

Project: **Delburn Wind Farm**

Prepared for: **Delburn Wind Farm Pty Ltd**
(part of the OSMI Australia group)

Attention: **Peter Marriott**

Report No.: **002 20190463**

Disclaimer

Reports produced by Marshall Day Acoustics Pty Ltd are prepared based on the Client's objective and are based on a specific scope, conditions and limitations, as agreed between Marshall Day Acoustics and the Client. Information and/or report(s) prepared by Marshall Day Acoustics may not be suitable for uses other than the original intended objective. No parties other than the Client should use any information and/or report(s) without first conferring with Marshall Day Acoustics.

Copyright

The concepts and information contained in this document are the property of Marshall Day Acoustics Pty Ltd. Use or copying of this document in whole or in part without the written permission of Marshall Day Acoustics constitutes an infringement of copyright. Information shall not be assigned to a third party without prior consent.

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final	-	Issued to client	20 Oct. 2020	C. Delaire	J. Adcock

TABLE OF CONTENTS

1.0	INTRODUCTION	4
2.0	BACKGROUND NOISE SURVEY & ANALYSIS METHODOLOGY	5
2.1	Noise monitoring locations	5
2.2	Survey description	8
2.3	Data analysis	10
3.0	SURVEY & ANALYSIS RESULTS	12
3.1	Background noise levels	12
3.2	Noise limits.....	13
4.0	SUMMARY.....	15
APPENDIX A	GLOSSARY	
APPENDIX B	TURBINE COORDINATES	
APPENDIX C	PREFERRED NOISE MONITORING LOCATIONS	
APPENDIX D	SURVEY INSTRUMENTATION	
APPENDIX E	SITE WIND SPEED DATA	
APPENDIX F	SUMMARY OF BACKGROUND NOISE LEVELS	
APPENDIX G	RECEIVER 600 DATA	
APPENDIX H	RECEIVER 609 DATA	
APPENDIX I	RECEIVER 824 DATA	
APPENDIX J	RECEIVER 832 DATA	
APPENDIX K	RECEIVER 853 DATA	
APPENDIX L	RECEIVER 864 DATA	
APPENDIX M	RECEIVER 867 DATA	
APPENDIX N	RECEIVER 1171 DATA	
APPENDIX O	RECEIVER 4585 DATA	

1.0 INTRODUCTION

This report presents the results of background noise monitoring undertaken for the proposed Delburn Wind Farm (subsequently referred to as the wind farm herein).

The background noise monitoring was commissioned by Delburn Wind Farm Pty Ltd, part of the OSMI Australia group (referred to as the proponent herein), as an element of the noise studies associated with the wind farm's planning application. The background noise monitoring was undertaken to obtain a representation of typical baseline conditions at receivers in the vicinity of the wind farm.

This report documents the survey methodology, the results of the monitoring, and the derived noise limits that apply to the wind farm.

Acoustic terminology used throughout this report is presented in Appendix A.

Site layout and relevant coordinates are detailed in Appendix B.

Throughout this report, the term receiver is used to identify any dwelling identified by the proponent in the vicinity of the proposed wind energy facility.

2.0 BACKGROUND NOISE SURVEY & ANALYSIS METHODOLOGY

The background noise survey and analysis has been conducted in accordance with the following:

- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), as required by *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* published by the Victorian Department of Environment, Land, Water and Planning in March 2019 (the *Victorian Guidelines*).
- Supplementary guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* dated May 2013 (the *UK IOA Good Practice Guide*).

This section of the report presents:

- An overview of the survey methodology
- Details of the selected noise monitoring locations
- A summary of the data analysis procedures.

2.1 Noise monitoring locations

Background noise monitoring was carried out at nine (9) receivers listed in Table 1.

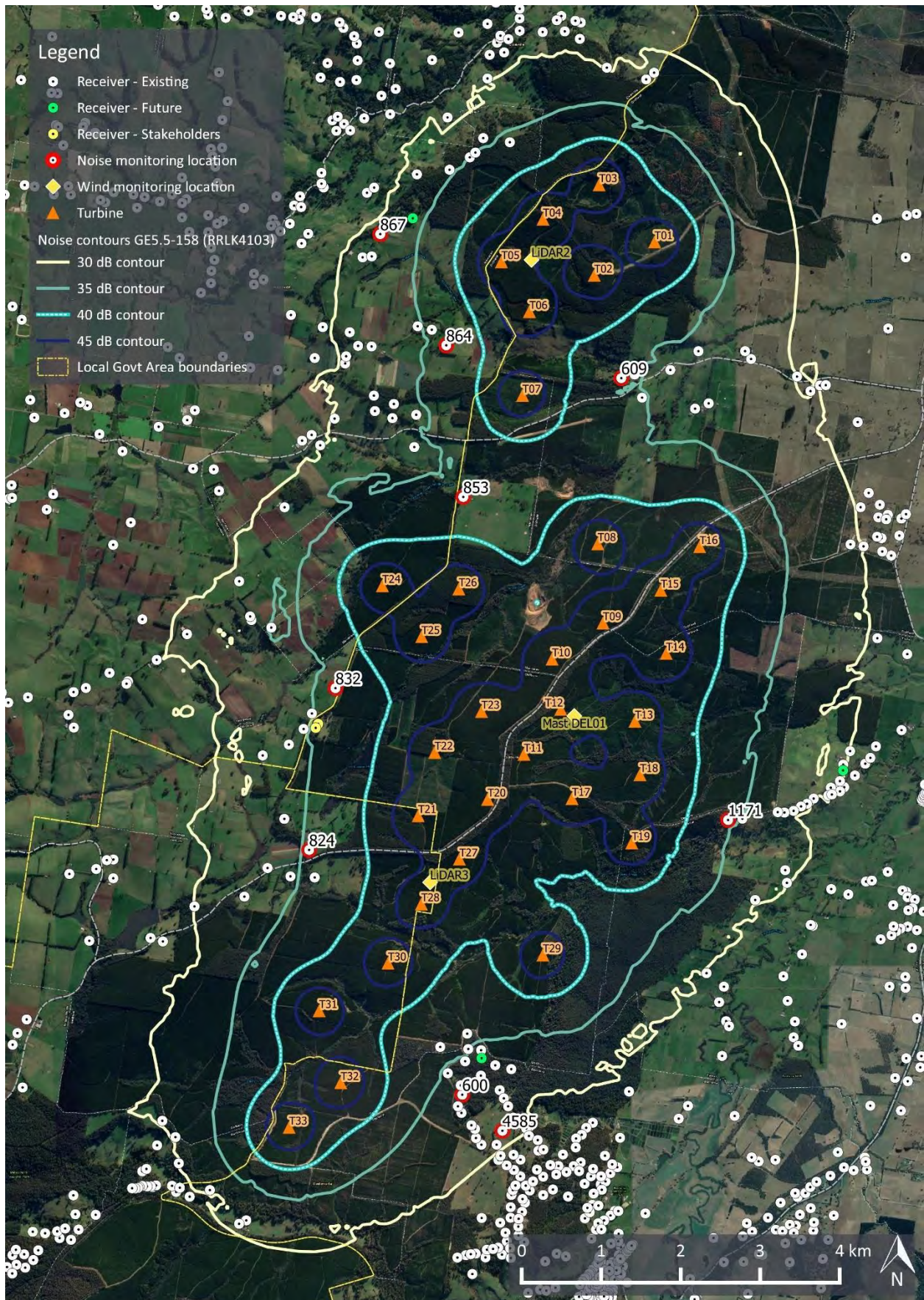
Table 1: Background noise monitoring locations

Receiver	Direction from wind farm	Distance from nearest turbine, m	Nearest turbine
600	South and east	1,544	T32
609	North, south, and east	1,270	T07
824	West	1,446	T21
832	West	1,273	T25
853	North and west	1,168	T26
864	West	1,139	T06
867	West	1,570	T05
1171	East	1,255	T19
4585	South and east	2,127	T32

The location of each of these receivers is illustrated in Figure 1, together with noise contours candidate turbine model with the highest predicted noise levels¹.

¹ See MDA Report Rp 003 20190463 *Delburn Wind Farm – Environmental noise assessment*, dated 20 October 2020 (the *Environmental Noise Assessment*)

Figure 1: Monitoring locations relative to the proposed Delburn Wind Farm



The monitoring locations were selected on the basis of:

- A total of thirty-five (35) turbines located at the coordinates detailed in the Preliminary Noise Assessment Report². The turbine layout has since been revised to comprise thirty-three (33) turbines, as presented in Appendix B
- The noise monitoring procedures outlined in NZS 6808:2010
- Upper predicted operational wind farm noise levels detailed in the Preliminary Noise Assessment Report.

The above information was used to identify the locations where background noise levels were required for the purpose of assessing the wind farm's compliance with the noise criteria established by NZS 6808:2010.

It is noted that consent to undertake background noise monitoring was not granted at all preferred receivers presented in Appendix C. Prior to construction of the wind farm, background noise monitoring may be undertaken at additional receivers, should consent be provided.

Accounting for the above factors, noise monitoring was undertaken at the locations where access was available for the deployment of unattended noise monitoring equipment.

At each of the receivers where noise monitoring was carried out, the positioning of the monitor relative to the dwelling accounted for the technical considerations specified in NZS 6808:2010 and any practical matters identified by the residents. The following specific considerations were factored:

- The noise monitors were located on the wind farm side of the dwelling
- The noise monitors were located at least 3.5 m away from the dwelling and any significant vertical reflecting structures
- The noise monitors were located as far as practical from taller vegetation and any obvious sources of extraneous noise.

Coordinates and photographs for the noise monitoring locations are provided in Appendix F to Appendix O.

² MDA report Rp 001 20190463 *Delburn Wind Farm - Preliminary noise assessment* dated 31 July 2019

2.2 Survey description

The background noise survey comprised unattended monitoring over a number of weeks to measure sound levels for a range of environmental conditions. Site wind speeds and local weather conditions were simultaneously recorded throughout the survey, along with periodic audio samples, to enable the relationship between background noise levels and site winds to be assessed.

The key elements of the background noise survey are summarised in Table 2 below.

Table 2: Summary of key elements of background noise survey

Item	Description
Monitoring locations	Nine (9) receivers as described in Section 2.1.
Monitoring Period	<p>6 March to 18 June 2020 equating to approximately 6 weeks at each location.</p> <p>The duration was chosen to satisfy the guidance of NZS 6808:2010 which indicates the measurements should be made for a representative range of wind speeds and directions for the site, and that a minimum of 1,440 individual 10-minute measurements, equivalent to 10 days of monitoring is normally required to obtain a satisfactory range.</p>
Sound level meters	<p>Class 1 automated sound loggers (most accurate class rating for field usage).</p> <p>Microphones mounted at approximately 1.5 m above ground level and fitted with enhanced wind shielding systems based on the design recommendations detailed in the UK IOA Good Practice Guide.</p> <p>See equipment specifications and calibration records in Appendix B.</p>
Noise measurement data	<p>A-weighted average and statistical sound pressure levels.</p> <p>One-third octave band frequency noise levels and a brief audio sample every ten (10) minutes to aid the identification of extraneous noise influences.</p>
Local wind speed and rainfall data	<p>A weather station was installed beside one of the noise monitoring locations to concurrently record rainfall and wind speeds at microphone height.</p> <p>This data was recorded to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone (i.e. rainfall).</p>

Item	Description
Site wind speed data	<p data-bbox="847 304 1442 360">Hub height wind speeds for correlating background noise levels with site wind speeds.</p> <p data-bbox="847 383 1350 439">Site wind speed data was sourced from three (3) monitoring locations at the site:</p> <ul data-bbox="847 465 1461 685" style="list-style-type: none"> <li data-bbox="847 465 1442 521">• Meteorological mast reference DEL01 located in the centre of the site extending to a height of 160 m <li data-bbox="847 544 1442 600">• LiDAR³ system reference LiDAR2 located to the north of the site <li data-bbox="847 622 1461 678">• LiDAR system reference LiDAR3 located to the south of the site. <p data-bbox="847 712 1453 801">The nearest wind monitoring location was generally referenced for each background noise monitoring location – full details are provided in Appendix E.</p>

³ Light Detection and Ranging

2.3 Data analysis

The analysis of the survey data has been conducted in accordance with the NZS 6808:2010.

This broadly involves:

- Collating the measured noise levels, site wind speeds and local weather data into a single dataset
- Filtering the data set to remove measurement results affected by extraneous or atypical noise
- Filtering the data where necessary to account for site wind directions
- Plotting a chart of noise levels versus wind speeds and determining the line of best fit to the data.

A summary of the key steps in the analysis of the data is presented in Table 3.

Table 3: Background noise data analysis

Process	Description
Data collation	<p>Time stamps for each source of measurement data are reviewed to clarify start or end times and measurement time zone.</p> <p>Measured noise levels, site wind speeds and local weather conditions are then collated for each ten-minute measurement interval.</p>
Local weather data filtering	<p>10 minute intervals are identified and filtered from the analysis if rainfall was identified for any 10 minute measurement interval</p>
Extraneous noise filtering	<p>The measured sound frequencies (one-third octave bands) in each 10 minute interval are used to identify periods that are significantly affected by bird or insect sounds.</p> <p>10 minute intervals have been identified, and filtered from the analysis, when the following conditions⁴ are satisfied:</p> <ul style="list-style-type: none"> • the highest A-weighted one-third octave band noise level is within 5 dB of the broadband A-weighted background noise level for that interval; and • the identified one-third octave band A-weighted noise level is greater than a level of 20 dB L_{A90}. <p>At locations where insect noise was found to be prevalent, an additional method was applied, comprising the objective method detailed in Annex K of ISO 1996-2:2017⁵. Specifically, if this method identified the presence of a tone, the corresponding 10 minute was considered to have been significantly affected by bird or insect sounds and filtered from the analysis.</p>
Time periods	<p>Neither NZS 6808:2010 nor the Victorian Guidelines define separate time periods for the analysis of background noise levels or assessment of wind farm noise. However, in accordance with the requirements commonly defined in Victorian wind farm planning permits, the data sets are considered for separate periods as follows:</p> <ul style="list-style-type: none"> • All periods: no restriction on hours (i.e. data during day and night hours included) • Night period: 2200 to 0700 hours

⁴ Griffin, D., Delaire, C., & Pischedda, P. (2013). Methods of identifying extraneous noise during unattended noise measurements. *20th International Congress of Sound & Vibration*.

⁵ ISO 1996-2:2017 *Acoustics - Description, measurement and assessment of environmental noise -, Part 2: Determination of sound pressure levels*

Process	Description
Regression analysis	<p>Two datasets are plotted on a chart of noise levels versus wind speeds:</p> <ul style="list-style-type: none"> • All data points that have been removed from the analysis using the above processes • The filtered dataset comprising all retained measurement data. <p>The chart of filtered noise levels versus wind speed is reviewed to determine if there are any distinctive trends or gaps in the data which could warrant separation of the measurement results into subgroups (e.g. subgroups for time of day or wind direction).</p> <p>A line of best fit is determined for the filtered data and, where applicable, any subgroups of the filtered data. The line of best fit is determined using a regression analysis of the range of noise levels and wind speeds or, where necessary, analysis of noise levels at individual wind speeds.</p>
Noise limits	<p>Noise limits are defined at each wind speed in accordance with NZS 6808:2010 by a value of 40 dB⁶ or the background plus 5 dB, whichever is higher. The value of the background noise level at each integer wind speed is defined by the line of best fit to the measurement results.</p> <p>In accordance with the requirements commonly defined in Victorian wind farm planning permits, the noise limits are separately defined for all-hours period (i.e. including all hours of the day and night) and the night time period.</p>

⁶ The Environmental Noise Assessment determined that high amenity base noise limit of 35 dB is not warranted for this site, and the applicable base noise limit is therefore 40 dB.

3.0 SURVEY & ANALYSIS RESULTS

This section presents a summary of the background noise measurement results, analysed in accordance with the methodology described in Section 2.3.

The analysis results include the noise limits determined in accordance with NZS 6808:2010.

3.1 Background noise levels

The tabulated data presented in Table 4 and Table 5 summarises the derived background noise levels for the all-time and night-time periods respectively.

The data in these tables is provided for the key wind speeds relevant to the assessment of wind farm noise. The results for all surveyed wind speeds are illustrated in the graphical data provided for each receiver location in Appendix G to Appendix O.

A summary of the background noise level regression coefficients is provided in Appendix F.

Table 4: All-time period – background noise levels, dB L_{A90}

Receiver	Hub height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
600 ³	23.4	23.5	24.0	24.8	25.8	27.2	28.8	30.7	32.8	35.1	37.5	40.1	42.9
609 ²	30.5	31.3	32.0	32.8	33.5	34.3	35.0	35.8	36.6	37.3	38.1	38.9	39.6
824 ³	26.9	27.6	28.5	29.6	31.0	32.4	34.0	35.7	37.5	39.3	41.2	43.0	44.8
832 ¹	27.8	27.8	28.3	29.3	30.8	32.7	34.8	37.2	39.6	42.2	44.7	47.0	49.2
853 ¹	28.8	28.7	29.0	29.6	30.4	31.5	32.9	34.4	36.1	37.9	39.8	41.8	43.8
864 ²	25.6	25.5	25.8	26.6	27.8	29.3	31.1	33.1	35.3	37.6	39.9	42.4	44.7
867 ²	27.0	27.0	27.5	28.3	29.6	31.1	32.9	35.0	37.2	39.6	42.1	44.6	47.2
1171 ¹	25.1	25.2	25.6	26.2	27.1	28.2	29.5	31.0	32.7	34.6	36.6	38.8	41.0
4585 ³	29.7	30.1	30.6	31.1	31.8	32.5	33.4	34.3	35.3	36.4	37.7	39.0	40.4

Notes ¹ 160 m above ground level at DEL01

² 160 m above ground level at LiDAR2

³ 160 m above ground level at LiDAR3

Table 5: Night-time period – background noise levels (dB L_{A90})

Receiver	Hub height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
600 ³	25.8	26.0	26.6	27.4	28.5	29.8	31.4	33.2	35.3	37.5	39.9	42.6	45.3
609 ²	25.8	26.7	27.5	28.4	29.3	30.2	31.0	31.9	32.8	33.7	34.5	35.4	36.3
824 ³	21.2	21.5	22.1	22.9	24.1	25.5	27.2	29.2	31.4	33.9	36.6	39.6	42.8
832 ¹	21.7	21.7	22.5	23.9	25.9	28.2	30.9	33.9	37.0	40.1	43.2	46.3	49.0
853 ¹	26.6	26.7	27.0	27.6	28.4	29.4	30.6	32.1	33.7	35.5	37.5	39.6	41.8
864 ²	27.1	27.1	27.5	28.3	29.5	30.9	32.6	34.6	36.6	38.7	40.9	43.1	45.2
867 ²	28.5	28.6	29.2	30.1	31.4	32.9	34.7	36.7	38.9	41.2	43.5	45.9	48.2
1171 ¹	20.8	21.0	21.5	22.2	23.2	24.4	25.8	27.5	29.3	31.3	33.5	35.8	38.2
4585 ³	24.4	24.8	25.4	26.2	27.1	28.2	29.5	30.9	32.4	34.1	36.0	37.9	40.1

Notes ¹ 160 m above ground level at DEL01

² 160 m above ground level at LiDAR2

³ 160 m above ground level at LiDAR3

3.2 Noise limits

The limits presented herein are based on background noise levels presented in Section 3.1 and the status of each receiver at the time of preparation of this report. In particular, the receivers are considered uninvolved locations and the minimum limit is therefore set at 40 dB L_{A90} in accordance with NZS 6808:2010 and the findings of the Environmental Noise Assessment. In particular, the discussion presented in the Environmental Noise Assessment determined that a high amenity noise limit is unlikely to be justified for the Delburn Wind Farm, accounting for the wind farm configuration presented in the assessment. As recommended in Section 6.1.1 of the Environmental Noise Assessment, the noise limits at receivers to the north west of the Boolarra township would be subject to a further review of high amenity consideration within the pre-construction noise assessment.

As per the background noise data, the tabulated data is provided for the key wind speeds relevant to the assessment of wind farm noise. The derived noise limits for all surveyed wind speeds are illustrated in the graphical data provided for each receiver location in Appendix F to Appendix O.

Table 6: All-time period - operational wind farm noise limits, dB L_{A90}

Receiver	Hub height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
600 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1	42.5	45.1	47.9
609 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.8	41.6	42.3	43.1	43.9	44.6
824 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.7	42.5	44.3	46.2	48.0	49.8
832 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.2	44.6	47.2	49.7	52.0	54.2
853 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	42.9	44.8	46.8	48.8
864 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.3	42.6	44.9	47.4	49.7
867 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.2	44.6	47.1	49.6	52.2
1171 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.6	43.8	46.0
4585 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.3	41.4	42.7	44.0	45.4

Notes ¹ 160 m above ground level at DEL01

² 160 m above ground level at LiDAR2

³ 160 m above ground level at LiDAR3

Table 7: Night-time period - operational wind farm noise limits, dB L_{A90}

Receiver	Hub height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
600 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.3	42.5	44.9	47.6	50.3
609 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.4	41.3
824 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.6	44.6	47.8
832 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.0	45.1	48.2	51.3	54.0
853 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.5	42.5	44.6	46.8
864 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.6	43.7	45.9	48.1	50.2
867 ²	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.7	43.9	46.2	48.5	50.9	53.2
1171 ¹	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.8	43.2
4585 ³	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.0	42.9	45.1

Notes ¹ 160 m above ground level at DEL01

² 160 m above ground level at LiDAR2

³ 160 m above ground level at LiDAR3

4.0 SUMMARY

Background noise monitoring has been conducted at nine (9) receivers around the proposed Delburn Wind Farm.

The survey and analysis have been carried out on the basis of:

- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*, as required by *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* published by the Victorian Department of Environment, Land, Water and Planning in March 2019
- Supplementary guidance contained in UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* dated May 2013.

The results have been analysed to derive noise limits in accordance with NZS 6808:2010 for surrounding receiver locations. Specifically, noise limits have been derived at integer hub-height wind speeds as the greater of a 40 dB L_{A90} base level and the background level plus 5 dB.

The background noise levels and derived noise limits have been documented for the purposes of the environmental noise assessment accompanying the planning application for the project.

APPENDIX A GLOSSARY

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996 1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report.

For example, sound pressure levels measured using an “A” frequency weighting are expressed as dB L_A.

Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear’s varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90 th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L _{A90}
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound pressure level	A measure of the level of sound expressed in decibels.	L _p

APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed thirty-three (33) turbine layout of the Delburn Wind Farm (Layout reference 3.4 supplied by the proponent on 5 May 2020).

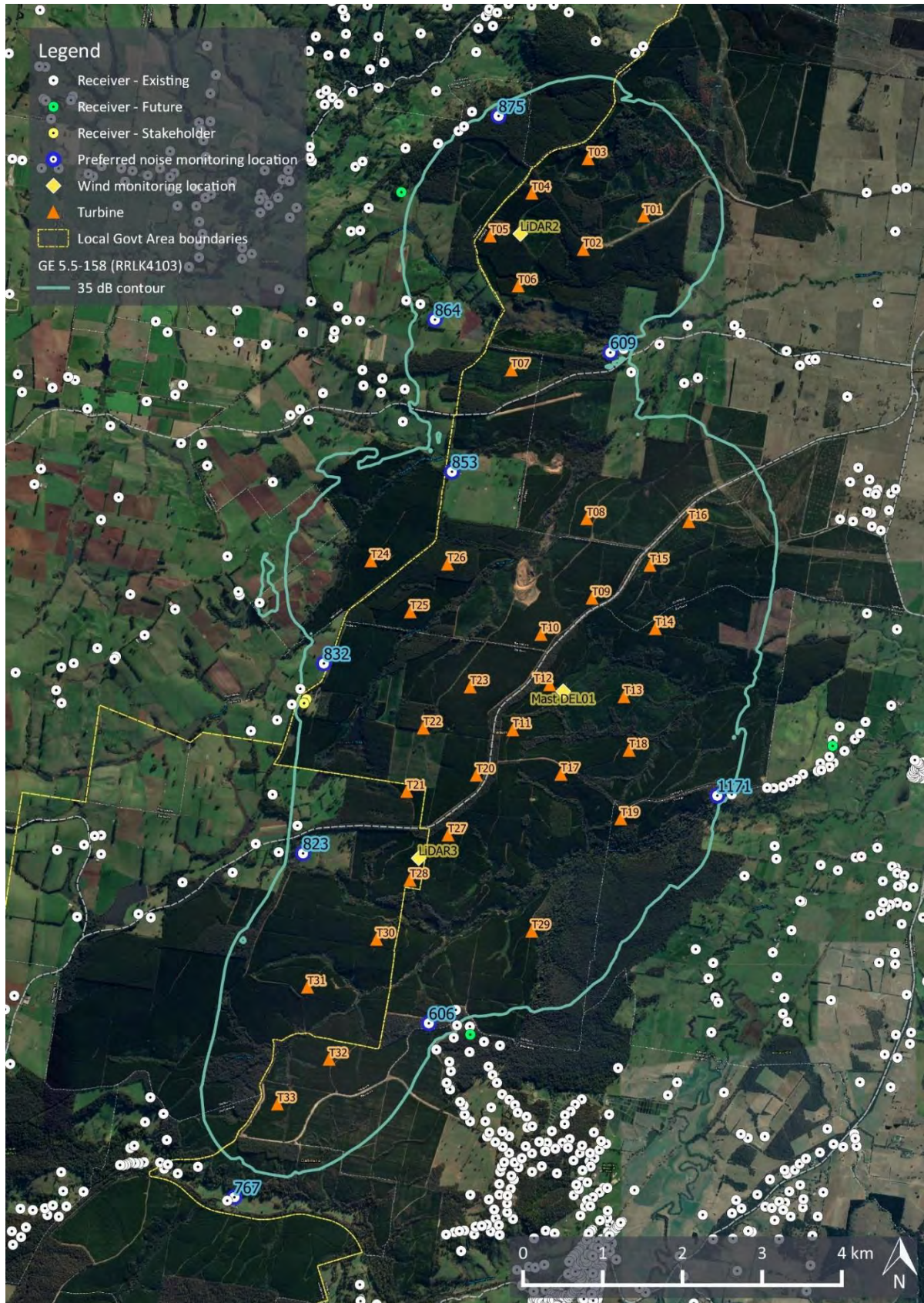
Table 8: Turbine coordinates – MGA 94 zone 55

Turbine	Easting, m	Northing, m	Terrain elevation, m
T01	436,525	5,765,561	197
T02	435,750	5,765,156	228
T03	435,296	5,764,592	263
T04	437,495	5,764,699	291
T05	436,473	5,764,438	290
T06	435,544	5,763,978	218
T07	435,470	5,762,948	203
T08	436,508	5,761,045	169
T09	437,789	5,761,008	206
T10	433,800	5,760,517	222
T11	437,282	5,760,457	241
T12	434,760	5,760,476	232
T13	436,493	5,760,073	193
T14	434,216	5,759,907	181
T15	435,787	5,759,639	167
T16	437,408	5,759,641	168
T17	436,532	5,759,218	195
T18	435,389	5,759,043	170
T19	437,040	5,758,715	180
T20	435,954	5,758,492	250
T21	434,976	5,758,338	213
T22	434,051	5,758,153	201
T23	437,056	5,758,069	211
T24	436,134	5,757,873	234
T25	434,704	5,757,718	191
T26	435,544	5,757,416	194
T27	436,935	5,757,281	248
T28	434,750	5,757,067	249
T29	434,253	5,756,519	166
T30	435,616	5,756,655	233
T31	435,767	5,755,772	207
T32	433,871	5,755,768	179
T33	433,005	5,755,169	175

APPENDIX C PREFERRED NOISE MONITORING LOCATIONS

The figure presented in this Appendix identifies the preferred noise monitoring locations which were identified prior to undertaking the background noise monitoring, subject to consent being provided by the landowners.

As noted in Section 2.1, consent to undertake background noise monitoring was not granted at all preferred receivers. Prior to construction of the wind farm, background noise monitoring may be undertaken at additional receivers, should consent be provided.



APPENDIX D SURVEY INSTRUMENTATION

Table 9: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB Cubes & DUOs
Instrumentation class	Certified to Type1 / Class 1 (precision grade) standards in accordance with AS/IEC 61672.1:2019 ⁷
Instrumentation noise floor	Less than 20 dB
Time synchronisation	Internal GPS clocks
Wind shielding	Enhanced wind shielding system based on the design recommendations detailed in the UK IOA Good Practice Guide. The system comprises an inner solid primary wind shield and an outer secondary large diameter hollow wind shield

Table 10: Equipment details and calibration

Receiver	Make & model	Serial number	Microphone serial number	Independent calibration date ¹	Calibration drift ^{2,3}
<i>Noise monitoring equipment</i>					
600	01dB DUO	10197	141100	13/05/2019	0.19
609	01dB CUBE	10422	224301	17/09/2019	-0.10
824	01dB CUBE	11877	331800	12/04/2019	0.11
832	01dB DUO	10339	144938	5/07/2018	0.06
853	01dB DUO	10196	331724	10/07/2019	0.10
864	01dB DUO	10196	331724	10/07/2019	0.04
867	01dB CUBE	10422	224301	17/09/2019	0.47
1171	01dB DUO	10344	144885	28/06/2018	0.00
4585	01dB DUO	10197	141100	13/05/2019	0.10
<i>Calibrator</i>					
-	01dB-Stell CAL21	34924044	-	9/07/2019	-

Notes: ¹ Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055:2018⁸

² Difference between reference level checks during deployment and collection of instruments

³ Calibration drift should not be greater than 1 dB as specified in AS 1055:2018

⁷ AS/IEC 61672.1-2019 *Electroacoustics - Sound level meters – Specifications* which is identical to IEC 61672.1:2.0 *Electroacoustics - Sound Level Meters - Part 1: Specifications* published in 2013

⁸ AS 1055:2018 *Acoustics – Description and measurement of environmental noise*

Table 11: Local wind speed measurement instrumentation

Receiver	Make & model	Serial number
609	Vaisala	K4120002
824	Vaisala	K1850003
867	Vaisala	K4120002

APPENDIX E SITE WIND SPEED DATA

E1 Wind monitoring locations

Wind monitoring was carried out at three (3) locations during the noise monitoring survey.

The wind monitoring locations are listed in Table 12 together with the noise monitoring locations which reference each mast.

Table 12: Wind monitoring locations

Reference	Location within the wind farm	Associated noise monitoring location	Distance to the associated noise monitoring location, m
DEL01	Centre	832	3,023
		853	3,088
		1171	2,335
LiDAR2	North	609	1,868
		864	1,518
		867	1,929
LiDAR3	South	600	2,702
		824	1,575
		4585	3,255

The location of each of these wind monitoring locations is illustrated in Figure 1.

Coordinates for the wind monitoring locations are detailed in Table 13.

Table 13: Wind monitoring location coordinates – MGA 94 Zone 55

Reference	Easting, m	Northing, m
DEL01	436,212	5,758,877
LiDAR2	435,675	5,764,615
LiDAR3	434,400	5,756,784

E2 Wind speed data derivation

Hub height wind speed and direction data (160 m above ground level) was provided by the proponent, based on analysis conducted by K2 Management.

The following information was provided by K2 Management, supplemented by additional explanatory text from Delburn Wind Farm Pty Ltd:

DEL01:

- *Raw 160 m anemometer data used without shear adjustments where measured 10 min data exists*
- *160 m anemometers spliced: mast wake affected anemometer sectors omitted with priority given to free stream anemometer, and remaining wind speed measurements averaged*

LiDAR2:

- *Raw 160 m data used without shear adjustments where measured 10 min data exists*
- *Where 10 min data gaps exist:*
 - *Wind speed data synthesized at 160 m, using the speed sort correlation method between 100 and 160 m at the LiDAR, to improve 160 m coverage*
 - *Wind direction data was also synthesized by correlation between 100 and 160 m in order to improve 160 m coverage*

LiDAR3:

- *Raw 160 m data used without shear adjustments where measured 10 min data exists*
- *Where 10 min data gaps exist:*
 - *Wind speed data synthesized at 160 m using the speed sort correlation method between 160 m at the LiDAR and Mast DEL01, with good agreement, to generate data for the periods and improve overall coverage for the remaining period*
 - *Wind direction data was also synthesized by correlation between 160 m at the LiDAR and Mast DEL01, with good agreement, in order to generate data for the periods and improve overall coverage for the remaining period*

APPENDIX F SUMMARY OF BACKGROUND NOISE LEVELS

Table 14: Regression equation coefficients – all time periods

Location	Regression equation coefficients for background noise equation of best fit $L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					Valid wind speed range
	a	b	c	d	R ²	
600	-0.0036	0.217	-1.2845	25.425	0.41	3-18
609	-	0.0008	0.7455	28.2708	0.17	3-18
824	-0.0047	0.1758	-0.3704	26.5377	0.29	3-17
832	-0.0133	0.4625	-2.8357	32.5442	0.43	3-17
853	-0.0052	0.2358	-1.5585	31.539	0.42	3-18
864	-0.0084	0.3415	-2.1951	29.3096	0.53	3-18
867	-0.0071	0.3068	-1.8696	30.0375	0.62	3-18
1171	-0.0025	0.1652	-0.9594	26.565	0.33	3-17
4585	-	0.0469	0.0447	29.1586	0.34	3-18

Table 15: Regression equation coefficients – night-time periods

Location	Regression equation coefficients for background noise equation of best fit $L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					Valid wind speed range
	a	b	c	d	R ²	
600	-0.0022	0.1734	-0.8794	26.896	0.42	3-17
609	-	0.0009	0.8591	23.2307	0.38	3-16
824	-0.0011	0.1637	-0.8327	22.2954	0.65	3-16
832	-0.0153	0.5372	-3.1072	26.5581	0.73	3-16
853	-0.0021	0.1554	-0.9502	28.1054	0.58	3-16
864	-0.0086	0.3315	-2.05	30.5484	0.49	3-16
867	-0.0073	0.2977	-1.6796	31.0624	0.61	3-18
1171	-0.0024	0.1683	-0.9059	22.1119	0.56	3-16
4585	-0.0006	0.0915	-0.1867	24.1261	0.56	3-16

APPENDIX G RECEIVER 600 DATA

G1 Receiver 600 location data

Table 16: Receiver 600 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	434,804	5,754,112
Background noise monitoring location	434,786	5,754,142

Figure 2: Receiver 600 aerial view - dwelling and noise monitor location



Table 17: Receiver 600 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

G2 Receiver 600 measurement data summary

Table 18: Receiver 600 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	6,890	4,331
Number of data points removed	1,072	601
Number of data points for analysis	5,818	3,730

Figure 3: Receiver 600 background noise level and wind speed time history

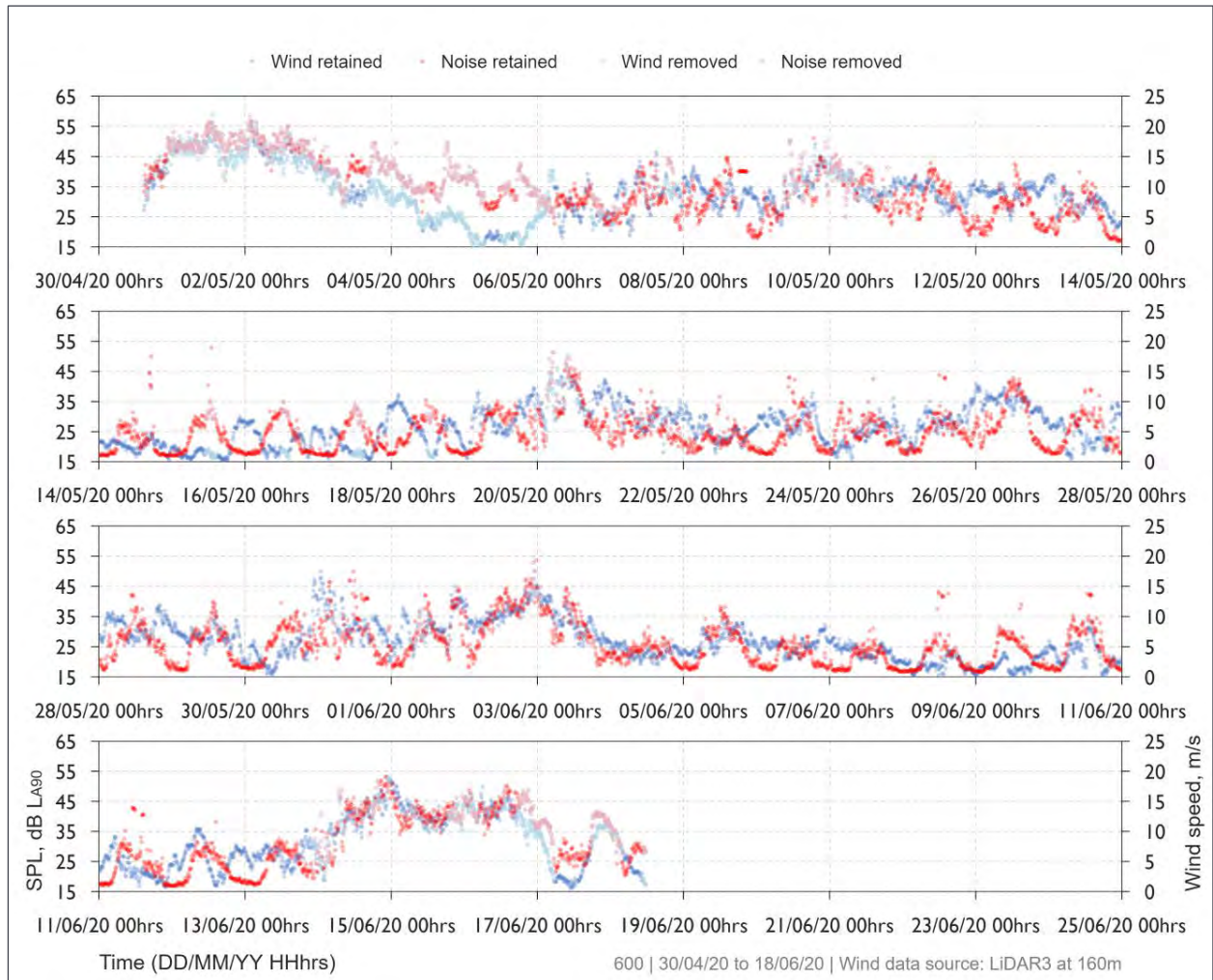


Figure 4: Receiver 600 all-time periods – derived background noise levels and noise limits

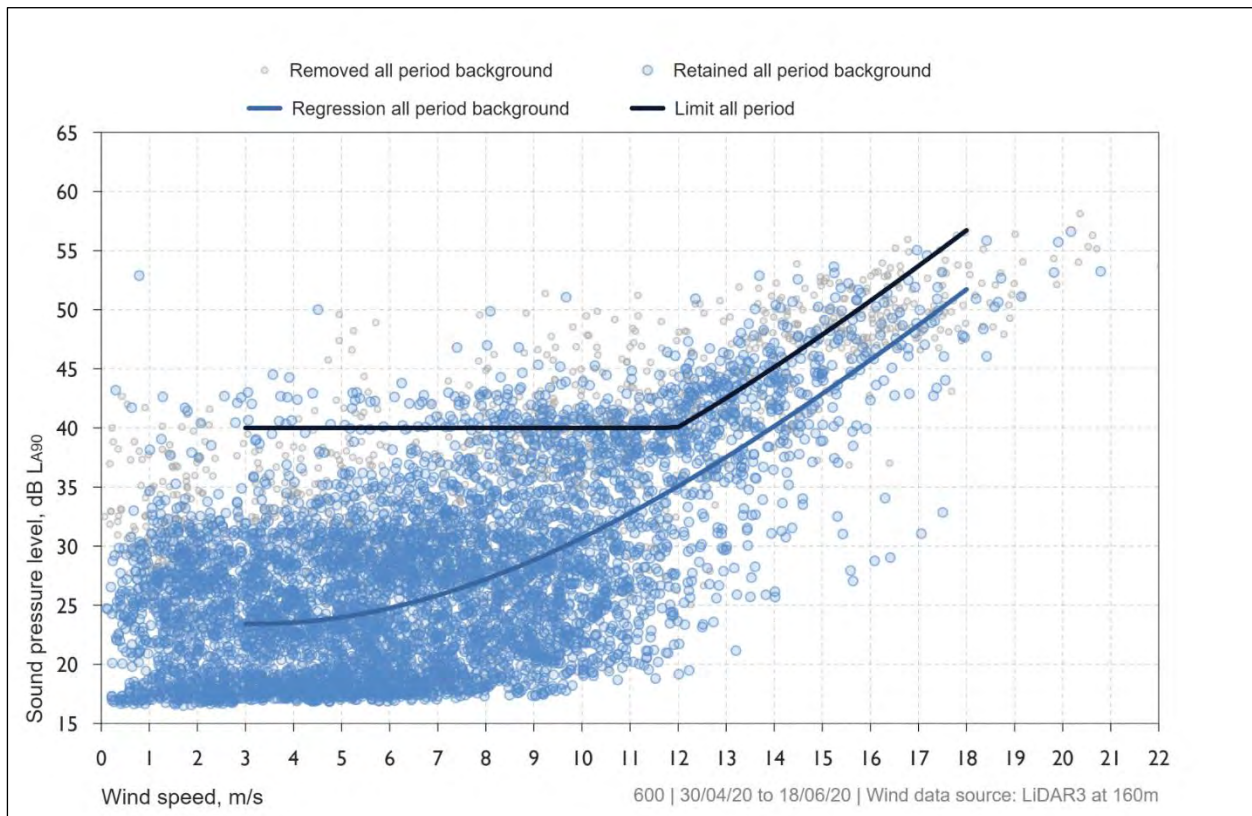
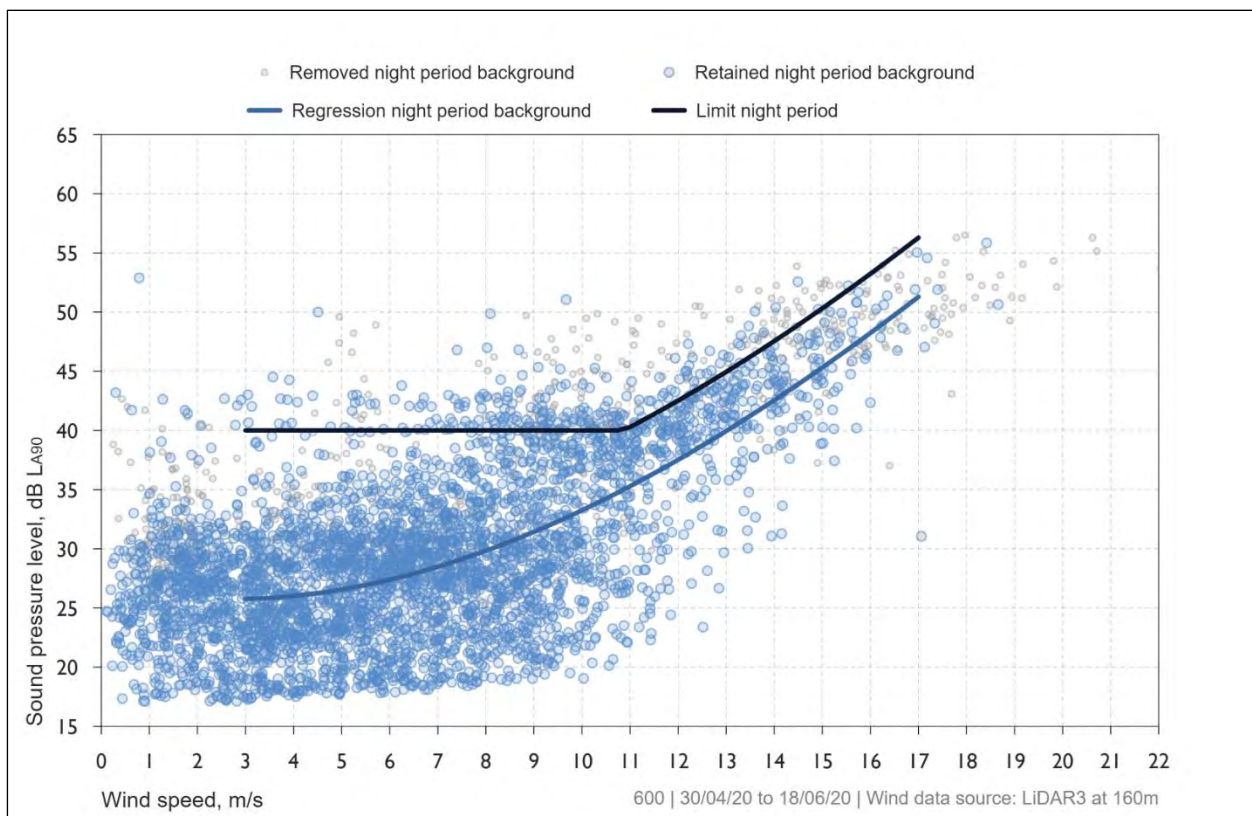


Figure 5: Receiver 600 night-time periods – derived background noise levels and noise limits



APPENDIX H RECEIVER 609 DATA

H1 Receiver 609 location data

Table 19: Receiver 609 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	436,804	5,763,126
Background noise monitoring location	436,806	5,763,120

Figure 6: Receiver 609 aerial view - dwelling and noise monitor location



Table 20: Receiver 609 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

H2 Receiver 609 measurement data summary

Table 21: Receiver 609 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	7,737	2,863
Number of data points removed	3,381	1,323
Number of data points for analysis	4,356	1,540

Figure 7: Receiver 609 background noise level and wind speed time history

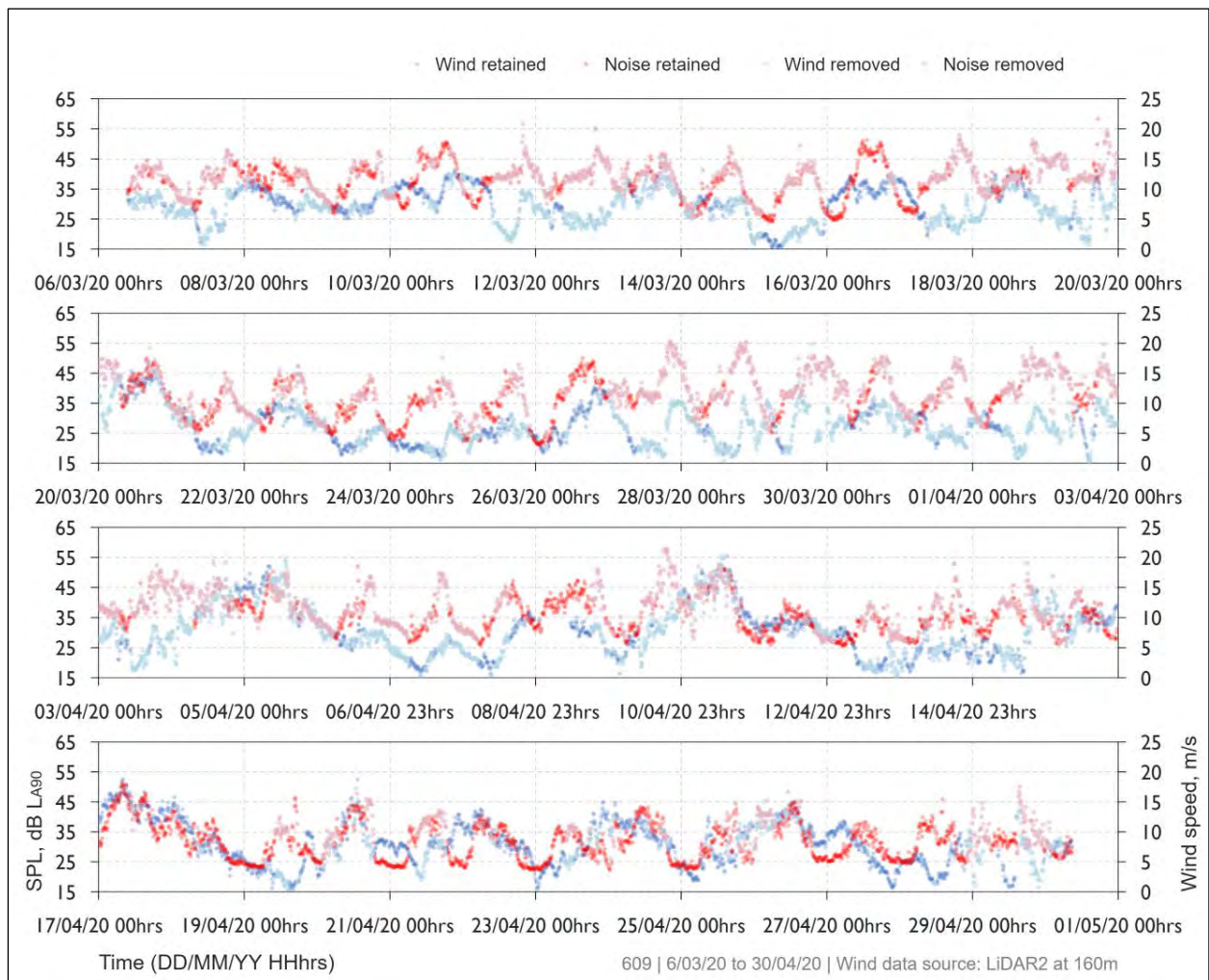


Figure 8: Receiver 609 all-time periods – derived background noise levels and noise limits

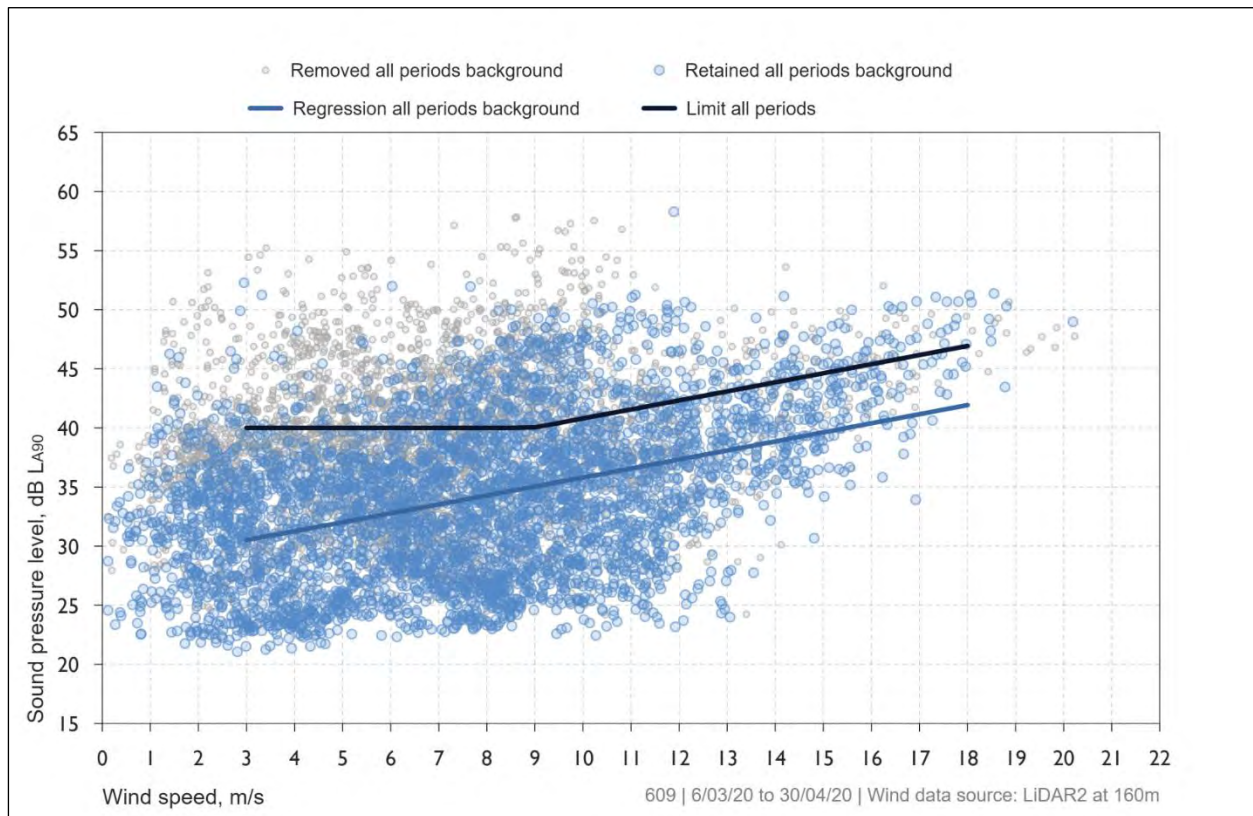
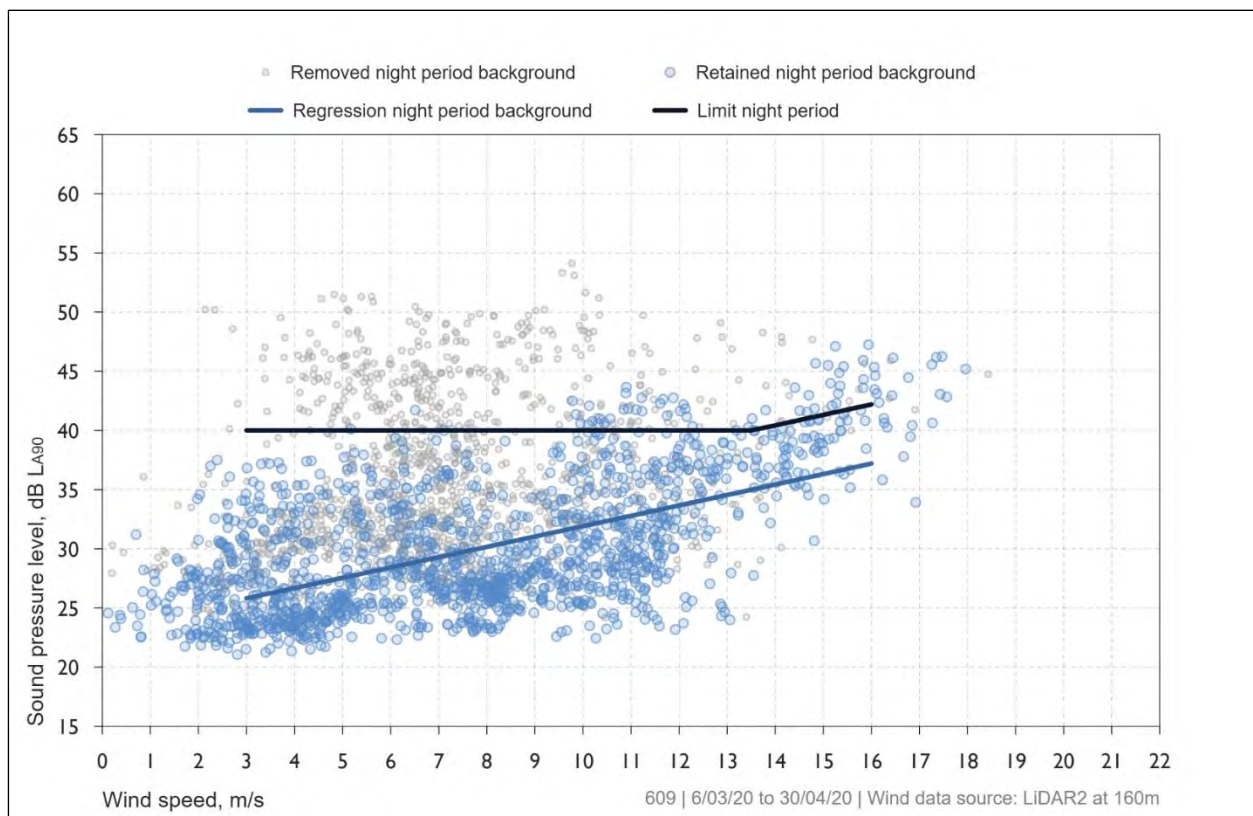


Figure 9: Receiver 609 night-time periods – derived background noise levels and noise limits



APPENDIX I RECEIVER 824 DATA

11 Receiver 824 location data

Table 22: Receiver 824 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	432,879	5,757,191
Background noise monitoring location	432,891	5,757,196

Figure 10: Receiver 824 aerial view - dwelling and noise monitor location



Table 23: Receiver 824 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

12 Receiver 824 measurement data summary

Table 24: Receiver 824 background noise level analysis summary

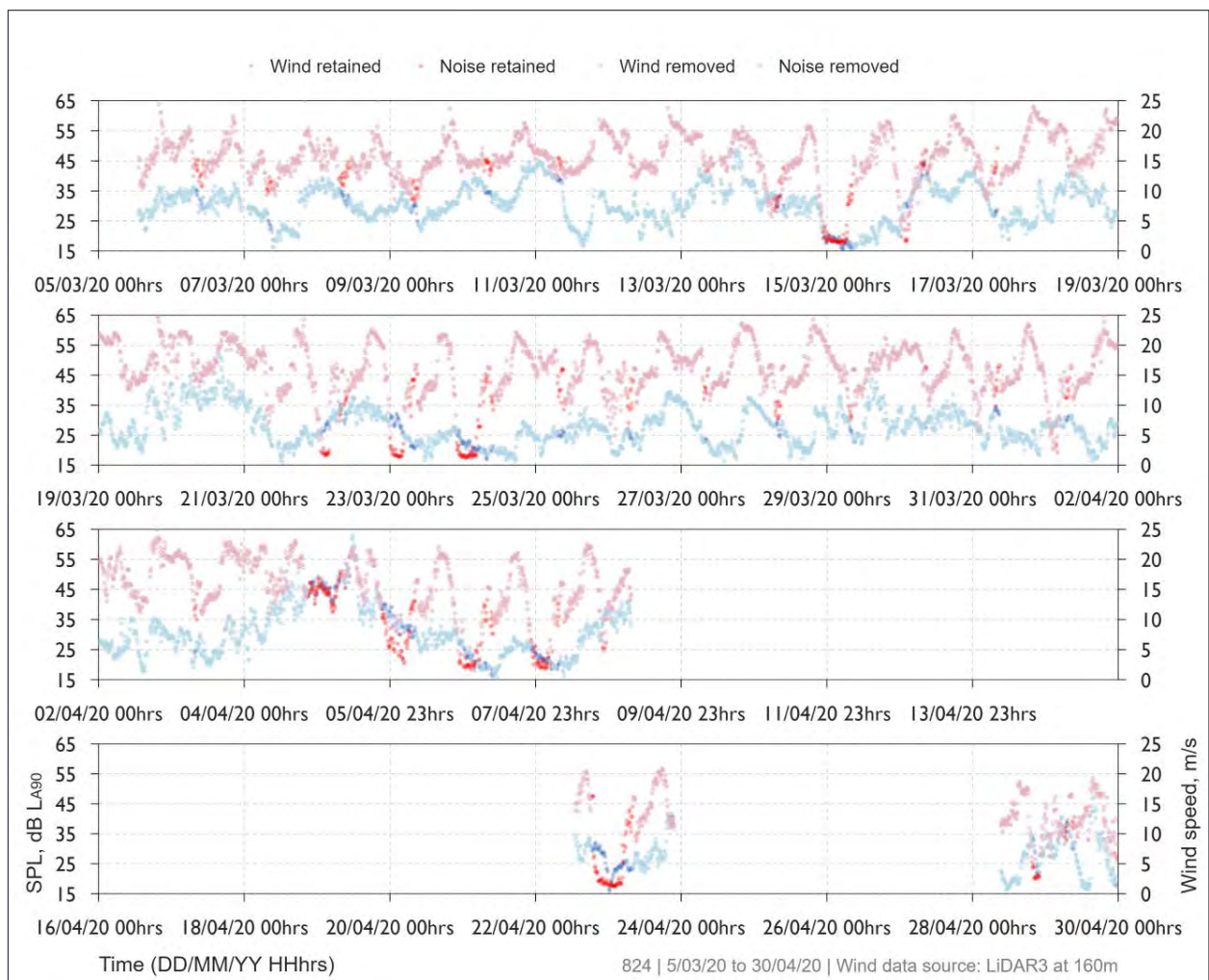
Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	5,318	1,975
Number of data points removed	4,485	1,539
Number of data points for analysis	833	436

It should be noted that the number of analysed data points during the night-time period is lower than 1,440, as recommended in Section C7.2.1 of NZS 6808:2010 *to give suitable range of data*.

However, the derived background level is representative of the lower range of noise levels that occurred at this receiver during the noise monitoring period. The derived background noise levels are also consistent with the general trend of background noise levels derived at other receivers.

The derived background noise level is therefore considered suitable for planning assessment purposes. Depending on the final wind turbine design, additional background noise monitoring may be required at this property.

Figure 11: Receiver 824 background noise level and wind speed time history



Note: The time history for this location indicate that there is no data available from 9/04 0710 hrs to 22/04 1300 hrs and 23/04 2150 hrs to 28/04 0910 hrs. This is due to a battery fault associated with the noise monitoring equipment.

Figure 12: Receiver 824 all-time periods – derived background noise levels and noise limits

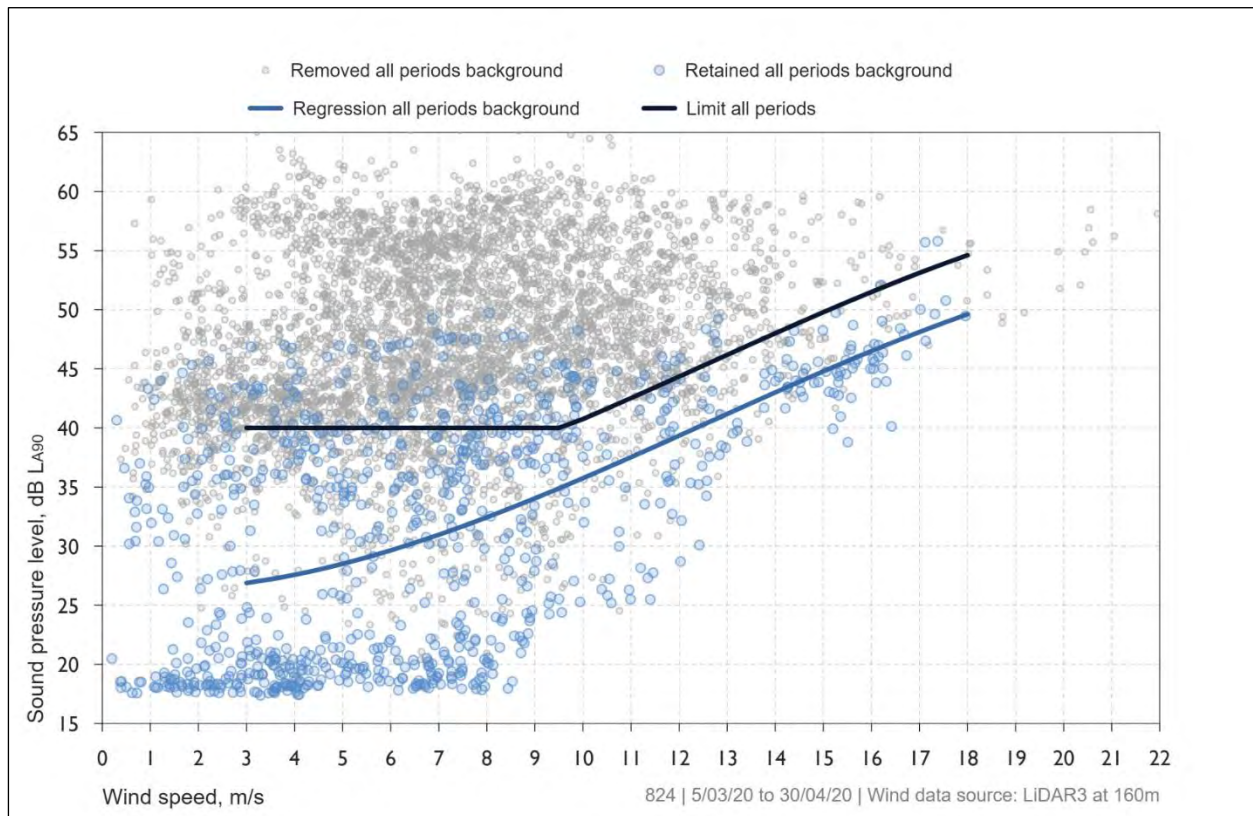
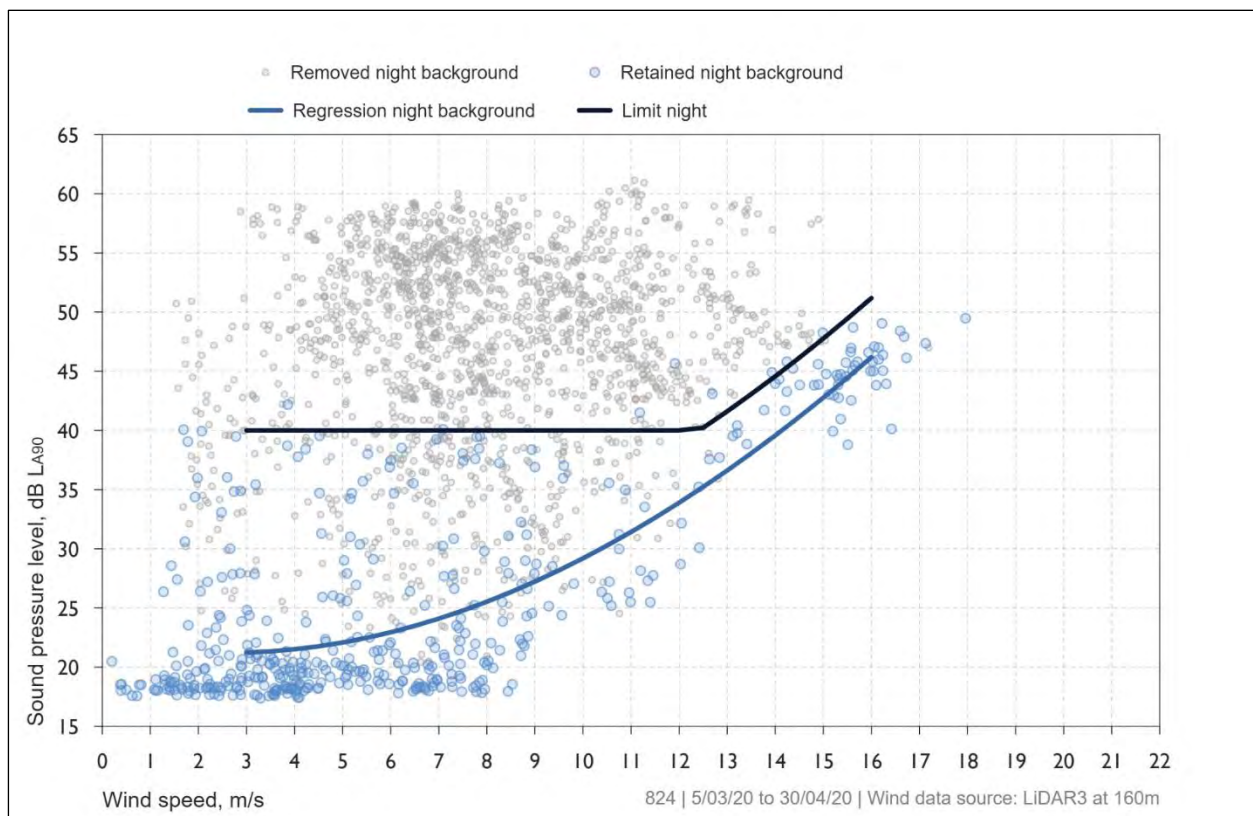


Figure 13: Receiver 824 night-time periods – derived background noise levels and noise limits



APPENDIX J RECEIVER 832 DATA

J1 Receiver 832 location data

Table 25: Receiver 832 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	433211	5759226
Background noise monitoring location	433227	5759274

Figure 14: Receiver 832 aerial view - dwelling and noise monitor location



Table 26: Receiver 832 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

J2 Receiver 832 measurement data summary

Table 27: Receiver 832 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	7,802	2,891
Number of data points removed	3,320	1,097
Number of data points for analysis	4,482	1,794

Figure 15: Receiver 832 background noise level and wind speed time history

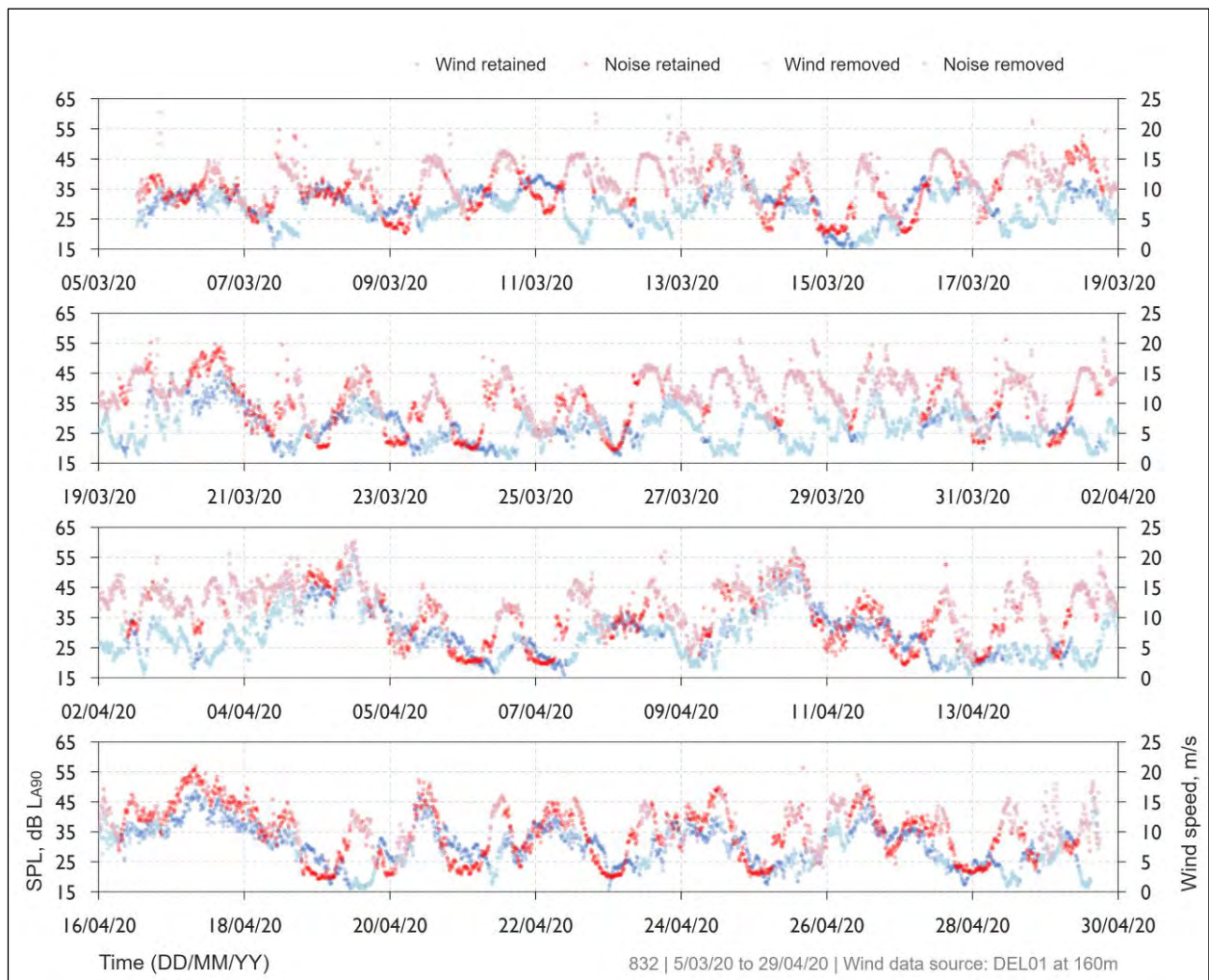


Figure 16: Receiver 832 all-time periods – derived background noise levels and noise limits

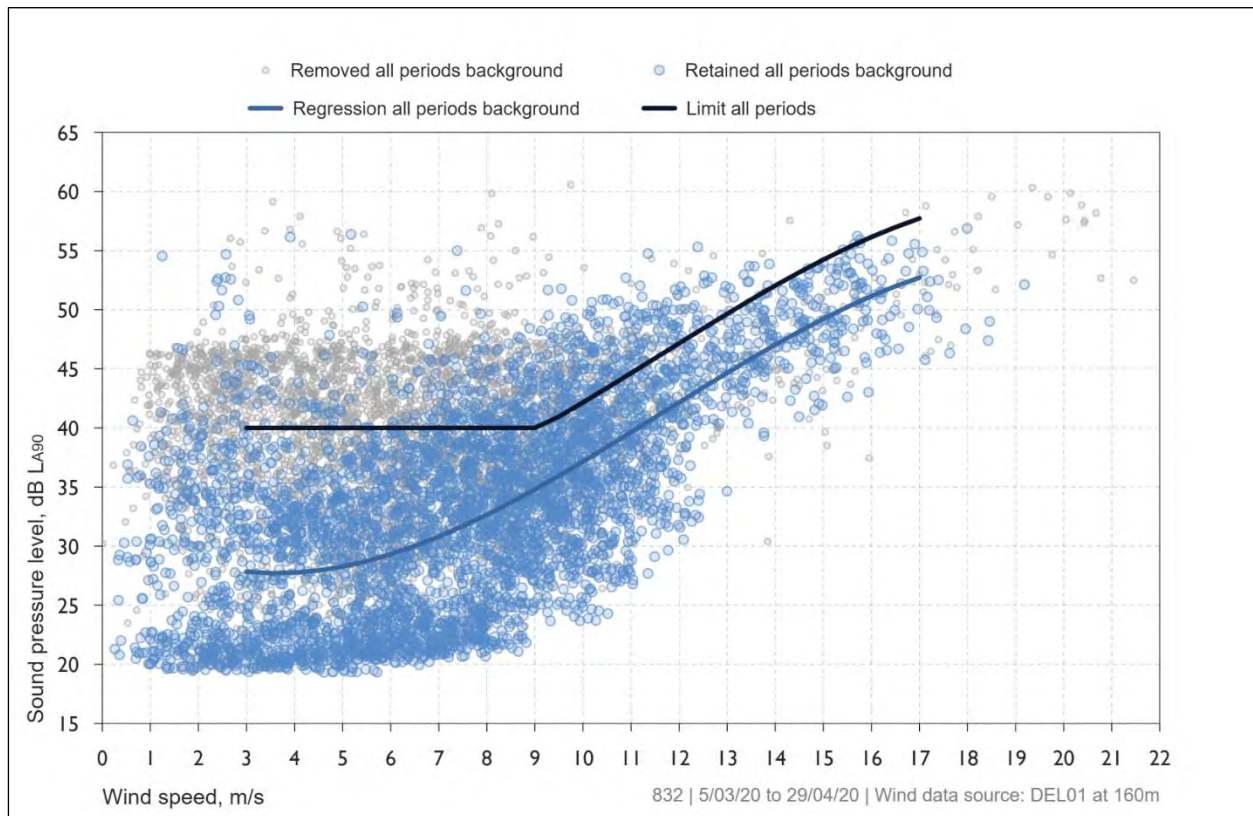
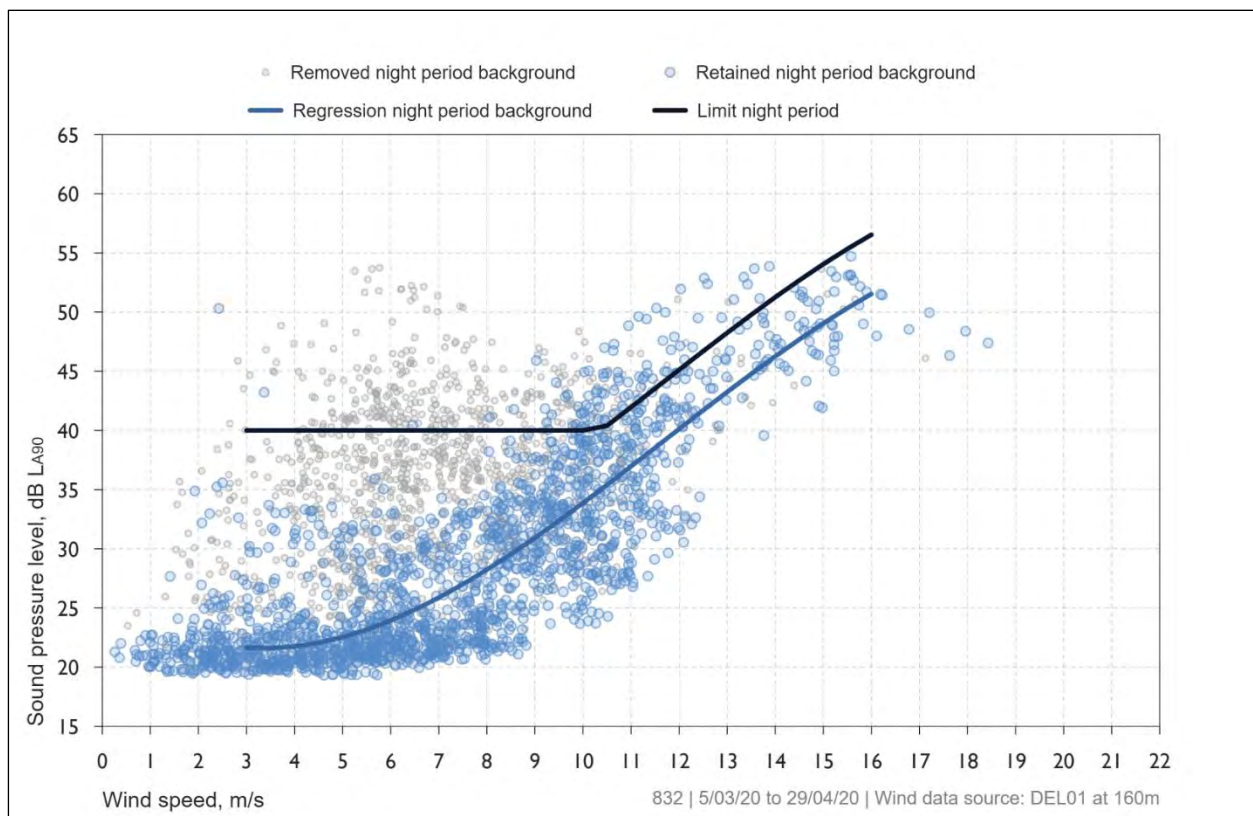


Figure 17: Receiver 832 night-time periods – derived background noise levels and noise limits



APPENDIX K RECEIVER 853 DATA

K1 Receiver 853 location data

Table 28: Receiver 853 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	434,817	5,761,631
Background noise monitoring location	434,809	5,761,609

Figure 18: Receiver 853 aerial view - dwelling and noise monitor location

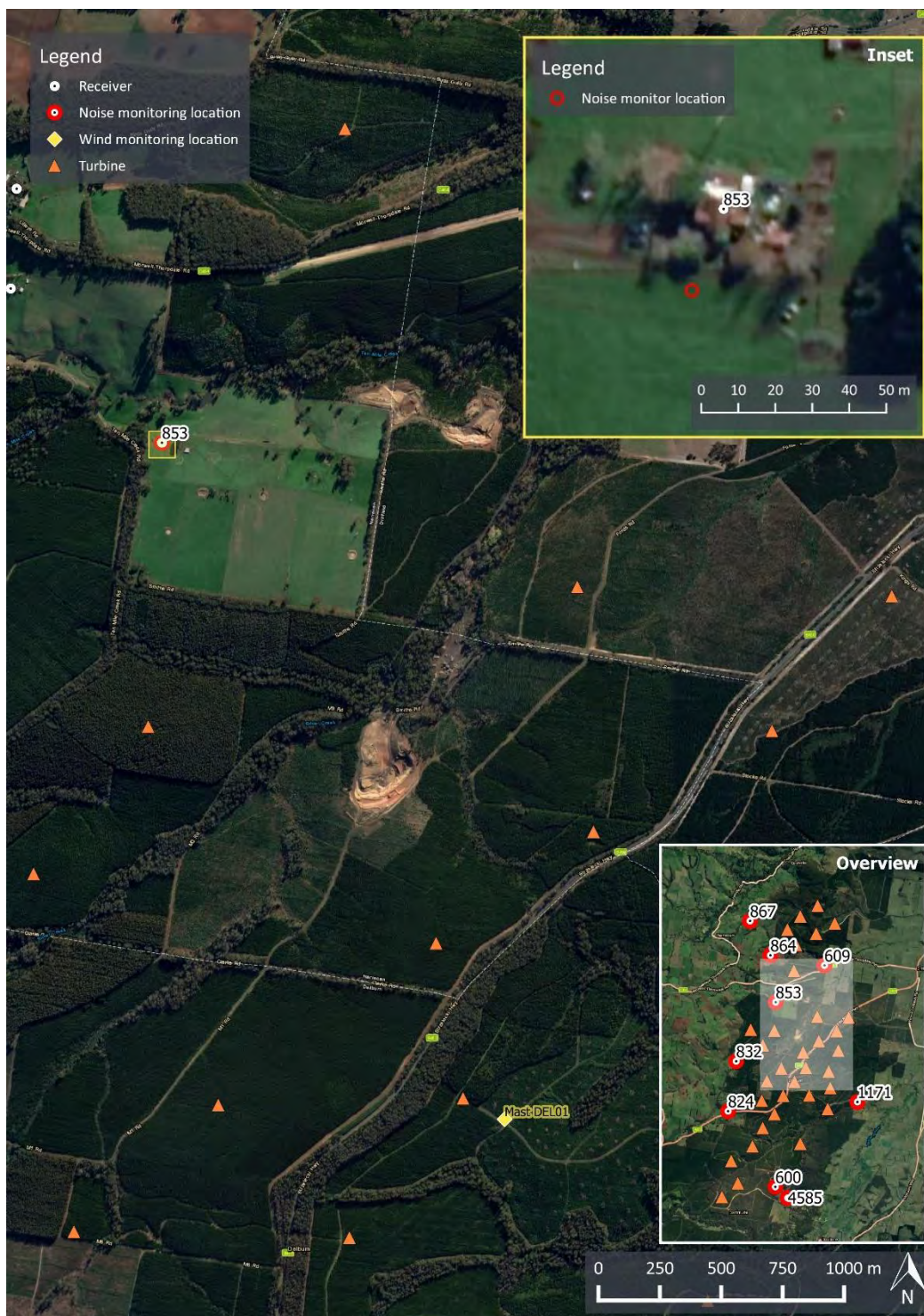


Table 29: Receiver 853 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

K2 Receiver 853 measurement data summary

Table 30: Receiver 853 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	7,765	2,895
Number of data points removed	3,219	646
Number of data points for analysis	4,546	2,249

Figure 19: Receiver 853 background noise level and wind speed time history

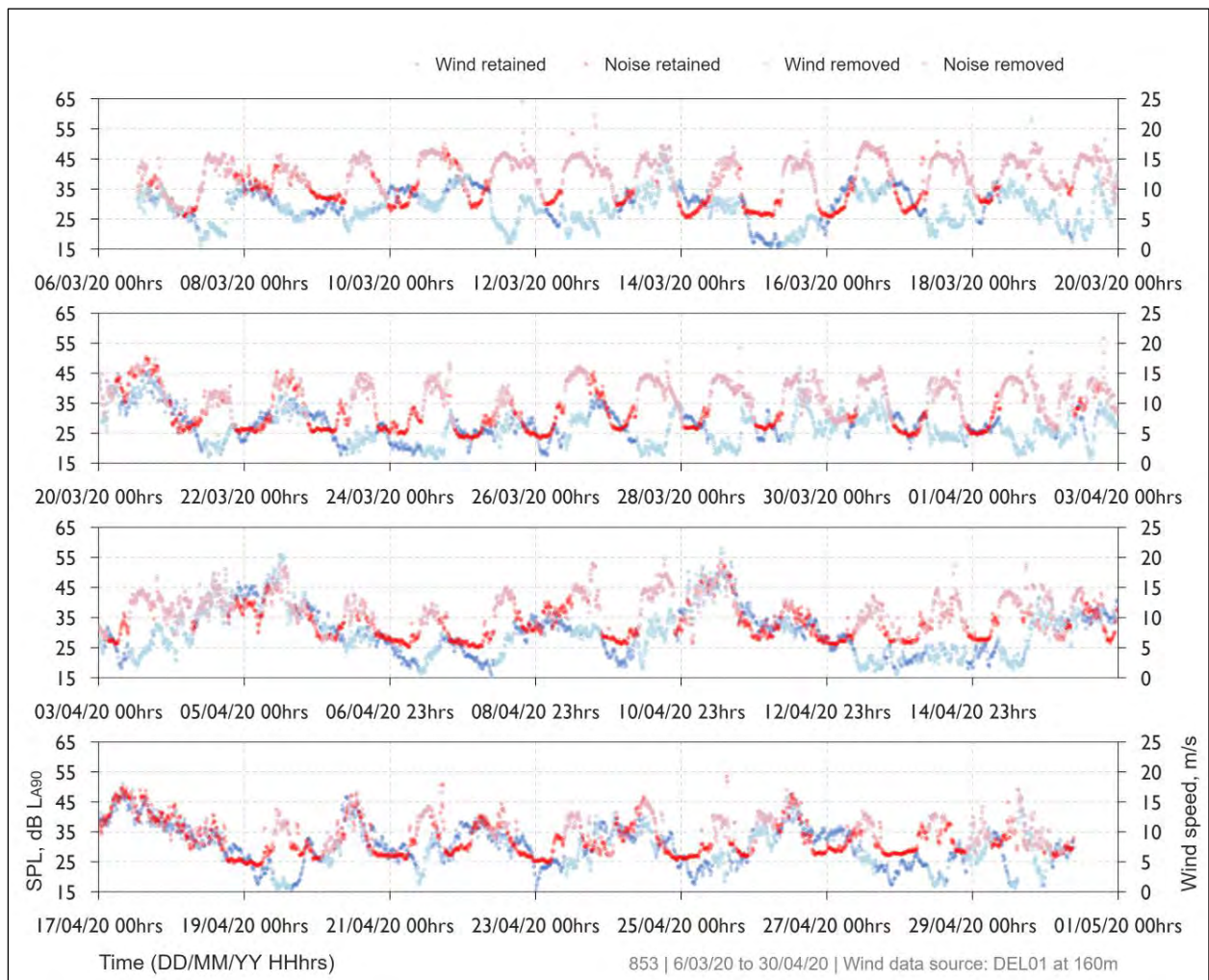


Figure 20: Receiver 853 all-time periods – derived background noise levels and noise limits

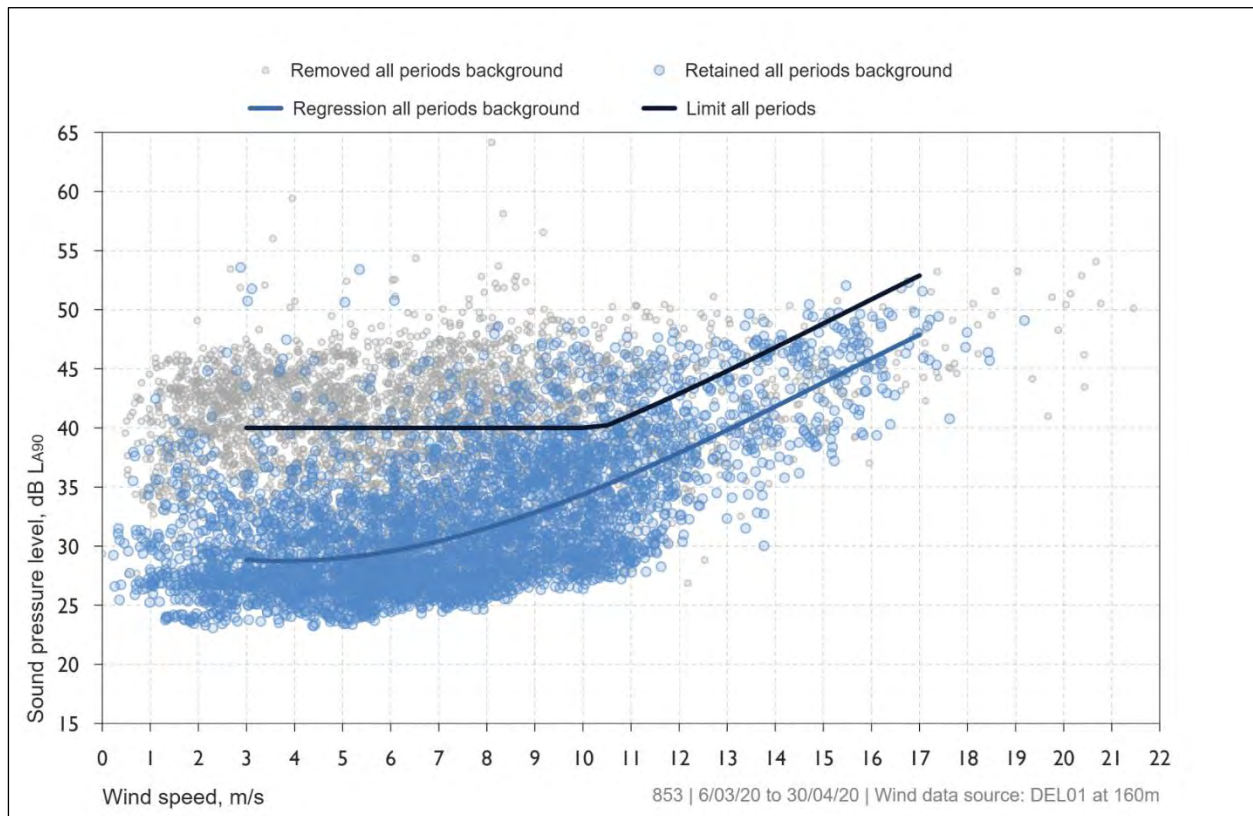
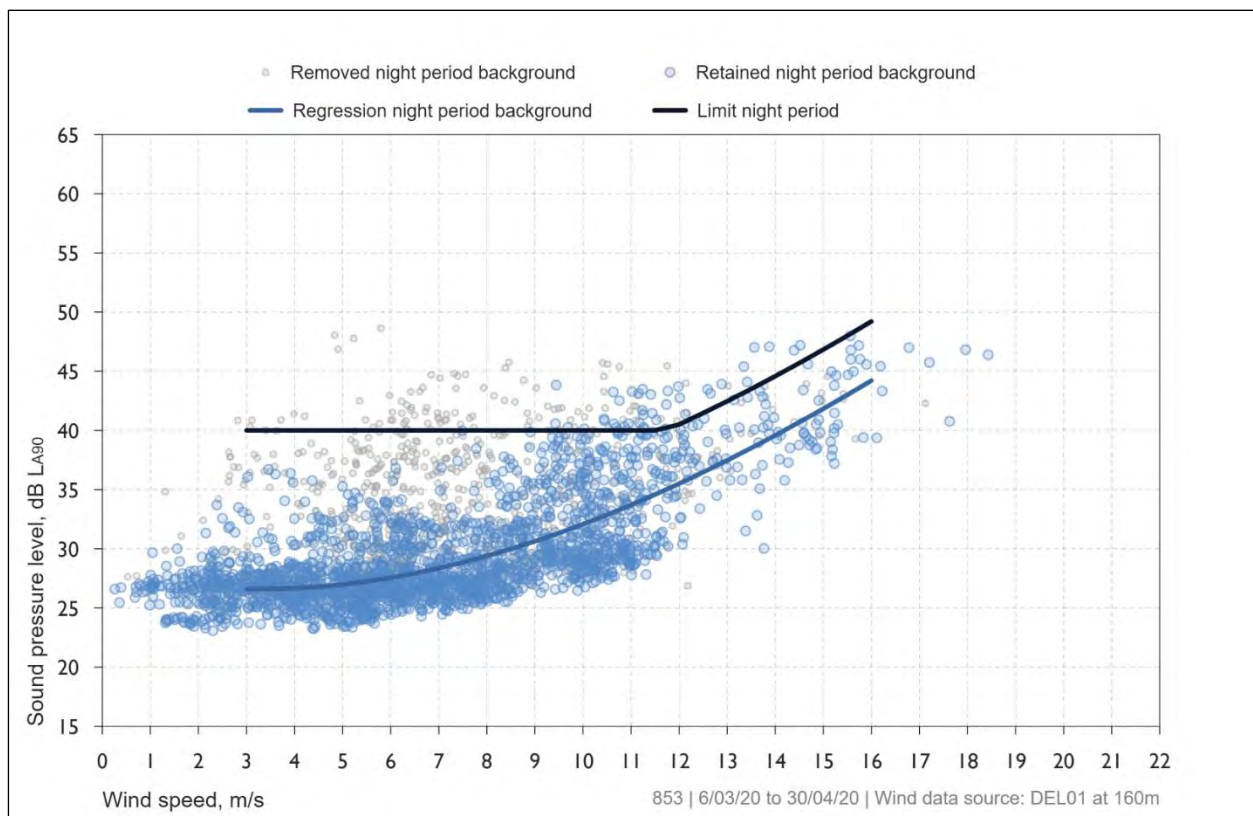


Figure 21: Receiver 853 night-time periods – derived background noise levels and noise limits



APPENDIX L RECEIVER 864 DATA

L1 Receiver 864 location data



Table 31: Receiver 864 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	434,603	5,763,539
Background noise monitoring location	434,615	5,763,519

Figure 22: Receiver 864 aerial view - dwelling and noise monitor location



Table 32: Receiver 864 monitor installation photos

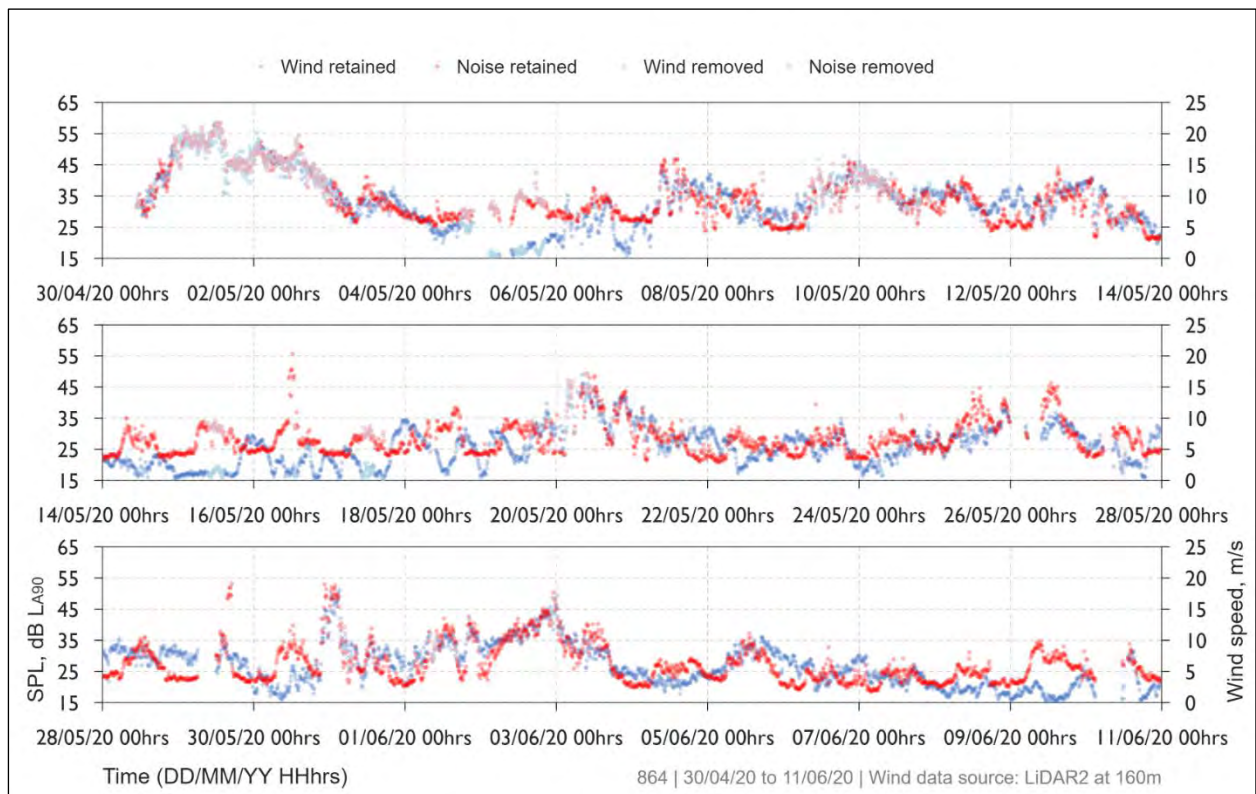
Looking North	Looking East
	
Looking South	Looking West
	

L2 Receiver 864 measurement data summary

Table 33: Receiver 864 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	5,649	3,583
Number of data points removed	506	339
Number of data points for analysis	5,143	3,244

Figure 23: Receiver 864 background noise level and wind speed time history



Note: The equipment at this location stopped monitoring prior to end of the survey as a result of the unit being displaced by livestock.

Figure 24: Receiver 864 all-time periods – derived background noise levels and noise limits

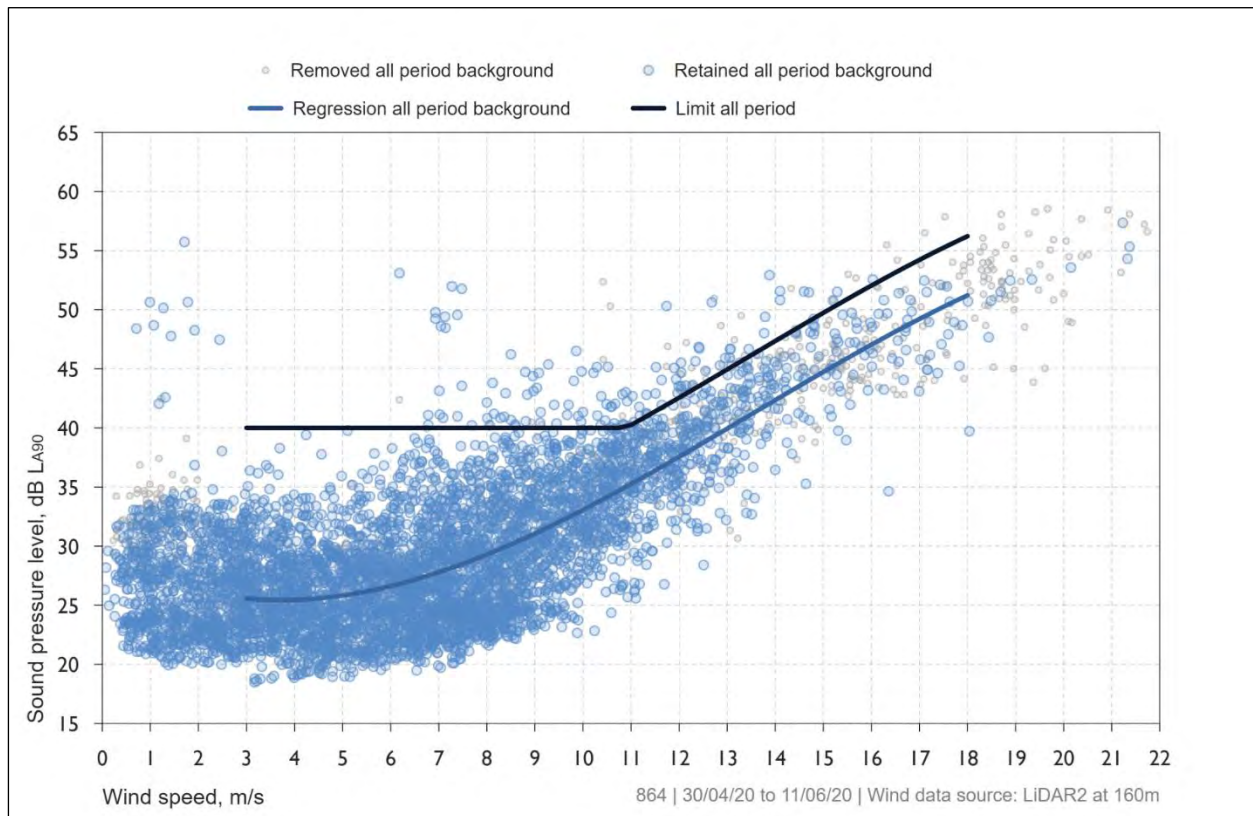
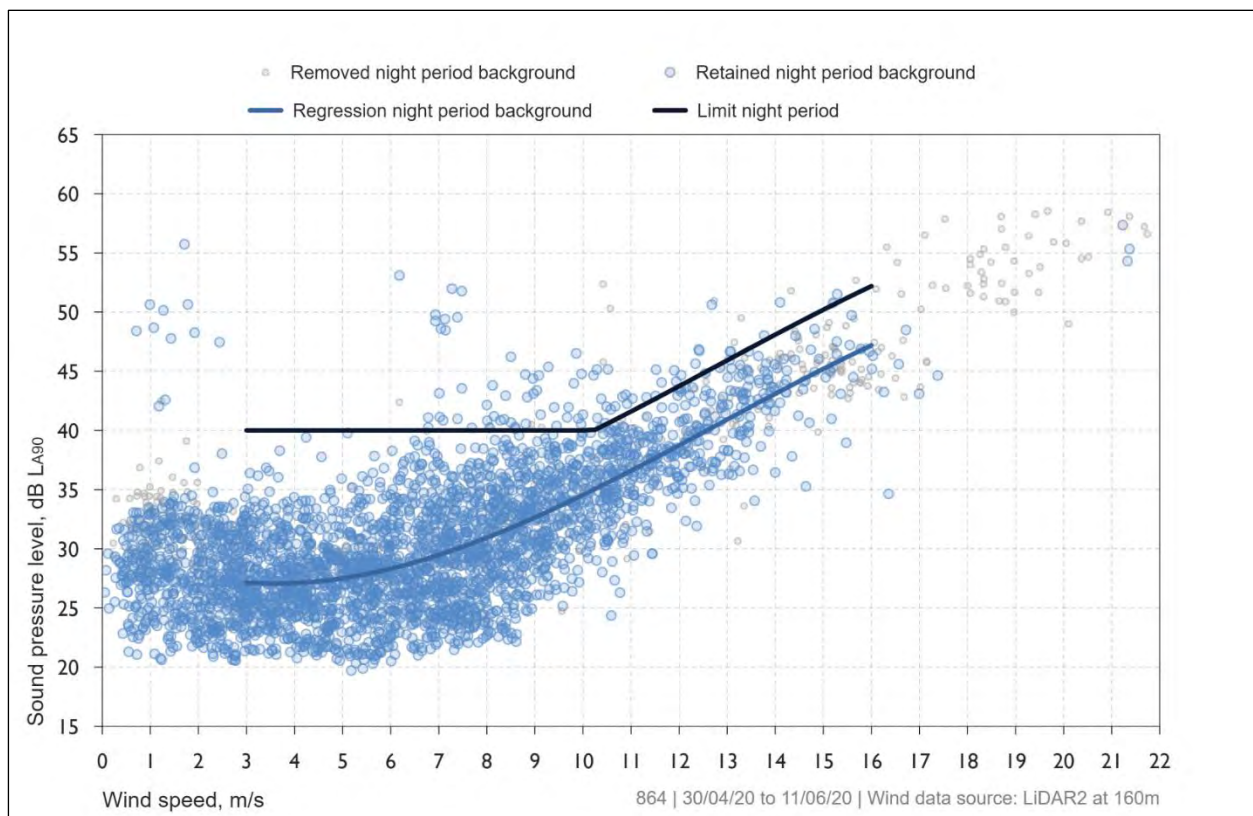


Figure 25: Receiver 864 night-time periods – derived background noise levels and noise limits



APPENDIX M RECEIVER 867 DATA

M1 Receiver 867 location data

Table 34: Receiver 867 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	433,773	5,764,938
Background noise monitoring location	433,751	5,764,908

Figure 26: Receiver 867 aerial view - dwelling and noise monitor location



Table 35: Receiver 867 monitor installation photos

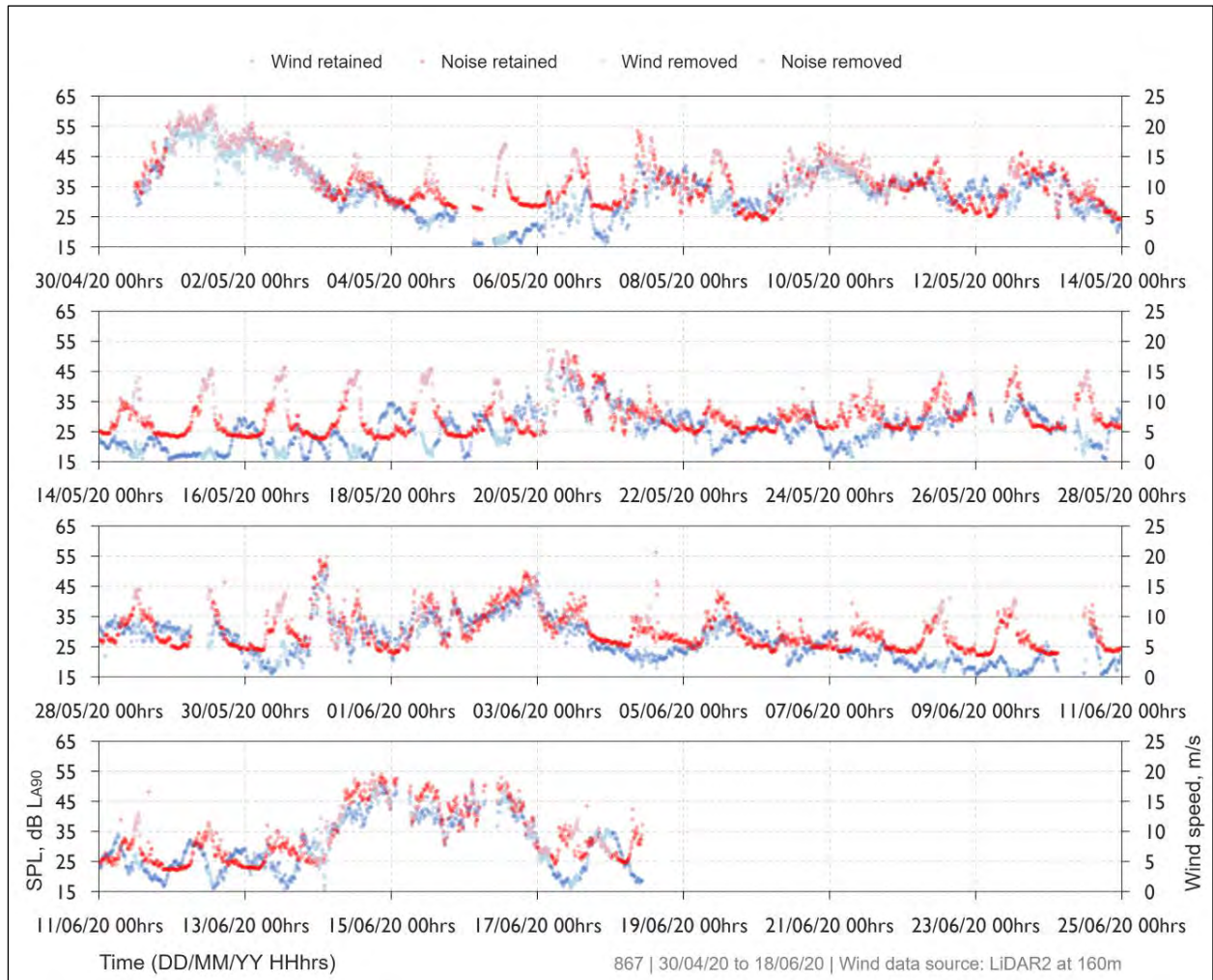
Looking North	Looking East
	
Looking South	Looking West
	

M2 Receiver 867 measurement data summary

Table 36: Receiver 867 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	6,531	4,147
Number of data points removed	833	625
Number of data points for analysis	5,698	3,522

Figure 27: Receiver 867 background noise level and wind speed time history



Note: Based on observations while in attendance at the site and our review of sample audio recordings, the minimum measured noise levels of the order of 25 dB L_{A90} are most likely to relate to domestic equipment (A/C unit) at the property. The noise contribution of this equipment does not sufficiently influence the derived background noise levels and noise limits presented in the figures below.

Figure 28: Receiver 867 all-time periods – derived background noise levels and noise limits

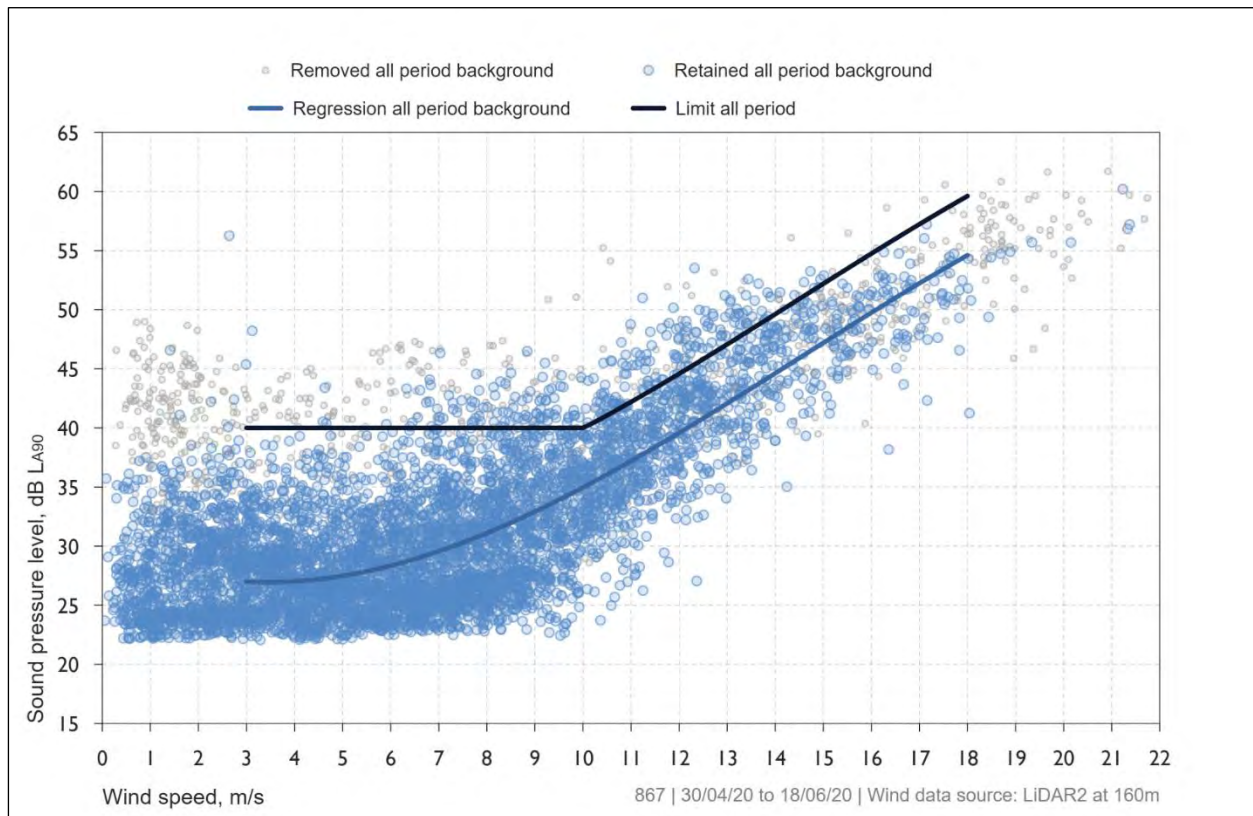
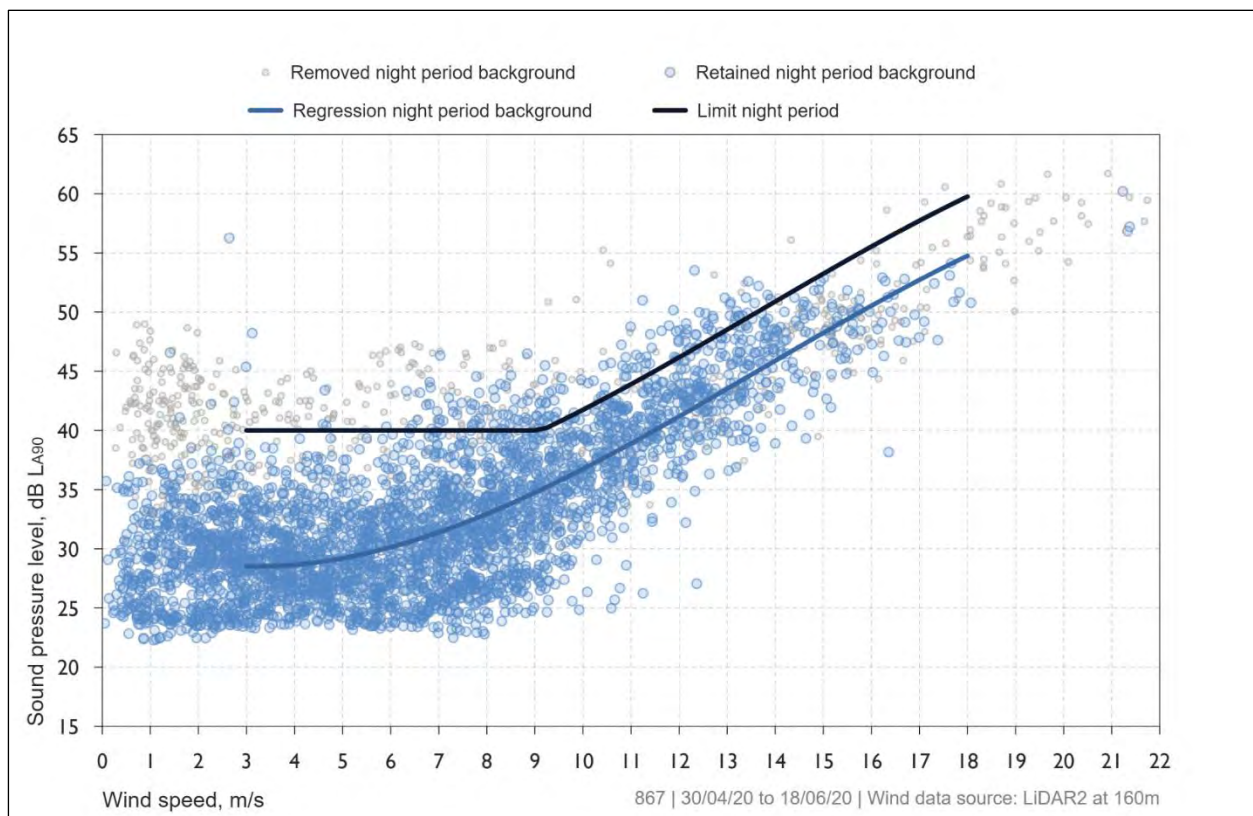


Figure 29: Receiver 867 night-time periods – derived background noise levels and noise limits



APPENDIX N RECEIVER 1171 DATA

N1 Receiver 1171 location data

Table 37: Receiver 1171 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	438,146	5,757,567
Background noise monitoring location	438,126	5,757,583

Figure 30: Receiver 1171 aerial view - dwelling and noise monitor location



Table 38: Receiver 1171 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

N2 Receiver 1171 measurement data summary

Table 39: Receiver 1171 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	6,953	2,563
Number of data points removed	2,220	471
Number of data points for analysis	4,733	2,092

Figure 31: Receiver 1171 background noise level and wind speed time history

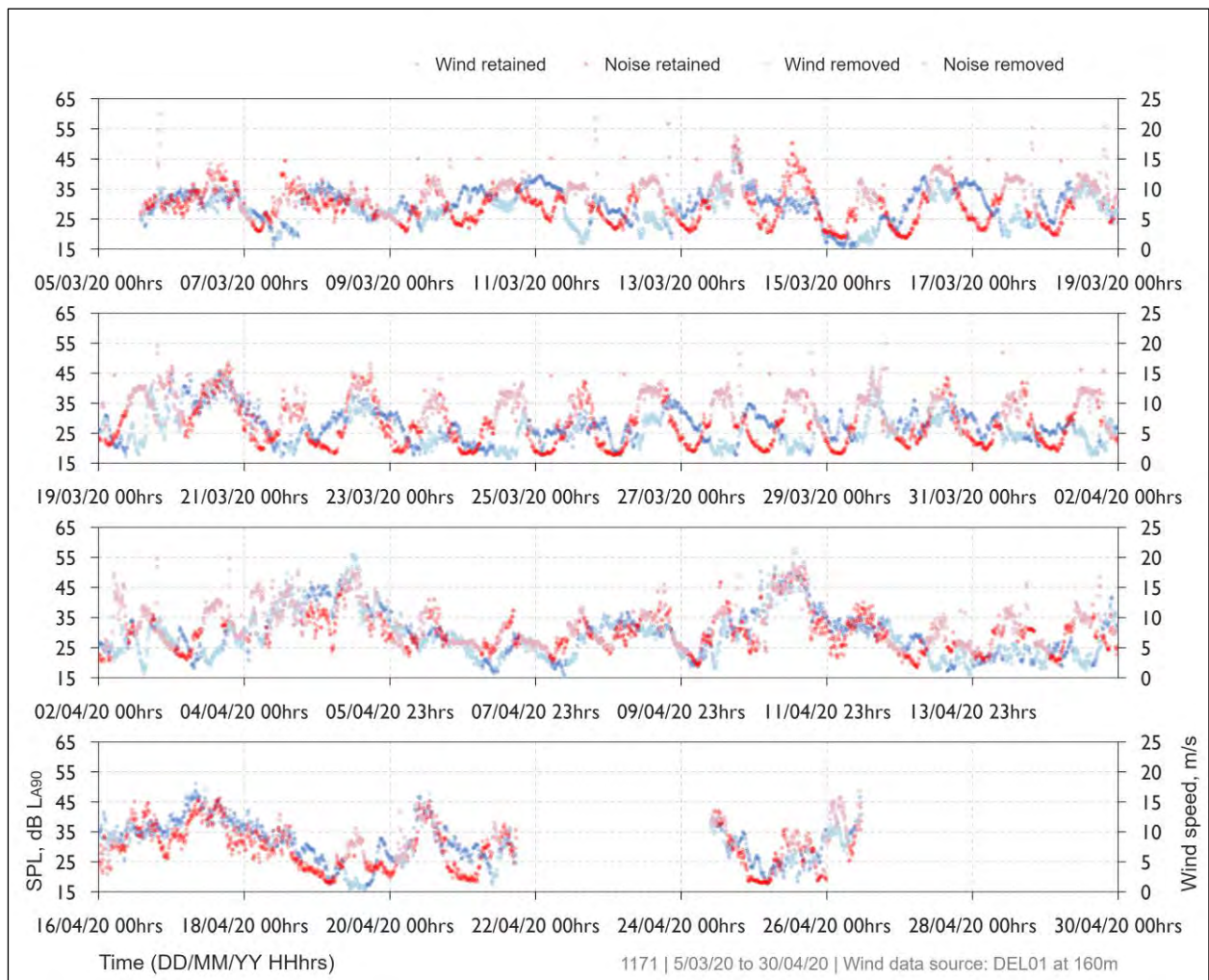


Figure 32: Receiver 1171 all-time periods – derived background noise levels and noise limits

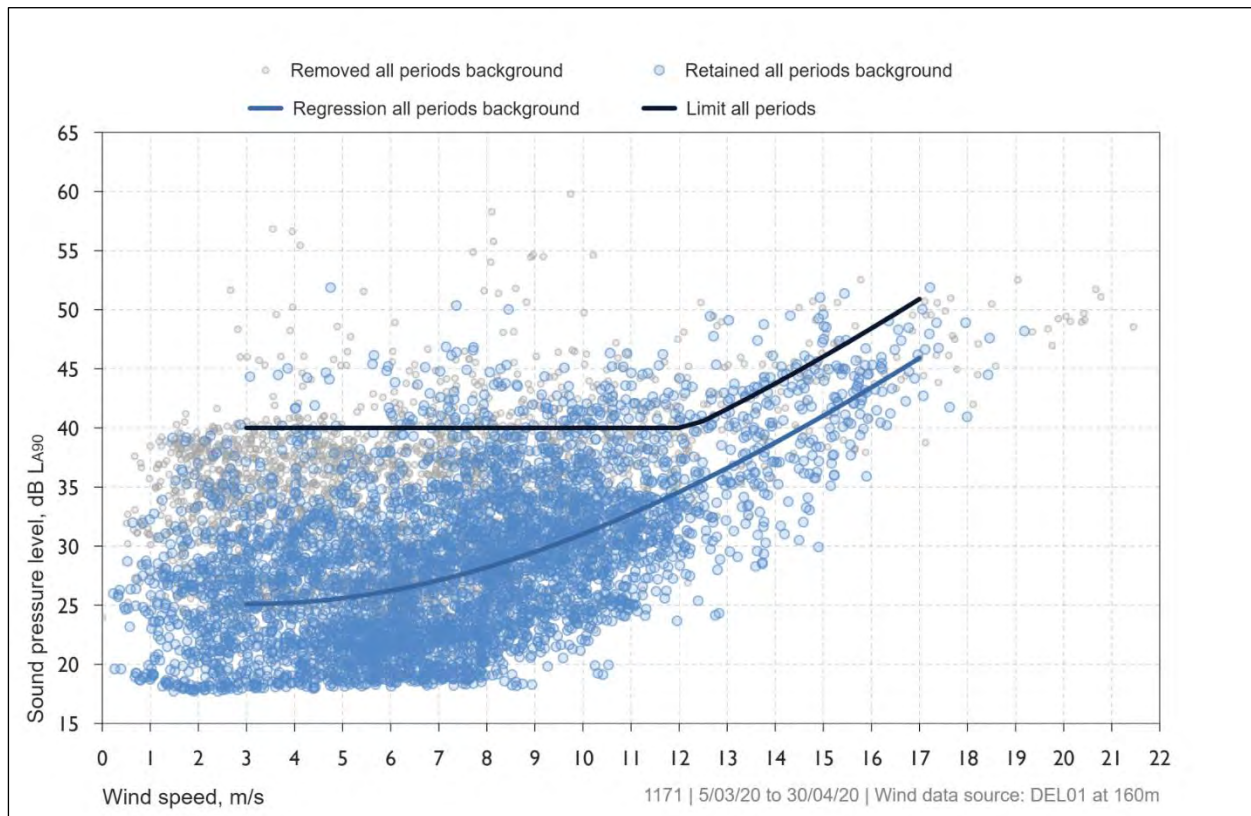
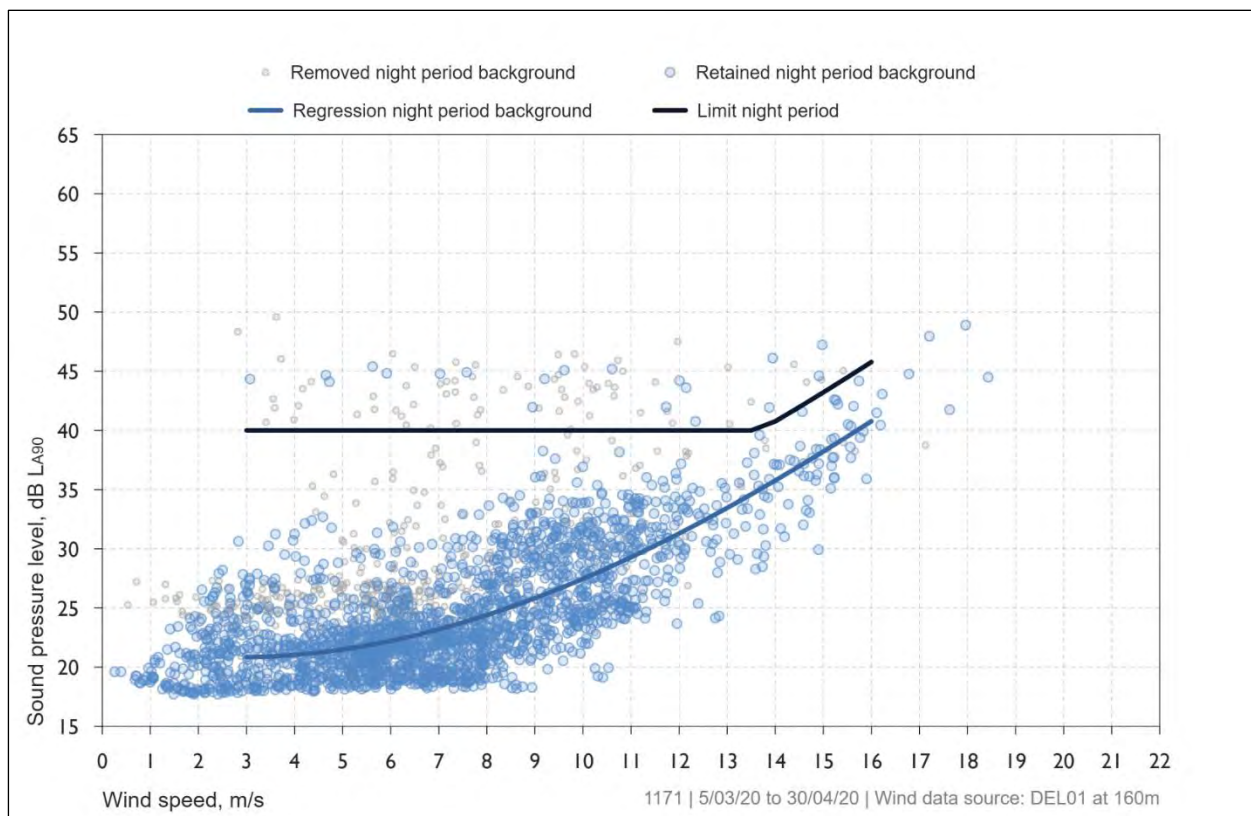


Figure 33: Receiver 1171 night-time periods – derived background noise levels and noise limits



APPENDIX O RECEIVER 4585 DATA

O1 Receiver 4585 location data

Table 40: Receiver 4585 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting	Northing
Dwelling location	435,309	5,753,658
Background noise monitoring location	435,268	5,753,687

Figure 34: Receiver 4585 aerial view - dwelling and noise monitor location



Table 41: Receiver 4585 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

O2 Receiver 4585 measurement data summary

Table 42: Receiver 4585 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 – 0700 hrs)
Number of data points collected	7,903	2,932
Number of data points removed	4,961	2,384
Number of data points for analysis	2,942	548

It should be noted that the number of analysed data points during the night-time period is lower than 1,440, as recommended in Section C7.2.1 of NZS 6808:2010 *to give suitable range of data*.

However, the derived background level is representative of the lower range of noise levels that occurred at this receiver during the noise monitoring period and consistent with the general trend of background noise levels derived at other receivers.

The derived background noise level is therefore considered suitable for planning assessment purposes. Depending on the final wind turbine design, additional background noise monitoring may be required at this property.

Figure 35: Receiver 4585 background noise level and wind speed time history

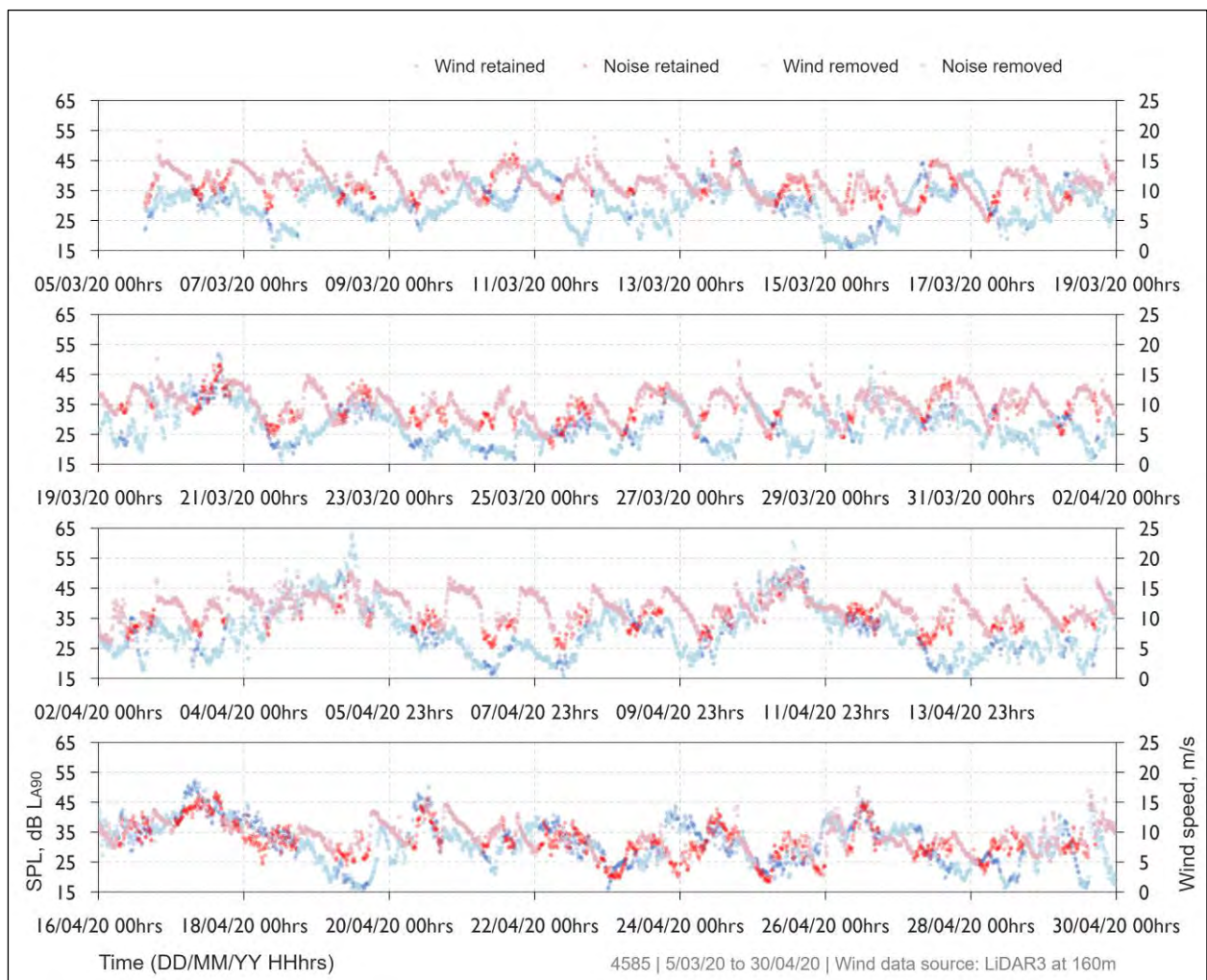


Figure 36: Receiver 4585 all-time periods – derived background noise levels and noise limits

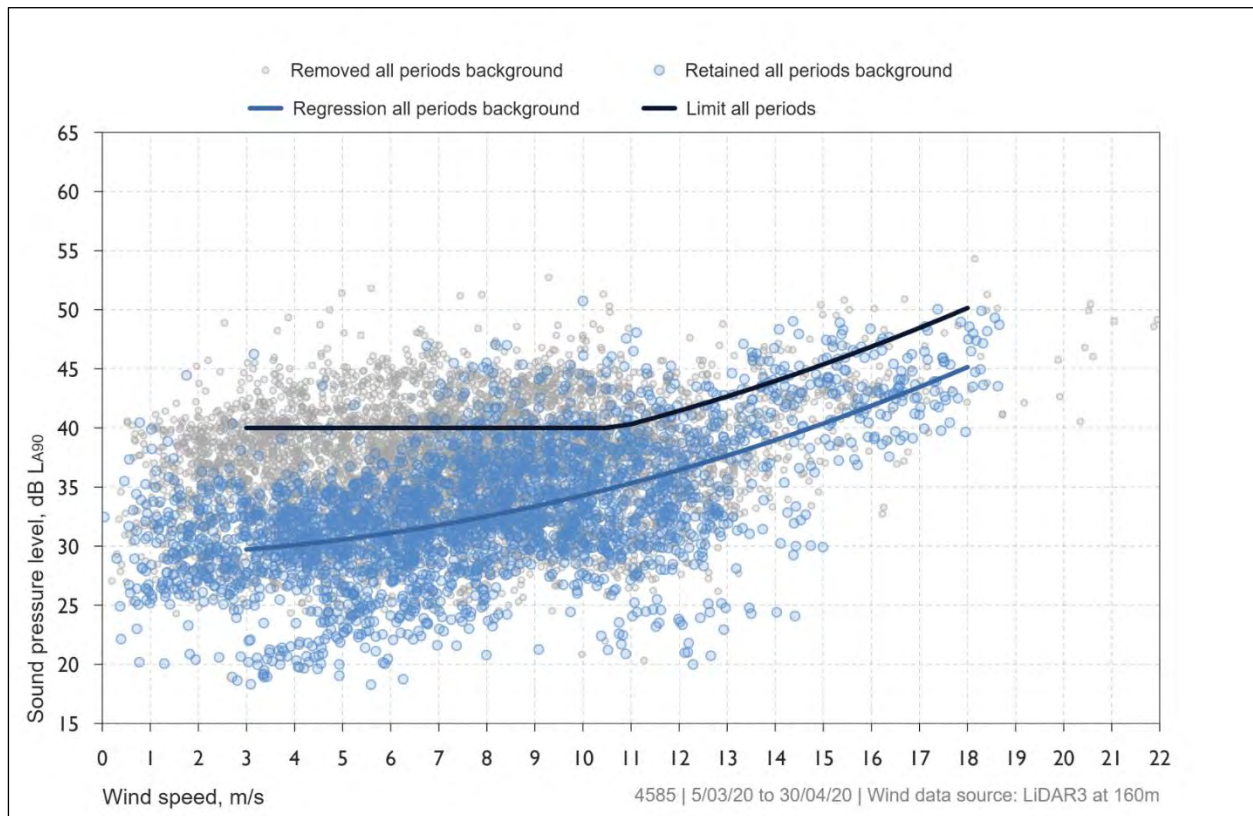


Figure 37: Receiver 4585 night-time periods – derived background noise levels and noise limits

