RE Future

Mumblin Wind Farm

Application for Planning Permit

Appendix B – Background Noise Assessment

October 2025

MARSHALL DAY Acoustics

MUMBLIN WIND FARM
BACKGROUND NOISE MONITORING

Rp 002 20200546 | 27 May 2024

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Project: **Mumblin Wind Farm**
Background noise monitoring

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1.0 INTRODUCTION

This report presents the results of background noise monitoring undertaken for the proposed Mumblin Wind Farm (the wind farm).

The background noise monitoring was commissioned by Mumblin Wind Farm Pty Ltd (the proponent) as part 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 method and the results of the background noise monitoring, along with the derived noise limits which would be used to assess the wind farm's operational compliance.

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 proposed wind energy facility.

2.0 BACKGROUND NOISE SURVEY & ANALYSIS METHOD

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), as required by Victorian Government's *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (Victorian Guidelines).
- 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 Institute of Acoustics guidance).

This section of the report presents:

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

2.1 Monitoring locations

The noise modelling results presented in the Noise Assessment Report[1] demonstrate that predicted noise levels are below 35 dB L_{A90} at all non-stakeholder receivers. As such, in accordance with NZS 6808, based on the wind turbine layout detailed in Appendix B and the selected candidate turbine model, background noise monitoring is not required to be undertaken.

However, for completeness, the two (2) background monitoring locations, listed in Table 1 and illustrated in Figure 1, were selected on the basis of:

- A total of eight (8) wind turbines located at the coordinates detailed in Appendix B
- The noise monitoring procedures outlined in NZS 6808
- Upper predicted operational wind farm noise levels presented in the Noise Assessment Report.

It is noted that consent to undertake background noise monitoring was not granted at one of the preferred receivers (Receiver 176). As such, noise monitoring was undertaken at Receiver 98 (stakeholder in the project), located approximately 200 m southwest across Retallacks Road. This location was considered representative of the noise environment at Receiver 176.

Prior to construction of the wind farm, background noise monitoring may be undertaken at additional receivers, should consent be provided.

Table 1: Background noise monitoring locations

Receiver	Direction from wind farm	Distance from nearest turbine
59	Northwest	Approximately 1,200 m
98 (S)	Northwest	Approximately 1,400 m

(S) Stakeholder receiver

[1] As detailed in MDA report Rp 001 R03 20200546 *Mumblin Wind Farm - Noise assessment*, dated 27 May 2024 (Noise Assessment Report)

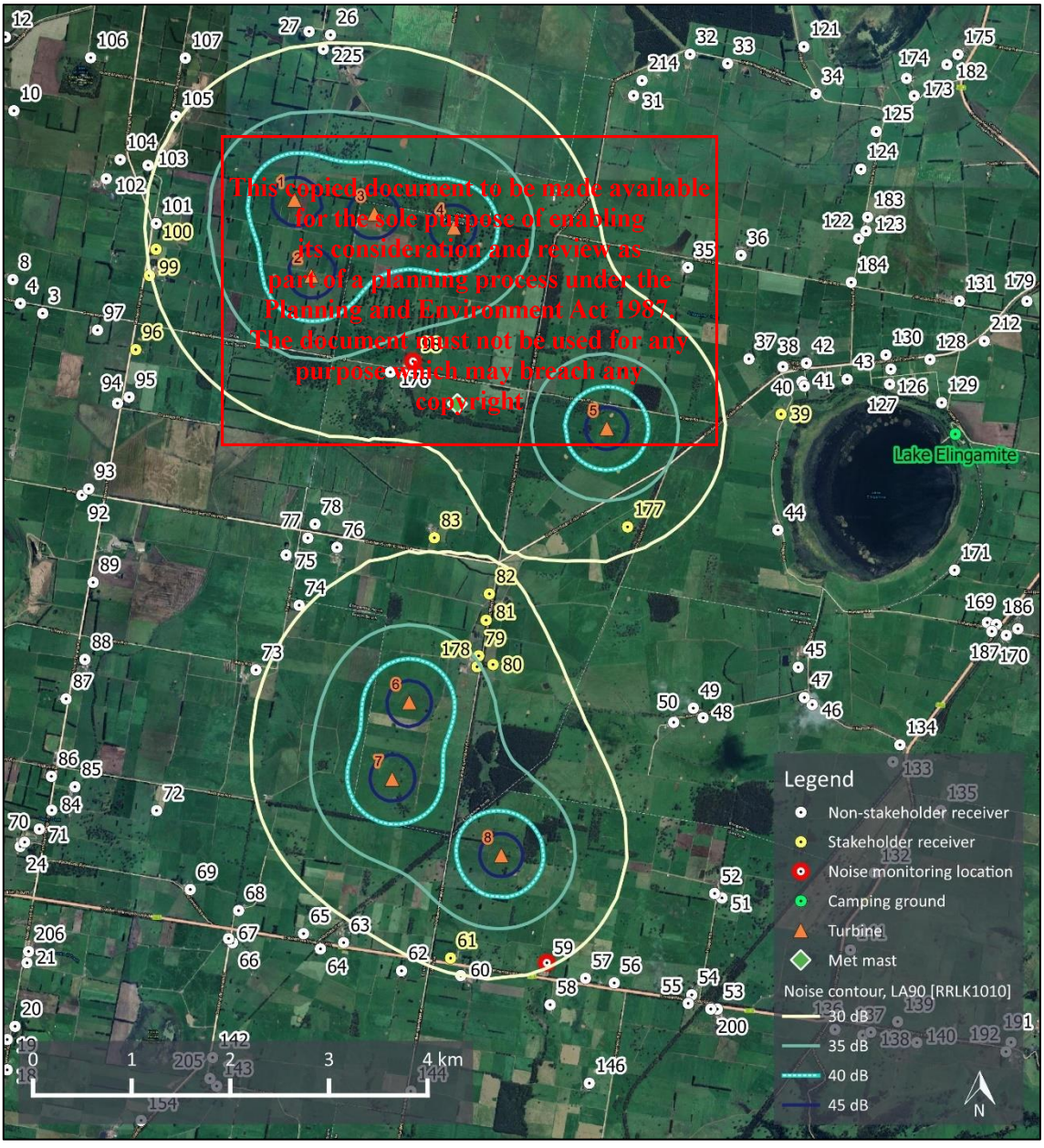
The above information was used to identify the locations where background noise levels were required.

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. The following specific considerations were factored:

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

Coordinates and photographs for the noise monitoring locations are provided in Appendix F and Appendix G

Figure 1: Monitoring locations relative to the proposed Mumblin 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	Two (2) residential receivers as described in Section 2.1.
Monitoring Period	8 June to 27 July 2023 equating to approximately seven (7) weeks at each location. The duration was chosen to satisfy the guidance of NZS 6808 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 Institute of Acoustics guidance. See equipment specifications and calibration records in Appendix B.
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 the site met mast, which extends to a height of 141 m, as shown in Figure 1 Hub height wind speed data (166 m above ground level) was provided by the proponent, based on analysis conducted by Wind Pioneers to extrapolate the 141 m height anemometer wind speed data to 166 m using site-specific wind shear calculations. Documentation summarising the analysis process is reproduced in Appendix D.

2.3 Data analysis

The analysis of the survey data has been conducted in accordance with the NZS 6808. 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[2] 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}.
Time periods	In accordance with Section 7.4.1 of NZS 6808, as separate trends were identified in the scatter plots, the data sets are considered for the following separate periods: • All periods: no restriction on hours (i.e. data during day and night hours included) • Night period: 2200 to 0700 hours

[2] 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	As detailed in Section 6.1.3 of the Noise Assessment Report, noise limits are defined at each wind speed in accordance with NZS 6808 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 Section 7.4.1 of NZS 6808, 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.

3.0 SURVEY & ANALYSIS RESULTS

This section presents a summary of the background noise measurement results, analysed in accordance with the method described in Section 2.2.

The analysis results include the derived background noise levels and noise limits which would be used during compliance monitoring to assess the operational noise of the 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 F and Appendix G.

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
59	- [2]	- [2]	37.8	37.9	38.0	38.2	38.5	39.0	39.6	40.3	41.1	42.1	43.1
98 (S)	- [2]	- [2]	38.8	38.9	39.1	39.5	40.1	40.8	41.6	42.5	43.5	44.5	45.7

1 166 m above ground level at 671095 E, 5753816 N (MGA 94 Zone 54)

2 Outside valid wind speed range of the regression analysis

(S) Stakeholder receiver

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
59	- [2]	- [2]	- [2]	32.0	32.0	32.4	33.1	34.0	35.1	36.4	37.9	39.5	41.2
98 (S)	- [2]	- [2]	- [2]	29.8	29.9	30.4	31.3	32.5	34.0	35.7	37.6	39.7	41.9

1 166 m above ground level at 671095 E, 5753816 N (MGA 94 Zone 54)

2 Outside valid wind speed range of the regression analysis

(S) Stakeholder receiver

3.2 Noise limits

The limits presented herein are based on background noise levels presented in Section 3.1 and the applicable noise limits detailed in Section 6.1.3 of the Noise Assessment Report. Specifically, the NZS 6808 minimum noise limit of 40 dB L_{A90} applies to non-stakeholder receivers in the vicinity of the wind farm.

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 and Appendix G.

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
59	-[2]	-[2]	42.8	42.9	43	43.2	43.5	44	44.6	45.3	46.1	47.1	48.1
98 (S)	-[2]	-[2]	43.8	43.9	44.1	44.5	45.1	45.8	46.6	47.5	48.5	49.5	50.7

1 166 m above ground level at 671095 E, 5753816 N (MGA 94 Zone 54)

2 Noise limits derived based on the minimum noise limit of 40 dB L_{A90} applicable at Receiver 176

(S) Stakeholder receiver

Table 7: Night 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
59	-[2]	-[2]	-[2]	40.0	40.0	40.0	40.0	40.0	40.1	41.4	42.9	44.5	46.2
98 (S)	-[2]	-[2]	-[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.7	42.6	44.7	46.9

1 166 m above ground level at 671095 E, 5753816 N (MGA 94 Zone 54)

2 Noise limits derived based on the minimum noise limit of 40 dB L_{A90} applicable at Receiver 176

(S) Stakeholder receiver

4.0 SUMMARY

Background noise monitoring has been conducted at two (2) receivers in the vicinity of the Mumblin Wind Farm.

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

- New Zealand Standard 6808:2010 *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZS 6808), as required by Victorian Government's *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023
- 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 background noise levels and noise limits in accordance with NZS 6808 for surrounding receivers. Specifically, noise limits have been derived at integer hub-height wind speeds as the greater of a minimum limit (40 dB L_{A90}) 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 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 set of frequency-dependent sound level adjustments that are used to better represent how humans hear sounds. Humans are less sensitive to low and very high frequency sounds. Sound levels using an "A" frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels are dBA or dB(A).	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	The interval between one frequency and its double. Sound is divided into octave bands for analysis. The typical octave band centre frequencies are 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz.	-
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 eight (8) turbine layout of the Mumblin Wind Farm as supplied by the proponent on 3 August 2023.

Table 8: Turbine coordinates – MGA 94 zone 54

Turbine	Easting	Northing
T1	669,442	5,755,885
T2	669,614	5,755,115
T3	670,254	5,755,744
T4	671,059	5,755,604
T5	672,610	5,753,566
T6	670,607	5,750,787
T7	670,433	5,750,006
T8	671,541	5,749,233

APPENDIX C SURVEY INSTRUMENTATION

Table 9: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB CUBE & DUO
Instrumentation class	Certified to Type1 / Class 1 (precision grade) standards in accordance with AS 1259.2-1990[3] and IEC 61672.1-2004[4]
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 Institute of Acoustics guidance. The system comprises an inner solid primary wind shield and an outer secondary large diameter hollow wind shield

Table 10: Sound level meter installation records

Receiver	System	Unit serial number	Microphone serial number	Independent calibration date [1]	Calibration drift [2,3]
59	01dB CUBE	11917	330738	10 February 2022	+0.33 dB
98 (S)	01dB DUO	10447	144898	8 April 2022	+0.20 dB

1 Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055-1:1997[5]

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 1055-1:1997

(S) Stakeholder receiver

Table 11: Wind speed measurement instrumentation

Wind speeds	Description
Local wind speeds	Vaisala VTX 520 weather station (serial number K2920006) positioned at Receiver 59
Site wind speeds	Third party owned and operated system comprising one (1) meteorological mast with anemometry at multiple heights up to 141 m Coordinates: 671095 E, 5753816 N (MGA 94 Zone 54) Further information provided in Appendix D.

3 AS 1259.2-1990: *Acoustics - Sound level meters - Integrating - Averaging*

4 IEC 61672.1-2004: *Electroacoustics - Sound level meters - Specification*

5 AS 1055-1:1997 *Acoustics – Description and measurement of environmental noise - Part 1: General Procedures*

APPENDIX D SITE WIND SPEED DATA DERIVATION

This appendix reproduces correspondence provided by the proponent on 4 September 2023 documenting the process used to derive the 166 m AGL wind speeds required to analyse the measured background noise data.

> *The anemometers on the mast are measuring the wind speeds at the heights of 60 m, 100 m, 120.2 m, and 141.4 m. The extrapolation to the hub heights of 150 m and 166 m is based on the time-series approach and it is a two-step process. In the first step, shear is estimated at each of the time-stamps from the measured wind speeds using a IEC standard power law that assumes a normal vertical-wind profile. In the second step, the wind speeds are extrapolated to the hub height at every time-stamp using the nearest measured height and the estimated shear value. In the below equation, V and V_{ref} represent wind speeds at hub height and measured height, while z and α represent height and shear alpha respectively.*
>
> $$V(z) = V_{ref}\left(\frac{z}{z_{ref}}\right)^{\alpha}$$

APPENDIX E SUMMARY OF BACKGROUND NOISE LEVELS

Table 12: Regression equation coefficients - All-time period

	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**
59	0.0005	0.0450	-0.5295	39.30	0.1784	5-21
98 (S)	-0.0023	0.1274	-1.1200	41.49	0.1251	5-21

(S) Stakeholder receiver

Table 13: Regression equation coefficients - Night period

	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**
59	-0.0059	0.2885	-2.967	40.70	0.4844	6-21
98 (S)	-0.0073	0.3604	-3.664	40.42	0.4949	6-21

(S) Stakeholder receiver

APPENDIX F RECEIVER 59 DATA

F1 Receiver 59 location data

Table 14: Receiver 59 noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	672,003	5,748,117
Background noise monitoring location	672,004	5,748,141

Figure 2: Receiver 59 aerial view – dwelling and noise monitor locations

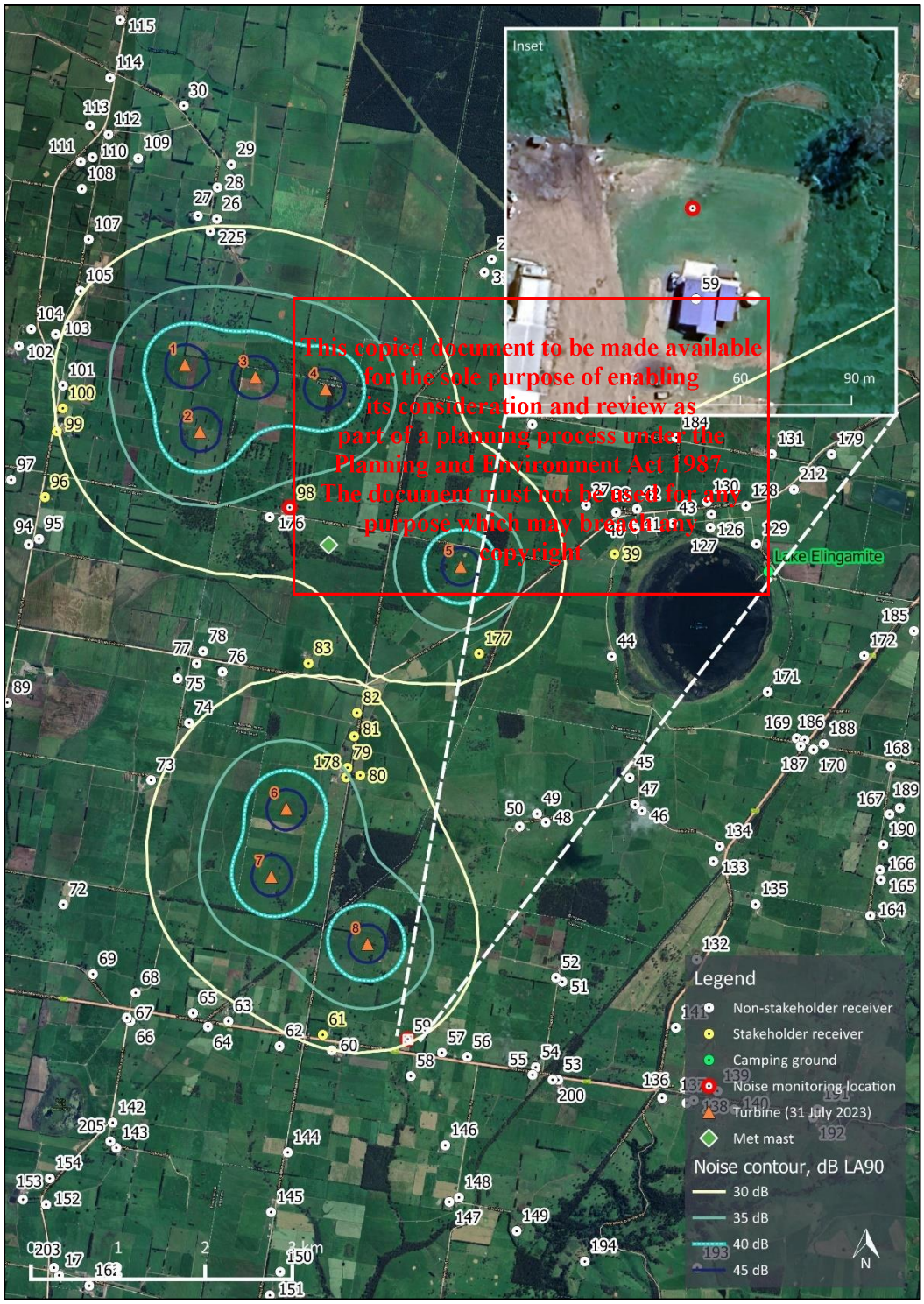


Table 15: Receiver 59 monitor installation photos

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

F2 Receiver 59 measurement data summary

Table 16: Receiver 59 background noise level analysis summary

Item	All-time period	Night period
Number of data points collected	6,839	2,537
Number of data points removed	2,337	1,215
Number of data points for analysis	4,502	1,322

Figure 3: Receiver 59 noise level and wind speed time history

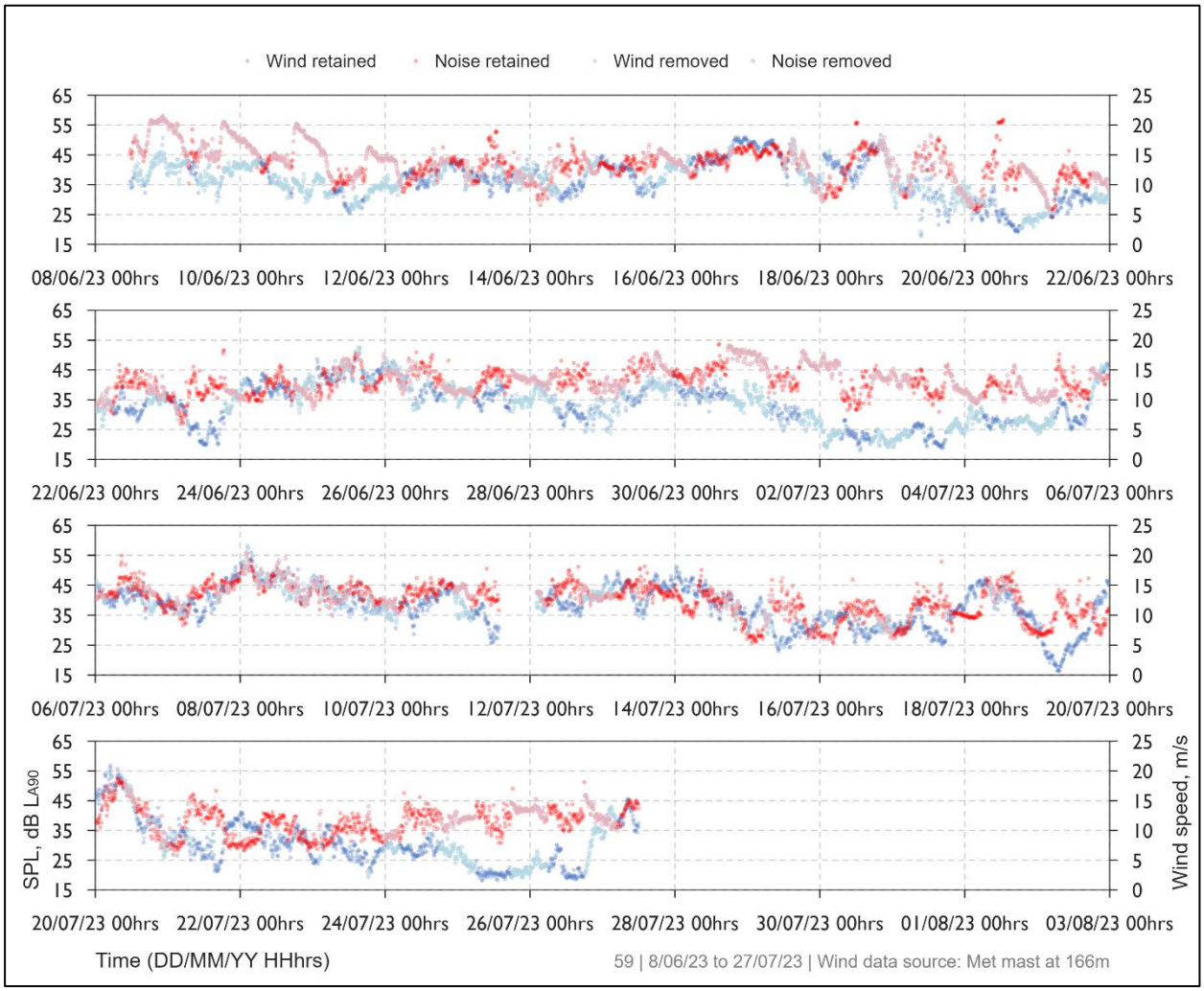


Figure 4: Receiver 59 background noise levels and noise limits – All-time period

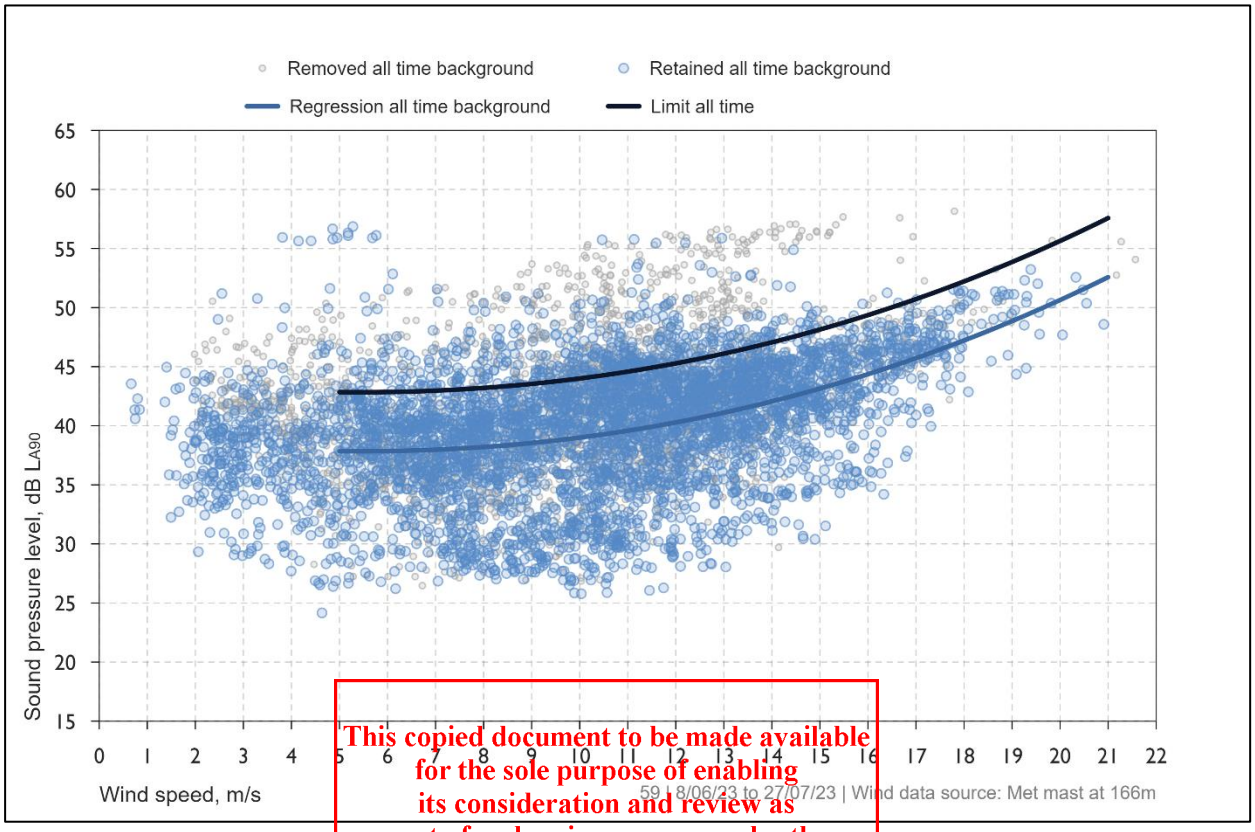
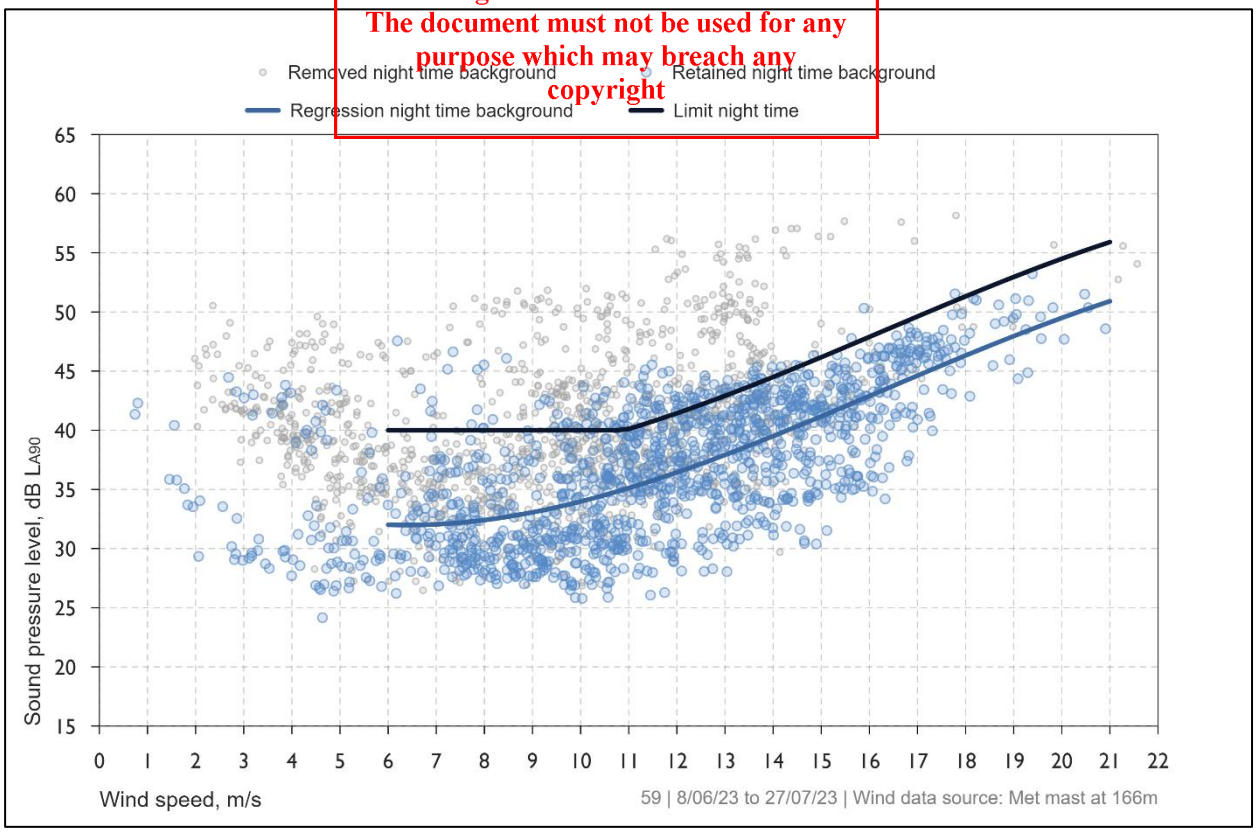


Figure 5: Receiver 59 background noise levels and noise limits – Night period



APPENDIX G RECEIVER 98 DATA

G1 Receiver 98 location data

Table 17: Receiver 98 noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	670,663	5,754,240
Background noise monitoring location	670,642	5,754,249

Figure 6: Receiver 98 aerial view – dwelling and noise monitor locations

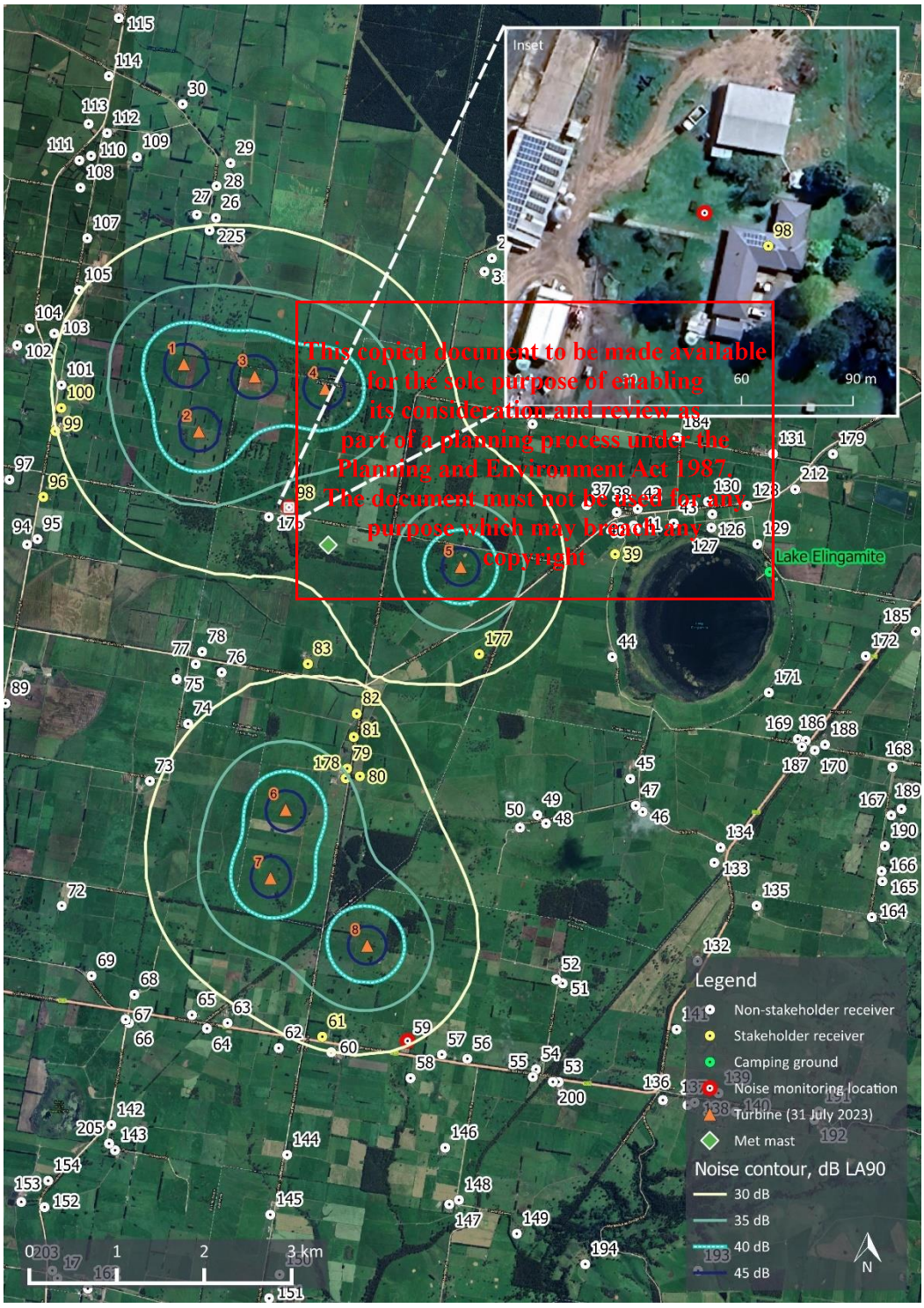


Table 18: Receiver 98 monitor installation photos

Looking North [1]	Looking East
	
Looking South	**Looking West**
	

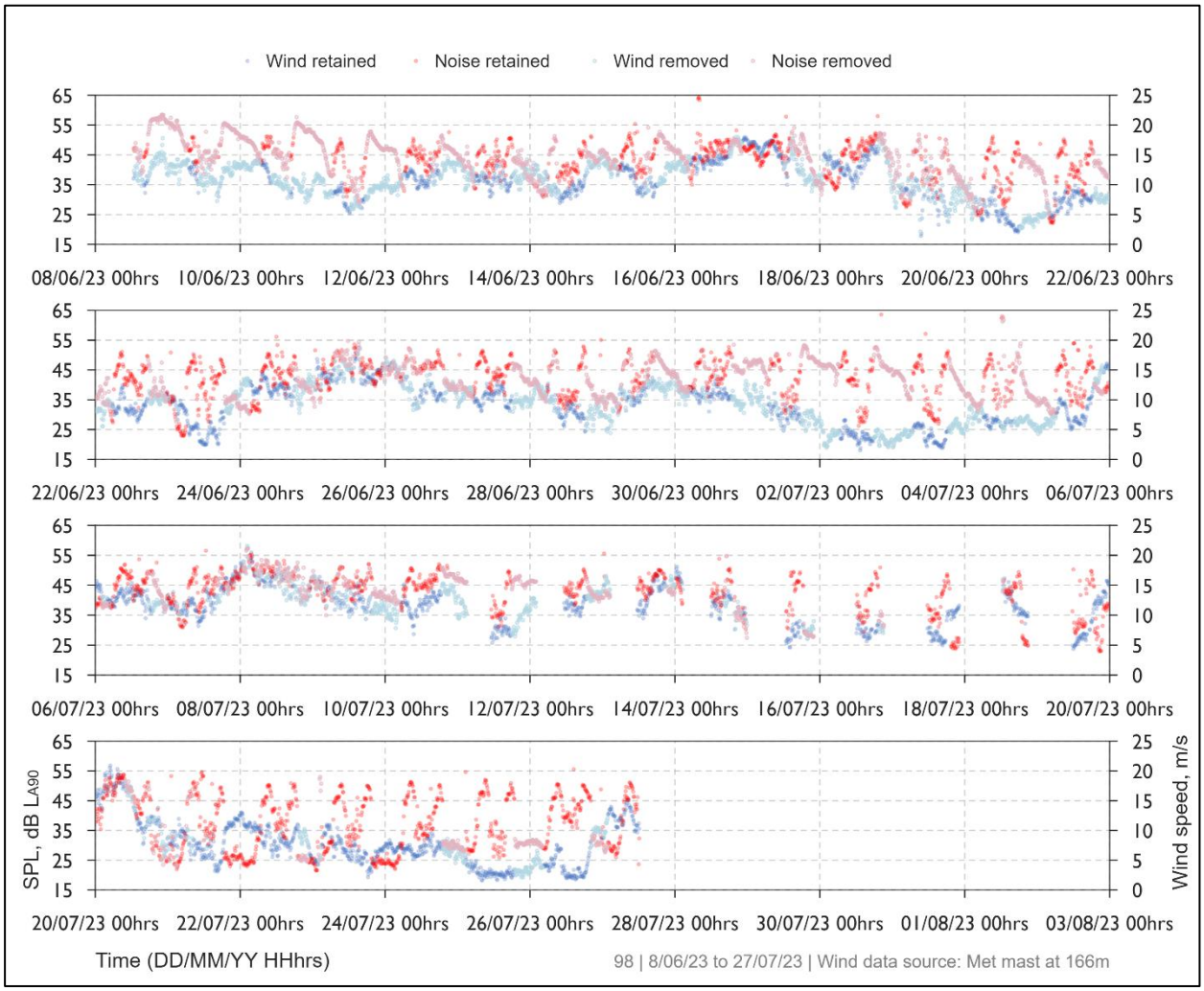
1 Noise monitor position indicated by orange rectangle due to picture taken against the sunlight

G2 Receiver 98 measurement data summary

Table 19: Receiver 98 background noise level analysis summary

Item	All-time period	Night period
Number of data points collected	6,308	2,227
Number of data points removed	2,525	1,335
Number of data points for analysis	3,783	892

Figure 7: Receiver 98 noise level and wind speed time history[6]



[6] The lack of data from 11-20 July 2023 is due to insufficient charging from the solar panel resulting in a depleted battery overnight.

Figure 8: Receiver 98 background noise levels and noise limits – All-time period

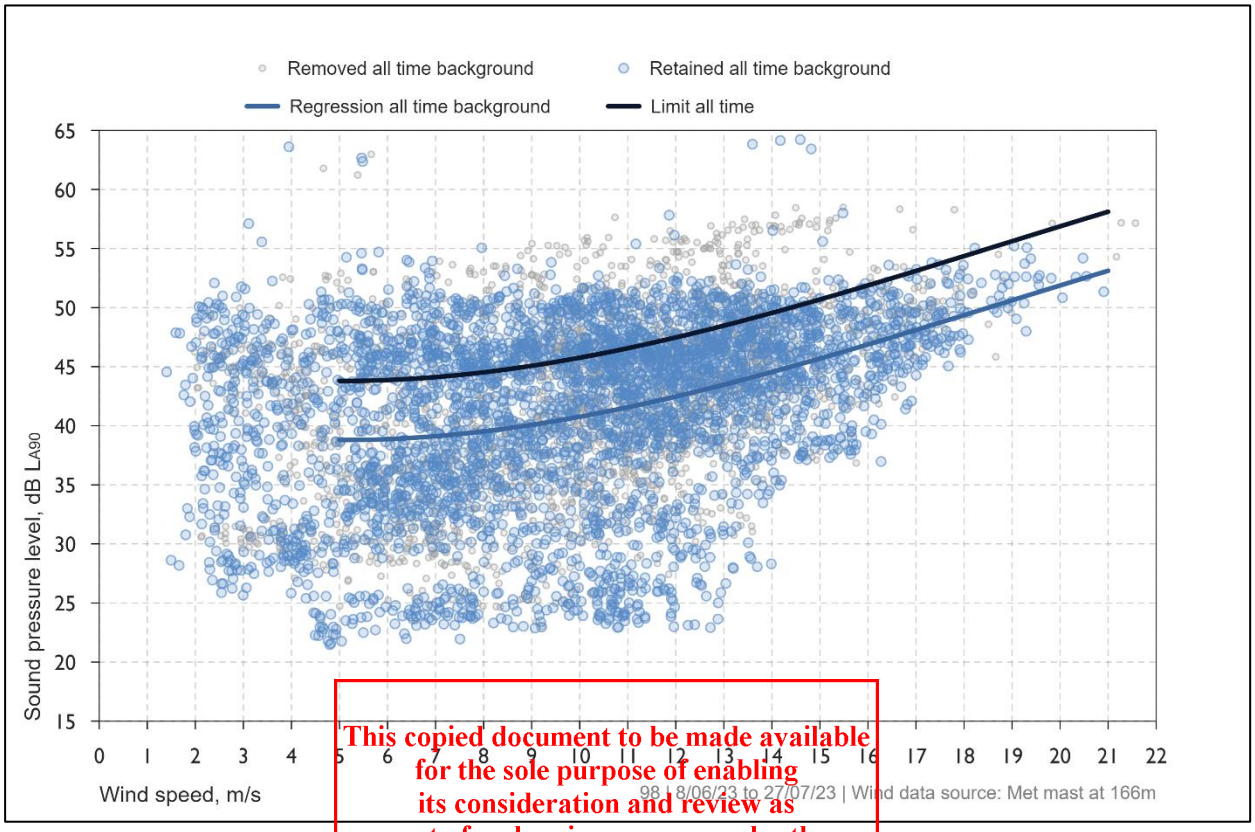
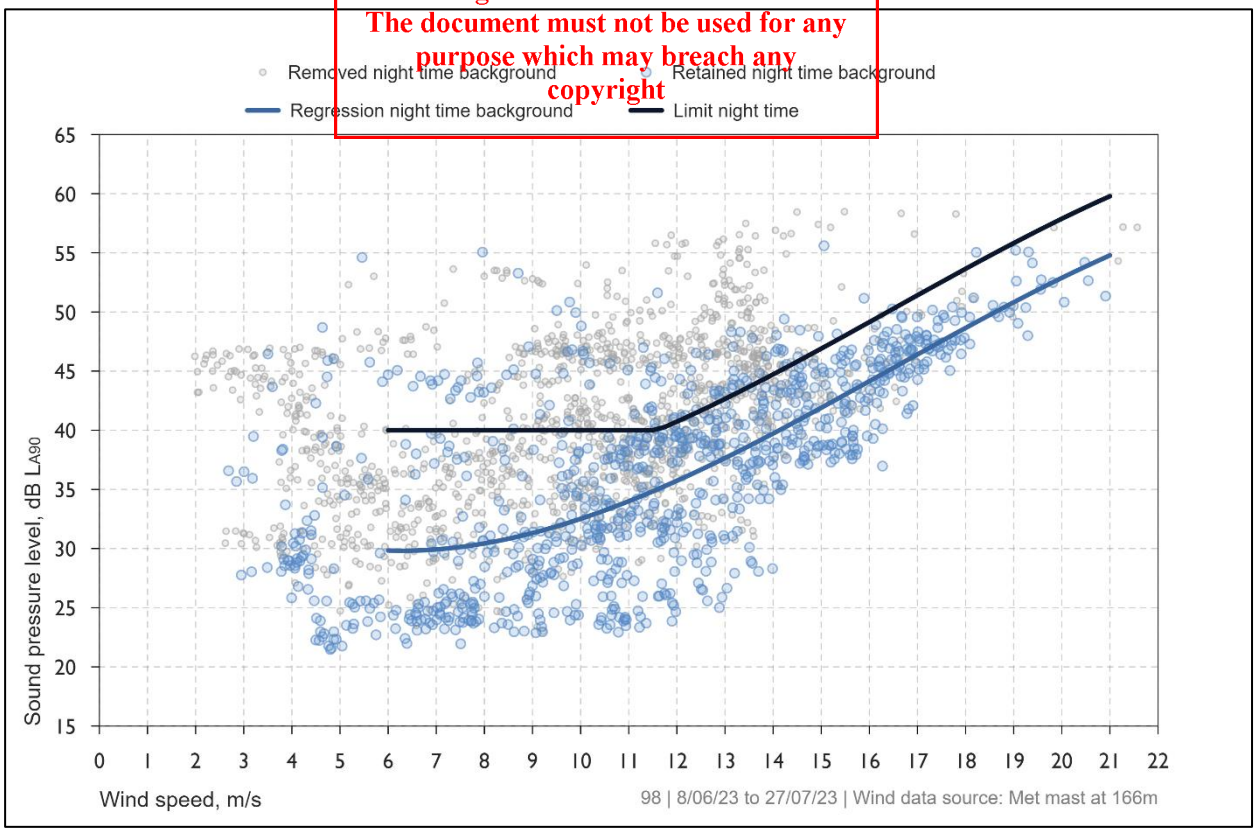
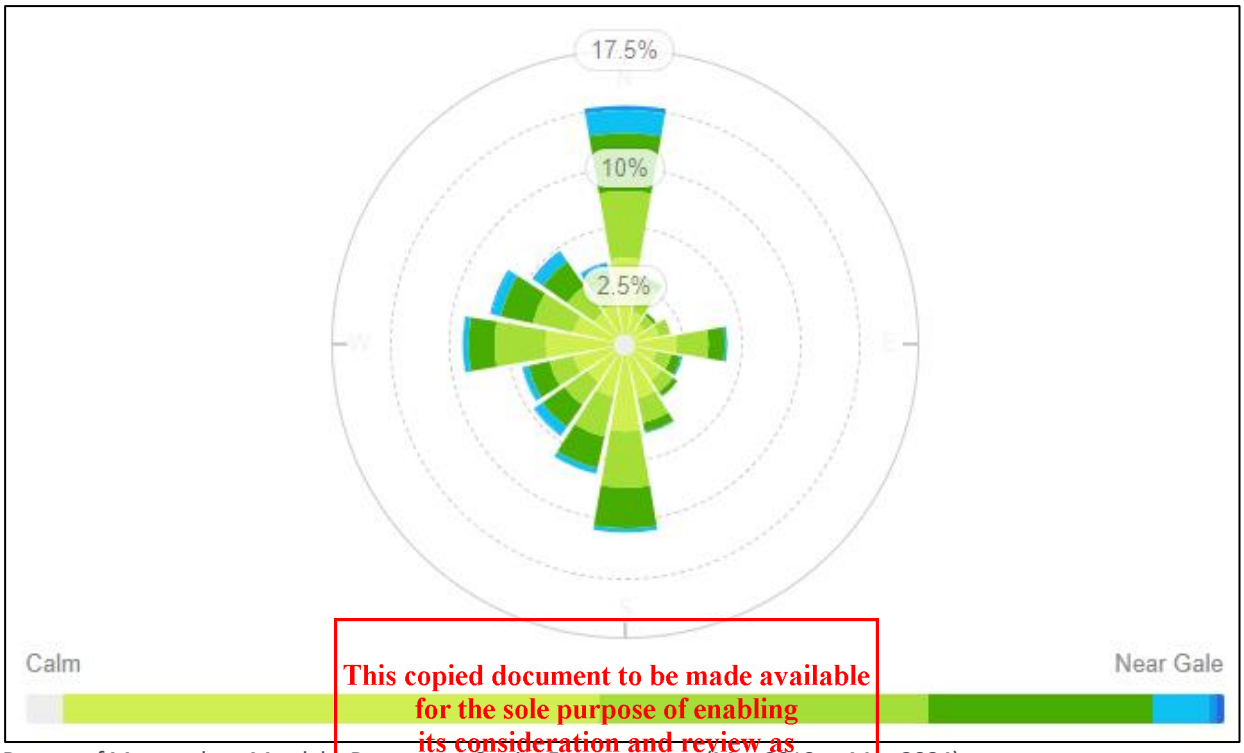


Figure 9: Receiver 98 background noise levels and noise limits – Night period



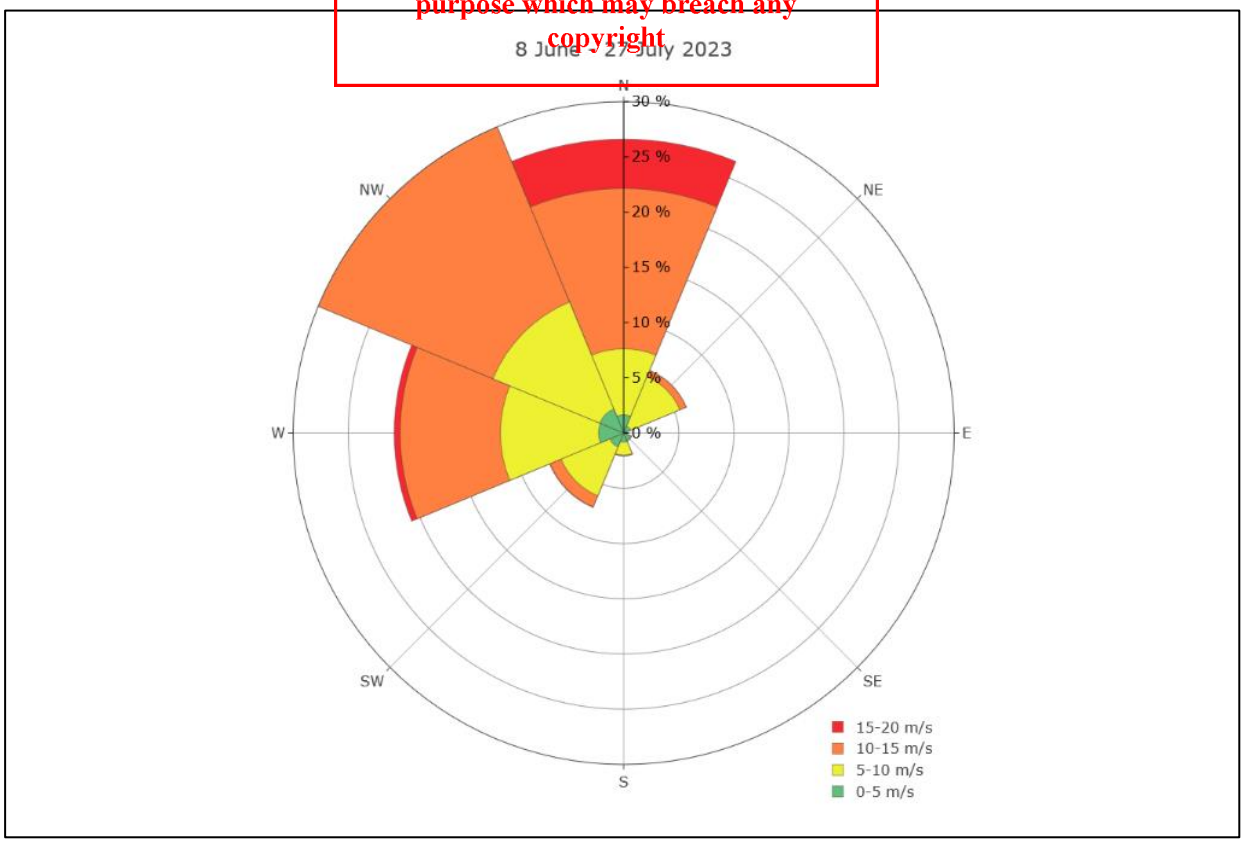
APPENDIX H WIND ROSE

H1 Annual wind rose



Bureau of Meteorology Mortlake Racecourse Station5 year average (May 2019 to May 2024)
Data courtesy of willyweather.com

H2 Background noise survey period wind rose



Project meteorological mast (8 June to 27 July 2023)

APPENDIX I DOCUMENTATION

Section 8.2 of NZS 6808 specifies the information to be included in a background noise measurement and assessment report. The information requirements, and the report section(s) where the information has been provided, are detailed below.

Table 20: NZS 6808 reporting requirements for background noise monitoring

Section 8.3 subclause	Reporting requirement	Report section
(a)	Description of the sound monitoring equipment including any ancillary equipment	Appendix C
(b)	The location of sound monitoring positions	Section 2.1
(c)	Description of the anemometry equipment including the height AGL of the anemometer	Section 2.2
(d)	Position of wind speed measurements	Section 2.2
(e)	Time and duration of monitoring period	Section 2.2
(f)	Averaging period for both sound and wind speed measurements	Section 2.1 and Section 2.2
(g)	Atmospheric conditions: the wind speed and direction at the wind farm position and rainfall shall be recorded	Data available upon request
(h)	Number of data pairs measured (wind speed in m/s, background sound in L_{90})	Appendix F and Appendix G
(i)	Description of the regression analysis	Section 2.2 and Appendix E
(j)	Graphical plots showing the data scatter and the regression curves	Appendix F and Appendix G