn Farm looking approximately south west.

Table B4 – Information on the measurement location, equipment and noise data at Genoch Cottage.

Measurement Location Name	Genoch Cottage
Measurement Location Description	 A measurement position was chosen at the end of the property towards the site, looking out over the Genoch Farm to the north. Water flow from the burn to the south of the property was less apparent at this position. Cows at Genoch Farm, wind in trees (local and more distant), distant aircraft, crows/birdsong, as well as occasional local road traffic noise heard on visits to this location. SLM Location: 239040, 600797 (acc. 10 m) - rain logger also installed

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-32	00630481	07/09/2016
Microphone	Rion UC-53A	305115	07/09/2016
Pre-amplifier	Rion NH-21	09098	07/09/2016
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	20 – 100 dB(A)		
Rain Logger	Campbell CR200X	4981	n/a
Rain Bucket	Davis 7852	HLA-01	n/a

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	2017/11/14 10:49:59	2017/11/28 11:09:59	94.0	93.9	0.2	No significant drift
2	2017/11/28 11:40:00	2017/12/12 10:10:00	94.0	93.8	0.2	No significant drift
3	2017/12/12 10:40:00	2018/01/04 10:30:00	94.0	94.0	0.0	No significant drift
4	2018/01/04 11:00:00	2018/01/26 10:50:00	94	94.0	0.0	No significant drift

Data Exclusions
On collection of the first data from the rain logger, it was found the internal clock maintenance battery had failed resulting in data being related to incorrect time and a correction to logged data was applied during processing, based on the noted clock offset at time of collection (logger: 11/04/2028 02:05:36 = correct time: 28/11/2017 11:44:00). Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded.

Figure B10 View of the monitoring location at Genoch Cottage looking approximately south east.

Figure B11 View of the monitoring location at Genoch Cottage looking approximately south west.

Figure B12 View of the monitoring location at Genoch Cottage looking approximately north.

Table B5 – Information on the measurement location, equipment and noise data at Tairlaw Toll Cottage.

Measurement Location Name	Tairlaw Toll Cottage
Measurement Location Description	 The property is near to the Tairlaw burn which was the dominant source of noise around the dwelling. The measurement position was chosen to the side of the dwelling at a position to minimise the sound of water flowing but remained apparent during equipment setup. Birdsong, distant aircraft and wind in the trees near the house were also heard on visits. SLM Location: 239796, 599531 (acc. 6 m)

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-52	00331820	19/07/2017
Microphone	Rion UC-59	04886	19/07/2017
Pre-amplifier	Rion NH-25	21771	19/07/2017
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	n/a (single range)		

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	2017/11/14 11:40:00	2017/11/28 12:40:00	94.0	93.9	0.1	No significant drift
2	2017/11/28 12:50:00	2017/11/29 06:10:00	94.0	94.0	0.0	No significant drift
3	2017/12/12 11:20:00	2017/12/30 20:20:00	94.0	94.0	0.0	No significant drift
4	2018/01/04 12:00:00	2018/01/25 08:50:00	94.0	94.0	0.0	No significant drift

Data Exclusions
Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded.

Figure B13 View of the monitoring location at Tairlaw Toll Cottage looking approximately north west.

Figure B14 View of the monitoring location at Tairlaw Toll Cottage looking approximately south west.

Figure B15 View of the monitoring location at Tairlaw Toll Cottage looking approximately north east.

Table B6 – Information on the measurement location, equipment and noise data at Tairlaw Toll House.

Measurement Location Name	Tairlaw Toll House
Measurement Location Description	 Additional location added at Tairlaw Toll House, further from the water flow noise than Tairlaw Toll Cottage and installed at a later date, when access to Tallaminnoch could not be confirmed. A measurement position was chosen to the rear of the property at a place most shielded from the water flow noise. The SLM was located within a trampoline 'frame' due to the residents concern the equipment may be damaged if in the immediate garden area of the house. This rear location is somewhat sheltered from the wind and the frame is unlikely to be an acoustically significant source of noise or reflections. Audible during the installation were wind in the trees/conifers around the house, birdsong, distant aircraft and maybe just audible was water flow noise but it was not a significant source at the time of the visit. Water flow and birdsong also heard during visits. SLM Location: 239830, 599516 (acc. 7 m)

Equipment	Type	Serial Number	Last Calibrated (UKAS)
Sound Level Meter	Rion NL-31	00110060	18/04/2016
Pre-amplifier	Rion NH-21	07772	18/04/2016
Microphone	Rion UC-53A	318925	18/04/2016
Calibrator	B&K 4231	2498799	05/04/2017
SLM Range	20 – 100 dB(A)		

File	Time Start (GMT)	Time End (GMT)	Cal Start	Cal End	Drift	Notes
1	Not installed					
2	2017/11/28 12:29:58	2017/12/12 14:09:58	94.0	94.1	0.1	No significant drift
3	2017/12/12 14:30:00	2018/01/04 11:20:00	94.0	94.0	0.0	No significant drift
4	2018/01/04 11:40:00	2018/01/26 10:30:00	94.0	93.8	0.2	No significant drift

Data Exclusions
Periods where rainfall were indicated and those periods within six hours of when rainfall was indicated were excluded.

Figure B16 View of the monitoring location at Tairlaw Toll House looking approximately north west.

Figure B17 View of the monitoring location at Tairlaw Toll House looking approximately west.

Figure B18 View of the monitoring location at Tairlaw Toll House looking approximately south east.

Annex C – Wind Speeds and Directions

Figure C1 - Wind speed and direction range during all quiet day-time periods at Glenalla Farm.

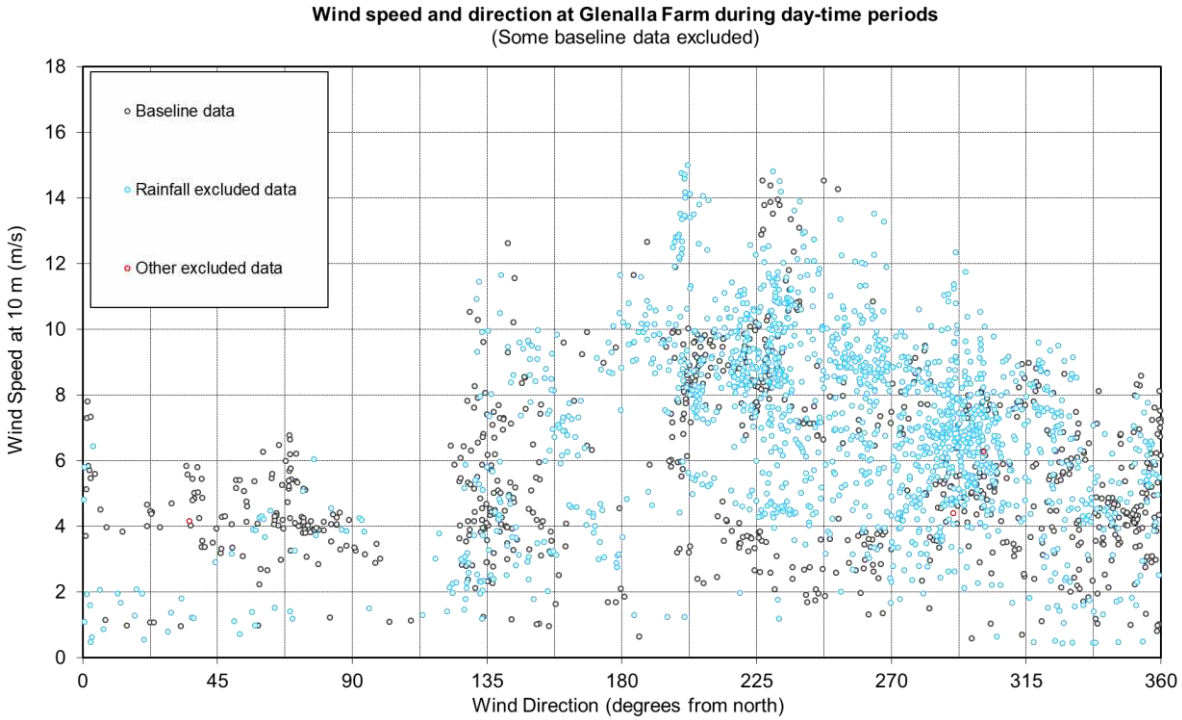


Figure C2 - Wind speed and direction range during all night-time periods at Glenalla Farm.

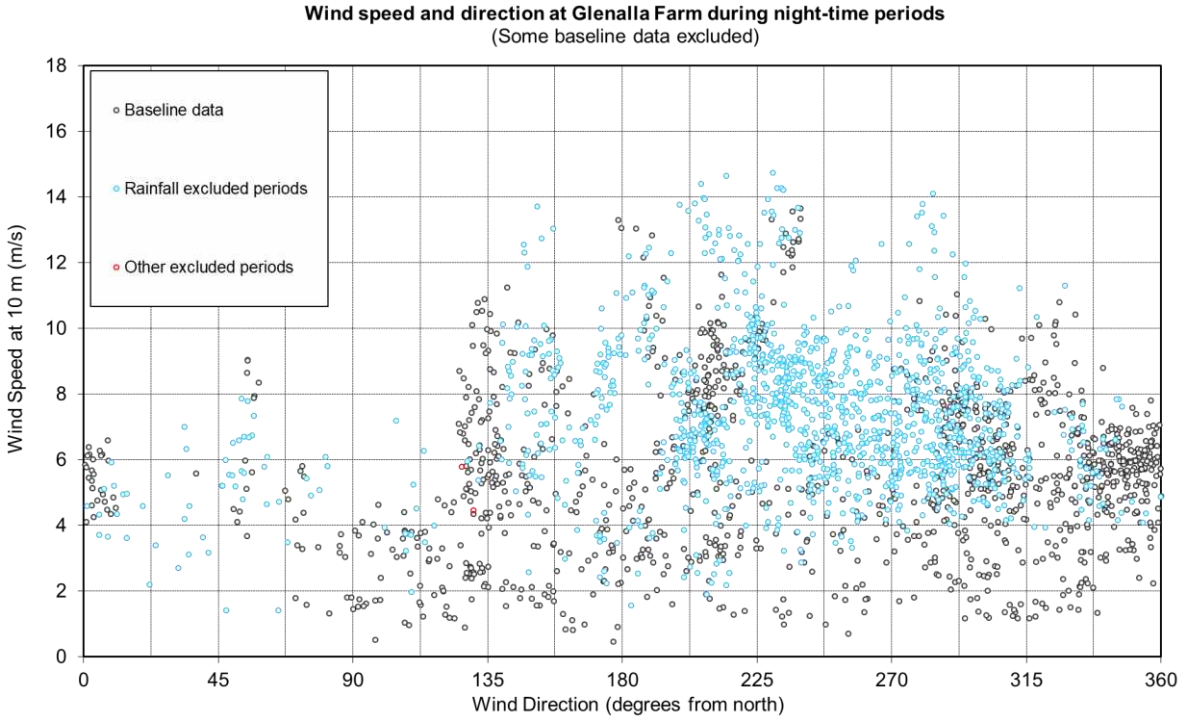


Figure C3 - Wind speed and direction range during all quiet day-time periods at Knockskae.

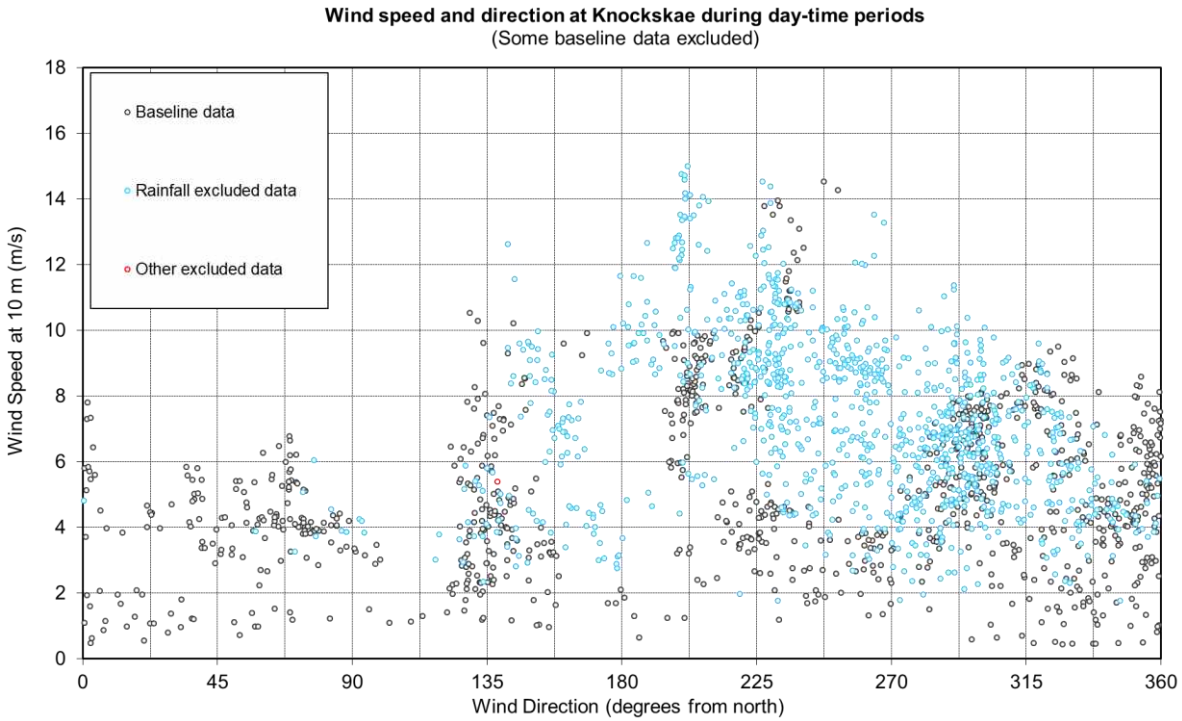


Figure C4 - Wind speed and direction range during all night-time periods at Knockskae.

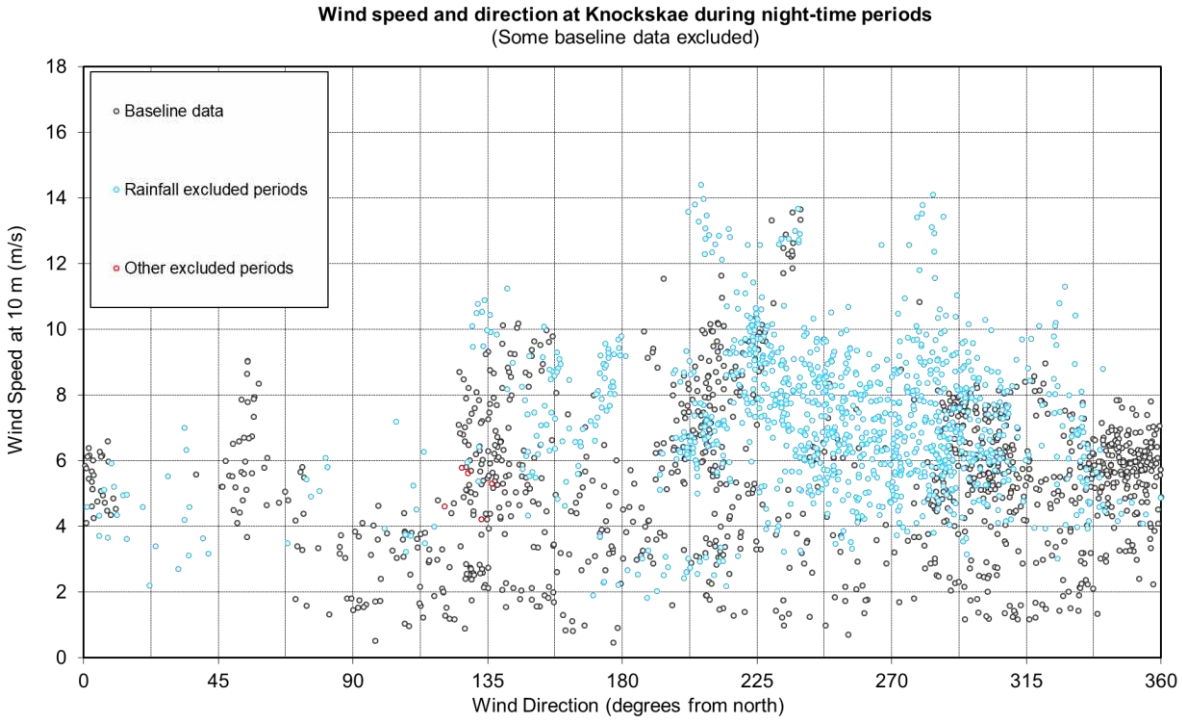


Figure C5 - Wind speed and direction range during all quiet day-time periods at Linfairn Farm.

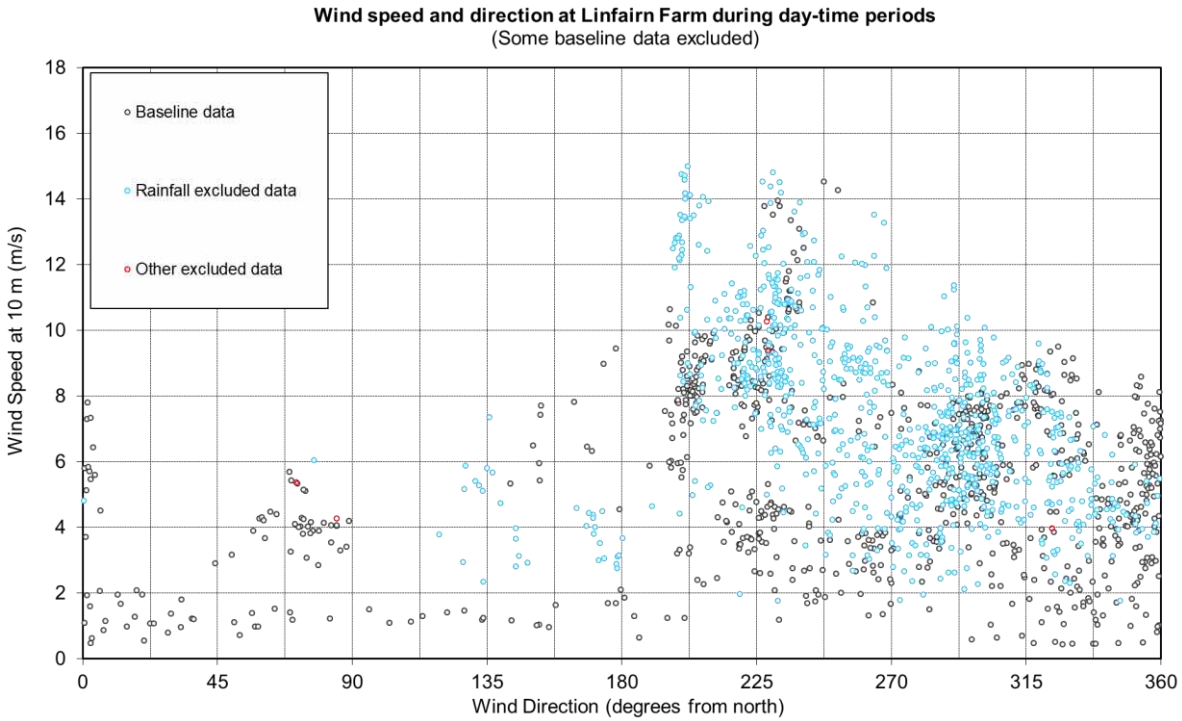


Figure C6 - Wind speed and direction range during all night-time periods at Linfairn Farm.

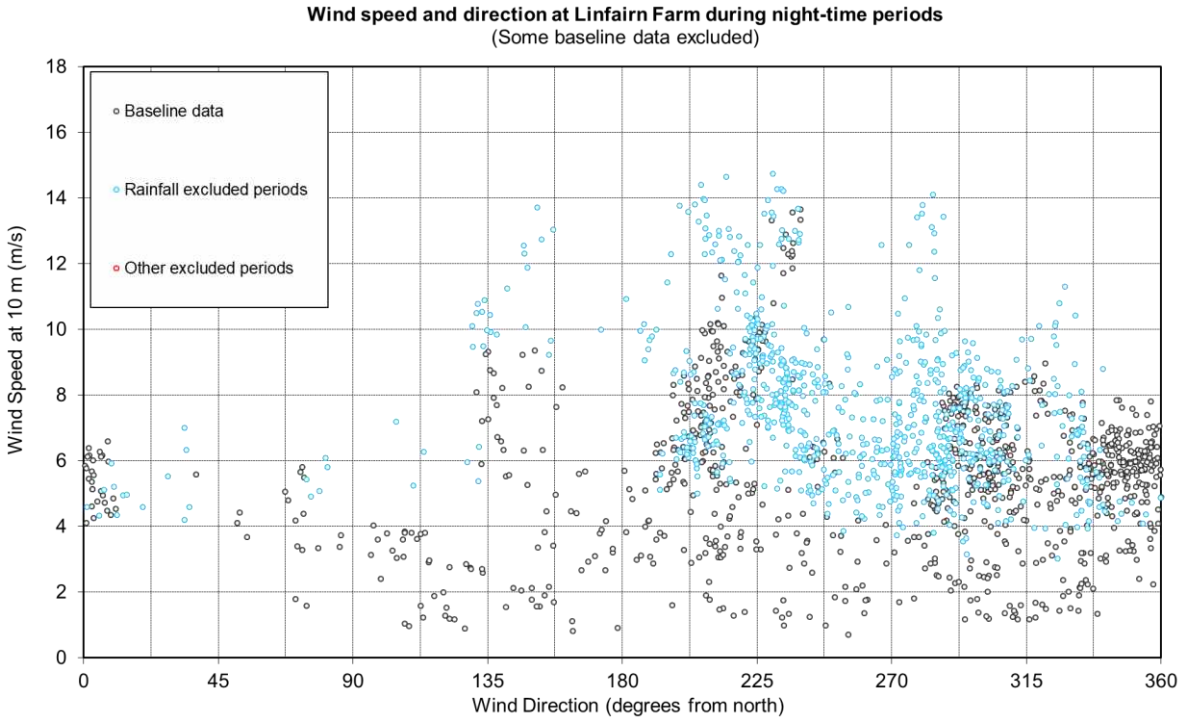


Figure C7 - Wind speed and direction range during all quiet day-time periods at Genoch Cottage.

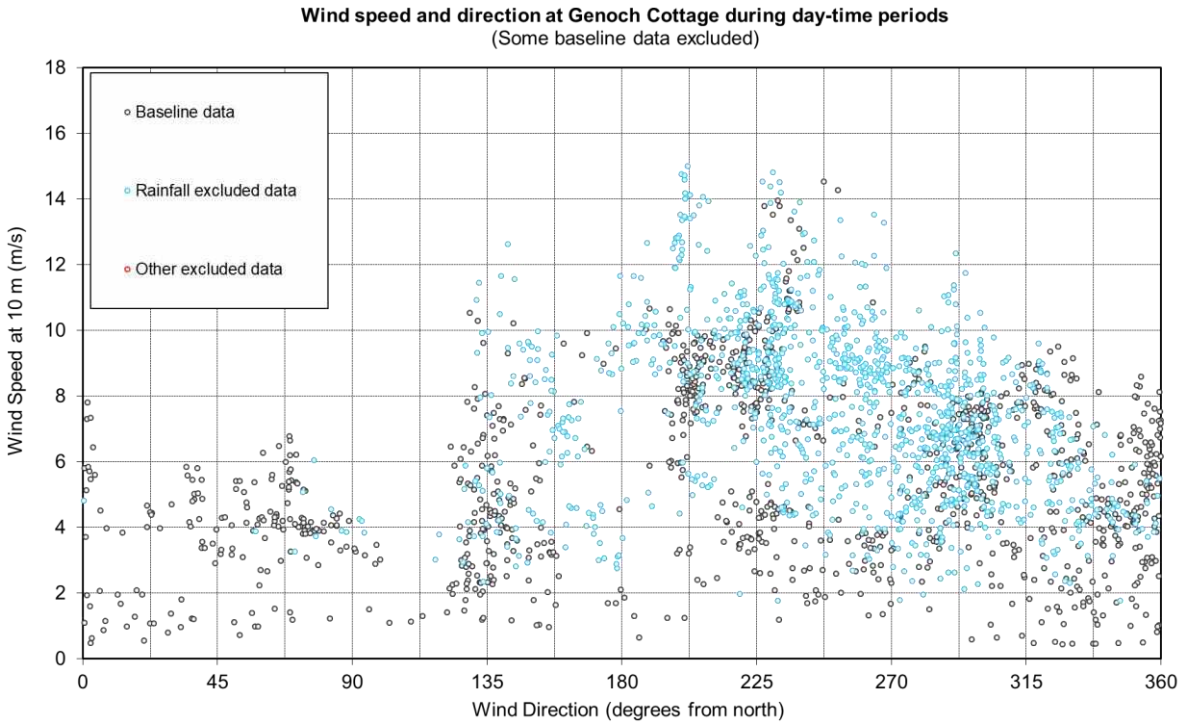


Figure C8 - Wind speed and direction range during all night-time periods at Genoch Cottage.

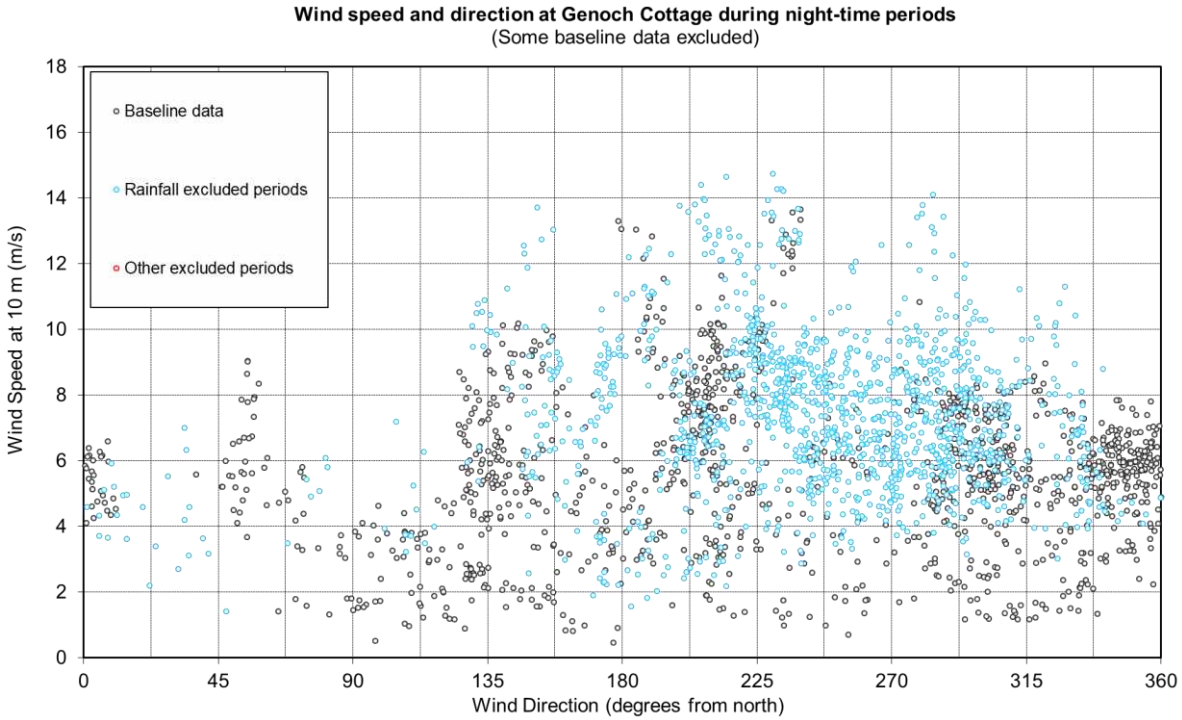


Figure C9 - Wind speed and direction range during all quiet day-time periods at Tairlaw Toll Cottage.

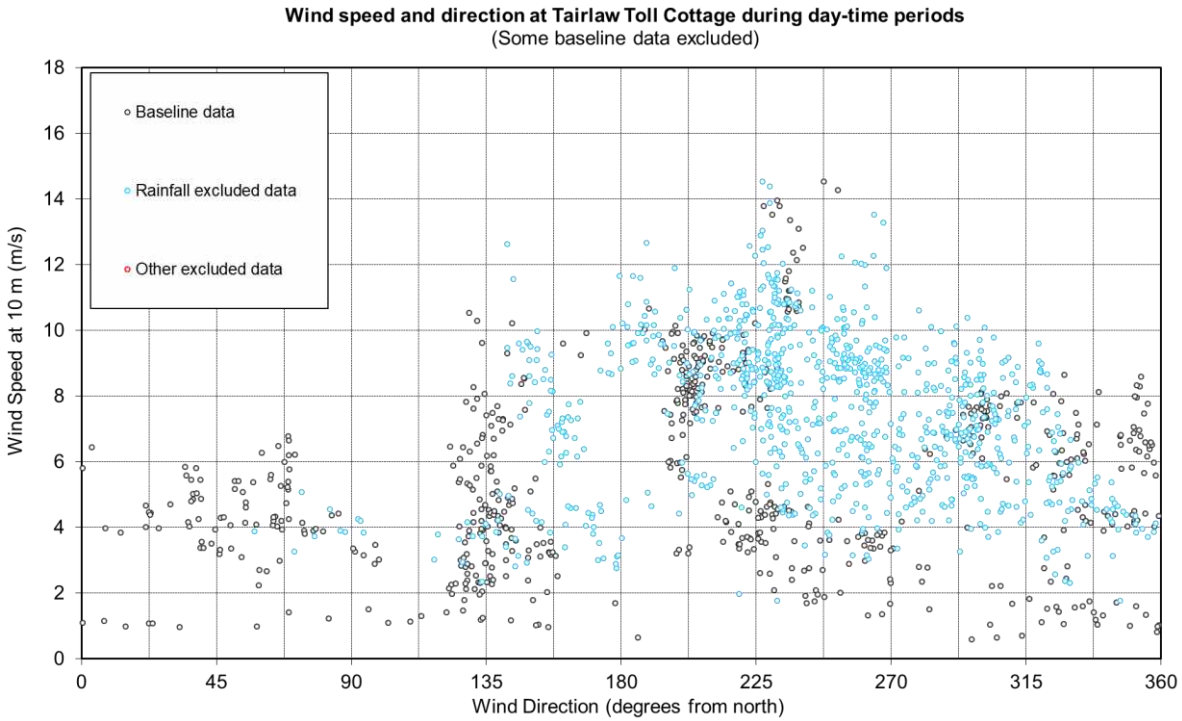


Figure C10 - Wind speed and direction range during all night-time periods at Tairlaw Toll Cottage.

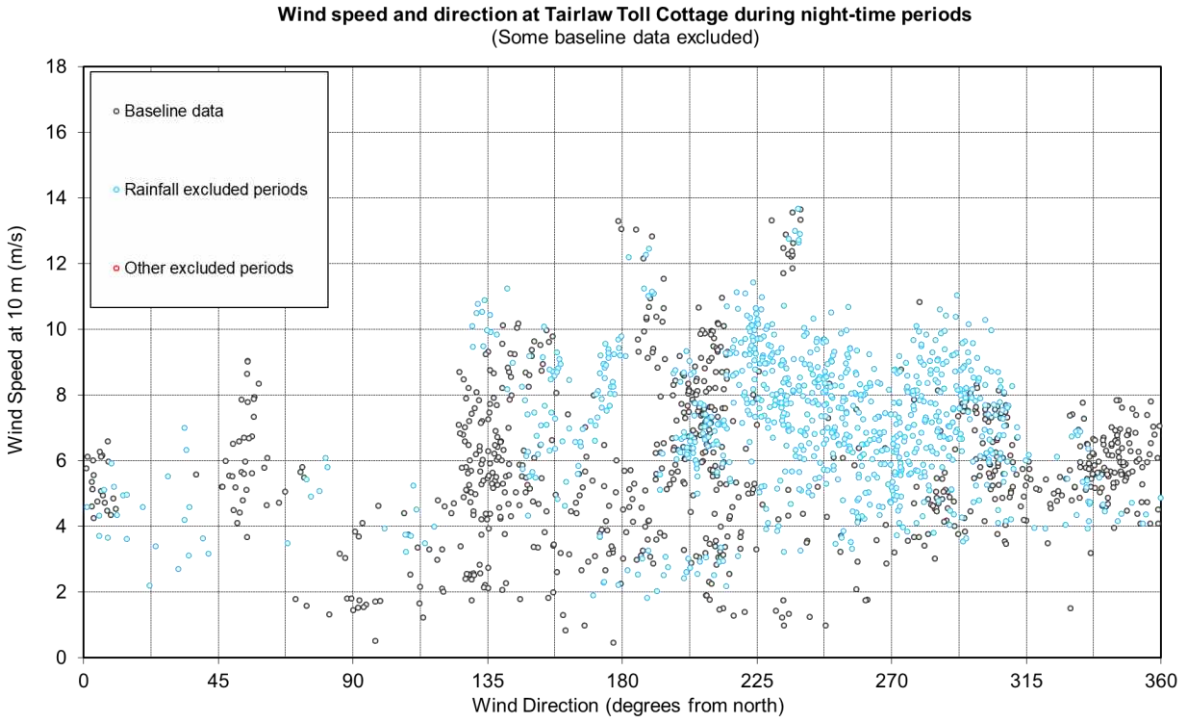


Figure C11 - Wind speed and direction range during all quiet day-time periods at Tairlaw Toll House.

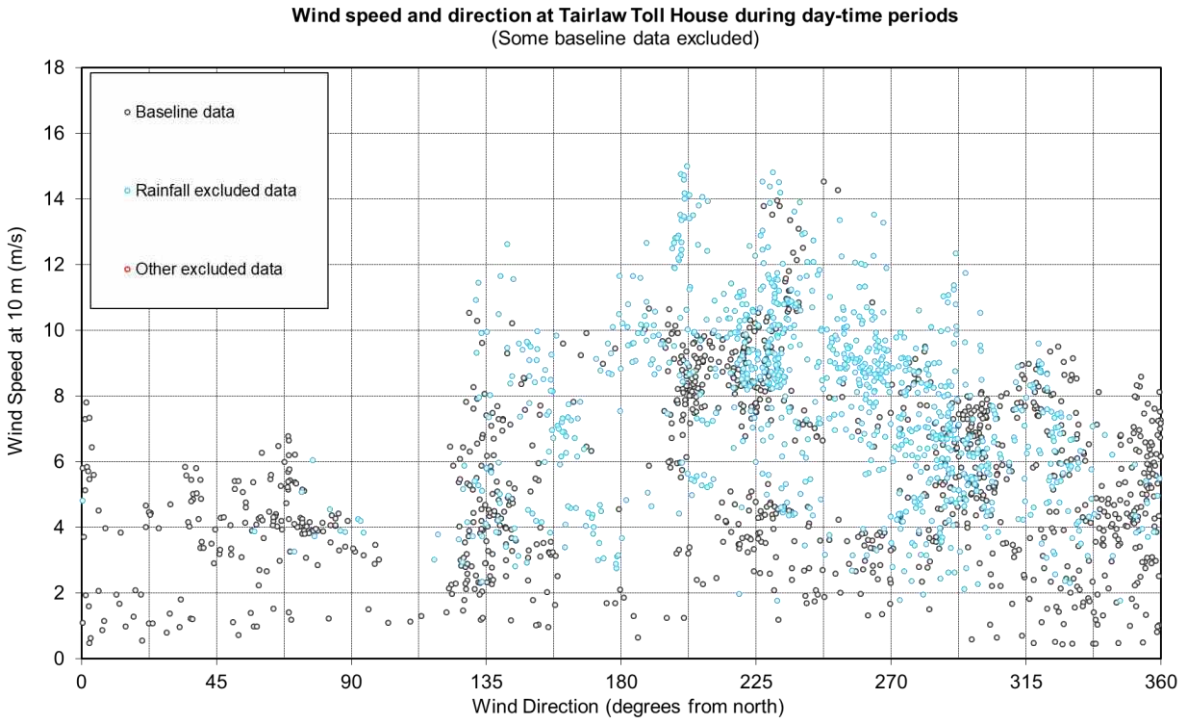
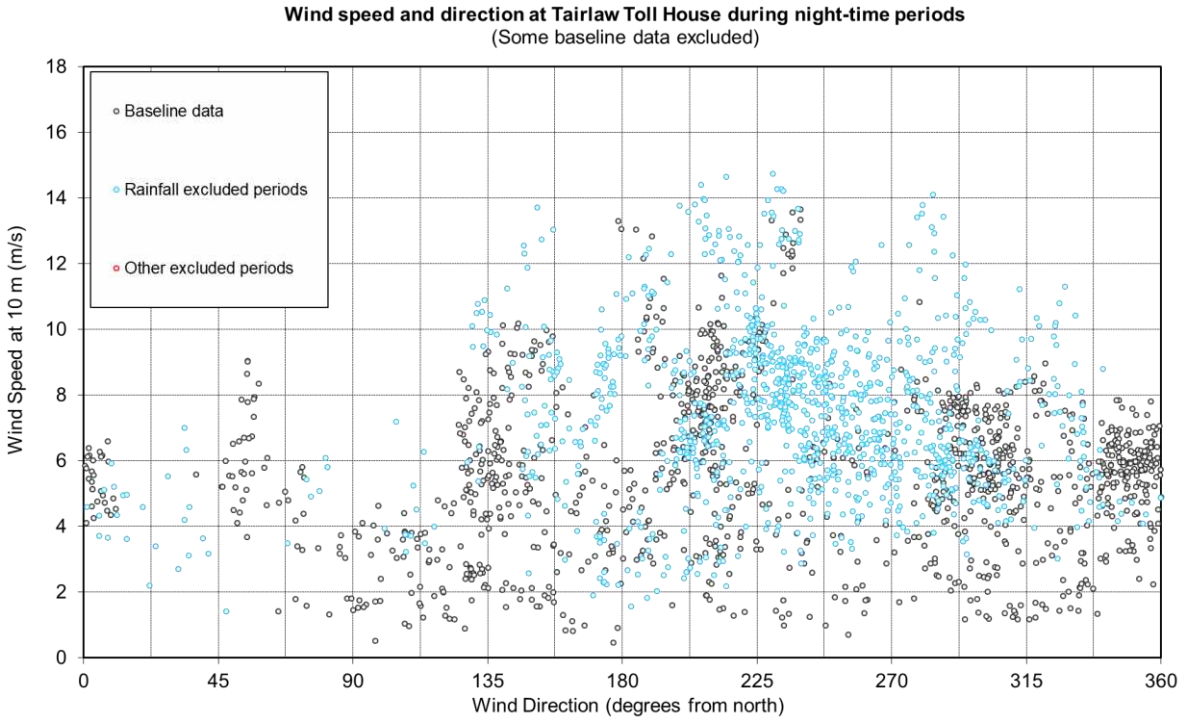


Figure C12 - Wind speed and direction range during all night-time periods at Tairlaw Toll House.



Annex D – Background Noise

Figure D1 - Chart of background noise levels against wind speeds and the best fit curve to the data for Glenalla Farm during quiet day-time periods.

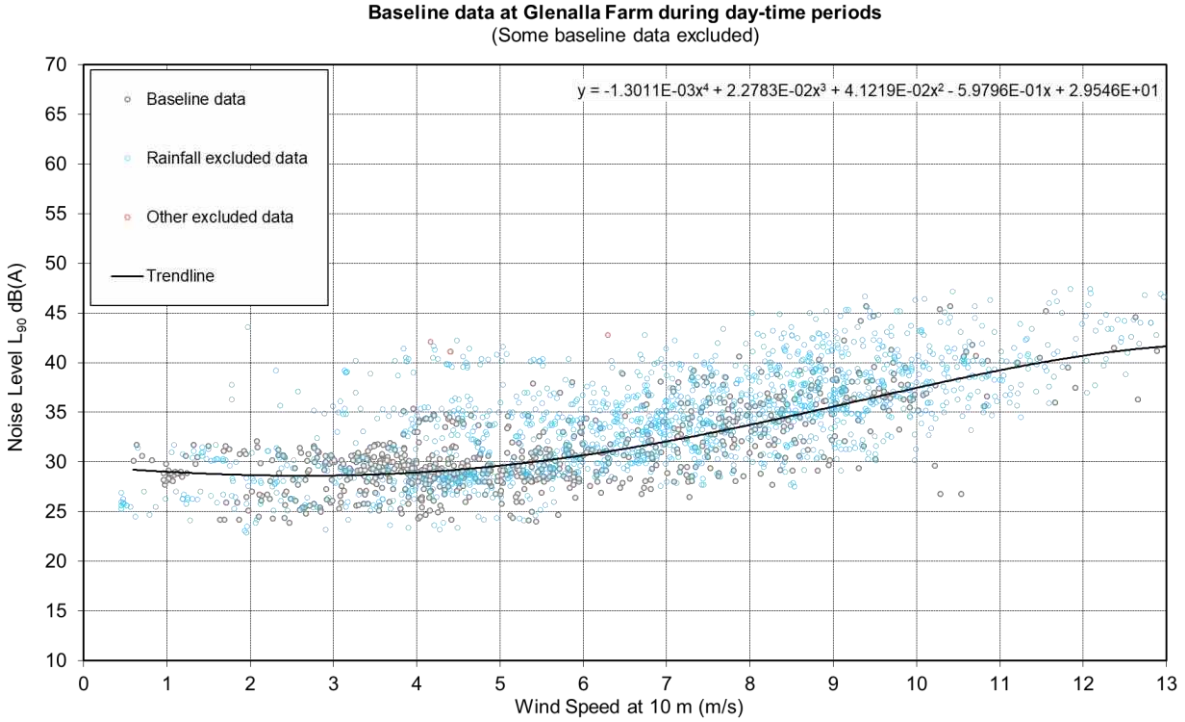


Figure D2 - Chart of background noise levels against wind speeds and the best fit curve to the data for Glenalla Farm during night-time periods.

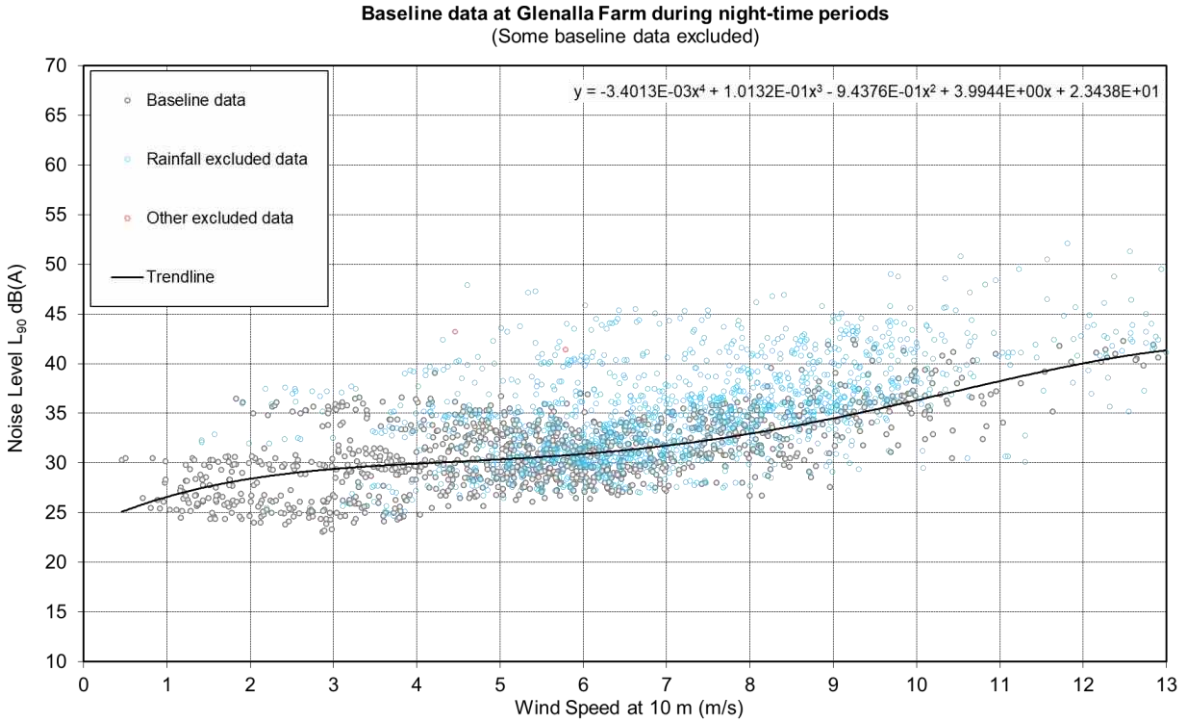


Figure D3 - Chart of background noise levels against wind speeds and the best fit curve to the data for Knockskae during quiet day-time periods.

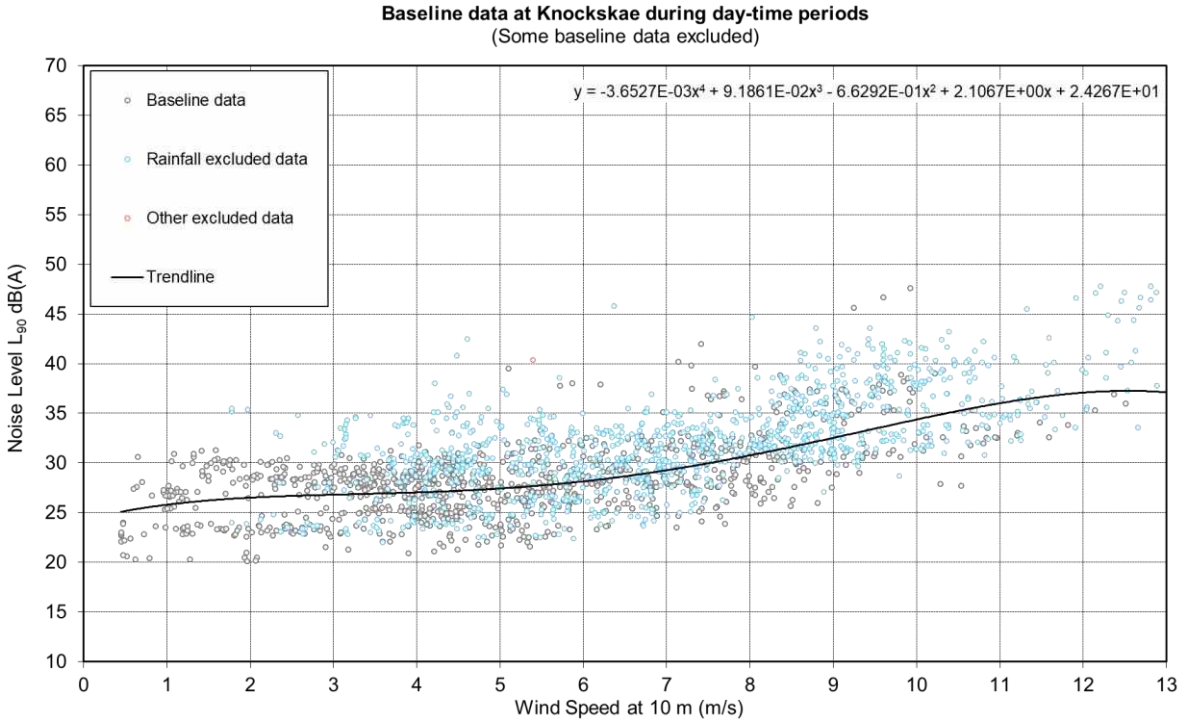


Figure D4 - Chart of background noise levels against wind speeds and the best fit curve to the data for Knockskae during night-time periods.

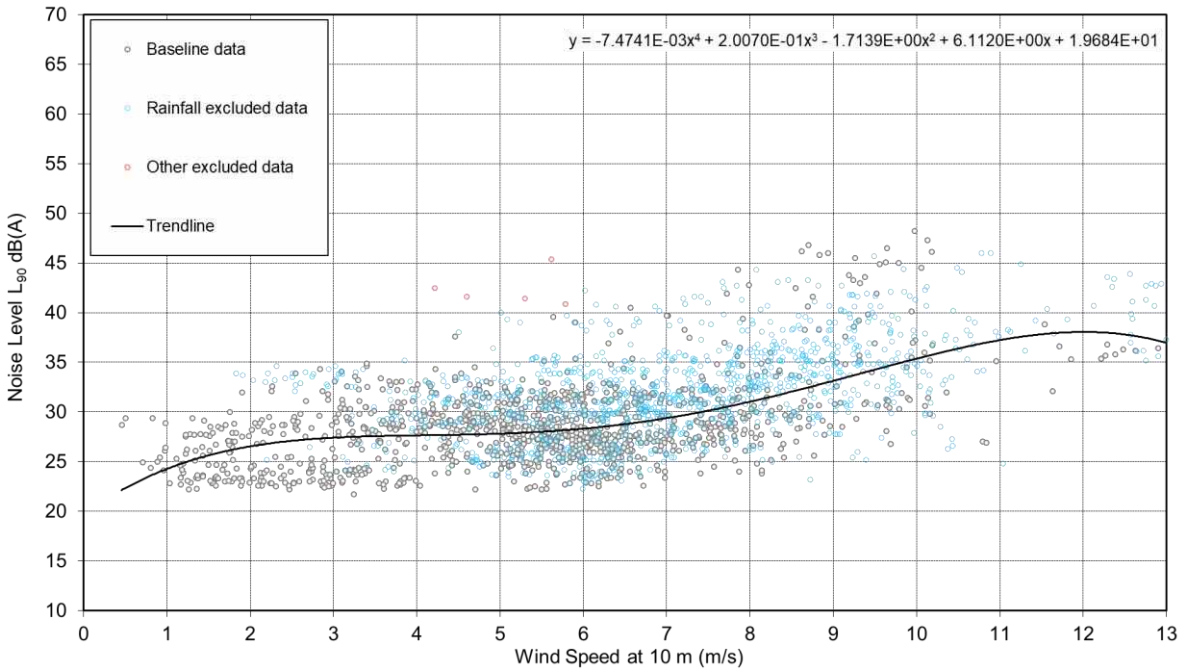


Figure D5 - Chart of background noise levels against wind speeds and the best fit curve to the data for Linfairn Farm during quiet day-time periods.

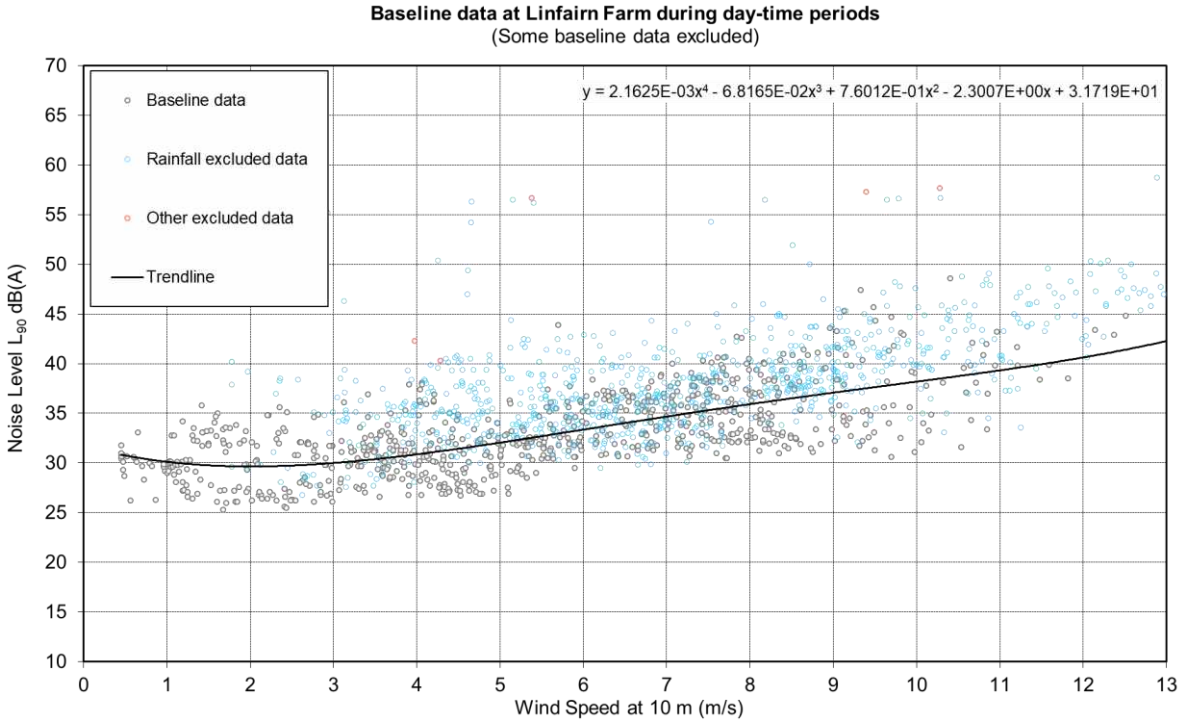


Figure D6 - Chart of background noise levels against wind speeds and the best fit curve to the data for Linfairn Farm during night-time periods.

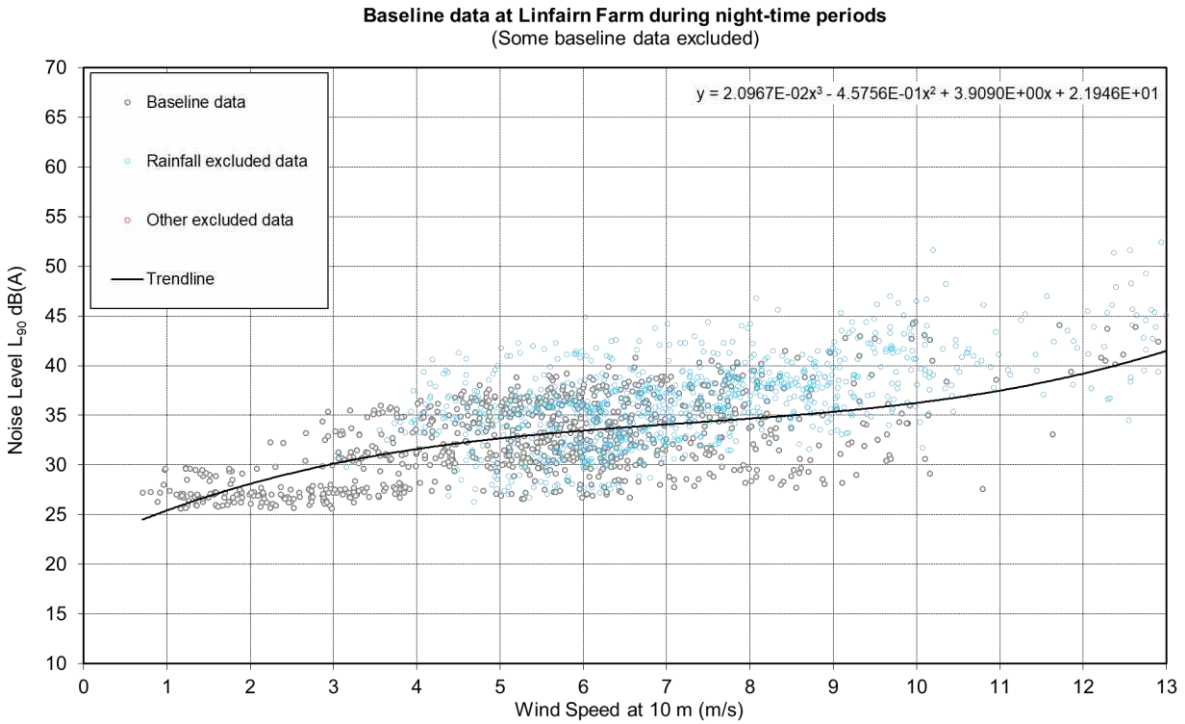


Figure D7 - Chart of background noise levels against wind speeds and the best fit curve to the data for Genoch Cottage during quiet day-time periods.

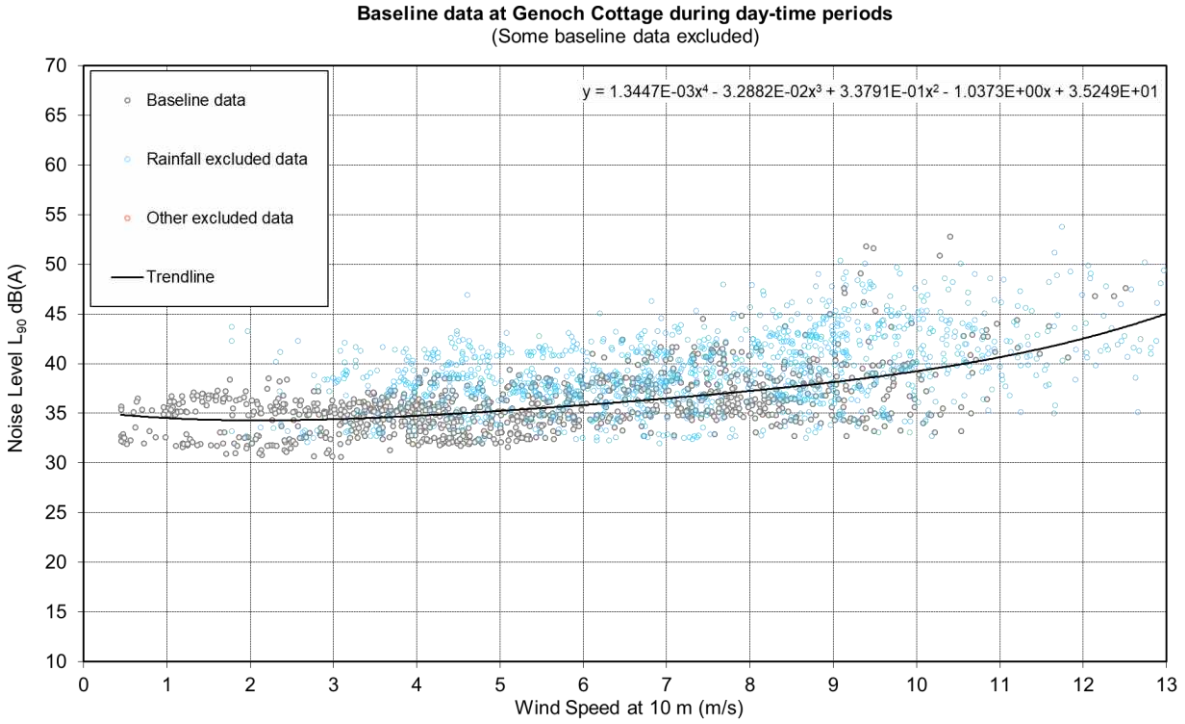


Figure D8 - Chart of background noise levels against wind speeds and the best fit curve to the data for Genoch Cottage during night-time periods.

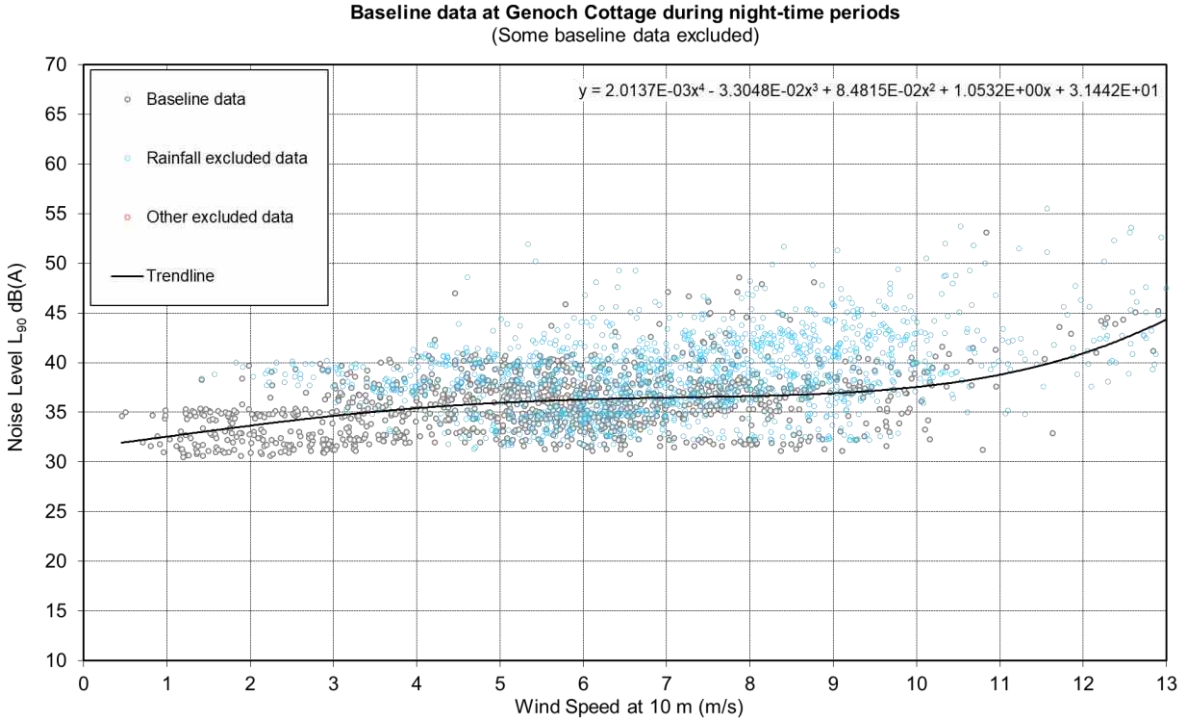


Figure D9 - Chart of background noise levels against wind speeds and the best fit curve to the data for Tairlaw Toll Cottage during quiet day-time periods.

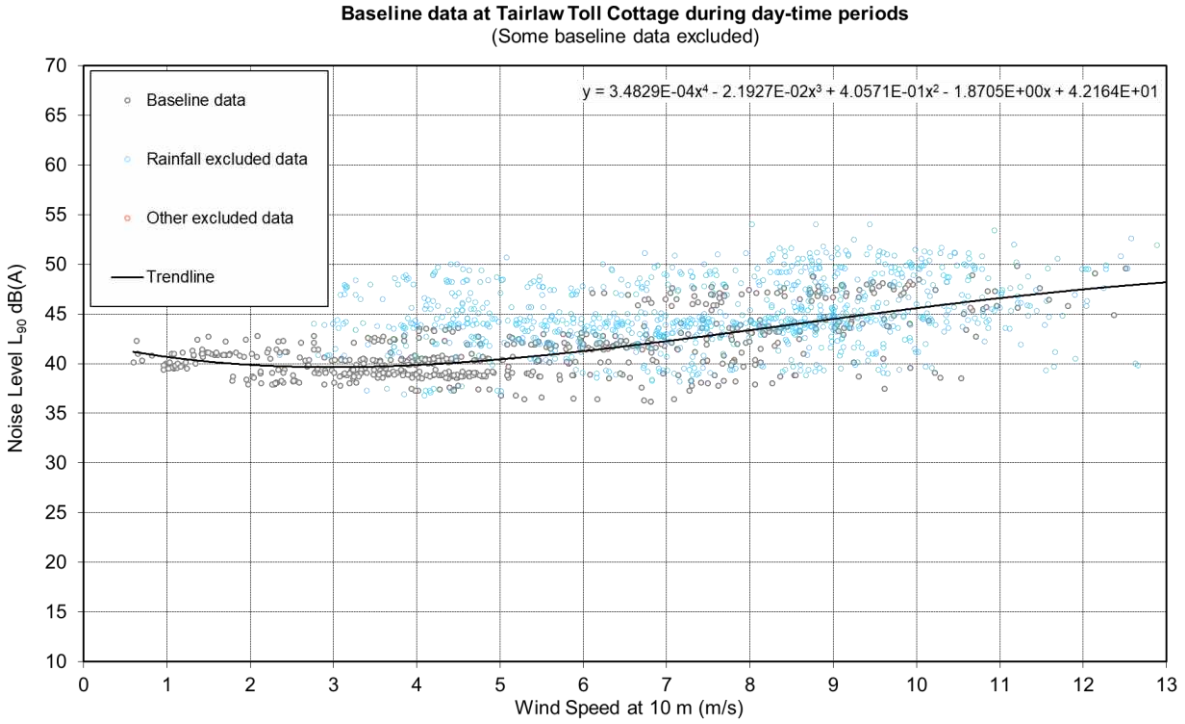


Figure D10 - Chart of background noise levels against wind speeds and the best fit curve to the data for Tairlaw Toll Cottage during night-time periods.

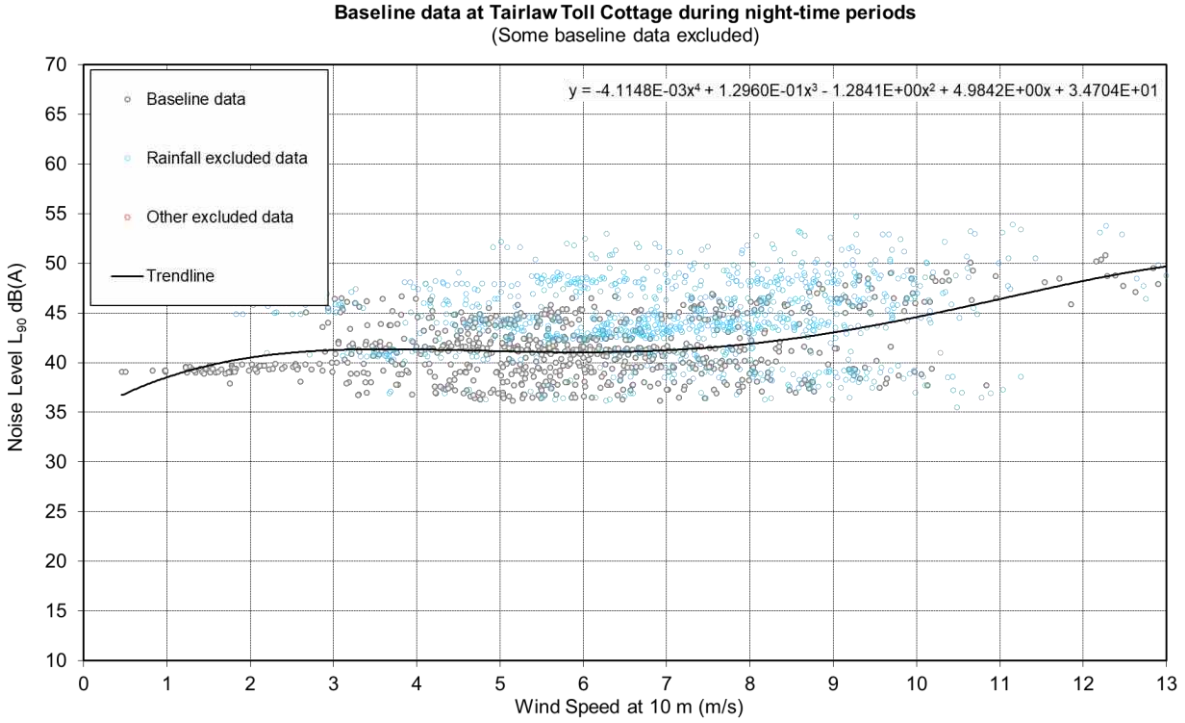


Figure D11 - Chart of background noise levels against wind speeds and the best fit curve to the data for Tairlaw Toll House during quiet day-time periods.

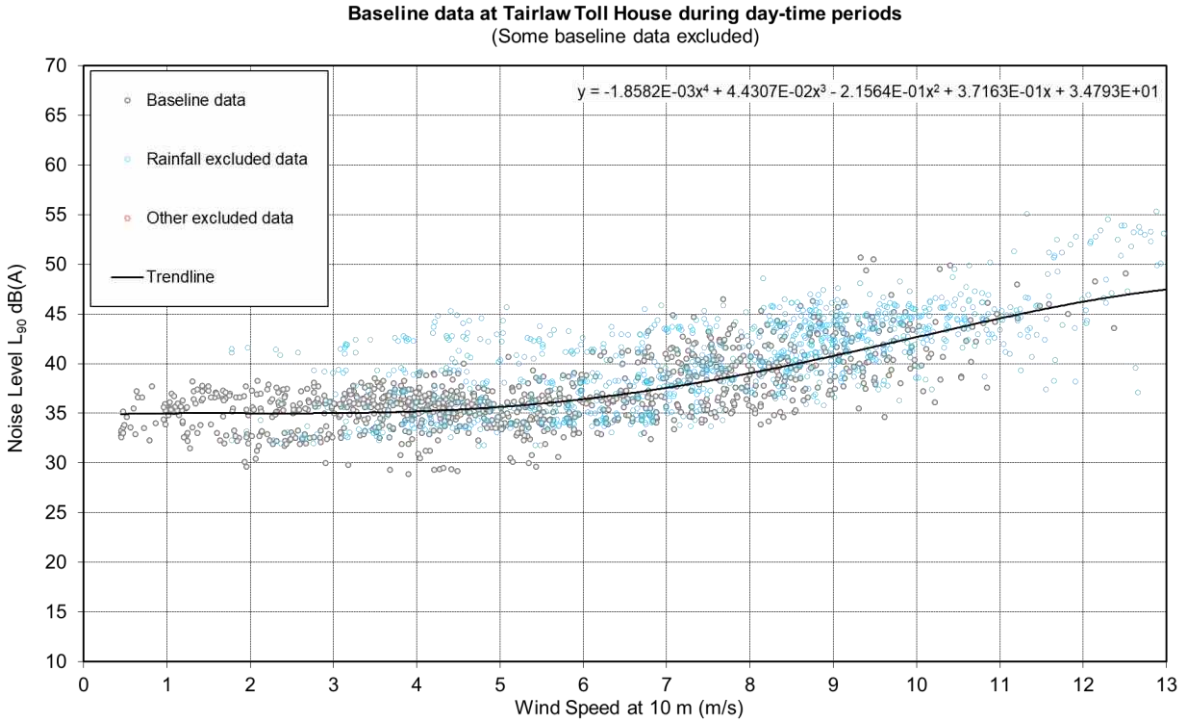


Figure D12 - Chart of background noise levels against wind speeds and the best fit curve to the data for Tairlaw Toll House during night-time periods.

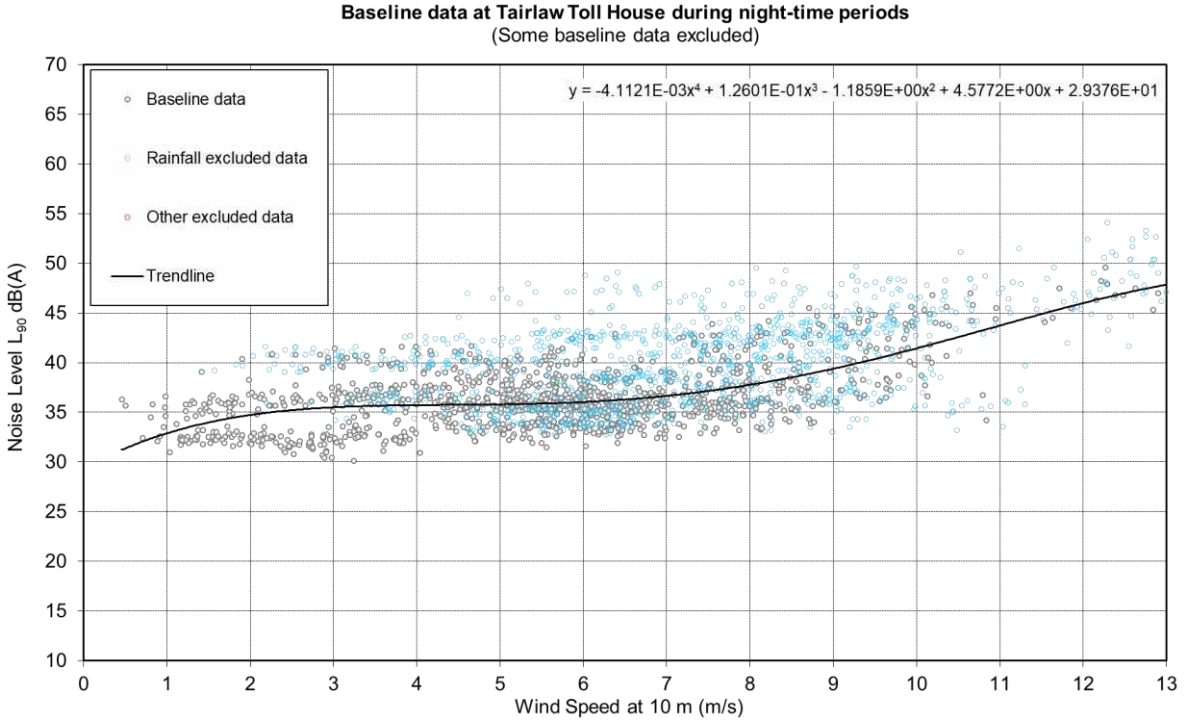


Figure D11 - Chart of an alternate analysis of background noise levels against wind speeds and the best fit curve to the data for Knockskae during quiet day-time periods. Data were additionally filtered to exclude those where the wind direction is between 30° and 80°, where the measurement location would experience downwind propagation from the Dersalloch Windfarm.

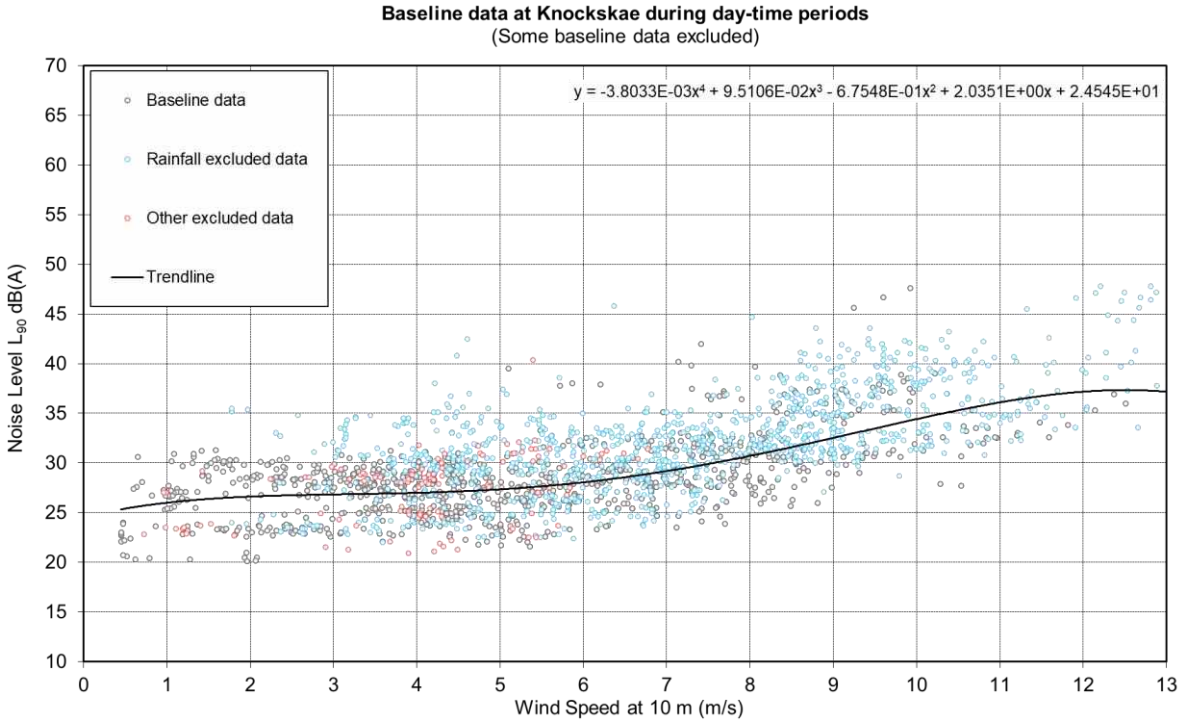
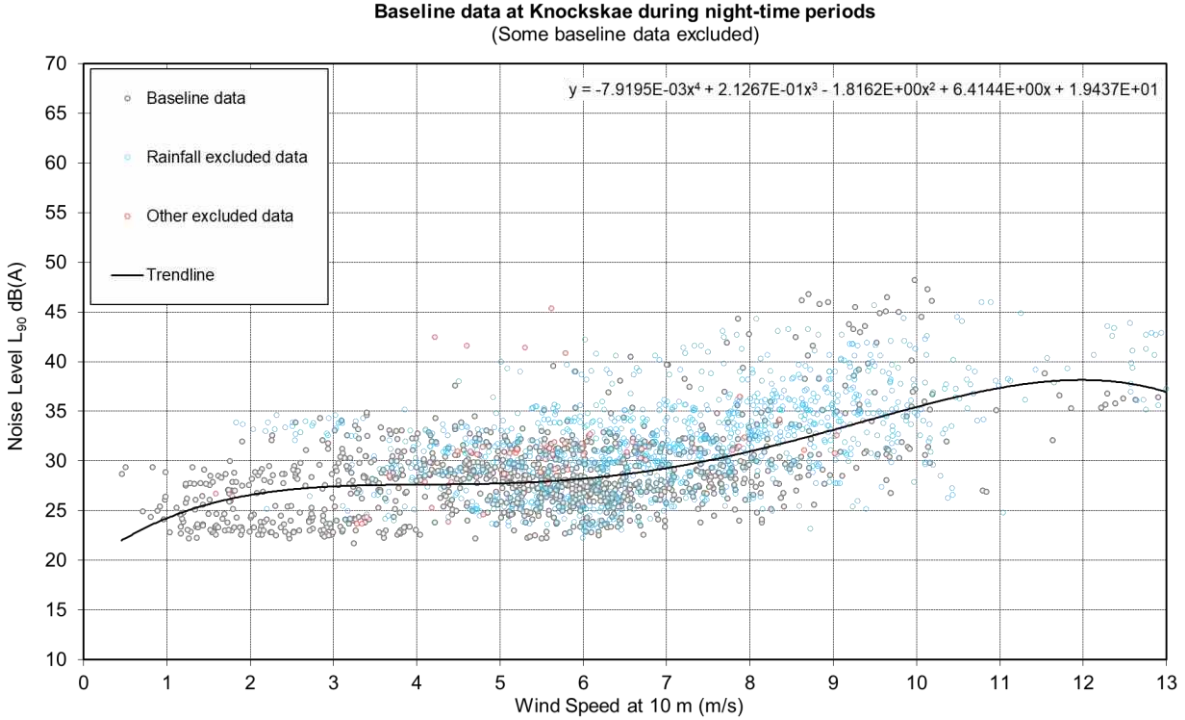


Figure D12 - Chart of an alternate analysis of background noise levels against wind speeds and the best fit curve to the data for Knockskae during quiet night-time periods. Data were additionally filtered to exclude those where the wind direction is between 30° and 80°, where the measurement location would experience downwind propagation from the Dersalloch Windfarm.



Annex E – Wind Speed Calculations

Background

E.1 The IOA GPG[1] requires that noise data recorded every 10 minutes are related to standardised ten metre wind speeds experienced at the hub height of the turbines, at a location on the wind farm representative of the wind farm. These wind speeds can be either measured directly at the turbine hub height or derived by calculation from measurements at two heights, with measurements at the upper height not less than 60% of the turbine hub height and measurements at least 15 metres below that. These are referred to as 'Method A' or 'Method B' in the IOA GPG. IOA GPG SGN4[2] provides additional guidance on these methods.

Approach & Methodology

E.2 The site of the previous Linfairn Wind Farm had a LIDAR remote sensing measuring system installed for the first part of the noise survey (2017-11-23 to 2018-01-10) and then a SODAR remote sensing measuring system installed for the remainder of the survey (2018-01-11 to 2018-01-25), both installed on site at approximately at OSGB 238149, 600032 and measured data at various heights. Following inspection of these data (and removal of remaining error values), it was concluded that the following sources of data would be used from these remote sensing systems:-

- LIDAR:
  - 120 m wind direction
  - 100 m wind speed
  - 120 m wind speed

- SODAR:
  - 120 m wind direction
  - 100 m wind speed
  - 120 m wind speed

E.3 These measurement heights meet the requirements of the IOA GPG: the lowest measurement height being at least 60% of the hub height of 132 metres and the lower height being at least 15 metres lower than the upper measurement.

E.4 Wind speed data were used to perform a calculation of the shear exponent found between the two wind speed measurement heights for every ten-minute period, by using Equation 3 of IOA GPG SGN4. Where wind speeds were the same at both heights or lower at greater height, the shear exponent was assumed to be zero. The shear exponent so calculated for every ten-minute period was then used to calculate the hub height wind speed using Equation 2 of SGN4 for each ten minute period. Equation 1 of SGN4 was then used to calculate a standardised ten-metre height wind speed from the hub height wind speed every ten minutes assuming the reference roughness length of 0.05 metres.

E.5 Wind speeds are standardised to a height of ten metres assuming a reference ground roughness length of 0.05 metres as described in the IOA GPG. This approach is of the same form as that given in BS EN 61400-11:2003[3] for calculating ten metre wind speeds related to hub height wind speeds when providing source noise emission data for wind turbines.

Conclusions

E.6 By using this method, measured background noise levels were related to ten metre wind speeds calculated (standardised) from wind speeds at hub height. Any likely difference in the shear profile during the 24 hours of the day will be accounted for within the method and be reflected in the resulting standardised ten metre wind speed data.

E.7 The method used to calculate ten metre wind speeds from those at hub height is the same as that used when deriving noise emission data for the turbines. Because the same method has been used, direct

comparison of background noise levels, noise limits and predicted turbine noise immission levels may be undertaken. This method is consistent with guidance published in the IOA GPG.

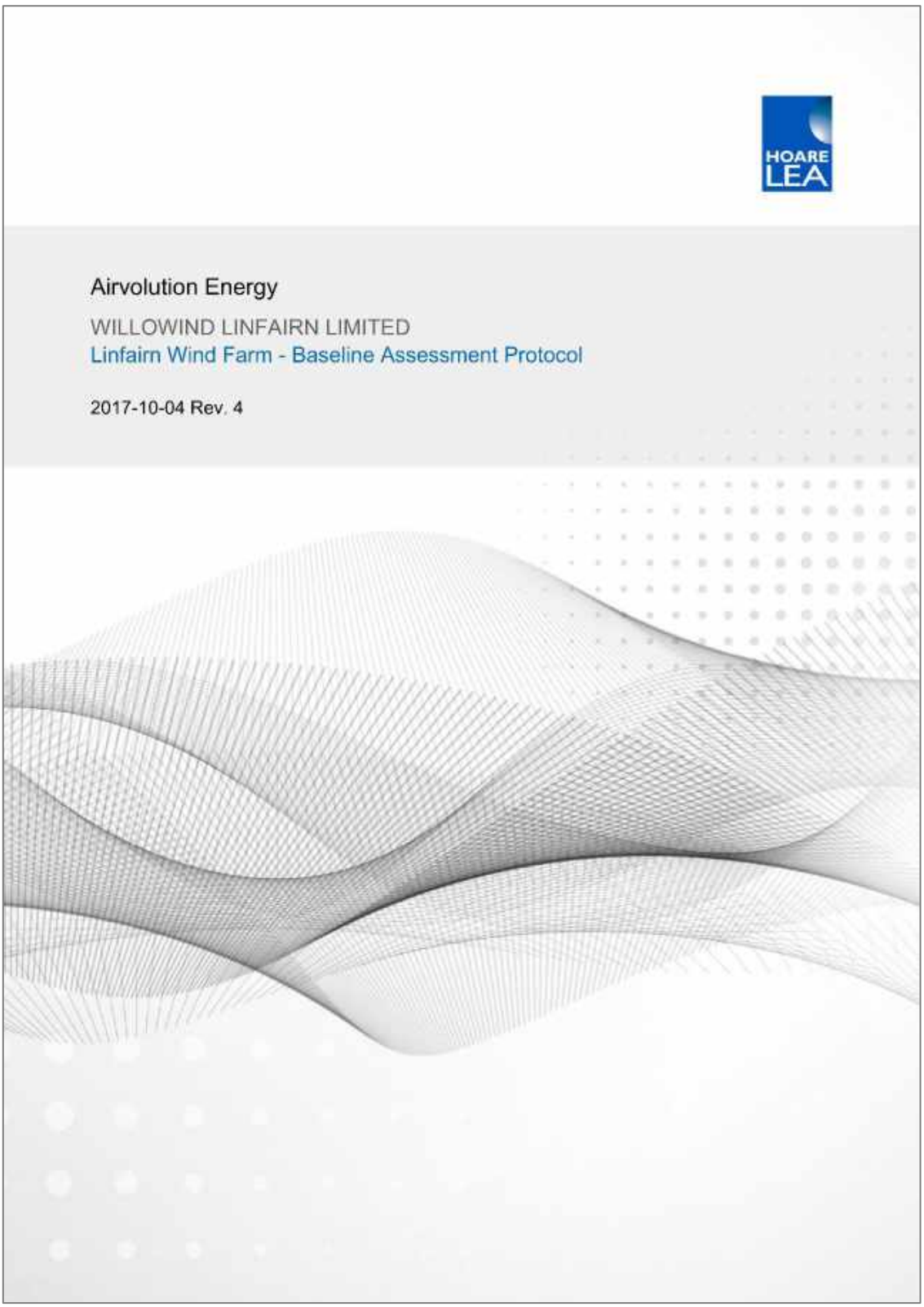
References for Wind Speed Calculations

[1] A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, M. Cand, R. Davis, C. Jordan, M. Hayes, R. Perkins, Institute of Acoustics, May 2013.

[2] A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Note 4: Wind Shear, M. Cand, R. Davis, C. Jordan, M. Hayes, R. Perkins, Institute of Acoustics, July 2014.

[3] IEC 61400 11:2003 Wind turbine generator systems - Part 11: Acoustic noise measurement techniques.

Annex F – Baseline Assessment Protocol



NOISE & VIBRATION

Linfairn Wind Farm Baseline Assessment Protocol

Audit sheet

Rev.	Date	Description	Prepared	Verified
1	2017-09-29	First draft for review	MJ	MMC
2	2017-09-29	Revised following review	MJ	Client
3	2017-10-03	Revised following review	MJ	Client
4	2017-10-04	Issued following review	MJ	

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Document Ref: **REP-1006935-MJ-20170929-4**

NOISE & VIBRATION

Linfairn Wind Farm Baseline Assessment Protocol

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3. Wind Data Acquisition 5
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5. Data Analysis 6
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NOISE & VIBRATION

Linfairn Wind Farm Baseline Assessment Protocol

1. Introduction & Background

1.1 Hoare Lea is acting on behalf of the developer (Willowind Linfairn Limited) to conduct a repeat baseline background noise survey around the proposed Linfairn Wind Farm to determine relevant noise limits. The intent of this document is to define a protocol describing the approach to be taken to determine these baseline background noise levels. The noise surveys and analysis of data will be undertaken in accordance with ETSU-R-97[1] 'The Assessment and Rating of Noise from Wind Farms' and the Institute of Acoustics Good Practice Guide (GPG)[2]. Noise limits derived from these baseline background noise levels will be used to assess the acoustic acceptability of the proposed development following ETSU-R-97, as commended by guidance applicable to Scotland[3].

1.2 An application for the proposed Linfairn Wind Farm was submitted to the Scottish Government under Section 36 of the Electricity Act in September 2013. The proposed development is situated within the local authority area of South Ayrshire Council (SAC), who were a consultee[4] during the application. The application was supported by an assessment of noise impact presented in an Environmental Statement (ES)[5]. Following a review of consultation responses from statutory consultees and the local communities the developer amended the layout of the wind farm, reducing the number of wind turbines from 25 to 17. This culminated in the submission of the Addendum in December 2014. This Addendum submission provided an update to the original ES and included a revised noise assessment[6].

1.3 The revised noise assessment considered the noise impact at noise sensitive receptors through the construction, operation and decommissioning of the Linfairn Wind Farm. The assessment was carried out by SgurrEnergy Ltd. New background noise measurements were obtained between 15 October 2014 and 20 November 2014 at Balbeg Cottage, Genoch Cottage and Linfairn Farm and from 23 October 2014 to 20 November 2014 at Tairlaw Farm. Wind speed measurements were also carried out over the duration of the noise measurements, using a LIDAR remote sensing device.

1.4 In the area surrounding the development there are two other operational wind farms which may need to be considered when undertaking background noise surveys in accordance with the GPG. Dersalloch Windfarm, is approximately 3.8 kilometres to the north east and consists of 23 wind turbines with a total capacity up to 69 MW and up to 125 metres to the tip. Hadyard Hill Wind Farm is approximately 6.8 kilometres to the west and consists 52 turbines each 2.3 MW and with a tip height up to 110 metres. Figure A1 of Annex A shows the overall layout of these sites in relation to the location of the Linfairn Wind Farm.

2. Survey Locations

2.1 Figure A2 of Annex A shows a more detailed layout of the wind farm and includes nearby noise sensitive receptor locations. Also indicated on Figure A2 are those locations where it is proposed to undertake a survey of background noise levels. Figure A3 provides a list of the survey locations. The proposed noise monitoring locations were identified as either residential or habitable, being in proximity to the project and are considered to be representative of the residential properties lying around the site. For other properties where an assessment of noise may be required, these would have their baseline background noise levels represented by results obtained from those locations surveyed.

2.2 The ability to undertake background noise surveys at each of the proposed properties will be subject to gaining consent from the occupiers/owners. Where permission to access a property is refused, then an alternate property or an adjacent measurement position may need to be considered and will be discussion with representatives of the council as necessary.

2.3 Noise measurement equipment will be placed at each property in the immediate vicinity of each of the dwellings. The precise monitoring location used at each property will be determined by discussion between Hoare Lea, representatives of the council and the property occupants. The monitoring locations will be selected in recognition of the requirements of ETSU-R-97 and the GPG. In particular, the monitoring locations will be selected in accordance with the following points:-

- An outdoor location will be used.
- The microphone will be located at 1.2 m to 1.5 m above local ground level and positioned at least 3.5 m from any acoustically reflective surface other than the ground.
- The monitoring location will be representative of the outdoor amenity area or areas associated with and adjacent to the dwelling and not more than 20 metres from the dwelling where possible.

2.4 The final choice of monitoring positions will also be subject to onsite inspections having specific regard to any local sources of noise which might be sufficient to elevate the measured levels or misrepresent the wider area (for example, local machinery, boiler flues, watercourses). Inspection of the mapping information shown in Figure A2 of Annex 1 suggests that many of the nearby noise sensitive receptor locations may have water nearby and water flow noise is likely to be a prevalent source of background noise during low wind speeds for locations in the vicinity of this source. The influence of this source will be considered but it may be a consistent feature of the background noise environment at many of the nearby noise sensitive receptors.

3. Wind Data Acquisition

3.1 Wind speeds and directions will be measured using a LIDAR wind measurement system located on site at approximately the same location used for the previous noise survey[6] (approximately 238156E, 600021N). The LIDAR will measure data at a height of 76 metres, again consistent with the previous survey. Ten metre standardised wind speed values will be calculated from those measured at the hub height of the wind turbines and corrected to ten metres height using the equation given on p120 of ETSU-R-97 assuming a ground roughness of 0.05 metres.

4. Noise Data Acquisition

4.1 The measurement survey is proposed to be carried out in Oct/Nov 2017 and will extend for a period of at least four weeks (an increase on the ETSU-R-97 stated minimum of one week) whilst concurrent wind speed and direction data are collected on-site.

4.2 The survey will aim to obtain a sufficient number of valid data-points within each wind speed bin and at each of the survey locations. The GPG recommend for pitch-regulated turbines that data between cut-in wind speeds and wind speeds corresponding to maximum power be obtained. This would equate to a range of standardised ten metre wind speeds between approximately 3 m/s and 8 m/s, and the aim of the survey would be to obtain sufficient data around each integer wind speed for both of the ETSU-R-97 quiet day-time and night-time periods in accordance with the GPG.

4.3 Noise measurement equipment will be battery-powered and will be calibrated on deployment, during routine servicing when changing batteries (approximately every two weeks) and on completion of the measurement survey. Measurement equipment will comply with the requirements of the GPG related to specification, periodic verification and use.

4.4 Noise data ($L_{A90,10minutes}$) will be collected in continuous and contiguous ten minute periods at each survey location, which are time synchronised with concurrent wind speed/direction measurements on site (see below) and measurements of rainfall at one of the noise monitoring locations.

4.5 A tipping-bucket rain monitoring device shall be installed at one of the noise monitoring locations to indicate when rainfall occurred during the survey period. Precise measurement of rainfall is unimportant as long as an indication of whether it was or was not raining sufficiently to directly affect measured noise levels is obtained. Rainfall indication shall be logged for the same time-synchronised ten-minute intervals noted above.

5. Data Analysis

5.1 The presence of the two other wind farms (see above) requires to be considered when determining representative background noise levels so that background noise levels do not contain a significant contribution from wind turbine noise, in accordance with ETSU-R-97. The GPG provides guidance on how this may be achieved, with the advice most relevant to this survey:-

> *"accounting for the contribution of the existing wind farm in the measurement data e.g. directional filtering (only including background data when it is not influenced by the existing turbines e.g. upwind of the receptor, but mindful of other extraneous noise sources e.g. motorways) or subtracting a prediction of noise from the existing wind farm from the measured noise levels;"*

5.2 Data from the survey will be reviewed and directional filtering or corrections using predictions applied as considered appropriate, based on a review of the data obtained and consideration of the likely influence from these adjacent sites. The separation distance from these existing sites however means that their influence on the measurements is likely to be relatively limited.

5.3 Measured background noise data at each of the survey locations shall be separated into ETSU-R-97 quiet day-time and night-time periods and plotted against the corresponding standardised ten metre height wind speed data. The sufficiency of the final data-sets will be reviewed in consultation with representatives of the Council.

5.4 Data affected by rain or increased flows in watercourses during/after rain and data obviously affected by extraneous sources of noise, e.g. central heating boiler flues, agricultural equipment, high levels of bird song associated with the 'dawn chorus', etc., shall be removed prior to analysis. Data excluded for extraneous sources and for rain will be separately shown on the data plots. A best-fit curve will be fitted to the included data for each period and at each survey location and provide values of the typical background noise levels at each wind speed.

6. Conclusions

6.1 This protocol sets out how and where repeat noise surveys are proposed to be undertaken to define baseline background noise levels around the Linfairn Wind Farm. These surveyed baseline

background noise levels are to be used to derive ETSU-R-97 noise limits for assessment of noise from the Linfairn Wind Farm.

7. References

1 ETSU R 97, the Assessment and Rating of Noise from Wind Farms, Final ETSU-R-97 Report for the Department of Trade & Industry. The Working Group on Noise from Wind Turbines, 1997.

2 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, Matthew Cand, Robert Davis, Chris Jordan, Malcolm Hayes, Richard Perkins, Institute of Acoustics, 20 May 2013.

3 Scottish Government, Online Renewables Planning Advice, Onshore Wind Turbines (http://www.gov.scot/Resource/0045/00451413.pdf). Updated May 28, 2014.

4 13/01130/DEEM | Application under Section 36 of the Electricity Act 1989 to the Scottish Ministers to operate a wind farm at Linfairn, comprising 25 turbines with a capacity of 62.5 megawatts and a blade tip height of up to 126.5 metres | Linfairn Straiton South Ayrshire.

5 Linfairn Wind Farm Environmental Statement: Chapter 11 Noise & Vibration, SgurrEnergy Ltd. 11/6267/001/GLA/O/R/002 Revision B1, 2013.

6 Linfairn Wind Farm Environmental Statement Addendum: Chapter A11, Noise & Vibration, SgurrEnergy Ltd. 14/7048/001/GLA/O/R/001 Revision B1, December 2014.

NOISE & VIBRATION

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Annex A – Layout Maps

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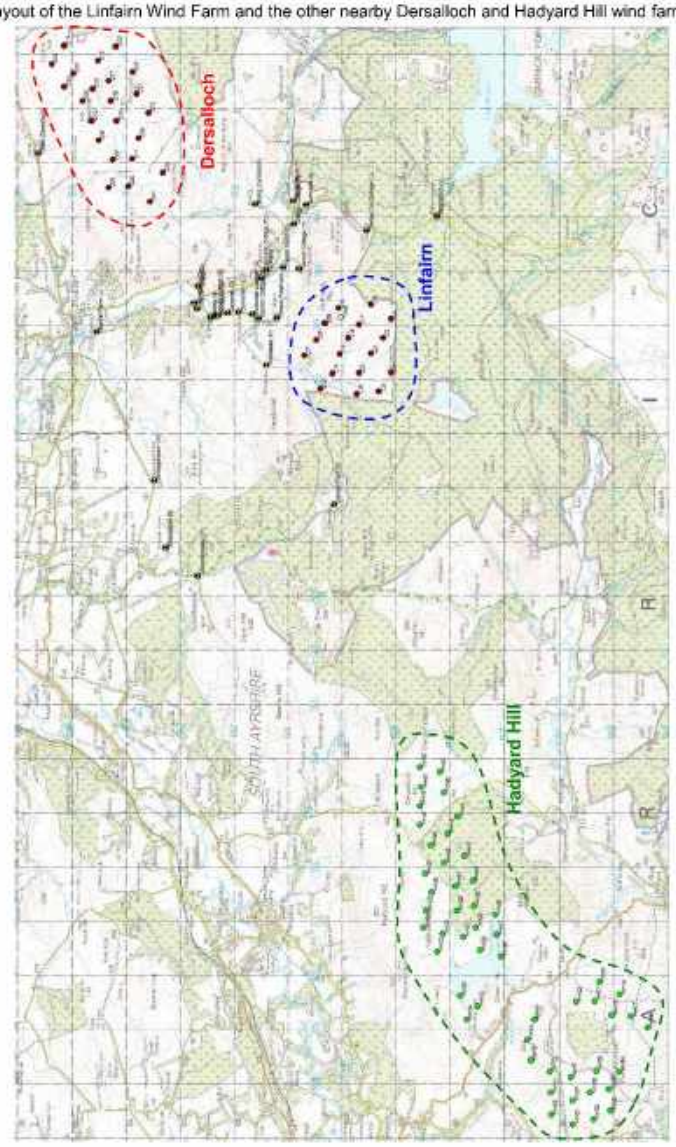
Figure A1 Layout of the Linfairn Wind Farm and the other nearby Dersalloch and Hadyard Hill wind farms.



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NOISE & VIBRATION

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Figure A2 Layout of the Linfairn Wind Farm and the nearby noise senstitive receptor. Indicated are the six propoerties where it is proposed to survey background noise levels.

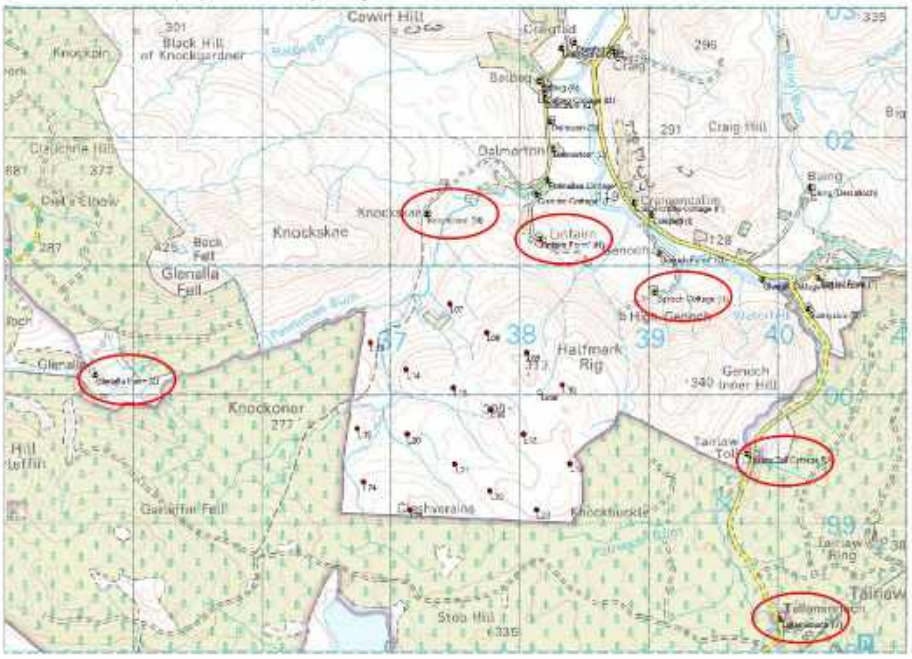

Figure A3 Background noise monitoring locations (approximate easting / northing).

No.	Property	Easting	Northing
1	Glenalla Farm	234709	600152
2	Knockskae	237279	601396
3	Linfairn Farm	238159	601207
4	Genoch Cottage	239049	600791
5	Tairlaw Toll Cottage	239762	599541
6	Tallaminnoch	240021	598257

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