Hornsby Ku-ring-gai Hospital Stage 2 Redevelopment

SSD Acoustic Assessment

SYDNEY
A: 9 Sarah St Mascot NSW 2020
T: (02) 8339 8000
F: (02) 8338 8399

SYDNEY MELBOURNE BRISBANE CANBERRA
LONDON DUBAI SINGAPORE GREECE

www.acousticlogic.com.au
ABN: 11 068 954 343

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1 INTRODUCTION

Acoustic Logic Consultancy (ALC) have been engaged by Health Infrastructure NSW (HI) to undertake an assessment of potential noise and vibration impacts resulting from the proposed Stage 2 redevelopment of the Hornsby Ku-ring-gai Hospital.

This report will:

- Conduct an external noise intrusion assessment (primarily of traffic noise to determine the building façade construction required to meet the internal noise requirements.
- Address the relevant Council and Environmental Protection Authority (EPA) noise emission criteria applicable to the development.
- Identify nearby noise sensitive receivers and anticipated operational noise sources with the potential to adversely impact surrounding sensitive receivers.
- Predict operational noise emissions and assess them against acoustic criteria.
- Where required, determine building and/or management controls necessary to ensure ongoing compliance with noise emission goals.

In addition, this report will also include a preliminary review of potential noise and vibration impacts resulting from the proposed demolition, excavation and constructions works associated with the Stage 2 redevelopment.

2 SITE DESCRIPTION AND PROPOSED WORKS

The Hornsby Ku-ring-gai Hospital is bound to the north by Lowe Road, to the west by Palmerston Road, to the east by Derby Road and to the south by Burdett Street. These local roads carry low to medium volumes of traffic.

The proposed Stage 2 redevelopment of the Hornsby Ku-ring-gai Hospital involves,

- Demolition and Enabling works;
- Construction of a new six storey building located towards the southern half of the hospital precinct. The development will include the following:
    - Ambulatory Care Centre;
    - Medical Assessment Unit;
    - Emergency Department;
    - Cardiology and Intensive Care Unit;
    - Rehabilitation facilities;
    - In-patient units;
    - Education and research facilities;
    - A new ambulance bay will be located towards the south-western boundary of the site along Burdett Street. Ambulances will enter from Palmerston Road and exit onto Burdett Street (see figure 2);
    - Café on the ground floor of the proposed development with outdoor seating areas.
- Construction of new roadways within the hospital precinct, primarily near the south-western boundary.

The proposed Stage 2 redevelopment is proposed to operate 24 hours a day, seven days a week.

We note that a new multi-storey car park has been approved and will be constructed prior to the completion of the Stage 2 redevelopment (see aerial photo). This multi-storey car park will cater for the additional parking demand generated by the Stage 2 redevelopment. Noise impacts from the proposed multi-storey car park have been addressed previously in the *Noise Impact Assessment* prepared by this office (re: 20161182.1/1008A/R1/BW, dated 12/09/2016).

In addition, we note that there is an existing emergency generator located near the south-western boundary of the site which will be retained as part of the Stage 2 works.

There are currently hospital buildings along the south-western boundary of the hospital precinct providing screening between the residents to the south across Burdett Street (see aerial photo) and an existing generator and the existing ambulance dock located on the hospital precinct. These hospital buildings will be demolished as part of the Stage 2 redevelopment which will result in the residents to the south along Burdett Street having direct line of sight to the generator and the proposed ambulance bay. The change in noise generation from the generator as a result has been addressed in section 6.1.2. Noise from the proposed ambulance bay has been addressed in section 6.1.1.

2.1 SURROUNDING DEVELOPMENT

The hospital precinct is generally surrounded by residential properties with local road networks carrying low to medium volumes of traffic.

The surrounding potentially affected receivers as a result of the proposed Stage 2 redevelopment project are as follows:

- Receiver 1: Residential development located to the south of the site across Burdett Street;
- Receiver 2: Residential development located to the east of the site across Derby Street;
- Receiver 3: Residential development located to the north-west of the site across Palmerston Road;
- Receiver 4: Childcare centre located to the immediate south-west of the site;
- Receiver 5: Commercial development located to the west of the site across Palmerston Road;
- Receiver 6: Waitara Anglican Church located to the south of the site across Burdett Street.

Figure 2 below illustrates location of surrounding sensitive land uses.

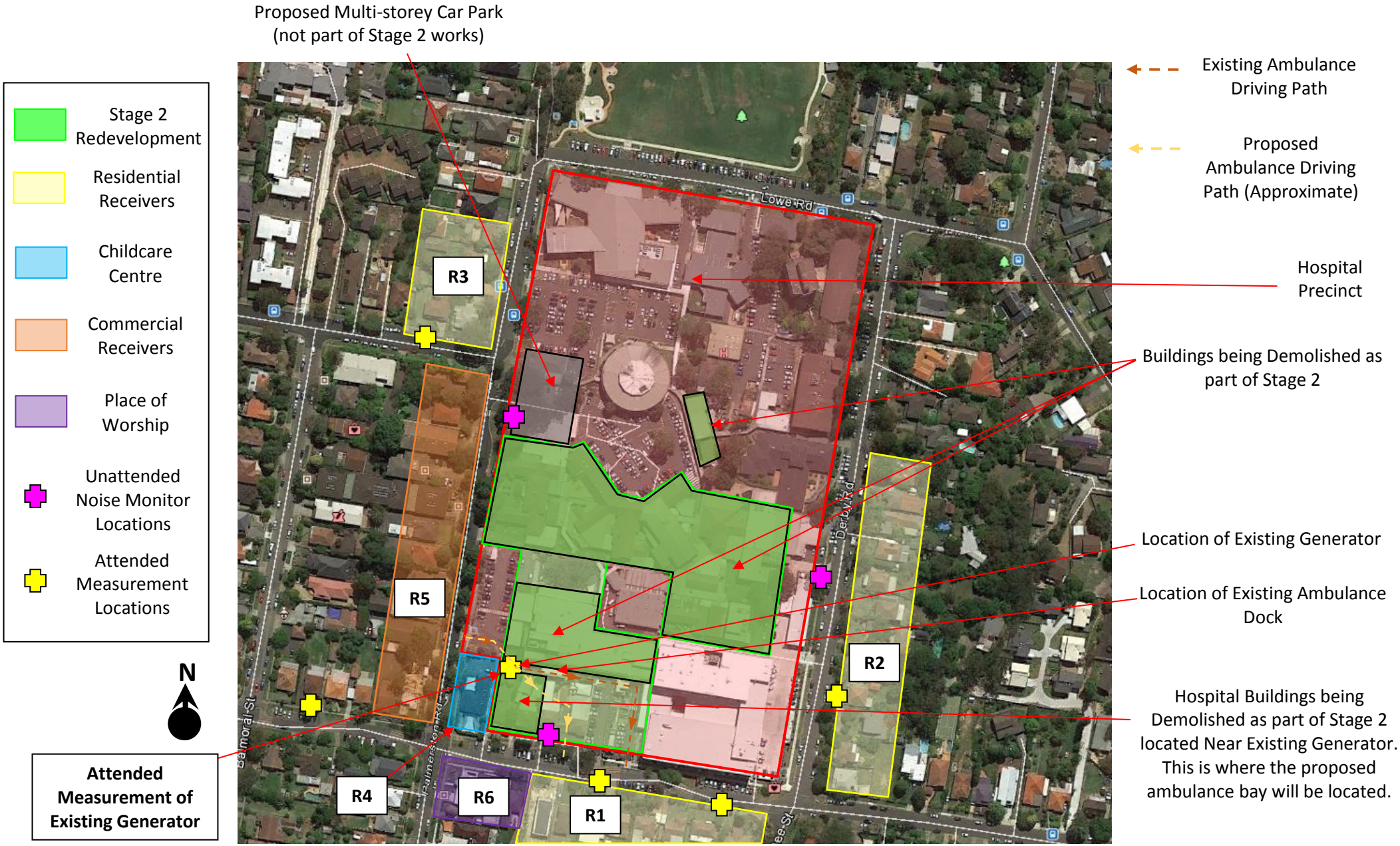


Figure 1 – Site Photo (Google Earth)

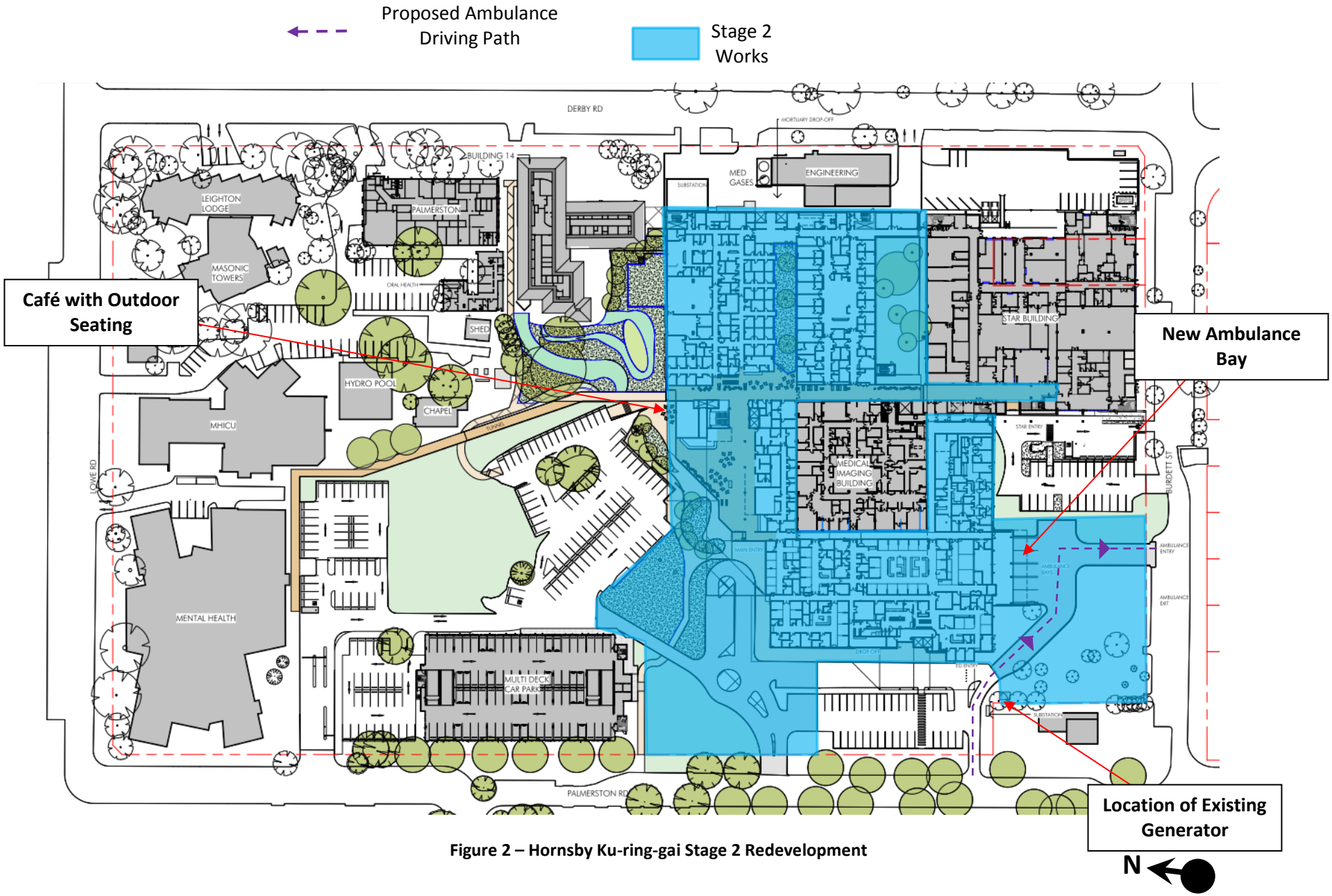


Figure 2 – Hornsby Ku-ring-gai Stage 2 Redevelopment

3 NOISE DESCRIPTORS

Environmental noise constantly varies. Accordingly, it is not possible to accurately determine prevailing environmental noise conditions by measuring a single, instantaneous noise level.

To accurately determine the environmental noise a 15-20 minute measurement interval is utilised. Over this period, noise levels are monitored on a continuous basis and statistical and integrating techniques are used to determine noise description parameters.

In analysing environmental noise, three-principle measurement parameters are used, namely L_{10}, L_{90} and L_{eq}.

The L_{10} and L_{90} measurement parameters are statistical levels that represent the average maximum and average minimum noise levels respectively, over the measurement intervals.

The L_{10} parameter is commonly used to measure noise produced by a particular intrusive noise source since it represents the average of the loudest noise levels produced by the source.

Conversely, the L_{90} level (which is commonly referred to as the background noise level) represents the noise level heard in the quieter periods during a measurement interval. The L_{90} parameter is used to set the allowable noise level for new, potentially intrusive noise sources since the disturbance caused by the new source will depend on how audible it is above the pre-existing noise environment, particularly during quiet periods, as represented by the L_{90} level.

The L_{eq} parameter represents the average noise energy during a measurement period. This parameter is derived by integrating the noise levels measured over the 15 minute period. L_{eq} is important in the assessment of traffic noise impact as it closely corresponds with human perception of a changing noise environment; such is the character of environmental noise.

L_1 levels represent is the loudest 1% noise event during a measurement period.

4 EXISTING ACOUSTIC ENVIRONMENT

Unattended long term monitoring and attended short term measurements were conducted at the hospital precinct, to quantify the existing acoustic environment.

4.1 UNATTENDED NOISE MEASUREMENTS

Unattended noise monitoring was conducted using three Acoustic Research Laboratories noise monitors. The monitors were set to an A-weighted fast response mode, recording continuously at 15 minute intervals. Both monitors were calibrated at the start and end of the monitoring period using a Rion NC-73 calibrator. No significant drift was noted.

The locations of the noise monitors were as follows:

- **Monitor 1**: Installed along Burdett Street on the southern boundary of the hospital precinct. Background noise levels measured by this logger are representative of existing levels at the residential properties along Burdett Street. The noise monitor was on site between the 31st May and the 7th June 2017. Refer to Appendix 1 for this logging data.

- **Monitor 2**: Installed along Derby Street on the eastern boundary of the hospital precinct. Background noise levels measured by this logger are representative of existing levels at the residential properties along Derby Street. The noise monitor was on site between the 24th and the 31st May 2017. Refer to Appendix 2 for this logging data.

- **Monitor 3**: Installed along Palmerston Road on the western boundary of the site. The noise monitor was on site between the 24th and the 31st May 2017. Refer to Appendix 3 for this logging data.

The noise monitor locations were located as close as possible to the nearby residential receivers (R1-R3). It was not possible to locate the noise monitors any closer to the residential receivers (i.e. on the same side of the road as the residents) without compromising the security of the noise monitoring equipment.

4.1.1 Unattended Noise Measurement Results

The measured ambient and background noise levels are presented in the tables below and have been based on the unattended measurements.

Table 1 – Measured Ambient and Background Noise Levels along Burdett Street (Monitor 1)

Date	Measured Rating Background Noise Level dB(A)$L_{90(period)}$			Measured Ambient Noise Level dB(A)$L_{eq(period)}$		
	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
31/05/2017	-	44	40	-	52	50
01/06/2017	45	46	40	55	52	48
02/06/2017	43	44	37	53	53	48
03/06/2017	44	41	37	54	49	46
04/06/2017	41	41	37	52	54	49
05/06/2017	39	38	37	53	50	48
06/06/2017	45	47*	44*	54	57*	55*
07/06/2017	48*	-	-	58*	-	-
	MEDIAN			**AVERAGE**		
	44	**43**	**35** ** **(37)**	**53**	**52**	**48**

*Noise data not used as it is affected by adverse weather conditions.

** Measured background noise level from the noise monitor was 37dB(A)L_{90}. However in order to be conservative, a background noise level of 35dB(A)L_{90} for the night time period has been adopted based on attended background noise measurements. Refer to section 4.2.1.

Table 2 – Measured Ambient and Background Noise Levels along Derby Street (Monitor 2)

Date	Measured Rating Background Noise Level dB(A)$L_{90(period)}$			Measured Ambient Noise Level dB(A)$L_{eq(period)}$		
	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
24/05/2017	-	41	41	-	49	55
25/05/2017	41	44	41	56	51	51
26/05/2017	42	44	42	55	52	48
27/05/2017	41	43	42	52	52	48
28/05/2017	43	42	41	54	48	56
29/05/2017	42	45	41	56	51	49
30/05/2017	41	43	42	53	51	53
	MEDIAN			**AVERAGE**		
	42	**43**	**41**	**54**	**51**	**51**

Table 3 – Measured Ambient and Background Noise Levels along Palmerston Road (Monitor 3)

Date	Measured Rating Background Noise Level dB(A)$L_{90(period)}$			Measured Ambient Noise Level dB(A)$L_{eq(period)}$		
	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
24/05/2017	-	44	40	-	50	49
25/05/2017	43	45	39	55	50	48
26/05/2017	44	41	37	54	50	44
27/05/2017	40	41	38	53	48	45
28/05/2017	43	42	37	55	49	47
29/05/2017	45	42	42	62	49	49
30/05/2017	43	43	41	52	49	47
31/05/2017	45	-	-	54	-	-
	MEDIAN			**AVERAGE**		
	43	**42**	**39**	**55**	**49**	**47**

4.2 ATTENDED NOISE MEASUREMENTS

Attended noise measurements were conducted at the nearest residential receivers to supplement the unattended noise measurements on the 18th January 2018 from 11pm onwards.

Attended measurements were obtained using a Norsonics Type 140 Sound Level Analyser. The Sound Level Analyser was calibrated at the beginning and the end of the measurement using a Norsonics Type 1251 Sound Level Calibrator. No significant drift was noted. All measurements were conducted on A-weighted fast response mode. There were no significant periods of adverse weather conditions during the measurement period.

The calibration certificate for the sound level meter is attached in Appendix 2.

The results of the attended night time measurements are as follows:

4.2.1 Burdett Street Residents (Receiver 1)

- Our attended survey of existing night time ambient conditions on 18/1/2017 showed that ambient conditions on Burdett Street residential receivers varied depending on the resident's location.

- Burdett Street residents further west (towards Palmerston Road such as 76A Burdett Street) were affected by noise from rooftop mechanical plant serving the hospital, with measured noise levels from mechanical plant of 42dB(A)L_{eq}.

- However, Burdett Street residents further east (towards Derby Street such as 88 Burdett Street) are screened such that plant noise is not audible and background noise levels as low as 37dB(A)L_{90} were measured.

- An additional background noise measurement was conducted further west along Burdett Street, past Palmerston Road (at 79 Burdett Street), where noise from the hospital was inaudible and dominated by distant traffic noise (from the Pacific Highway). The measured background noise level was 35dB(A)L_{90}.

- Based on these measurement results it can be concluded that the existing background noise level at the Burnett Street residents, in the absence of any noise from the existing hospital, is between 35dB(A)L_{90} and 37dB(A)L_{90}.

- While in our opinion, 37dB(A)L_{90} is in fact the correct background noise level, a background noise level of 35dB(A)L_{90} will be adopted for the Burdett Street residents for the purposes of the setting noise emission criteria.

4.2.2 Derby Road Residents (Receiver 2)

- A site investigation on the 18/01/2018 revealed that the residents along Derby Street were affected by plant noise from fans serving the hospital loading dock.

- This measured noise level (on the 18/01/2017) from the hospital plant at the property boundary of the resident at 8 Derby Road was 42dB(A)L_{eq}.

- An attempt was made to conduct background noise measurements further north along Derby Road that were not affected by plant noise from the hospital, however background noise levels further north were measured to be over 44dB(A)L_{90} as they were affected by distant traffic noise from the Pacific Highway.

- We also note that the existing mechanical plant servicing the loading dock will not be altered as part of the Stage 2 redevelopment works at the hospital.

- The measured hospital plant noise levels at the Derby Road residents will be used in setting the Amenity noise emission criteria for the Stage 2 development (refer to section 5.2.2).

4.2.3 Palmerston Road Residents (Receiver 3)

- During our late night attended noise measurements on 18/1/2018, it was not possible to take background noise measurements at the residences on Palmerston Road, as there was noise from temporary construction plant associated with the Hornsby Hospital multi-storey car park. We note that this plant noise was not audible at the Burdett Street or Derby Road residents.

- This being the case, the 18/1/2018 background noise measurements were conducted at the property boundary 2 Northcote Road, which is further away from the hospital site than the Palmerston Road residents. No hospital generated noise was audible at this location.

- The measured background noise level was 39dB(A)L_{90}, which is consistent with the 39dB(A)L_{90} night time noise level measured by the Palmerston Road noise monitor. The long term logging data along Palmerston Road is therefore appropriate for use in setting noise emission goals.

4.3 METEOROLOGICAL CONDITIONS DURING MONITORING PERIOD

Section 3.4 of the NSW Environment Protection Authority (EPA) Industrial Noise Policy document outlines the following with regards to meteorological impacts on noise monitoring:

"Noise monitoring should not be conducted (or the data should be excluded) when average wind speeds (over 15-minute periods or shorter) at microphone height are greater than 5 m/s, or when rainfall occurs."

However, the same section of this policy also outlines that;

"Exceptions to this rule are allowed, provided the proponent is able to show that the wind-induced noise on the microphone, and sound levels due to rain, are at least 10 dB below the noise levels (that is, background and/or ambient) under investigation."

Weather conditions during the monitoring period have been assessed and the periods of inclement weather are highlighted in the logging data in Appendices 1-3.

On review of the monitoring data, the measured L_{90} noise levels during high wind speed days generally do not increase background noise levels significantly as periods with little to no wind. This demonstrates that even though wind speeds measured at Terrey Hills exceed EPA guidelines, either:

- The wind speed on site at this time was significantly lower than at Terrey Hills (which is likely given Terrey Hills weather station is located in a very exposed area) and/or
- The wind on site was not sufficiently consistent to increase background noise levels compared to calm periods.

Nevertheless, periods where it appears that adverse weather have affected the noise monitoring data have been eliminated when determining the rating background noise level at the site, which is presented in the section above.

For example, the monitoring data along Burdett Street (refer to Appendix 1) on the 6th June from 6pm onwards and all of the data on the 7th June have not been used in formulating rating background noise levels, as it is evident that the noise measurements have been adversely impacted by wind and rain.

5 NOISE & VIBRATION EMISSION CRITERIA

The following noise controls and guidelines are applicable to the site:

- NSW Department of Planning & Environment SEARs Requirements.
- Hornsby Shire Council's *Policy and Guidelines for Noise and Vibration Generating Development*.
- NSW EPA Industrial Noise Policy.
- NSW EPA Road Noise Policy.
- NSW EPA Guidelines for Sleep Arousal (Application Notes to the Industrial Noise Policy).
- NSW EPA Noise Control Manual

In addition, the following guidelines will be referenced with respect to construction noise and vibration impacts:

- NSW EPA Interim Construction Noise Guidelines.
- German Standard DIN 4150-3 (1999-02).
- EPA "Assessing Vibration: A Technical Guideline" 2006

5.1 HORNSBY SHIRE COUNCIL'S POLICY AND GUIDELINES FOR NOISE AND VIBRATION GENERATING DEVELOPMENT

The Hornsby Shire Council's *Policy and Guidelines for Noise and Vibration Generating Development* does not present any noise emission requirements relating specifically to hospital development. It does however reference the NSW EPA Industrial Noise Policy.

5.2 EPA INDUSTRIAL NOISE POLICY

Noise sources covered by this code will include vehicle noise (generated on the site), patron noise from the café and mechanical services noise. Both the Intrusiveness and the Amenity criteria (as set out below) must be complied with.

5.2.1 INP - Intrusiveness Assessment

Intrusiveness criteria permit noise generation to be no more than 5dB(A) above existing background noise levels. The criteria are as follow:

Table 4 – EPA Intrusiveness Criteria

Location	Time of Day	Measured Background noise Level dB(A)L_{90}	Intrusiveness Noise Objective dB(A)$L_{eq(15min)}$ (Background + 5dB)
Residences located to the south of the site along Burdett Street (R1)	Day Time (7am - 6pm)	44	49
	Evening (6pm - 10pm)	43	48
	Night (10pm - 7am)	35	40
Residences located to the east of the site along Derby Street (R2)	Day Time (7am - 6pm)	42	47
	Evening (6pm - 10pm)	43	48
	Night (10pm - 7am)	41	46
Residences located to the north-west of the site along Palmerston Road (R3)	Day Time (7am - 6pm)	43	48
	Evening (6pm - 10pm)	42	47
	Night (10pm - 7am)	39	44

5.2.2 INP - Amenity Assessment

The Amenity criteria set additional criteria based on the land use of the noise sensitive receivers.

Amenity criteria are as follows:

Table 5 – EPA Amenity Criteria

Receiver Location	Land Type	Time of Day	Amenity Noise Objective dB(A)$L_{eq(Period)}$
Residential properties along Burdett Street (R1)	Suburban	Day Time (7am – 6pm)	55
		Evening (6pm – 10pm)	45
		Night (10pm-7am)	40
Residential properties along Derby Road (R2)	Suburban	Day Time (7am – 6pm)	55*
		Evening (6pm – 10pm)	42*
		Night (10pm-7am)	32*
Residential properties along Palmerston Road (R3)	Suburban	Day Time (7am – 6pm)	50**
		Evening (6pm – 10pm)	40**
		Night (10pm-7am)	35**
Active Recreation Area (e.g. school playground, gold course) – to be used for Childcare Centre (R4)	All	When in use	55
Commercial	All	When in use	65
Place of Worship – Internal	All	When in use	40

*Residents along Derby Road are affected by existing plant noise from the hospital. Given this, the Amenity criteria for these residents have been set based on Table 2.2 of the Industrial Noise Policy (*Modification to acceptable noise level to account for existing level of industrial noise).*

**The amenity criteria for mechanical plant for the residents along Palmerston Road (R3) have been adjusted to factor in the cumulative noise impact from the proposed multi-storey car park and proposed mechanical plant.

Provided that noise emissions from any proposed mechanical plant comply with the criteria outlined above, the cumulative noise impacts from the proposed multi-storey car park (as detailed in *Noise Impact Assessment* prepared by this office (re: 20161182.1/1008A/R1/BW, dated 12/09/2016)) and Stage 2 mechanical plant will comply with the noise emission goals.

There will be no adverse noise impacts on the residents along Burdett Street or Derby Street (R1 and R2) from the operation of the proposed multi-storey car park.

5.3 SLEEP AROUSAL CRITERIA

Potential sleep arousal impacts should be considered for noise generated before 7am or after 10pm.

Short duration, intermittent noise events (such as vehicle engine starts) are typically assessed for potential sleep disturbance.

Potential impacts are assessed using the recommended procedure in the Application Notes to the EPA Industrial Noise Policy. As recommended in the Application Notes, when assessing potential sleep arousal impacts, a two stage test is carried out:

- Step 1 - An "emergence" test is first carried out. That is, the L_1 noise level of any specific noise source should not exceed the background noise level (L_{90}) by more than 15 dB(A) outside a resident's bedroom window between the hours of 10pm and 7am. If the noise events are within this, then sleep arousal impacts are unlikely and no further analysis is needed. This is consistent with the Noise Guide for Local Government. The guideline level is set out below.

Table 6 – Sleep Arousal (Emergence Criteria)

Location	Background Noise Level (10pm-7am) dB(A)$_{L90}$	Emergence Level dB(A) $L_{1(1min)}$
Residences located to the south of the site along Burdett Street (R1)	35	50
Residences located to the east of the site along Derby Street (R2)	41	56
Residences located to the north-west of the site along Palmerston Road (R3)	39	54

- Step 2 - If there are noise events that could exceed the emergence level, then an assessment of sleep arousal impact is required to be carried out taking into account the level and frequency of noise events during the night, existing noise sources, etc. This test takes into account the noise level and number of occurrences of each event with the potential to create a noise disturbance. As is recommended in the explanatory notes of the EPA Industrial Noise Policy, this more detailed sleep arousal test is conducted using the guidelines in the EPA Road Noise Policy. Most relevantly, the Road Noise Policy states:

  For the research on sleep disturbance to date it can be concluded that:

  - *Maximum internal noise levels below 50-55dB(A) are unlikely to awaken people from sleep.*
  - *One to two noise events per night with maximum internal noise levels of 65-70dB(A) are not likely to affect health and wellbeing significantly.*

5.4 CONSTRUCTION NOISE AND VIBRATION IMPACTS

5.4.1 EPA Interim Construction Noise Guideline (ICNG)

5.4.1.1 Residential Receivers (R1, R2 & R3)

EPA guidelines adopt differing strategies for noise control depending on the predicted noise level at the nearest residences:

- *"Noise affected" level*. Where construction noise is predicted to exceed the "noise affected" level at a nearby residence, the proponent should take reasonable/feasible work practices to ensure compliance with the "noise affected level". For residential properties, the "noise effected" level occurs when construction noise exceeds ambient levels by more than:
    - 10dB(A)$L_{eq(15min)}$ for work during standard construction hours (7am-6pm Monday to Friday and 8am to 1pm on Saturdays) and
    - 5dB(A)$L_{eq(15min)}$ for work outside of standard construction hours.
- "*Highly noise affected level"*. Where noise emissions are such that nearby properties are "highly noise effected", noise controls such as respite periods should be considered. For residential properties, the "highly noise effected" level occurs when construction noise exceeds 75dB(A)$L_{eq(15min)}$ at nearby residences.

5.4.1.2 Childcare Centre (R4)

Noise management levels for construction noise impacts on the outdoor play area of the childcare centre receiver to the south-west of the site will be formulated with reference to table 3 of the ICGN for Active Recreation Areas, which is 65dB(A)$L_{eq(15min)}$.

5.4.1.3 Commercial Receivers (R5)

Section 4.1.3 of the ICGN recommends a noise management level of 70dB(A)$L_{eq(15min)}$ for construction noise impacts on the external areas of offices/retail outlets.

5.4.1.4 Places of Worship (R6)

Section 4.1.2 of the ICGN recommends a noise management level of 45dB(A)$L_{eq(15min)}$ for construction noise impacts on the internal areas of places of worship.

5.4.2 Summary of Construction Noise Management Levels

A summary of construction noise management levels for both standard hours of construction and outside standard hours are presented in the table below. We note that after-hours construction is not proposed as part of this application, however noise emission goals have been included for completeness.

Table 7 – Construction Noise Emission Goals

Location	"Noise Affected" Level - dB(A)$L_{eq(15min)}$	"Highly Noise Affected" Level - dB(A)$L_{eq(15min)}$
Residences to the south along Burdett Street (R1)	54 (Normal Construction Hours) 49 (Outside Normal Hours - 6pm-10pm) 42 (Outside Normal Hours - 10pm-7am)	75
Residences to the east along Derby Street (R2)	52 (Normal Construction Hours) 48 (Outside Normal Hours - 6pm-10pm) 46 (Outside Normal Hours - 10pm-7am)	75
Residences to the north-west along Palmerston Road (R3)	53 (Normal Construction Hours) 47 (Outside Normal Hours - 6pm-10pm) 44 (Outside Normal Hours - 10pm-7am)	75
Childcare Centre Outdoor Play Areas (R4)	65 (based on management level for Active Recreation Areas of ICGN)	N/A
Commercial Receivers (R5)	70	N/A
Place of Worship (R6)	45 (internal)	N/A

5.4.3 Construction Vibration

The construction vibration criteria applicable to the site are presented below.

5.4.3.1 German Standard DIN 4150-3 (Building Damage Limit)

German Standard DIN 4150-3 (1999-02) provides vibration velocity guideline levels for use in evaluating the effects of vibration on structures. The criteria presented in DIN 4150-3 (1999-02) are presented in the table below.

It is noted that the peak velocity is the absolute value of the maximum of any of the three orthogonal component particle velocities as measured at the foundation, and the maximum levels measured in the x- and y-horizontal directions in the plane of the floor of the uppermost storey.

Table 8 – DIN 4150-3 (1999-02) Safe Limits for Building Vibration

TYPE OF STRUCTURE		PEAK PARTICLE VELOCITY (mms^{-1})			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		< 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used in commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

5.4.3.2 Amenity Criteria (Human Comfort)

Table 2.2 of EPA "Assessing Vibration: A technical guideline" specifies the following vibration criteria for the protection of human comfort:

Table 9 – Construction Vibration Goals

Location	Time	Peak velocity (mm/s)	
		Preferred	Maximum
Continuous Vibration			
Residences (R1-R3)	Daytime	0.28	0.56
Offices (to be used for R4 & R5)	When in use	0.56	1.1
Critical Working Areas (e.g. Hospital Operating Theatres)	Day or Night Time	0.14	0.28
Impulsive Vibration			
Residences	Daytime	8.6	17
Offices (to be used for R4 & R5)	When in use	18	36
Critical Working Areas (e.g. Hospital Operating Theatres)	Day or Night Time	0.14	0.28

6 NOISE EMISSION ASSESSMENT

This section addresses potential noise impacts resulting from the future operation of the proposed hospital development, and also noise and vibration impacts associated with the construction works.

6.1 OPERATIONAL NOISE

Operational noise sources with the potential to impact on the amenity of surrounding sensitive land include:

- Vehicular noise on site from the new ambulance bay.
- Noise from the existing generator towards to the south-western boundary of the site.
- Patron noise from the café.
- A preliminary assessment of noise from any new external mechanical plant and equipment.

6.1.1 Vehicular Noise from the Ambulance Bay

6.1.1.1 Average L_{eq} Noise Emissions

Noise generated from the new ambulance bay is assessed with reference to the EPA Industrial Noise Policy.

Noise emission predictions are based on the following data/assumptions:

- In typical use, an ambulance would not be expected to use its siren when travelling within hospital grounds.
- Primary noise source will be from ambulances manoeuvring in the ambulance bay. Ambulances will enter the bay via Palmerston Road and exit onto Burdett Street as indicated in Appendix A of the Traffic Impact Assessment prepared by TTW (re: TTW-TF-S2-RP01, dated 15/12/2016).
- Sound power level (SWL) of 90dB(A) for an ambulance travelling at 10km/hr.
- Sound power level (SWL) of 95dB(A) for an ambulance reversing at 10km/hr (based on measurements conducted by this office). This noise level applies a 5dB(A) penalty (i.e. increase) to account for tonality from the reverse beacon
- For the purposes of this assessment, we have assumed that the following:
    - Up to 4 ambulances entering and exiting the ambulance bay in a 15 minute period during the day and evening period (7am-10pm);
    - Up to 2 ambulances entering and exiting the ambulance bay in a 15 minute period during the night time period (10pm-7am).

These are likely to be conservatively high levels of vehicle movements.

Noise at the residents emissions will be assessed against the Intrusiveness criteria of the Industrial Noise Policy as detailed in section 5.2.1.

Noise at the Waitara Anglican Church will be assessed against the Amenity criteria presented in section 5.2.2.

The nearest receivers to be impacted by the ambulance bay are the residents to the south along Burdett Street (R1) and the Waitara Anglican Church to the south across Burdett Street (R6). If noise impacts are compliant at these receivers, then they will be compliant at all receivers in the vicinity of the development. Predicted noise levels are presented in the table below.

Predicted noise levels to the internal spaces of the Waitara Anglican Church are based on the assumption that windows to the church are open.

Table 10 – Predicted Noise Levels from Ambulance Bay

Noise Receiver Location	Time Period	Predicted Noise Level dB(A)$L_{eq(15min)}$	Noise Emission Criteria dB(A)$L_{eq(15min)}$	Complies
Northern Boundary of Residents along Burdett Street (R1)	Day & Evening (7am-10pm)	43	Day – 49* Evening – 48*	Yes
	Night (10pm-7am)	40	42*	Yes
Waitara Anglican Church (R6)	Day & Evening (7am-10pm)	32 (internal)	40 (internal)	Yes

*For intermittent, peak periods of use it is the INP Intrusiveness criteria (which utilises a $L_{eq(15min)}$ noise descriptor which is most appropriate. Long term average noise levels (4-11 hours, depending on the period being considered) used in the Amenity Criteria are not appropriate when assessing peak periods of ambulance bay use.

Noise from ambulances manoeuvring within the proposed ambulance bay will comply with the noise emission requirements.

We note that ambulance sirens are only used in emergencies and are not subject to the noise emission requirements of the INP. Sirens to ambulances are not typically used within the site as ambulances will have their own dedicated access road to the ambulance bay and would not run into conflict with other vehicles.

6.1.1.2 Transient Noise Events (Sleep Arousal)

Given that the ambulance bay will potentially be in use during the night time period (10pm and 7am), noise impacts should be assessed for sleep disturbance impacts on nearby residents.

Primary noise sources which have been considered are:

- Noise from a door closing or an engine starting, both with an approximate sound power level of approximately 95dB(A)$L_{1(1min)}$.
- Noise created by the ambulance pass-by as it leaves the site (the peak noise level as the ambulance travels past the closest point to the residences).

The nearest receiver to be impacted by the ambulance bay are the residents to the south along Burdett Street (R1). If noise impacts are compliant at these receivers, then they will be compliant at all receivers in the vicinity of the development. Predicted noise levels are presented in the table below.

Analysis will be conducted as follows:

- Firstly, the noise event will be assessed with reference to the "background+15dB(A)" criteria (this is the first step of the sleep arousal test outlined in section 5.3).
- Secondly, in the event that compliance with the "background+15" test is not satisfied, a more detailed assessment will be undertaken, in which the noise level is predicted inside the bedroom itself.

Step 1 - Predicted noise levels and assessment against "background+15dB(A)" criteria are as follows.

Table 11 – Sleep Arousal Assessment

Receiver Location	Noise Source	Predicted Noise Level dB(A)$L_{1(1min)}$	Emergence Criteria dB(A)$L_{1(1min)}$	Complies
Northern Façade Windows of Residents along Burdett Street (R1)	Engine Start-Up/Door Slamming in Ambulance Bay	51	50	Marginal Exceedance
	Engine Noise When Ambulance Leaving the Site.	53	50	No
	Ambulance Reversing in Ambulance Bay	53	50	No

As shown in the table above, noise emissions from engine start-ups or closing doors marginally exceeds the "background+15dB(A)" acoustic criteria. Noise from ambulances leaving the site and ambulances reversing in the ambulance bay is predicted to exceed the sleep arousal criteria by 3dB(A). Given this, a more detailed assessment has been conducted. This involves predicting the noise level in the bedroom itself, and comparing to the EPA recommended criteria as presented in section 5.3, and is outlined below.

Step 2 - The predicted noise levels *inside* the bedroom (assuming the bedroom window is left open) is presented below.

Table 12 – Sleep Arousal Assessment (Internal Noise Level Test)

Receiver Location	Noise Source	Predicted Noise Level dB(A)$L_{1(1min)}$	Acoustic Criteria* dB(A)$L_{1(1min)}$	Complies
Within Bedrooms of Residents along Burdett Street (R1) (assuming windows are open)	Engine Start-Up/Door Slamming in Ambulance Bay	41	50-55	Yes
	Engine Noise When Ambulance Leaving the Site.	43	50-55	Yes
	Ambulance Reversing in Ambulance Bay	43	50-55	Yes

*As noted in section 5.3 of this report, where emergence test is not satisfied, EPA guidelines note that L_{Max} noise levels of 50-55dB(A) *inside a habitable area,* maximum internal noise levels below 50-55dB(A) are unlikely to awaken people from sleep.

Predicted noise levels inside the bedrooms are less 50dB(A)$L_{1(1min)}$, which is compliant with the more stringent end of the range specified in the EPA guidelines.

6.1.2 Noise from Existing Generator (near South-Western Boundary of Hospital Precinct)

This section of the report presents our assessment of future noise impacts from the existing emergency generator located near the south-western boundary of the site.

There are currently hospital buildings along the south-west boundary of the hospital precinct along Burdett Street providing screening between this generator and the residents to the south across Burdett Street (R1). We note that these hospital buildings will be demolished as part of the Stage 2 works (and be replaced with an ambulance bay and associated roadways) which will result in the Burdett Street residents having direct line of sight to the generator. This will result in an increased noise impact on the Burdett Street residents from the generator.

Acoustic treatments should be implemented such that noise emissions from the generator at the Burdett Street residents (R1) are compliant with the intrusiveness criteria of the INP (see section 5.2.1) after the demolition of the hospital buildings on along the south-western boundary hospital precinct.

As part of this assessment, noise measurements have been conducted of the existing generator during operation. Attended noise measurements of the generator were conducted on the 3rd June 2017 between 7am and 8am. Measurements were undertaken using a Norsonics Type 140 precision sound level analyser, set to A-weighted fast response. The precision sound level analyser was calibrated before and after the measurements using a Norsonics 1251 sound level calibrator. No significant drift was recorded.

Measured noise levels indicate that the generator has a noise level of 77dB(A)L_{eq} at a distance of 4m.

Recommended treatments are presented in section 6.3.

6.1.3 Patron Noise from Café

The main source of noise from the proposed café will be patron speech in the outdoor seating area of the café. The café will be located towards the middle of the hospital precinct.

The nearest receivers to be impacted are:

- Residents along Derby Street to the east (R2) which have a partial view of the café;
- Commercial receivers along Palmerston Road to the west (R5).

If noise emissions from the café are compliant at these receivers, then noise emissions will be compliant at all receivers in the vicinity of the site.

Patron noise impacts on the residential receivers will be assessed against the intrusiveness criteria (see section 5.2.1) for residential receivers and the amenity criteria for commercial receivers (see section 5.2.2).

Noise emission predictions are based on the following data/assumptions:

- A sound power level of 75dB(A) L_{eq} was used for patron voice levels (raised speech) for this assessment.
- 1 in 3 patrons are speaking at any given time.
- 32 patrons using the outdoor seating area.
- No music in the outdoor dining area.

The predicted noise levels are presented in the table below. The predicted noise levels factor in distance attenuation and barrier effects.

Table 13 - Predicted Patron Noise Levels from Cafe

Receiver Location	Predicted Noise Level dB(A)$L_{eq(15min)}$	Noise Emission Criteria dB(A)$L_{eq(15min)}$	Complies
Residents along Derby Street (R2)	35	Day – 47 Evening – 48 Night – 46	Yes
Commercial along Palmerston Road (R5)	38	65	Yes

Noise emissions from proposed café are compliant with the nominated acoustic criteria.

6.1.4 Noise from Mechanical Plant

Detailed acoustic design of mechanical plant cannot be undertaken at approval stage, as plant selections have not been finalised.

Preliminary mechanical drawings provided to this office indicate that the majority of the Stage 2 mechanical plant will be located on level 6 of the development. An indicative assessment of primary plant items is presented below.

Primary plant items will include:

- Cooling towers.
- Air handling plant (air handling units, supply/exhaust/outside air fans).
- Chillers.
- Emergency diesel generator.

With respect to the above, we note:

- Cooling towers
    - Two cooling towers are proposed to be located in an external area on level 6 of the development.
    - Preliminary plant selections indicate that the cooling towers will have a sound power level of 86dB(A) when operating at full speed.
    - Given the distance between the cooling towers and the surroundings residents and shielding provided by the hospital building structure, the proposed cooling towers will comply with the noise emission requirements.
    - Despite this, it recommended that cooling towers are fitted with variable speed drives, to allow for reduced fan speed during periods of low load. Typically, a fan speed of no more than 50% would be expected at night time.
- Chillers (assumed sound power of 102dB(A)).
    - Three chillers are proposed to be located within an enclosed plant room on level 6 of the development.
    - The plant rooms housing the chillers should not have any external ventilation opening/louvre.
    - Light weight cladding to plant room walls and ceiling will potentially require internal plasterboard sheeting to ensure noise breakout through wall/roof to nearby receivers are compliant with INP requirements. Final plant room building shell design to be conducted following final chiller selection.
    - Typical vibration isolation would consist of 25mm static deflection springs sitting on a concrete plinth isolated from the structural slab using 10mm rubber matting.

- Fans and air-handling units.
    - Air handling units are proposed to be located within a plant room on level 6 of the development.
    - Air handling units do not typically require extensive acoustic treatment to ensure compliant noise emissions at nearby properties.
    - Air handling unit exhaust and outside air ducting (both of which are typically ducted to outside) are to be acoustically reviewed following layout design by mechanical engineer/contractor to determine whether internal lining to this ductwork is required.
    - It is recommended that a the outside air intakes of the air handling units are ducted to a dedicated louvre rather than having a naturally ventilated plant room housing the air handling units.
    - Major fans (typically with a sound power over 90(A) – such as kitchen exhaust, major toilet exhaust and major relief air fans) will require acoustic treatment if located externally. This treatment would include internal lining to any external ductwork. Acoustic treatment of fan casing may also be required. Review of all external fans (including fans ducted to external locations) must be conducted once selected to ensure compliant noise emissions to external areas.
- New emergency power backup generator.
    - Two new emergency generators are proposed to be located in an external area on level 6 of the development.
    - It is likely that the generators will need to be located in a proprietary acoustic enclosure if not being located in a plant room.
    - Acoustic attenuators will be required to the plant room/acoustic enclosure air inlet and air discharge (indicatively 1.8m long, 40% open area attenuators). Additionally, the exhaust gas discharge will require a muffler such that it creates a noise level of no more than 85dB(A) at 1m distance.
    - Detailed acoustic performance of plant room (or any acoustic enclosure) to be finalised following final generator selection/location.

Compliance with INP acoustic criteria as set out in Section 5.2 will be achievable, provided that detailed acoustic review of plant items is undertaken once plant is selected.

6.2 CONSTRUCTION IMPACTS

6.2.1 Construction Noise

With respect to general construction noise, the impacts on nearby development will be dependent on the activity in question and where on the site the activity is undertaken. Excavation and piling works tend to be the loudest typical construction activity. Work close to the boundaries will have greatest potential impact on the residents surrounding the site and the childcare centre to the south-west and the commercial development to the west. Detailed acoustic assessment of individual activities cannot be undertaken prior to knowing the activities/construction methods proposed, their duration and location. This office has been advised that the total construction period (demolition, excavation, piling and construction) will be approximately between the beginning of 2018 until the last quarter of 2020.

Based on initial analysis we make the following comments:

Demolition/Excavation Phase

Primary noise emissions occur during demolition, excavation and earth retention (piling), with equipment items typically having sound power levels of approximately 115dB(A)$L_{eq(15min)}$. Some exceedance of the EPA "Noise Affected" target levels may occur at the boundary of existing residences along Derby Street, Burdett Street and Palmerston Road. Noise levels exceeding the "Highly Noise Affected" level of 75dB(A) at the residences are unlikely to occur for extended periods.

For the childcare centre and Waitara Anglican Church, some exceedances of the noise management levels (presented in section 5.4.1) are predicted when activities are taking place near the south-western boundary of the site.

Construction Phase

During erection of structure, it is the use of hand tools (angle grinders etc) and concrete pumps which are the loudest typical activity (sound power levels of approximately 105dB(A)$L_{eq(15min)}$). Intermittent exceedances of the EPA "Noise Affected" levels may occur, at the boundary of existing residences along Derby Street, Burdett Street and Palmerston Road, however there may be some screening provided by the existing buildings on site depending on the location of the equipment. Noise levels exceeding the "Highly Noise Affected" level of 75dB(A) at the residences are unlikely to occur for extended periods. Intermittent exceedances of the noise management levels (presented in section 5.4.1) are predicted for the childcare centre and Waitara Anglican Church when activities are taking place near the south-western boundary of the site.

Once construction of the building shell is complete, noise from hand tools will be relatively low, as the new building façade will provide considerable noise attenuation. Once the building shell is largely complete, use of hand tools in internal areas is unlikely to exceed EPA recommended levels. Vehicle noise and crane noise will create the greatest possibility of noise disturbance during this phase.

Noise impacts can be minimised using the following:

- Careful planning/scheduling of noisy works, particularly when located near the property boundaries.

- Location of static plant (concrete pumps, cranes) as far as practicable away from the boundaries is recommended.

- Use of augured rather than driven or vibratory piling should be considered if feasible.

- Locate cranes as close to the middle of the site as practicable.

- Letter box drops or similar to advise residents on activities with the potential to result in noise levels reaching the "Highly Noise Affected" noise level. Leaflet should advise of the likely duration of the activity.

In light of the above, we recommend:

- On completion of the construction program, an acoustic review of proposed construction activities and plant/methods/selections should be undertaken to identify the extent and duration of potential exceedances of EPA construction noise management levels;

- Community consultation to inform adjacent property owners of potential noise sensitive activities;

- Identify feasible acoustic controls or management techniques (for example, selection of plant, use of screens around static plant, scheduling of noisy works, notification of adjoining land users, respite periods) when exceedance of management noise levels may occur;

- For activities where acoustic controls and management techniques still cannot guarantee compliant noise levels, implement a notification process whereby nearby residences are made aware of the time and duration of noise intensive construction processes; and

- Implementation of a noise monitoring program during construction to provide feedback to the Builder to ascertain whether construction noise goals are being exceeded and determine additional management strategies.

Through adoption of the above, noise impacts on nearby residences can be suitably managed to prevent unreasonable impact.

6.2.2 Construction Vibration

Excavation and earth retention works (piling) are the primary vibration generating activities.

Given the distance between the site and the nearest residential buildings (R1-R3) and the commercial buildings (R5), it is unlikely that construction vibration will exceed EPA guidelines at these receivers.

The childcare centre (R4) is in close proximity to the proposed development. In order to manage/minimise vibration impacts on the childcare centre we recommend:

- That attended vibration measurements are conducted at the commencement of the excavation stages to ensure that vibration impacts on this receivers are compliant with criteria presented in section 5.4.3.

In addition, consultation with hospital users should be undertaken to identify any highly vibration sensitive spaces in close proximity to the excavation area. Potentially it will be necessary to conduct vibration monitoring with SMS notification system to protect highly vibration sensitive spaces such as operating theatres or laboratories.

6.3 RECOMMENDATIONS

We recommend the following acoustic treatments/management controls to ensure compliance with EPA noise emission guidelines.

6.3.1 Existing Generator (near South-Western Boundary of Hospital Precinct)

- Install a solid, imperforate (i.e. no holes) screen around the south, east and western sides of the generator as shown in Figure 3 below.
- The screen is to extend a minimum 500mm above the top of the generator and is to be located no more than 1.2 metres from the generator.
- Suitable materials for the screen include 6mm fibre cement, lapped and capped timber or Colorbond metal.

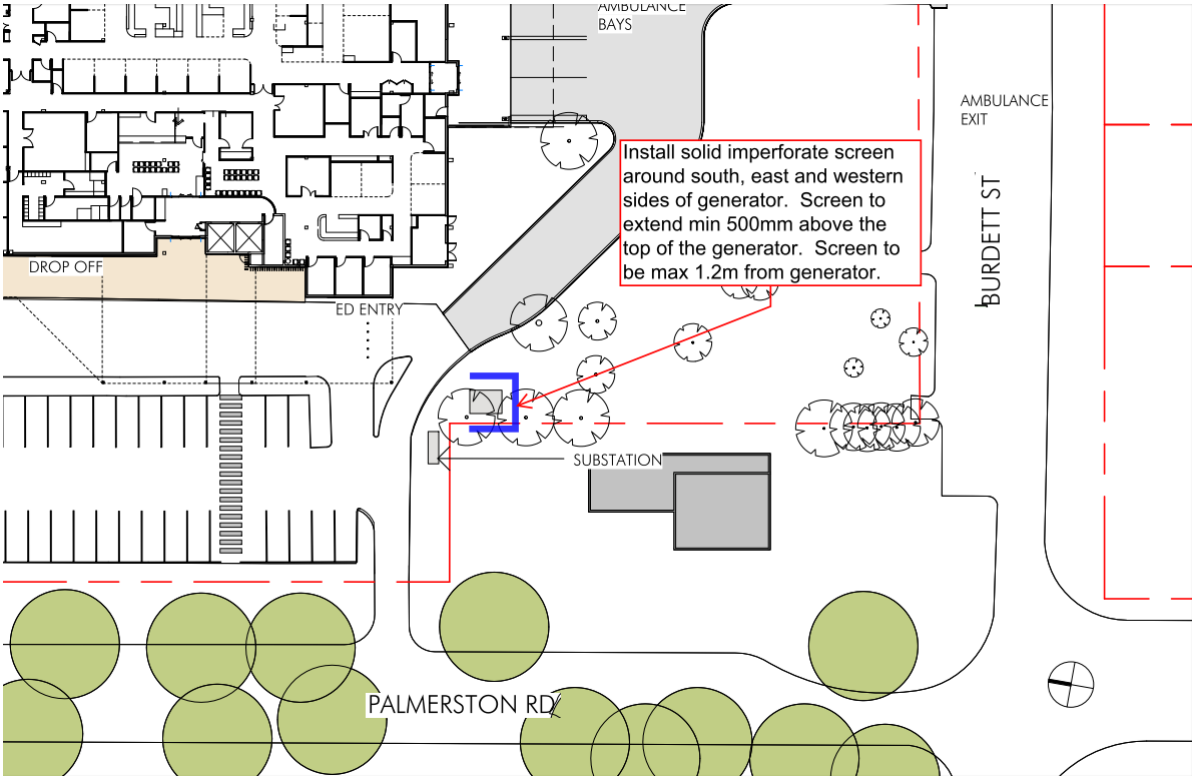


Figure 3 – Recommended Screen Around Existing Generator

6.3.2 Construction Noise and Vibration

- A detailed construction noise and vibration management plan should be implemented. Review of the mitigation techniques outlined in this report should be carried once the construction methods have been determined.

6.3.3 Mechanical Plant

- Detailed acoustic review of all external plant items should be undertaken following equipment selection and duct layout design. Initial analysis indicates that with acoustic treatment, all plant items will be capable of meeting noise emission requirements. However this is likely to require:
    - Noise screening (using either a dedicated noise screen or the building shell) for roof top cooling towers.
    - An acoustic enclosure for any externally located back-up generator.
    - Acoustic treatment to fan casing and lining of external ducting for major external fans.
    - Plant room wall/roof construction for any plant room housing chiller plant.
    - Detailed acoustic review of external louvres for any plant rooms to determine whether acoustic louvres/attenuators are required.

7 EXTERNAL NOISE IMPACT ASSESSMENT

Significant noise sources in the vicinity of the site are as follows:

- Traffic noise from surrounding roadways.

Noise impacts should comply with the requirements of the Hornsby Shire Council DCP, NSW Health Infrastructure Engineering Services Guidelines and Australian Standard AS2107:2016.

7.1 ACOUSTIC OBJECTIVES

The determination of an acceptable level of traffic noise within the health spaces requires consideration of the activities carried out within the space and the degree to which noise will interfere with those activities

Internal traffic noise level criteria are to comply with the requirements of the

- NSW Health Infrastructure Engineering Services Guidelines
- AS2107-2000 "Recommended Design Sound Levels and Reverberation Times for Building Interiors"
- NSW Department of Planning's *Development Near Rail Corridors and Busy Roads – Interim Guideline 2008*

7.1.1 Hornsby Shire Council's *Policy and Guidelines for Noise and Vibration Generating Development*

Table 5.1.3 of the Hornsby Shire Council's *Policy and Guidelines for Noise and Vibration Generating Development* references the NSW Environmental Criteria for Road Traffic Noise for traffic noise criteria for hospital wards. This is presented in the table below.

Table 14 – Traffic Noise Criteria from NSW Environmental Criteria for Road Traffic Noise

Sensitive Land Use	Criteria	
	Day (7am-10pm) dB(A)	Night (10pm-7am) dB(A)
Hospital Wards	$L_{Aeq(1hour)}$ 35 (internal)	$L_{Aeq(1hour)}$ 35 (internal)

7.1.2 NSW Health Infrastructure Engineering Services Guidelines

7.1.2.1 Continuous Noise Sources

Table 12 of the NSW Health Infrastructure Engineering Services Guidelines (July 2017) presents internal noise criteria for hospitals with respect to continuous/steady-state noise sources (such as traffic noise impacts). The criteria is presented in the table below:

Table 15 – Health Infrastructure Engineering Services Guidelines Internal Noise Criteria

Area Designation	Continuous Internal Noise Levels dB(A)L_{eq}	
	Satisfactory	Maximum
Corridors and Lobby Spaces	40	45
Intensive Care	40	45
Patient Wards	35	40
Consultation/Interview Rooms	40	45
Treatment/Medication/Examination Room	40	45
Waiting Rooms, Reception Areas	45	50
Cafeterias/Dining	45	50
Meeting Room	35	40
Board/Conference Room	30	35
Open Plan Offices	40	45
Private Offices	35	40
Laboratories	45	50
Toilet/Ensuite	50	55

7.1.3 Australian Standard AS2107:2016

The Australian Standards recommends internal design sound levels for different areas of health buildings depending on the use of the space.

The recommended internal noise criteria are presented in the table below and will also be used to develop internal noise criteria for traffic noise impacts:

Table 16 – AS2107:2016 Internal Noise Criteria

Space/Activity Type	Design Sound Level Range dB(A)L_{eq}
Emergency Areas	40-45
Cafeterias	40-50
Corridors and Lobby Spaces	< 50
Consulting Rooms	40-45
Dining Areas	40-45
Intensive Care Wards	40-45
Laboratories	40-50
Office areas	35-45
Surgeries/Treatment/Procedure Rooms	40-45
Wards	35-40
Waiting Rooms, Reception Areas	40-50

7.1.4 NSW Department of Planning's Development Near Rail Corridors and Busy Roads – Interim Guideline 2008

Table 3.1 of the NSW Department of Planning's *Development Near Rail Corridors and Busy Roads – Interim Guideline 2008* outlines the following internal noise criteria for hospitals.

Table 17 – NSW Department of Planning's Development Near Rail Corridors and Busy Roads (Interim Guideline) Internal Noise Criteria

Space	Recommended Max Level dB(A)
Wards	35
Other Noise Sensitive Areas	45

7.1.5 Summarised Internal Noise Criteria

Based on the criteria listed above, the summarised internal noise criteria to be adopted for the development from external noise impacts is presented in the table below.

Table 18 – Project Internal Noise Criteria from External Noise Impacts

Space/Activity Type	Internal Noise Goal $dB(A)L_{eq(1\ hour)}$
Emergency Areas	40
Cafeterias	45
Corridors and Lobby Spaces	45
Consulting/Interview Rooms	40
Dining Areas	45
Intensive Care Wards	40
Laboratories	45
Meeting Room	40
Board/Conference Room	35
Open Plan Offices	45
Private Offices	40
Surgeries/Treatment/Procedure Rooms	40
Wards	35
Waiting Rooms, Reception Areas	45
Toilet/Ensuite	50

7.2 TRAFFIC NOISE MEASUREMENTS

Traffic noise impacts on the site have been determined by means of attended noise measurements conducted around the site as detailed in Figure 1 above.

Attended measurements were obtained using a Norsonics Type 140 Sound Level Analyser. The Sound Level Analyser was calibrated at the beginning and the end of the measurement using a Norsonics Type 1251 Sound Level Calibrator. No significant drift was noted. All measurements were conducted on A-weighted fast response mode. There were no significant periods of adverse weather conditions during the measurement period.

Traffic noise measurements were conducted on 31st May 2017 between 4pm and 6pm (afternoon peak hour) and are presented in the table below.

Table 19 - Measured Traffic Noise Levels

Location	Time Period	Measured Noise Level dB(A)$L_{eq(1\ hour)}$
Along Burdett Street – 4m from kerb	4pm – 6pm	60
Along Palmerston Road – 4m from kerb	4pm – 6pm	59
Along Derby Street – 4m from kerb	4pm – 6pm	52

7.3 RECOMMENDATIONS

External noise intrusion into the proposed development (primarily traffic noise) is assessed using the measured external noise levels reported in section 7.1 as a basis. Internal noise levels will primarily be as a result of noise transfer through the windows as these are relatively light building elements that offer less resistance to the transmission of sound. Noise transfer through masonry elements will not be significant and need not be considered further.

The following constructions are recommended to comply with the noise objectives outlined in section 7.1.

7.3.1 Glazed Windows and Doors

The recommended glazing constructions for this project are listed in the table below. Thicker glazing may be required for structural, safety or other purposes. Where it is required to use thicker glazing than scheduled, this will also be acoustically acceptable.

Table 20 - Recommended Glazing Constructions

Facade	Level	Space	Glazing Thickness	Acoustic seals
North	0	All	6.38mm laminated	Yes
	1	Patient Bays, Occupational Therapy Rooms, Gymnasium Group Treatment, Consult Rooms	10.38mm laminated	
		Remaining	6.38mm laminated	
	2	Bedroom Wards and Consult Rooms	10.38mm laminated	
		Remaining	6.38mm laminated	
	3	Bedrooms Wards and OT Therapy Room	10.38mm laminated	
		Remaining	6.38mm laminated	
	4	Bedroom Wards and Lounges	10.38mm laminated	
		Remaining	6.38mm laminated	
	5	All	10.38mm laminated	
West	1-4	All	6.38mm laminated	
	5	All	10.38mm laminated	
East	1	All	6.38mm laminated	
	2	Bedroom Wards	10.38mm laminated	
		Ensuites, Meeting Rooms and Offices	6.38mm laminated	
	3	Independent Assessment Rooms	10.38mm laminated	
		Remaining	6.38mm laminated	
	4	Bedroom Wards, Allied Health Assessment Area	10.38mm laminated	
		Remaining	6.38mm laminated	
	5	All	10.38mm laminated	

*If double glazed units are to be used, the corresponding double glazed units are as follows:

- 12.38mm laminated/12mm air gap/6mm float = 12.38mm laminated

- 10.38mm laminated/12mm air gap/6mm float = 10.38mm laminated

- 6.38mm laminated/12mm air gap/6mm float = 6.38mm laminated

Table 20 - Recommended Glazing Constructions (continued)

Facade	Level	Space	Glazing Thickness	Acoustic seals
South	1	Bedroom Wards	10.38mm laminated	Yes
		Ensuites and Staff Rooms	6.38mm laminated	
	2	Bedroom Wards and Patient Bays	10.38mm laminated	
		Remaining	6.38mm laminated	
	3	Bedroom Wards	10.38mm laminated	
		Remaining	6.38mm laminated	
	4	Bedroom Wards	10.38mm laminated	
		Remaining	6.38mm laminated	
	5	All	10.38mm laminated	
Central Courtyard	1	Consult Rooms	12.38mm laminated	
		Bedroom Wards	10.38mm laminated	
		Bedroom Ward Ensuites	6.38mm laminated	
		Corridors	6.38mm laminated	
	2	Patient Bays, ECG Room, ECG Stress Testing Room, Echo Room	12.38mm laminated	
		Remaining	10.38mm laminated	
	3	Bedroom Wards	12.38mm laminated	
		Ensuites	10.38mm laminated	
		Remaining	6.38mm laminated	
	4	Bedroom Wards and Consult Room	12.38mm laminated	
		Lounge	10.38mm laminated	
		Interview Room	12.38mm laminated	
		Remaining	6.38mm laminated	
	5	All	10.38mm laminated	

*If double glazed units are to be used, the corresponding double glazed units are as follows:

- 12.38mm laminated/12mm air gap/6mm float = 12.38mm laminated

- 10.38mm laminated/12mm air gap/6mm float = 10.38mm laminated

- 6.38mm laminated/12mm air gap/6mm float = 6.38mm laminated

In addition to complying with the minimum scheduled glazing thickness, the STC/R_w rating of the glazing fitted into operable frames and fixed into the building opening should not be lower than the values listed in the table below in all areas. Where nominated, this will require the use of acoustic seals around the full perimeter of operable frames and the frame will need to be sealed into the building opening using a flexible sealant. **Note that mohair seals in windows and doors are not acceptable where acoustic seals are required**. The proposed suppliers should provide evidence that the window systems proposed have been tested in a registered laboratory with the recommended glass thicknesses and comply with the minimum STC/R_w requirements listed in table below, and that they will be constructed and installed in a manner equal to the test samples.

Table 21 – Minimum STC/R_w of Glazing

Glazing Assembly	Acoustic Seals	Minimum STC/R_w of Installed Window
12.38mm laminated OR 12.38mm laminated/12mm air gap/6mm float	Yes	37
10.38mm laminated OR 10.38mm laminated/12mm air gap/6mm float	Yes	35
6.38mm laminated OR 6.38mm laminated/12mm air gap/6mm float	Yes	31

7.3.2 Roof / Ceiling Construction

The proposed concrete roof for the development will be acoustically acceptable and will not require any additional treatment.

7.3.3 External Walls

There should not be vents on the internal skin of external walls. All penetrations in the internal skin of external walls should be acoustically sealed with a flexible sealant.

7.3.3.1 Masonry External Walls

Any proposed masonry external wall construction will be acoustically acceptable and will not require any additional treatment.

7.3.3.2 Lightweight External Walls

The recommended constructions for lightweight external walls are presented below:

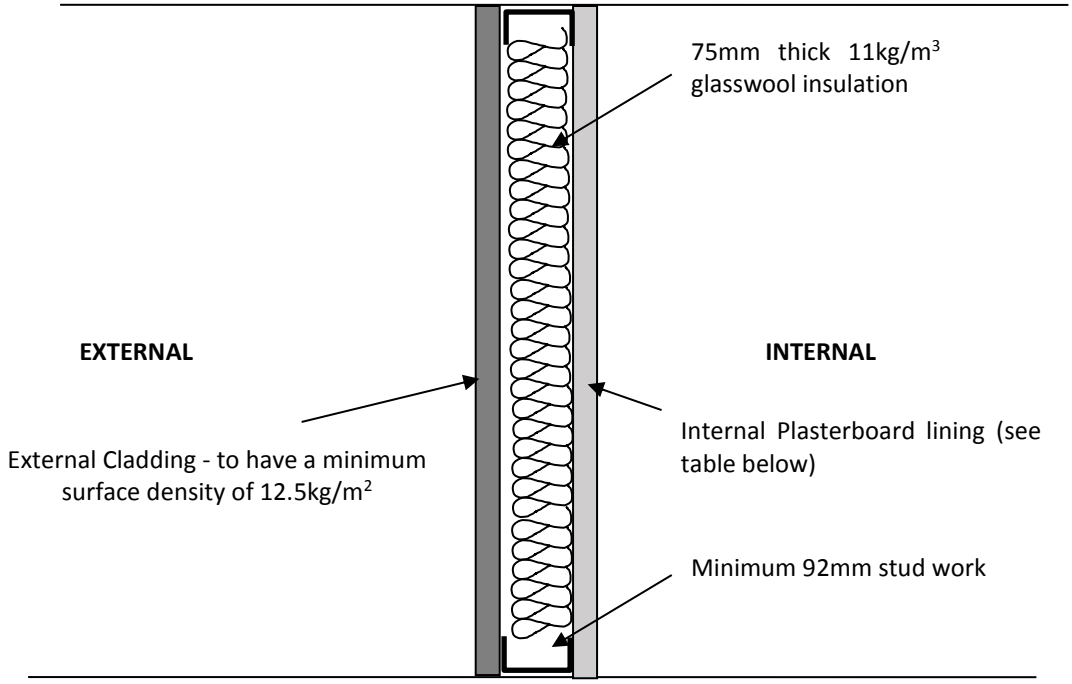


Table 22 – Lightweight External Wall Construction

Facade	Level	Space	Internal Plasterboard Lining Requirement
North	0	All	1 x 13mm plasterboard
	1	All	1 x 13mm plasterboard
	2	Consult Rooms	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	3-5	All	1 x 13mm plasterboard
West	1-5	All	1 x 13mm plasterboard
East	1-5	All	1 x 13mm plasterboard
South	1	All	1 x 13mm plasterboard
	2	Patient Bays	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	3	All	1 x 13mm plasterboard
	4	Bedrooms Wards	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	5	All	1 x 13mm plasterboard
Central Courtyard	1	All	1 x 13mm plasterboard
	2	Patient Bays, ECG Room, ECG Stress Testing Room, Echo Room	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	3	Bedroom Wards	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	4	Bedrooms, Interview and Consult Room	2 x 13mm plasterboard
		Remaining	1 x 13mm plasterboard
	5	All	1 x 13mm plasterboard

8 CONCLUSION

Potential noise and vibration impacts associated with the Stage 2 redevelopment at the Hornsby Ku-ring-gai Hospital have been assessed in this report.

An analysis of typical operational noise (new ambulance bay, café, noise from existing generator, new proposed mechanical equipment) associated with the proposed hospital redevelopment indicates that the site is capable of complying with relevant noise emission criteria. Relevant acoustic treatments and management controls have been presented in Section 6.3 of this report.

Detailed acoustic review of mechanical plant should be undertaken once design is further progressed (plant selections finalised etc.). In-principal review indicates that acoustic treatment to any major plant items located externally is likely to be required (screens, in-duct attenuation and enclosures), however through appropriate treatment, noise emissions are capable of complying with EPA Industrial Noise Policy requirements.

Similarly, detailed noise management practices should be implemented for the control of construction noise and vibration. In principal acoustic review indicates that demolition, excavation and piling works have the potential to exceed EPA Interim Construction Noise Policy guidelines, particularly when working in areas near the property boundaries. Noise mitigation through work scheduling and equipment selection should be considered. This should be implemented via a Noise/Vibration Management Plan, which should be determined once a construction program is complete.

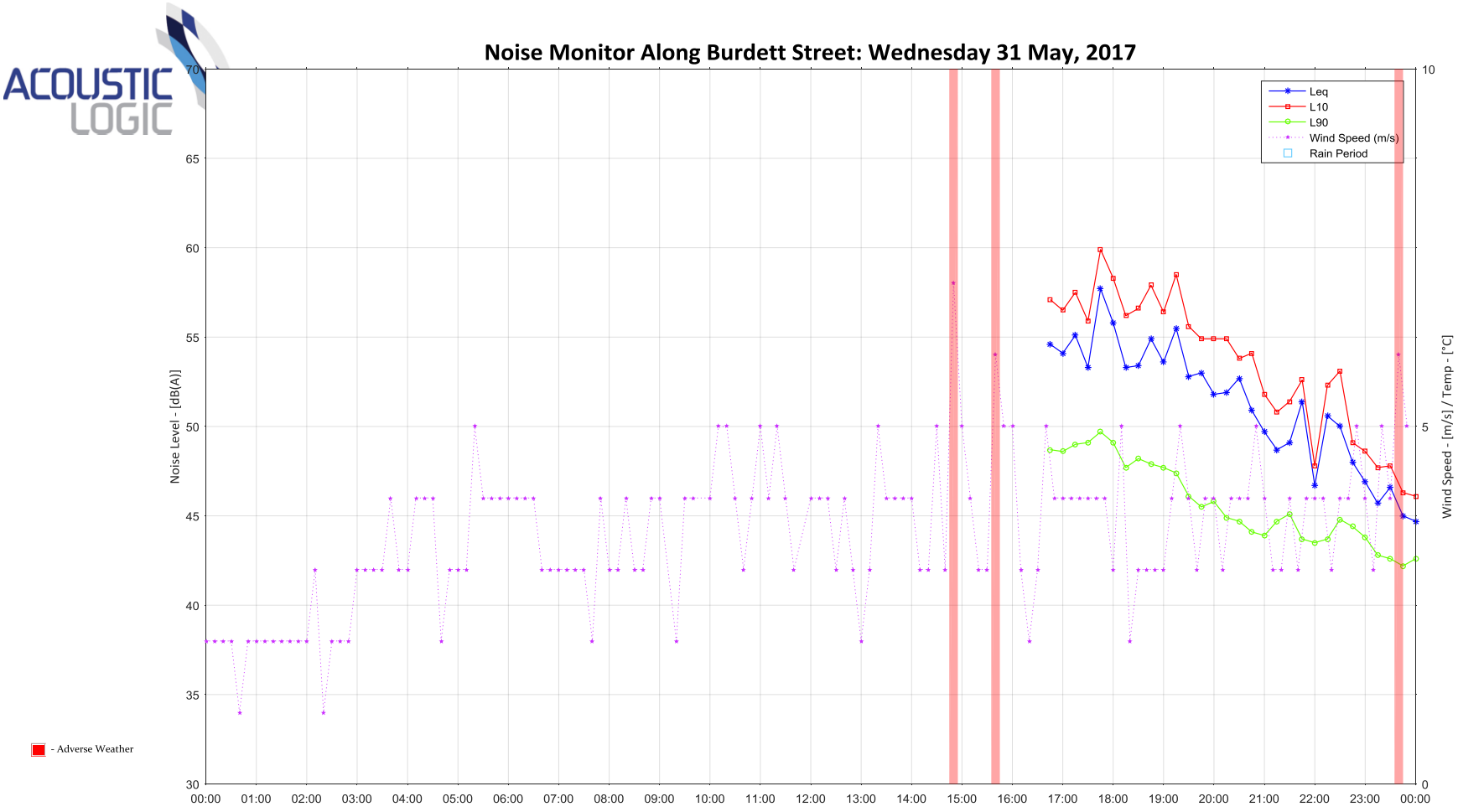
An assessment of external noise intrusion into the development (primarily traffic noise) has been carried out and recommended constructions for the building façade have been presented in section 7.3 in order to ensure compliance with the internal noise criteria outlined in section 7.1.

We trust this information is satisfactory. Please contact us should you have any further queries.

Yours faithfully,

Acoustic Logic Consultancy Pty Ltd
Justin Leong

APPENDIX 1 – NOISE MONITORING ALONG BURDETT STREET


Noise Monitor Along Burdett Street: Wednesday 31 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
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L10
L90
Wind Speed (m/s)
Rain Period
- Adverse Weather
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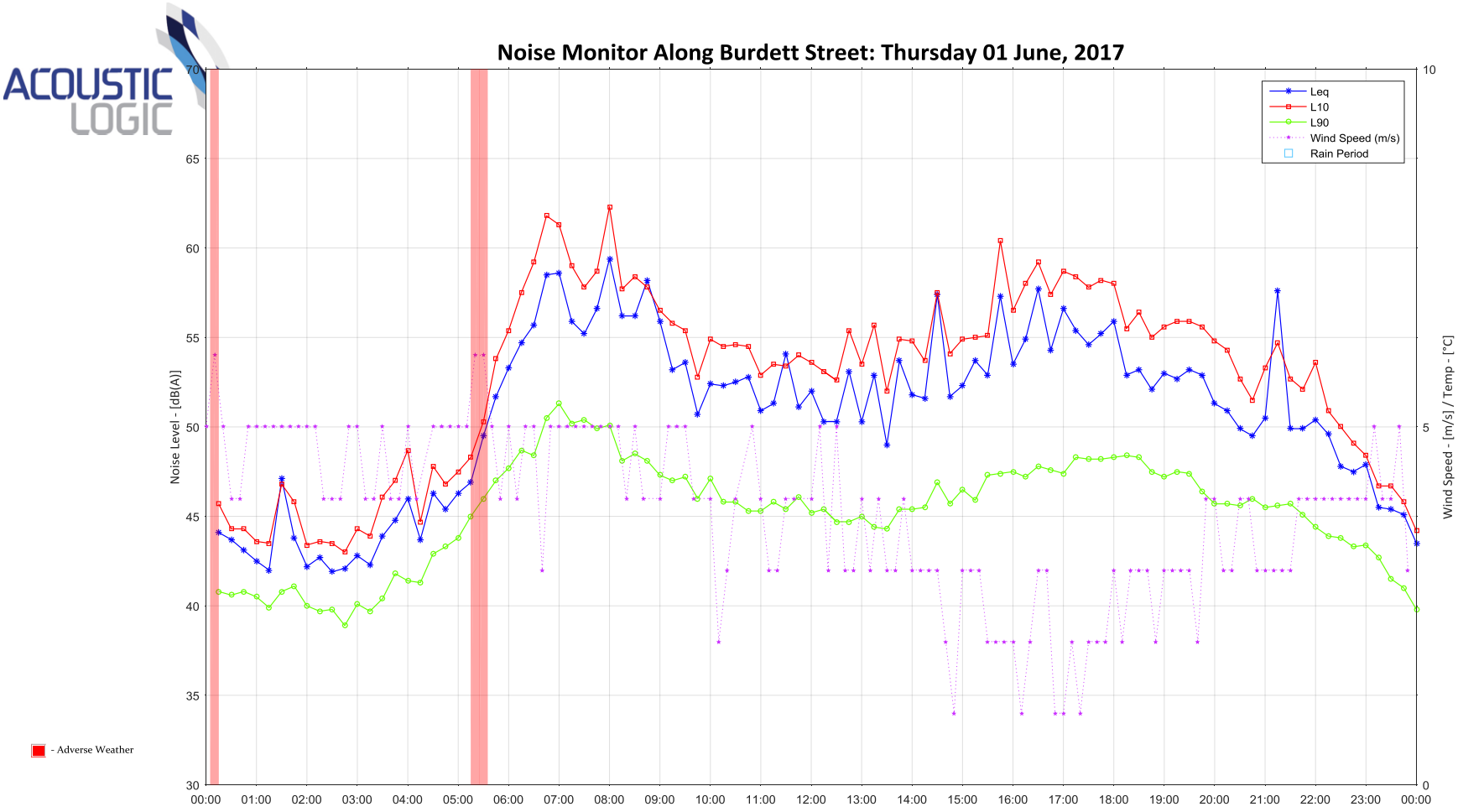
Noise Monitor Along Burdett Street: Thursday 01 June, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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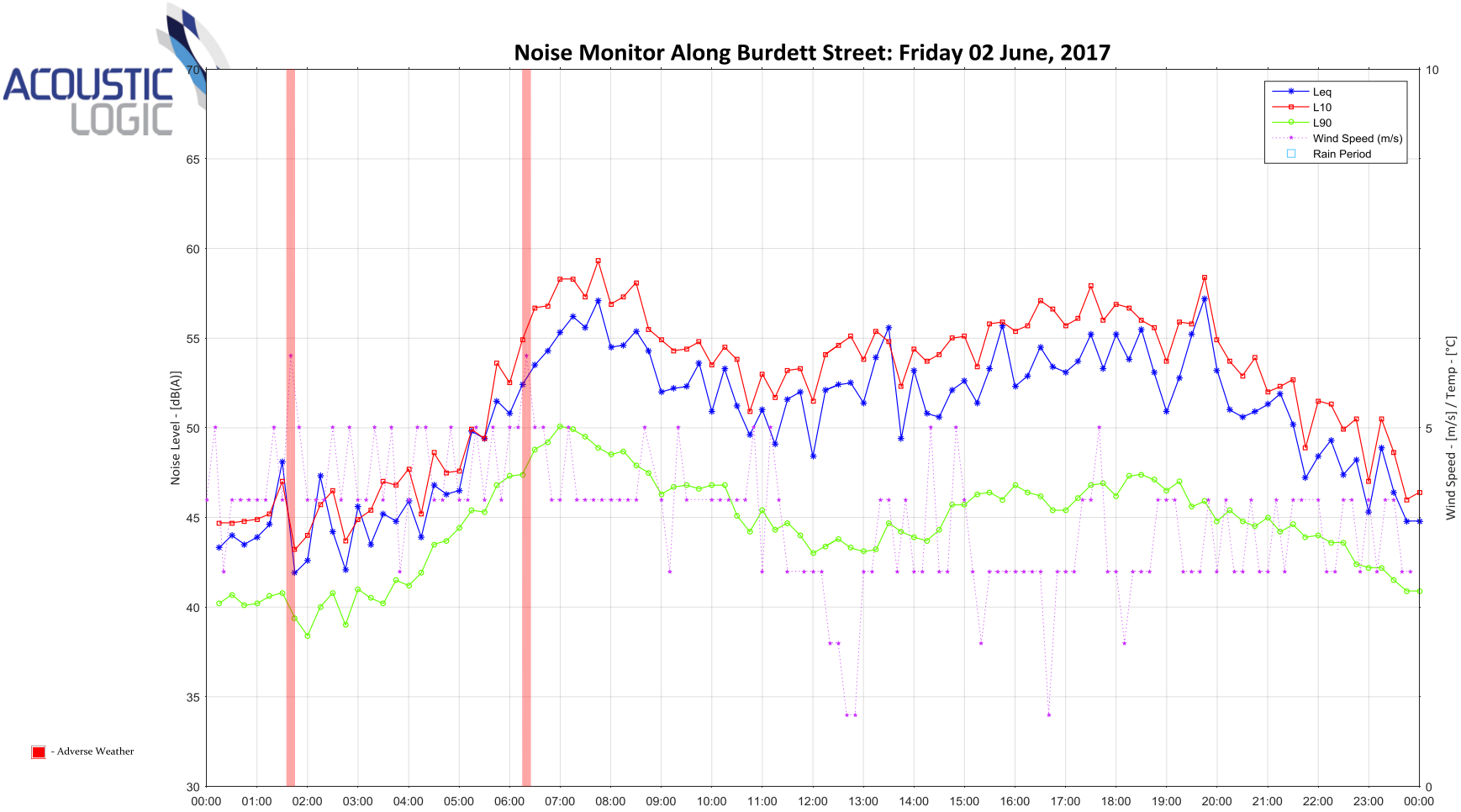
Noise Monitor Along Burdett Street: Friday 02 June, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
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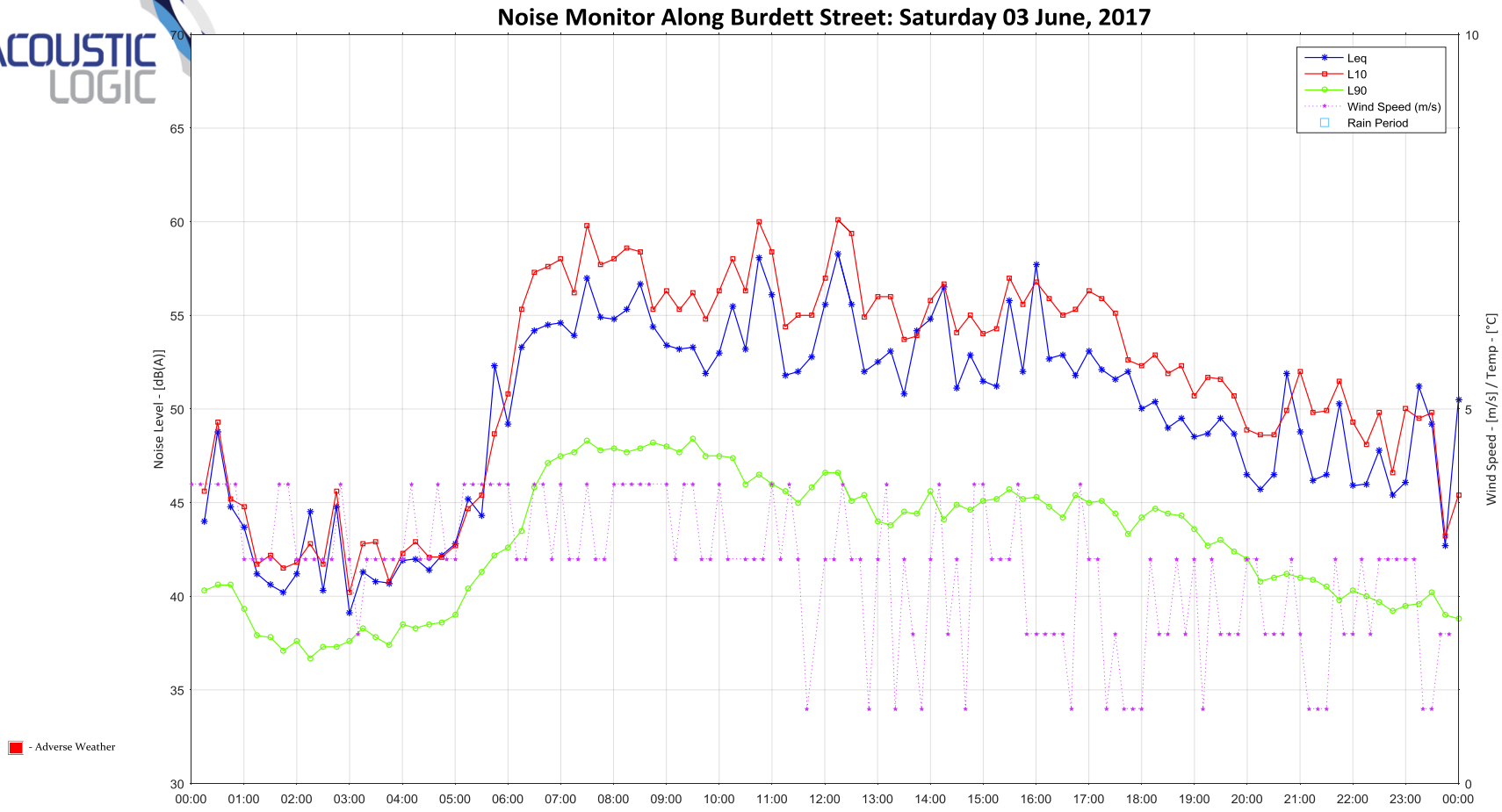
Noise Monitor Along Burdett Street: Saturday 03 June, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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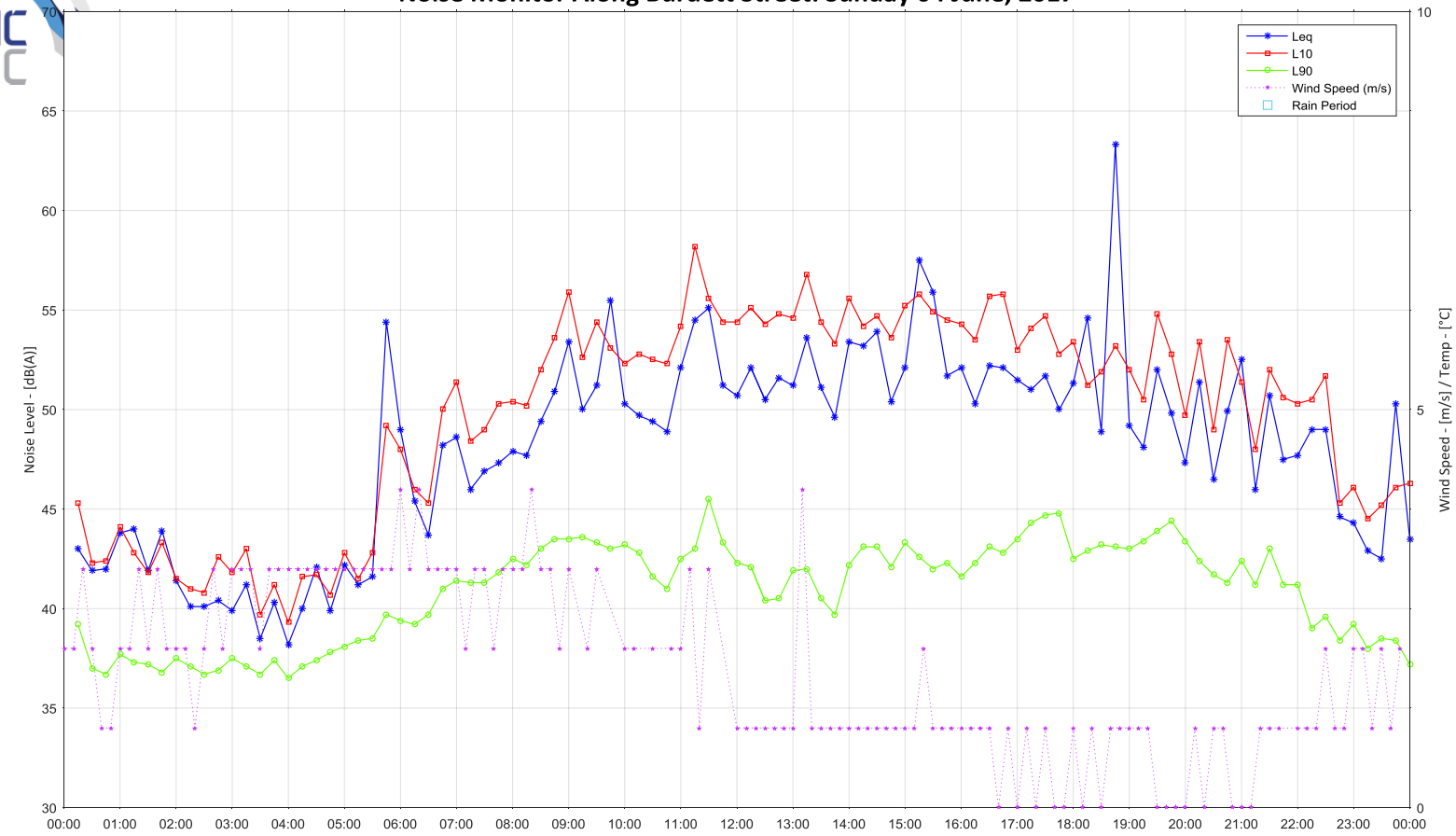
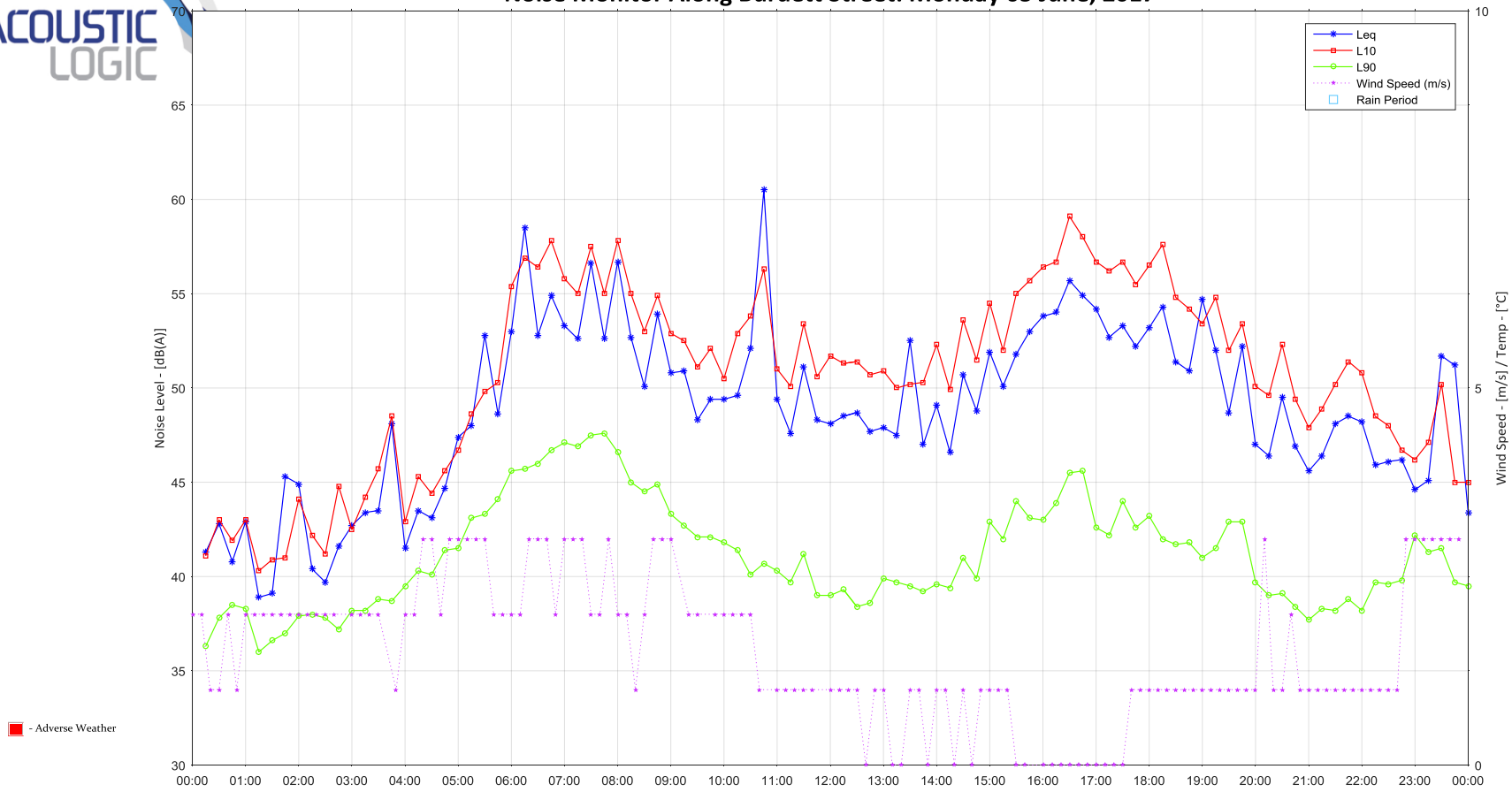
Noise Monitor Along Burdett Street: Sunday 04 June, 2017



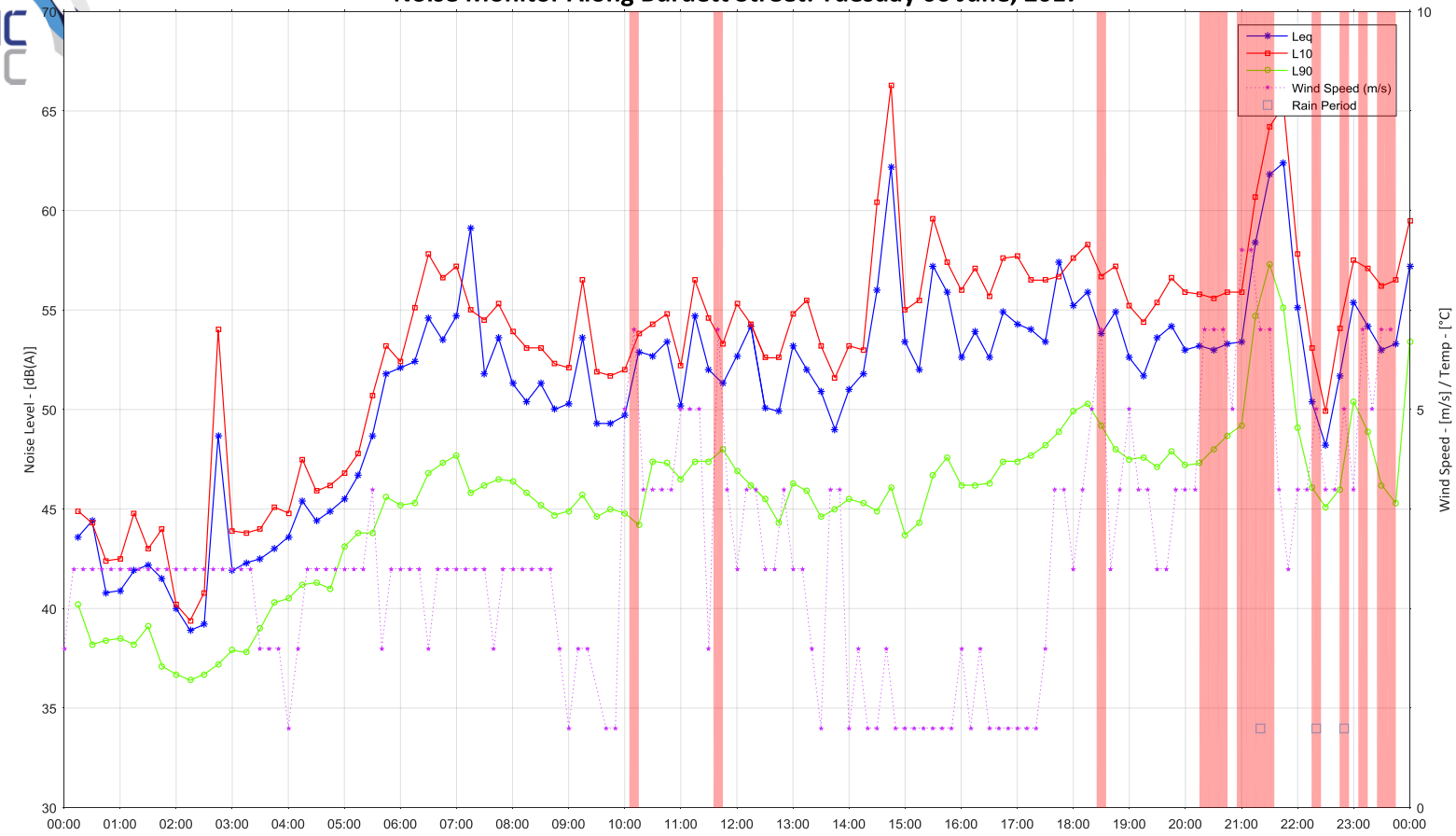
- Adverse Weather

Noise Monitor Along Burdett Street: Monday 05 June, 2017

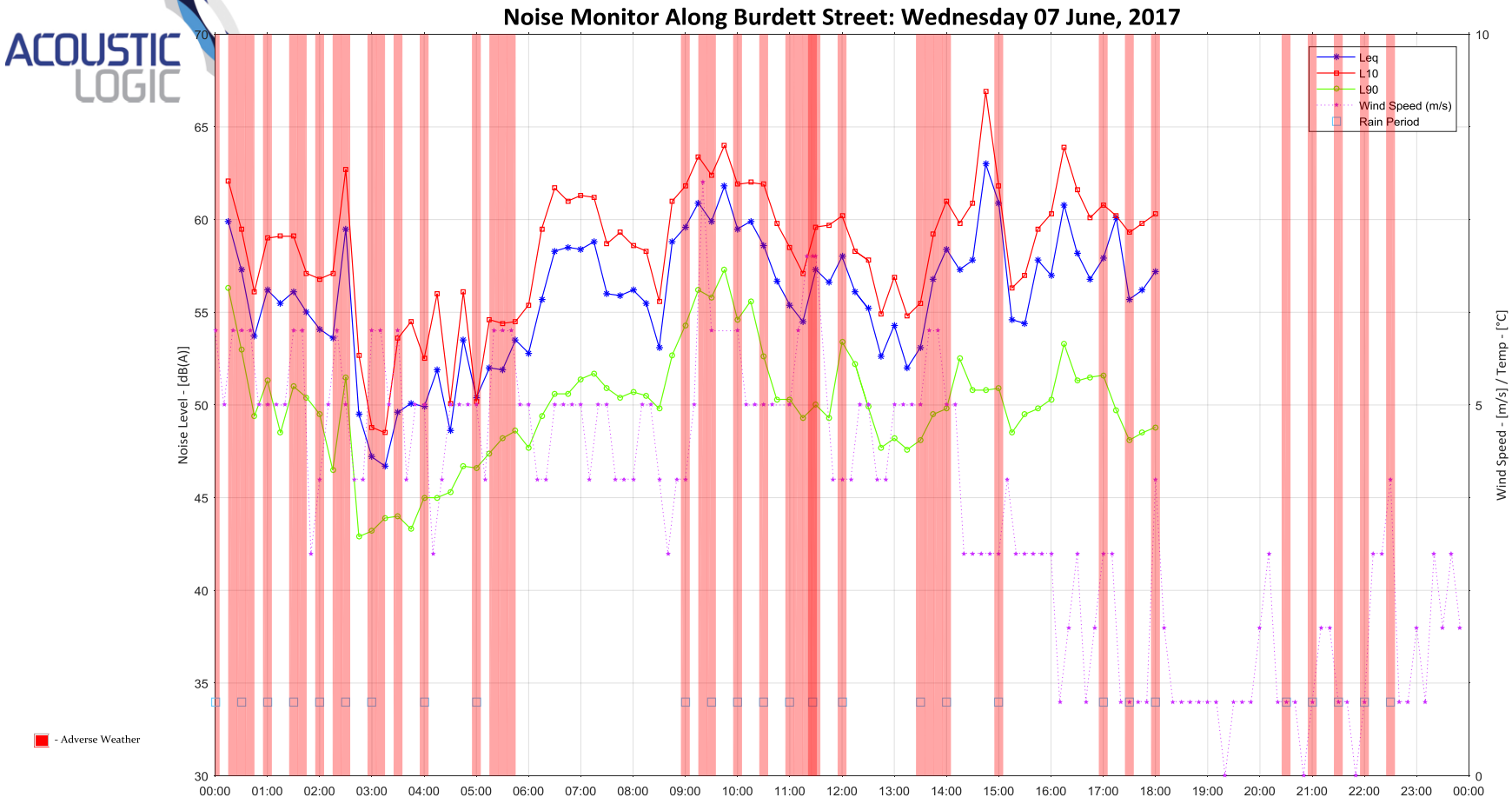


- Adverse Weather

Noise Monitor Along Burdett Street: Tuesday 06 June, 2017



- Adverse Weather


Noise Monitor Along Burdett Street: Wednesday 07 June, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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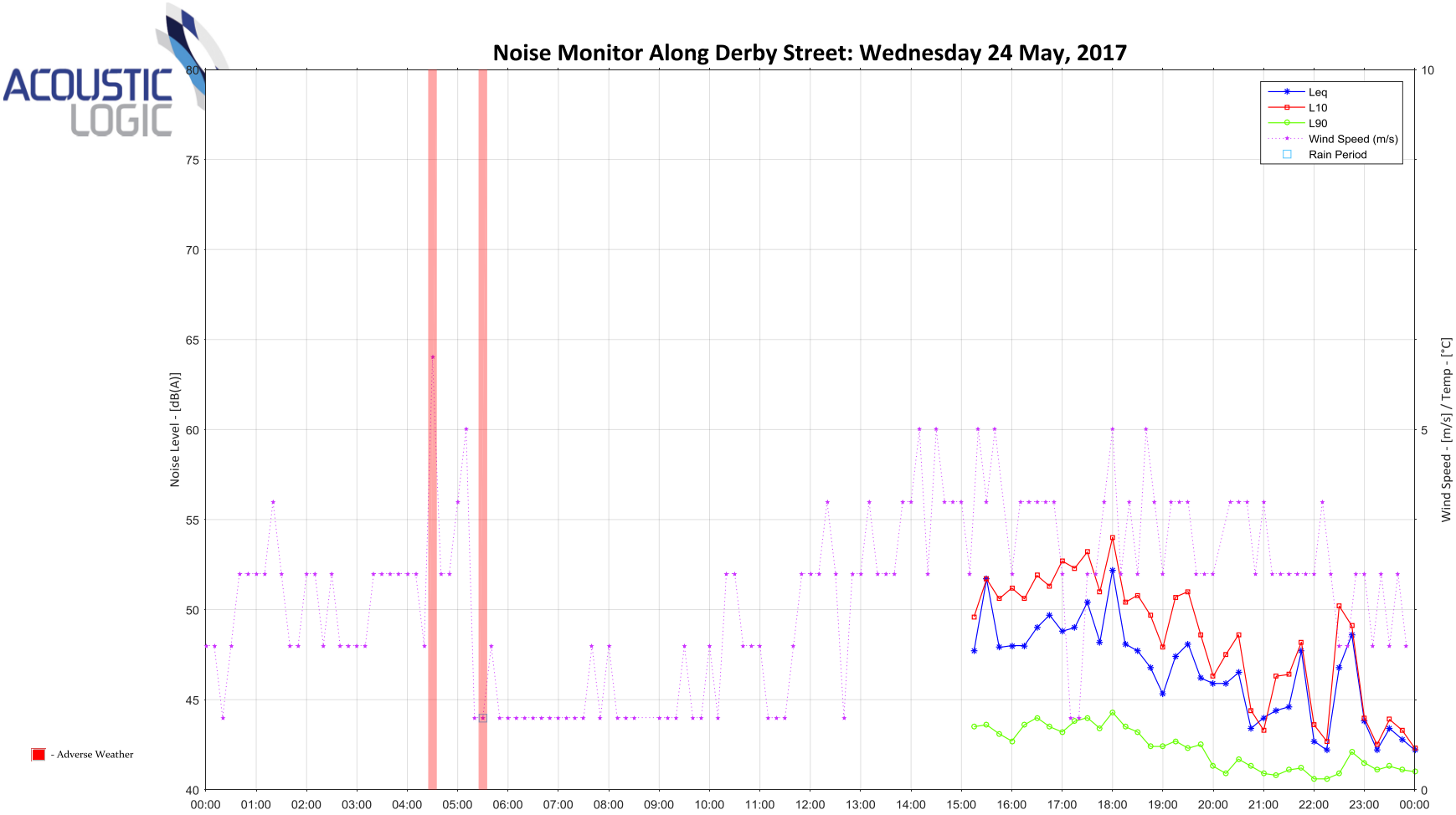
APPENDIX 2 – NOISE MONITORING ALONG DERBY STREET


Noise Monitor Along Derby Street: Wednesday 24 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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L90
Wind Speed (m/s)
Rain Period
- Adverse Weather
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75
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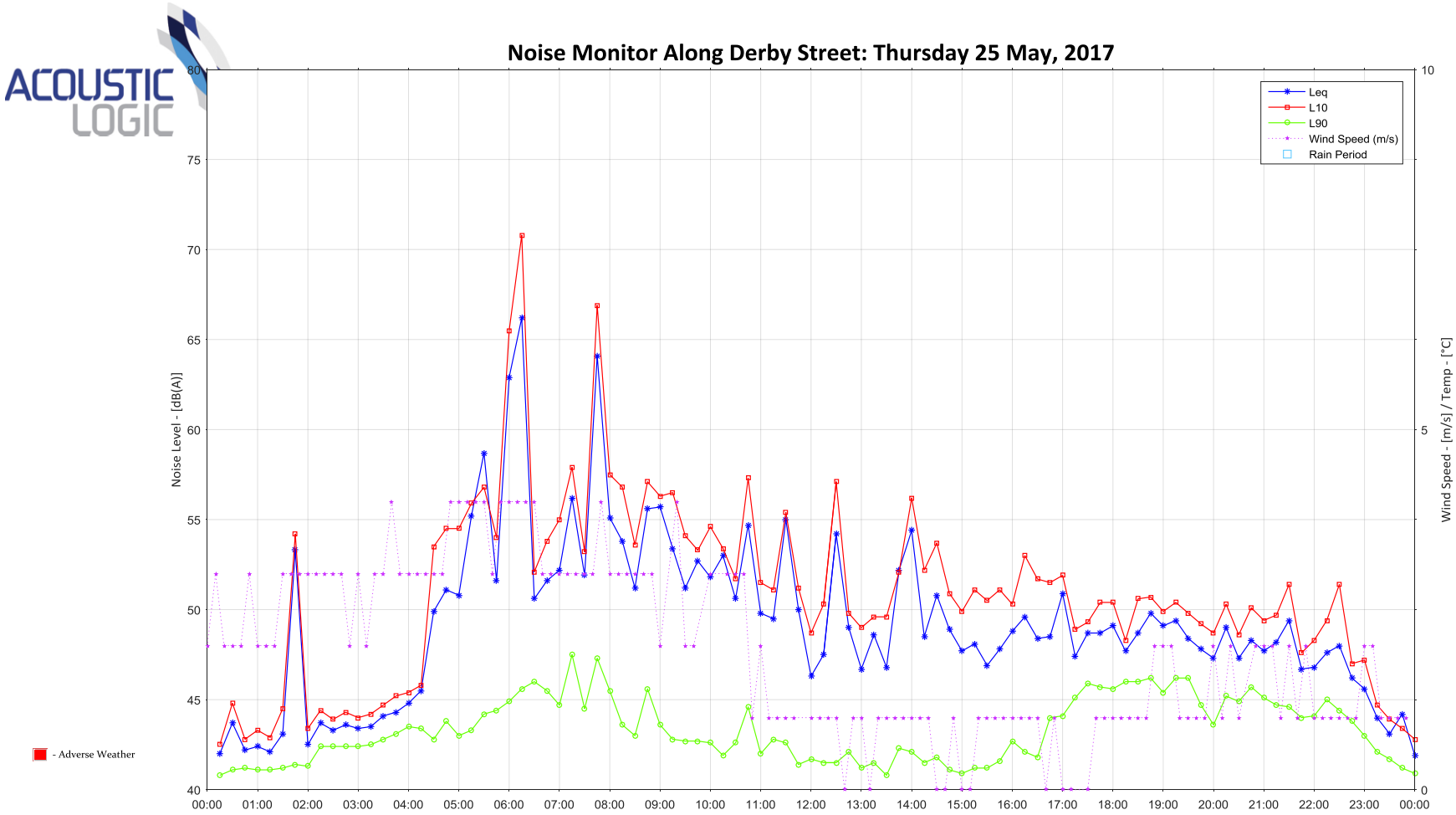
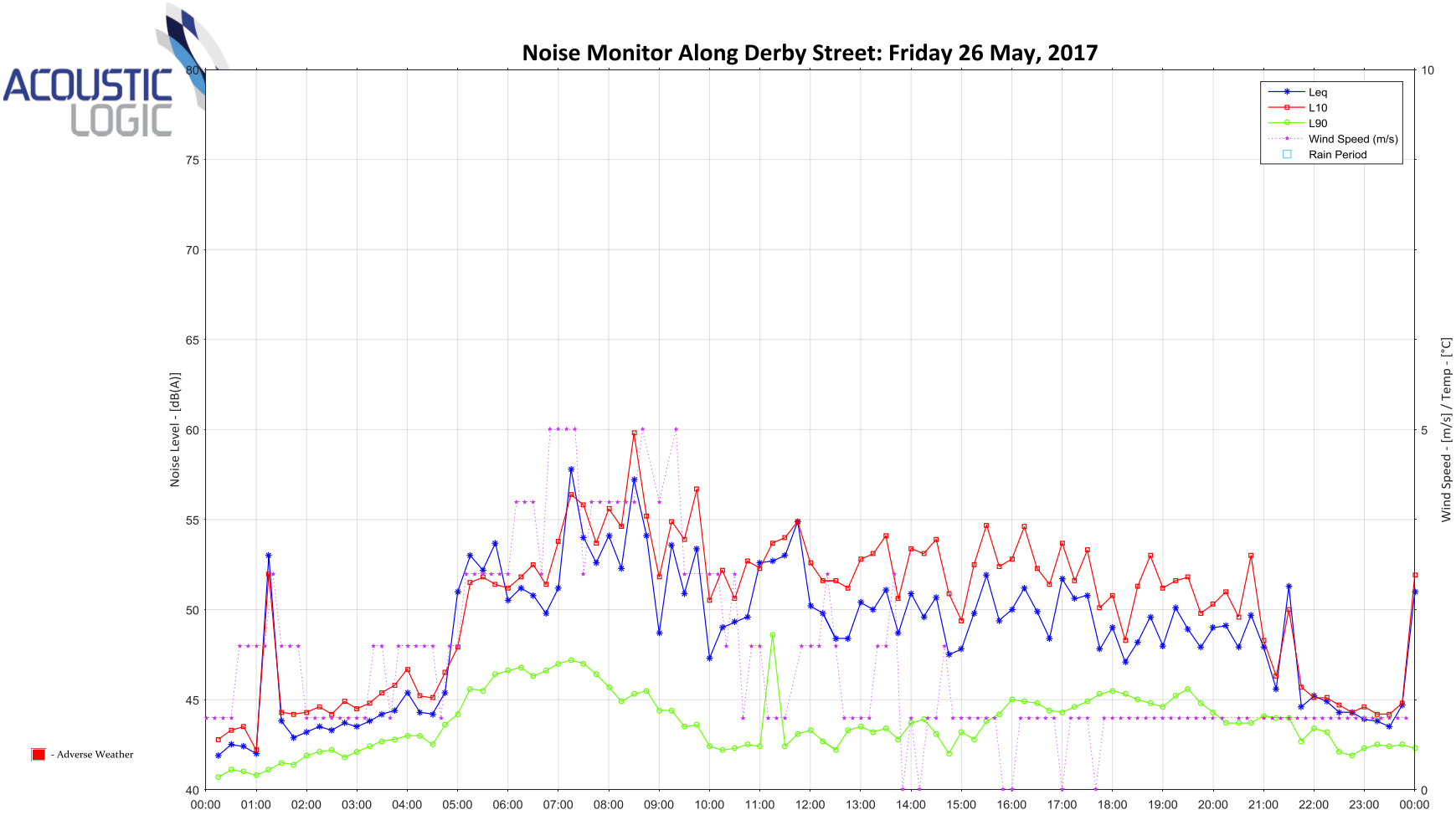

Noise Monitor Along Derby Street: Thursday 25 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
L10
L90
Wind Speed (m/s)
Rain Period
- Adverse Weather


Noise Monitor Along Derby Street: Friday 26 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
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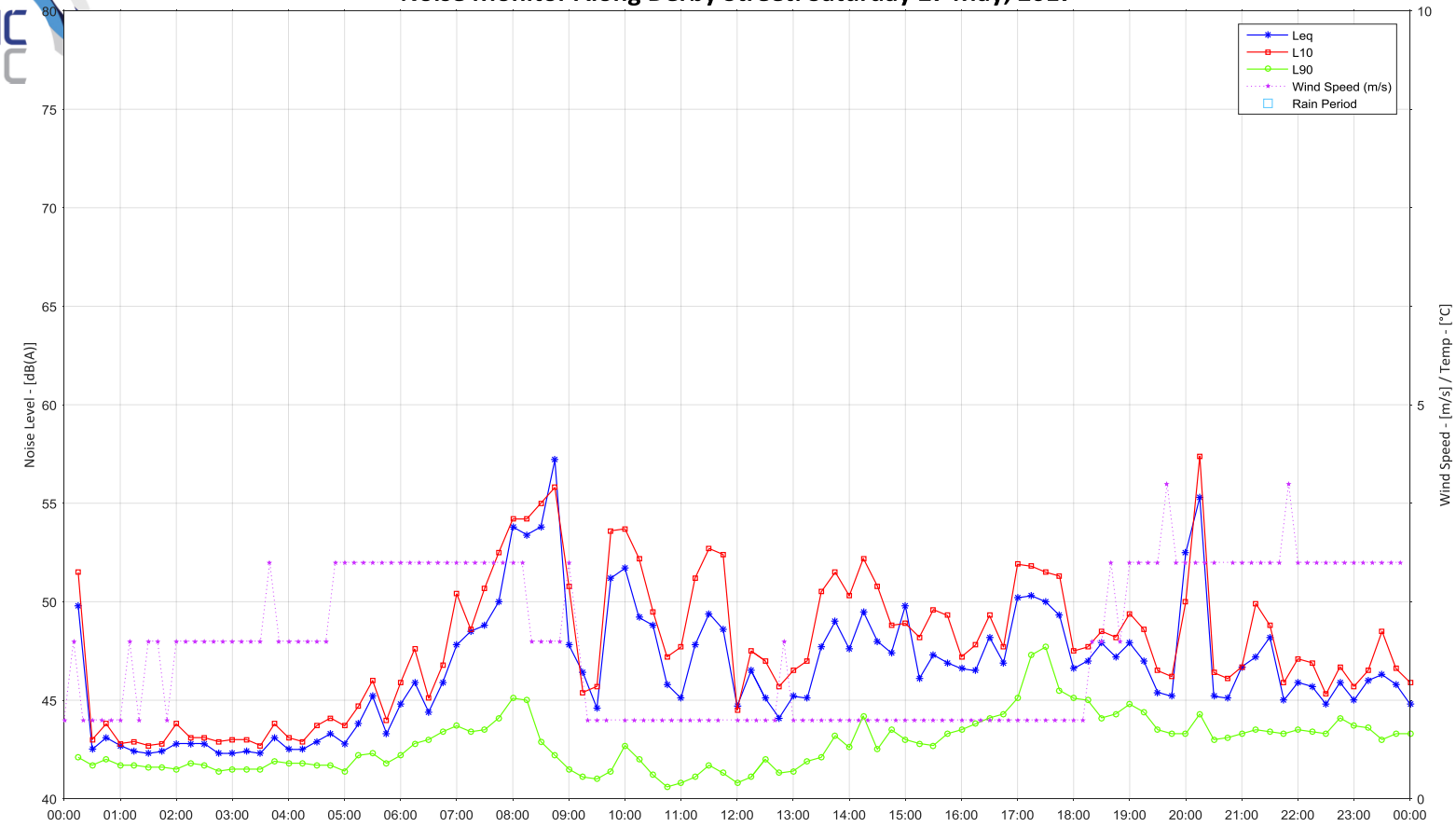
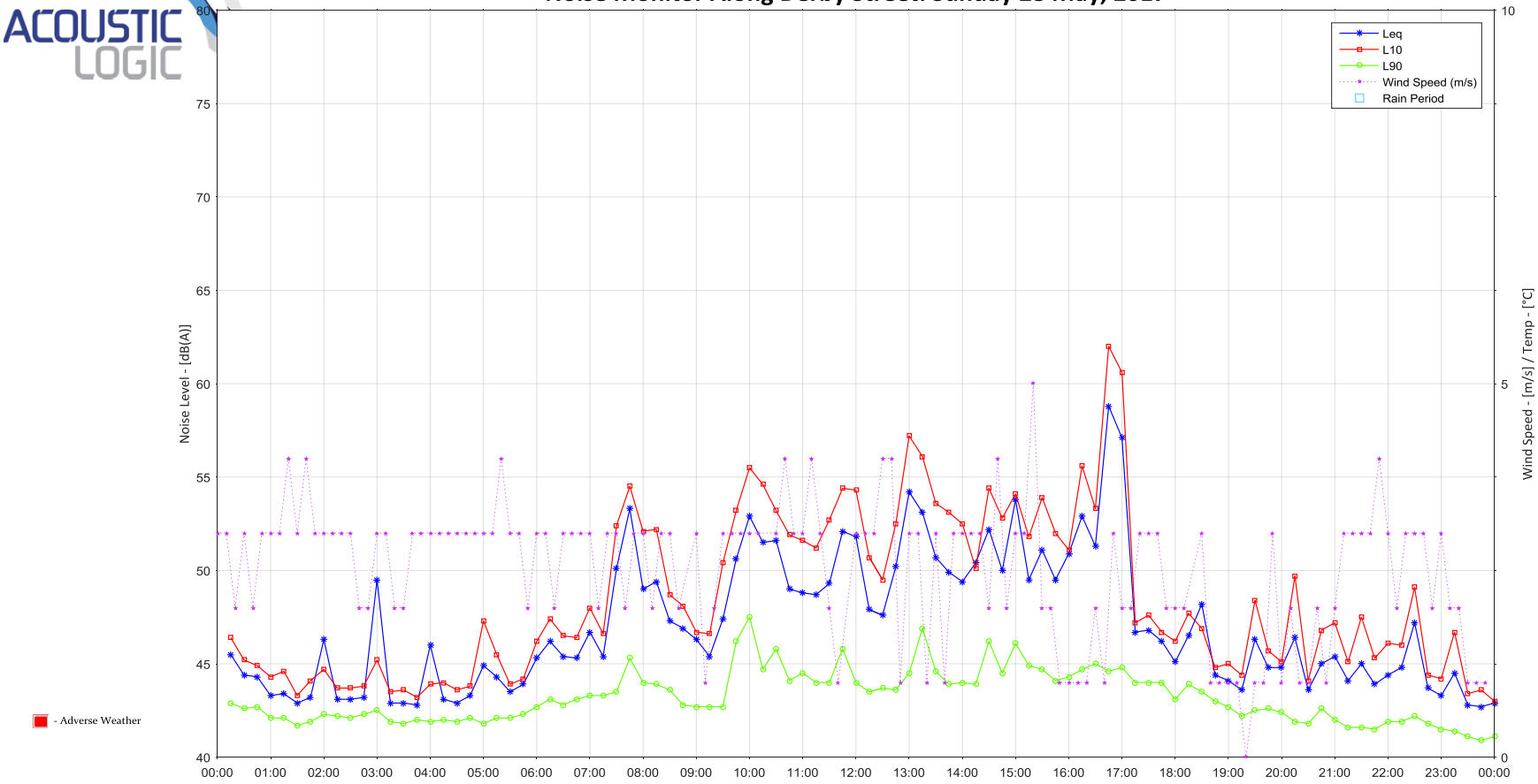
Noise Monitor Along Derby Street: Saturday 27 May, 2017



- Adverse Weather


Noise Monitor Along Derby Street: Sunday 28 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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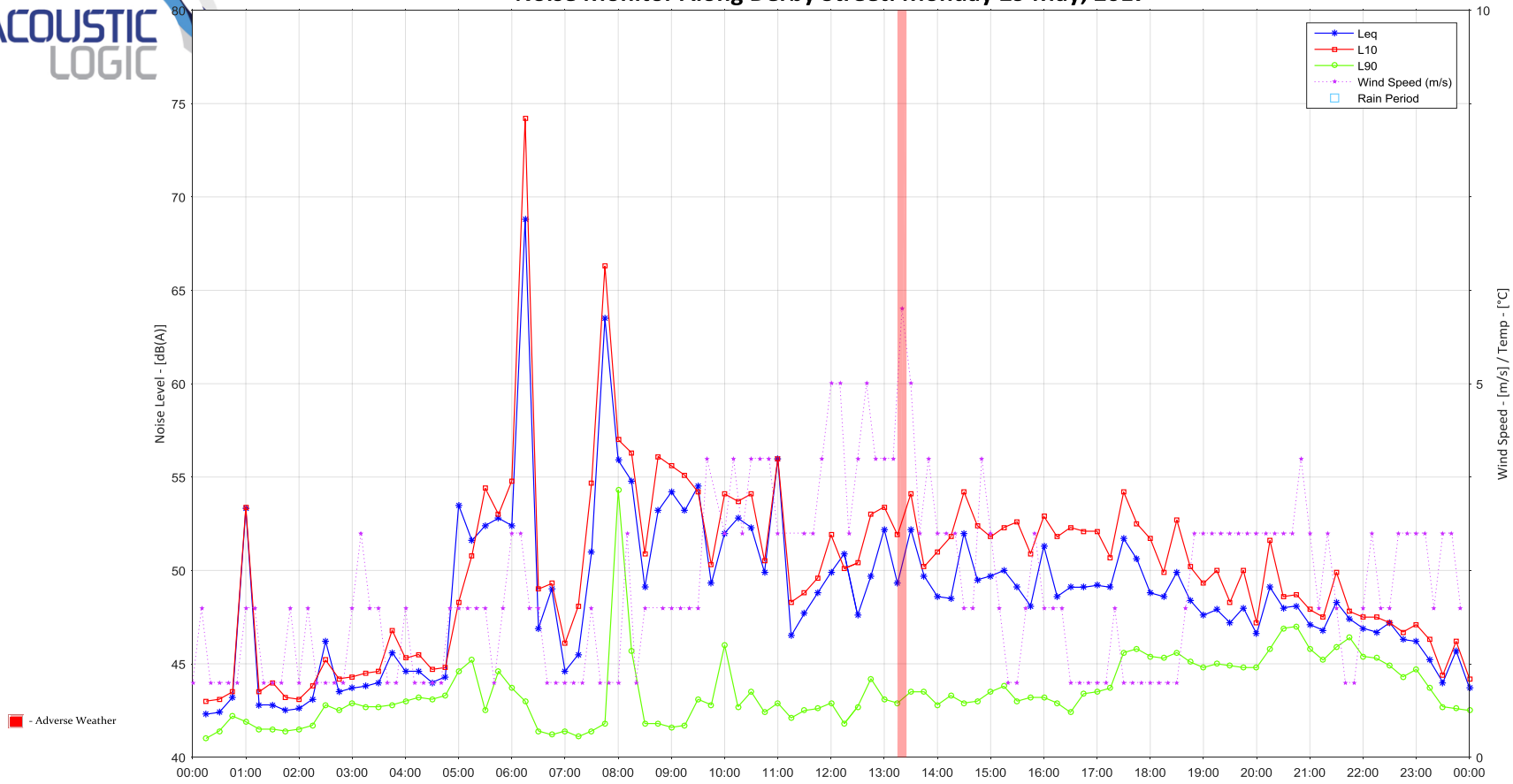
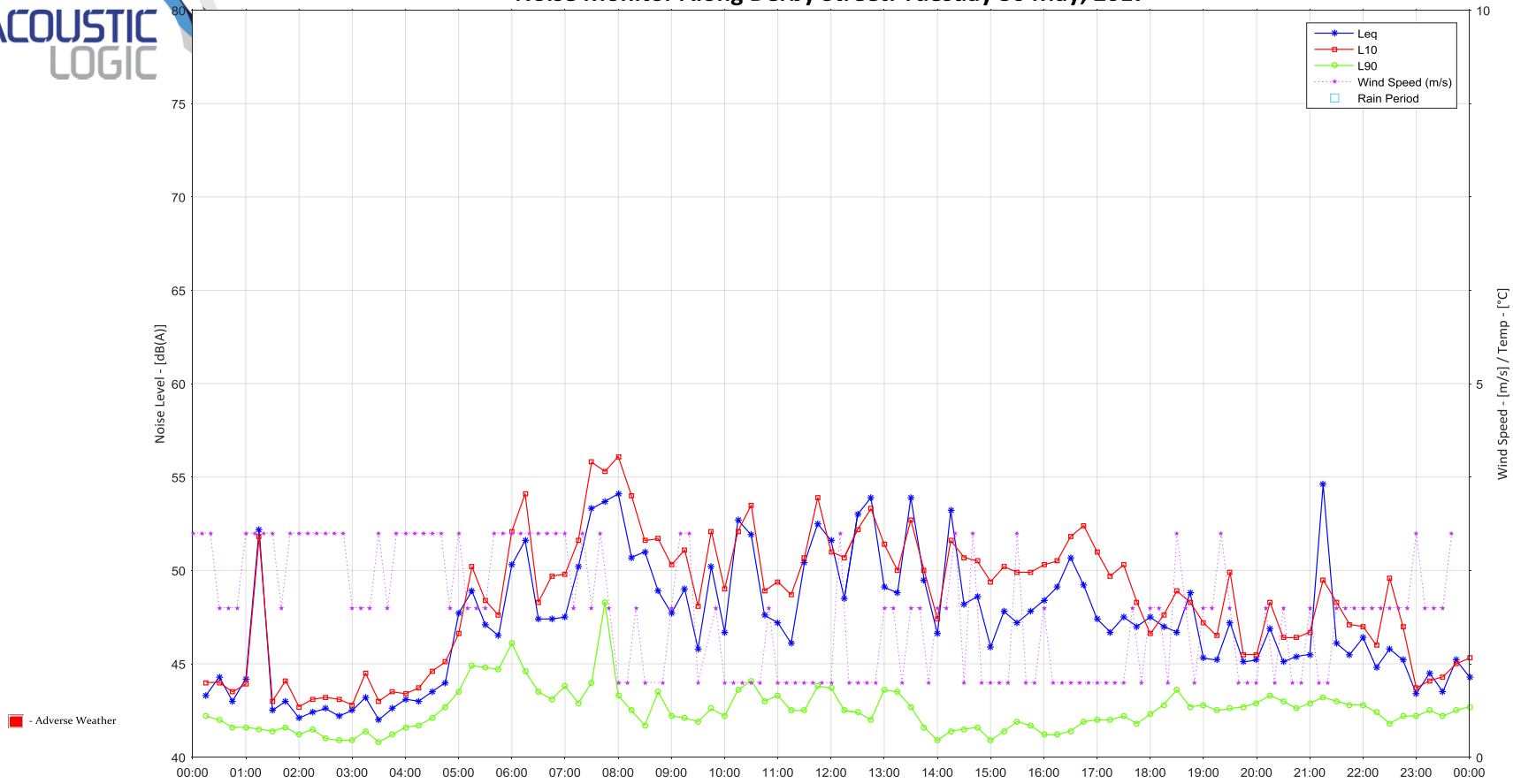
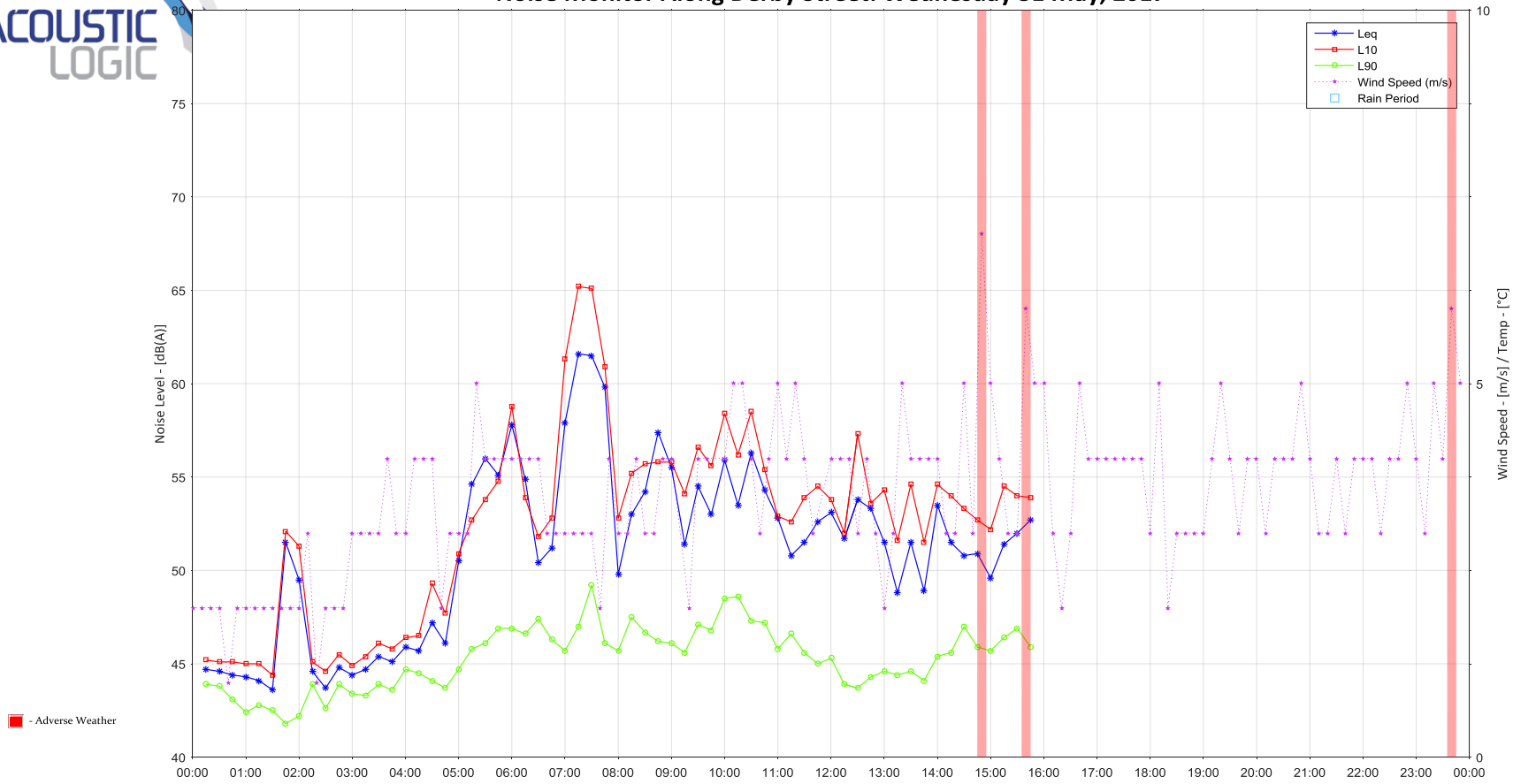
Noise Monitor Along Derby Street: Monday 29 May, 2017



Noise Monitor Along Derby Street: Tuesday 30 May, 2017



Noise Monitor Along Derby Street: Wednesday 31 May, 2017



APPENDIX 3 – NOISE MONITORING ALONG PALMERSTON ROAD


Noise Monitor Along Palmerston Road: Wednesday 24 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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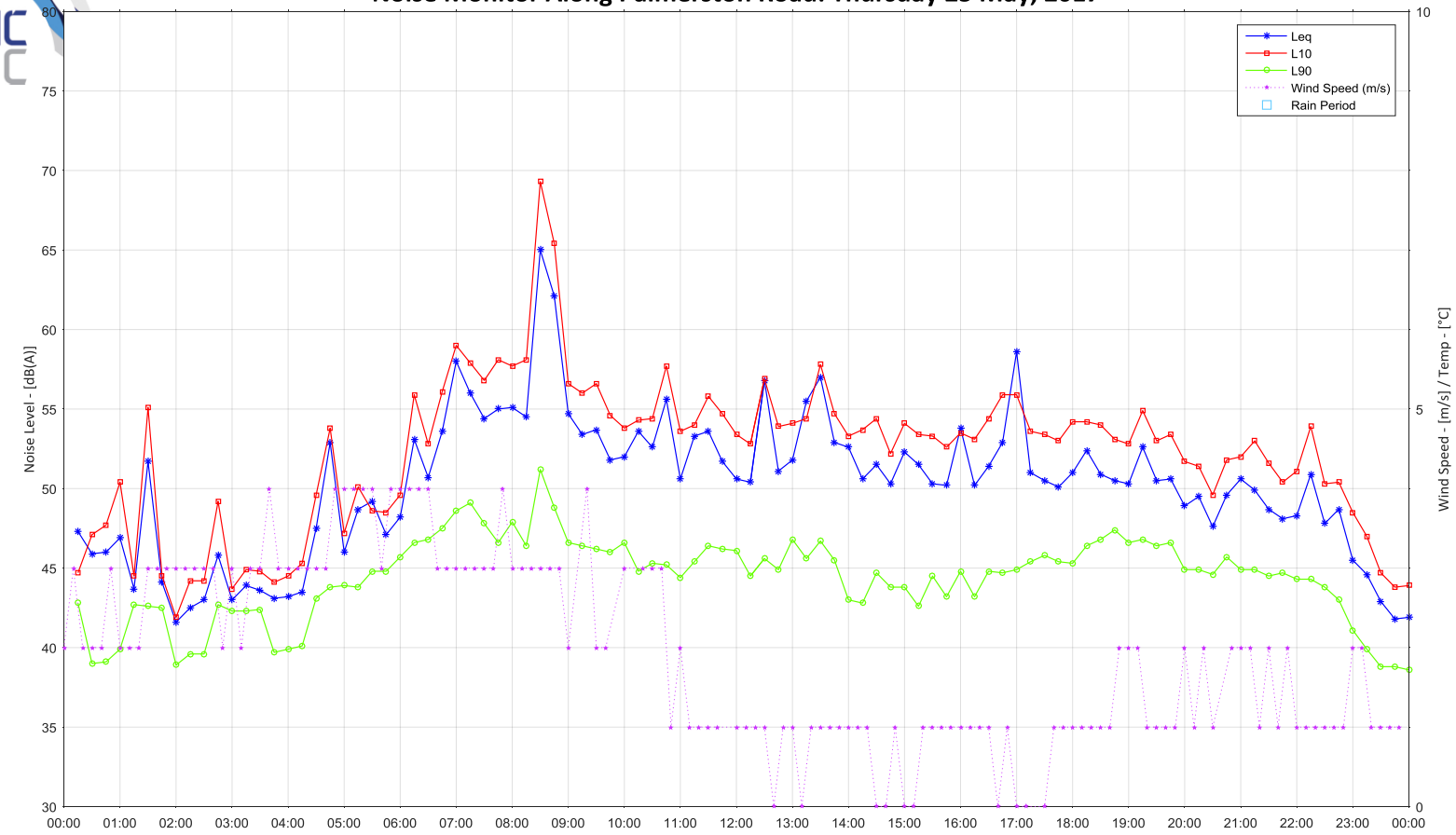
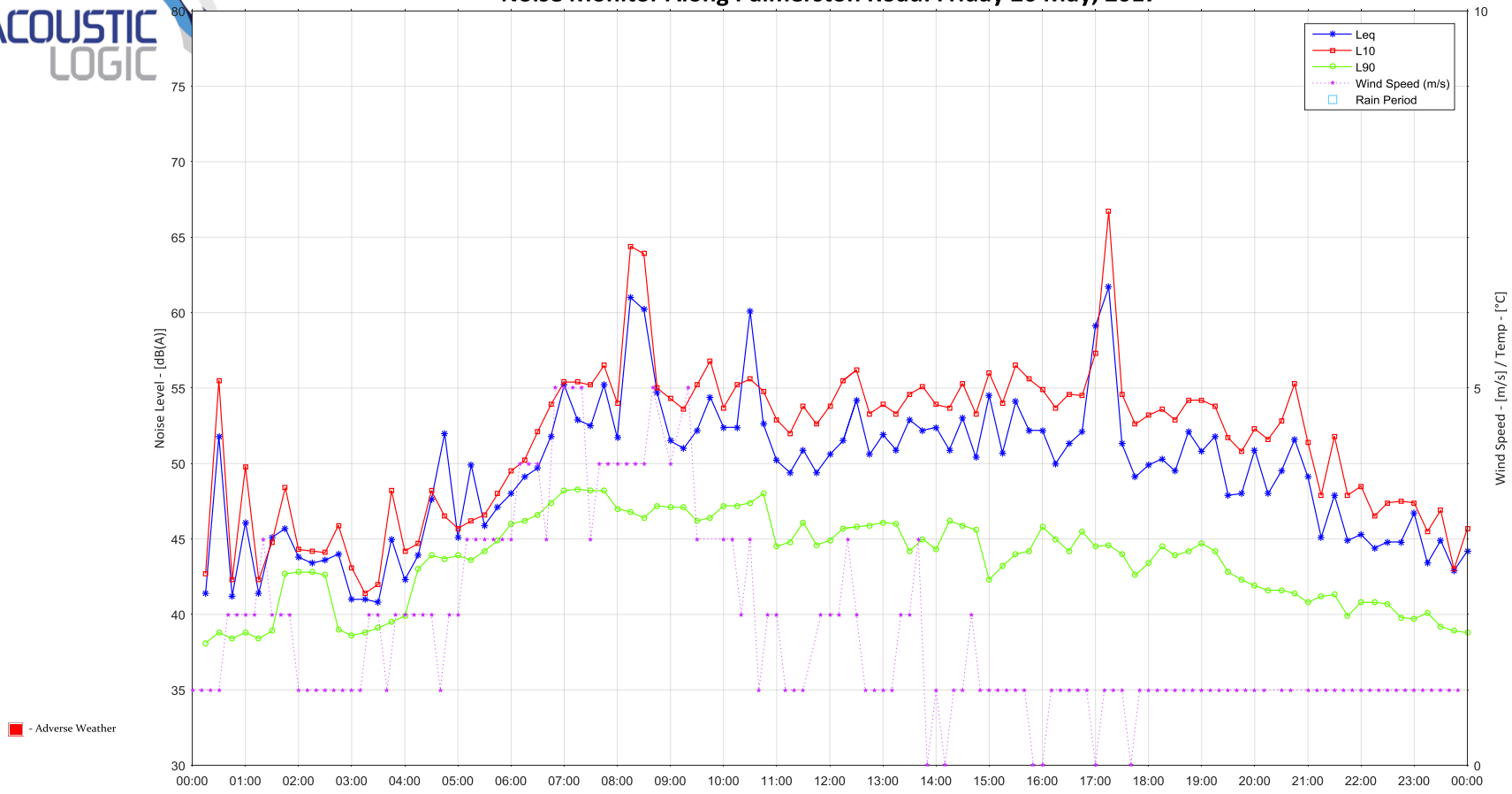
Noise Monitor Along Palmerston Road: Thursday 25 May, 2017



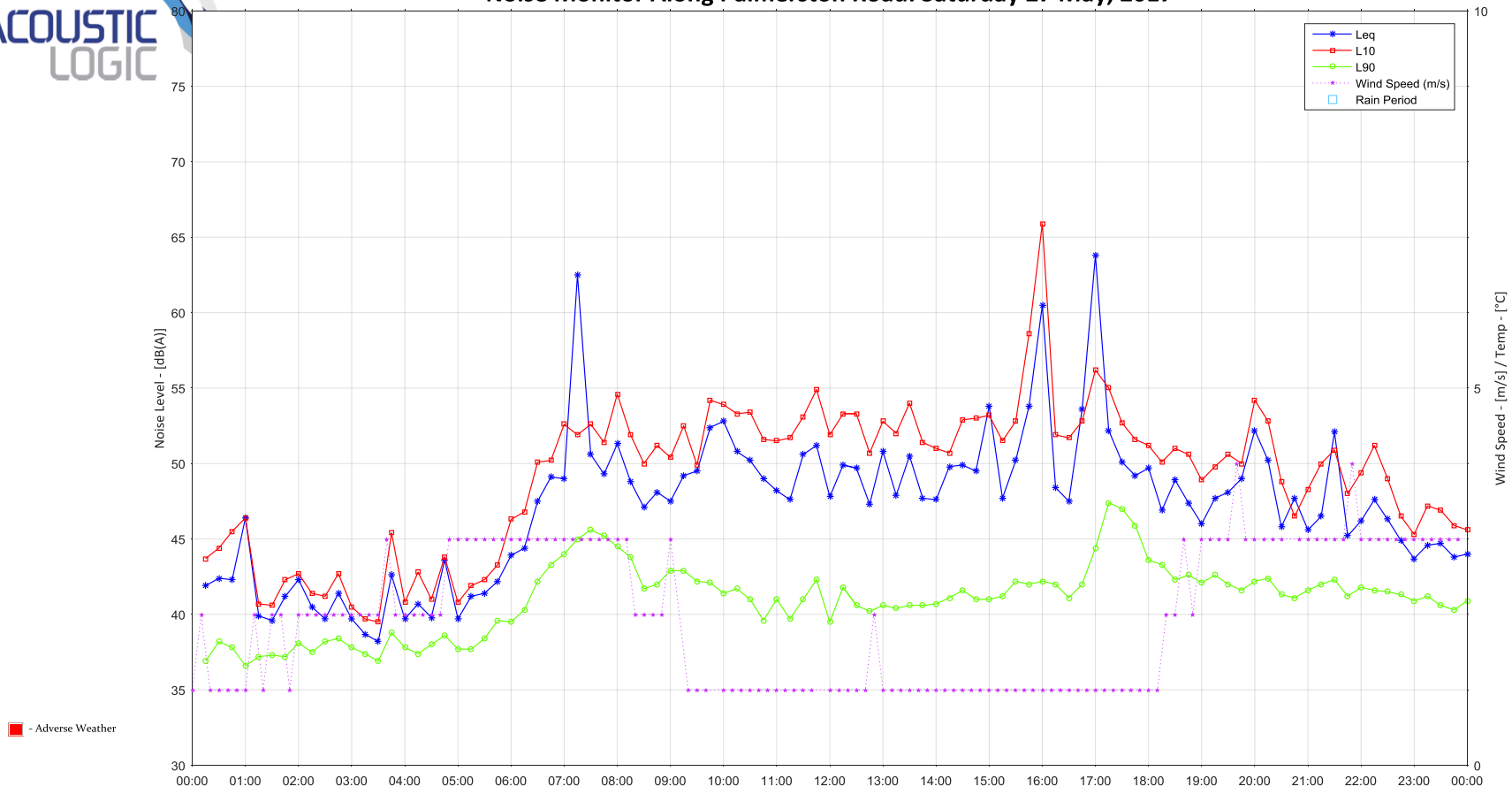
- Adverse Weather

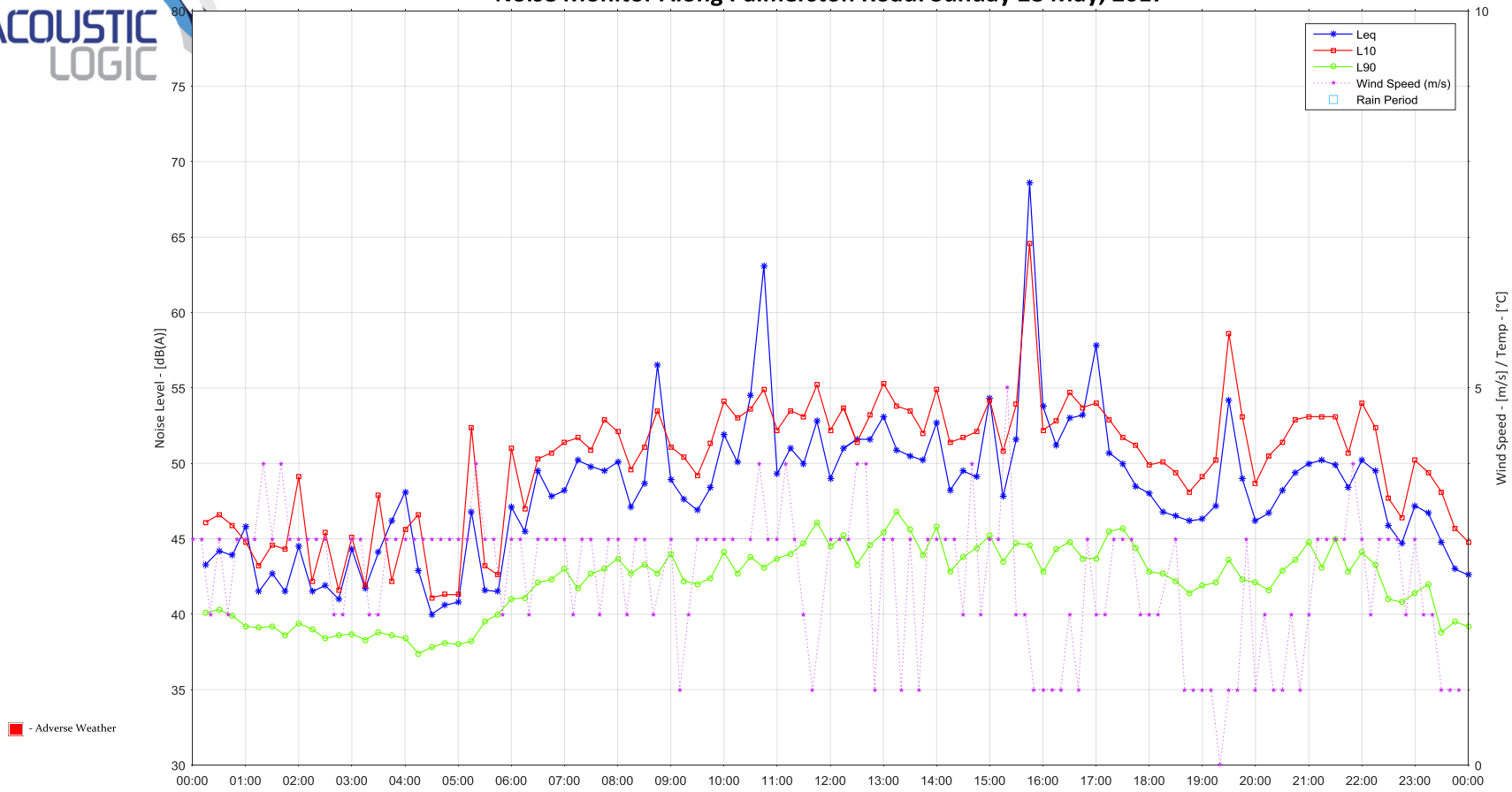
Noise Monitor Along Palmerston Road: Friday 26 May, 2017



- Adverse Weather

Noise Monitor Along Palmerston Road: Saturday 27 May, 2017




Noise Monitor Along Palmerston Road: Sunday 28 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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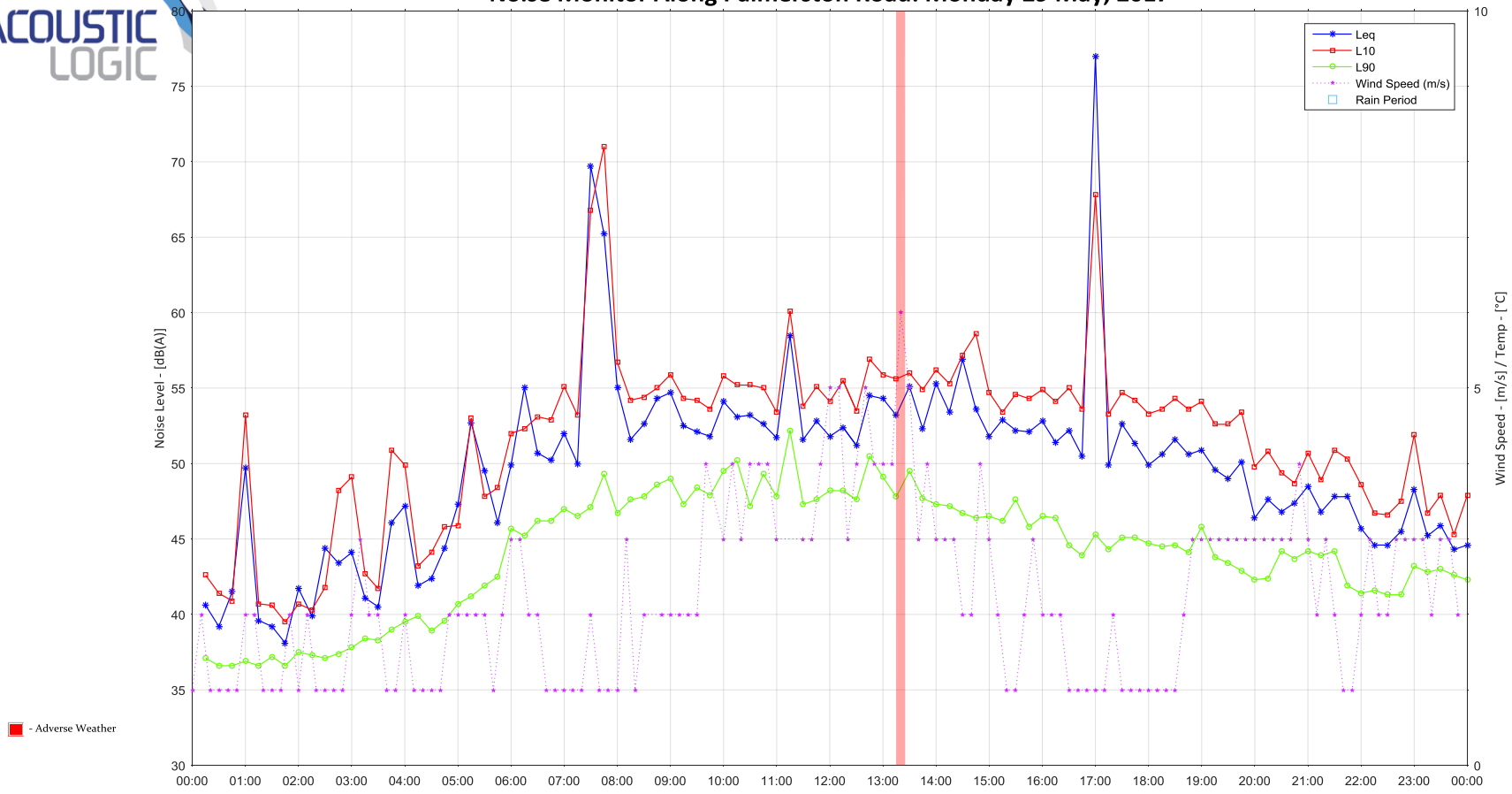
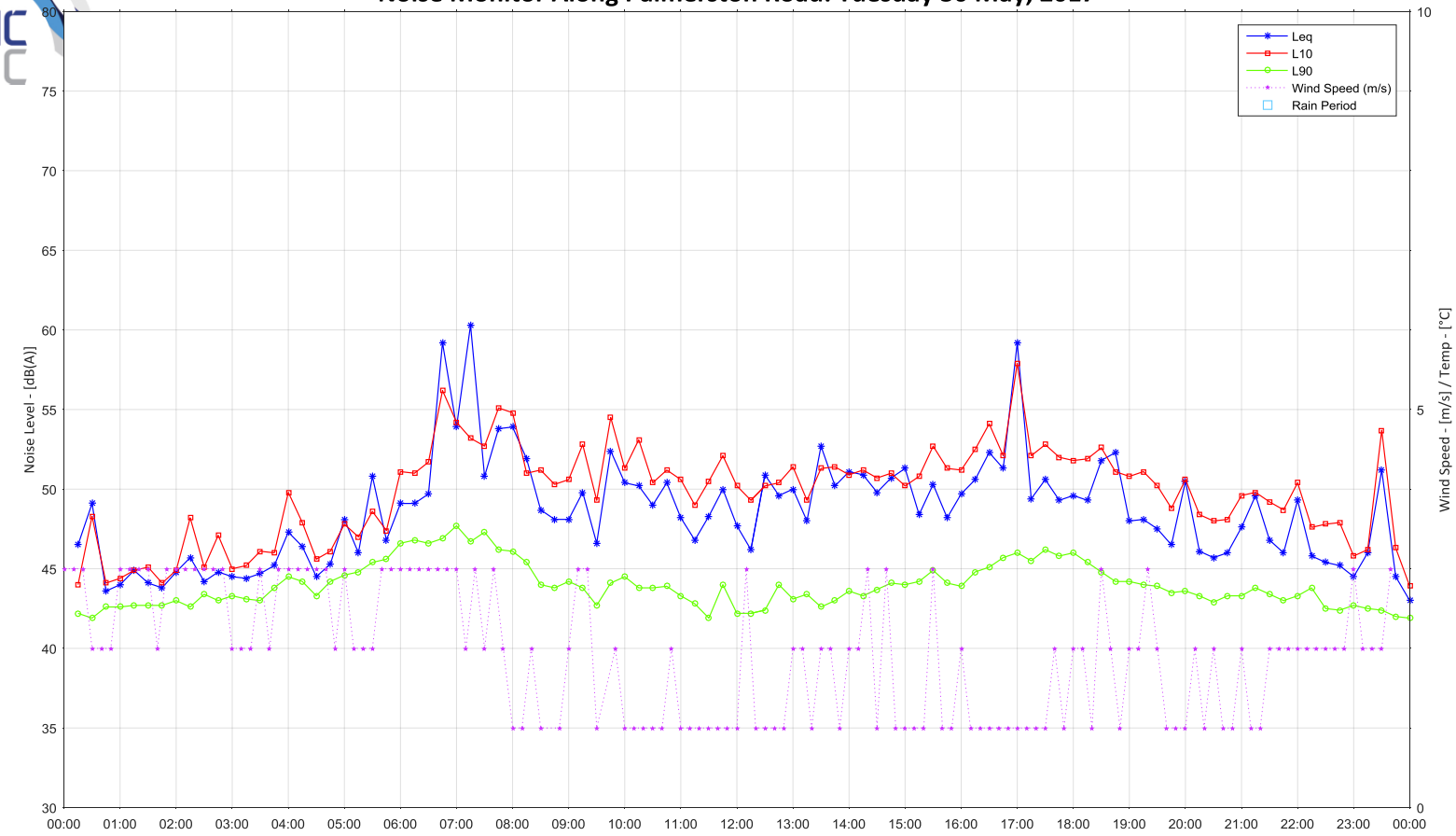
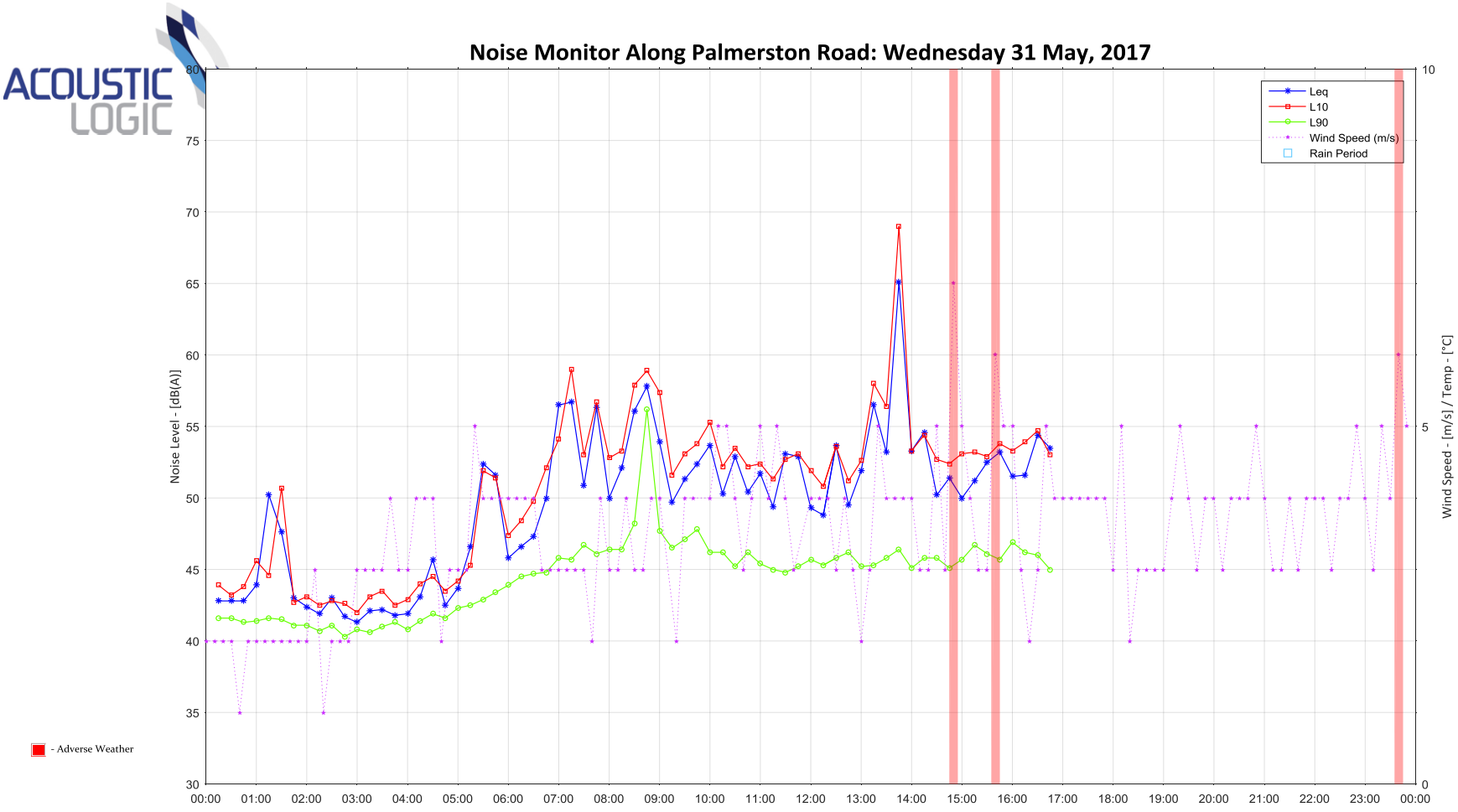
Noise Monitor Along Palmerston Road: Monday 29 May, 2017



Noise Monitor Along Palmerston Road: Tuesday 30 May, 2017



- Adverse Weather


Noise Monitor Along Palmerston Road: Wednesday 31 May, 2017
Noise Level - [dB(A)]
Wind Speed - [m/s] / Temp - [°C]
Leq
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Wind Speed (m/s)
Rain Period
- Adverse Weather
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APPENDIX 2 – CALIBRATION CERTIFICATES

Calibration Certificate for Noise Monitor Along Burdett Street and Derby Road

Acoustic Research Labs Pty Ltd
Level 7 Building 2 423 Pennant Hills Rd
Pennant Hills NSW AUSTRALIA 2120
Ph: +61 2 9484 0800 A.B.N. 65 160 399 119
www.acousticresearch.com.au

Sound Level Meter

IEC 61672-3.2006

Calibration Certificate

Calibration Number C16216

Client Details Acoustic Logic Consultancy Pty Ltd
9 Sarah Street
Mascot NSW 2020

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 87807E
Microphone Serial Number : 320559
Pre-amplifier Serial Number : 28296

Pre-Test Atmospheric Conditions
Ambient Temperature : 22.2°C
Relative Humidity : 46%
Barometric Pressure : 99.33kPa

Post-Test Atmospheric Conditions
Ambient Temperature : 20.9°C
Relative Humidity : 41%
Barometric Pressure : 99.6kPa

Calibration Technician : Jeff Yu
Calibration Date : 23/05/2016
Secondary Check: Riley Cooper
Report Issue Date : 24/05/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10: Self-generated noise	*Pass*	14: Level linearity on the reference level range	*Pass*
11: Acoustical tests of a frequency weighting	*Pass*	15: Level linearity incl. the level range control	*Pass*
12: Electrical tests of frequency weightings	*Pass*	16: Toneburst response	*Pass*
13: Frequency and time weightings at 1 kHz	*Pass*	17: Peak C sound level	*Pass*
		18: Overload Indication	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2002 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002 and because the periodic tests of IEC 61672-3:2006 cover only a limited subset of the specifications in IEC 61672-1:2002.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.12dB*	*Temperature*	*±0.05°C*
12.5kHz	*±0.18dB*	*Relative Humidity*	*±0.46%*
16kHz	*±0.31dB*	*Barometric Pressure*	*±0.017kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.12dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

NATA WORLD RECOGNISED ACCREDITATION

This calibration certificate is to be read in conjunction with the calibration test report.

Acoustic Research Labs Pty Ltd is NATA Accredited Laboratory Number 14172.
Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National standards.

Calibration Certificate for Noise Monitor Along Palmerston Road

Acoustic Research Labs Pty Ltd
Level 7 Building 2 423 Pennant Hills Rd
Pennant Hills NSW AUSTRALIA 2120
Ph: +61 2 9484 0800 A.B.N. 65 160 399 119
www.acousticresearch.com.au

Sound Level Meter
AS 1259.1:1990 - AS 1259.2:1990
Calibration Certificate

Calibration Number C15643

Client Details Acoustic Logic Consultancy Pty Ltd
9 Sarah Street
MASCOT NSW 2020

Equipment Tested/ Model Number : ARL EL-315
Instrument Serial Number : 15-203-518
Microphone Serial Number : 149333
Pre-amplifier Serial Number : 26941

Atmospheric Conditions
Ambient Temperature : 21.4°C
Relative Humidity : 51%
Barometric Pressure : 99.78kPa

Calibration Technician : Dennis Kim
Calibration Date : 08/12/2015
Secondary Check: Sandra Minto
Report Issue Date : 08/12/2015

Approved Signatory : Juan Aguero

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	*Pass*	10.3.4: Inherent system noise level	*Pass*
10.2.3: Frequency weighting	*Pass*	10.4.2: Time weighting characteristic F and S	*Pass*
10.3.2: Overload indications	*Pass*	10.4.3: Time weighting characteristic I	*Pass*
10.3.3: Accuracy of level range control	*Pass*	10.4.5: R.M.S performance	*Pass*
8.9: Detector-indicator linearity	*Pass*	9.3.2: Time averaging	*Pass*
8.10: Differential level linearity	*Pass*	9.3.5: Overload indication	*Pass*

Least Uncertainties of Measurement -

Acoustic Tests
- *31.5 Hz to 8kHz* ±0.120dB
- *12.5kHz* ±0.165dB
- *16kHz* ±0.245dB

Electrical Tests
- *31.5 Hz to 20 kHz* ±0.098dB

Environmental Conditions
- *Temperature* ±0.3°C
- *Relative Humidity* ±4.1%
- *Barometric Pressure* ±0.1kPa

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

The sound level meter under test has been shown to conform to the type 2 requirements for periodic testing as described in AS 1259.1:1990 and AS 1259.2:1990 for the tests stated above.

NATA
WORLD RECOGNISED ACCREDITATION

This calibration certificate is to be read in conjunction with the calibration test report.

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Accredited for compliance with ISO/IEC 17025.

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Calibration Certificate for Sound Level Meter Used for Attended Background Noise Measurements Conducted on 18/01/2018

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 19054 & FILT 1319**

Equipment Description:	Sound Level Meter		
Manufacturer:	Norsonic		
Model No:	NOR-140	**Serial No:**	1405928
Microphone Type:	1225	**Serial No:**	208208
Filter Type:	1/3 Octave	**Serial No:**	1405929
Comments:	All tests passed for class 1. (See over for details)		
Owner:	Acoustic Logic Consultancy 9 Sarah Street Mascot, NSW 2020		
Ambient Pressure:	1012 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	30% ±5%
Date of Calibration:	29/06/2016	**Issue Date:**	29/06/2016

Acu-Vib Test Procedure: AVP10 (SLM) & AVP06 (Filters)

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....

Jack Kielt

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
WORLD RECOGNISED ACCREDITATION

Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB
ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 19053 & FILT 1316**

Equipment Description:	Sound Level Meter		
Manufacturer:	Norsonic		
Model No:	NOR-140	**Serial No:**	1405928
Microphone Type:	1225	**Serial No:**	208206
Filter Type:	1/3 Octave	**Serial No:**	1405928
Comments:	All tests passed for class 1. (See over for details)		
Owner:	Acoustic Logic Consultancy 9 Sarah Street Mascot, NSW 2020		
Ambient Pressure:	1000 hPa ±1.5 hPa		
Temperature:	21 °C ±2° C	**Relative Humidity:**	38% ±5%
Date of Calibration:	27/06/2016	**Issue Date:**	27/06/2016

Acu-Vib Test Procedure: AVP10 (SLM) & AVP06 (Filters)

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....

Jack Kielt

Accredited for compliance with ISO/IEC 17025
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CERTIFICATE NO.: SLM 19054 & FILT 1319

The performance characteristics listed below were tested. The tests are based on the relevant clauses of IEC 61672-3:2013

Tests Performed:	*Clause*	*Result*
Absolute Calibration	10	Pass
Acoustical Frequency Weighting	12	Pass
Self Generated Noise	11.1	Entered
Electrical Noise	11.2	Entered
Long Term Stability	15	Pass
Electrical Frequency Weightings	13	Pass
Frequency and Time Weightings	14	Pass
Reference Level Linearity	16	Pass
Range Level Linearity	17	N/A
Toneburst	18	Pass
Peak C Sound Level	19	Pass
Overload Indicator	20	Pass
High Level Stability	21	Pass

Statement of Compliance: The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent organization responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2013, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013, the sound level meter submitted for testing conforms to the class 1 requirements of IEC61672-1:2013.
A full technical report is available if required.

This Sound Level Meter included an Octave Filter Set. Tests were based on IEC 1260: 1995 and AS/NZS 4476 - 1997 and were conducted to test the following performance characteristics:

1. Relative attenuation clause 5.3

Least uncertainty for relative attenuation (at 95% c.l.) k=2:
±0.1 dB for attenuation equal to an less than 6 dB
±0.3 dB for RA from above 6 dB to 18 dB
±0.6 dB for RA from above 18 dB to 80 dB

Date of Calibration: 29/06/2016 **Issue Date:** 29/06/2016

Checked by: .....

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

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