

Liverpool Health and Academic Precinct

Redevelopment of Multi-Storey Carpark (SSD: 10388)

Project ID	20181547.2
Document Title	Redevelopment of Multi-Storey Carpark (SSD:
Attention To	Health Infrastructure

Revision	Date	Document Reference	Prepared By	Checked By	Approved By
0	5/11/2019	20181547.2/0511A/R0/SN	SN		GW
1	5/03/2020	20181547.2/0503A/R1/SN	SN		GW
2	6/03/2020	20181547.2/0603A/R2/SN	SN		GW
3	9/03/2020	20181547.2/0903A/R3/SN	SN		GW
4	25/03/2020	20181547.2/2503A/R4/SN	SN		GW
5	22/04/2020	20181547.2/2204A/R5/SN	SN		GW
6	7/05/2020	20181547.2/0705A/R6/SN	SN		GW

TABLE OF CONTENTS

1	EXECUTIVE SUMMARY.....	6
2	INTRODUCTION	8
3	SITE DESCRIPTION	8
4	EXISTING BACKGROUND NOISE SURVEY	10
4.1	BACKGROUND NOISE LEVELS	10
4.1.1	Equipment Used.....	10
4.1.2	Measurement Period/Locations.....	10
4.1.3	Measured Rating Background Noise Levels.....	14
5	CAR PARK OPERATIONAL NOISE EMISSION ASSESSMENT	19
5.1	LIVERPOOL DEVELOPMENT CONTROL PLAN 2008.....	19
5.2	NSW ENVIRONMENTAL PROTECTION AUTHORITY 'NOISE POLICY FOR INDUSTRY' 2017	19
5.2.1	Intrusiveness Criterion.....	19
5.2.2	Project Amenity Criterion	20
5.2.3	Sleep Arousal Criteria.....	21
5.3	NSW ROAD NOISE POLICY.....	21
5.4	SUMMARY OF OPERATIONAL NOISE EMISSION CRITERIA.....	22
6	CARPARK OPERATIONAL NOISE EMISSION ASSESSMENT	23
6.1	CAR PARK NOISE – AVERAGE/L_{EQ} NOISE EMISSIONS.....	23
6.1.1	Multi-storey Carpark – 7:00am to 10:00pm Period	23
6.2	MULTI-STOREY CAR PARK - SLEEP DISTURBANCE (INTERMITTENT) NOISE ASSESSMENT.....	24
6.3	MECHANICAL PLANT AND EQUIPMENT	25
6.3.1	Fans and Other General Plant Items.....	25
6.3.2	Supply / Exhaust Fans	25
6.3.3	Minor Plant Items	25
6.3.4	Major Plant Items	25
7	CONSTRUCTION NOISE AND VIBRATION IMPACTS.....	26
7.1	SENSITIVE RECEIVERS.....	26
7.2	NOISE MANAGEMENT LEVEL.....	26
7.2.1	Liverpool Development Control Plan 2008.....	26
7.2.2	NSW EPA Interim Construction Noise Guideline.....	28
7.2.3	Australian Standard AS2107:2016.....	30
7.2.4	Australian Standard AS2436:2010 "Guide to noise control on construction, maintenance and demolition sites"	31
7.2.5	Summarised Noise Management Levels.....	32
7.3	CONSTRUCTION VIBRATION CRITERIA.....	33
7.3.1	DIN 4150	33
7.3.2	Assessing Amenity	34
7.3.3	Hospital Specific Vibration Limits.....	35
7.3.4	Summarised Recommended Vibration Limits	37
8	PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (STANDARD CONSTRUCTION HOURS)	38
8.1	PROPOSED SCOPE OF WORK DURING STANDARD CONSTRUCTION HOURS.....	38
8.2	PROPOSED STANDARD CONSTRUCTION HOURS OF WORK.....	38
8.3	ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES.....	38

8.4	PRELIMINARY NOISE ASSESSMENT DURING STANDARD CONSTRUCTION HOURS	39
8.4.1	Methodology.....	39
8.4.2	Predicted Noise Levels.....	39
8.5	AMELIORATIVE MEASURES	46
8.5.1	Site Specific Recommendations.....	46
8.6	GENERAL RECOMMENDATIONS	46
8.6.1	Acoustic Barrier	46
8.6.2	Silencing Devices	46
8.6.3	Material Handling.....	46
8.6.4	Treatment of Specific Equipment.....	46
8.6.5	Establishment of Site Practices.....	46
9	PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (STANDARD CONSTRUCTION HOURS)	47
9.1	VIBRATION PRODUCING ACTIVITIES	47
9.2	SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES	47
9.3	VIBRATION MONITORING (IF REQUIRED)	47
9.3.1	Downloading of Vibration Monitor Data.....	47
9.3.2	Presentation of Vibration Monitor Results	47
10	PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS)	48
10.1	OUTSIDE STANDARD CONSTRUCTION HOURS CONSTRUCTION WORK JUSTIFICATION	48
10.2	PROPOSED SCOPE OF WORK OUTSIDE STANDARD CONSTRUCTION HOURS ...	49
10.3	PROPOSED OUTSIDE STANDARD CONSTRUCTION HOURS OF WORK.....	49
10.4	ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES	49
10.5	PRELIMINARY NOISE ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS) 50	
10.5.1	Methodology.....	50
10.5.2	Predicted Noise Levels.....	50
10.6	AMELIORATIVE MEASURES.....	57
10.6.1	Site Specific Recommendations.....	57
10.7	GENERAL RECOMMENDATIONS.....	57
10.7.1	Acoustic Barrier	57
10.7.2	Silencing Devices	57
10.7.3	Material Handling.....	57
10.7.4	Treatment of Specific Equipment.....	57
10.7.5	Establishment of Site Practices.....	57
11	PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS)	58
11.1	VIBRATION PRODUCING ACTIVITIES.....	58
11.2	SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES	58
11.3	VIBRATION MONITORING (IF REQUIRED)	58
11.3.1	Downloading of Vibration Monitor Data.....	58
11.3.2	Presentation of Vibration Monitor Results	58
12	PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS).....	59
12.1	SPECIAL CONSTRUCTION HOURS JUSTIFICATION	59
12.2	PROPOSED SCOPE OF WORK DURING SPECIAL CONSTRUCTION HOURS	60
12.3	PROPOSED SPECIAL CONSTRUCTION HOURS OF WORK.....	60

12.4	ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES	61
12.5	PRELIMINARY NOISE ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS).....	62
12.5.1	Methodology.....	62
12.5.2	Predicted Noise Levels.....	62
12.6	AMELIORATIVE MEASURES.....	73
12.6.1	Site Specific Recommendations.....	73
12.7	GENERAL RECOMMENDATIONS.....	73
12.7.1	Acoustic Barrier	73
12.7.2	Silencing Devices	73
12.7.3	Material Handling.....	73
12.7.4	Treatment of Specific Equipment.....	73
12.7.5	Establishment of Site Practices.....	73
13	PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS).....	74
13.1	VIBRATION PRODUCING ACTIVITIES.....	74
13.2	SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES	74
13.3	VIBRATION MONITORING (IF REQUIRED)	74
13.3.1	Downloading of Vibration Monitor Data.....	74
13.3.2	Presentation of Vibration Monitor Results	74
14	CONCLUSION.....	75
	APPENDIX 1 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 1).76	
	APPENDIX 2 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 2).90	
	APPENDIX 3 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 3).99	

1 EXECUTIVE SUMMARY

Acoustic Logic Consultancy (ALC) has been engaged to prepare an acoustic assessment report to support the redevelopment of the multi-storey carpark located at Liverpool Hospital, Liverpool.

The redevelopment of the multi-storey carpark located in the north-eastern corner of the campus is proposed to include an on-grade and a six-storey carpark providing 1,097 car parking spaces, 42 motorcycle spaces, a management office and accessible restroom.

This report will include acoustic assessment of the potential noise and vibration impacts during the redevelopment and construction of the multi-storey carpark, the proposed operation of the multi-storey carpark such as vehicle movements and associated mechanical plant and equipment which will be servicing the carpark once under operation.

The proposed redevelopment of the multi-storey carpark will be assessed based on the requirements below:

- Requirements of *SEARs* document, '*SSD: 10388*';
- Liverpool Health and Academic Precinct '*Schematic Design Transport Assessment*' prepared by GTA Consultants (Ref: N170560);
- Liverpool Development Control Plan 2008;
- NSW Environmental Protection Authority, '*Interim Construction Noise Guideline*';
- Australian Standard AS2107:2016;
- Australian Standards AS2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- NSW Environmental Protection Authority, '*Assessing Vibration: A technical Guideline*';
- DIN 4150, '*Vibration in Buildings (1999-02)*';
- ASHRAE Handbook 2007;
- NSW Environmental Protection Authority, '*Noise Policy for Industry*' 2017; and
- NSW Road Noise Policy.

Table 1 – Secretary’s Environmental Assessment Requirements

Key Issue	Requirement	Relevant Report Section
Noise and Vibration	Identify and provide a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation, construction. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.	Section 8.1 – 9.3.2
	Identify and provide a quantitative assessment of the potential noise and vibration impacts on the identified sensitive receivers due to the operations of the carpark.	Section 6.1 – 6.3
	Identify proposed construction hours and provide details of the instances where it is expected that works will be required to be carried out outside the standard construction hours.	Section 8.2 & 10.2
	Justify work hours outside of standard Interim Construction Noise Guidelines Policy.	Section 10.1 & 12.1

2 INTRODUCTION

This report presents our assessment for the redevelopment of the multi-storey carpark located at Liverpool Hospital, Liverpool. The assessment is based on the Schematic Design Plans provided to this office.

See Table 2 below for the architectural drawing information provided by Fitzpatrick + partners.

Table 2 – Architectural Concept Drawing List

Architect	Drawing Title	Date
Fitzpatrick + partners	Ground Level 01	13/09/2019
	Ground Level 02	
	Level 1	
	Level 2	
	Level 3	
	Level 4	
	Level 5	
	Level 6	
	Section A & B	
	Elevation N & E	
	Elevation S & W	
	Façade Details	

3 SITE DESCRIPTION

The land uses surrounding the multi-storey carpark are the existing hospital, commercial, residential and educational receivers. Site investigation has been carried out and the nearest potentially most affected receivers are:

- **Receiver 1:** Liverpool Hospital Development to the South.
- **Receiver 2:** Tafe NSW Liverpool located at 14 College Street to the South. Educational receiver is double storey.
- **Receiver 3:** Liverpool Girls High School located at 96 Forbes Street to the North. Educational receiver is double storey.
- **Receiver 4:** Health Services Building and Ingham Institute located at 1 Campbell Street to the North. Receivers are multi-storey.
- **Receiver 5:** Residential receiver located at 41 Forbes Street to the North-West. Residential receiver is multi-storey.
- **Receiver 6:** South Western Sydney Local Health District to the South-East, Across the T2, T3 and T5 Rail Corridor.

See Figure 1 below for a site survey and noise monitoring and measurement locations.

Multi-Story Car Park and On Grade Car Park Redevelopment Project Site

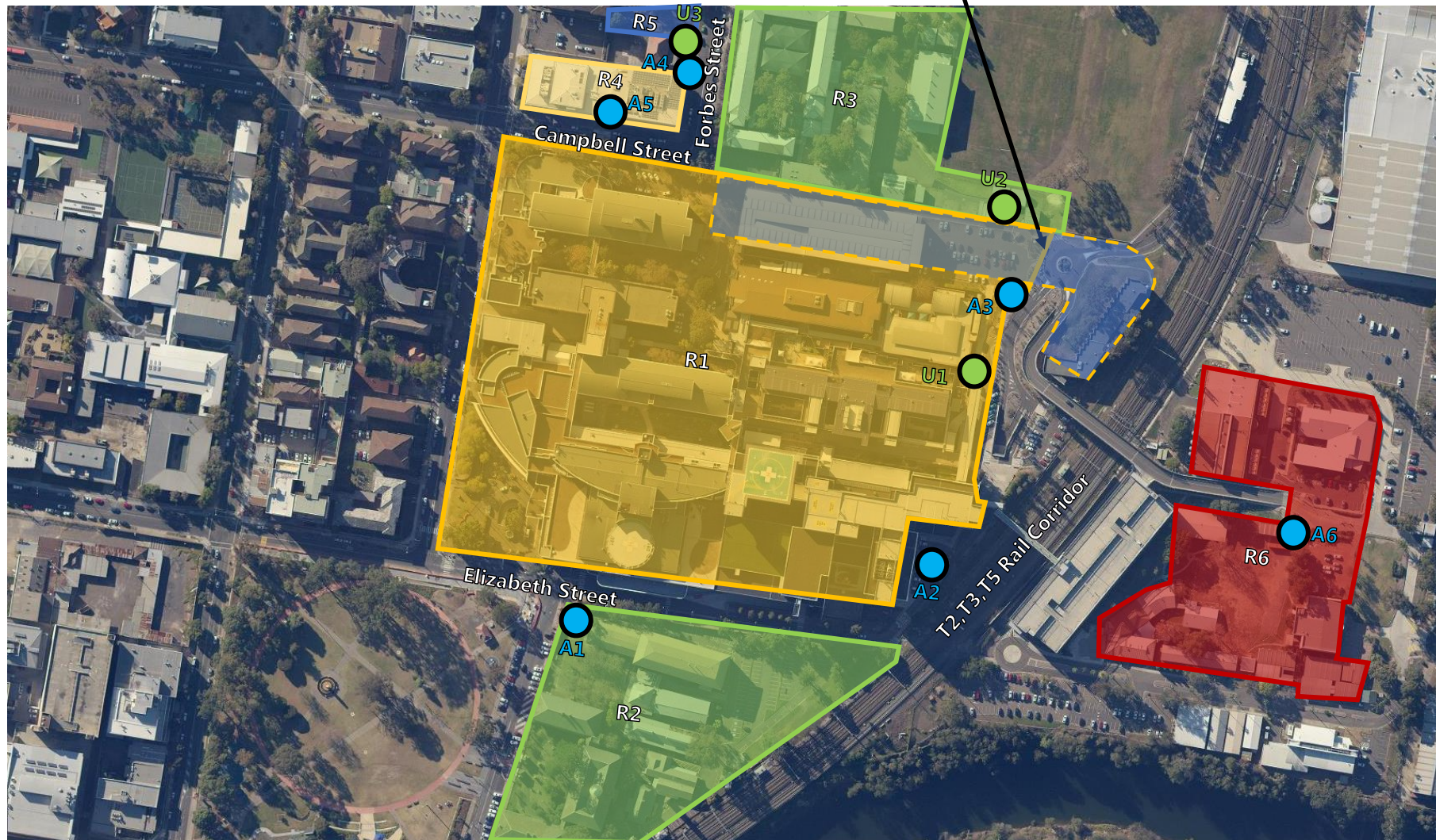


Figure 1: Aerial Map and Noise Monitor Locations

- Attended Noise Measurement
- Unattended Noise Monitor

- Commercial Receiver
- Health Services Building/Ingham Institute
- Residential Receiver
- Educational Receiver
- Health/Medical Receiver

4 EXISTING BACKGROUND NOISE SURVEY

4.1 BACKGROUND NOISE LEVELS

Background noise measurements around the project site have been ascertained through the means of attended noise measurements and unattended noise monitoring.

4.1.1 Equipment Used

Attended Noise Measurements: Attended background noise measurements were conducted using a Norsonic 140 Sound Analyser. The analyser was set to fast response and calibrated before and after the measurements using a Norsonic Sound Calibrator type 1251. No significant drift was noted.

Unattended Noise Monitoring: Background noise was recorded using three Acoustic Research Laboratories Pty Ltd noise loggers. The loggers were programmed to store 15-minute statistical noise levels throughout the unattended monitoring period. The equipment was calibrated at the beginning and the end of the measurement using a Rion NC-73 calibrator; no significant drift was detected. All measurements were taken on A-weighted fast response mode.

4.1.2 Measurement Period/Locations

Attended Noise Measurements: Attended background noise measurements were conducted at all sensitive receiving locations around the project site on Thursday, 28th June 2019 between 11:00am and 4:00pm. See Figure 1 for detailed attended noise measurement locations.

Unattended Noise Monitoring:

Except of Fact Sheet A of the NSW Noise Policy for Industry states:

Monitoring location	Reasonably most- or potentially most-affected residence(s). ³	Reasonably most- or potentially most-affected residence(s) ³ and/or location of complaint. ³
---------------------	--	--

Site investigation indicates that the most-potentially affected noise receiver is a future residential apartment building to be located at 41 Forbes Street. The receiver site was open vacant land, however; it was not secure to setup noise monitoring equipment at this premise. However, the monitor was set up at the boundary of 43 and 41 Forbes Street. In addition, short term attended noise measurements were carried out along 41 Forbes Street and the difference of simultaneous noise measurement results at the monitor location and 41 Forbes Street have been adopted to correct the RBL for the potential receiver. Details refer to Figure 4 below.

U1: Noise monitoring was conducted between Thursday, 28th June 2019 and Tuesday 9th July 2019. The noise monitor was setup along the façade of the Brain Injury Unit facing the rail corridor. See Figure 1 for a detailed noise monitoring location and Figure 2 below for a photo of the installed noise monitor.



Figure 2 – Photo of Unattended Noise Monitoring Location U1 (Within Liverpool Hospital)

U2: Noise monitoring was conducted between Tuesday, 9th July 2019 and Tuesday, 16th July 2019. The noise monitor was setup along the southern boundary of the Liverpool Girls High School. See Figure 1 for a detailed noise monitoring location and Figure 3 below for a photo of the installed noise monitor.

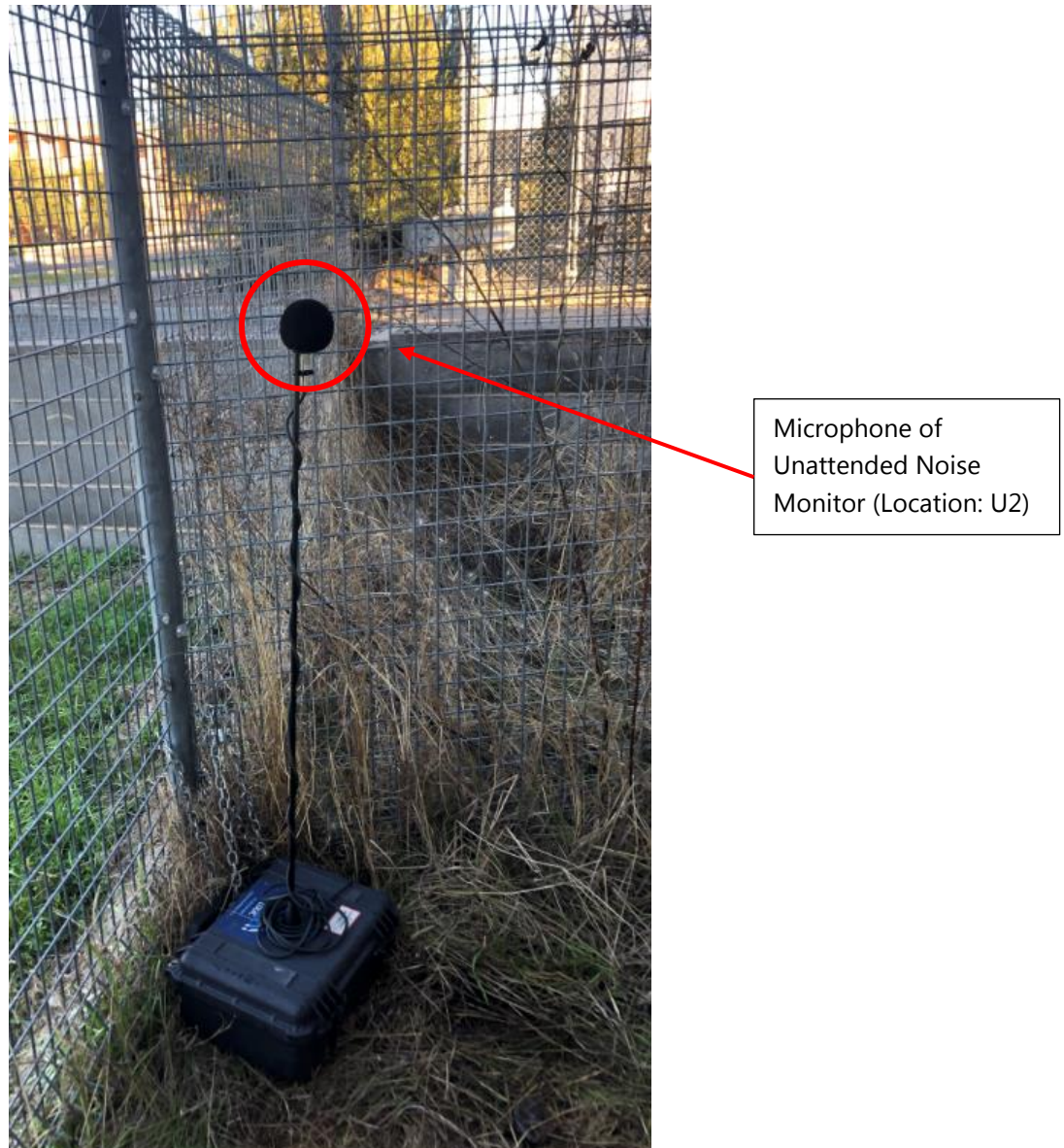


Figure 3 – Photo of Unattended Noise Monitoring Location U2 (Within Liverpool Girls High School)

U3: Noise monitoring was conducted between Tuesday, 9th July 2019 and Tuesday, 16th July 2019. The noise monitor was setup along the northern boundary of 43 Forbes Street, Liverpool. See Figure 1 for a detailed noise monitoring location and Figure 4 below for a photo of the installed noise monitor.



Figure 4 – Photo of Unattended Noise Monitoring Location U3 (On northern boundary of 43 Forbes Street)

4.1.3 Measured Rating Background Noise Levels

The NPfI states:

Monitoring should not be conducted (or monitoring data are to be excluded) when average wind speeds are greater than 5 metres per second at microphone height, or during rain. 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(A) below the background noise levels under investigation.

And;

Re-monitoring may not be required, where monitoring contains weather affected data, if it can be ascertained that the affected samples are not within the expected 'quieter' times of an assessment period (day/evening/night); that is, those time periods where the lowest 10th percentile background noise level might occur. In this case it should be fully justified in the noise-assessment report that the weather-affected data would not affect the lowest 10th percentile background noise level. This could be done through the clear identification of set daily noise patterns of 'quiet' periods exhibited by the measured data from the non-affected days. There should be enough non-affected data available for the assessor to be confident that any pattern identified is valid. For these cases the affected samples need **not** be removed from the data set before the 10th percentile is determined in Step 2.

In respect of the above it is noted that:

- The weather data used was obtained from the Bankstown Airport Weather Station. While the weather station data provides the most accurate indicator of likely wind effects, it cannot predict the actual wind speed at the noise measurement site. Given that the logging locations are likely to be more screened from wind, the wind speed at the noise measurement site is likely to be less than at the weather station used.
- However, the noise data of dB(A)_{L_{min}} has been adopted for periods affected by adverse weather conditions to provide a conservative acoustic assessment.

The results of the attended and unattended background noise measurements are presented in the tables below:

Attended Noise Measurement Results

Table 3 – Attended Noise Measurements

Location	Time	Measured Background Noise Level dB(A) _{L₉₀}
A1 – Corner of Elizabeth Street and College Street Receivers	Thursday, 28 th June 2019 11:00am – 4:00pm	56
A2 – Western Boundary, Liverpool Hospital		49
A3 – Brain Injury Unit, Liverpool Hospital		47
A4 – 41 Forbes Street Receivers		50
A5 – Campbell Street Receivers		55
A6 - South Western Sydney Local Health District		53

Unattended Noise Monitoring Results

Table 4 – Rating Background Noise Levels – Unattended Noise Monitoring Location #1

Noise Monitoring Location	Date	Day ABL (7am-6pm)	Evening ABL (6pm-10pm)	Night ABL (10pm-7am)
U1: Unattended Noise Monitoring (See Figure 1)	Thursday, 27 th June 2019	-	46	43
	Friday, 28 th June 2019	47	48	43
	Saturday, 29 th June 2019	46	47	42
	Sunday, 30 th June 2019	43	44	42
	Monday, 1 st July 2019	46	45	44
	Tuesday, 2 nd July 2019	46	47	44
	Wednesday, 3 rd July 2019		45	44
	Thursday, 4 th July 2019		46	
	Friday, 5 th July 2019	48	47	43
	Saturday, 6 th July 2019	45	44	42
	Sunday, 7 th July 2019	44	45	42
	Monday, 8 th July 2019	46	45	43
	Tuesday, 9 th July 2019	-	-	-
	RBL	46	46	43

Note: Items marked "-" above did not record data through the entire period due to the monitor being installed prior during or after the period and therefore have been excluded.

Table 5 – Rating Background Noise Levels – Unattended Noise Monitoring Location #2

Noise Monitoring Location	Date	Day ABL* (7am-6pm)	Evening ABL (6pm-10pm)	Night ABL* (10pm-7am)
U2: Unattended Noise Monitoring (See Figure 1)	Tuesday, 9 th July 2019	-	46	44
	Wednesday, 10 th July 2019	45	47	42*
	Thursday, 11 th July 2019	42*	46	43
	Friday, 12 th July 2019	44*	45*	42*
	Saturday, 13 th July 2019	42*	43	40*
	Sunday, 14 th July 2019	40*	44	41*
	Monday, 15 th July 2019	42*	45	43
	Tuesday, 16 th July 2019	-	-	-
	RBL	42	42	42

*Note: dB(A)Lmin has been adopted to exclude weather affected data during monitoring periods.

Items marked "-" above did not record data through the entire period due to the monitor being installed prior during or after the period and therefore have been excluded.

Table 6 – Rating Background Noise Levels – Unattended Noise Monitoring Location #3

Noise Monitoring Location	Date	Day ABL (7am-6pm)	Evening ABL (6pm-10pm)	Night ABL (10pm-7am)
U3: Unattended Noise Monitoring (See Figure 1)	Tuesday, 9 th July 2019	-	43	41
	Wednesday, 10 th July 2019	45	44	38*
	Thursday, 11 th July 2019	41*	44	40
	Friday, 12 th July 2019	43*	40*	38*
	Saturday, 13 th July 2019	40*	42	39*
	Sunday, 14 th July 2019	40*	42	39*
	Monday, 15 th July 2019	42*	42	41
	Tuesday, 16 th July 2019	-	-	-
	RBL	42	42	39

*Note: dB(A)Lmin has been adopted to exclude weather affected data during monitoring periods.

Items marked “-” above did not record data through the entire period due to the monitor being installed prior during or after the period and therefore have been excluded.

Table 7 – Summarised Unattended Rating Background Noise Levels

Location	Time	Measured Background Noise Level dB(A)L₉₀
U1 - Liverpool Hospital Brain Injury Unit (Facing T2, T3 & T5 Rail Corridor) (See Figure 1)	Day (7am-6pm)	46
	Evening (6pm-10pm)	46
	Night (10pm-7am)	43
U2 - Liverpool Girls High School (See Figure 1)	Day (7am-6pm)	42
	Evening (6pm-10pm)	42
	Night (10pm-7am)	42
U3 - 43 Forbes Street, Liverpool (See Figure 1)	Day (7am-6pm)	42
	Evening (6pm-10pm)	42
	Night (10pm-7am)	39

Note: The lowest RBL of each time period will be adopted to setup noise emission criteria to provide conservative noise emission assessment.

5 CAR PARK OPERATIONAL NOISE EMISSION ASSESSMENT

Establishment of criteria for noise emissions from the operation of the multi-storey carpark will be accordance with the following documents:

- Liverpool Development Control Plan 2008;
- NSW Environmental Protection Authority 'Noise Policy for Industry' 2017; and
- NSW Road Noise Policy.

5.1 LIVERPOOL DEVELOPMENT CONTROL PLAN 2008

The Liverpool Development Control Plan 2008 document does not contain any explicit noise criteria for noise emissions. Therefore; the NSW EPA Noise Policy for Industry and NSW Road Noise Policy criteria will be adopted.

5.2 NSW ENVIRONMENTAL PROTECTION AUTHORITY 'NOISE POLICY FOR INDUSTRY' 2017

The NPfI 2017 provides guidelines for assessing noise impacts from industrial developments. The recommended assessment objectives vary depending on the potentially affected receivers, the time of day, and the type of noise source. The NPfI has two requirements which both have to be complied with, namely project amenity criterion and an intrusiveness criterion.

5.2.1 Intrusiveness Criterion

The guideline is intended to limit the audibility of noise emissions at residential receivers and requires that noise emissions measured using the L_{eq} descriptor not exceed the background noise level by more than 5 dB(A).

Intrusive criteria based on the minimum RBL recommended by EPA for project site are detailed in table below.

Table 8 – NPfI Intrusiveness Criteria (Mechanical Plant)

Time of day	Background Noise Level dB(A)L_{90}	Intrusiveness Criteria (Background + 5dB(A)) dB(A)L_{eq}
Day (7am-6pm)	42	47
Evening (6pm-10pm)	42	47
Night (10pm-7am)	39	44

5.2.2 Project Amenity Criterion

The guideline is intended to limit the absolute noise level from all noise sources to a level that is consistent with the general environment.

The NPfI requires Project Amenity Noise Levels to be calculated below:

$$L_{Aeq, 15 \text{ min}} = \text{Recommended Amenity Noise Level} - 5 \text{ dB(A)} + 3 \text{ dB(A)}$$

Pursuant to the NPfI, the residential receivers in the vicinity would be considered suburban. Corresponding Project Amenity Criteria noise emission goals are presented below.

Table 9 –NPfI Project Amenity Criteria (Mechanical Plant)

Type of Receiver	Time of day	Recommended Amenity Noise Level dB(A)L_{eq}	Project Amenity Noise Level dB(A)$L_{eq, 15 \text{ min}}$
Residential (Suburban)	Day (7am-6pm)	55	53
	Evening (6pm-10pm)	45	43
	Night (10pm-7am)	40	38
Commercial	When in use	63	
School Classroom (Internal)	Noisiest 1-hour period when in use	35	
Hospital Ward	Noisiest 1-hour (Internal)	35	
	Noisiest 1-hour (External)	50	

5.2.3 Sleep Arousal Criteria

Section 2.5 of NPfI 2017 recommended the following noise limit to mitigate sleeping disturbance:

Where the subject development/ premises night -time noise levels at a residential location exceed:

- $L_{Aeq, 15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater.

A detailed maximum noise level even assessment should be undertaken.

Table 10 - Sleep Arousal Emergence Criteria (Night)

Location	Rating Background Noise Level (Night) - dB(A) L_{90}	Emergence Level
All Potentially Affected Residential Properties	39	44 dB(A) $L_{eq, 15min}$; 54 dB(A) $L_{max, F}$

5.3 NSW ROAD NOISE POLICY

The NSW 'Road Noise Policy' Tables 3 and 4 set out the assessment criteria for surrounding receivers to be applied to particular types of project, road category and land use. For existing land uses that are sensitive to noise (e.g. hospitals and schools) more stringent standards are expected.

Given the nearest sensitive receivers surrounding the Multi Storey Car Park project site, the following noise emission criteria from vehicle movements utilizing the multi storey carpark are applicable:

Table 11 – Carpark Operational Noise Emission Criteria

Existing Receiver	Assessment Criteria dB(A) Day (7am – 10pm)	Assessment Criteria dB(A) Night (10pm – 7am)
Hospital Wards (internal)	35dB(A) L_{eq} (1 hour)	35dB(A) L_{eq} (1 hour)
School Classrooms (internal)	40dB(A) L_{eq} (1 hour)	-
Open Space (Passive Use)	55dB(A) L_{eq} (15 hour)	-
Residential (Local Roads)	55dB(A) L_{eq} (1 hour)	50dB(A) L_{eq} (1 hour)

5.4 SUMMARY OF OPERATIONAL NOISE EMISSION CRITERIA

The noise emission criteria have been summarised below.

Table 12 - Summarised Operational Noise Emission Criteria

Noise Source	Location	Time	Noise Objectives
Mechanical Plant & Equipment	Residential Boundaries around Project site	Day (7am-6pm)	47 dB(A) _{Leq, 15min}
		Evening (6pm-10pm)	43 dB(A) _{Leq, 15min}
		Night (10pm-7am)	38 dB(A) _{Leq, 15min} 54 dB(A) _{L_{max}, F}
	Commercial Boundaries	When in use	63 dB(A) _{Leq}
	School Classroom (Internal)	Noisiest 1-hour period when in use	35 dB(A) _{Leq, 15min}
	Hospital Ward (internal)	Noisiest 1-hour (Internal)	35 dB(A) _{Leq, 15min}
		Noisiest 1-hour (External)	50 dB(A) _{Leq, 15min}
Carpark Operational Noise	Hospital Wards (internal)	Day (7am-10pm)	35dB(A) _{Leq (1 hour)}
		Night (10pm-7am)	
	School Classrooms (internal)	Day When in use	40dB(A) _{Leq (1 hour)}
		Night (10pm-7am)	-
	Open Space (Passive Use)	Day (7am-10pm)	55dB(A) _{Leq (15 hour)}
		Night (10pm-7am)	-
	Residential (Local Roads)	Day (7am-10pm)	55dB(A) _{Leq (1 hour)}
		Night (10pm-7am)	50dB(A) _{Leq (1 hour)}

6 CARPARK OPERATIONAL NOISE EMISSION ASSESSMENT

The major noise sources generated by the operation of the multi-storey carpark are below:

- External noise emissions from vehicle movements within the on-grade and multi-storey carpark; and
- External noise emissions from the plant servicing the multi-story carpark.

6.1 CAR PARK NOISE – AVERAGE/ L_{eq} NOISE EMISSIONS

Noise emissions have been assessed to the nearest sensitive receiver being Liverpool Girls High School during the day time period. If noise emissions are compliant to this receiving location, they will be satisfactory to the surrounding receivers.

6.1.1 Multi-storey Carpark – 7:00am to 10:00pm Period

- Noise emissions to the nearest receivers surrounding the proposed on-grade and multi-storey carpark will be predicted based on the traffic generation increase detailed in the 'Schematic Design Transport Assessment' prepared by GTA Consultants (Ref: N170560) and the following assumptions:
- Cars are driving in the car park at approximately 5-10km/h.
- A worst (AM) peak hour period with a maximum of 591 Trips.
- The average sound power level per car when driving within the car park is 84dB(A) L_{eq} .

Predicted noise levels are as follows below:

Table 13 - Car Park Noise Emission Assessment

Receiver Location	Predicted Noise Level – dB(A)L_{eq}	Acoustic Criteria dB(A)L_{eq}	Complies
Receiver 3: Outdoor Play Area (External)	55dB(A) L_{eq}	55 dB(A) L_{eq} , (15 hour)	Yes
Receiver 3: Classroom (Internal)	35dB(A) L_{eq} *	40dB(A) L_{eq} (1 hour)	Yes

*It is assumed that the windows are closed.

6.2 MULTI-STOREY CAR PARK - SLEEP DISTURBANCE (INTERMITTENT) NOISE ASSESSMENT

Short duration noise events (door close/car start) are assessed with reference to EPA Sleep Disturbance Guidelines if used between 10:00pm and 7:00am.

The sleep disturbance assessment is conducted with reference to the guidelines set out in section 5.2.3.

The assessment is based on the following assumptions:

- Car door Slam/Car Start (night time peak noise event): 90dB(A)_{L_{Max}} sound power.
- Car engine noise: 84dB(A)_{L_{Max}} sound power.

As noted in section 5.2.3, sleep disturbance assessment is a two-step process:

Firstly, the peak noise events are assessed with reference to a "Background+15dB(A)" assessment. If this test is passed, the noise emissions should be considered satisfactory.

In the event that the first test cannot be complied with, an assessment is then made of the actual noise level inside the residence (assuming window open) and comparison made to the EPA guidance regarding peak noise events and probability of awakening.

The results of this assessment are presented below:

Table 14 –Sleep Arousal/_{L_{max}} Assessment
(Background + 15dB(A) test)

Receiver Location	Activity	Predicted External Noise Level	BG+15dB(A) Test (10pm-7am)	Complies
Receiver 5	Door close/car start	39dB(A) _{L_(Max)}	54dB(A) _{L_(Max)}	Yes
	Car Engine	33dB(A) _{L_(Max)}		Yes

6.3 MECHANICAL PLANT AND EQUIPMENT

Detailed acoustic assessment of the mechanical plant and equipment to service the Multi-Storey carpark is unable to be undertaken at this stage as the finalised mechanical design is not complete. The mechanical plant and equipment shall be designed to satisfy the noise emission requirements detailed in section 5.3 of this report.

Plant shall be acoustically treated to prevent noise emissions from adversely impacting the surrounding properties in conjunction with the criteria detailed in this report. This may include selecting the quietest plant practicable, or treating the plant with enclosures, barriers, duct lining and silencers, etc as required to comply with the sound level recommendations.

Experience with similar projects indicates that it would be possible to achieve the requirement with appropriate treatment of the plant. General requirements for a number of potential plant items on the site are expanded on below. A preliminary review of typical mechanical plant items has been provided below.

6.3.1 Fans and Other General Plant Items

All fans are capable of meeting the noise emission criteria, set out in section 5.3 of this report, with the implementation of lined duct work and bends.

6.3.2 Supply / Exhaust Fans

The project carpark is of natural ventilation, some locations may need additional supply/exhaust fans. Those fans can be located within plant rooms or boxed by FC sheeting with noise attenuators on both sides of the fans. Silencer requirements would be determined once fan selections have been completed.

6.3.3 Minor Plant Items

Other minor plant items, such as bathroom exhaust fans, may also be required. These items typically emit relatively low noise levels and may require minimal acoustic treatment of a standard nature, such as internally lining of ductwork.

6.3.4 Major Plant Items

It is at the construction design stage that consideration should be given to the placement of equipment including intake and discharge air locations. In addition to the location of the equipment acoustic treatments to the major plant items may include silencers, treatment to ducting, time control, operational limitations, vibration isolation and the like.

7 CONSTRUCTION NOISE AND VIBRATION IMPACTS

7.1 SENSITIVE RECEIVERS

The nearest sensitive receivers in the vicinity of the project site are as follows below:

- **Receiver 1:** Liverpool Hospital Development to the South.
- **Receiver 2:** Tafe NSW Liverpool located at 14 College Street to the South. Educational receiver is double storey.
- **Receiver 3:** Liverpool Girls High School located at 96 Forbes Street to the North. Educational receiver is double storey.
- **Receiver 4:** Health Services Building and Ingham Institute located at 1 Campbell Street to the North. Receivers are multi-storey.
- **Receiver 5:** Residential receiver located at 41 Forbes Street to the North-West. Residential receiver is multi-storey.
- **Receiver 6:** South Western Sydney Local Health District to the South-East, Across the T2, T3 and T5 Rail Corridor.

7.2 NOISE MANAGEMENT LEVEL

Establishment of criteria for construction noise requirements will be in accordance with the following documents.

- Liverpool Development Control Plan 2008;
- NSW Environmental Protection Authority, '*Interim Construction Noise Guideline*';
- Australian Standard AS2107:2016; and
- Australian Standards AS2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites.

7.2.1 Liverpool Development Control Plan 2008

Part 1 – General Controls for all development

14. Demolition of Existing Developments

Controls

Demolition

1. All demolition work must comply with the *Australian Standard AS2601 - 1991, The Demolition of Structures*.
2. Security fencing such as hoardings must be provided around the perimeter of the demolition site prior to work commencing to prevent access by unauthorised persons at all times during the demolition period. Approval of the fencing by Council must be received prior to erection.
3. Demolition must not be conducted in high winds to ensure dust does not spread beyond the site boundaries.
4. All lead contaminated materials identified in the building must be handled and disposed of in accordance with the *NSW Environment Protection Authority's* requirements.
5. Dust Controls must be implemented on site prior to and during demolition.

6. Asbestos, if identified in the building, must be removed and disposed of in accordance with the requirements of Work Cover.
7. All trucks/trailers entering or leaving the site must have their loads adequately covered. A sign indicating this should be placed at the entry to and exit from the site.
8. Temporary toilet facilities must be provided on the site until all demolition work is completed.
9. Demolition activities on site must be limited to the following hours:
 - Monday to Friday 7:00am to 6:00pm
 - Saturday 8:00am to 1:00pm
 - No work on Sunday and Public Holidays
10. Sound pressure levels emanating from the site must not exceed levels established by the *NSW Environment Protection Authority*.
11. A Waste Management Plan (WMP) is to be submitted with the Development Application. The WMP must include volume or area estimates and information about reuse, recycling and disposal options for all types of waste produced on-site, including excavation materials.
12. The waste management plan together with proof of lawful disposal for all waste that is disposed of, or otherwise recycled from the site must be retained on site. Proof is to include a log book with associated receipt/invoices, waste classification, and site validation certificate. All entries must include:
 - Time and Date
 - Description and size of waste
 - Waste facility used
 - Vehicle registration and company nameBoth the log book and the associated receipts must be made available for inspection by authorised Council Officer at any time during site works.
13. Where subdivision works are proposed, relevant sections of the WMP must be completed. If the destination for excavation material is not a licensed waste facility, it must have development consent to receive such material.
14. Where subdivision works are proposed, relevant sections of the WMP must be completed. If the destination for excavation material is not a licensed waste facility, it must have development consent to receive such material.
15. A Dilapidation Report for any demolition within the zone of influence of any other building.

7.2.2 NSW EPA Interim Construction Noise Guideline

Given the scale of the proposed works, the “quantitative” assessment procedure, as outlined in the Interim Construction Noise Guideline (ICNG) will be used (as opposed to the simpler “qualitative” assessment method outlined in the guidelines). The quantitative assessment method requires:

- Determination of noise generation management levels (based on background noise levels on site).
- Prediction of operational noise levels at nearby development.
- If necessary, recommendation of noise controls strategies in the event that compliance with noise emission management levels is not possible.

7.2.2.1 At Residential Receivers

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

Recommended Standard Hours

Monday to Friday (7am – 6pm) & Saturday (8am – 1pm)

- *“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 affected” level occurs when construction noise exceeds ambient levels by more than 10dB(A)_{Leq(15min)}.
- *“Highly noise affected level”.* Where noise emissions are such that nearby properties are “highly noise affected”, noise controls such as respite periods should be considered. For residential properties, the “highly noise affected” level occurs when construction noise exceeds 75dB(A)_{Leq(15min)} at nearby residences.

Outside Recommended Standard Hours

Saturday (1pm-3pm)

- *“Noise affected” level.* Where construction noise is predicted to exceed the “noise affected” level at a nearby residence, and all feasible and reasonable practices have been applied and the proponent should negotiate with the community. The noise affected level for works being undertaken outside of the “*Recommended Standard Hours*” period is more stringent where the “noise affected” level occurs when construction noise exceeds ambient levels by more than 5dB(A)_{Leq(15min)}.

Outside Recommended Standard Hours (Special Construction Hours)

Friday (6pm-10pm), Saturday (5pm-10pm), Sunday (8am-10pm)

- *“Noise affected” level.* Where construction noise is predicted to exceed the “noise affected” level at a nearby residence, and all feasible and reasonable practices have been applied and the proponent should negotiate with the community. The noise affected level for works being undertaken outside of the “*Recommended Standard Hours*” period is more stringent where the “noise affected” level occurs when construction noise exceeds ambient levels by more than 5dB(A)_{Leq(15min)}.

Table 15 – Construction Noise Management Levels to Residential Receivers

Location	Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}	"Highly Noise Affected" Level - dB(A)_{Leq(15min)}	Saturday: 1pm-3pm Outside Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}
Residential Receivers	BG 42 + 10 = 52	75	BG 42 + 5 = 47

In addition, the following special construction hours have been recommended for the construction of the MSCP on selected evenings and weekends so as to maintain operation of the existing hospital and in consideration of Council restricted hours of operation on Campbell street during weekdays.

Table 16 – Construction Noise Management Levels to Residential Receivers (Special Construction Hours)

Location	Friday: 6pm-10pm Outside Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}	Saturday: 5pm-10pm Outside Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}	Sunday: 8am-5pm Outside Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}	Sunday: 5pm-10pm Outside Recommended Standard Hours "Noise Affected" Level - dB(A)_{Leq(15min)}
Residential Receivers	BG 42 + 5 = 47	BG 42 + 5 = 47	BG 42 + 5 = 47	BG 42 + 5 = 47

7.2.2.2 To Educational Receivers

Table 3 of the ICGN outlines the following management noise levels to internal areas of classrooms at schools and other educational institutions:

Table 17 – Noise Management Level for Educational Buildings (ICGN)

Space	Internal Management Level dB(A)_{Leq (15 min)}
Within Classrooms at schools and other educational institutions	45

7.2.2.3 To Commercial Receivers

Section 4.1.3 "Commercial and industrial premises" of the ICGN outlines the following external management noise levels to the most-affected occupied point of the premises:

Table 18 – Noise Management Level for Commercial Premises (ICGN)

Space	Management Level dB(A)_{Leq (15 min)}
Facade of Offices, retail outlets	70

7.2.2.4 To Hospital Noise Receivers

Table 3 of the ICGN outlines the following management noise levels to internal areas of hospital buildings:

Table 19 – Noise Management Level for Hospital Buildings (ICGN)

Space	Internal Management Level dB(A) L_{eq} (15 min)
Within Hospital Wards and operating theatres	45

The ICGN does not have management noise levels for other areas of the nearby hospital receivers (offices, consulting rooms etc. as discussed in Section 2). Section 4.1.3 of the ICGN states:

“4.1.3 Commercial and industrial premises

... The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended ‘maximum’ internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).”

7.2.3 Australian Standard AS2107:2016

Excavation/Construction noise management levels for noise sensitive spaces in the nearby hospital buildings not covered in the ICGN will be based on the maximum recommended noise levels presented in section AS2107:2016. These are presented in the table below:

Table 20 – Noise Management Level for Hospital Buildings (Internal - AS2107:2016)

Space	Management Level dB(A) L_{eq} (15 min)
Consulting Rooms	45
Treatment Rooms	45
Office Areas	45
Operating Theatres	50
X-Ray Areas	50

7.2.4 Australian Standard AS2436:2010 “Guide to noise control on construction, maintenance and demolition sites”

Australian Standard AS2436 provides guidance on noise and vibration control in respect to construction and demolition sites, and the preparation of noise and vibration management plans, work method statements and impact studies. The Standard states that:

- “Some construction and demolition activities are by their very nature noisy. The authorities responsible for setting noise level criteria for essential works will take note of the constraints imposed by such activities, especially when they are of short duration.”
- Construction, demolition and maintenance works pose different problems of noise and vibration control when compared with most other types of industrial activity, since
 - (a) they are mainly carried on in the open;
 - (b) they are often temporary in nature although they may cause considerable disturbance whilst they last;
 - (c) the noise and vibration arise from many different activities and kinds of plant, and their intensity and character may vary greatly during different phases of the work; and
 - (d) the sites cannot be separated by planning control, from areas that are sensitive to noise and vibration.

The standard provides advice and guidelines for the prediction of impacts and the methods available to manage impacts. It guideline promulgates feasible and reasonable mitigation strategies and controls, and stakeholder liaison, in the effort to reach a realistic compromise between site activities and impacts on neighbouring properties.

Based on the above, the following procedure will be used to assess noise emissions:

- Predict noise levels produced by typical construction activities at the sensitive receivers.
- Develop a suitable noise criterion based on the NSW Environmental Protection Authority Interim Construction Noise Guideline.
- Adopt management conditions as per AS 2436 in the event of a non-compliance.

7.2.5 Summarised Noise Management Levels

The summarised noise management levels for the proposed demolition/excavation/construction activities are presented in the table below.

Table 21 – Summarised Noise Management Levels

Location	Management Level dB(A) _{Leq} (15 min)
Residential Receivers	<p><u>Recommended Standard Hours</u> "Noise Affected" Level - 52 "Highly Noise Affected" Level – 75 <u>Outside Recommended Standard Hours</u> "Noise Affected" Level – 47 <u>Outside Recommended Standard Hours</u> <u>(Special Construction Hours)</u> Friday: 6pm-10pm "Noise Affected" Level – 47 Saturday: 5pm-10pm "Noise Affected" Level – 47 Sunday: 8am-5pm "Noise Affected" Level – 47 Sunday: 5pm-10pm "Noise Affected" Level - 47</p>
Commercial Receivers	70
Educational Receivers	45 (Internal)
Bedroom Wards	
Consulting Rooms	
Treatment Rooms	
Office Areas	
Operating Theatres	
X-Ray Areas	50 (Internal)

7.3 CONSTRUCTION VIBRATION CRITERIA

Vibration criteria for the nearest receivers will be based on the following documents:

- DIN 4150, 'Vibration in Buildings (1999-02)';
- EPA "Assessing Vibration: A technical guideline"; and
- ASHRAE Handbook 2007.

7.3.1 DIN 4150

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 22 – 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

7.3.2 Assessing Amenity

Table 2.2 of EPA "Assessing Vibration: A technical guideline" specified the following vibration goal for human comfort:

Table 23 – Preferred and Maximum Weighted RMS Values for Vibration Acceleration (m/s^2) 1-80 Hz

Location	Assessment Period	Preferred Values Z-axis	Preferred Values X & Y-axis	Maximum Values Z-axis	Maximum Values X & Y-axis
Continuous Vibration					
Critical Areas	Day time	0.005	0.0036	0.010	0.0072
Residences	Day time	0.010	0.0071	0.020	0.014
Office	Day time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical Areas	Day time	0.005	0.0036	0.010	0.0072
Residence	Day time	0.3	0.21	0.6	0.42
Office	Day time	0.64	0.46	1.28	0.92

Acceptable values for intermittent vibration shall comply with the requirements in Table 2.4 of EPA "Assessing Vibration: A technical guideline" detailed as below.

Table 24 - Acceptable Vibration Dose Values for Intermittent Vibration ($\text{m/s}^{1.75}$)

Location	Day time preferred value	Day time maximum value
Critical Areas	0.10	0.20
Residences	0.20	0.40
Office	0.40	0.80

7.3.3 Hospital Specific Vibration Limits

This office has been advised that vibration sensitive equipment is located within the existing hospital.

No specific allowable vibration levels have been provided to this office. Given this, the appropriate vibration curve from the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Handbook based on the equipment type will be used.

The ASHRAE Handbook specifies vibration levels associated with potential disruption to the use of sensitive equipment within a building. The maximum vibration velocities [mm.s^{-1}] recommended from 1-100Hz is given in Figure 37 of the ASHRAE used in conjunction with recommended equipment requirements curves given in table 46. Figure 37 and table 46 from the 2007 ASHRAE document is presented below in Figure 6 and Table 25 respectively.

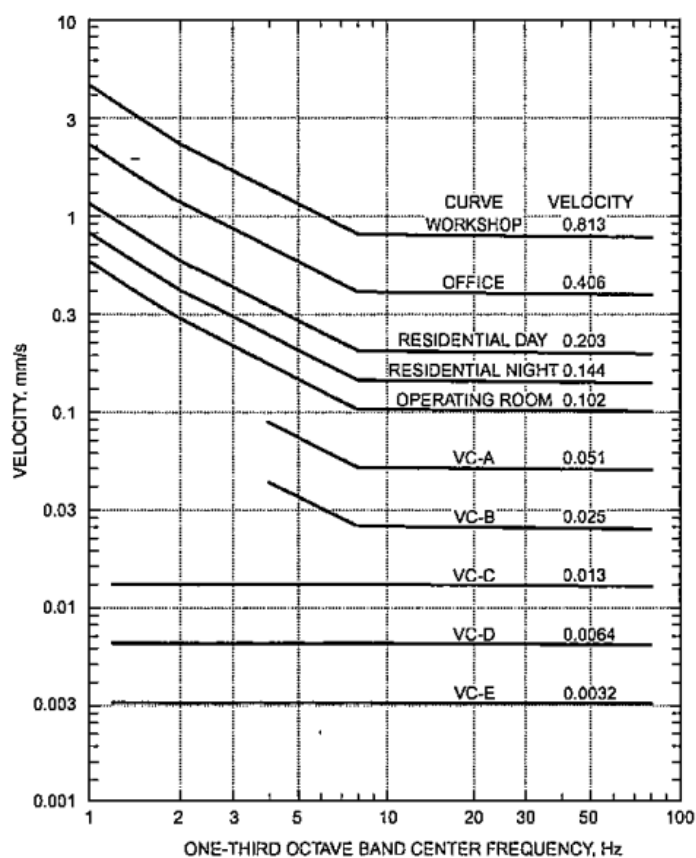


Fig. 37 Building Vibration Criteria for Vibration Measured on Building Structure

Figure 6 – Fig. 37 from 2007 ASHRAE Handbook: Vibration Criteria Curves

Table 25 – Tab. 46 from 2007 ASHRAE Handbook: Equipment Vibration Criteria

Equipment Requirements	Curve
Adequate for computer equipment, probe test equipment, and microscopes less than 40x magnification	0.203 (Residential – day)
Bench Microscopes up to 100x magnification; laboratory robots	0.102 (Operating Room)
Bench microscopes up to 400x magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 (VC – A)
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400x magnification; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3mm line widths	0.025 (VC – B)
Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1mm detail size	0.013 (VC – C)
Electron microscopes at magnification greater than 30,000x magnification; mass spectrometers; cell implant equipment; microelectronic manufacturing equipment such as, aligners, steppers and other critical equipment for photolithography with line widths of 1/2µm; includes electron beam systems	0.0064 (VC – D)
Un-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers and other critical equipment for photolithography with line widths of 1/4µm; includes electron beam systems	0.0032 (VC – E)

a. See Figure for corresponding vibration curve.

We note that that Table 46 of ASHRAE does not have any vibration criteria for X-Ray imaging machines. **Given this, vibration criteria for the X-ray imaging will be based on the “Operating Room” Curve of Figure 37 of the ASHRAE vibration criteria.**

All vibration monitoring results recorded on site are presented against the vibration curves listed above. The appropriate level of vibration will ultimately be determined by the staff operating the equipment and whether or not the level of distortion created by the excavation works is acceptable. We note that the VC curves are a representation of the level of disruption to the activities and/or operations undertaken by the machine and not the limit where damage would be expected to occur to the unit.

7.3.4 Summarised Recommended Vibration Limits

The summarised vibration criteria are presented in the table below.

Table 26 – Recommended Vibration Limit

Vibration Receiver	Recommended Vibration Limits PPV (mm/s)
Operating Theatres	VC – B Curve of Figure 37 of the ASHRAE vibration criteria
X-Ray Imaging Room	“Operating Theatre” Curve of Figure 37 of the ASHRAE vibration criteria
Residential Buildings	5
Commercial/Other Hospital Buildings	20

8 PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (STANDARD CONSTRUCTION HOURS)

8.1 PROPOSED SCOPE OF WORK DURING STANDARD CONSTRUCTION HOURS

The proposed scope of work to be undertaken during this stage is detailed as follows:

- Demolition of the existing multi-storey carpark structure;
- Bulk excavation of the foundation;
- Piling; and
- Construction of the new six-storey multi-storey carpark structure.

8.2 PROPOSED STANDARD CONSTRUCTION HOURS OF WORK

The above scope of work is proposed to be undertaken during the following standard construction hour periods:

Monday to Friday: 7:00am to 6:00pm;

Saturday: 8:00am to 1:00pm; and

Sunday/Public Holidays: No Works.

See Figure 1 for a detailed location where the construction works are to be undertaken and the nearest surrounding receivers to the project site.

8.3 ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES

Preliminary noise impacts will be determined from primary processes and equipment. The sound power levels of these activities/equipment are presented in the table below.

Table 27 – Sound Power Levels of the Proposed Equipment

EQUIPMENT / PROCESS	SOUND POWER LEVEL dB(A)
Handheld Jackhammer	120*
Excavator with Bucket	105
Excavator with Hydraulic Hammer	118
Semi-Trailer	105
Grader	114
Demolition Saw	113
Vibrating Roller	108
Excavator with Compacting Wheel Attachment	105
Bobcat with Broom Attachment	105
Slipform Paver	105
Plate Compactor	105
Bobcat	105
Concrete Pump	105
Cement Mixing Truck	105
Powered Hand Tools	95*
Electric Tower Crane	96
Mobile Crane	105
CFA Piling	103

*** Includes 5dB(A) addition for characteristics of noise source.**

The noise levels presented in the above table are derived from the following sources, namely:

- On site measurements;
- Table A1 of Australian Standard 2436-2010 & Table A1 of Australian Standard 2436-2010; and
- Data held by this office from other similar studies.

8.4 PRELIMINARY NOISE ASSESSMENT DURING STANDARD CONSTRUCTION HOURS

8.4.1 Methodology

Noise from the loudest typical construction activities have been predicted to the nearest most affected sensitive receivers. The predicted noise levels are presented in this section and are based on the areas on site in which the plant is likely to be used.

Where the position of the construction activity is variable, a range of predicted noise levels is presented to take into account the change in noise impact depending on where on the site the work is conducted.

Predictions take into account:

- The distance between the noise source and the receiver; and
- The screening effect provided by barriers or building structures (where relevant).

8.4.2 Predicted Noise Levels

Please see the tables below for predicted noise levels for each receiver.

Table 28 – Predicted Noise Generation to Receiver 1 – Remaining Liverpool Hospital Development

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (Internal Areas)
Handheld Jackhammer	<p><u>Bedroom Wards/ Consulting Rooms/Treatment Rooms/Office Areas/Operating Theatres</u> 45dB(A)</p> <p><u>X-Ray Areas</u> 50dB(A)</p>	21-65
Excavator with Bucket		6-50
Excavator with Hydraulic Hammer		21-65
Semi-Trailer		6-50
Grader		15-59
Demolition Saw		14-58
Vibrating Roller		9-53
Excavator with Compacting Wheel Attachment		6-50
Bobcat with Broom Attachment		6-50
Slipform Paver		6-50
Plate compactor		6-50
Bobcat		6-50
Concrete Pump		6-50
Cement Mixing Truck		6-50
Powered Hand Tools		0-40
Electric Tower Crane		0-31
Mobile Crane		6-40
CFA Piling		14-48

Table 29 – Predicted Noise Generation to Receiver 2 – Tafe NSW Liverpool

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	19-27
Excavator with Bucket		4-12
Excavator with Hydraulic Hammer		19-27
Semi-Trailer		4-12
Grader		13-21
Demolition Saw		12-20
Vibrating Roller		7-15
Excavator with Compacting Wheel Attachment		4-12
Bobcat with Broom Attachment		4-12
Slipform Paver		4-12
Plate compactor		4-12
Bobcat		4-12
Concrete Pump		4-12
Cement Mixing Truck		4-12
Powered Hand Tools		0-2
Electric Tower Crane		0-5
Mobile Crane		14-22
CFA Piling		12-20

Table 30 – Predicted Noise Generation to Receiver 3 – Liverpool Girls High School

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	32-59
Excavator with Bucket		17-44
Excavator with Hydraulic Hammer		32-59
Semi-Trailer		17-44
Grader		26-53
Demolition Saw		25-52
Vibrating Roller		20-47
Excavator with Compacting Wheel Attachment		17-44
Bobcat with Broom Attachment		17-44
Slipform Paver		17-44
Plate compactor		17-44
Bobcat		17-44
Concrete Pump		17-44
Cement Mixing Truck		17-44
Powered Hand Tools		7-34
Electric Tower Crane		8-35
Mobile Crane		17-44
CFA Piling		15-42

Table 31 – Predicted Noise Generation to Receiver 4 – Health Services Building/Ingham Institute

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (Internal Areas)
Handheld Jackhammer	<u>Consulting Rooms/Treatment Rooms/Office Areas</u> 45dB(A)	32-40
Excavator with Bucket		17-25
Excavator with Hydraulic Hammer		32-40
Semi-Trailer		17-25
Grader		26-34
Demolition Saw		25-33
Vibrating Roller		20-28
Excavator with Compacting Wheel Attachment		17-25
Bobcat with Broom Attachment		17-25
Slipform Paver		17-25
Plate compactor		17-25
Bobcat		17-25
Concrete Pump		17-25
Cement Mixing Truck		17-25
Powered Hand Tools		7-15
Electric Tower Crane		8-16
Mobile Crane		17-25
CFA Piling		15-23

Table 32 – Predicted Noise Generation to Receiver 5 – Residents at 41 Forbes Street

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (External Areas)
Handheld Jackhammer	Standard Construction Hours (Monday – Friday) <u>7:00am – 6:00pm</u> 52dB(A) (Saturday) <u>8:00am – 1:00pm</u> 52dB(A)	53-58
Excavator with Bucket		38-43
Excavator with Hydraulic Hammer		53-58
Semi-Trailer		38-43
Grader		47-52
Demolition Saw		46-51
Vibrating Roller		41-46
Excavator with Compacting Wheel Attachment		38-43
Bobcat with Broom Attachment		38-43
Slipform Paver		38-43
Plate compactor		38-43
Bobcat		38-43
Concrete Pump		38-43
Cement Mixing Truck		38-43
Powered Hand Tools		28-33
Electric Tower Crane		29-34
Mobile Crane		48-53
CFA Piling		46-51

Table 33 – Predicted Noise Generation to Receiver 6 – South Western Sydney Local Health District

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (External Areas)
Handheld Jackhammer	(Monday – Friday) <u>7:00am – 6:00pm</u> 70dB(A) (Saturday) <u>8:00am – 1:00pm</u> 70dB(A)	61-72
Excavator with Bucket		46-57
Excavator with Hydraulic Hammer		61-72
Semi-Trailer		46-57
Grader		55-66
Demolition Saw		54-65
Vibrating Roller		49-60
Excavator with Compacting Wheel Attachment		46-57
Bobcat with Broom Attachment		46-57
Slipform Paver		46-57
Plate compactor		46-57
Bobcat		46-57
Concrete Pump		46-57
Cement Mixing Truck		46-57
Powered Hand Tools		36-47
Electric Tower Crane		37-48
Mobile Crane		46-57
CFA Piling		44-55

8.5 AMELIORATIVE MEASURES

8.5.1 Site Specific Recommendations

Detailed site-specific recommendations to mitigate noise and vibration impacts on surrounding receivers are to be determined once construction methodology is finalised.

8.6 GENERAL RECOMMENDATIONS

General noise management practices which may be adopted are discussed below. In addition, notification, reporting and complaints handling procedures should be adopted as recommended in section in this report.

8.6.1 Acoustic Barrier

Barriers or screens can be an effective means of reducing noise. Barriers can be located either at the source or receiver.

The placement of barriers at the source is generally only effective for static plant. Equipment which is on the move or working in rough or undulating terrain cannot be effectively attenuated by placing barriers at the source.

Barriers can also be placed between the source and the receiver.

The degree of noise reduction provided by barriers is dependent on the amount by which line of sight can be blocked by the barrier. If the receiver is totally shielded from the noise source reductions of up to 15 dB(A) can be affected. Where only partial obstruction of line of sight occurs, noise reductions of 5 to 8 dB(A) may be achieved. Where no line of sight is obstructed by the barrier, generally no noise reduction will occur.

As barriers are used to provide shielding and do not act as an enclosure, the material they are constructed from should have a noise reduction performance which is approximately 10dB(A) greater than the maximum reduction provided by the barrier. In this case the use of a material such as 10 or 15mm plywood would be acceptable for the barriers.

8.6.2 Silencing Devices

Where construction process or appliances are noisy, the use of silencing devices may be possible. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

8.6.3 Material Handling

The installation of rubber matting over material handling areas can reduce the sound of impacts due to material being dropped by up to 20dB(A).

8.6.4 Treatment of Specific Equipment

In certain cases, it may be possible to specially treat a piece of equipment to reduce the sound levels emitted. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

8.6.5 Establishment of Site Practices

This involves the formulation of work practices to reduce noise generation. This includes locating fixed plant items as far as possible from residents as well as rotating plant and equipment to provide respite to receivers.

Construction vehicles accessing the site should not queue in residential streets and should only use the designated construction vehicle routes. Loading of these vehicles should occur as far as possible from any sensitive receiver.

9 PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (STANDARD CONSTRUCTION HOURS)

9.1 VIBRATION PRODUCING ACTIVITIES

Proposed activities that have the potential to produce significant ground vibration include:

- Demolition Work; and
- Excavation Work.

9.2 SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES

It is impossible to predict the vibrations induced by the demolition and excavation operations on site at potentially affected receivers. This is because vibration levels are principally proportional to the energy impact which is unknown, the nature of the terrain in the area (type of soil), drop weight, height etc.

Note: Sample testing of vibration impacts from the demolition and excavation works to the sensitive receiving spaces of the Liverpool Hospital is recommended prior to commencement of the multi-storey car park works.

9.3 VIBRATION MONITORING (IF REQUIRED)

In the event that complaints are made from neighbouring properties regarding vibration impacts from the subject site, vibration monitors will be installed at the property boundaries of the neighbouring properties nearest to the subject site to monitor vibration levels.

9.3.1 Downloading of Vibration Monitor Data

Downloading of the vibration monitor data will be conducted on a regular basis. In the event of exceedance of the vibration criteria, downloading of the vibration monitor data will be conducted more frequently. Results obtained from the vibration monitor will be presented in a graph format and will be forwarded to the client for review. It is proposed that reports are provided fortnightly with any exceedances in the vibration criteria reported as detailed in this report.

9.3.2 Presentation of Vibration Monitor Results

A fortnightly report will be submitted to the client via email summarising the vibration events. The vibration exceedance of criteria is recorded, and the report shall be submitted within 24 hours. Complete results of the continuous vibration logging will be presented in fortnight reports including graphs of the collected data.

10 PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS)

10.1 OUTSIDE STANDARD CONSTRUCTION HOURS CONSTRUCTION WORK JUSTIFICATION

The following commentary has been provided to this office from Johnstaff in regard to justification for construction works to be undertaken outside of the *"Recommended Standard Construction Hours"* detailed in the Interim Construction Noise Guideline (ICNG) document.

"The "recommended standard hours" for "normal construction", as proposed in the Interim Construction Noise Guideline (ICNG), are:

- *Monday to Friday 7:00am to 6:00pm;*
- *Saturday 8:00am to 1:00pm; and*
- *No work on Sundays and Public Holidays.*

Section 4.12 outlines the proposed general hours of work for construction and the special construction hours required on selected weekends. The reasons for the extended general construction hours on Saturday afternoons, plus the additional selected "weekend work" outside of the "recommended standard hours", are to ensure continuity of excellence in the provision of health services and patient care in accordance with the requirements of Liverpool Hospital. Currently Liverpool City Council impose restricted hours of operation on Campbell Street during weekdays to reduce impacts to the adjacent high schools and therefore the additional hours allow for health services and patient care to continue during weekday periods.

Having regard to the above, it is considered that the proposed hours of work are a "reasonable" variation or departure from the "recommended standard hours". The basis for this conclusion is to be found in:

- *the definition of "reasonable" in the ICNG having regard to the nature and purpose of the proposed development.*
- *the analysis of the source/type of construction work noise likely to be generated by the ISB.*
- *the proposed construction management and recommended mitigation measures."*

Given the above justification for construction works to be undertaken outside of the *"Recommended Standard Hours"* we note the following:

The *'Outside Standard Construction Hours'* period proposed for construction works to be undertaken is from 1:00pm to 3:00pm on Saturday. The Preliminary Construction Noise Assessment presented in Section 10.5 of this report, predicted construction noise levels to the nearest sensitive receiver (residential receiver located at 41 Forbes Street), is generally lower than the BG + 5 Noise Management Level of 47dB(A) and all predicted construction noise levels are lower than the *"Recommended Standard Hours, Highly Noise Affected Level"* of 75dB(A) which is applied during the Recommended Standard Hours period.

Given that the predicted construction noise levels to the nearest sensitive receiver are generally lower than the BG + 5 Noise Management Level of 47dB(A) and significantly lower than the Highly Noise Affected Level of 75dB(A) which would be applied during the recommended standard hours period, adverse noise impacts from construction works being undertaken during the 1:00pm to 3:00pm Saturday period on the nearest sensitive receivers would therefore be considered minimal.

10.2 PROPOSED SCOPE OF WORK OUTSIDE STANDARD CONSTRUCTION HOURS

The proposed scope of work to be undertaken during this stage is detailed as follows:

- Demolition of the existing multi-storey carpark structure;
- Bulk excavation of the foundation;
- Piling; and
- Construction of the new six-storey multi-storey carpark structure.

10.3 PROPOSED OUTSIDE STANDARD CONSTRUCTION HOURS OF WORK

The above scope of work is proposed to be undertaken during the following period:

Saturday: 1:00pm to 3:00pm.

See Figure 1 for a detailed location where the construction works are to be undertaken and the nearest surrounding receivers to the project site.

10.4 ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES

Preliminary noise impacts will be determined from primary processes and equipment. The sound power levels of these activities/equipment are presented in the table below.

Table 34 – Sound Power Levels of the Proposed Equipment

EQUIPMENT / PROCESS	SOUND POWER LEVEL dB(A)
Handheld Jackhammer	120*
Excavator with Bucket	105
Excavator with Hydraulic Hammer	118
Semi-Trailer	105
Grader	114
Demolition Saw	113
Vibrating Roller	108
Excavator with Compacting Wheel Attachment	105
Bobcat with Broom Attachment	105
Slipform Paver	105
Plate Compactor	105
Bobcat	105
Concrete Pump	105
Cement Mixing Truck	105
Powered Hand Tools	95*
Electric Tower Crane	96
Mobile Crane	105
CFA Piling	103

*** Includes 5dB(A) addition for characteristics of noise source.**

The noise levels presented in the above table are derived from the following sources, namely:

- On site measurements;
- Table A1 of Australian Standard 2436-2010 & Table A1 of Australian Standard 2436-2010; and
- Data held by this office from other similar studies.

10.5 PRELIMINARY NOISE ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS)

10.5.1 Methodology

Noise from the loudest typical construction activities have been predicted to the nearest most affected sensitive receivers. The predicted noise levels are presented in this section and are based on the areas on site in which the plant is likely to be used.

Where the position of the construction activity is variable, a range of predicted noise levels is presented to take into account the change in noise impact depending on where on the site the work is conducted.

Predictions take into account:

- The distance between the noise source and the receiver; and
- The screening effect provided by barriers or building structures (where relevant).

10.5.2 Predicted Noise Levels

Please see the tables below for predicted noise levels for each receiver.

Table 35 – Predicted Noise Generation to Receiver 1 – Remaining Liverpool Hospital Development

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (Internal Areas)
Handheld Jackhammer	<p><u>Bedroom Wards/ Consulting Rooms/Treatment Rooms/Office Areas/Operating Theatres</u> 45dB(A)</p> <p><u>X-Ray Areas</u> 50dB(A)</p>	21-65
Excavator with Bucket		6-50
Excavator with Hydraulic Hammer		21-65
Semi-Trailer		6-50
Grader		15-59
Demolition Saw		14-58
Vibrating Roller		9-53
Excavator with Compacting Wheel Attachment		6-50
Bobcat with Broom Attachment		6-50
Slipform Paver		6-50
Plate compactor		6-50
Bobcat		6-50
Concrete Pump		6-50
Cement Mixing Truck		6-50
Powered Hand Tools		0-40
Electric Tower Crane		0-31
Mobile Crane		6-40
CFA Piling		14-48

Table 36 – Predicted Noise Generation to Receiver 2 – Tafe NSW Liverpool

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	It is assumed that the receiver is not operational during the proposed extended construction hours
Excavator with Bucket		
Excavator with Hydraulic Hammer		
Semi-Trailer		
Grader		
Demolition Saw		
Vibrating Roller		
Excavator with Compacting Wheel Attachment		
Bobcat with Broom Attachment		
Slipform Paver		
Plate compactor		
Bobcat		
Concrete Pump		
Cement Mixing Truck		
Powered Hand Tools		
Electric Tower Crane		
Mobile Crane		
CFA Piling		

Table 37 – Predicted Noise Generation to Receiver 3 – Liverpool Girls High School

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	It is assumed that the receiver is not operational during the proposed extended construction hours
Excavator with Bucket		
Excavator with Hydraulic Hammer		
Semi-Trailer		
Grader		
Demolition Saw		
Vibrating Roller		
Excavator with Compacting Wheel Attachment		
Bobcat with Broom Attachment		
Slipform Paver		
Plate compactor		
Bobcat		
Concrete Pump		
Cement Mixing Truck		
Powered Hand Tools		
Electric Tower Crane		
Mobile Crane		
CFA Piling		

Table 38 – Predicted Noise Generation to Receiver 4 – Health Services Building/Ingham Institute

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) $L_{eq}(15min)$ (Internal Areas)
Handheld Jackhammer	<u>Consulting Rooms/Treatment Rooms/Office Areas</u> 45dB(A)	32-40
Excavator with Bucket		17-25
Excavator with Hydraulic Hammer		32-40
Semi-Trailer		17-25
Grader		26-34
Demolition Saw		25-33
Vibrating Roller		20-28
Excavator with Compacting Wheel Attachment		17-25
Bobcat with Broom Attachment		17-25
Slipform Paver		17-25
Plate compactor		17-25
Bobcat		17-25
Concrete Pump		17-25
Cement Mixing Truck		17-25
Powered Hand Tools		7-15
Electric Tower Crane		8-16
Mobile Crane		17-25
CFA Piling		15-23

Table 39 – Predicted Noise Generation to Receiver 5 – Residents at 41 Forbes Street

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Handheld Jackhammer	Outside Standard Construction Hours (Saturday) 1:00pm – 3:00pm 47dB(A)	53-58
Excavator with Bucket		38-43
Excavator with Hydraulic Hammer		53-58
Semi-Trailer		38-43
Grader		47-52
Demolition Saw		46-51
Vibrating Roller		41-46
Excavator with Compacting Wheel Attachment		38-43
Bobcat with Broom Attachment		38-43
Slipform Paver		38-43
Plate compactor		38-43
Bobcat		38-43
Concrete Pump		38-43
Cement Mixing Truck		38-43
Powered Hand Tools		28-33
Electric Tower Crane		29-34
Mobile Crane		48-53
CFA Piling		46-51

Table 40 – Predicted Noise Generation to Receiver 6 – South Western Sydney Local Health District

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Handheld Jackhammer	Outside Standard Construction Hours (Saturday) <u>1:00pm – 3:00pm</u> <u>70dB(A)</u>	61-72
Excavator with Bucket		46-57
Excavator with Hydraulic Hammer		61-72
Semi-Trailer		46-57
Grader		55-66
Demolition Saw		54-65
Vibrating Roller		49-60
Excavator with Compacting Wheel Attachment		46-57
Bobcat with Broom Attachment		46-57
Slipform Paver		46-57
Plate compactor		46-57
Bobcat		46-57
Concrete Pump		46-57
Cement Mixing Truck		46-57
Powered Hand Tools		36-47
Electric Tower Crane		37-48
Mobile Crane		46-57
CFA Piling		44-55

10.6 AMELIORATIVE MEASURES

10.6.1 Site Specific Recommendations

Detailed site-specific recommendations to mitigate noise and vibration impacts on surrounding receivers are to be determined once construction methodology is finalised.

10.7 GENERAL RECOMMENDATIONS

General noise management practices which may be adopted are discussed below. In addition, notification, reporting and complaints handling procedures should be adopted as recommended in section in this report.

10.7.1 Acoustic Barrier

Barriers or screens can be an effective means of reducing noise. Barriers can be located either at the source or receiver.

The placement of barriers at the source is generally only effective for static plant. Equipment which is on the move or working in rough or undulating terrain cannot be effectively attenuated by placing barriers at the source.

Barriers can also be placed between the source and the receiver.

The degree of noise reduction provided by barriers is dependent on the amount by which line of sight can be blocked by the barrier. If the receiver is totally shielded from the noise source reductions of up to 15 dB(A) can be affected. Where only partial obstruction of line of sight occurs, noise reductions of 5 to 8 dB(A) may be achieved. Where no line of sight is obstructed by the barrier, generally no noise reduction will occur.

As barriers are used to provide shielding and do not act as an enclosure, the material they are constructed from should have a noise reduction performance which is approximately 10dB(A) greater than the maximum reduction provided by the barrier. In this case the use of a material such as 10 or 15mm plywood would be acceptable for the barriers.

10.7.2 Silencing Devices

Where construction process or appliances are noisy, the use of silencing devices may be possible. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

10.7.3 Material Handling

The installation of rubber matting over material handling areas can reduce the sound of impacts due to material being dropped by up to 20dB(A).

10.7.4 Treatment of Specific Equipment

In certain cases, it may be possible to specially treat a piece of equipment to reduce the sound levels emitted. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

10.7.5 Establishment of Site Practices

This involves the formulation of work practices to reduce noise generation. This includes locating fixed plant items as far as possible from residents as well as rotating plant and equipment to provide respite to receivers.

Construction vehicles accessing the site should not queue in residential streets and should only use the designated construction vehicle routes. Loading of these vehicles should occur as far as possible from any sensitive receiver.

11 PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS)

11.1 VIBRATION PRODUCING ACTIVITIES

Proposed activities that have the potential to produce significant ground vibration include:

- Demolition Work; and
- Excavation Work.

11.2 SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES

It is impossible to predict the vibrations induced by the demolition and excavation operations on site at potentially affected receivers. This is because vibration levels are principally proportional to the energy impact which is unknown, the nature of the terrain in the area (type of soil), drop weight, height etc.

Note: Sample testing of vibration impacts from the demolition and excavation works to the sensitive receiving spaces of the Liverpool Hospital is recommended prior to commencement of the multi-storey car park works.

11.3 VIBRATION MONITORING (IF REQUIRED)

In the event that complaints are made from neighbouring properties regarding vibration impacts from the subject site, vibration monitors will be installed at the property boundaries of the neighbouring properties nearest to the subject site to monitor vibration levels.

11.3.1 Downloading of Vibration Monitor Data

Downloading of the vibration monitor data will be conducted on a regular basis. In the event of exceedance of the vibration criteria, downloading of the vibration monitor data will be conducted more frequently. Results obtained from the vibration monitor will be presented in a graph format and will be forwarded to the client for review. It is proposed that reports are provided fortnightly with any exceedances in the vibration criteria reported as detailed in this report.

11.3.2 Presentation of Vibration Monitor Results

A fortnightly report will be submitted to the client via email summarising the vibration events. The vibration exceedance of criteria is recorded, and the report shall be submitted within 24 hours. Complete results of the continuous vibration logging will be presented in fortnight reports including graphs of the collected data.

12 PRELIMINARY CONSTRUCTION NOISE EMISSION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS)

12.1 SPECIAL CONSTRUCTION HOURS JUSTIFICATION

The following commentary has been provided to this office from Johnstaff in regard to justification for construction works to be undertaken outside of the *"Recommended Standard Construction Hours"* detailed in the Interim Construction Noise Guideline (ICNG) document.

"Special construction hours will be required to for the construction of the MSCP on selected evenings and weekends so as to maintain operation of the existing hospital and in consideration of Council restricted hours of operation on Campbell street during weekdays."

Given the above justification for construction works to be undertaken outside of the *"Recommended Standard Hours"* we note the following:

The 'Outside Standard Construction Hours' period proposed for construction works to be undertaken is from Friday: 6:00 pm to 10:00 pm; Saturday: 5:00 pm to 10:00 pm and Sunday: 8:00 am to 10:00 pm.

The Preliminary Construction Noise Assessment presented in Section 12.5 of this report, predicted construction noise levels to the nearest sensitive receiver (residential receiver located at 41 Forbes Street), is generally lower than the BG + 5 Noise Management Level of 47dB(A) and all predicted construction noise levels are lower than the *"Recommended Standard Hours, Highly Noise Affected Level"* of 75dB(A) which is applied during the Recommended Standard Hours period.

Given that the predicted construction noise levels to the nearest sensitive receiver are generally lower than the BG + 5 Noise Management Level of 47dB(A) and significantly lower than the Highly Noise Affected Level of 75dB(A) which would be applied during the recommended standard hours period, adverse noise impacts from construction works being undertaken during the special construction hours period(s) on the nearest sensitive receivers would therefore be considered minimal.

12.2 PROPOSED SCOPE OF WORK DURING SPECIAL CONSTRUCTION HOURS

The proposed scope of work to be undertaken during this stage is detailed as follows:

- Friday: Limited to site establishment activities in preparation for weekend works.
- Saturday: General construction activities excluding excavation, sawing of rock, jack hammers, pile drivers, vibratory rollers/compactors of the like.
- Sunday: General construction activities including excavation, sawing of rock, jack hammers, pile drivers, vibratory rollers/compactors of the like.
- Sunday: General construction activities excluding excavation, sawing of rock, jack hammers, pile drivers, vibratory rollers/compactors of the like.

12.3 PROPOSED SPECIAL CONSTRUCTION HOURS OF WORK

The above scope of work is proposed to be undertaken during the following periods:

Friday: 6:00 pm to 10:00 pm;

Saturday: 5:00 pm to 10:00 pm;

Sunday: 8:00 am to 5:00 pm; and

Sunday: 5:00 pm to 10:00 pm.

See Figure 1 for a detailed location where the construction works are to be undertaken and the nearest surrounding receivers to the project site.

12.4 ACTIVITIES TO BE CONDUCTED AND THE ASSOCIATED NOISE SOURCES

Preliminary noise impacts will be determined from primary processes and equipment. The sound power levels of these activities/equipment are presented in the table below.

Table 41 – Sound Power Levels of the Proposed Equipment

EQUIPMENT / PROCESS	SOUND POWER LEVEL dB(A)
Handheld Jackhammer	120*
Excavator with Bucket	105
Excavator with Hydraulic Hammer	118
Semi-Trailer	105
Grader	114
Demolition Saw	113
Vibrating Roller	108
Excavator with Compacting Wheel Attachment	105
Bobcat with Broom Attachment	105
Slipform Paver	105
Plate Compactor	105
Bobcat	105
Concrete Pump	105
Cement Mixing Truck	105
Powered Hand Tools	95*
Electric Tower Crane	96
Mobile Crane	105
CFA Piling	103

*** Includes 5dB(A) addition for characteristics of noise source.**

The noise levels presented in the above table are derived from the following sources, namely:

- On site measurements;
- Table A1 of Australian Standard 2436-2010 & Table A1 of Australian Standard 2436-2010; and
- Data held by this office from other similar studies.

12.5 PRELIMINARY NOISE ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS)

12.5.1 Methodology

Noise from the loudest typical construction activities have been predicted to the nearest most affected sensitive receivers. The predicted noise levels are presented in this section and are based on the areas on site in which the plant is likely to be used.

Where the position of the construction activity is variable, a range of predicted noise levels is presented to take into account the change in noise impact depending on where on the site the work is conducted.

Predictions take into account:

- The distance between the noise source and the receiver; and
- The screening effect provided by barriers or building structures (where relevant).

12.5.2 Predicted Noise Levels

Please see the tables below for predicted noise levels for each receiver.

**Table 42 – Predicted Noise Generation to Receiver 1 – Remaining Liverpool Hospital Development
(Friday 6pm-10pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Semi-Trailer	<u>Bedroom Wards/ Consulting Rooms/Treatment Rooms/Office Areas/Operating Theatres</u> 45dB(A) <u>X-Ray Areas</u> 50dB(A)	6-50
Bobcat		6-50
Powered Hand Tools		0-40
Electric Tower Crane		0-31
Mobile Crane		6-40

**Table 43 – Predicted Noise Generation to Receiver 1 – Remaining Liverpool Hospital Development
(Saturday 5pm-10pm & Sunday 5pm-10pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Semi-Trailer	<u>Bedroom Wards/ Consulting Rooms/Treatment Rooms/Office Areas/Operating Theatres</u> 45dB(A) <u>X-Ray Areas</u> 50dB(A)	6-50
Bobcat		6-50
Concrete Pump		6-50
Cement Mixing Truck		6-50
Powered Hand Tools		0-40
Electric Tower Crane		0-31
Mobile Crane		6-40

**Table 44 – Predicted Noise Generation to Receiver 1 – Remaining Liverpool Hospital Development
(Sunday 8am-5pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<p><u>Bedroom Wards/ Consulting Rooms/Treatment Rooms/Office Areas/Operating Theatres</u> 45dB(A)</p> <p><u>X-Ray Areas</u> 50dB(A)</p>	21-65
Excavator with Bucket		6-50
Excavator with Hydraulic Hammer		21-65
Semi-Trailer		6-50
Grader		15-59
Demolition Saw		14-58
Vibrating Roller		9-53
Excavator with Compacting Wheel Attachment		6-50
Bobcat with Broom Attachment		6-50
Slipform Paver		6-50
Plate compactor		6-50
Bobcat		6-50
Concrete Pump		6-50
Cement Mixing Truck		6-50
Powered Hand Tools		0-40
Electric Tower Crane		0-31
Mobile Crane		6-40
CFA Piling		14-48

Table 45 – Predicted Noise Generation to Receiver 2 – Tafe NSW Liverpool

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	It is assumed that the receiver is not operational during the proposed extended special construction hours
Excavator with Bucket		
Excavator with Hydraulic Hammer		
Semi-Trailer		
Grader		
Demolition Saw		
Vibrating Roller		
Excavator with Compacting Wheel Attachment		
Bobcat with Broom Attachment		
Slipform Paver		
Plate compactor		
Bobcat		
Concrete Pump		
Cement Mixing Truck		
Powered Hand Tools		
Electric Tower Crane		
Mobile Crane		
CFA Piling		

Table 46 – Predicted Noise Generation to Receiver 3 – Liverpool Girls High School

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	<u>Classrooms/Teaching Spaces</u> 45dB(A)	It is assumed that the receiver is not operational during the proposed extended special construction hours
Excavator with Bucket		
Excavator with Hydraulic Hammer		
Semi-Trailer		
Grader		
Demolition Saw		
Vibrating Roller		
Excavator with Compacting Wheel Attachment		
Bobcat with Broom Attachment		
Slipform Paver		
Plate compactor		
Bobcat		
Concrete Pump		
Cement Mixing Truck		
Powered Hand Tools		
Electric Tower Crane		
Mobile Crane		
CFA Piling		

**Table 47 – Predicted Noise Generation to Receiver 4 – Health Services Building/Ingham Institute
(Friday 6pm-10pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Semi-Trailer	<u>Consulting Rooms/Treatment Rooms/Office Areas</u> 45dB(A)	17-25
Bobcat		17-25
Powered Hand Tools		7-15
Electric Tower Crane		8-16
Mobile Crane		17-25

**Table 48 – Predicted Noise Generation to Receiver 4 – Health Services Building/Ingham Institute
(Saturday 5pm-10pm & Sunday 5pm-10pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Semi-Trailer	<u>Consulting Rooms/Treatment Rooms/Office Areas</u> 45dB(A)	17-25
Bobcat		17-25
Concrete Pump		17-25
Cement Mixing Truck		17-25
Powered Hand Tools		7-15
Electric Tower Crane		8-16
Mobile Crane		17-25

**Table 49 – Predicted Noise Generation to Receiver 4 – Health Services Building/Ingham Institute
(Sunday 8am-5pm Only)**

Activity	Internal Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (Internal Areas)
Handheld Jackhammer	Consulting Rooms/Treatment Rooms/Office Areas 45dB(A)	32-40
Excavator with Bucket		17-25
Excavator with Hydraulic Hammer		32-40
Semi-Trailer		17-25
Grader		26-34
Demolition Saw		25-33
Vibrating Roller		20-28
Excavator with Compacting Wheel Attachment		17-25
Bobcat with Broom Attachment		17-25
Slipform Paver		17-25
Plate compactor		17-25
Bobcat		17-25
Concrete Pump		17-25
Cement Mixing Truck		17-25
Powered Hand Tools		7-15
Electric Tower Crane		8-16
Mobile Crane		17-25
CFA Piling		15-23

**Table 50 – Predicted Noise Generation to Receiver 5 – Residents at 41 Forbes Street
(Friday 6pm-10pm Only)**

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Semi-Trailer	<u>Outside Standard Construction Hours, Special Construction Hours</u> (Friday) 6:00pm – 10:00pm 47dB(A)	38-43
Bobcat		38-43
Powered Hand Tools		28-33
Electric Tower Crane		29-34
Mobile Crane		48-53

**Table 51 – Predicted Noise Generation to Receiver 5 – Residents at 41 Forbes Street
(Saturday 5pm-10pm & Sunday 5pm-10pm Only)**

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Semi-Trailer	<u>Outside Standard Construction Hours, Special Construction Hours</u> (Saturday) 5:00pm – 10:00pm 47dB(A) (Sunday) 5:00pm – 10:00pm 47dB(A)	38-43
Bobcat		38-43
Concrete Pump		38-43
Cement Mixing Truck		38-43
Powered Hand Tools		28-33
Electric Tower Crane		29-34
Mobile Crane		48-53

**Table 52 – Predicted Noise Generation to Receiver 5 – Residents at 41 Forbes Street
(Sunday 8am-5pm Only)**

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Handheld Jackhammer	<u>Outside Standard Construction Hours, Special Construction Hours (Sunday)</u> 8:00am – 5:00pm 47dB(A)	53-58
Excavator with Bucket		38-43
Excavator with Hydraulic Hammer		53-58
Semi-Trailer		38-43
Grader		47-52
Demolition Saw		46-51
Vibrating Roller		41-46
Excavator with Compacting Wheel Attachment		38-43
Bobcat with Broom Attachment		38-43
Slipform Paver		38-43
Plate compactor		38-43
Bobcat		38-43
Concrete Pump		38-43
Cement Mixing Truck		38-43
Powered Hand Tools		28-33
Electric Tower Crane		29-34
Mobile Crane		48-53
CFA Piling		46-51

**Table 53 – Predicted Noise Generation to Receiver 6 – South Western Sydney Local Health District
(Friday 6pm-10pm Only)**

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Semi-Trailer	<u>Outside Standard Construction Hours, Special Construction Hours</u> <u>(Friday)</u> <u>6:00pm – 10:00pm</u> <u>70dB(A)</u>	46-57
Bobcat		46-57
Powered Hand Tools		36-47
Electric Tower Crane		37-48
Mobile Crane		46-57

**Table 54 – Predicted Noise Generation to Receiver 6 – South Western Sydney Local Health District
(Saturday 5pm-10pm & Sunday 5pm-10pm Only)**

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Semi-Trailer	<u>Outside Standard Construction Hours, Special Construction Hours</u> <u>(Saturday)</u> <u>5:00pm – 10:00pm</u> <u>70dB(A)</u> <u>(Sunday)</u> <u>5:00pm – 10:00pm</u> <u>70dB(A)</u>	46-57
Bobcat		46-57
Concrete Pump		46-57
Cement Mixing Truck		46-57
Powered Hand Tools		36-47
Electric Tower Crane		37-48
Mobile Crane		46-57

Table 55 – Predicted Noise Generation to Receiver 6 – South Western Sydney Local Health District
(Sunday 8am-5pm Only)

Activity	External Noise Management Level dB(A) L_{eq} (15min)	Predicted Noise Level dB(A) L_{eq}(15min) (External Areas)
Handheld Jackhammer	Outside Standard Construction Hours, Special Construction Hours (Sunday) <u>8:00am – 5:00pm</u> <u>70dB(A)</u>	61-72
Excavator with Bucket		46-57
Excavator with Hydraulic Hammer		61-72
Semi-Trailer		46-57
Grader		55-66
Demolition Saw		54-65
Vibrating Roller		49-60
Excavator with Compacting Wheel Attachment		46-57
Bobcat with Broom Attachment		46-57
Slipform Paver		46-57
Plate compactor		46-57
Bobcat		46-57
Concrete Pump		46-57
Cement Mixing Truck		46-57
Powered Hand Tools		36-47
Electric Tower Crane		37-48
Mobile Crane		46-57
CFA Piling		44-55

12.6 AMELIORATIVE MEASURES

12.6.1 Site Specific Recommendations

Detailed site-specific recommendations to mitigate noise and vibration impacts on surrounding receivers are to be determined once construction methodology is finalised.

12.7 GENERAL RECOMMENDATIONS

General noise management practices which may be adopted are discussed below. In addition, notification, reporting and complaints handling procedures should be adopted as recommended in section in this report.

12.7.1 Acoustic Barrier

Barriers or screens can be an effective means of reducing noise. Barriers can be located either at the source or receiver.

The placement of barriers at the source is generally only effective for static plant. Equipment which is on the move or working in rough or undulating terrain cannot be effectively attenuated by placing barriers at the source.

Barriers can also be placed between the source and the receiver.

The degree of noise reduction provided by barriers is dependent on the amount by which line of sight can be blocked by the barrier. If the receiver is totally shielded from the noise source reductions of up to 15 dB(A) can be affected. Where only partial obstruction of line of sight occurs, noise reductions of 5 to 8 dB(A) may be achieved. Where no line of sight is obstructed by the barrier, generally no noise reduction will occur.

As barriers are used to provide shielding and do not act as an enclosure, the material they are constructed from should have a noise reduction performance which is approximately 10dB(A) greater than the maximum reduction provided by the barrier. In this case the use of a material such as 10 or 15mm plywood would be acceptable for the barriers.

12.7.2 Silencing Devices

Where construction process or appliances are noisy, the use of silencing devices may be possible. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

12.7.3 Material Handling

The installation of rubber matting over material handling areas can reduce the sound of impacts due to material being dropped by up to 20dB(A).

12.7.4 Treatment of Specific Equipment

In certain cases, it may be possible to specially treat a piece of equipment to reduce the sound levels emitted. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

12.7.5 Establishment of Site Practices

This involves the formulation of work practices to reduce noise generation. This includes locating fixed plant items as far as possible from residents as well as rotating plant and equipment to provide respite to receivers.

Construction vehicles accessing the site should not queue in residential streets and should only use the designated construction vehicle routes. Loading of these vehicles should occur as far as possible from any sensitive receiver.

13 PRELIMINARY CONSTRUCTION VIBRATION ASSESSMENT (OUTSIDE STANDARD CONSTRUCTION HOURS, SPECIAL CONSTRUCTION HOURS)

13.1 VIBRATION PRODUCING ACTIVITIES

Proposed activities that have the potential to produce significant ground vibration include:

- Demolition Work; and
- Excavation Work.

13.2 SAFEGUARDS TO PROTECT SENSITIVE STRUCTURES

It is impossible to predict the vibrations induced by the demolition and excavation operations on site at potentially affected receivers. This is because vibration levels are principally proportional to the energy impact which is unknown, the nature of the terrain in the area (type of soil), drop weight, height etc.

Note: Sample testing of vibration impacts from the demolition and excavation works to the sensitive receiving spaces of the Liverpool Hospital is recommended prior to commencement of the multi-storey car park works.

13.3 VIBRATION MONITORING (IF REQUIRED)

In the event that complaints are made from neighbouring properties regarding vibration impacts from the subject site, vibration monitors will be installed at the property boundaries of the neighbouring properties nearest to the subject site to monitor vibration levels.

13.3.1 Downloading of Vibration Monitor Data

Downloading of the vibration monitor data will be conducted on a regular basis. In the event of exceedance of the vibration criteria, downloading of the vibration monitor data will be conducted more frequently. Results obtained from the vibration monitor will be presented in a graph format and will be forwarded to the client for review. It is proposed that reports are provided fortnightly with any exceedances in the vibration criteria reported as detailed in this report.

13.3.2 Presentation of Vibration Monitor Results

A fortnightly report will be submitted to the client via email summarising the vibration events. The vibration exceedance of criteria is recorded, and the report shall be submitted within 24 hours. Complete results of the continuous vibration logging will be presented in fortnight reports including graphs of the collected data.

14 CONCLUSION

An acoustic assessment of the proposed redevelopment of the multi-storey carpark to be constructed at Liverpool Hospital has been undertaken.

Noise emission management levels have been setup based on the requirements of the Liverpool Development Control Plan 2008, NSW Interim Construction Noise Guideline, Australian Standard AS2107:2016 and AS2436:2010. A preliminary noise emission assessment during the Standard Construction Hours, Outside Standard Construction Hours and Special Construction Hours has been undertaken, however; detailed noise controls are to be determined once a contractor has been engaged and the demolition/excavation/construction methodology is finalised.

Vibration limits has been setup in Section 7.3 based on requirements of DIN 4150, EPA document Assessing Vibration: A technical guideline and the 2007 ASHRAE Handbook. Detailed vibration safeguard system will be determined once a contractor has been engaged and the demolition/excavation/construction methodology is finalised.

Noise emissions from the operation of the multi-storey carpark and associated mechanical plant and equipment servicing the carpark have been assessed in section 6 of this report.

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

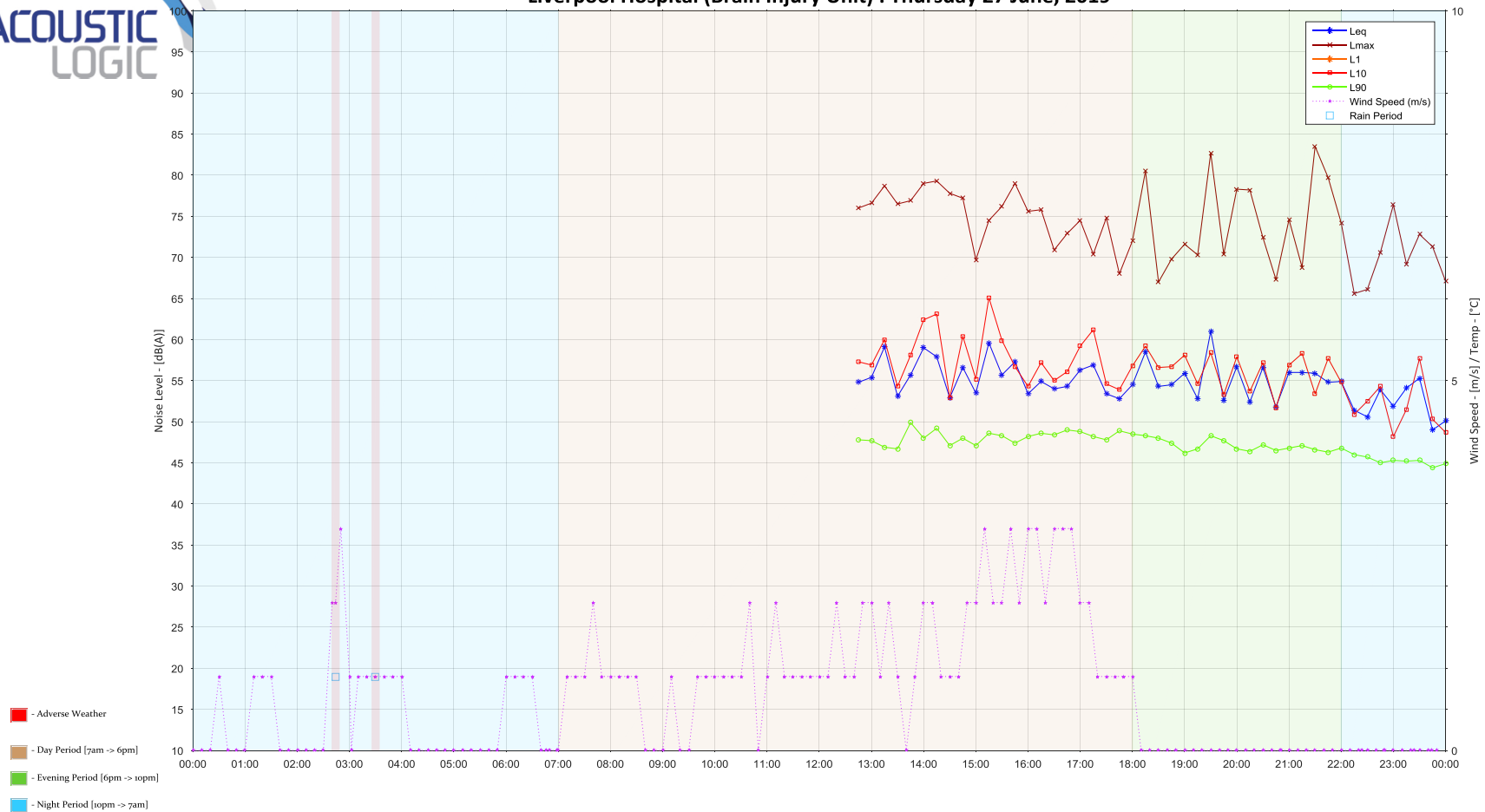
Yours faithfully,

A handwritten signature in black ink, appearing to read 'S. Nichols', with a stylized flourish at the end.

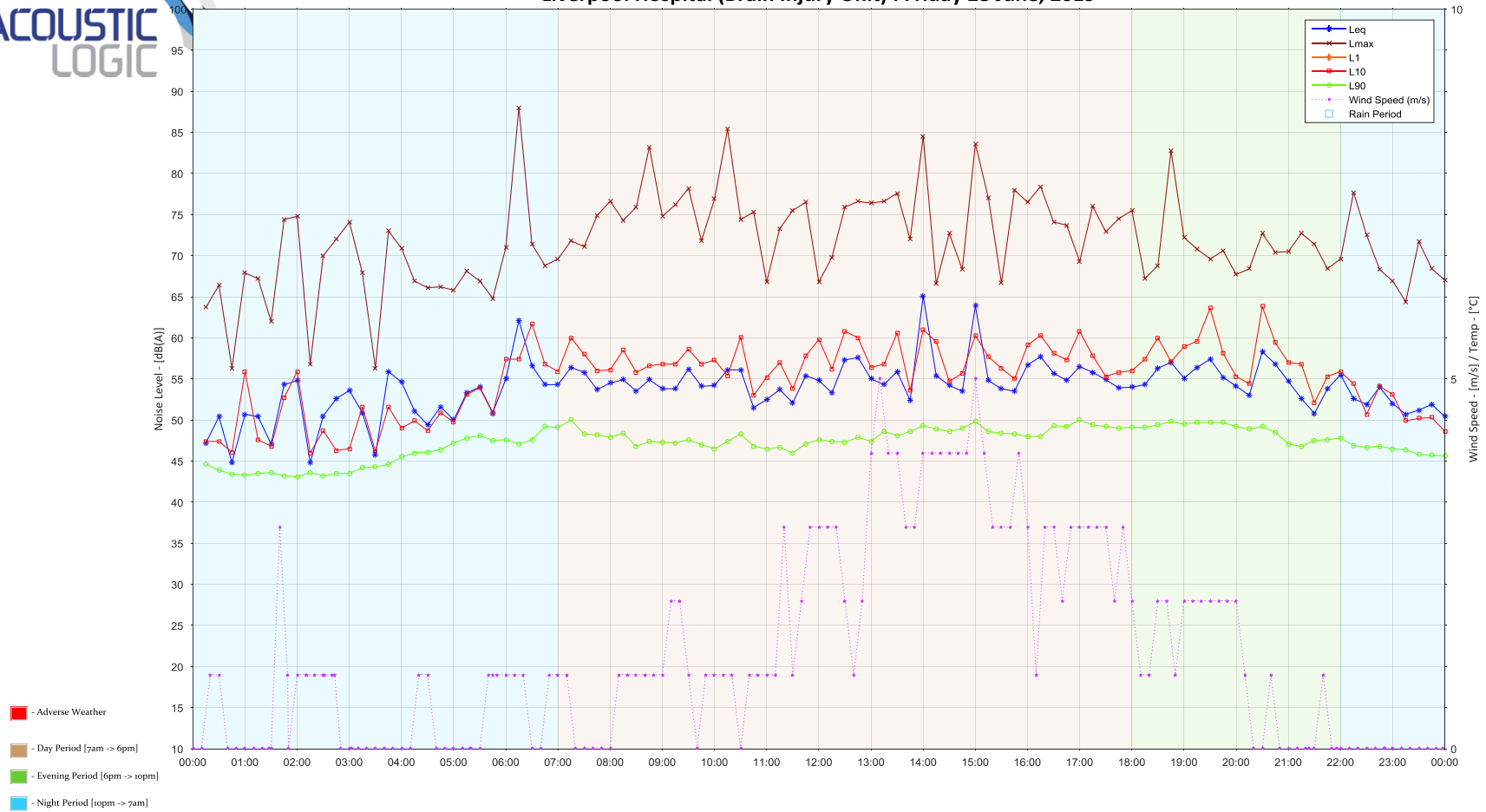
Acoustic Logic Consultancy Pty Ltd
Shane Nichols

APPENDIX 1 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 1)

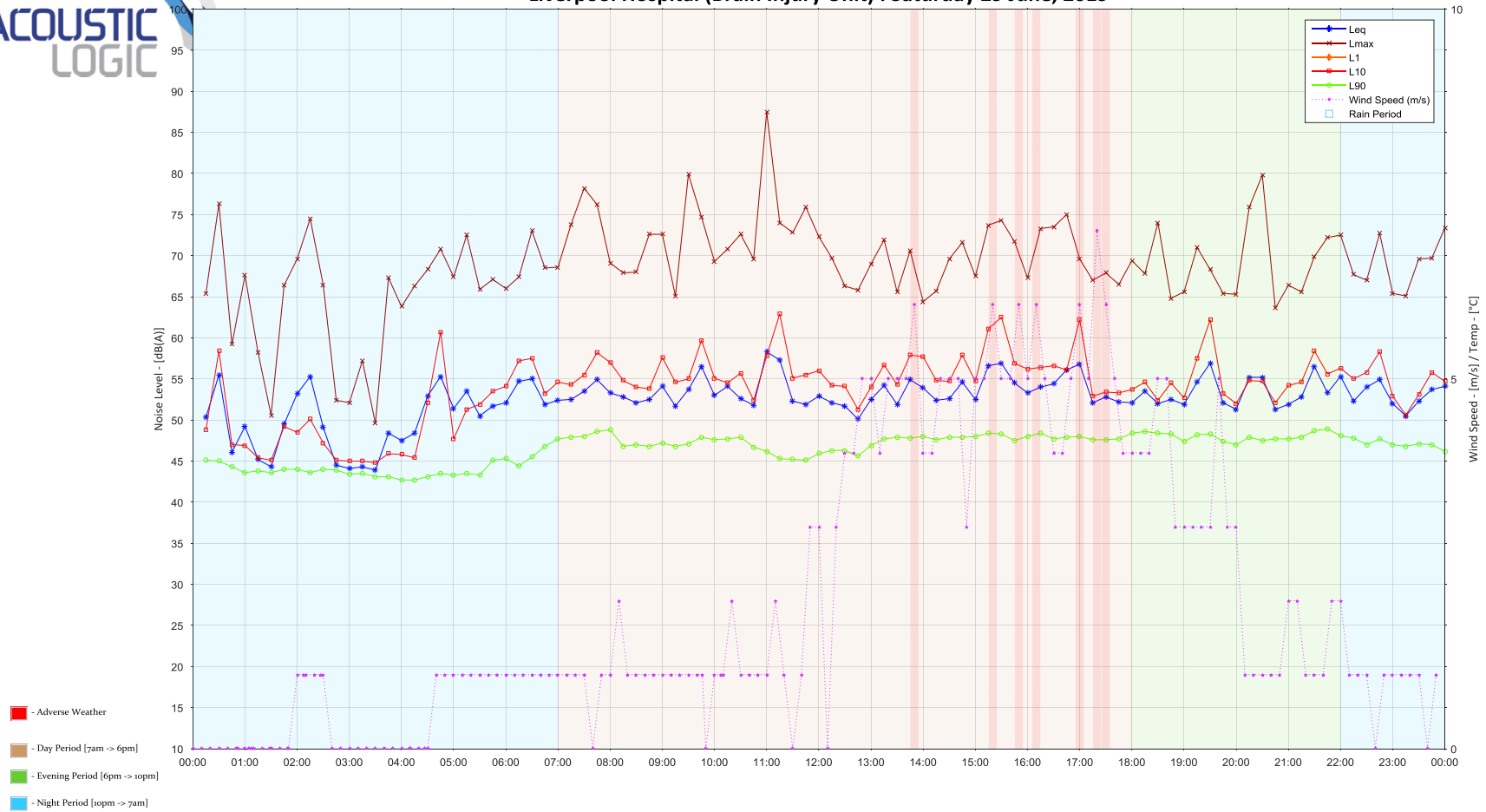
Liverpool Hospital (Brain Injury Unit) : Thursday 27 June, 2019



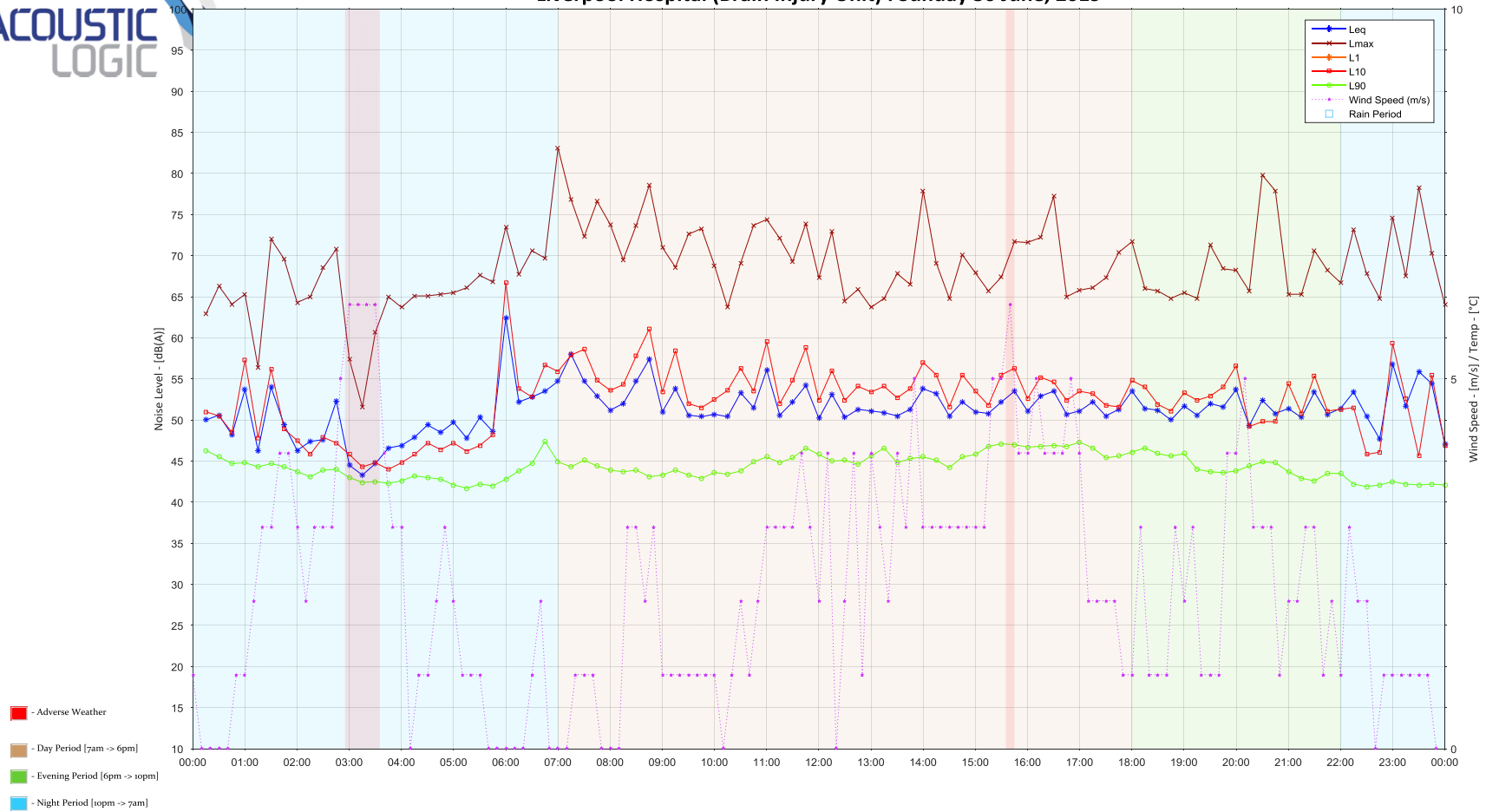
Liverpool Hospital (Brain Injury Unit) : Friday 28 June, 2019



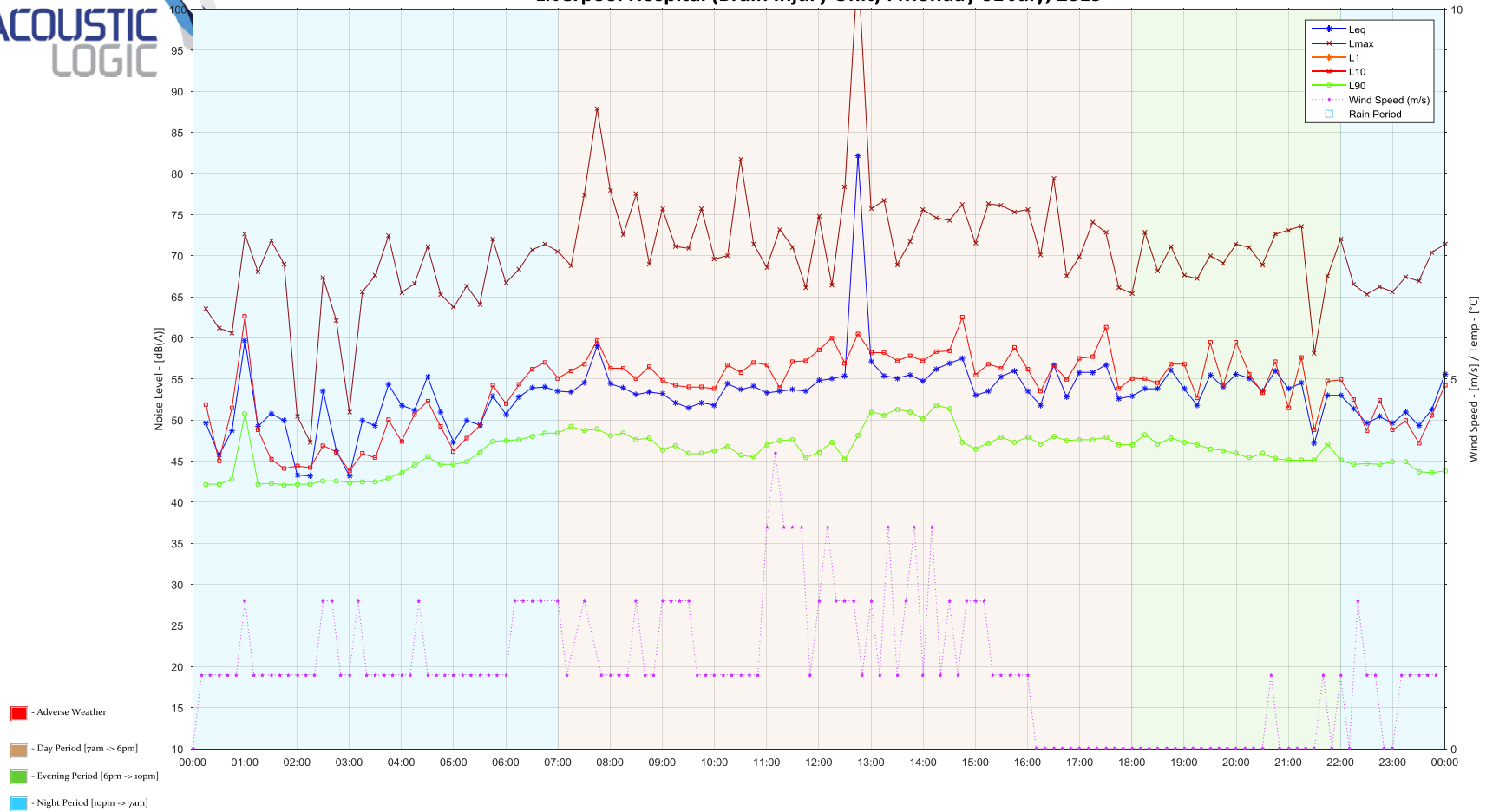
Liverpool Hospital (Brain Injury Unit) : Saturday 29 June, 2019



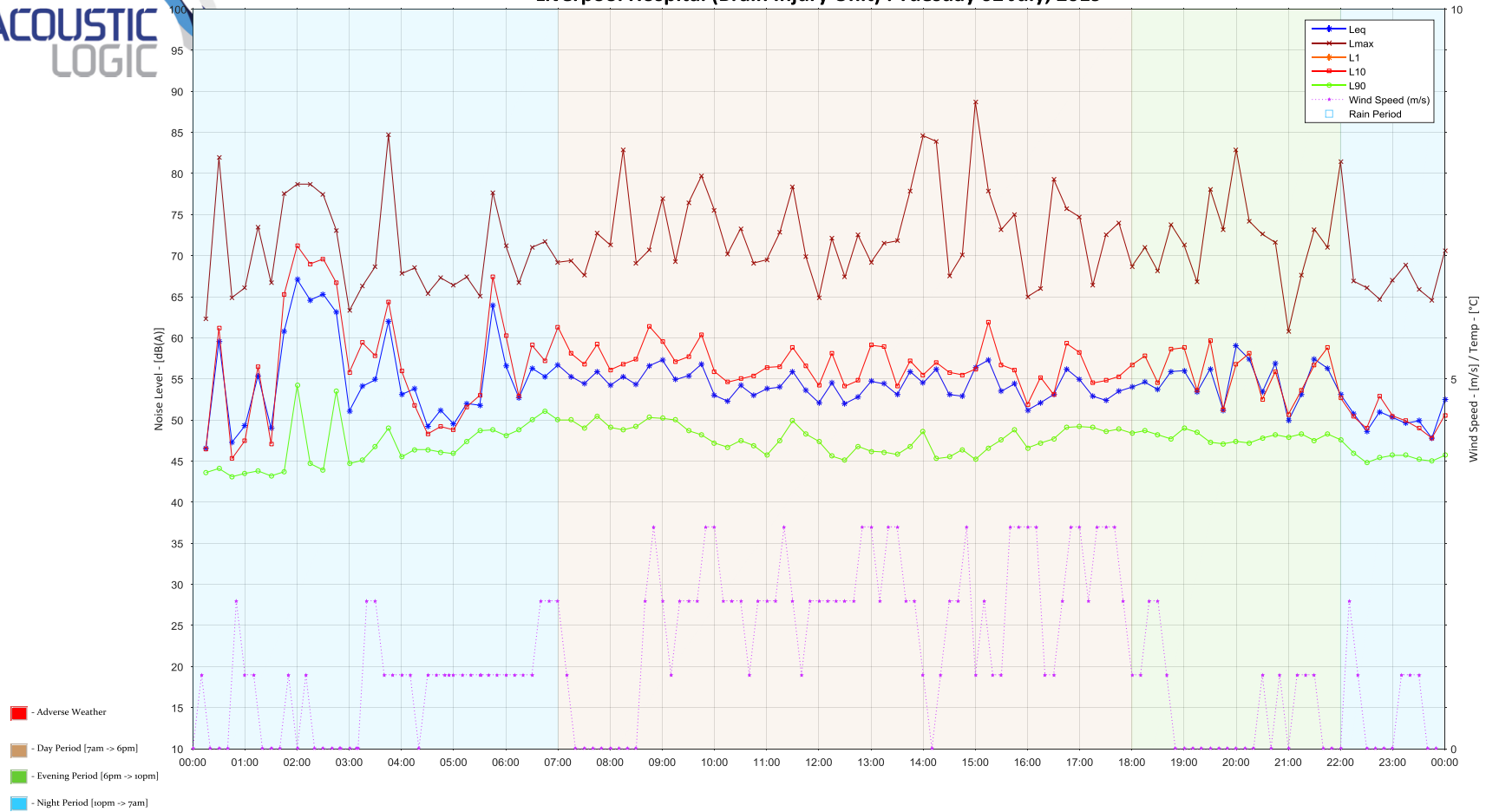
Liverpool Hospital (Brain Injury Unit) : Sunday 30 June, 2019



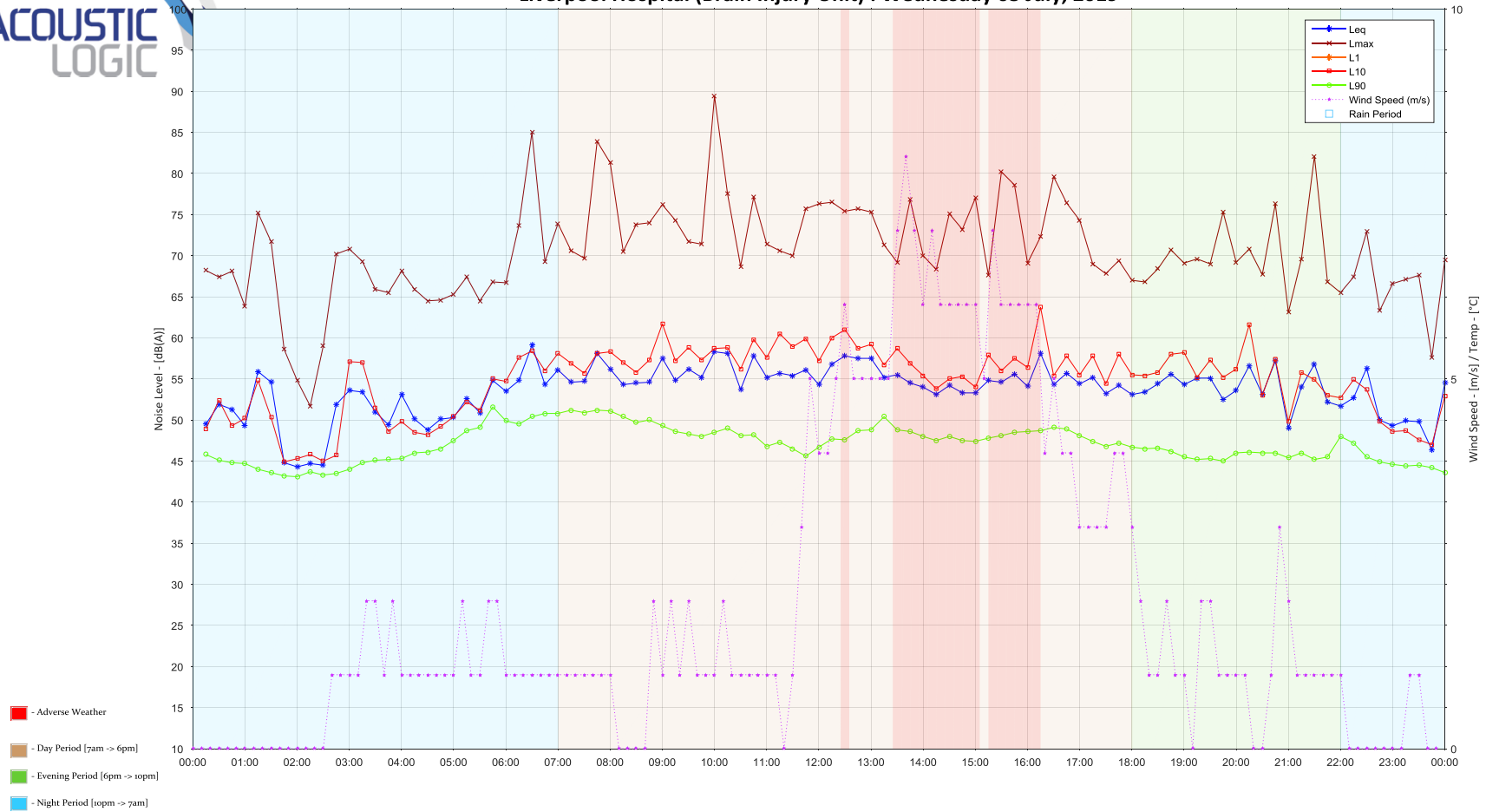
Liverpool Hospital (Brain Injury Unit) : Monday 01 July, 2019



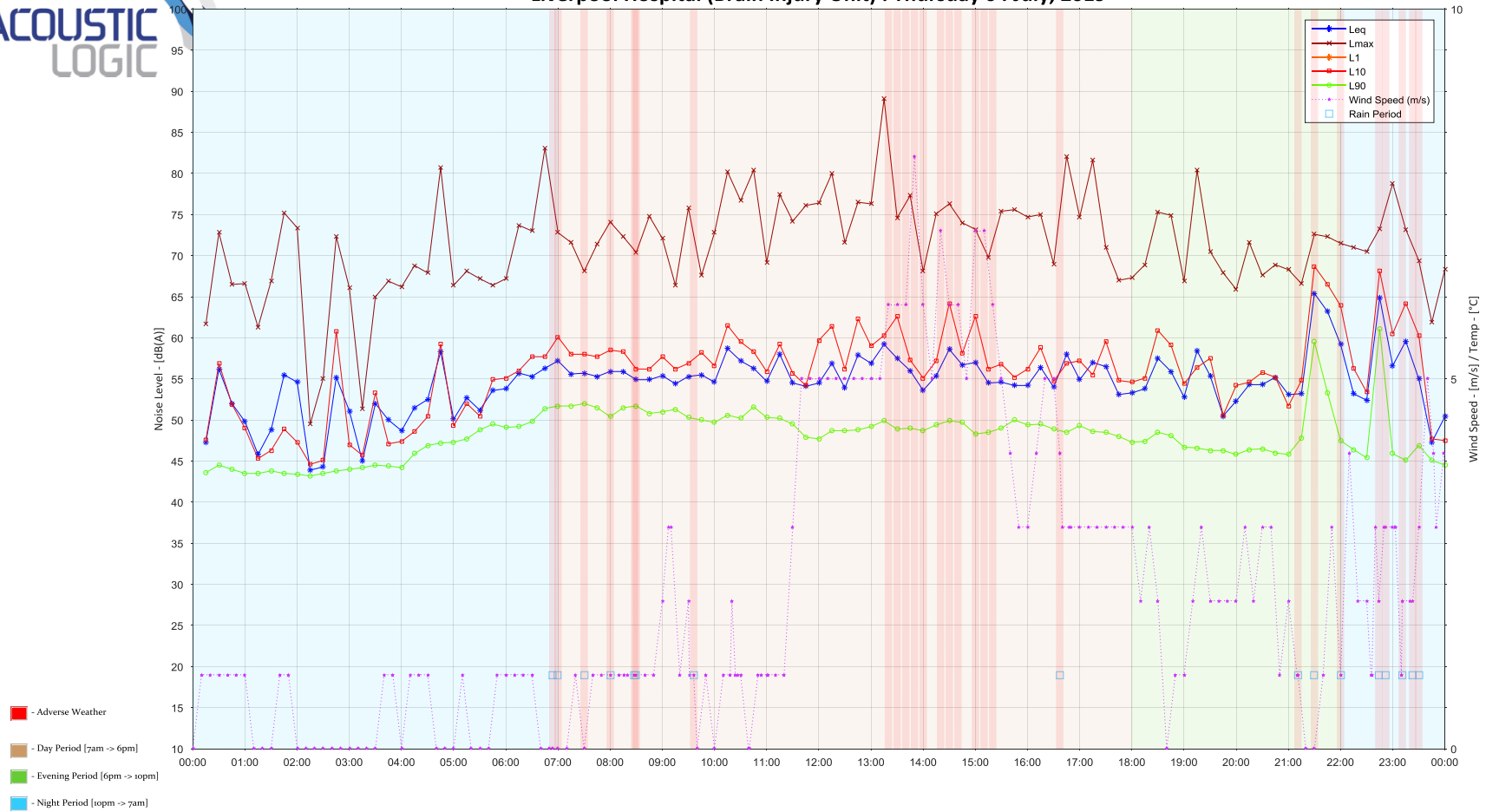
Liverpool Hospital (Brain Injury Unit) : Tuesday 02 July, 2019



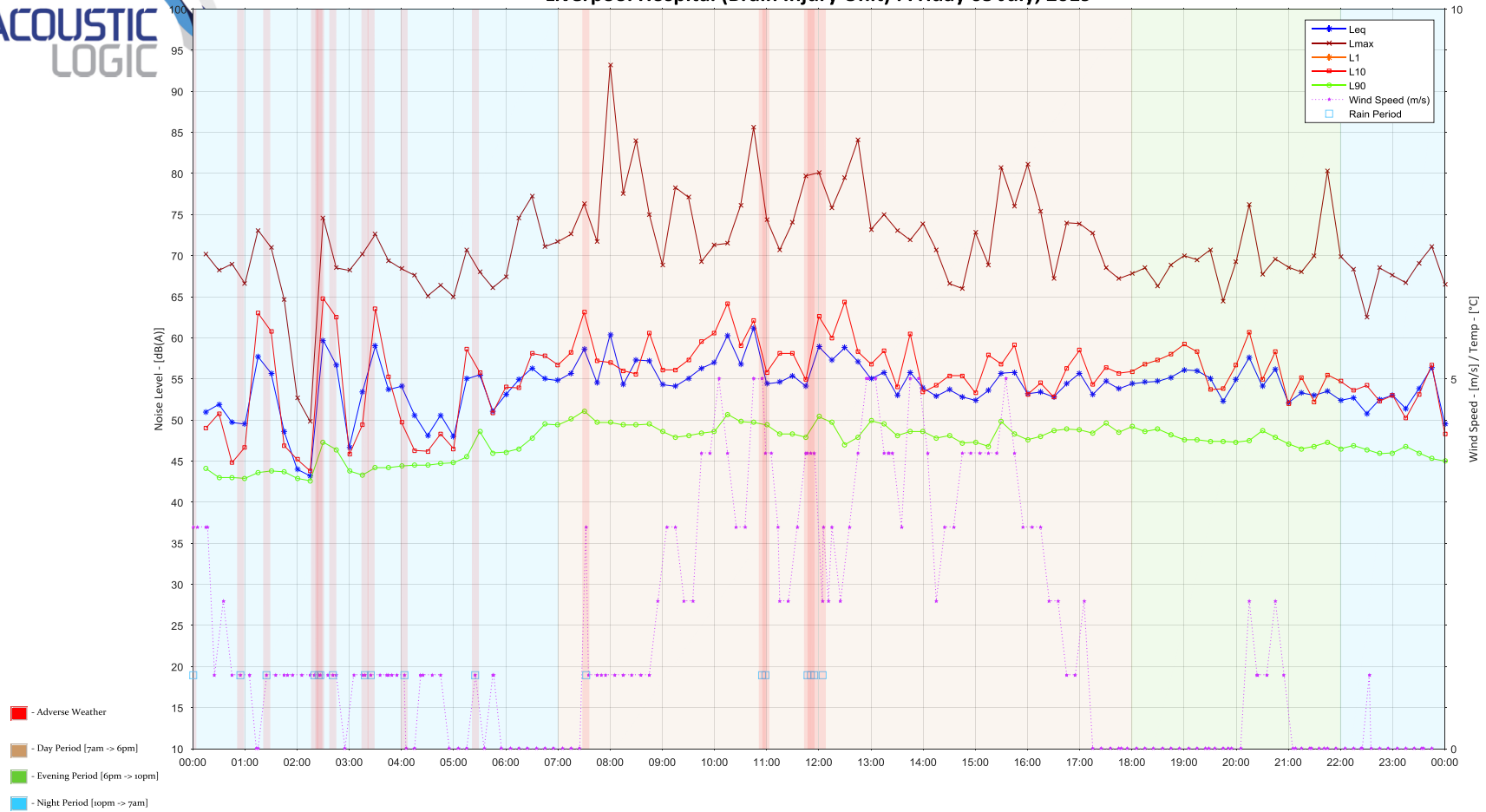
Liverpool Hospital (Brain Injury Unit) : Wednesday 03 July, 2019



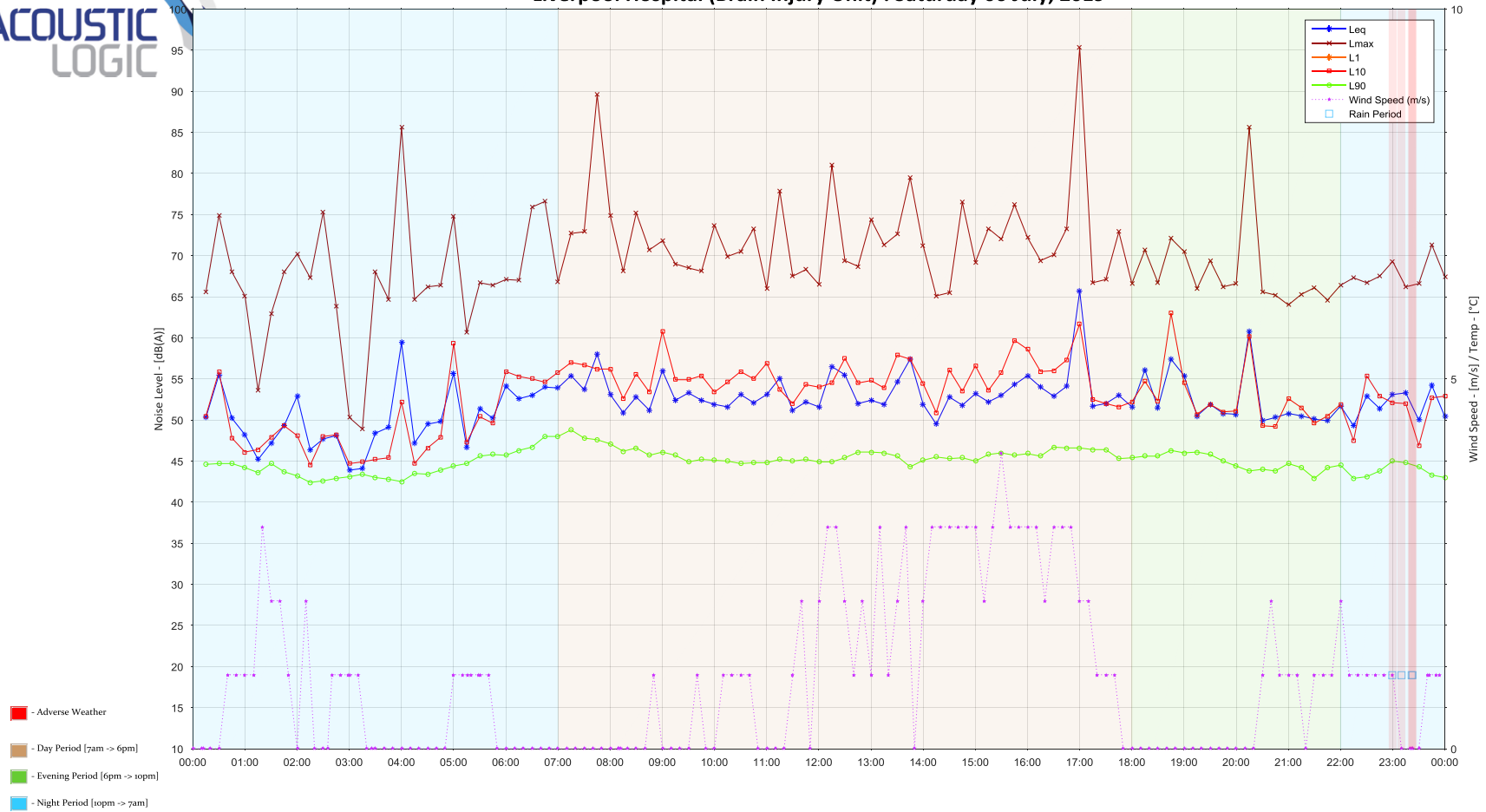
Liverpool Hospital (Brain Injury Unit) : Thursday 04 July, 2019



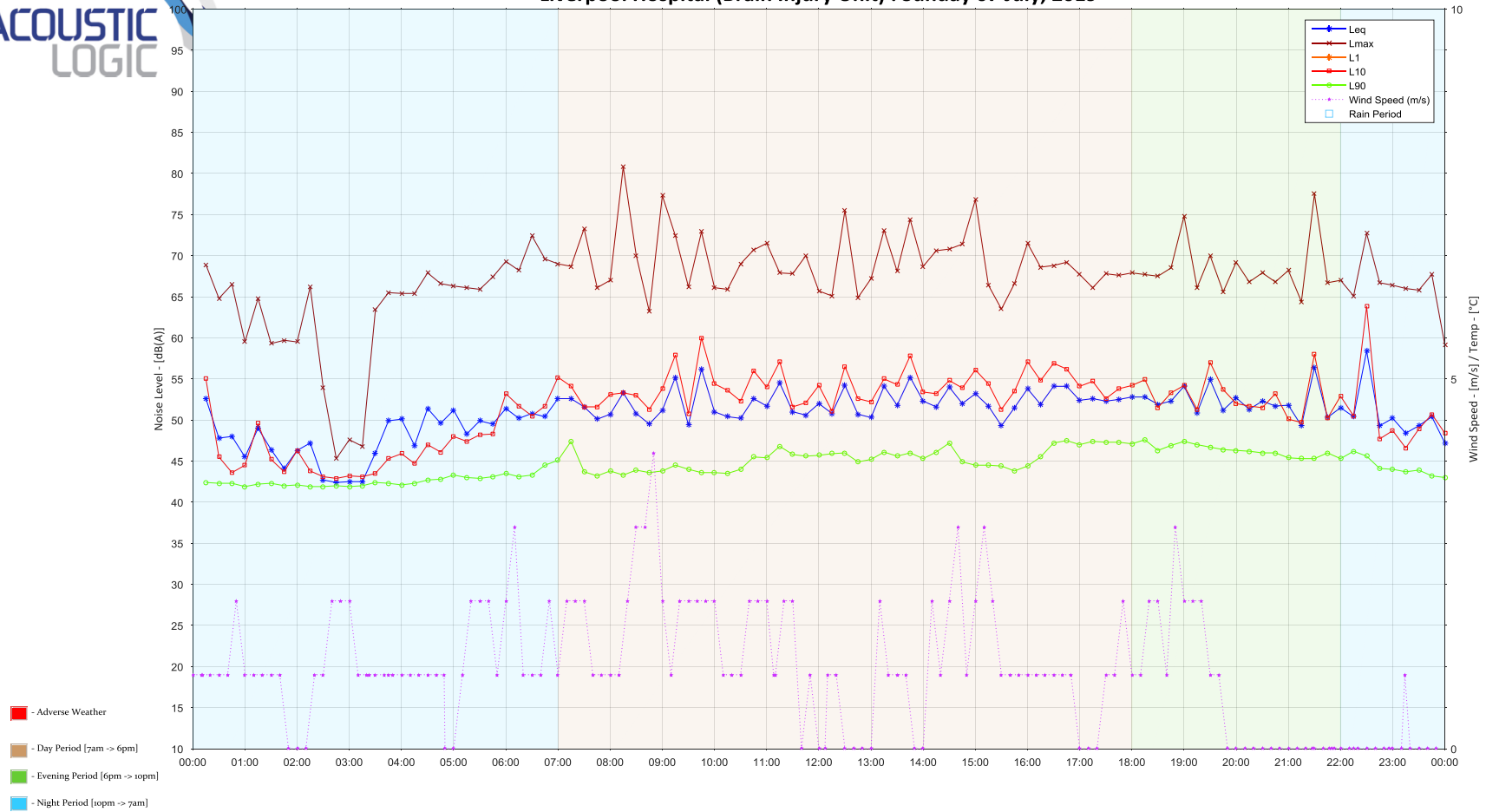
Liverpool Hospital (Brain Injury Unit) : Friday 05 July, 2019



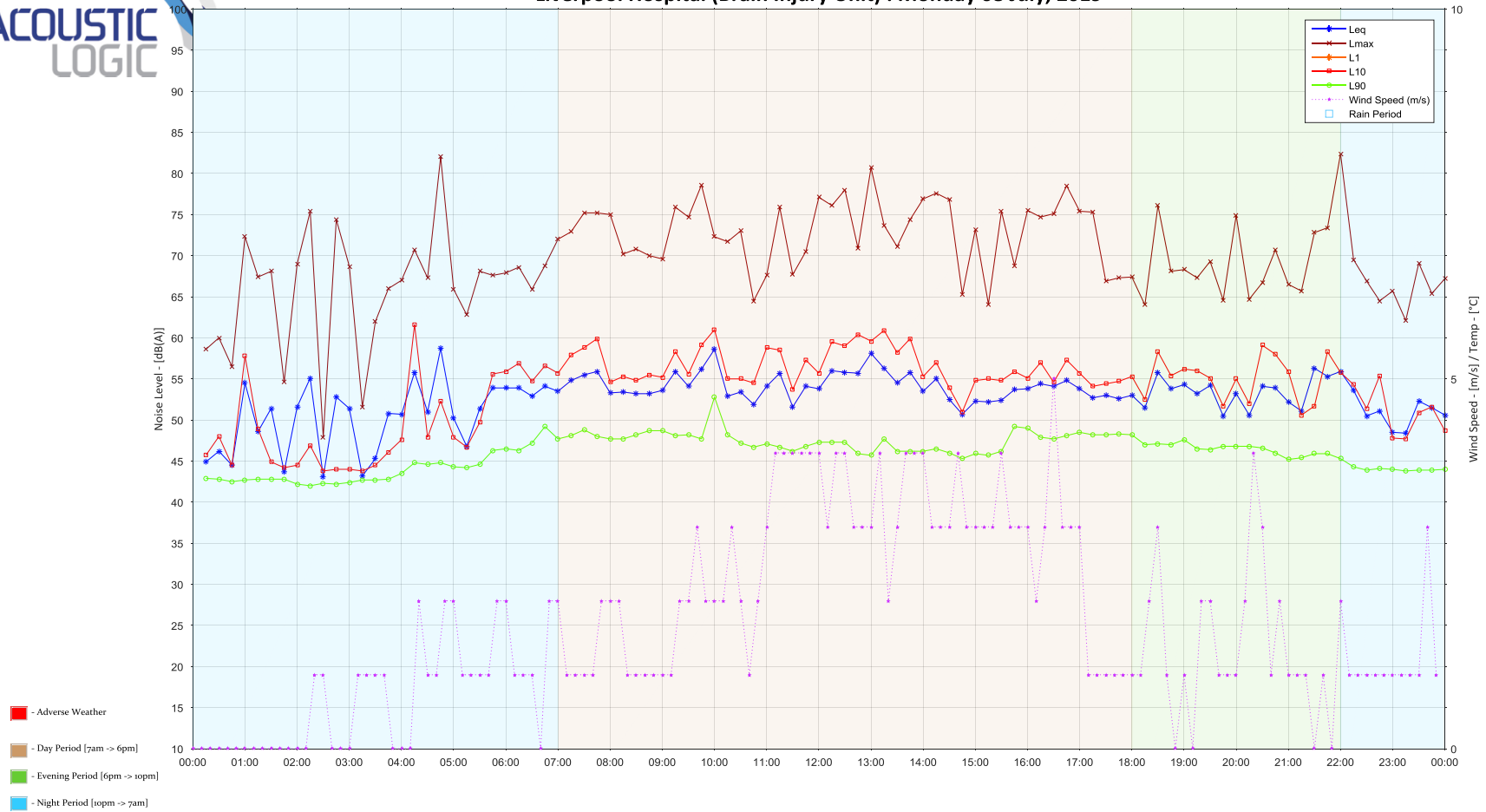
Liverpool Hospital (Brain Injury Unit) : Saturday 06 July, 2019



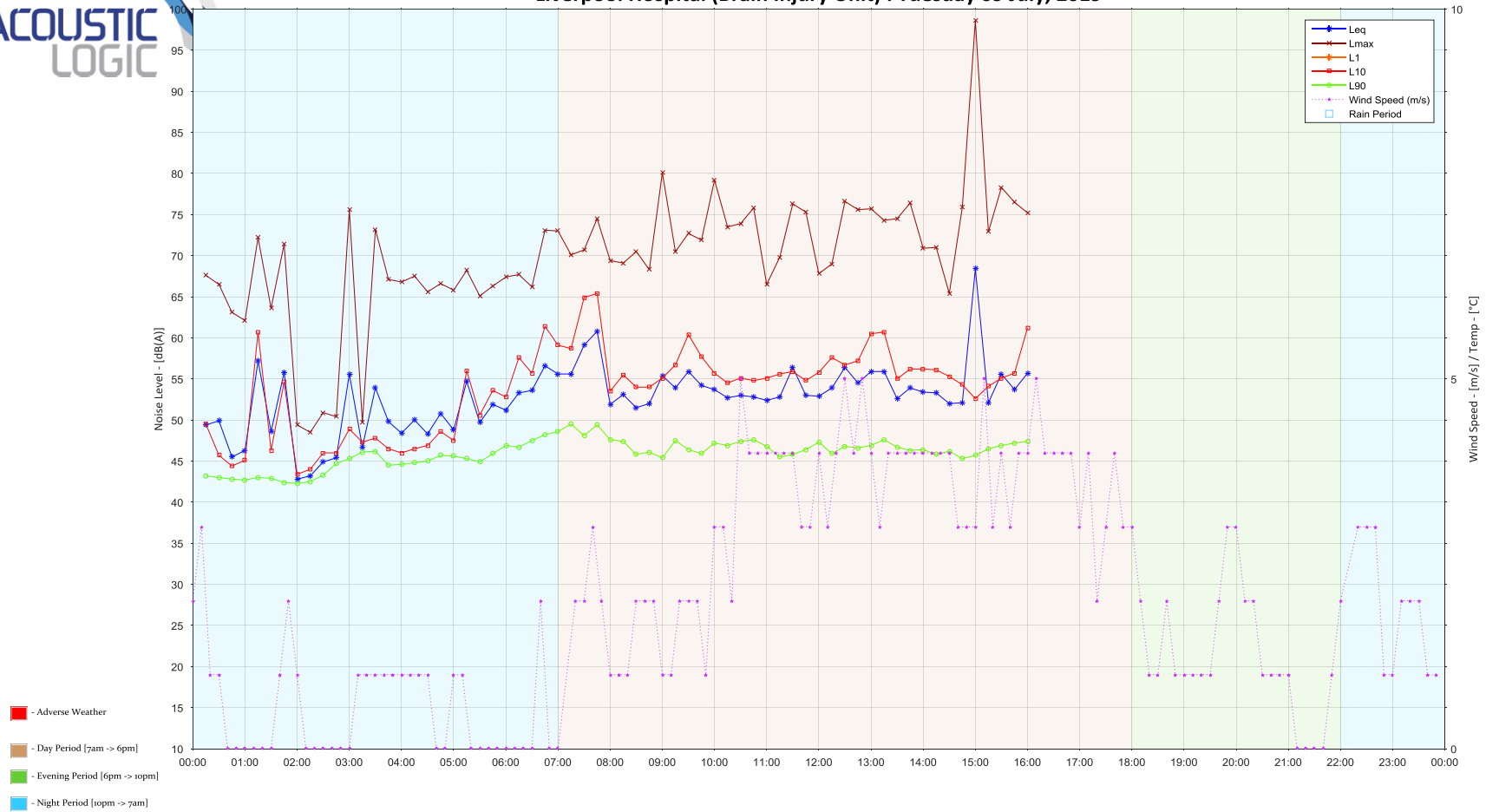
Liverpool Hospital (Brain Injury Unit) : Sunday 07 July, 2019



Liverpool Hospital (Brain Injury Unit) : Monday 08 July, 2019

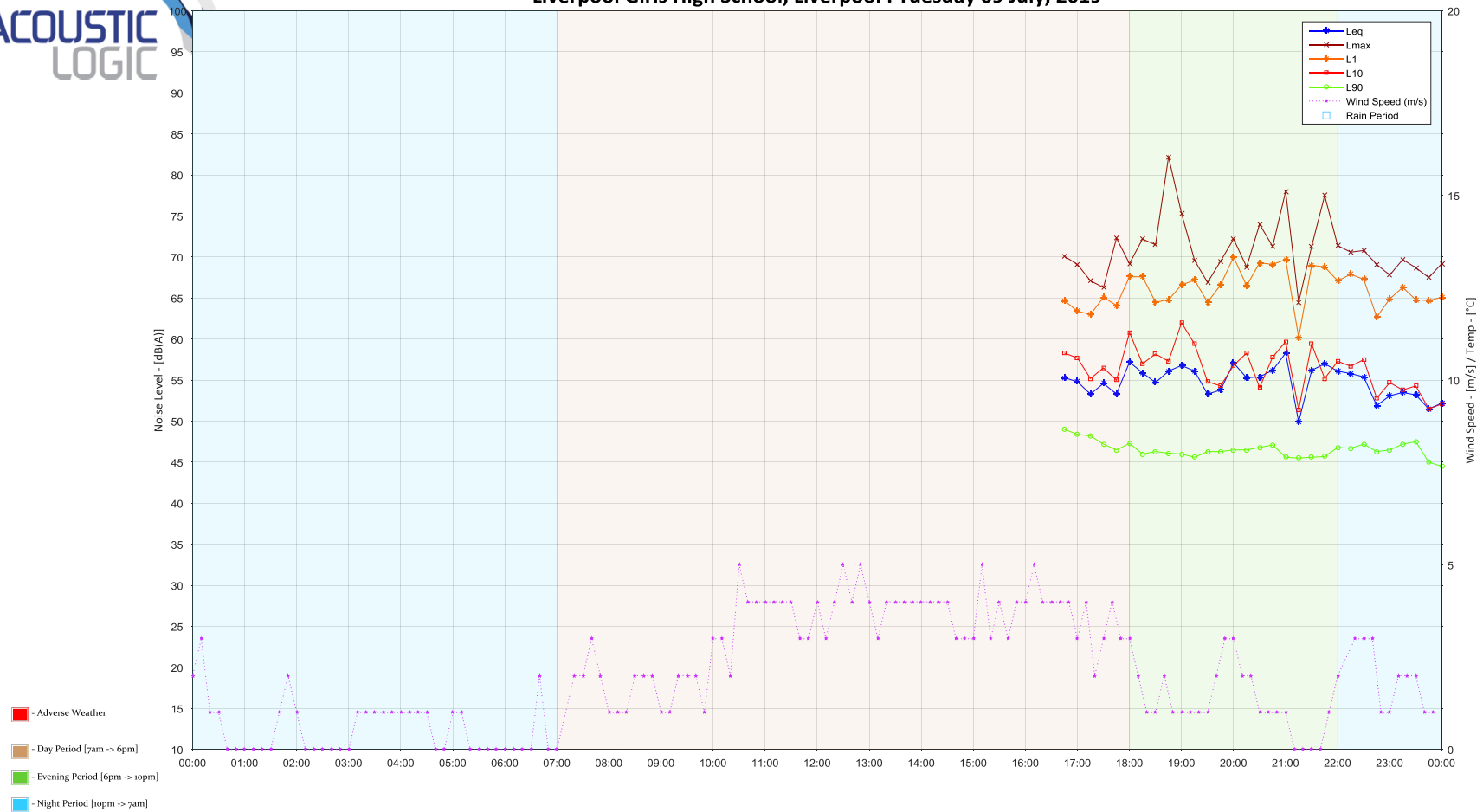


Liverpool Hospital (Brain Injury Unit) : Tuesday 09 July, 2019

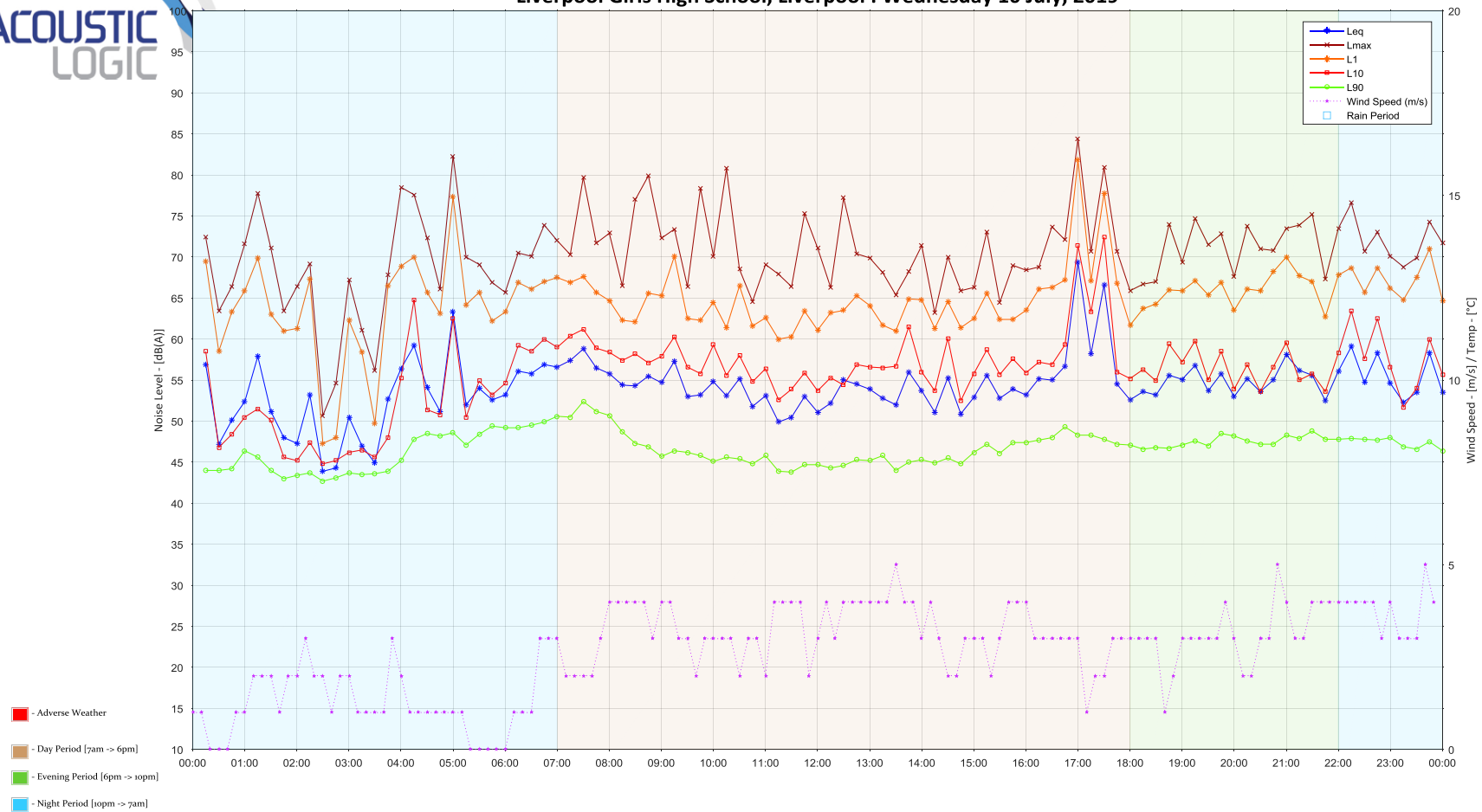


APPENDIX 2 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 2)

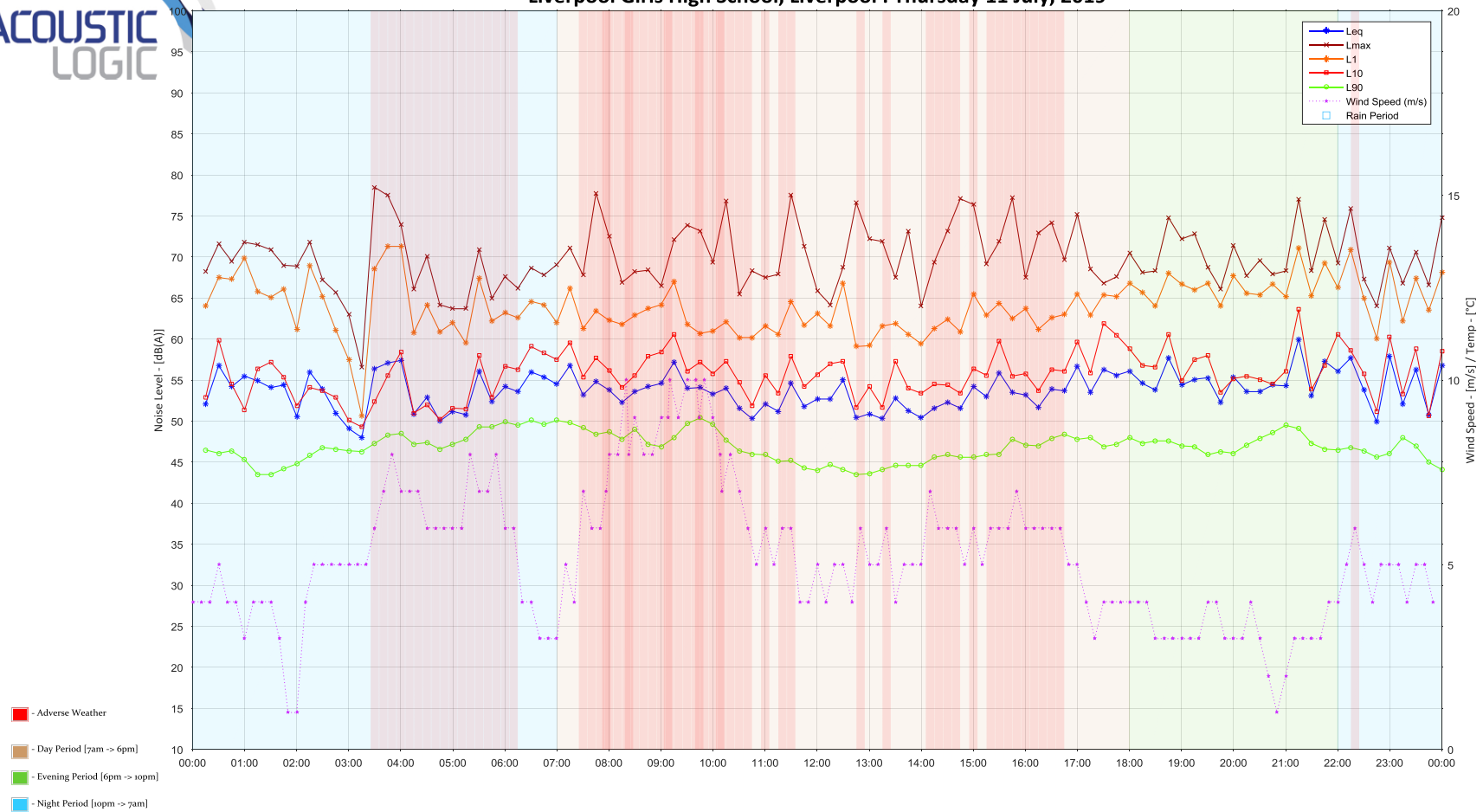
Liverpool Girls High School, Liverpool : Tuesday 09 July, 2019



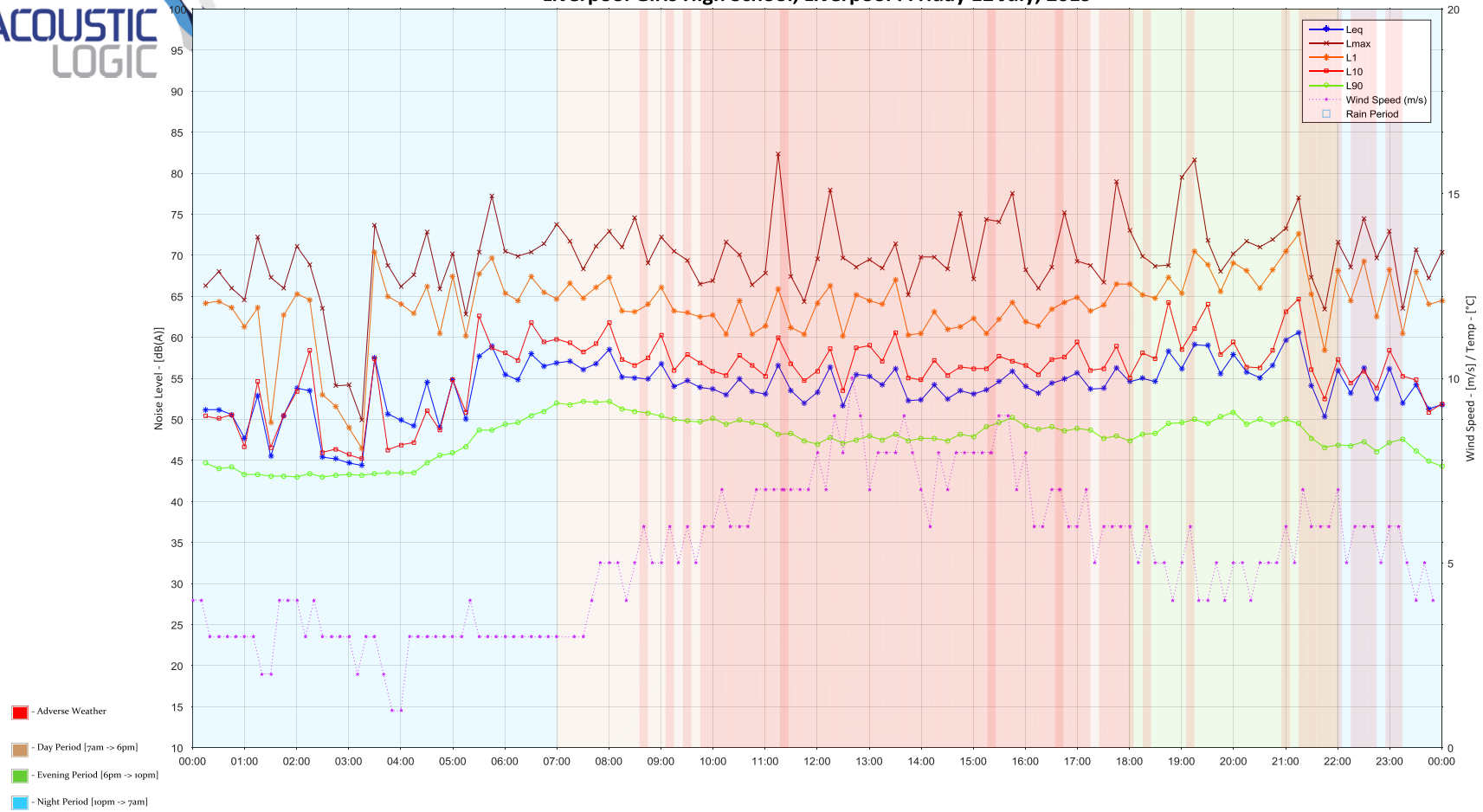
Liverpool Girls High School, Liverpool : Wednesday 10 July, 2019



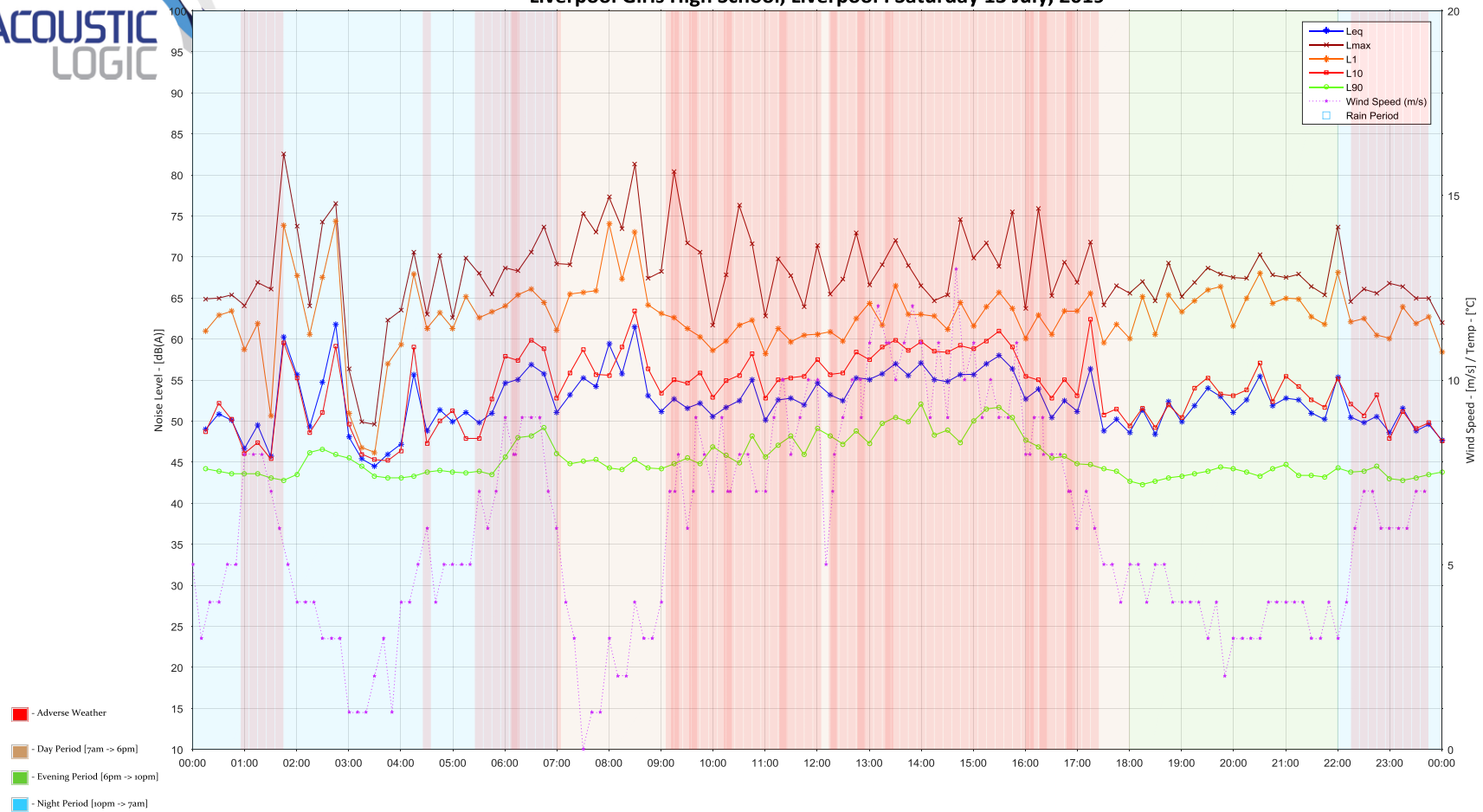
Liverpool Girls High School, Liverpool : Thursday 11 July, 2019



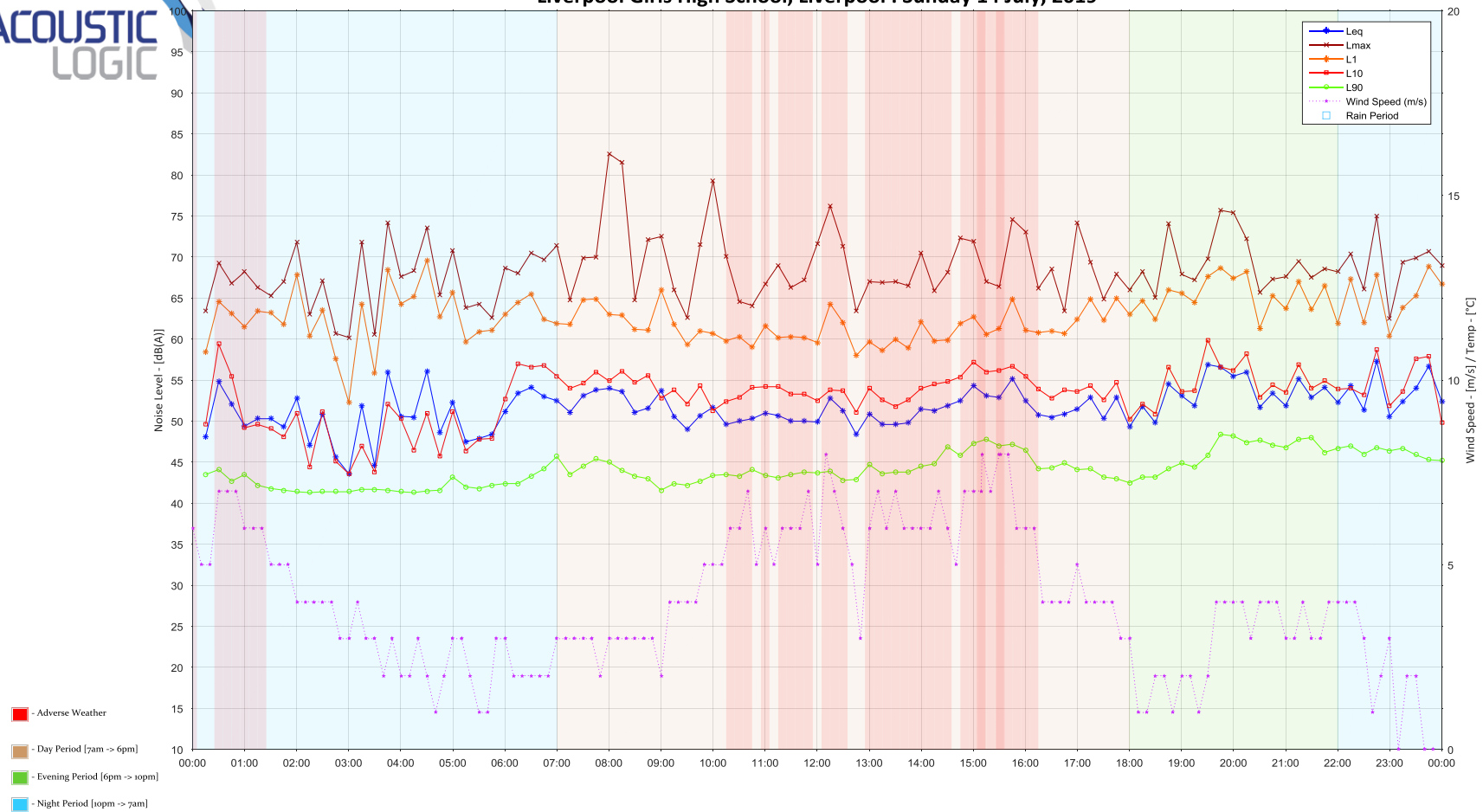
Liverpool Girls High School, Liverpool : Friday 12 July, 2019



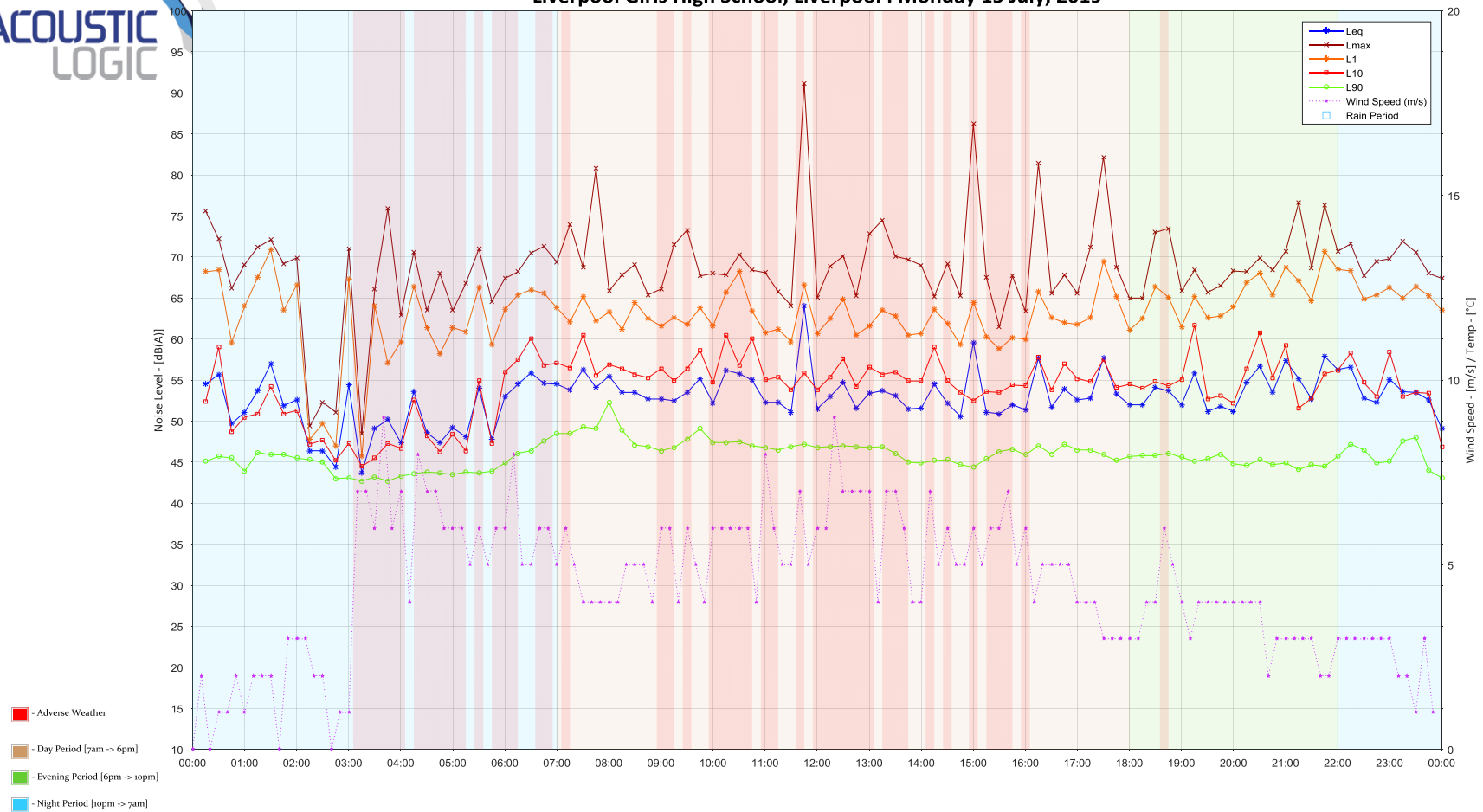
Liverpool Girls High School, Liverpool : Saturday 13 July, 2019



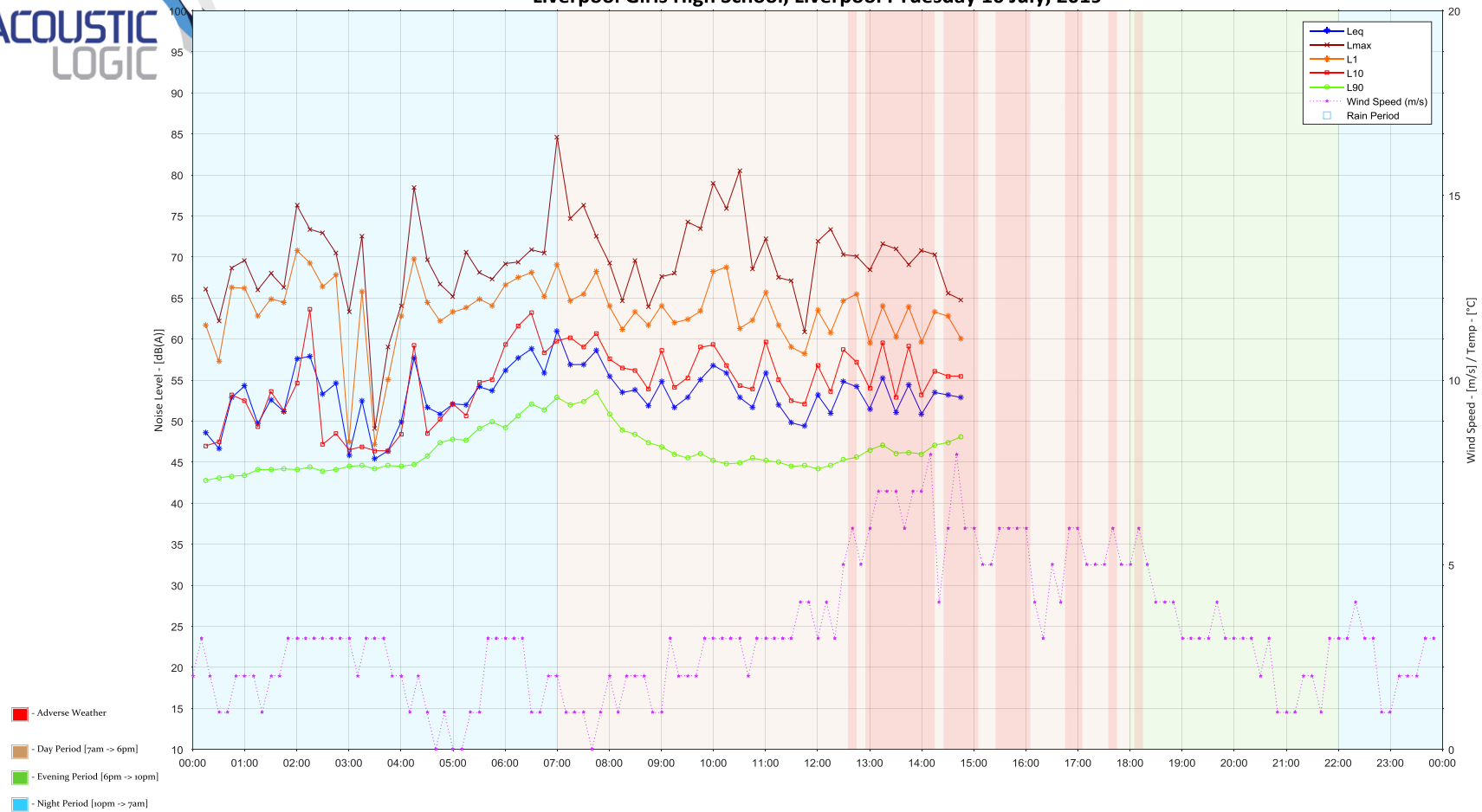
Liverpool Girls High School, Liverpool : Sunday 14 July, 2019



Liverpool Girls High School, Liverpool : Monday 15 July, 2019

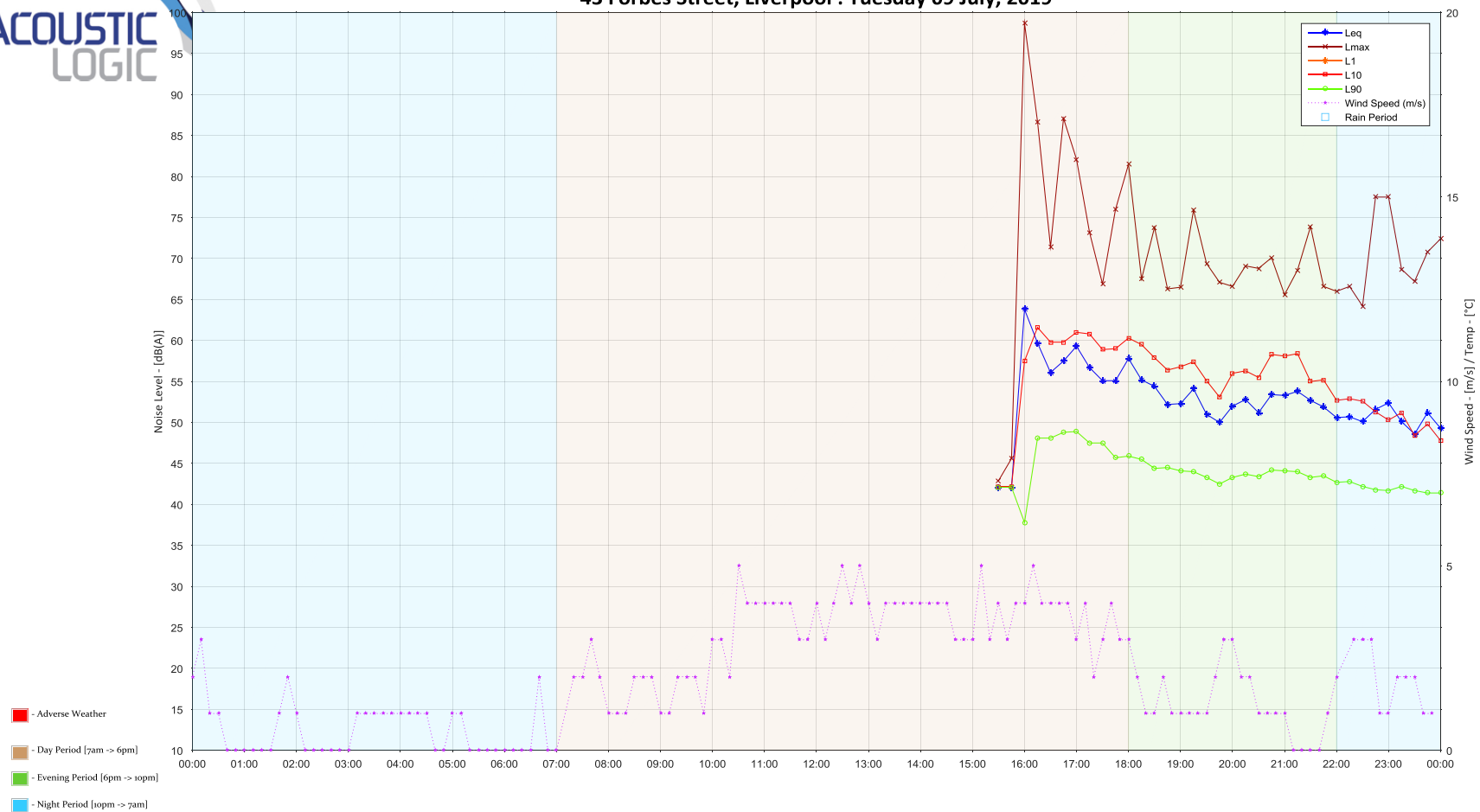


Liverpool Girls High School, Liverpool : Tuesday 16 July, 2019

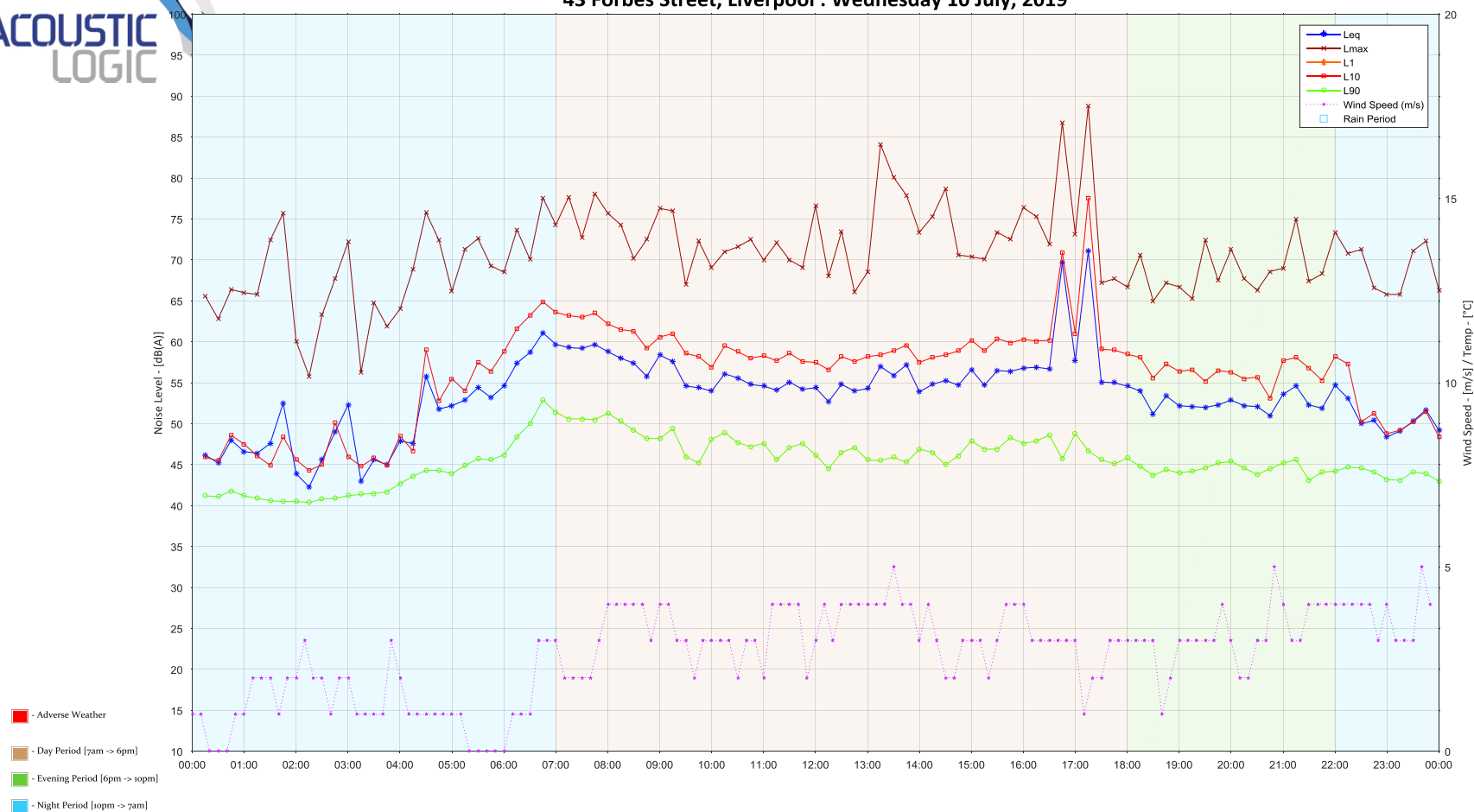


APPENDIX 3 – UNATTENDED BACKGROUND NOISE MONITORING DATA: (LOCATION 3)

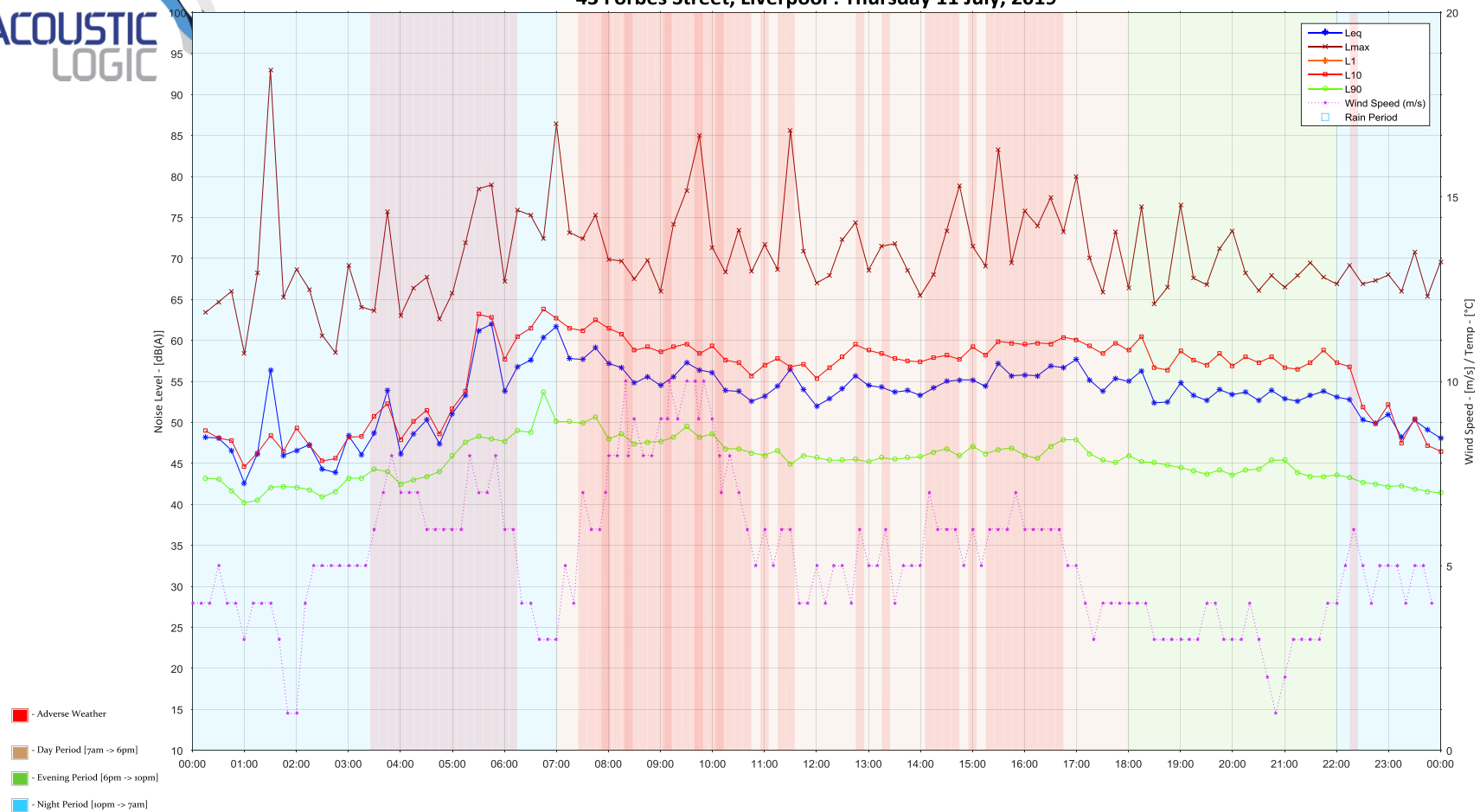
43 Forbes Street, Liverpool : Tuesday 09 July, 2019



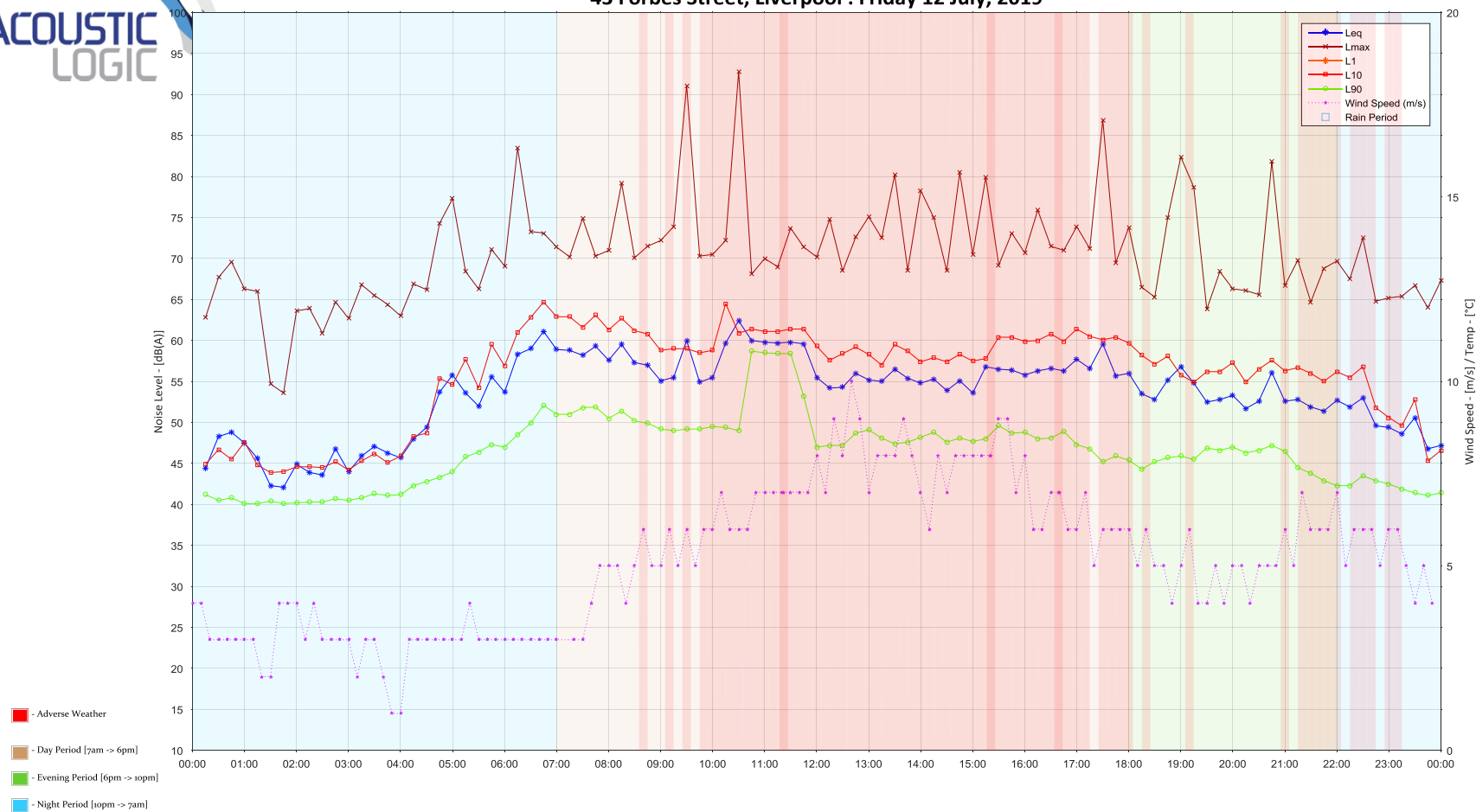
43 Forbes Street, Liverpool : Wednesday 10 July, 2019



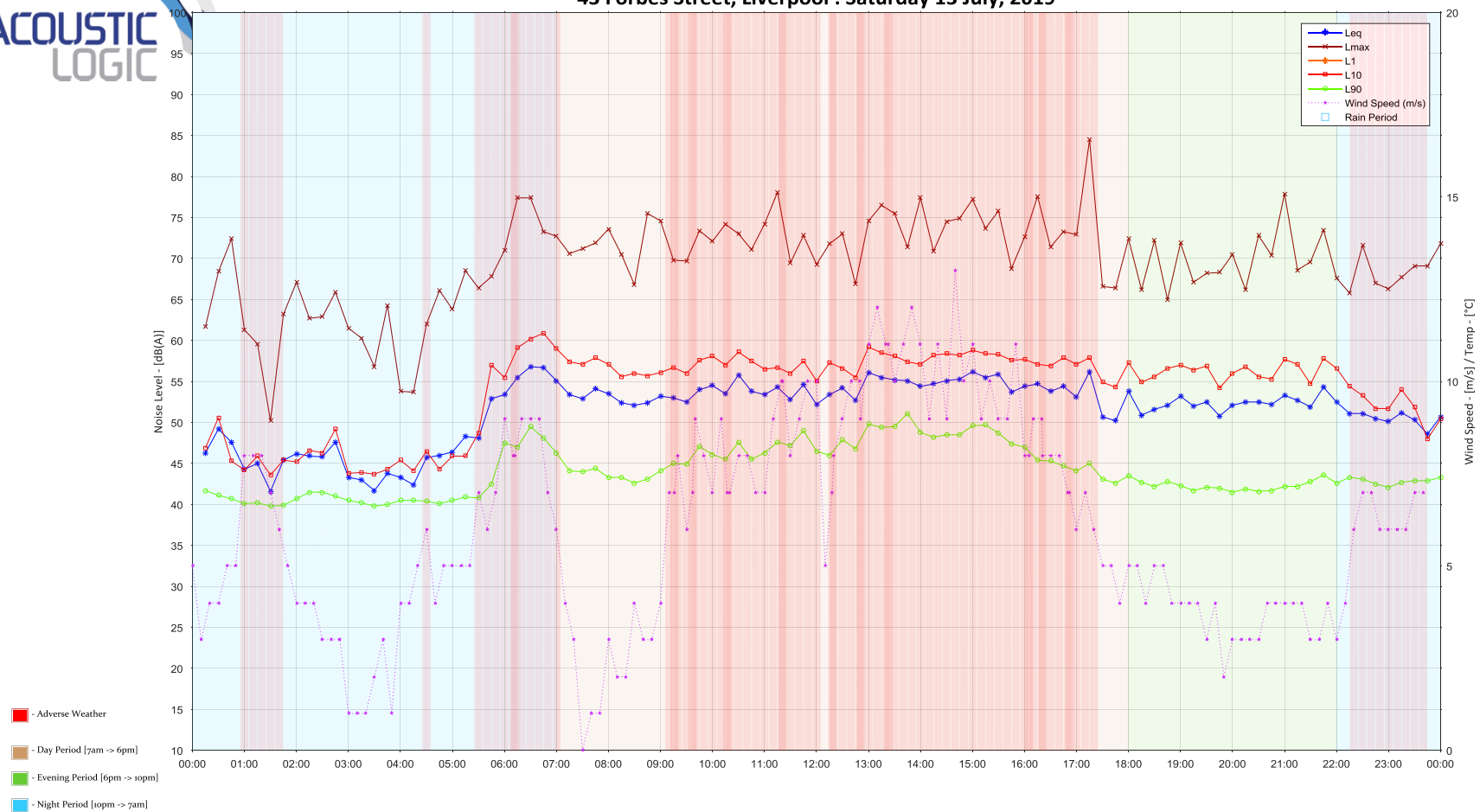
43 Forbes Street, Liverpool : Thursday 11 July, 2019



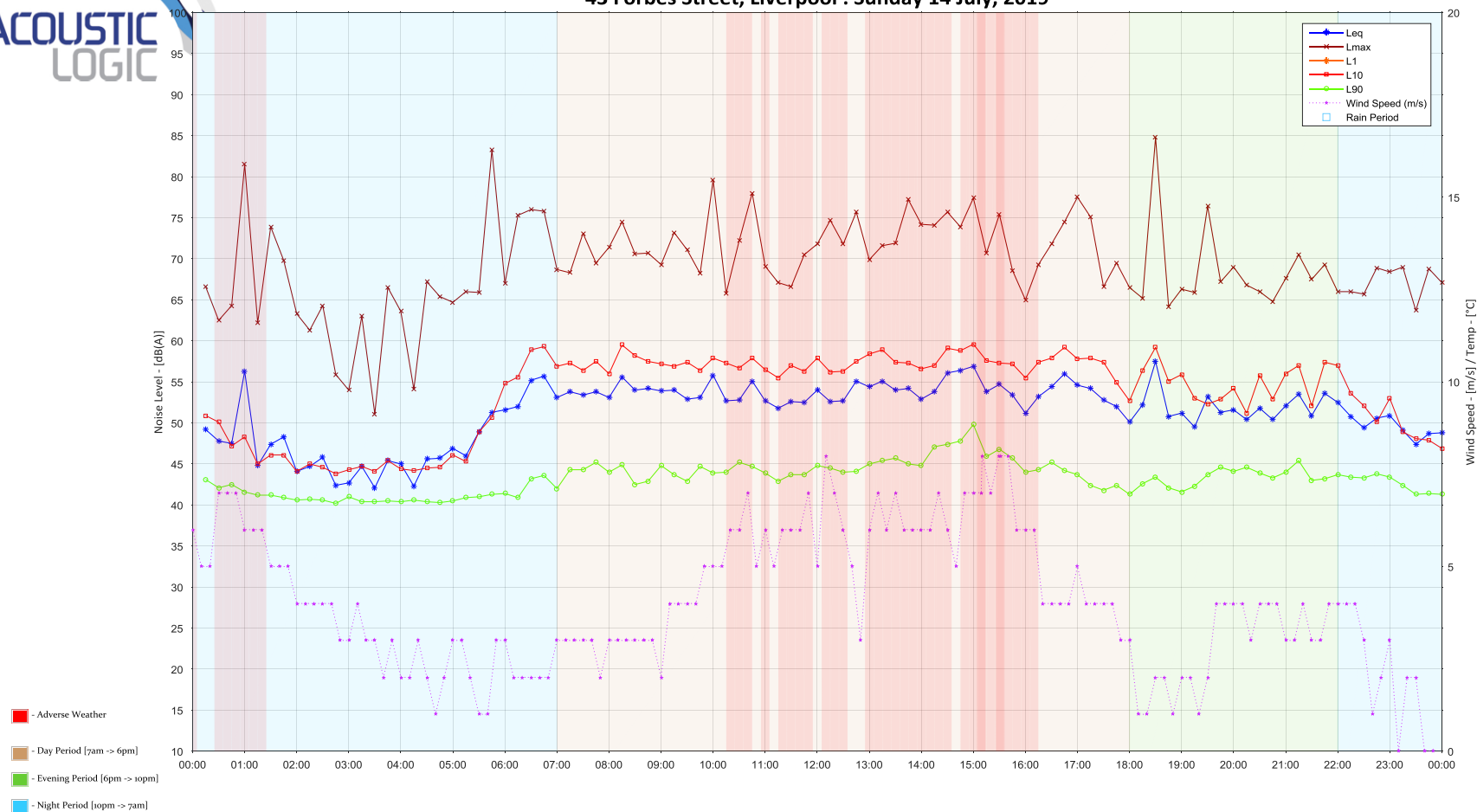
43 Forbes Street, Liverpool : Friday 12 July, 2019



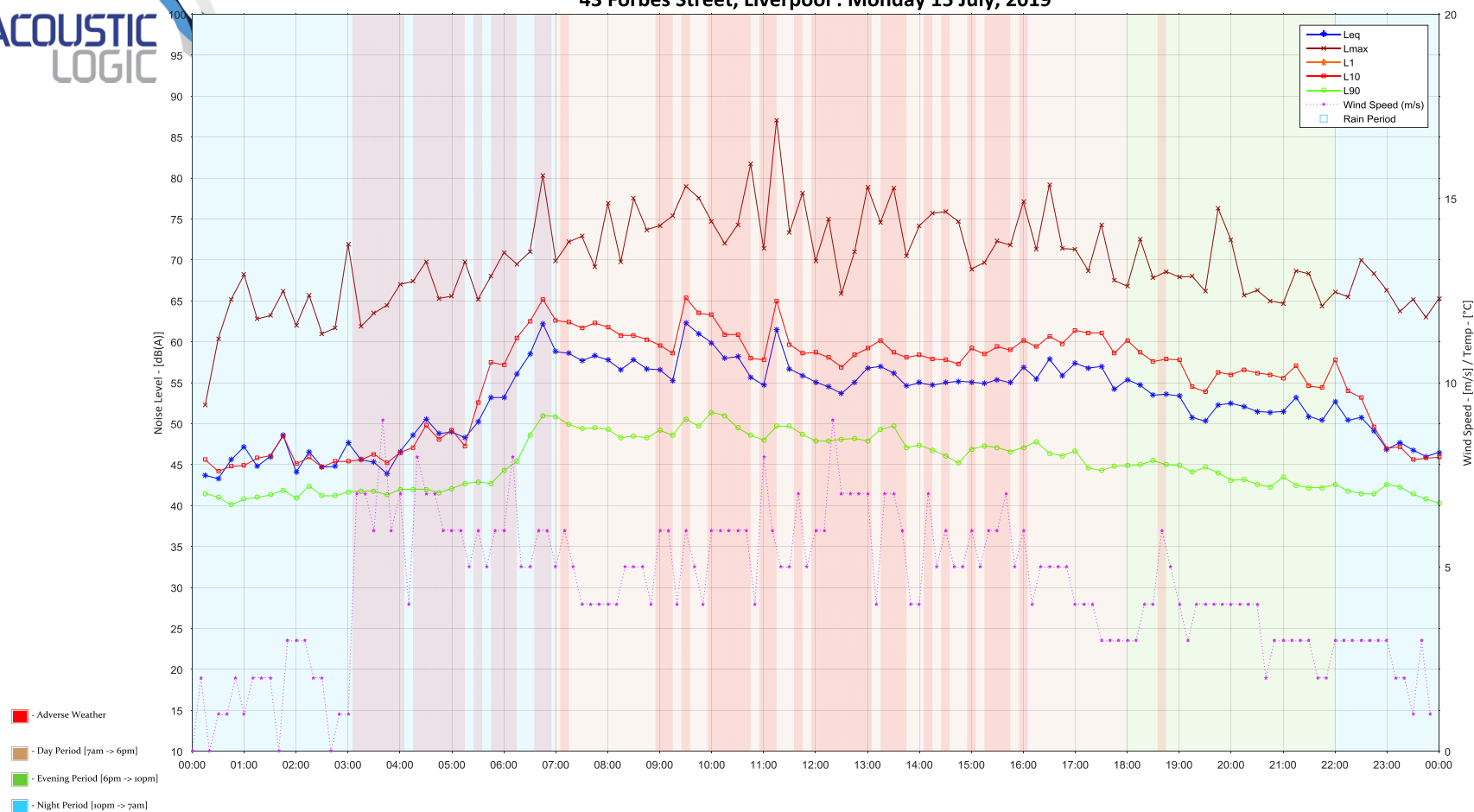
43 Forbes Street, Liverpool : Saturday 13 July, 2019



43 Forbes Street, Liverpool : Sunday 14 July, 2019



43 Forbes Street, Liverpool : Monday 15 July, 2019



43 Forbes Street, Liverpool : Tuesday 16 July, 2019

