MARSHALL DAY Acoustics

RYAN CORNER WIND FARM
BACKGROUND NOISE MONITORING

Rp 002 20180786 | 20 August 2020

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1.0 INTRODUCTION

This report presents the results of background noise monitoring undertaken for the approved Ryan Corner Wind Farm.

The planning permit[1] for the Ryan Corner Wind Farm allows for the development of fifty-six (56) wind turbines and associated infrastructure, subject to a set of conditions relating to matters including environmental noise levels.

In accordance with the requirements of the planning permit, a Noise Compliance Test Plan (NCTP[2]) was prepared for the wind farm. The NCTP identifies the preferred locations for conducting noise compliance monitoring after the wind farm commences operating.

Ryan Corner Development Pty Ltd (RCD), a subsidiary of Global Power Generation Pty Ltd. (GPG), are developing the wind farm, and commissioned the background noise survey to:

- Determine operational noise limits in accordance with the planning permit
- Assist the analysis of noise data obtained from compliance monitoring after the wind farm commences operating.

This report documents the survey methodology and the results of the background noise monitoring, along with the derived noise limits which would be used to assess the wind farm's compliance with operational noise conditions contained in the planning permit.

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 existing on land in the vicinity of the approved wind energy facility as of 28 February 2017, as stated in the planning permit.

1 Planning Permit No.: 20060222-A as amended 21 December 2017.

2 MDA draft report Rp 001 01Draft *20180786 Ryan Corner Wind Farm – Noise Compliance Test Plan* dated 20 August 2018

2.0 BACKGROUND NOISE SURVEY & ANALYSIS METHODOLOGY

The background noise survey and analysis were carried out in accordance with the following:

- The planning permit for the Ryan Corner Wind Farm. The relevant extracts from the planning permit are reproduced in Appendix C.
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), as referenced in the planning permit
- 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 (UK IOA good practice guide).

This section of the report presents:

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

2.1 Monitoring locations

The NCTP nominates a total of nine (9) receivers that are preferred locations for conducting post-construction noise compliance monitoring, subject to permission being granted by the landowners. The NCTP also notes that if permission is not able to be obtained for the monitoring, alternative locations shall be considered.

In the time since the NCTP was prepared, the preferred monitoring location identified as receiver 9 was determined to be shed or office related to a quarry[3] and is therefore no longer a noise sensitive location to be addressed in the noise compliance assessment.

RCD subsequently sought permission for monitoring at the remaining eight (8) preferred locations. Permission was not able to be obtained at one (1) location, receiver 77. Consistent with the NCTP, potential substitute locations were reviewed. In lieu of an access to monitor at receiver 77, or an alternative nearby receiver location, an intermediate location positioned between the wind farm site and the original preferred noise compliance monitoring location was adopted as the substitute. Background noise data obtained at the intermediate location is used solely as a reference for the potential contribution of background noise to any future post-construction noise measurements undertaken at 78 (S) (i.e. not for the purpose of setting noise limits).

[3] Based on advice provided by consultants ERM via email dated 23 March 2020.

Background noise monitoring was subsequently carried out at a total of eight (8) locations listed in Table 1.

Table 1: Background noise monitoring locations – distance and direction relative to wind farm

Receiver	Direction from nearest turbine	Distance from nearest turbine (m)
7	SSW	1,117
10	SSW	1,344
11	NNW	1,070
26	NE	1,315
27	E	1,195
29	E	1,137
31	E	1,227
78 (S)	NW	983

The location of each of these receivers is illustrated in Figure 1.

At each of the receivers where noise monitoring was carried out, the choice of location relative to the dwelling was made on account of the range of considerations specified in NZS 6808:2010. The following specific considerations were factored:

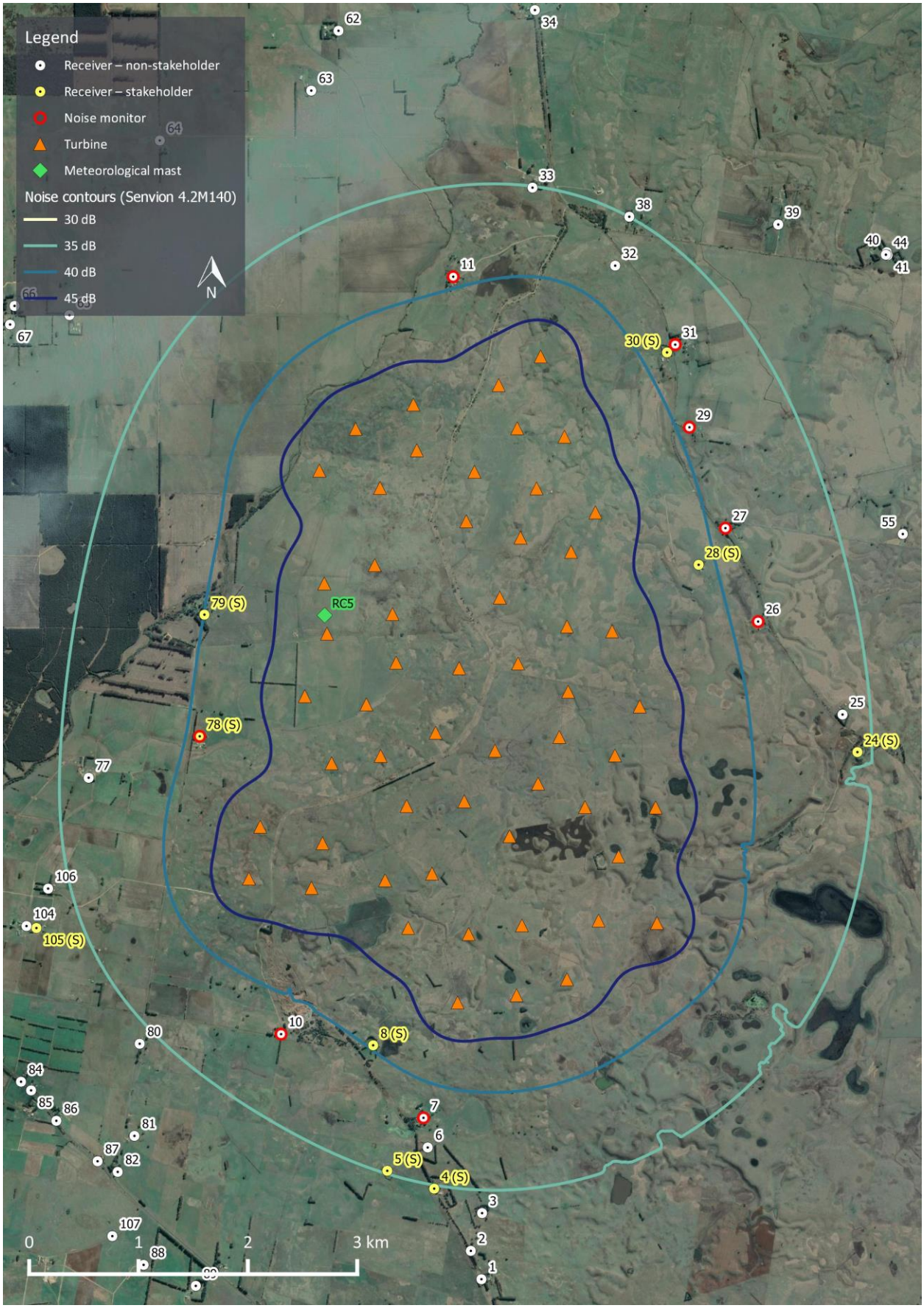
- The noise monitors were located on the approved wind farm side of the dwelling
- The noise monitors were located at least 5 m away from the dwelling and any significant vertical reflecting structures
- The noise monitors were generally located as far as practical from taller vegetation and any obvious sources of extraneous noise (where practical).

In the case of receiver 7, a standby diesel generator and water pump were noted to be in the rear yard of the main dwelling at the property, and are intermittent sources of noise at the property. The location selection at this receiver was made on account of a range of factors, including the proximity of the identified equipment (and the likelihood of their noise contribution being more readily identifiable at positions nearer to the equipment), vegetation, the orientation of the dwelling relative to the proposed turbine locations, and practical considerations identified by the land owner. The noise contribution of the identified equipment, and the removal of periods likely to have been affected by their operation, are discussed in subsequent sections.

In the case of receiver 10, the property is noted to be in the vicinity of an operational quarry to the north (i.e. on the same side of the dwelling as the proposed wind turbine layout). The noise of the quarry was an identifiable feature in the ambient noise environment at the property. Subsequent sections provide details of the periods most likely to have been affected by increased quarry noise which have been removed from the analysis.

Coordinates and photographs for the noise monitoring locations are provided in Appendix G to Appendix N.

Figure 1: Monitoring locations relative to the approved Ryan Corner Wind Farm



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	Eight (8) receiver locations as described in Section 2.1.
Monitoring Period	14/5/2020 to 3/7/2020 equating to approximately six (6) to seven (7) weeks at each location. 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.
Sound level meters	Class 1 automated sound loggers (most accurate class rating for field usage). 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. See equipment specifications and calibration records in Appendix D.
Noise measurement data	A-weighted average and statistical sound pressure levels. One-third octave band frequency noise levels and a brief audio sample every ten (10) minutes to aid the identification of extraneous noise influences.
Local wind speed and rainfall data	A weather station was installed beside one of the noise monitoring locations to concurrently record rainfall and wind speeds at microphone height. This data was recorded to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone (i.e. rainfall).
Site wind speed data	Hub height wind speeds for correlating background noise levels with site wind speeds. Site wind speed data was sourced from mast reference RC5, extending to a height of 40 m above ground level. RC5 was chosen on account of the anticipated availability of comparable data in the future. Hub height wind speed data (112 m above ground level) was provided by wind data analysts Energy3 Services, based on their analysis to extrapolate the 20 m and 40 m height anemometer wind speed data to 112 m using site-specific wind shear calculations. A summary of the wind data and the analysis process is reproduced in Appendix E.

2.3 Data analysis

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

This analysis 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 for the range of site wind speeds in which the turbines are expected to operate
- 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	Time stamps for each source of measurement data are reviewed to clarify start or end times and measurement time zone. Measured noise levels, site wind speeds and local weather conditions are then collated for each 10-minute measurement interval.
Local weather data filtering	10-minute intervals are identified and filtered from the analysis if rainfall was identified for any ten-minute measurement interval
Extraneous noise filtering	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. 10-minute intervals have been identified, and filtered from the analysis, when the following conditions[4] are satisfied: • 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}. Additional data filtering procedures were applied for receivers 7, 10, 11 and 78 (S), based on inspection of the time history of the measured noise levels. Further details specific to these locations are provided following this table.
Time periods	In accordance with the planning permit, the data sets are considered for separate periods as follows: • 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*.

Process	Description
Regression analysis	Two datasets are plotted on a chart of noise levels versus wind speeds: • All data points that have been removed from the analysis using the above processes • The filtered dataset comprising all retained measurement data 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). 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.
Noise limits	Noise limits are defined at each wind speed in accordance with NZS 6808:2010 by a value of 40 dB 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 to the measurement results. In accordance with the planning permit, these noise limits are separately defined for all periods (i.e. including all hours of the day and night) and the night period.

The following provides further details regarding the additional extraneous noise filtering carried out for receivers 7, 10, 11 and 78 (S):

- Receiver 7: occasional periods of elevated semi-steady noise consistent with the influence of the water pump and standby generator at the property were clearly evident, primarily during the day (0700 - 2200 hrs). However, their influence was not always clearly identifiable, nor were there any clearly identifiable markers of their influence in the logged frequency data. In contrast, the operation of the equipment was not evident the night-time period measured noise levels. Given these characteristics, and the absence of clear markers to identity and remove affected periods during the day, only the background noise data measured during the night has been used to set limits. The data for the all-time period (which includes the day period) is provided for reference purposes only.
- Receiver 10: elevated noise levels that are likely to be attributable to the operation of the quarry to the north of the property were most evident during working hours on weekdays. All background noise data for the period 0700 - 1700 hrs was therefore removed from the analysis for this receiver.
- Receiver 11: elevated noise levels were regularly evident in the time history during the day period. A selection of audio recordings were reviewed and indicated the periods of elevated noise were attributable to activity within an adjoining workshop at the property. The periods affected by workshop noise were not always able to be clearly identified in the time history, nor were there clearly identifiable markers of the influence in the logged frequency data. Accordingly, only the background noise data measured during the night has been used to set limits. The data for the all-time period (which includes the day period) is provided for reference purposes only.
- Receiver 78 (S): elevated noise levels were occasionally evident in the time history. A selection of audio recordings for this location were reviewed and identified elevated noise levels associated with building work at the property, gardening activities and extraneous noise on the microphone. Based on visual inspection of the trend of the data, and the audio reviews, noise levels above 45 dB L_{A90} at wind speeds below 10 m/s have been filtered from the analysis, as well as a number of isolated periods in the time history profile that were characterised by atypical and distinct noise level increases.

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 2.2.

The analysis results include the noise limits which would be used during compliance monitoring to assess the operational noise of the Ryan Corner Wind Farm.

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 N.

All data presented in these tables has been analysed and filtered according to the procedures described in Section 2.3 (including the removal of data during 0700 - 1700 hrs on weekdays at receiver 10).

Further, as per the observations and analysis procedures described in Section 2.0, the data for all-time periods for receivers 7 and 11 were affected by local sources of extraneous noise at each property which could not be filtered from the analysis. The results for these receivers for the all-time period are therefore provided for general reference purposes only.

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

Location	Hub height wind speed (m/s) [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
7 [2]	29.5	30.3	31.1	32.0	33.0	34.0	35.2	36.5	38.0	39.5	41.3	43.1	45.2
10	28.8	29.2	29.8	30.6	31.5	32.7	34.1	35.7	37.4	39.4	41.5	43.8	46.4
11 [2]	27.7	28.1	28.6	29.4	30.4	31.5	32.9	34.4	36.1	38.0	40.1	42.4	44.8
26	26.8	27.2	27.8	28.6	29.6	30.8	32.3	33.9	35.8	37.8	40.1	42.6	45.2
27	26.8	27.2	27.8	28.8	29.9	31.3	32.9	34.8	36.8	39.0	41.3	43.8	46.5
29	28.9	29.4	30.1	31.0	32.0	33.3	34.8	36.4	38.3	40.3	42.5	44.8	47.3
31	27.8	28.3	28.9	29.8	30.7	31.9	33.2	34.6	36.2	38.0	39.9	42.0	44.3
78 (S)	27.8	28.1	28.6	29.3	30.1	31.2	32.4	33.8	35.4	37.2	39.1	41.3	43.6

Note 1: 112 m above ground level at 596543 m E, 5762211 N (AMG66 Zone 54)

Note 2: Data for the receiver locations affected by local sources of extraneous noise – data presented for reference only

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

Location	Hub height wind speed (m/s) [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
7	28.2	28.4	28.8	29.4	30.1	31.1	32.2	33.4	34.9	36.5	38.3	40.3	42.5
10	-	-	-	31.2	31.5	32.1	33.1	34.4	36.0	38.1	40.4	43.1	46.2
11	22.6	22.9	23.4	24.2	25.2	26.5	28.0	29.9	31.9	34.2	36.8	39.7	42.8
26	-	24.2	24.5	25.0	25.8	26.9	28.3	30.0	31.9	34.2	36.7	39.5	42.6
27	22.4	22.7	23.3	24.2	25.3	26.8	28.5	30.6	32.9	35.5	38.5	41.7	45.2
29	-	25.5	25.8	26.3	27.2	28.4	29.9	31.8	33.9	36.4	39.2	42.4	45.8
31	22.5	23.1	23.9	24.8	25.9	27.2	28.6	30.2	31.9	33.8	35.9	38.1	40.5
78 (S)	-	27.0	27.1	27.4	28.0	28.8	29.9	31.3	32.9	34.8	36.9	39.3	41.9

Note 1: 112 m above ground level at 596543 m E, 5762211 N (AMG66 Zone 54)

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 the planning permit and NZS 6808:2010.

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 at applicable locations are illustrated in the graphical data provided for each receiver location in Appendix G to Appendix M.

Background noise dependent noise limits for receivers 7 and receiver 11 are presented for the night-time period, on account of the local sources of extraneous noise which were evident in the background noise data during the day time periods.

Noise limits are also not presented for receiver 78 (S) on account of this location being an involved receiver where the planning permit noise limits do not apply.

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

Location	Hub height wind speed (m/s) [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
10	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.7	42.4	44.4	46.5	48.8	51.4
26	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.8	42.8	45.1	47.6	50.2
27	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.8	44.0	46.3	48.8	51.5
29	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.4	43.3	45.3	47.5	49.8	52.3
31	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.0	44.9	47.0	49.3

Note 1: 112 m above ground level at 596543 m E, 5762211 N (AMG66 Zone 54)

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

Location	Hub height wind speed (m/s) [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
7	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.5	43.3	45.3	47.5
10	-	-	-	40.0	40.0	40.0	40.0	40.0	41.0	43.1	45.4	48.1	51.2
11	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.8	44.7	47.8
26	-	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.7	44.5	47.6
27	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.5	43.5	46.7	50.2
29	-	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.4	44.2	47.4	50.8
31	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.9	43.1	45.5

Note 1: 112 m above ground level at 596543 m E, 5762211 N (AMG66 Zone 54)

4.0 SUMMARY

Background noise monitoring was carried out at eight (8) receiver locations around the approved Ryan Corner Wind Farm.

The monitoring was carried out at all locations detailed in the Noise Compliance Test Plan (NCTP) where permission was able to be obtained from landowners (excluding receiver 9 which was subsequently verified as an office or shed associated with a quarry). In accordance with the NCTP, a substitute location was nominated and surveyed for receiver 77 where permission for monitoring was not able to be obtained.

The survey and analysis were carried out on the basis of:

- The planning permit for the Ryan Corner Wind Farm dated 21 December 2017
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), as referenced in the planning permit.

The results have been analysed to derive noise limits in accordance with the planning permit (where applicable and appropriate). Specifically, noise limits have been derived at integer hub-height wind speeds as the greater of a minimum limit (40 dB) and the background level plus 5 dB.

The results of the measurements are to be referenced during the compliance monitoring phase of the project as an indication of potential background noise levels contributing to the compliance measurements.

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 – Part 1: 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 L_A dB. 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 above this table.
A-weighted 90th 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 SITE LAYOUT

B1 Turbine coordinates

The following table sets out the coordinates of the fifty-six (56) turbine layout of the Ryan Corner Wind Farm (data sourced from NCTP).

Table 8: Ryan Corner Wind Farm turbine coordinates – AMG66 zone 54

Turbine	Easting (m)	Northing (m)	Turbine	Easting (m)	Northing (m)	Turbine	Easting (m)	Northing (m)
B6	598757	5758884	B30	598310	5761771	B52	596999	5762670
B8	599580	5759399	B31	599170	5762065	B54	596538	5762502
B9	599046	5759421	B32	598757	5762109	B55	597162	5762223
B10	597757	5758672	B33	598794	5762791	B58	596563	5762043
B13	597858	5759298	B34	598143	5762373	B59	597195	5761778
B14	597305	5759354	B35	599017	5763152	B60	597771	5761728
B15	597523	5759851	B36	598332	5762921	B62	596360	5761472
B16	597291	5760468	B37	597836	5763071	B63	596923	5761397
B17	597818	5760511	B38	598479	5763372	B64	597556	5761138
B18	598232	5760192	B39	597911	5763523	B66	596605	5760859
B20	599229	5760008	B40	598734	5763844	B67	597053	5760926
B21	599568	5760455	B41	598302	5763921	B69	595952	5760279
B22	598922	5760458	B43	598516	5764577	B70	595849	5759805
B23	598493	5760673	B44	598133	5764316	B72	596522	5760128
B24	599196	5760931	B45	597353	5764138	B73	597094	5759789
B25	598687	5761099	B46	596825	5763915	B74	596421	5759720
B26	598099	5760974	B47	597384	5763720	B75	598345	5759377
B28	599422	5761378	B48	596493	5763534	B76	598296	5758739
B29	598768	5761513	B49	597048	5763375			

B2 Dwelling coordinates

The following table sets out the coordinates of receiver locations considered in the preparation of the Ryan Corner Wind Farm NCTP. Locations annotated with the text (S) indicate participating receiver locations where a noise agreement is in place with the landowner.

Table 9: Ryan Corner Wind Farm receiver locations – AMG66 zone 54

Property	Easting (m)	Northing (m)	Distance to nearest turbine (m)	Property	Easting (m)	Northing (m)	Distance to nearest turbine (m)
1	597975	5756143	2541	57	604892	5762497	5584
2	597878	5756402	2276	58	605747	5762311	6394
3	597981	5756747	1941	59	607068	5762746	7768
4 (S)	597543	5756971	1718	60	597138	5768213	3890
5 (S)	597114	5757134	1671	61	596888	5768507	4255
6	597484	5757347	1357	62	596668	5767554	3486
7	597445	5757618	1105	63	596419	5767007	3019
8 (S)	596985	5758281	872	64	595034	5766551	3189
9	596409	5758436	1288	65	594208	5764955	2692
10	596143	5758383	1370	66	593706	5765039	3169
11	597717	5765306	1079	67	593665	5764869	3129
12	604630	5753104	8071	68	593571	5765006	3273
13	603817	5753670	7126	69	593218	5764987	3584
14	603420	5754084	6558	70	592447	5764982	4298
15	603370	5754550	6155	71	593393	5766801	4486
16	603058	5755340	5346	72	593391	5765794	3839
17	603865	5755329	5911	73	593389	5765028	3446
18	603766	5755796	5524	74	593355	5764456	3272
19	603660	5756021	5298	75	593354	5763088	3172
20	603411	5758532	3929	76	592993	5761115	3077
21	602957	5759722	3394	77	594399	5760739	1623
22	602613	5760102	3067	78 (S)	595399	5761105	999
23	602358	5760760	2809	79 (S)	595442	5762217	1138
24 (S)	601413	5760961	1917	80	594850	5758295	1814
25	601277	5761304	1860	81	594802	5757453	2577
26	600505	5762154	1337	82	594649	5757124	2939
27	600206	5763008	1202	83	593568	5758118	2839
28 (S)	599961	5762673	1004	84	593765	5757948	2794
29	599864	5763944	1140	85	593857	5757869	2780
30 (S)	599672	5764614	1161	86	594088	5757591	2831

Property	Easting (m)	Northing (m)	Distance to nearest turbine (m)	Property	Easting (m)	Northing (m)	Distance to nearest turbine (m)
31	599747	5764685	1241	87	594465	5757221	2933
32	599198	5765407	1080	88	594886	5756274	3662
33	598442	5766120	1548	89	595363	5756082	3529
34	598464	5767743	3168	91	596050	5755830	3317
35	598304	5768202	3633	92	596476	5755382	3532
36	603583	5756999	4669	93	596806	5755033	3763
37	598335	5768563	3992	94	597289	5754740	3961
38	599327	5765854	1517	95	597115	5753882	4834
39	600689	5765783	2488	96	598847	5754153	4620
40	601682	5765530	3308	97	599056	5754284	4520
41	601688	5765503	3306	98	599934	5753384	5601
42	603023	5766174	4783	99	600495	5753780	5393
43	603149	5766336	4957	100	600296	5753102	5982
44	601673	5765507	3293	101	600296	5753102	5982
45	604208	5766335	5958	102	600554	5752786	6358
46	604305	5766271	6033	103	600486	5752655	6466
47	604371	5763651	5378	104	593815	5759371	2083
48	604258	5763410	5247	105 (S)	593906	5759353	1998
49	604108	5762116	4745	106	594013	5759713	1841
50	603909	5759583	4334	107	594600	5756537	3500
51	604080	5767164	6137	108	605095	5757584	5807
52	604884	5760860	5333	109	605164	5757571	5877
53	606155	5759651	6581	110	605306	5757550	6018
54	606057	5758536	6535	111	605699	5758051	6267
55	601828	5762954	2805	112	605285	5751821	9486
56	602065	5762934	3025				

(S) Stakeholder property

APPENDIX C PLANNING PERMIT – RELEVANT NOISE EXTRACTS

The planning permit for the Ryan Corner Wind Farm (Permit No.: 20060222-A), as amended 21 December 2017, contains the following requirements that are relevant to the background noise monitoring.

NOISE STANDARD

31. Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808:2010 Acoustics — Wind farm noise in relation to any dwelling existing on land in the vicinity of the wind energy facility as at 28 February 2017, to the satisfaction of the Minister of Planning. In determining compliance with the standard, the following requirements apply:

(a) The sound level from the wind energy facility, when measured outdoors within 10 metres of a dwelling at any relevant nominated wind speed, must not exceed the background level (LA90) by more than 5 dB or a level of 40 dB LA90, whichever is the greater. If access cannot be gained to undertake testing within 10 metres of a property, consent from the Minister for Planning may be sought to test at another location.

(b) Compliance at night must be separately assessed with regard to night-time data. For these purposes the night is defined as 10.00pm to 7.00am.

(c) Where special audible characteristics, including tonality, impulsive sound or excessive amplitude modulation occur, the measured noise level with the identified special audible characteristics will be modified by applying a penalty of up to +6 dB LA90 in accordance with Section 5.4 of the Standard.

The limits specified under this condition do not apply if an agreement has been entered into with the relevant landowner waiving the limits. Evidence of the agreement must be provided to the satisfaction of the Minister for Planning upon request, and be in a form that applies to the land for the life of the wind energy facility.

NOISE COMPLIANCE ASSESSMENT

32. An independent post-construction noise monitoring program must be commissioned by the proponent within 2 months from the commissioning of the first turbine and continue for 12 months after the commissioning of the last turbine, to the satisfaction of the Minister for Planning. The independent expert must have experience in acoustic measurement and analysis of wind turbine noise. The program must be carried out in accordance with New Zealand Standard 6808:2010 as varied by Condition 31 above. The operator under this permit must pay the reasonable costs of the monitoring program.

33. The results of the post-construction noise monitoring program, data and details of compliance and non-compliance with the New Zealand Standard must be forwarded to the Minister for Planning within 14 months after the commissioning of any turbine. The results must be written in plain English and formatted for reading by laypeople.

34. All noise compliance reports must be accompanied by a report from an environmental auditor appointed under the Environment Protection Act 1970 with their opinion on the methodology and results contained in the noise compliance testing plan. If a suitable auditor cannot be engaged, the proponent may seek the written consent of the Minister for Planning to obtain an independent peer review of the noise report instead.

APPENDIX D SURVEY INSTRUMENTATION

Table 10: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB CUBE & DUO
Instrumentation class	Class 1 (precision grade) in accordance with AS/IEC 61672.1:2019[5]
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 11: Sound level meter installation records

Receiver	System	Unit serial number	Microphone serial number	Independent calibration date [1]	Calibration drift [2,3]
7	01DB CUBE	10421	260714	27/07/2018	+0.38
10	01DB DUO	10496	141230	5/07/2018	-0.35
11	01DB CUBE	10514	161824	3/07/2018	+0.16
26	01DB CUBE	10522	224366	10/03/2020	-0.14
27	01DB DUO	10302	144986	14/05/2019	-0.20
29	01DB CUBE	10512	255851	9/05/2019	+0.23
31	01DB DUO	10498	207226	11/09/2018	0.00
78 (S)	01DB CUBE	10511	255808	19/11/2018	-0.29

Note 1: Independent laboratory calibration date to be within 2 years of measurement period as per AS 1055:2018

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

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

Table 12: Wind speed measurement instrumentation

Wind speeds	Description
Local wind speeds	Vaisala WXT520 weather station (serial number K1850004 positioned at receiver 29.
Site wind speeds	Third party owned and operated system comprising a meteorological mast with anemometry at multiple heights. Further information provided in Appendix E.

[5] 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 2013

APPENDIX E SITE WIND SPEED DATA DERIVATION

This appendix summarises the wind speed data and analysis undertaken by consultants Energy3 Services to produce a continuous data set of wind speeds at the proposed hub height of the turbines.

Hub height wind speed data can be sourced either directly from measurements at the proposed hub height or, as is more commonly the case, by calculations to extrapolate wind speed measurements made at lower heights to the required hub-height. In this case, the hub-height data was determined by calculation from lower measurement heights. A summary of the data sources and analysis methodology is provided in Table 13.

Table 13: Wind data source and analysis methodology

Item	Description
Wind speed measurement data source	Meteorological mast reference: RC5 Coordinates: 596543 m E, 5762211 N (AMG66 Zone 54) Other masts were located at the site during the survey period. Mast RC5 nominated as the appropriate reference on account of the anticipated availability of comparable data in the future, and the unavailability of 60 m anemometer data from RC3, which was not operational during the monitoring period. RC5 is also located to the northwest of the site and may therefore be a more practical location for sourcing wake-free wind data for prevailing wind directions at the site following construction of the wind farm.
Wind speed measurement heights	20 m and 40 m
Data extrapolation methodology	The analysis methodology adopted by Energy3 Services was generally based on the procedure detailed in the UK Institute of Acoustic 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) which is commonly referenced in Australia. The procedure involved calculation of wind shear exponents for each 10-minute period, based on the simultaneously measured 20 m and 40 m height wind speeds. The calculated wind shear was then used to determine the corresponding 112 m height wind speed (proposed hub-height) for the 10-minute period, provided that the calculated wind shear was not or above or below a set of upper and lower bounds. If the wind shear for a given 10-minute period was below the lower bound, the lower bound shear value was used to determine the 112 m height wind speed; conversely if the calculated wind shear was above the upper bound, the upper bound shear value was used to determine the 112 m height wind speed. The upper and lower bounds were determined from statistical analysis (mean plus or minus two standard deviations) of an historic long term wind speed dataset measured by a LiDAR which was located the site from 1/6/2017 to 10/4/2018), providing simultaneous measurements up to 110 m. The upper and lower were determined on a wind sector and wind speed dependent basis (i.e. separate lower and upper bounds were defined for each wind sector and wind speed). The UK IOA good practice guide indicates that an anemometer height greater than 60 % of the propose hub-height is preferred. The available 40 m measurement height is lower than 60 % of the proposed hub-height. However, analysis undertaken by Energy3 Services indicates that the approach used here based on 40 m height wind speeds is likely to slightly overestimate wind speeds at 112 m (based on comparison of the shear values determined from this method with shear values determined from the historic lidar data). For the purposes of a background noise survey, an overestimate of the wind speed provides a conservative assessment (i.e. it suggests higher wind speeds are needed to reach a given background sound level). The available 60 m measurement height is therefore considered acceptable.

Item	Description
Extrapolated wind speed data file	Spreadsheet *RC5_20200101_20200714_extrapolation_2.xlsx* received via email from Energy3 Services on 30 July 2020.
Time series	The format of the timeseries was confirmed by Energy3 Services by email on 21 July 2020 as follows: • Data time zone: UTC +10 (Australian Eastern Standard Time) • Time stamp format: all timestamps designate the end of a 10-minute measurement period.

APPENDIX F SUMMARY OF BACKGROUND NOISE LEVELS

Table 14: Regression equation coefficients – all-time periods

	Regression equation coefficients for background noise equation of best fit $L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					
Location	**a**	**b**	**c**	**d**	**R^2**	**Valid wind speed range (m/s)**
7	0.0017	0.0134	0.5938	27.58	0.3144	3-19
10	-	0.0967	-0.2738	28.72	0.3315	3-16
11	-0.0001	0.0972	-0.2863	27.67	0.2585	3-19
26	-	0.1031	-0.3159	26.77	0.3946	3-19
27	-0.0024	0.1671	-0.7151	27.54	0.4133	3-19
29	-0.0008	0.1150	-0.3115	28.87	0.4319	3-19
31	-	0.0799	-0.0663	27.28	0.2620	3-19
78 (S)	-	0.0923	-0.3496	28.06	0.3391	3-20

Table 15: Regression equation coefficients – night-time periods (2200 to 0700 hrs)

	Regression equation coefficients for background noise equation of best fit $L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					
Location	**a**	**b**	**c**	**d**	**R^2**	**Valid wind speed range (m/s)**
7	-	0.0888	-0.4102	28.66	0.2847	3-16
10	-	0.1740	-1.9880	36.87	0.2994	6-16
11	-	0.1288	-0.6382	23.35	0.4217	3-16
26	-	0.1425	-1.0360	26.09	0.4102	4-16
27	-	0.1479	-0.7638	23.41	0.4892	3-16
29	-	0.1622	-1.2370	27.90	0.4750	4-16
31	-	0.0811	0.0443	21.62	0.3289	3-16
78 (S)	-	0.1278	-1.0780	29.29	0.2777	4-16

APPENDIX G RECEIVER 7 DATA

G1 Receiver 7 location data

Table 16: Receiver 7 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	597445	5757618
Background noise monitoring location	597,396	5,757,620

Figure 2: Receiver 7 aerial view - dwelling and noise monitor locations

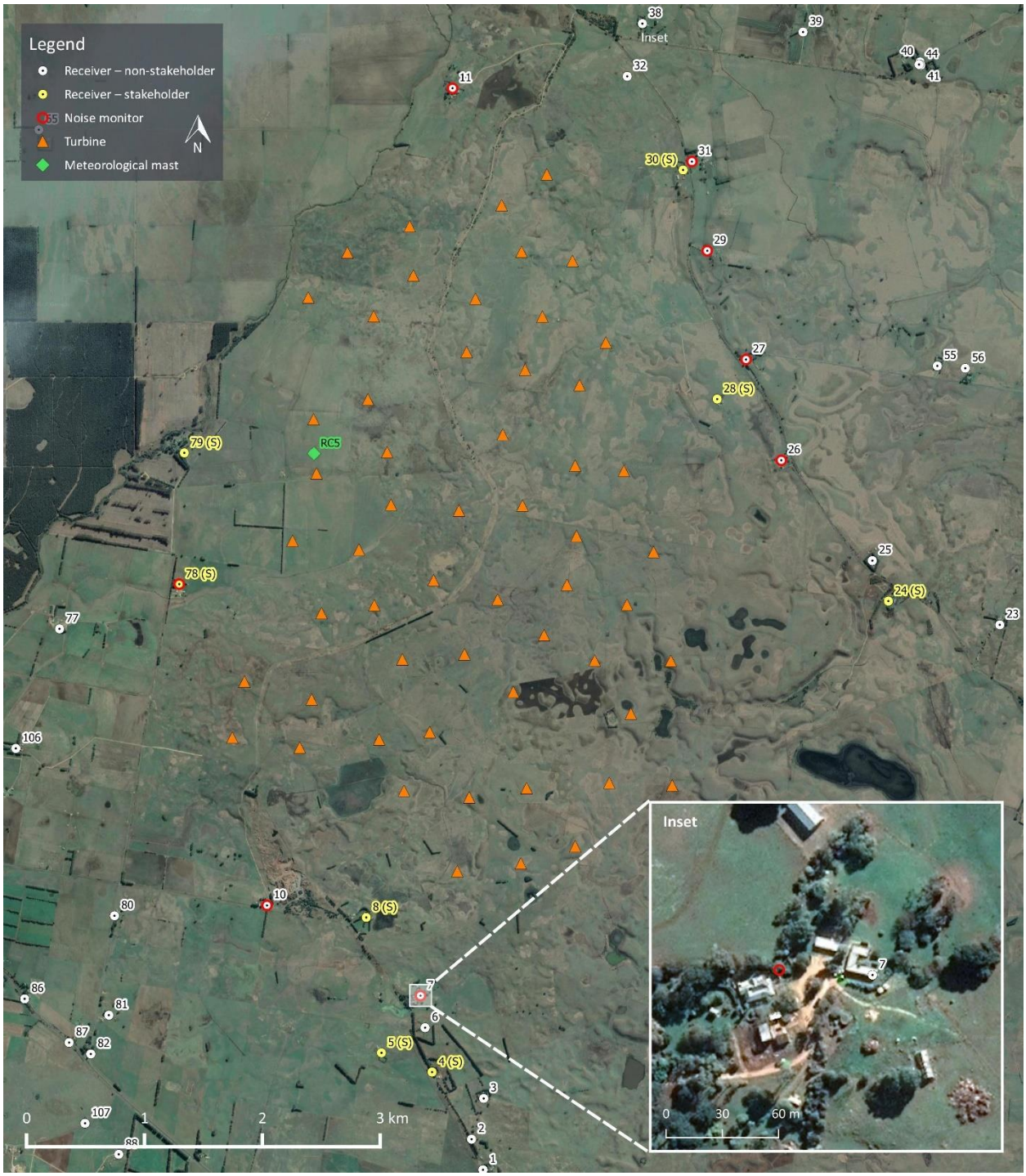


Table 17: Receiver 7 monitor installation photos

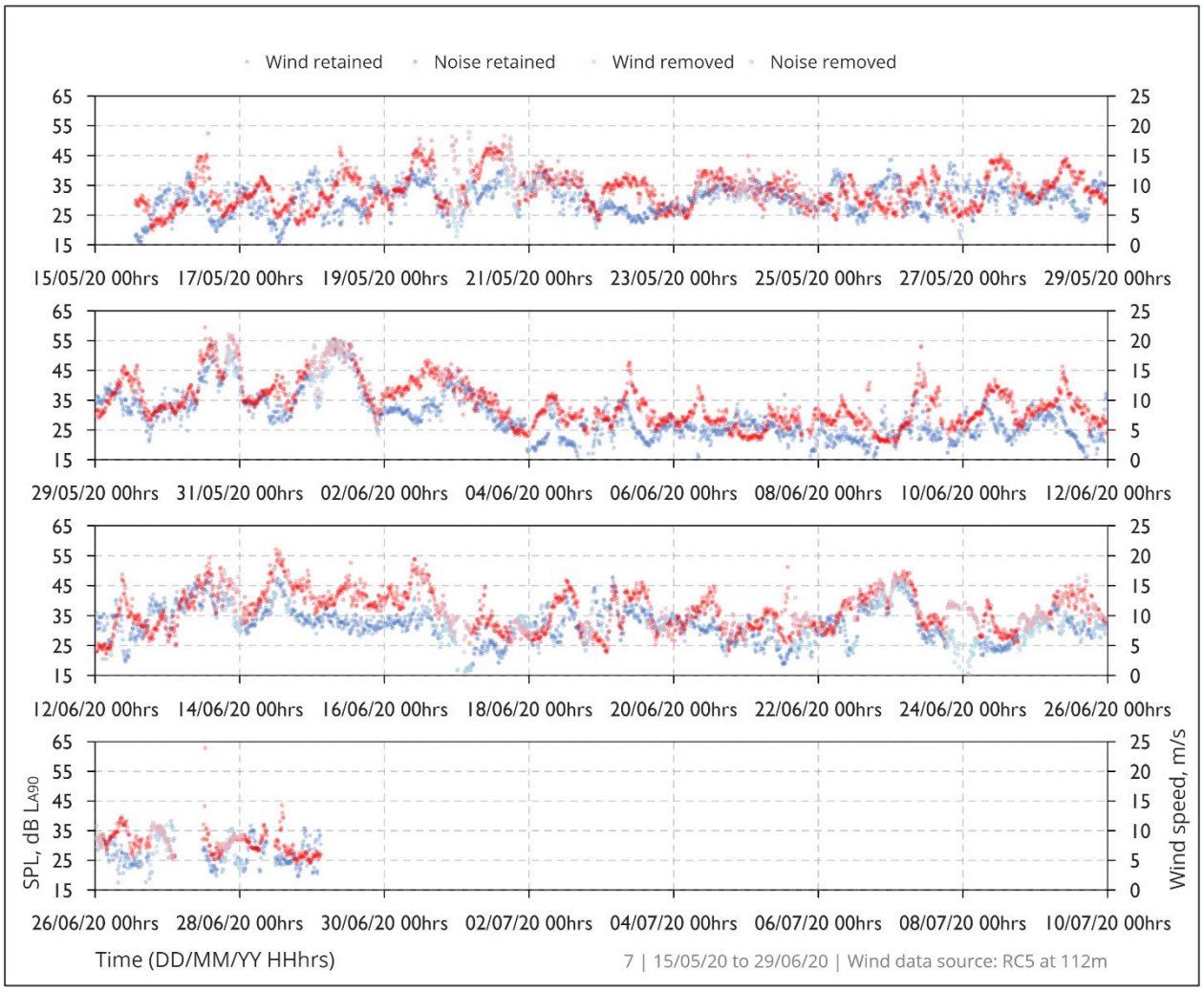
Looking North	Looking East
	
Looking South	**Looking West**
	

G2 Receiver 7 measurement data summary

Table 18: Receiver 7 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6096	2262
Number of data points removed	633	296
Number of data points for analysis	5463	1966

Figure 3: Receiver 7 background noise level and wind speed time history



Occasional periods of elevated semi-steady noise consistent with the influence of the water pump and standby generator at the property were clearly evident, primarily during the day (0700 - 2200 hrs). As their influence was not always clearly identifiable, nor were there any clearly identifiable markers of their influence in the logged frequency data, only the background noise data measured during the night has been used to set limits. The data for the all-time period (which includes the day period) is provided for reference purposes only.

Figure 4: Receiver 7 all-time periods – derived background noise levels

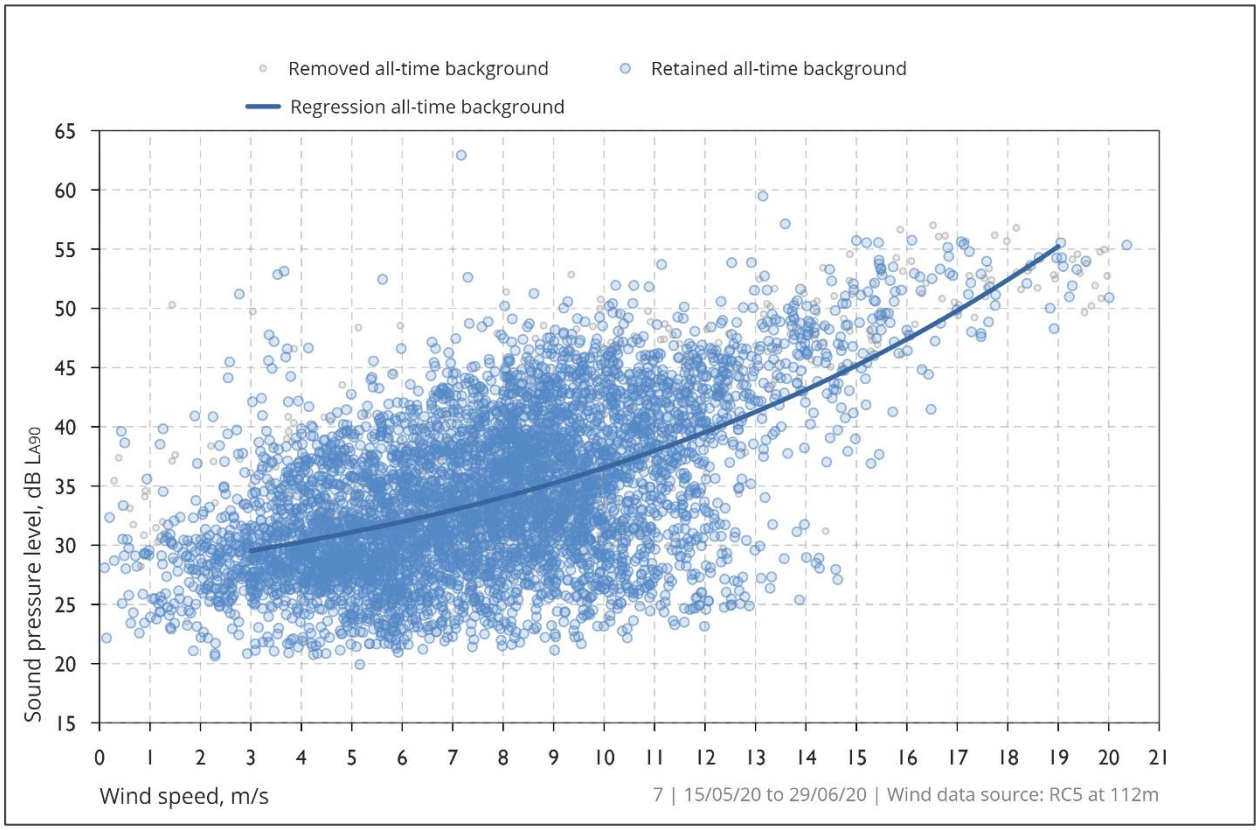
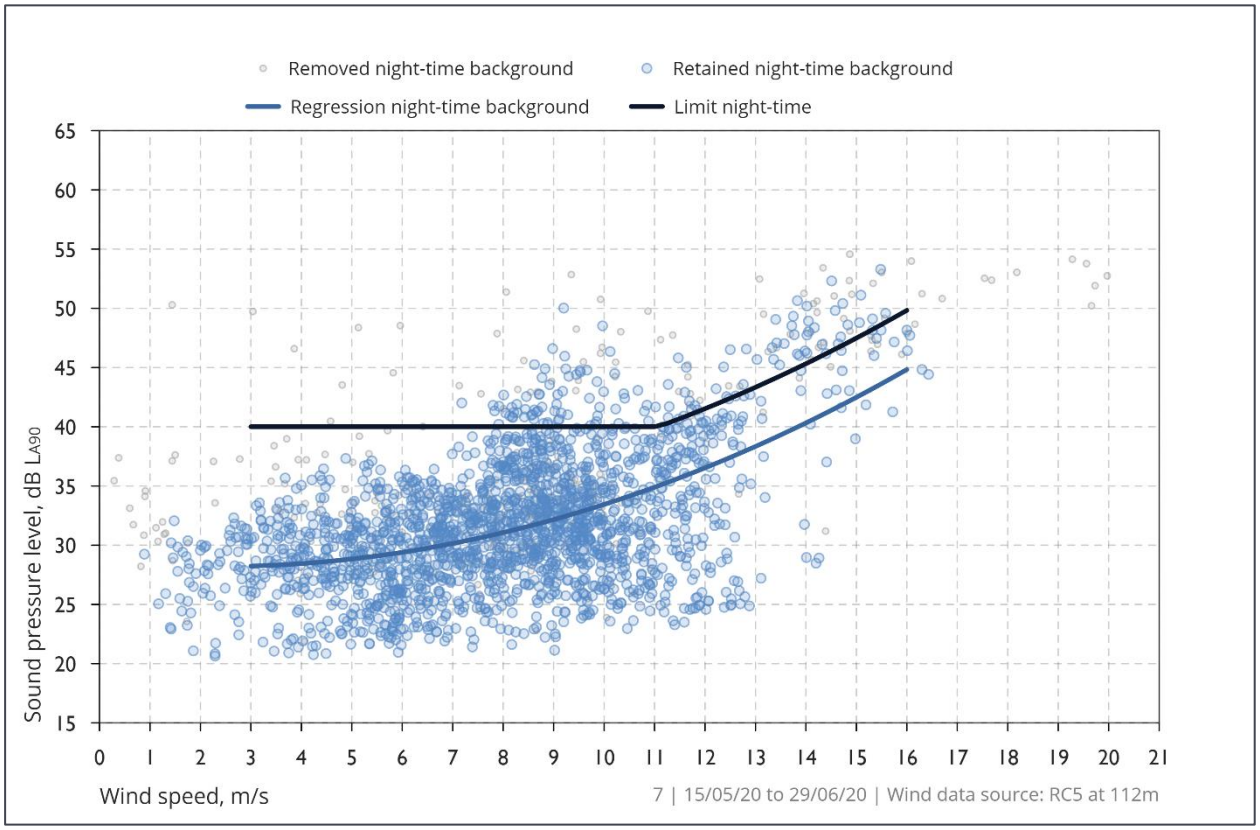


Figure 5: Receiver 7 night-time periods – derived background noise levels and noise limits



APPENDIX H RECEIVER 10 DATA

H1 Receiver 10 location data

Table 19: Receiver 10 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	596,143	5,758,383
Background noise monitoring location	596,119	5,758,415

Figure 6: Receiver 10 aerial view - dwelling and noise monitor locations

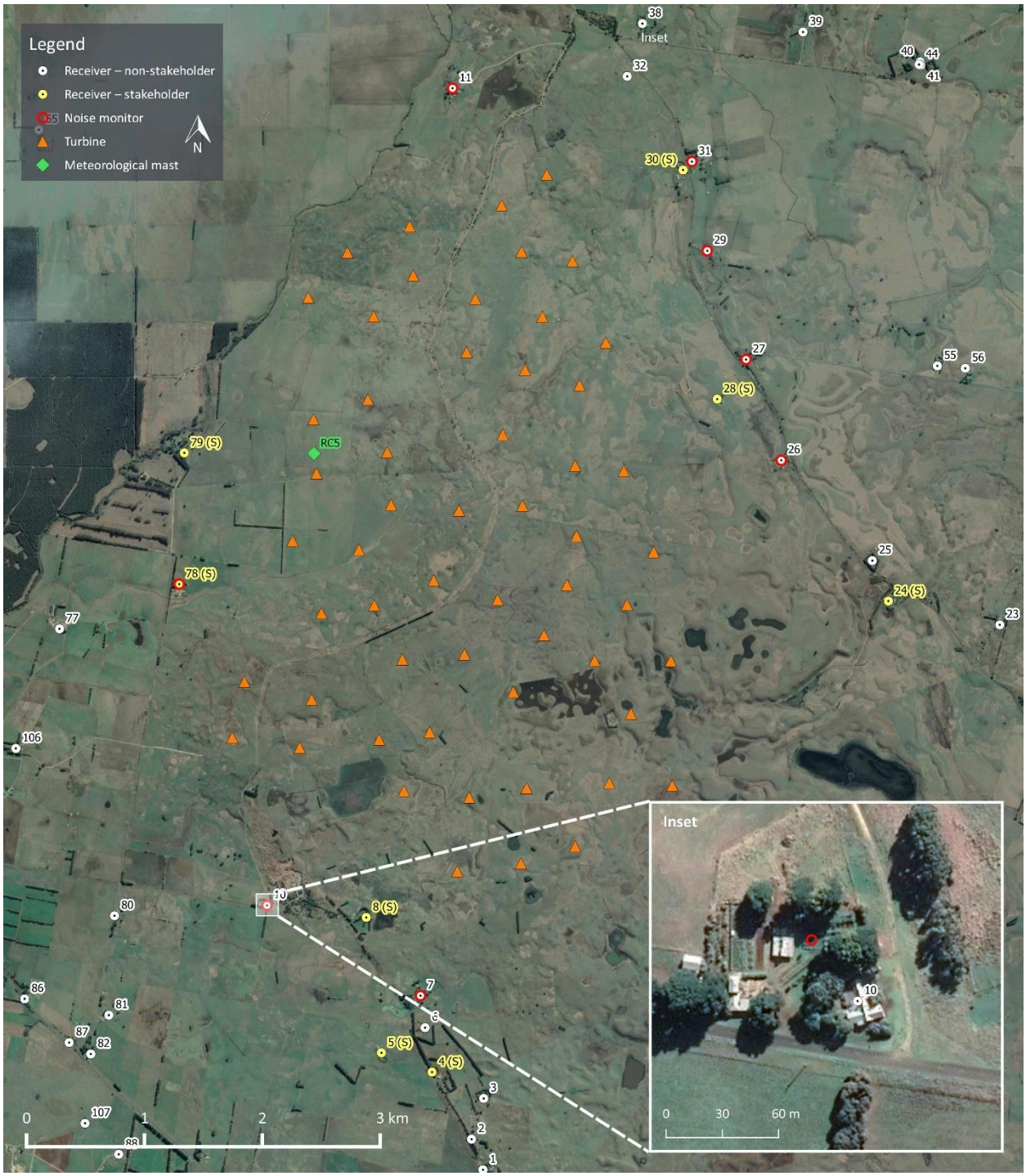


Table 20: Receiver 10 monitor installation photos

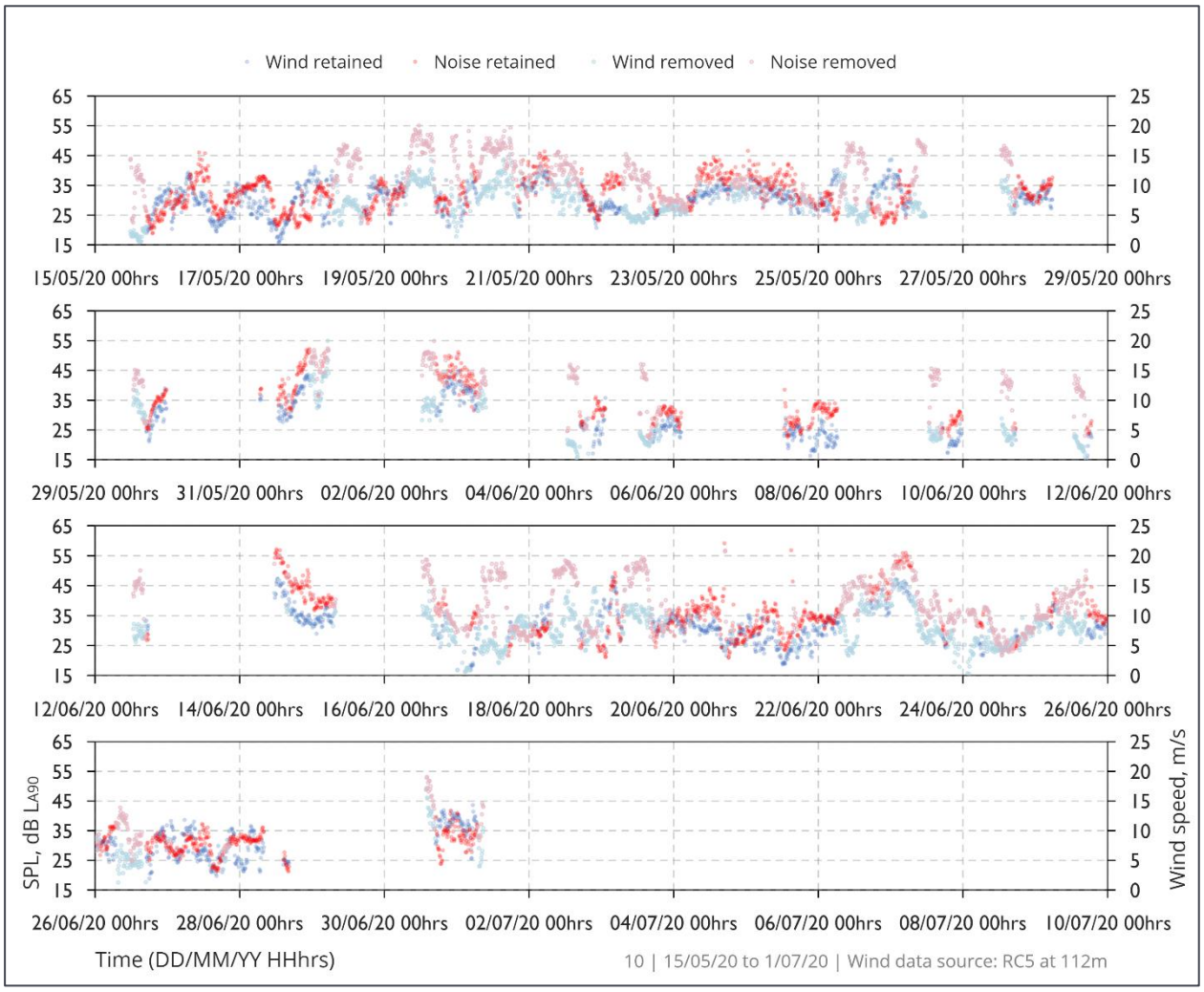
Looking North	Looking East
	
Looking South	**Looking West**
	

H2 Receiver 10 measurement data summary

Table 21: Receiver 10 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	4190	1537
Number of data points removed	1707	270
Number of data points for analysis	2483	1267

Figure 7: Receiver 10 background noise level and wind speed time history



Elevated noise levels that are likely to be attributable to the operation of the quarry to the north of the property were most evident during working hours on weekdays. All background noise data for the period 0700 - 1700 hrs was therefore removed from the analysis for this receiver.

The time history for this property also indicates intermittent periods when data was not available as a result of power losses caused by shading of the solar panel for the instrument.

Figure 8: Receiver 10 all-time periods – derived background noise levels and noise limits

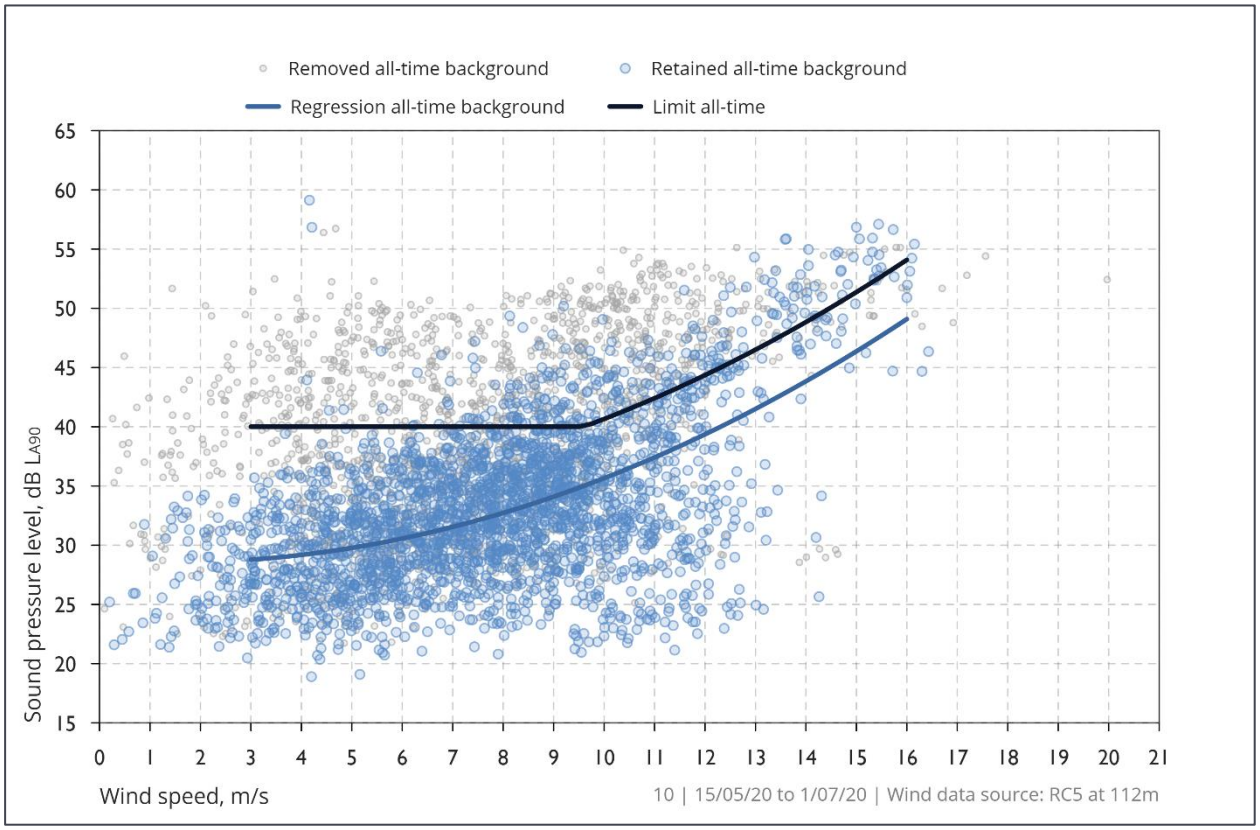
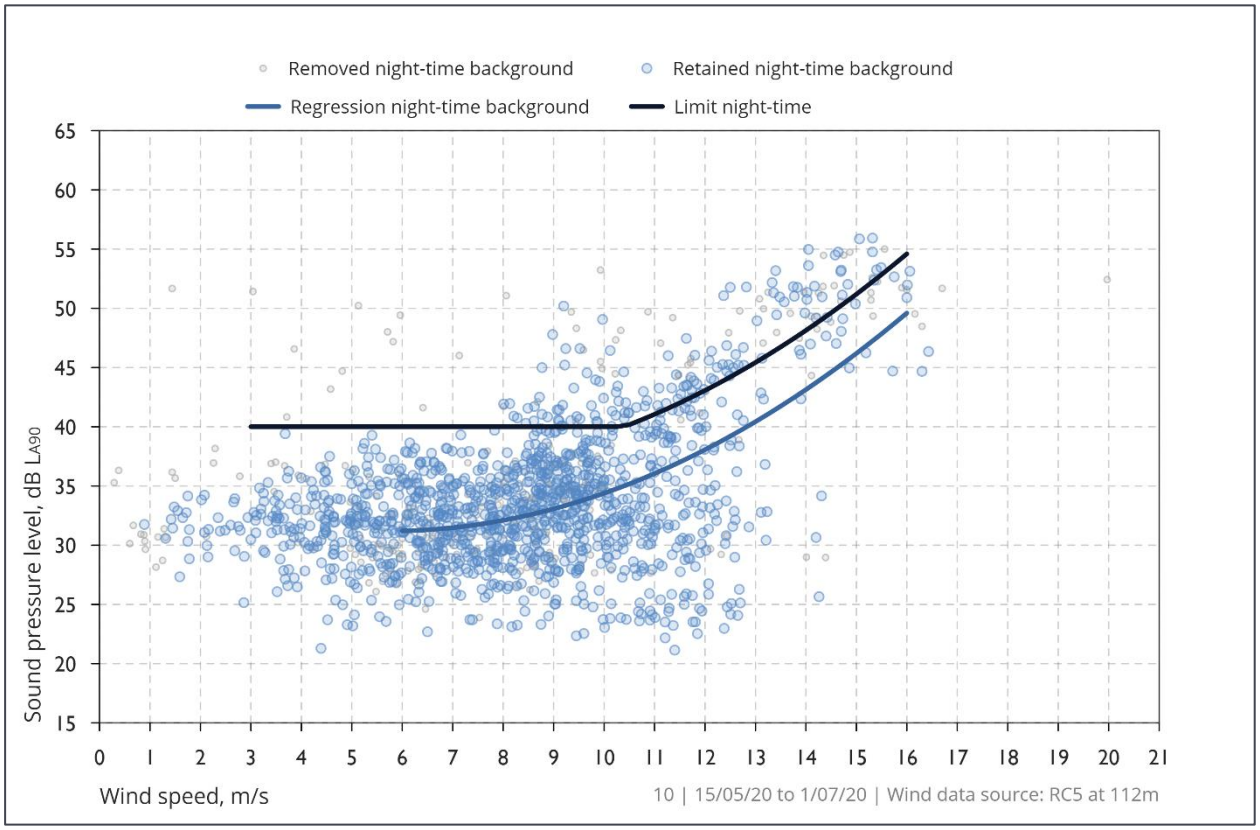


Figure 9: Receiver 10 night-time periods – derived background noise levels and noise limits



APPENDIX I RECEIVER 11 DATA

I1 Receiver 11 location data

Table 22: Receiver 11 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	597,717	5,765,306
Background noise monitoring location	597,704	5,765,290

Figure 10: Receiver 11 aerial view - dwelling and noise monitor locations

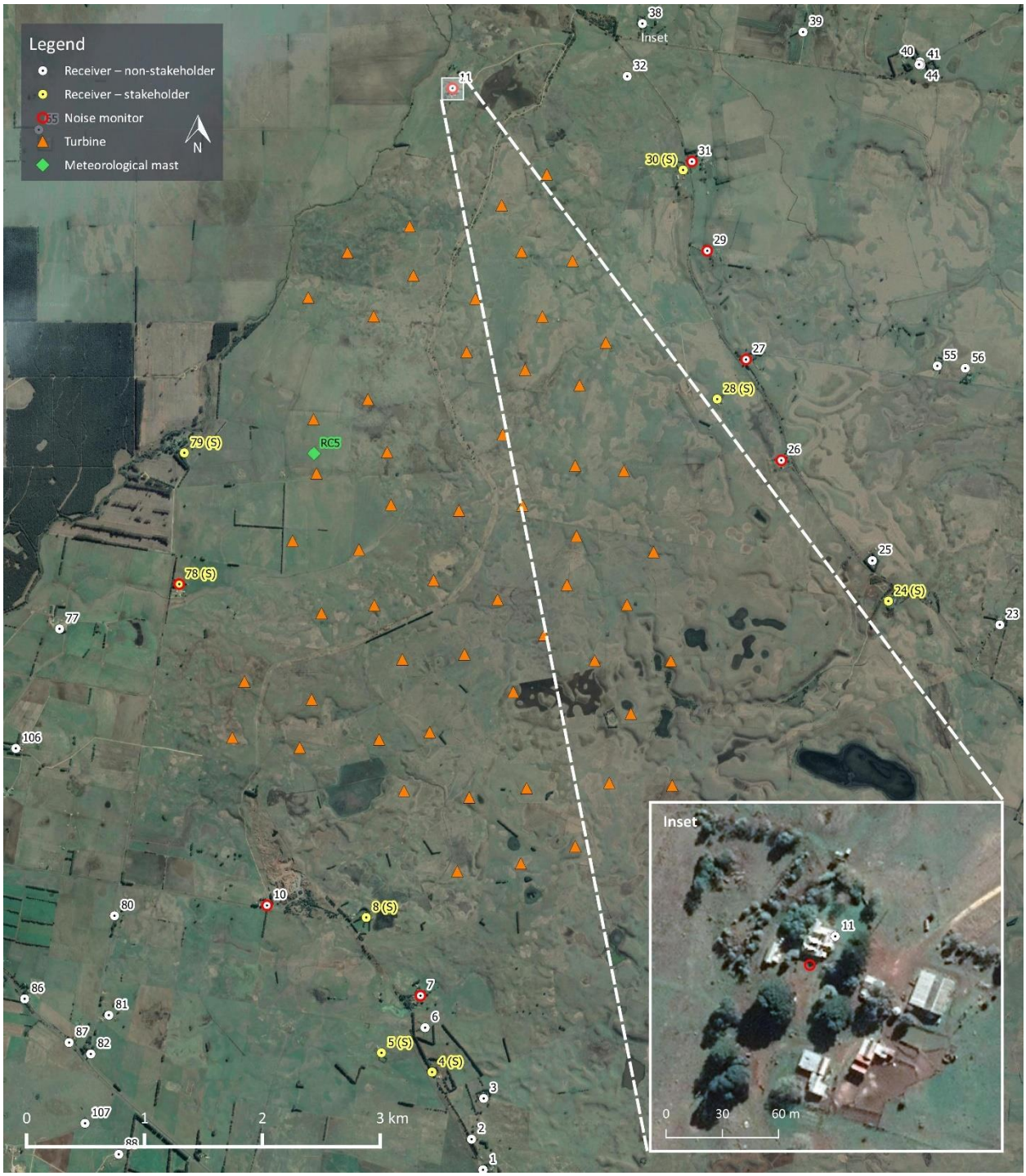


Table 23: Receiver 11 monitor installation photos

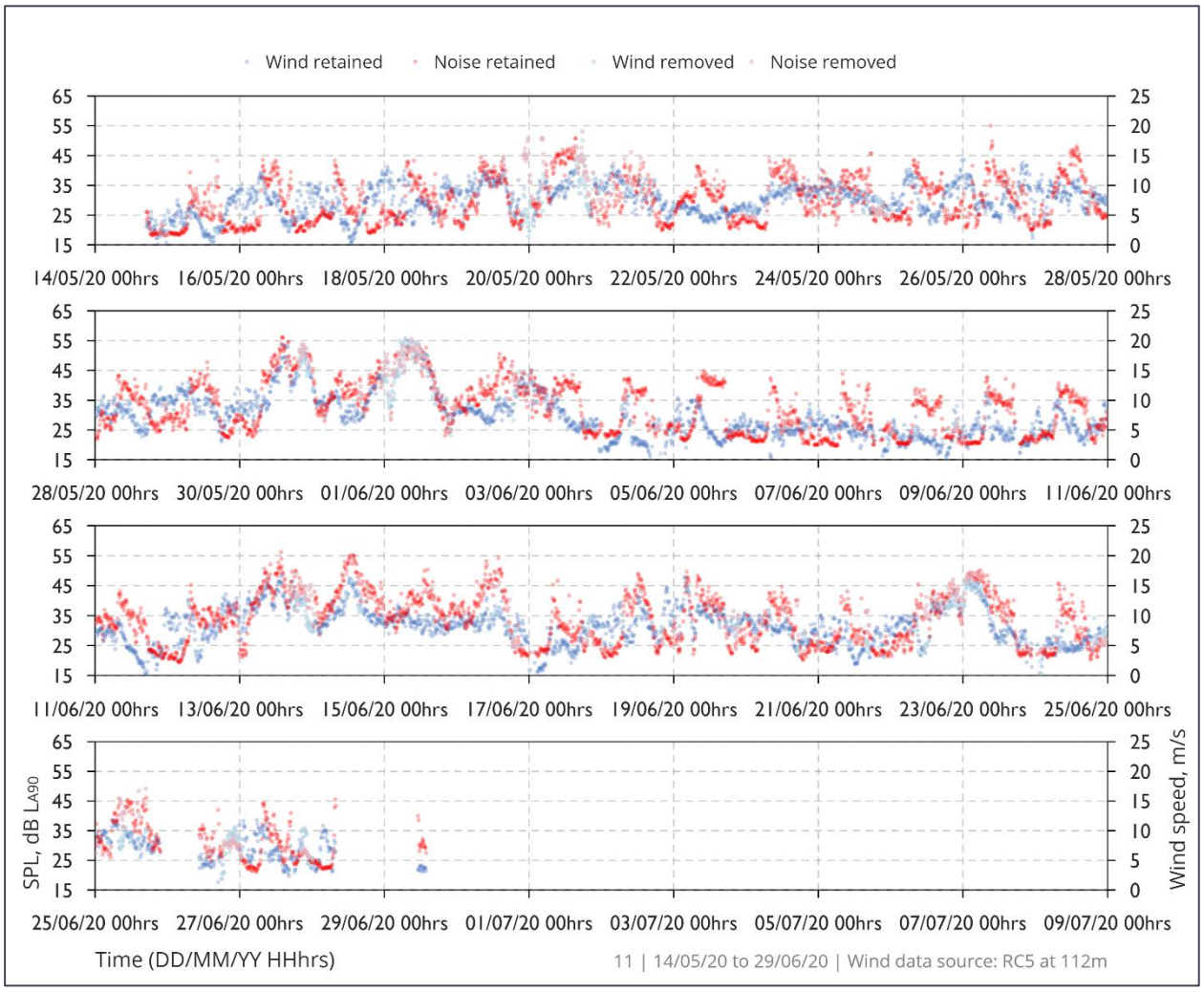
Looking North	Looking East
	
Looking South	**Looking West**
	

I2 Receiver 11 measurement data summary

Table 24: Receiver 11 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6143	2269
Number of data points removed	464	191
Number of data points for analysis	5679	2078

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



Elevated noise levels were regularly evident in the time history during the day period. A selection of audio recordings were reviewed and indicated the periods of elevated noise were attributable to activity within an adjoining workshop at the property. The periods affected by workshop noise were not always able to be clearly identified in the time history, nor were there clearly identifiable markers of the influence in the logged frequency data. Accordingly, only the background noise data measured during the night has been used to set limits. The data for the all-time period (which includes the day period) is provided for reference purposes only.

Figure 12: Receiver 11 all-time periods – derived background noise levels

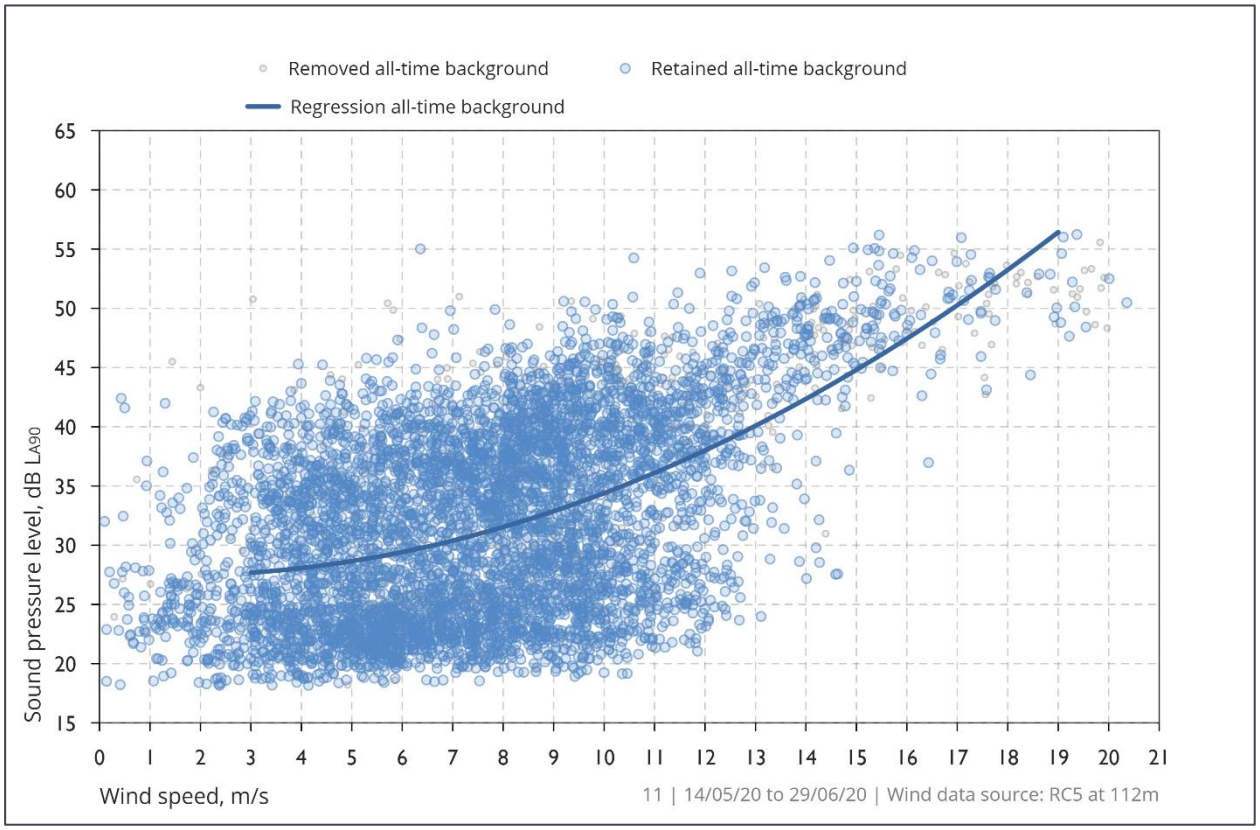
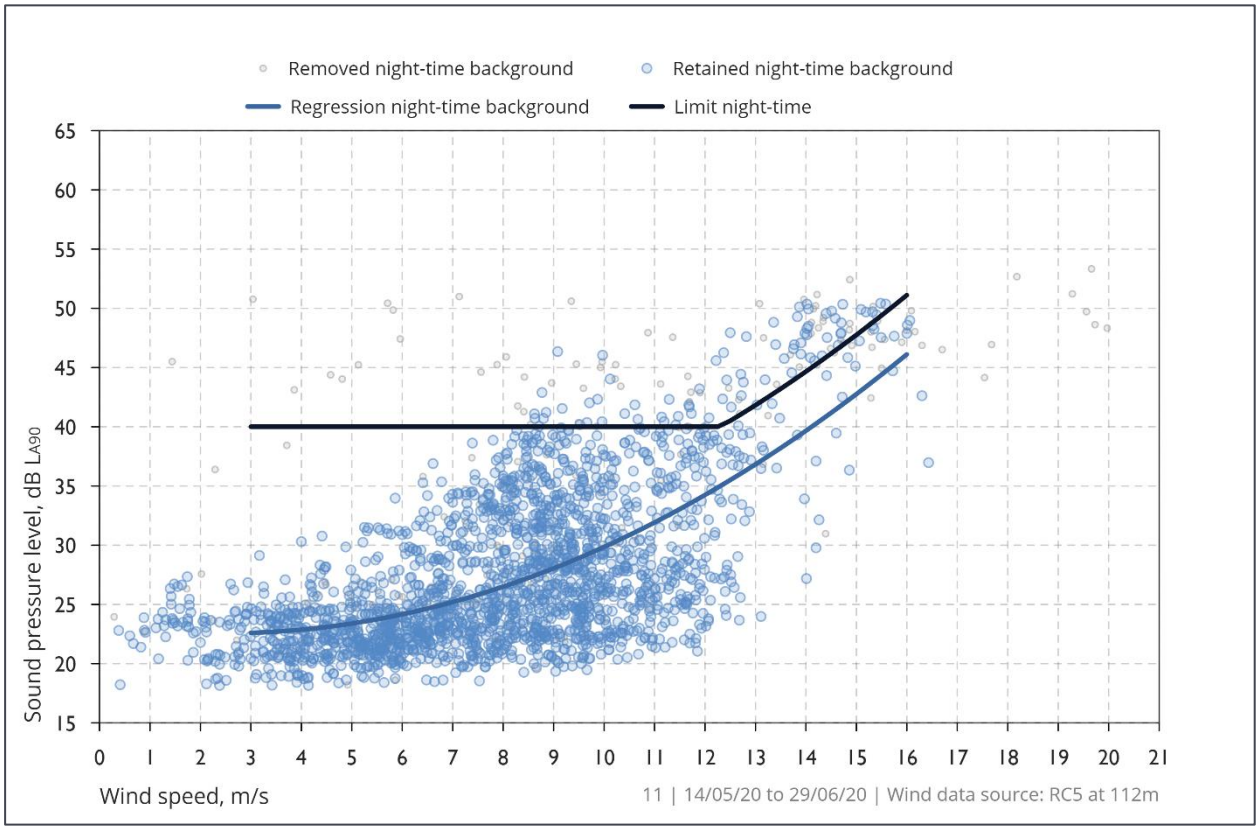


Figure 13: Receiver 11 night-time periods – derived background noise levels and noise limits



APPENDIX J RECEIVER 26 DATA

J1 Receiver 26 location data

Table 25: Receiver 26 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	600,505	5,762,154
Background noise monitoring location	600,494	5,762,131

Figure 14: Receiver 26 aerial view - dwelling and noise monitor locations

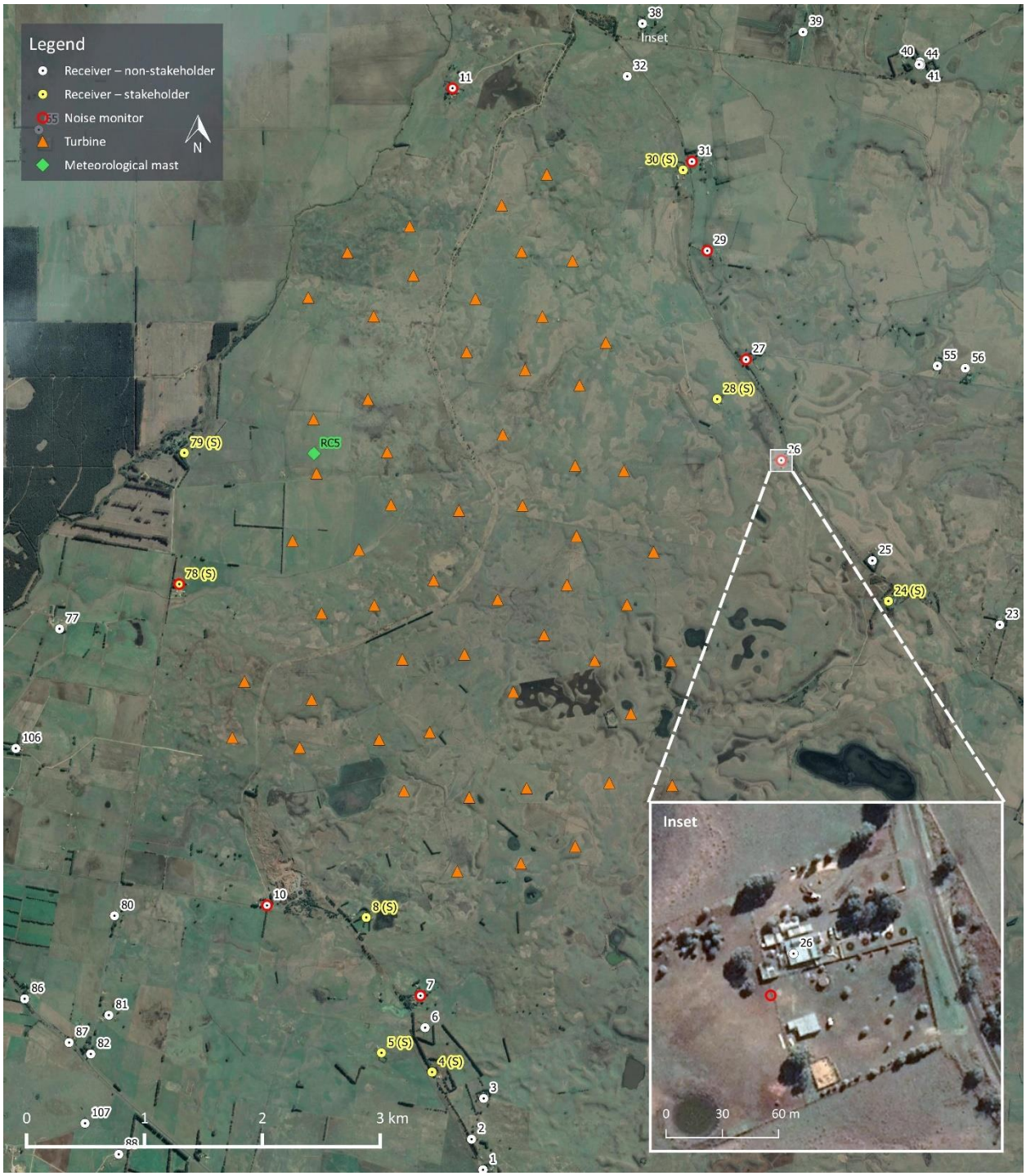


Table 26: Receiver 26 monitor installation photos

Looking North	Looking East
	
Looking South	**Looking West**
	

J2 Receiver 26 measurement data summary

Table 27: Receiver 26 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6410	2387
Number of data points removed	1191	566
Number of data points for analysis	5219	1821

Figure 15: Receiver 26 background noise level and wind speed time history

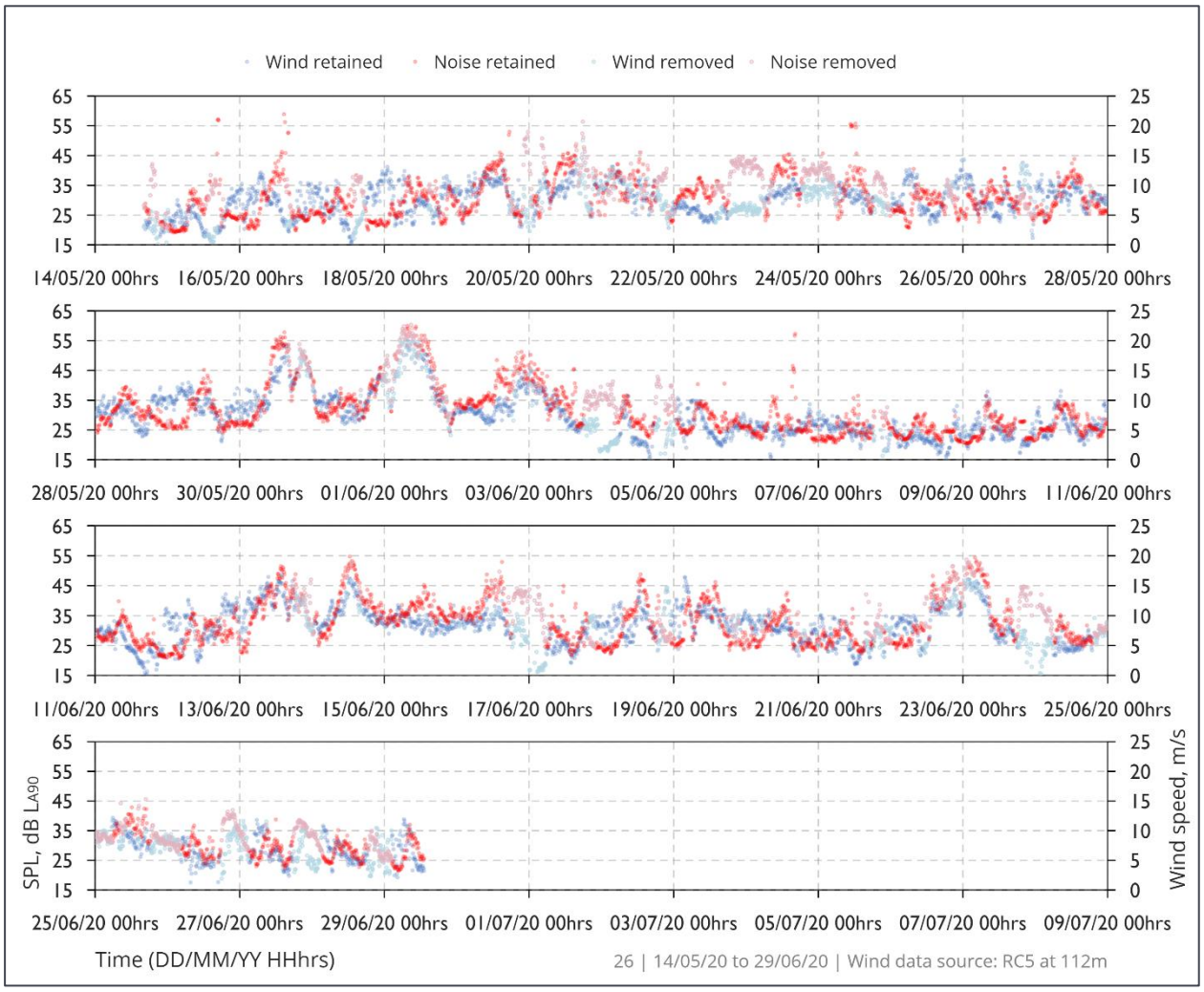


Figure 16: Receiver 26 all-time periods – derived background noise levels and noise limits

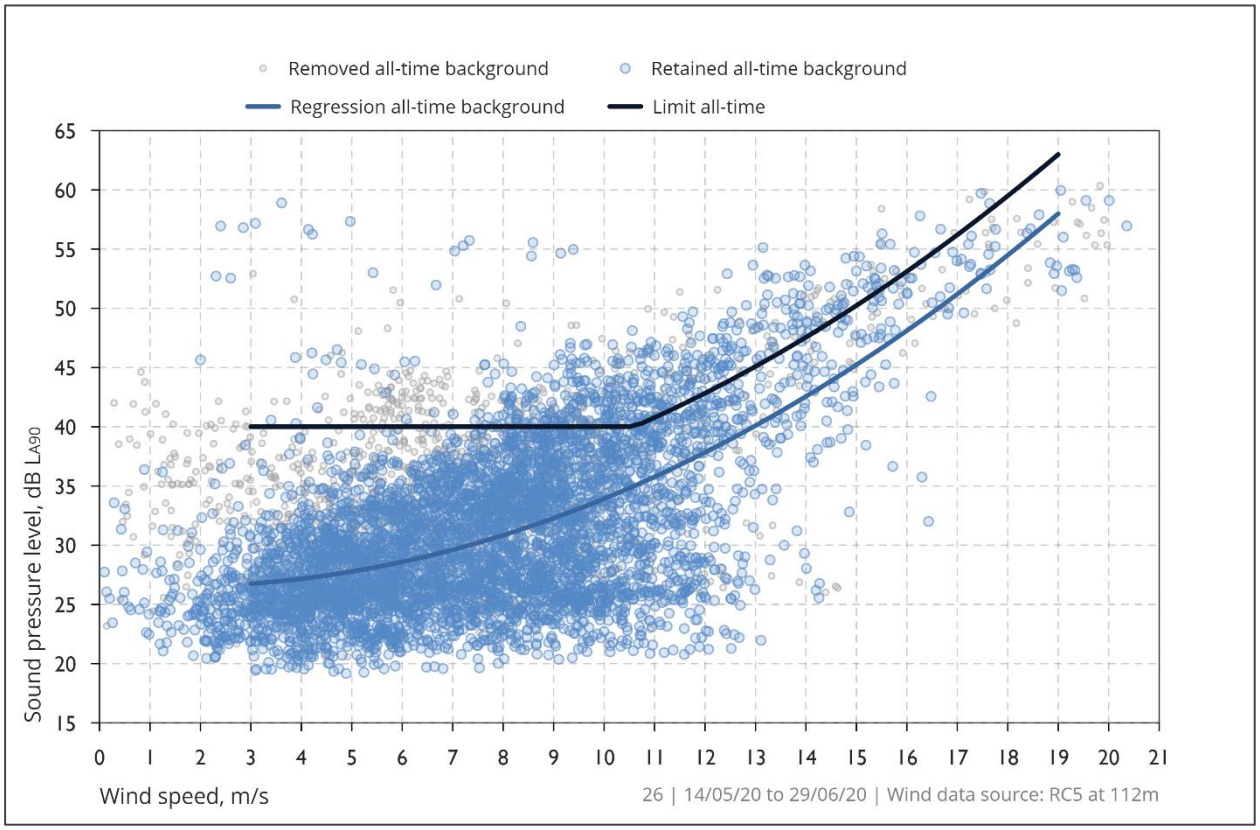
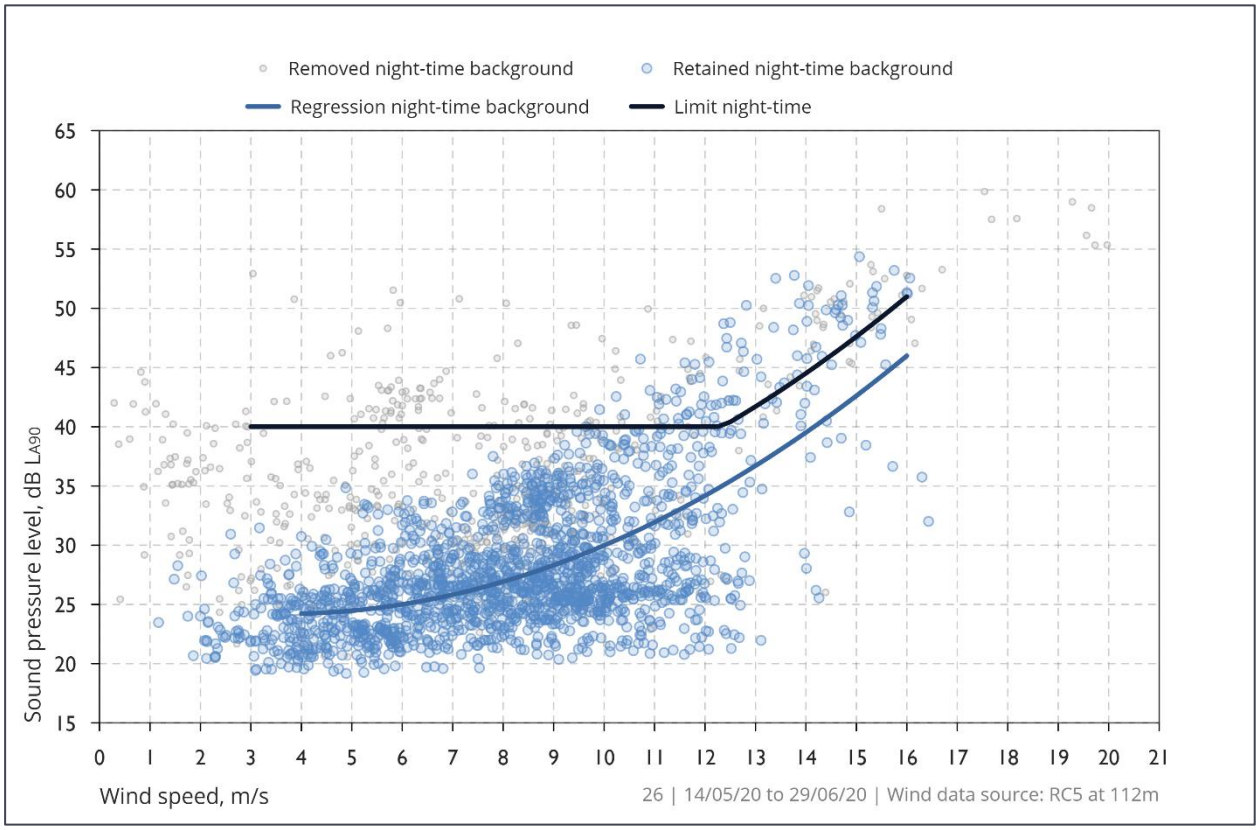


Figure 17: Receiver 26 night-time periods – derived background noise levels and noise limits



APPENDIX K RECEIVER 27 DATA

K1 Receiver 27 location data

Table 28: Receiver 27 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	600,206	5,763,008
Background noise monitoring location	600,198	5,763,002

Figure 18: Receiver 27 aerial view - dwelling and noise monitor locations

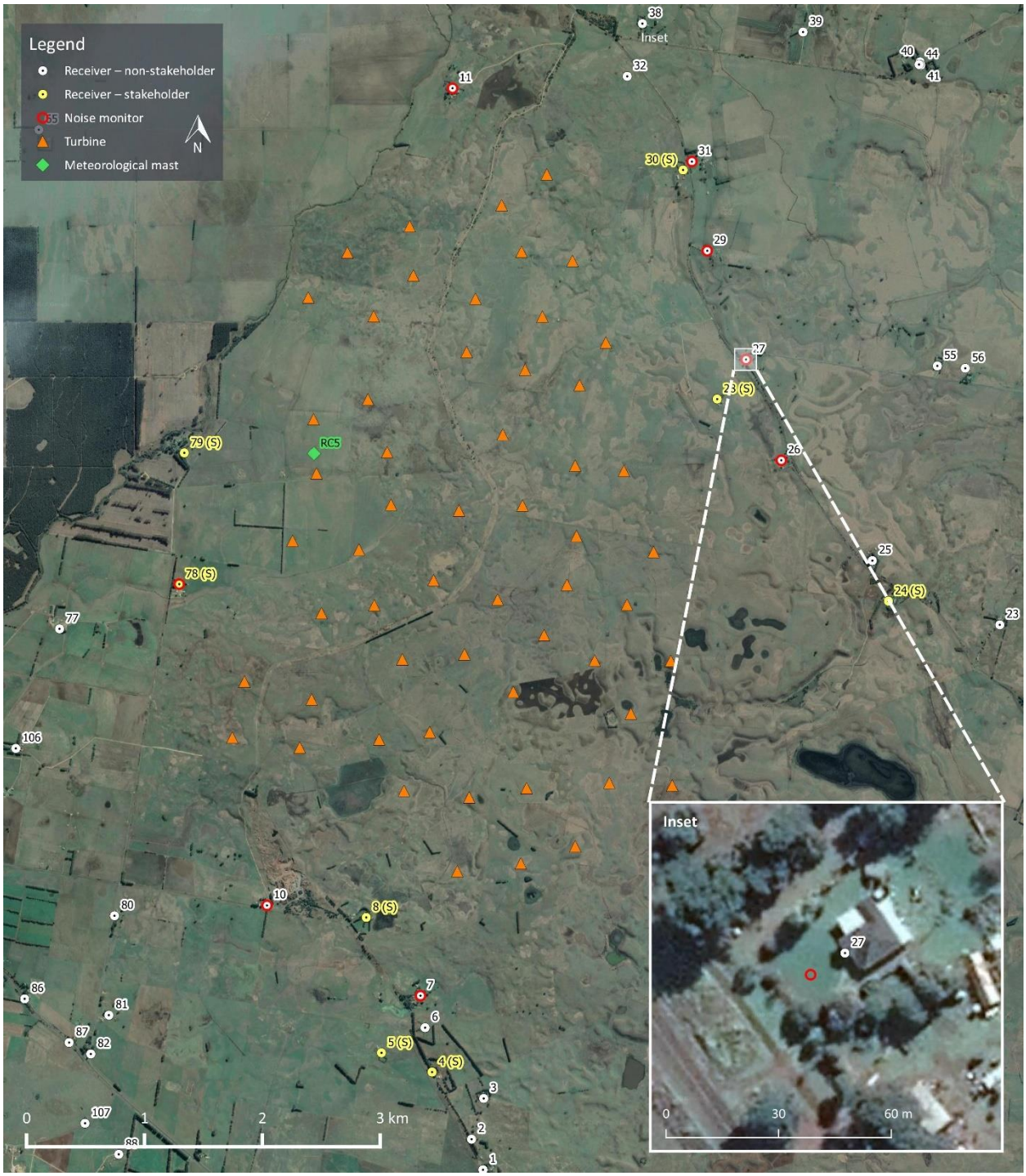


Table 29: Receiver 27 monitor installation photos

Looking North	Looking East
	
Looking South	**Looking West**
	

K2 Receiver 27 measurement data summary

Table 30: Receiver 27 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6199	2313
Number of data points removed	1578	809
Number of data points for analysis	4621	1504

Figure 19: Receiver 27 background noise level and wind speed time history

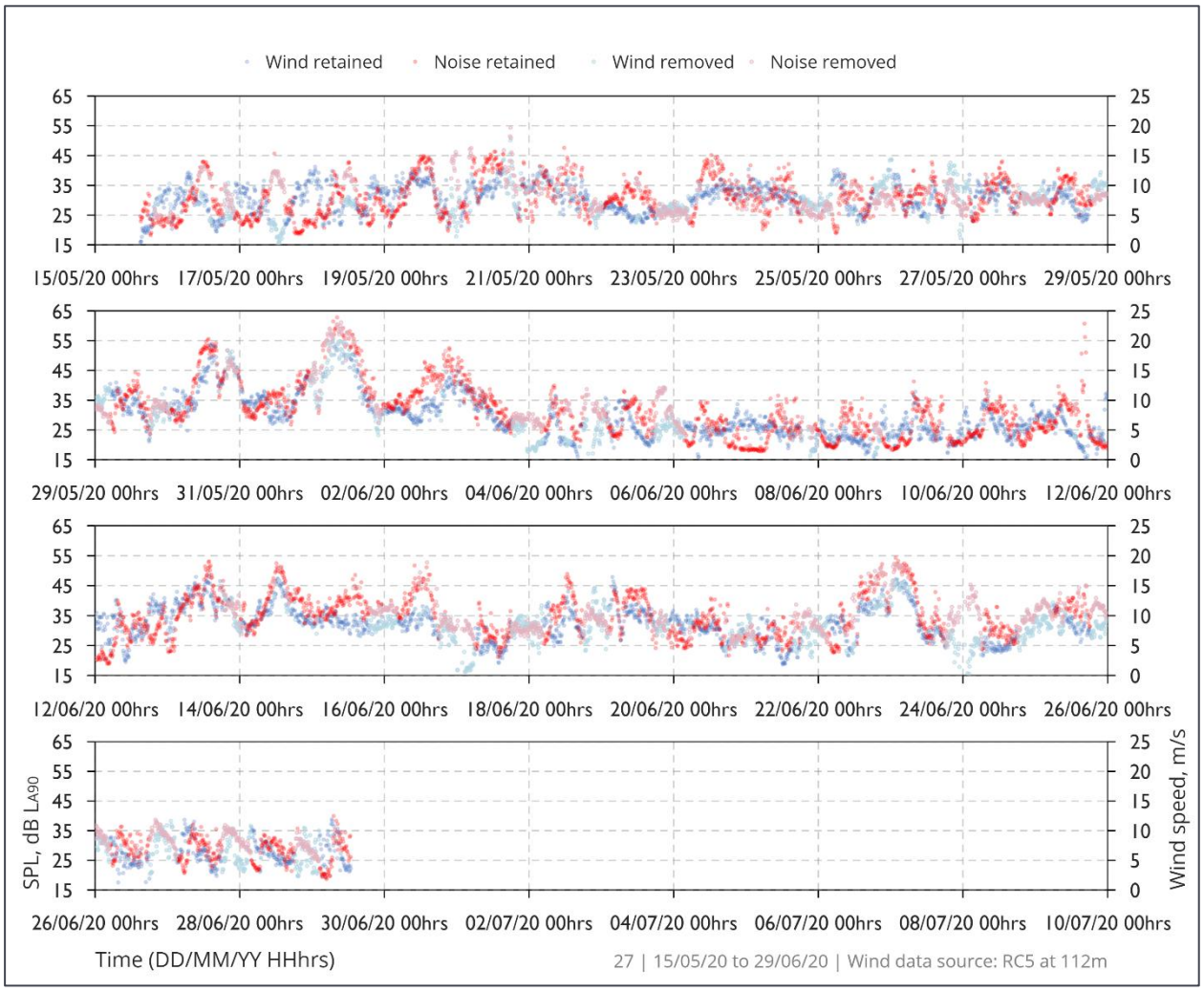


Figure 20: Receiver 27 all-time periods – derived background noise levels and noise limits

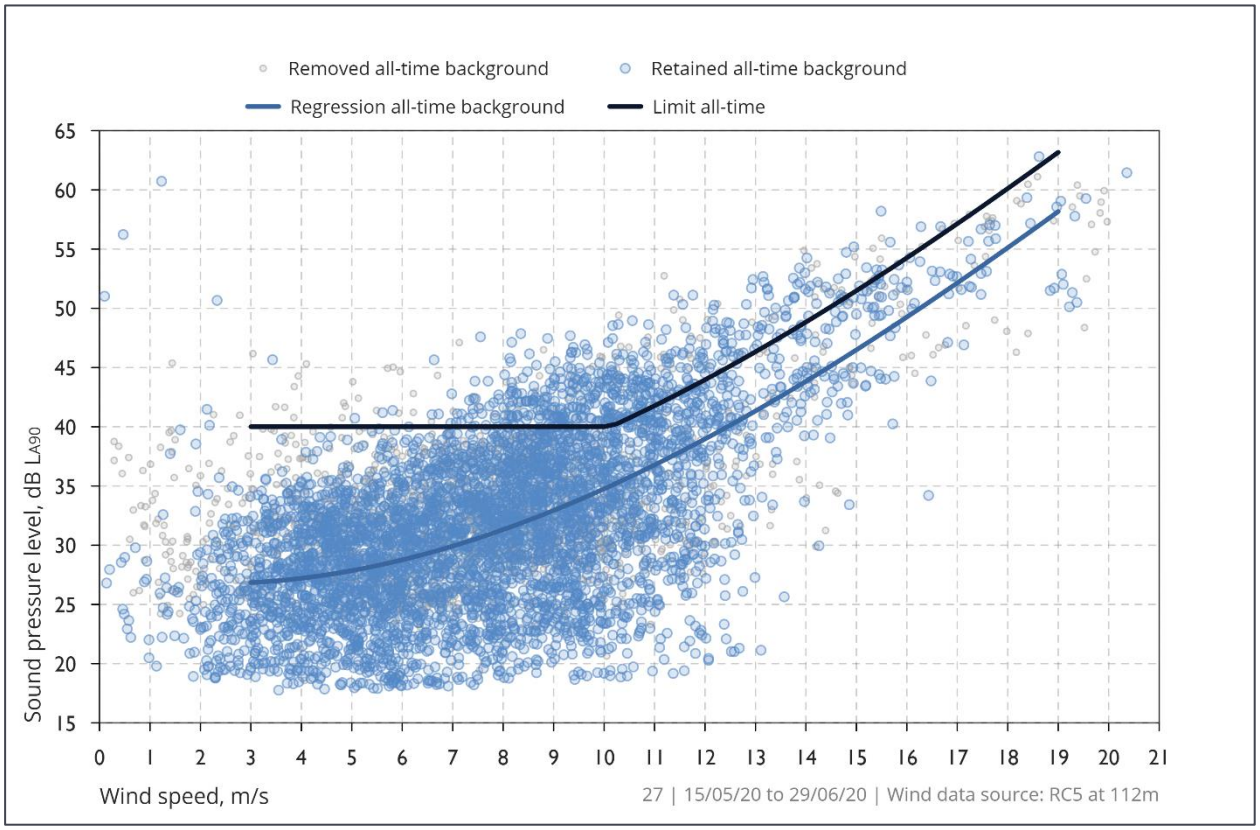
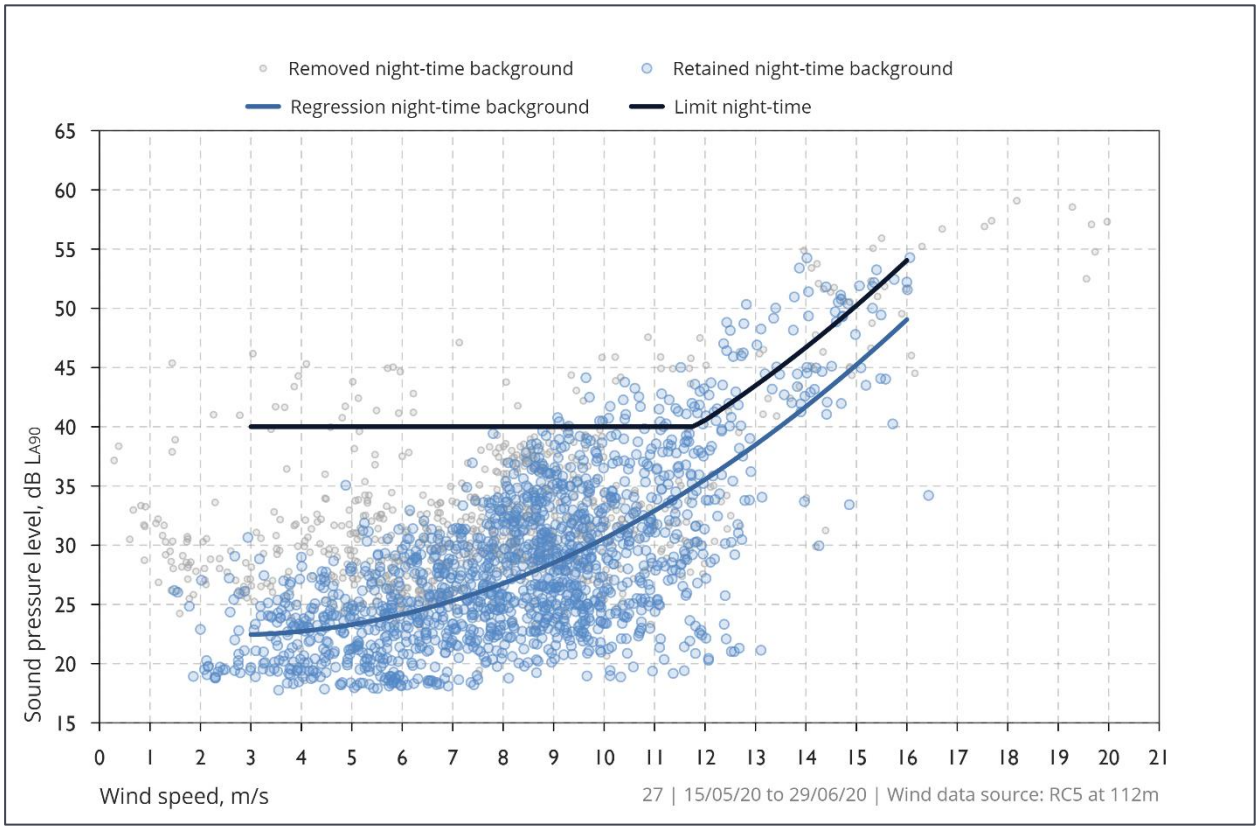


Figure 21: Receiver 27 night-time periods – derived background noise levels and noise limits



APPENDIX L RECEIVER 29 DATA

L1 Receiver 29 location data

Table 31: Receiver 29 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	599,864	5,763,944
Background noise monitoring location	599,863	5,763,925

Figure 22: Receiver 29 aerial view - dwelling and noise monitor locations

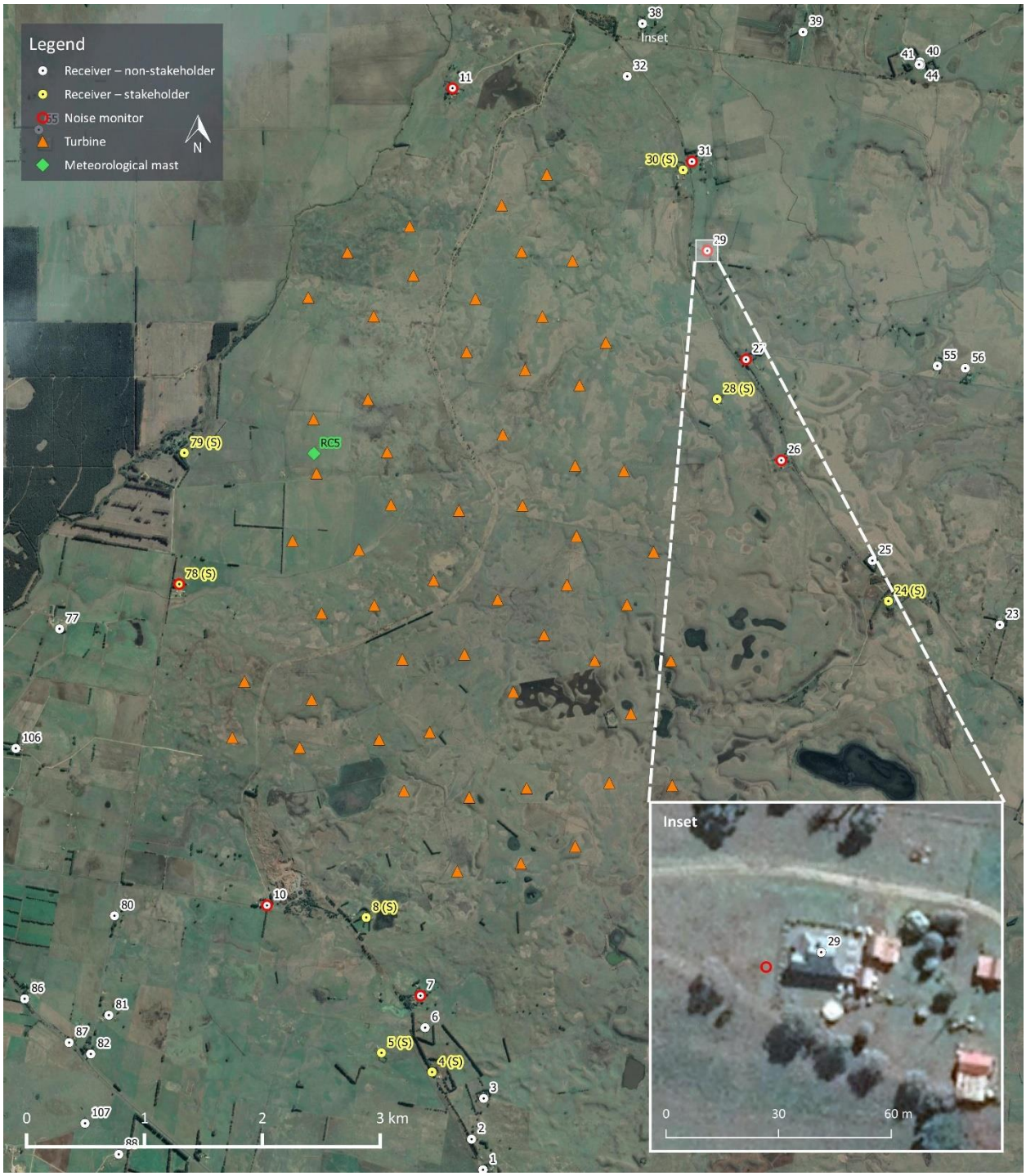


Table 32: Receiver 29 monitor installation photos

Looking North	Looking East
	
Looking South	**Looking West**
	

L2 Receiver 29 measurement data summary

Table 33: Receiver 29 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6205	2308
Number of data points removed	1912	1004
Number of data points for analysis	4293	1304

Figure 23: Receiver 29 background noise level and wind speed time history

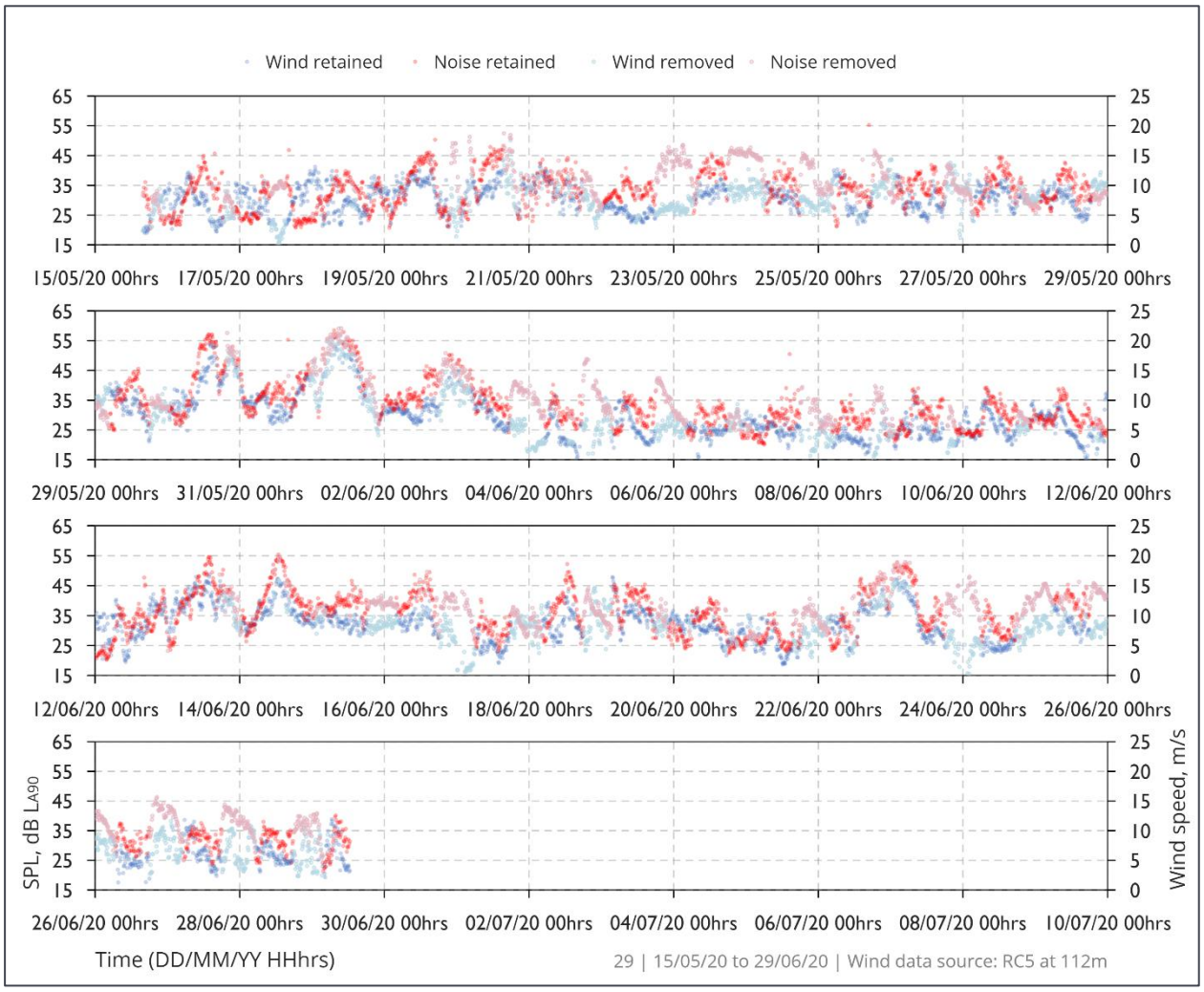


Figure 24: Receiver 29 all-time periods – derived background noise levels and noise limits

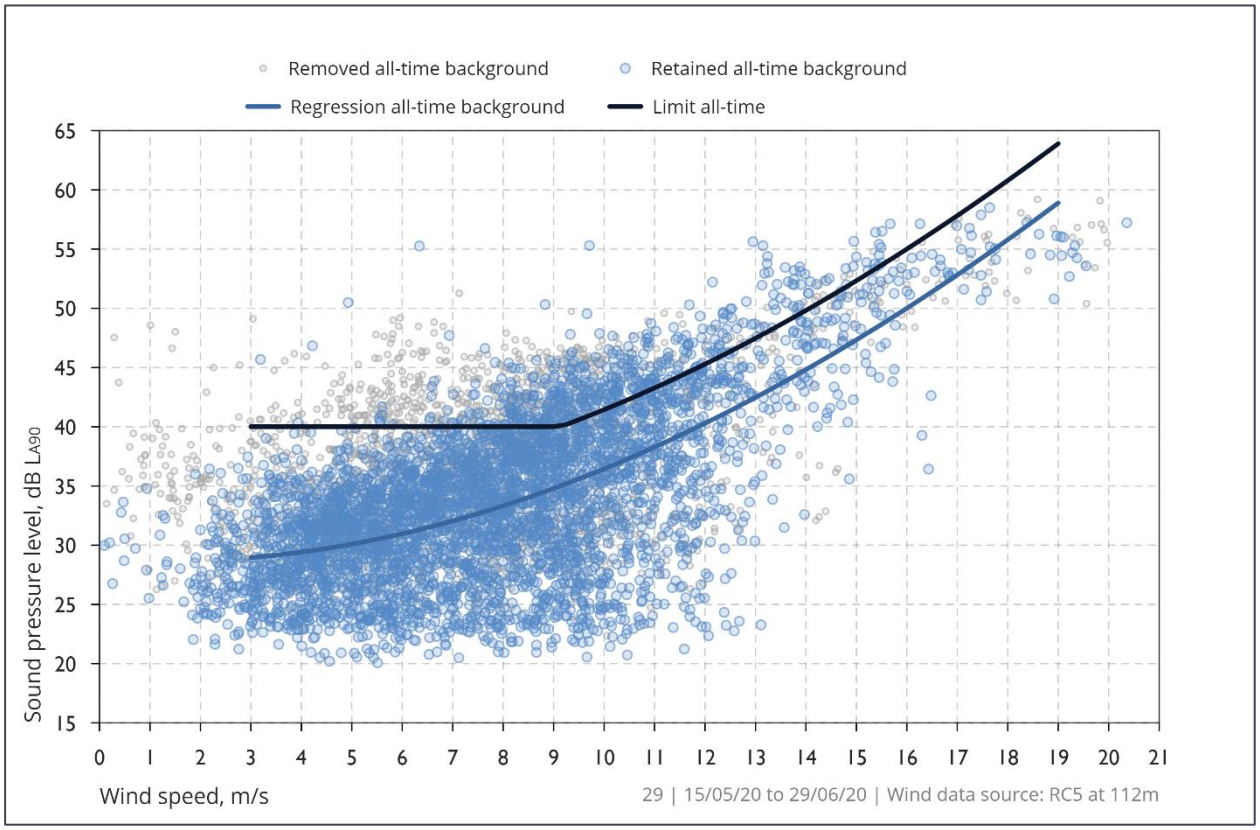
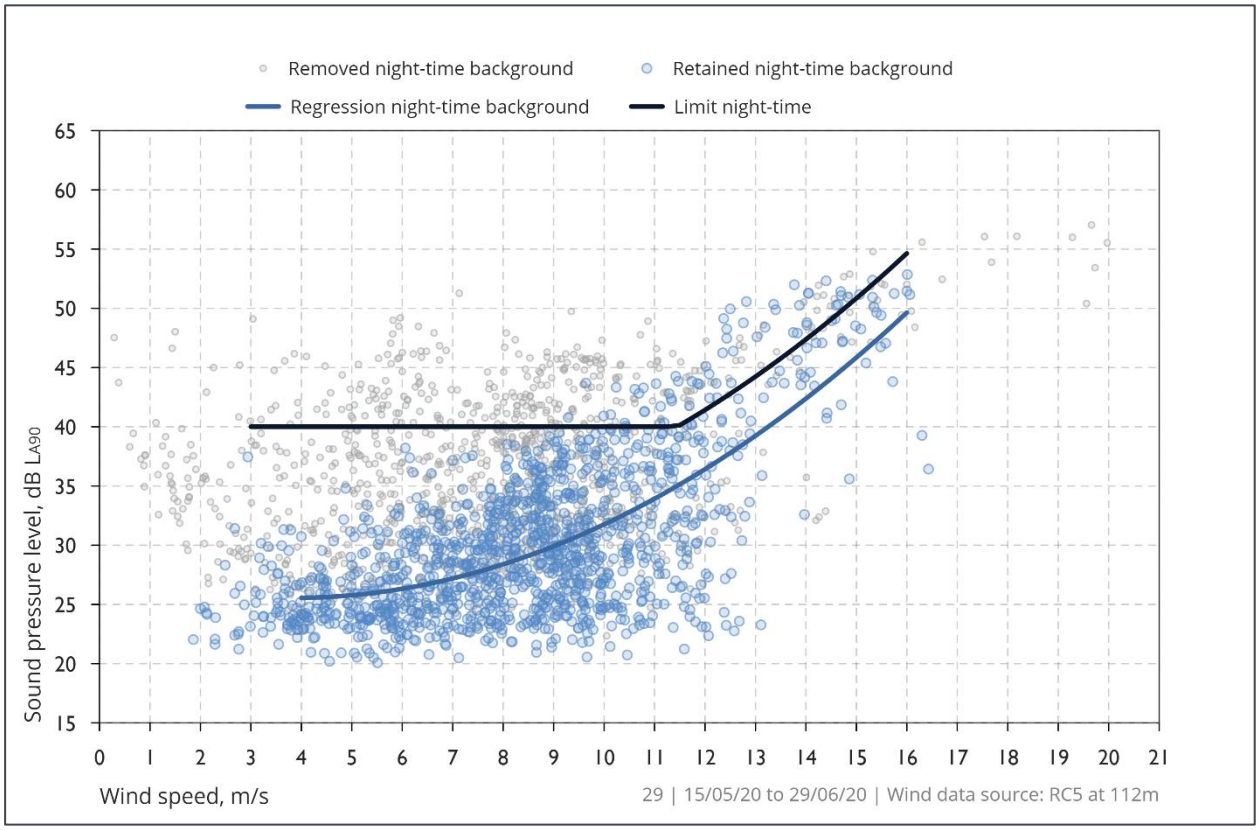


Figure 25: Receiver 29 night-time periods – derived background noise levels and noise limits



APPENDIX M RECEIVER 31 DATA

M1 Receiver 31 location data

Table 34: Receiver 31 dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	599,747	5,764,685
Background noise monitoring location	599,734	5,764,678

Figure 26: Receiver 31 aerial view - dwelling and noise monitor locations

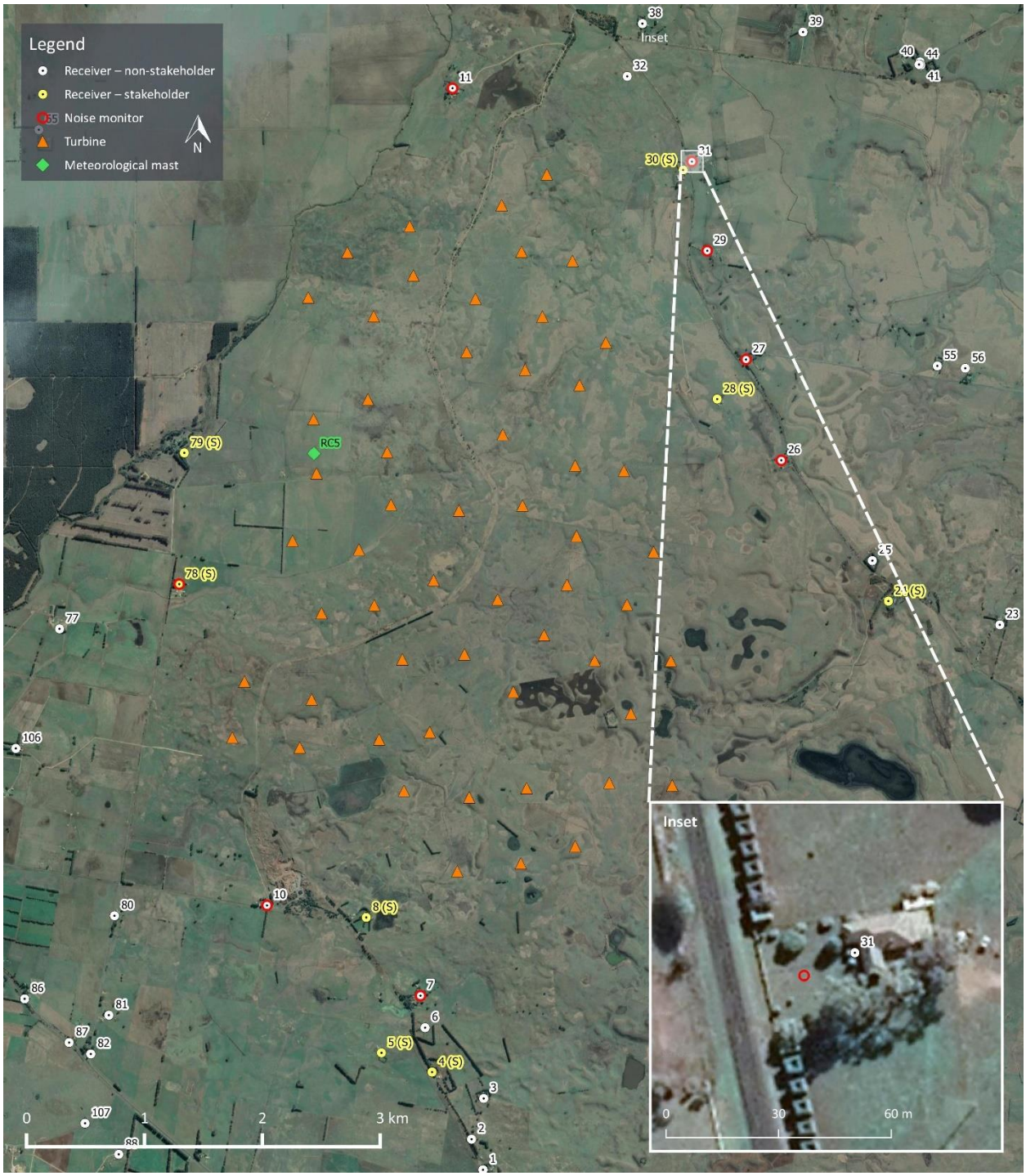


Table 35: Receiver 31 monitor installation photos

Looking North	Looking East
	
Looking South	**Looking West**
	

M2 Receiver 31 measurement data summary

Table 36: Receiver 31 background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6236	2300
Number of data points removed	898	382
Number of data points for analysis	5338	1918

Figure 27: Receiver 31 background noise level and wind speed time history

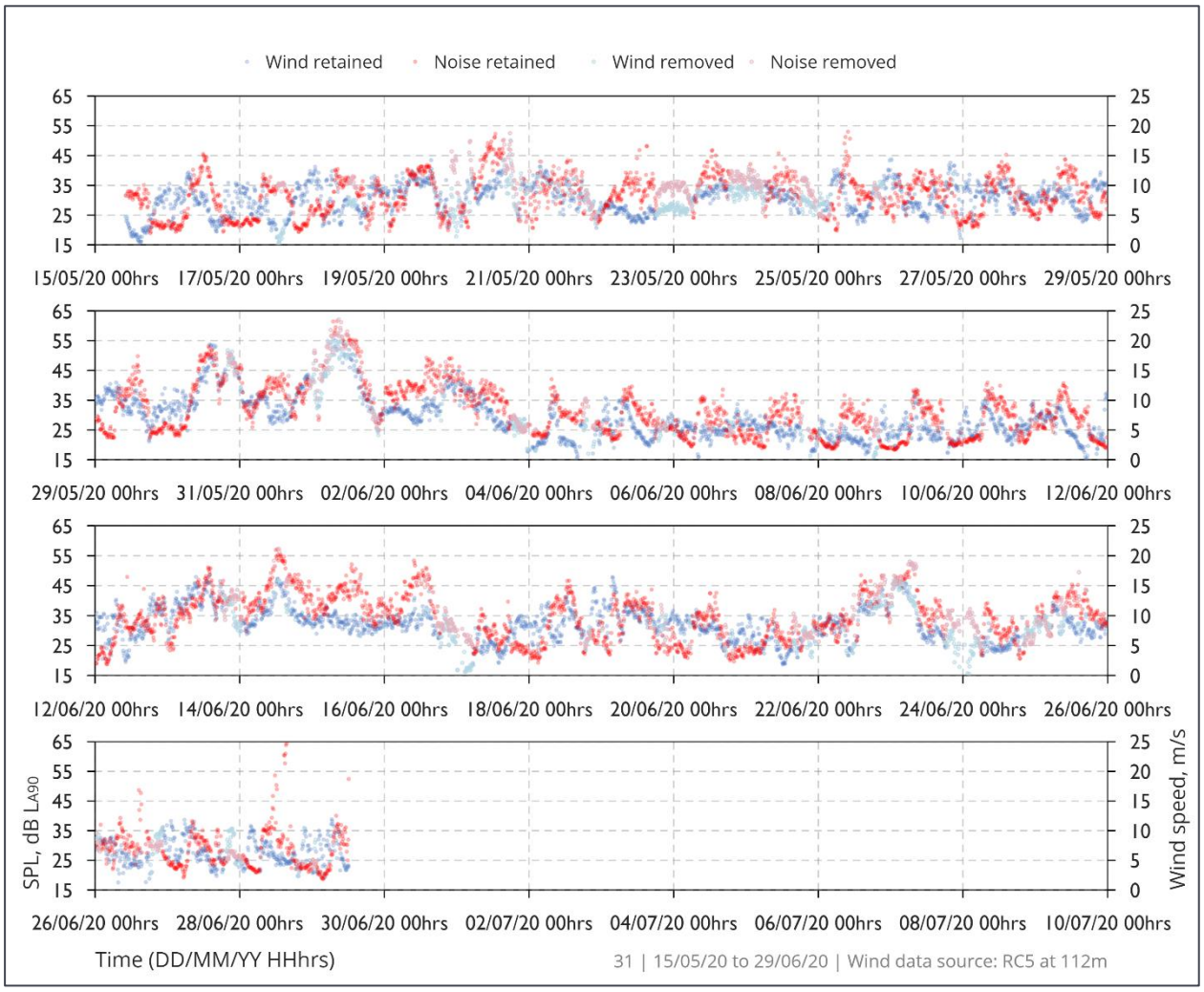


Figure 28: Receiver 31 all-time periods – derived background noise levels and noise limits

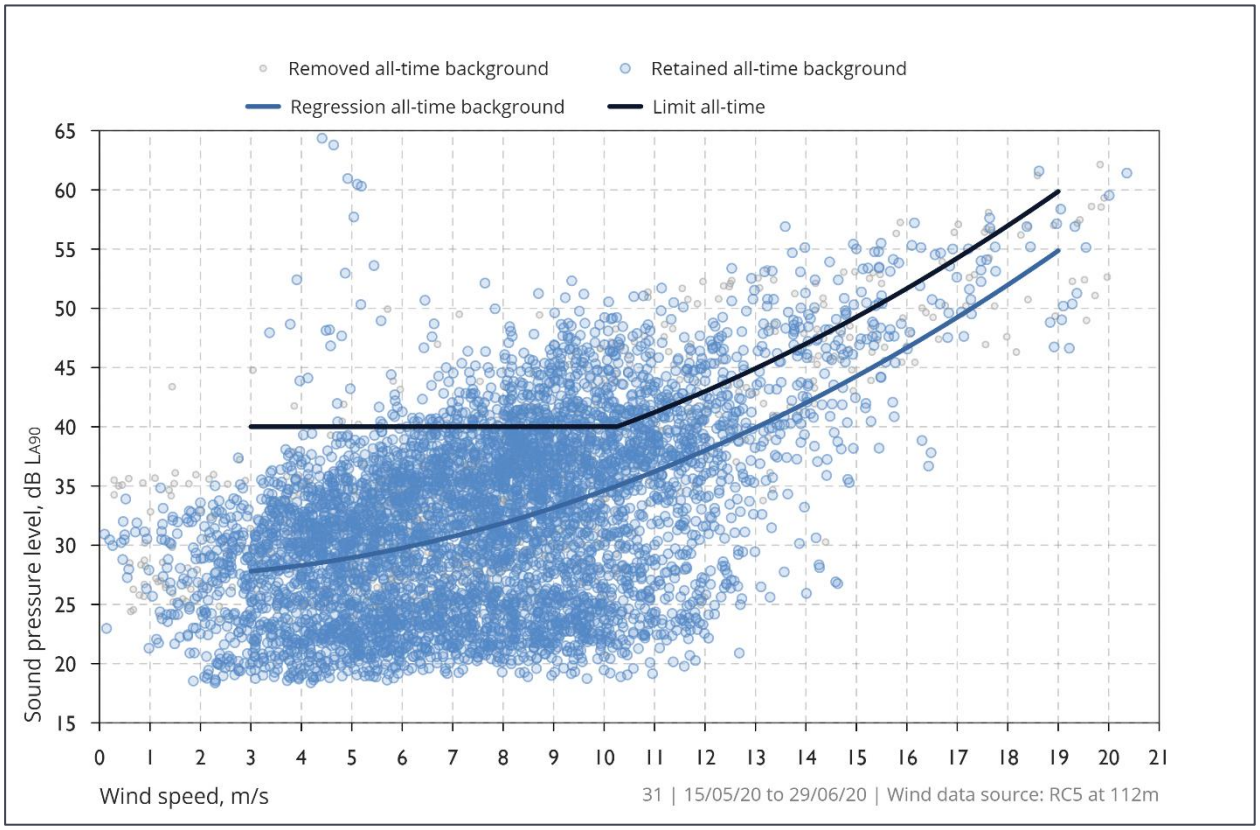
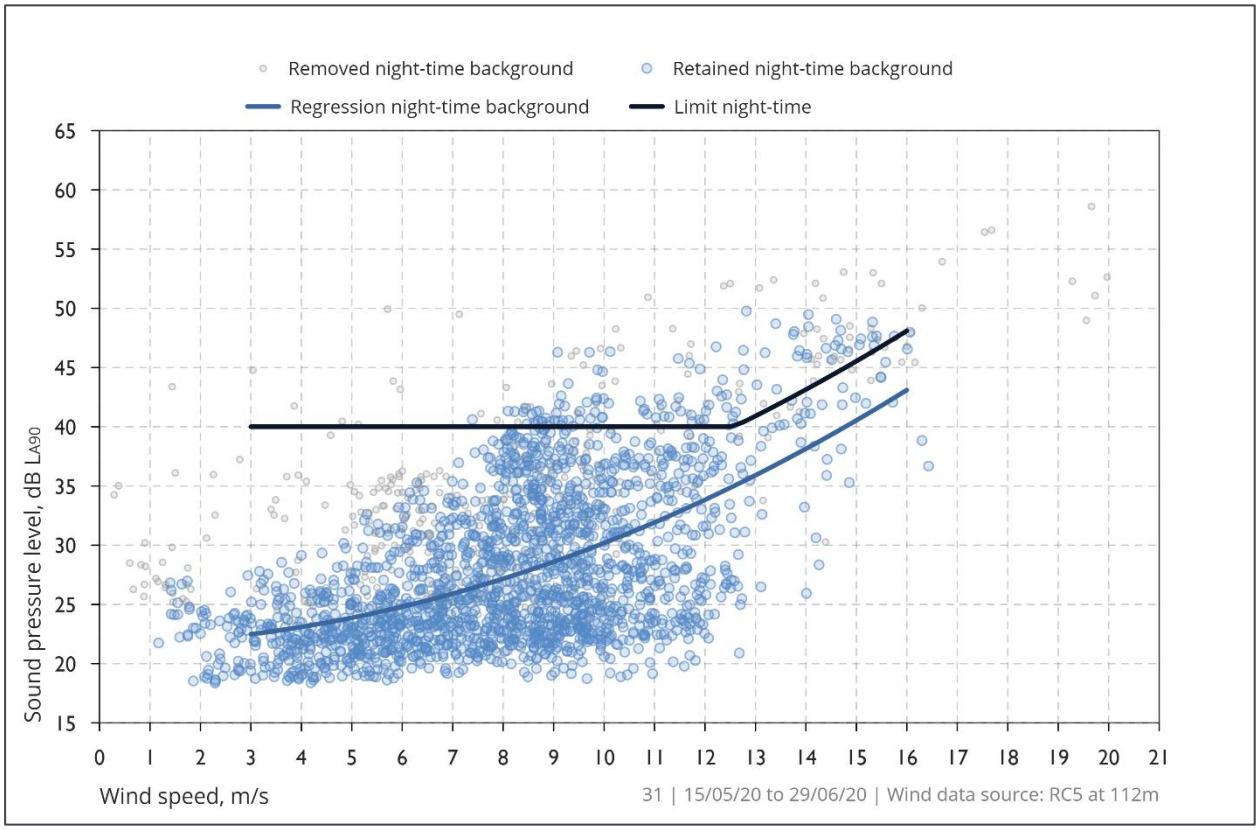


Figure 29: Receiver 31 night-time periods – derived background noise levels and noise limits



APPENDIX N RECEIVER 78 (S) DATA

N1 Receiver 78 (S) location data

Table 37: Receiver 78 (S) dwelling and noise monitor coordinates for each receiver – AMG66 Zone 54

Location	Easting	Northing
Dwelling location	595,399	5,761,105
Background noise monitoring location	595,407	5,761,090

Figure 30: Receiver 78 (S) aerial view - dwelling and noise monitor locations

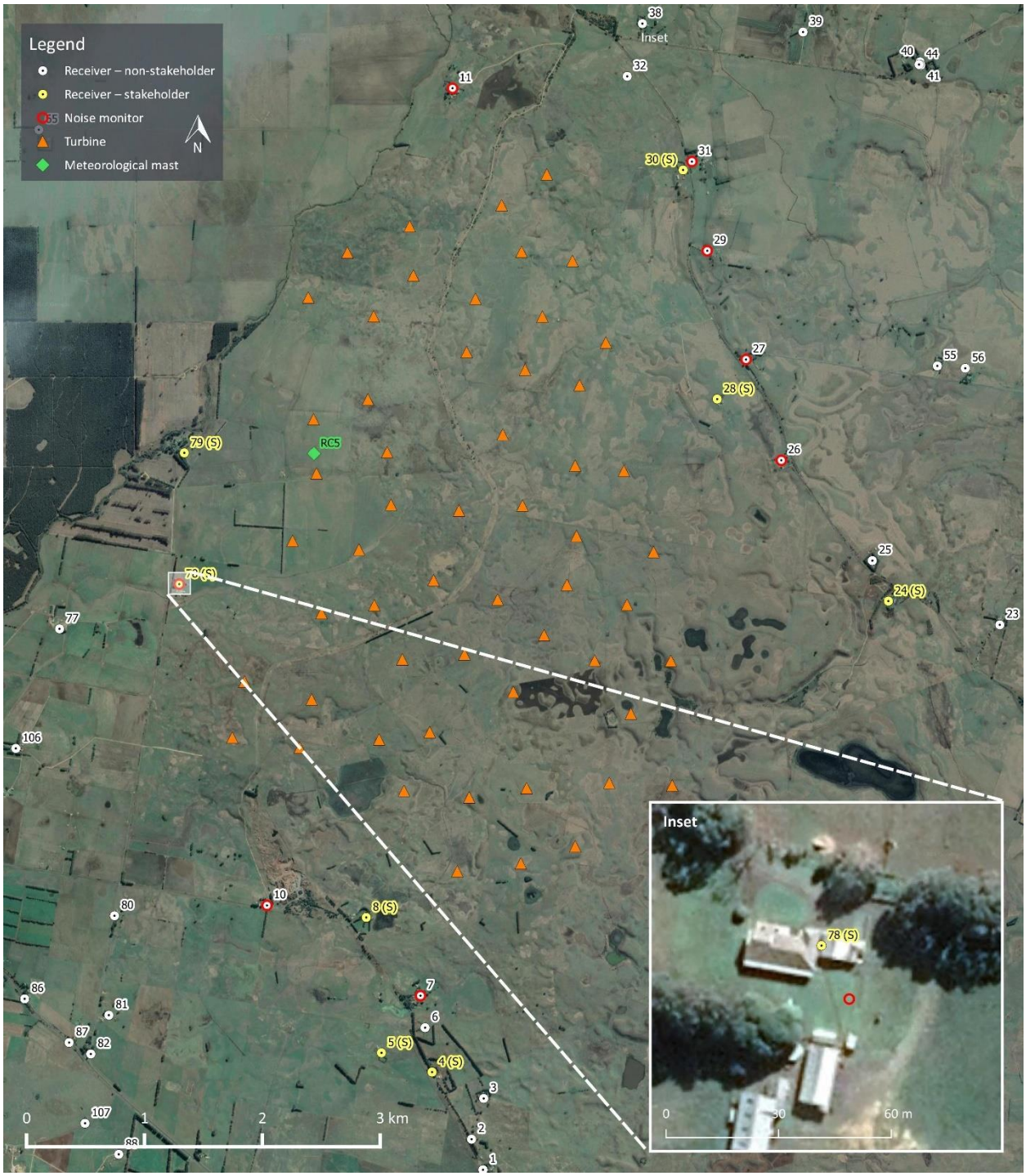


Table 38: Receiver 78 (S) monitor installation photos

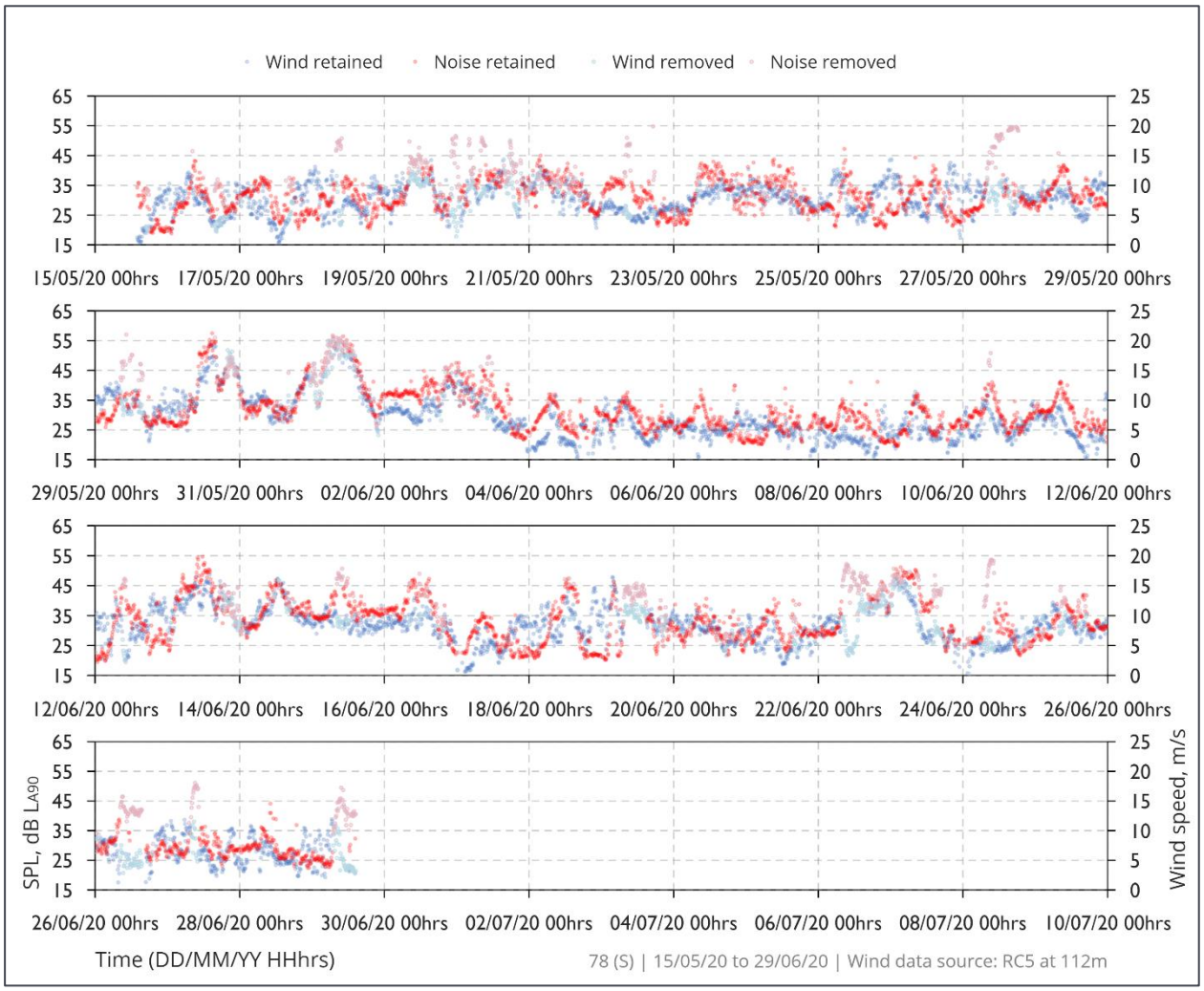
Looking North	Looking East
	
Looking South	**Looking West**
	

N2 Receiver 78 (S) measurement data summary

Table 39: Receiver 78 (S) background noise level analysis summary

Item	All-time (day & night combined)	Night-time (2200 - 0700 hrs)
Number of data points collected	6231	2318
Number of data points removed	781	161
Number of data points for analysis	5450	2157

Figure 31: Receiver 78 (S) background noise level and wind speed time history



Elevated noise levels were occasionally evident in the time history. A selection of audio recordings for this location were reviewed and identified elevated noise levels associated with building work at the property, gardening activities and extraneous noise on the microphone. Based on visual inspection of the trend of the data, and the audio reviews, noise levels above 45 dB L_{A90} at wind speeds below 10 m/s have been filtered from the analysis, as well as a number of isolated periods in the time history profile that were characterised by atypical and distinct noise level increases.

Figure 32: Receiver 78 (S) all-time periods – derived background noise levels

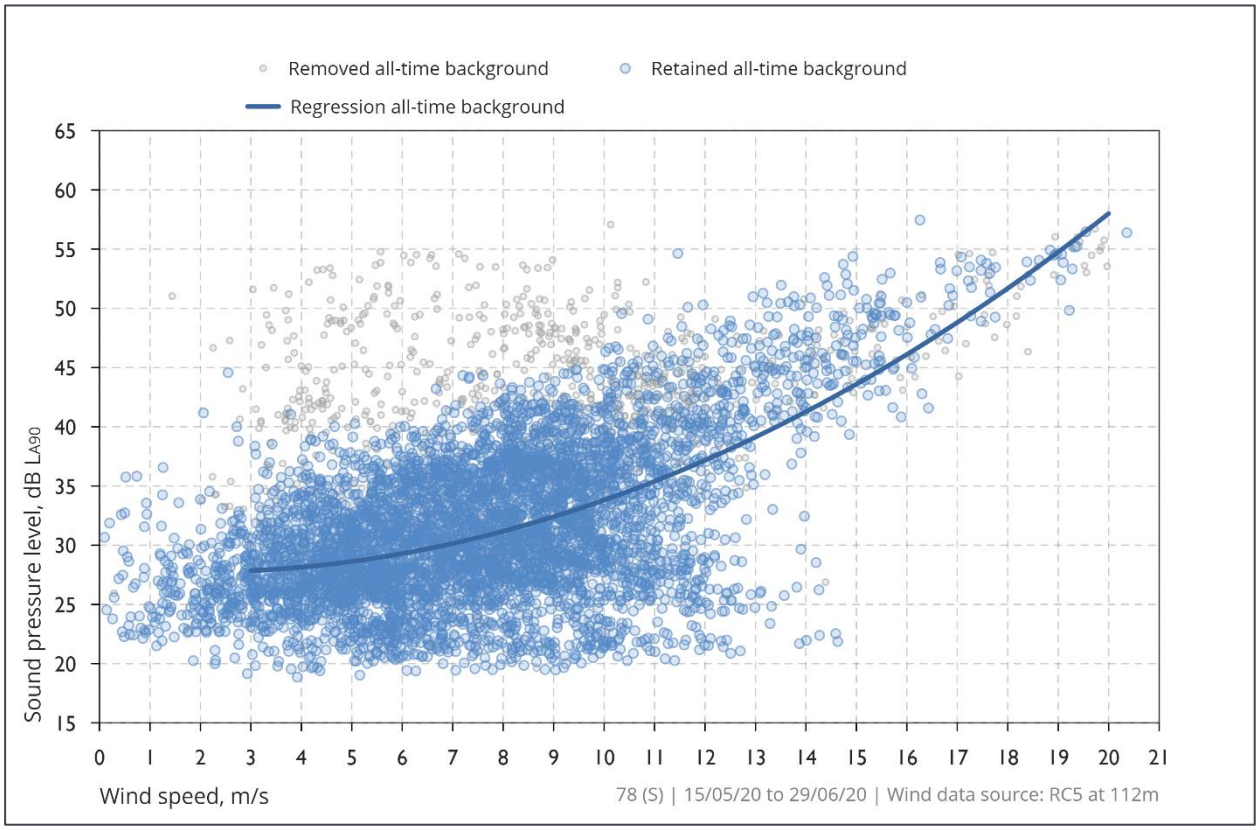


Figure 33: Receiver 78 (S) night-time periods – derived background noise levels