SYDNEY FOOTBALL STADIUM REDEVELOPMENT

STATE SIGNIFICANT DEVELOPMENT APPLICATION

Concept Proposal and Stage 1 Demolition

SSDA 9249

APPENDIX K:

Noise and Vibration Assessment

NSW GOVERNMENT

Infrastructure New South Wales

Sydney Football Stadium Redevelopment

Stage 1 SSDA - Noise and Vibration Impact Assessment

R05

| 5 June 2018

Job number 259997

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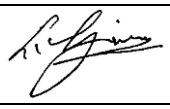
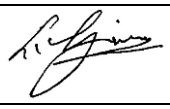
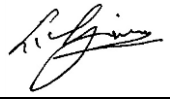
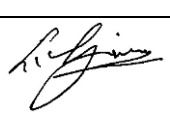
Document Verification

ARUP

Job title		Sydney Football Stadium Redevelopment			**Job number** 259997
Document title		Stage 1 SSDA - Noise and Vibration Impact Assessment			**File reference** AC01-v5
Document ref		R05			
Revision	**Date**	**Filename**	AC01-v1_SFSR_Noise and Vibration Impact Assessment.docx		
Draft 1	6 April 2018	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	M Simon	N Boulter	N Boulter
		Signature			
Draft 2	9 May 2018	**Filename**	AC01-v2_SFSR_Noise and Vibration Impact Assessment.docx		
		Description	Second draft		
			Prepared by	Checked by	Approved by
		Name	M Simon	G Wheatley	G Wheatley
		Signature			
Draft 3	11 May 2018	**Filename**	AC01-v3_SFSR_Noise and Vibration Impact Assessment.docx		
		Description	Appendices and figures updated		
			Prepared by	Checked by	Approved by
		Name	M Simon	G Wheatley	G Wheatley
		Signature			
Draft 4	25 May 2018	**Filename**	AC01-v4_SFSR_Noise and Vibration Impact Assessment.docx		
		Description	Updated as per INSW and SCGT comments		
			Prepared by	Checked by	Approved by
		Name	M Simon	G Wheatley	G Wheatley
		Signature			

Final	5 June 2018	**Filename**	AC01-v5_SFSR_Noise and Vibration Impact Assessment.docx		
		Description	Updated as per DPE adequacy comments		
			Prepared by	Checked by	Approved by
		Name	M Simon	G Wheatley	G Wheatley
		Signature			
			Issue Document Verification with Document		✓

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1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) for the redevelopment of the Sydney Football Stadium which is submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). A staged approach to the planning applications is proposed which includes:

- Stage 1 – Concept Proposal for the stadium envelope and supporting retail and functional uses as well as development consent for the carrying out of early works, including demolition of the existing facility and associated structures.
- Stage 2 – Detailed design, construction and operation of the stadium and supporting business, retail and functional uses.

This report relates to the Stage 1 Concept DA and detailed Early Works package.

Infrastructure NSW is the Proponent for the Stage 1 planning application.

A list of referenced documents is provided in Appendix A.

A glossary of the acoustic terminology used in this report has been included in Appendix B.

1.1 Background

The Sydney Football Stadium (SFS) is a significant component of the sports facilities that comprise the Sydney Cricket and Sports Ground (SC&SG). Completed in 1988, the SFS has hosted numerous sporting events in its 30 years of operation for a number of sporting codes including football (soccer), rugby league and rugby union as well as occasional music concerts.

In 2012, the NSW Government announced the *NSW Stadia Strategy 2012* which provided a vision for the future of stadia within NSW, prioritising investment to achieve the optimal mix of venues to meet community needs and to ensure a vibrant sports and event environment in NSW. A key component of the strategy included development of master plans for Tier 1 stadia and their precincts covering transport, integrated ticketing, spectator experience, facilities for players, media, corporate and restaurant and provision for entertainment. SFS is one of three Tier 1 stadia within NSW, the others being Stadium Australia (Olympic Park) and the Sydney Cricket Ground.

To qualify for Tier 1 status, a stadium is required to include:

- Seating capacity greater than 40,000;
- Regularly host international sporting events;
- Offer extensive corporate facilities, including suites, open-air corporate boxes and other function/dining facilities; and
- Be the home ground for sporting teams playing in national competitions.

Following release of the NSW Stadia Strategy, the Sydney Cricket and Sports Ground Trust (SCSGT) undertook master planning culminating in the 2015 Preliminary SCG Master Plan. This master plan defines the context for future redevelopment of the SCG, SFS and related sports infrastructure to ensure that the precinct continues to meet the needs and expectations of visitors and tenants into the future.

In a competitive national landscape, the existing Allianz Stadium (SFS) is now facing serious commercial and operational challenges to remain relevant and competitive. The SFS was constructed many years ago and therefore it fails to meet certain criteria for modern Tier 1 stadiums. The stadium has aged poorly and fails to meet expectations with regards to patron experience, crowd management, safety/security, accessibility, facilities for core tenants, operational efficiency, premium hospitality and food/beverage offerings and media requirements.

On 24 November 2017, the NSW Premier announced the redevelopment of the SFS into a world-class stadium with up to 45,000 seats. The redevelopment will include demolition of the existing facility and replacement with a modern, globally competitive stadium that achieves the requirements for a Tier 1 stadium to meet future requirements. Redevelopment of the SFS will assist in supporting the realisation of the Master Plan principles to:

- Create a flexible venue suitable for sports, e-sports and major events alike;
- Include technology for the future;
- Create a venue for the growth of men's and women's elite sport, as well as the ability to adapt to new sports and the rise of e-sports;
- Create a publicly accessible entertainment and recreational facility;
- Create a stadium integrated with its surrounds including Centennial and Moore Parks and the surrounding residential and business areas; and
- Create a sustainable future.

1.2 Site description

The site is located at 40-44 Driver Avenue, Moore Park within the Sydney Cricket Ground Precinct. It is bound by Moore Park Road to the north, Paddington Lane to the east, the existing SCG stadium to the south and Driver Avenue to the west. The site is located within the City of Sydney local government area.

The site is legally described as Lots 1528 and 1530 in Deposited Plan 752011 and Lot 1 in Deposited Plan 205794. The site is Crown Land, with the SCSGT designated as the sole trustee under the *Sydney Cricket and Sports Ground Act 1978*. The site is wholly contained within designated land controlled by the Sydney SCSGT under Schedule 2A of the *Sydney Cricket and Sports Ground Act 1978*.

In a broader context, the site is largely surrounded by Centennial and Moore Parks, the Fox Studios and Entertainment Quarter precincts and the residential

suburb of Paddington. Located approximately 3 km from the Sydney CBD and approximately 2km from Central Station, the site is connected to Sydney's transport network through existing bus routes and will benefit from a dedicated stop on the soon to be completed Sydney CBD and South East Light Rail.

The locational context of the Site is shown in Figure 1, whilst the site boundaries and existing site features are shown in Figure 2.

Figure 1: Regional site context

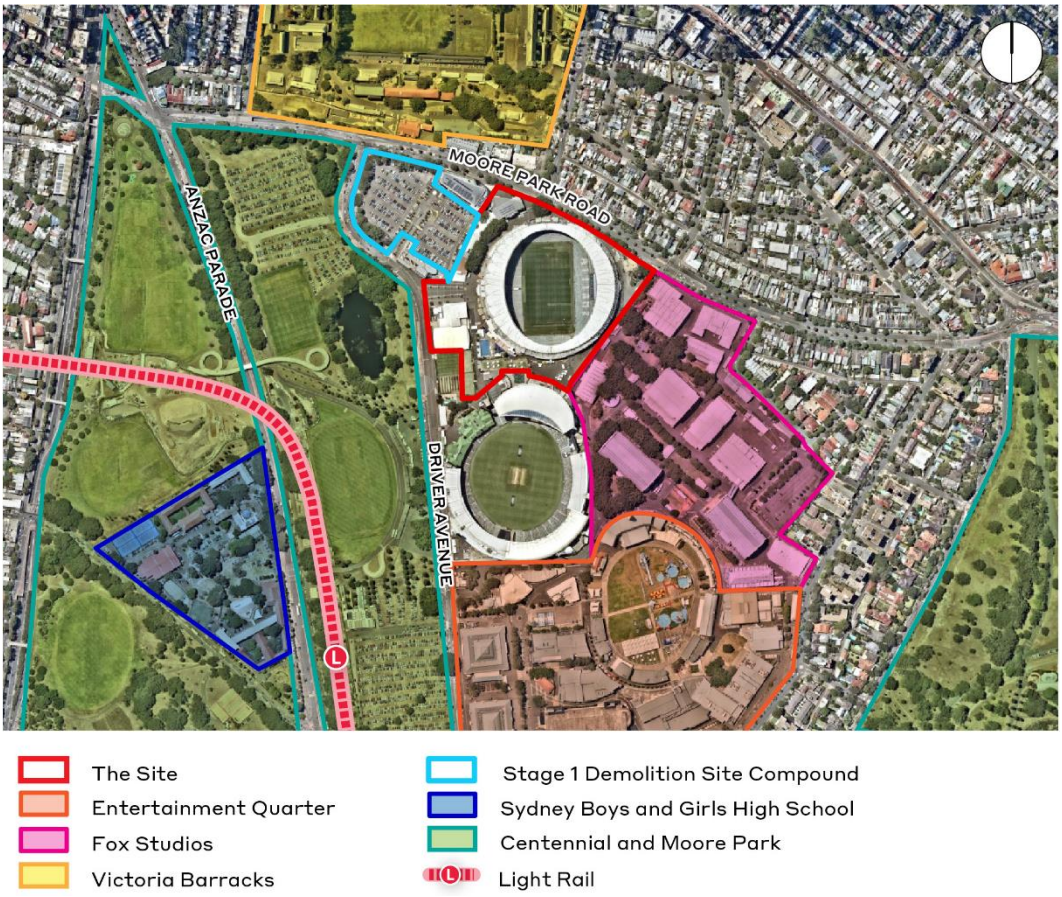

Figure 2: Site area and local context

1.3 Overview of proposed development

The SFS Redevelopment Stage 1 application includes a Concept Proposal and Early Works package.

The Concept Proposal comprises:

- A new stadium with up to 45,000 seats on the site of the existing stadium including:
    - New facilities for general admission;
    - New playing pitch;
    - Hospitality facilities; and
    - Ancillary food and beverage and entertainment facilities.
- New basement with service vehicular access for servicing and bump-in/bump-out;
- New public domain works surrounding the stadium, building on the venue's unique parkland setting;
- Urban Design and Public Domain Guidelines; and

- Signage strategy.

Indicative concept building envelope plans are included within the Environmental Impact Statement for the project. These plans outline the extent of the proposed stadium building envelope and surrounding public domain to be included in the Stage 1 planning application.

From a capacity, operational and mix-of-use perspective, the new stadium will be consistent with the existing Allianz Stadium.

The Stage 1 Early Works comprises:

Site establishment, including erection of site protection fencing and temporary relocation of facilities;

Decommissioning and demolition of the existing stadium and associated structures including the existing Sheridan, Roosters and Waratahs buildings and the administration building of Cricket NSW to ground level and 'make safe' of the site;

Use of the existing Moore Park 1 (MP1) car park for construction staging; and

Make good of the site suitable for construction of the new stadium (subject to separate Stage 2 application).

The SFS Redevelopment will create a new stadium with up to 45,000 seats through a range of seating styles and corporate facilities. The stadium will include state of the art technology with digital screens throughout to improve the fan experience. Sightlines will be improved and facilities including catering, amenities and accessibility will be designed to service future needs, creating a world-class customer experience befitting a global city such as Sydney.

1.4 Purpose of report

This report describes the outcomes of an early works construction and operational noise and vibration assessment to address the requirements for SSD 9249 application for the redevelopment of the Sydney Football Stadium dated 3 2018.

Concept Proposal Key Issue 7 and Stage 1 Works Key Issue 2 of the SEARs for application SSD 9249 sets out the following requirements regarding the assessment of noise and vibration:

> ***Concept Proposal***
>
> *The EIS must address the following specific matters:*
>
> ***7. Noise and Vibration***
>
> - *Identify and provide a qualitative assessment of the main noise and vibration generating sources including demolition, site preparation, piling, earthworks, construction, concrete crushing and operation of the stadium (including pre, during, and post- events where amplification will be used).*

- *Outline key noise mitigation and management measures that would inform the final design of the stadium to minimise potential noise impacts on the surrounding sensitive receivers.*

Stage 1 Works

The EIS for the Stage 1 works including demolition of the existing stadium to ground level must address the following specific matters:

2. Noise and Vibration

- *Identify and provide a quantitative assessment of the main noise and vibration generating sources and activities during Stage 1 including, where applicable, demolition, site preparation, piling, earthworks, construction, concrete crushing. This should include an assessment of:*
  - *background noise at the most affected sensitive receivers within the site, adjacent to the site and in close proximity to the site in accordance with the guidance material provided in EPA's Noise Policy for Industry (NPI) 2017;*
  - *detailed noise modelling of noise generated as part of the Stage 1 works at sensitive receivers;*
  - *intra-day respite periods for continuous, noisy works; and*
  - *the locations and hours of all noisy equipment, including the concrete batching plant, if relevant;*
- *Outline measures to minimise and mitigate the potential noise impacts on all surrounding sensitive receivers.*

SSD 9249 also references the following policies relevant to acoustics:

- NSW Noise Policy for Industry 2017 (EPA) [1];
- Interim Construction Noise Guideline (DECC) [2];
- Assessing Vibration: A Technical Guideline 2006 [3]; and
- Development Near Rail Corridors and Busy Roads – Interim Guideline (Department of Planning 2008) [4].

The Development Near Rail Corridors and Busy Roads (Department of Planning, NSW) addresses noise from rail and road traffic on residential use, a place of worship, a hospital, an educational establishment or childcare centre. This document is referred to in Key Issue 7 of the SEARs; however, as these types of development are not proposed for the SFS it is considered that the guideline is not applicable.

The Site is not located adjacent to a 'busy road', defined as a road with an Average Annual Daily Traffic volume of >40,000 vehicles, or a rail corridor, the assessment of the Project under this Guideline is not required.

1.5 Report Structure

The policies and guidelines outlined in Section 1.4 have been addressed in this report as follows:

Acoustic aspect	SEARs addressed	Policy or guideline	Report section
Construction noise & vibration	• Identify and provide a qualitative assessment of the main noise and vibration generating sources including demolition, site preparation, piling, earthworks, construction, concrete crushing	Interim Construction Noise Guideline (DECC) [2] Assessing Vibration: A Technical Guideline 2006 [3]	Section 3
Operational noise & vibration	• Identify and provide a qualitative assessment of the main noise and vibration generating sources including… operation of the stadium (including pre, during, and post- events where amplification will be used).	NSW Noise Policy for Industry 2017 (EPA) [1]	Section 4 & 5
Mitigation measures	• Outline key noise mitigation and management measures that would inform the final design of the stadium to minimise potential noise impacts on the surrounding sensitive receivers. • Outline measures to minimise and mitigate the potential noise impacts on all surrounding sensitive receivers.	-	Section 6

2 Existing Conditions

2.1 Site location

The proposed site is in the suburb of Moore Park, located approximately three kilometres from the Sydney CBD. Moore Park is comprised mainly of open parkland; except for the former Showground (now Fox Studios, the Entertainment Quarter and the Equestrian Centre). Although Moore Park Golf Course comprises open space, it is not publicly accessible parkland. The parklands are generally surrounded by residential zones, including the suburbs of Paddington to the north-east, Kensington to the south, and Surry Hills to the west. with educational facilities and commercial zones interspersed.

The site is bounded by Moore Park Road to the north, with the residential suburb of Paddington located beyond. Fox Studios is located adjacent to the south-east, with residences in the suburb of Centennial Park located further south-east. The Sydney Cricket Ground (SCG) is located adjacent to the south with the Entertainment Quarter located further south. To the immediate west lies Driver Avenue, and beyond it Moore Park, with Anzac Parade intersecting it and South Dowling further west. The residential suburbs of Surry Hills and Redfern lie further west of South Dowling street.

Event noise has been a feature of the area for over 150 years, with the current Allianz Stadium constructed in 1988, which was built upon the former Sydney Sports Ground which opened in 1911.

Sporting events hosted at the site have including athletics, rugby league, rugby union, soccer, motorcycle and car speedway racing.

Maps showing the location of the site and the surroundings are included in Section 1.2 above.

2.2 Acoustic environment

As the site is located on the outskirts of the Sydney CBD, traffic noise is the dominant acoustic feature of the area. The site is located adjacent to Moore Park Road to the north, with Anzac Parade located to the west beyond Moore Park East, and the Eastern Distributor located further west beyond Moore Park West.

The main noise sources on site are:

- Road traffic along Moore Park Road and Anzac Parade;
- CBD ‘urban hum’;
- Aircraft noise;
- General activity noise from users of the existing facilities; and
- Infrequent event noise from Allianz Stadium and the SCG.

The above sources generally vary in level over the day.

2.3 Noise sensitive receivers

The proposed site is near a built-up residential zone, with residential areas located to the north and north-east in Paddington, east and south-east in Centennial Park, as well as west along South Dowling Street in Surry Hills and Redfern.

Rating Background Levels (RBLs) vary across receivers surrounding the site. Residential receivers located within similar environments and with comparable relationship to surrounding noise sources have been grouped into Noise Catchment Areas (NCAs), also shown in Figure 3 and described in Table 1.

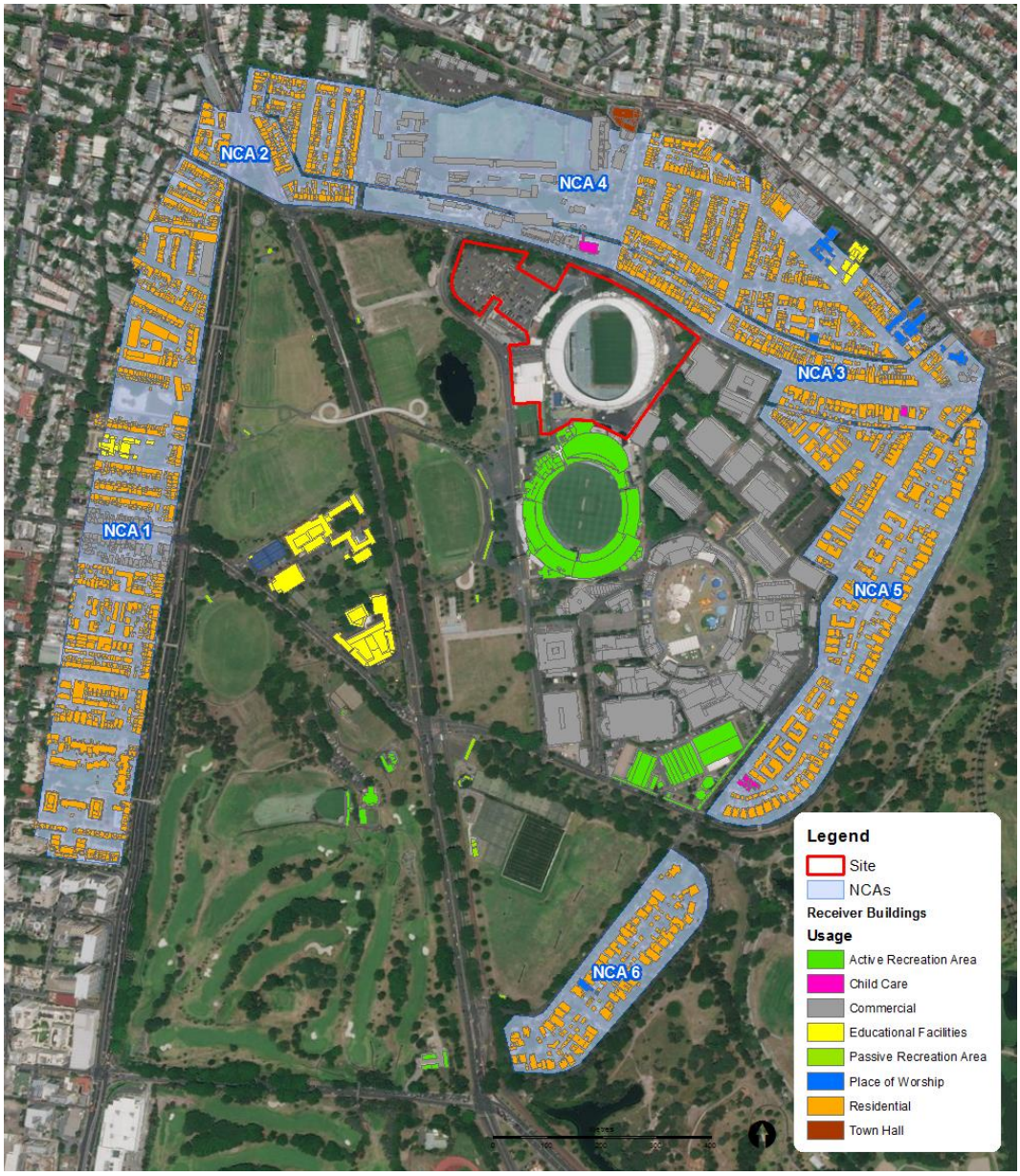

Figure 3: Noise sensitive receiver locations and NCAs

Table 1: NCAs and description

NCA	Description	Classification
NCA 1	Surry Hills & Redfern along South Dowling Street	Urban
NCA 2	Surry Hills intersection between Anzac Parade and Flinders Street	Urban
NCA 3	Paddington, Moore Park Road	Urban
NCA 4	Paddington local roads	Urban
NCA 5	Centennial Park Lang Road and local roads	Suburban
NCA 6	Centennial Park Robertson Road and local roads	Suburban

NCA boundaries have been determined based on site observations and attended measurements, which are detailed in Table 7. Classifications of NCAs 1, 2, 3 and 4 as urban are based on on-site observations, and in accordance with the NPI, that these areas have "*through-traffic with characteristically heavy and continuous traffic flows during peak periods"*, and NCAs 5 and 6 are areas that have *"local traffic with characteristically intermittent traffic flows"* and have the following characteristic: "*evening ambient noise levels defined by the natural environment and human activity*".

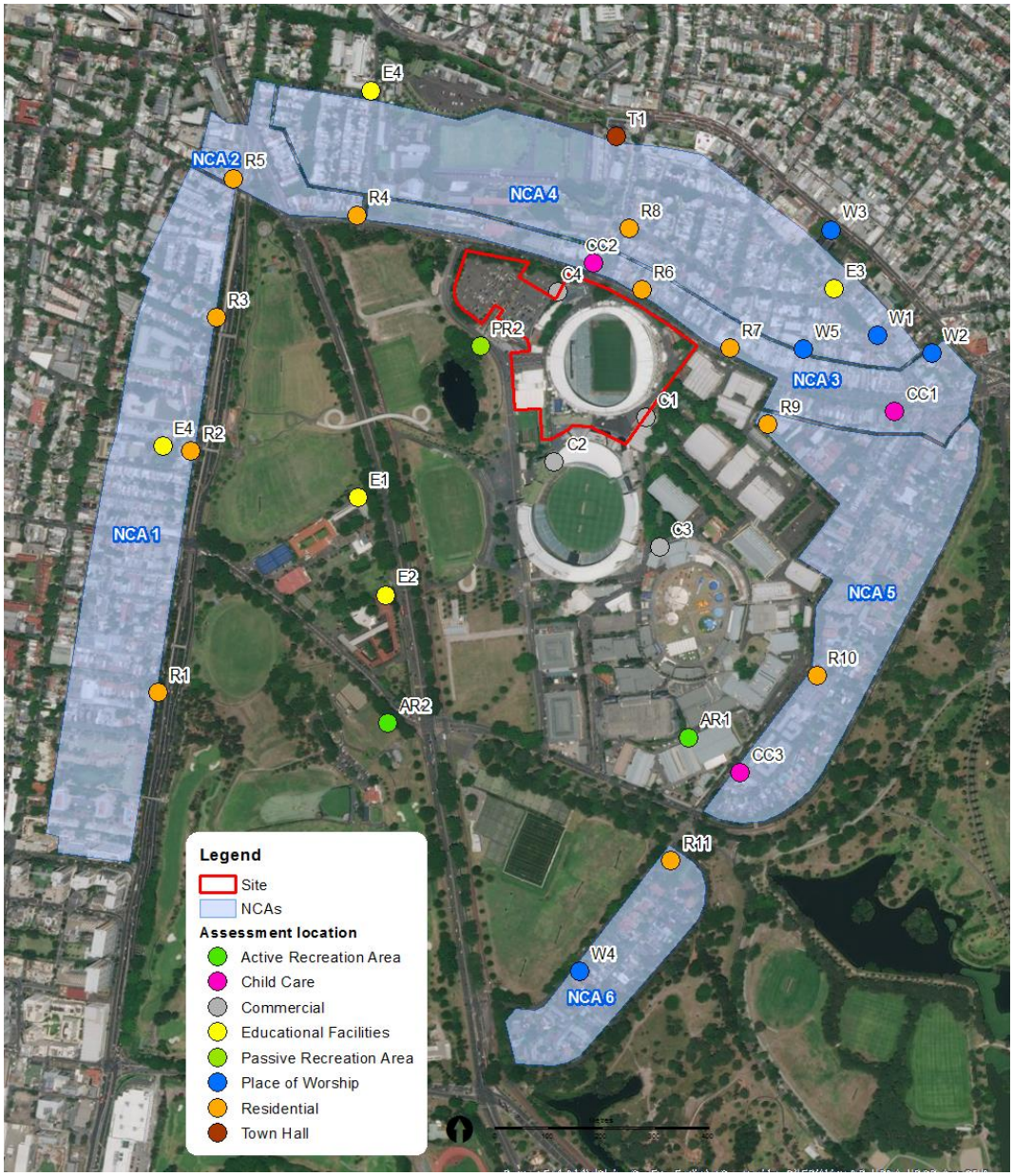

Figure 4: Assessment locations and NCAs

In accordance with the NPI the reasonably most-affected residences have been identified in each NCA have been identified and are presented in Table 2. While noise predictions have been carried out to each receiver, for clarity, the assessment of residential receivers presented in this report is isolated to the reasonably most-affected receivers.

Table 2: Reasonably most-affected residential receivers

Receiver ID	Address	No. of floors	NCA
R1	749 South Dowling Street, Redfern	2	1
R2	635 South Dowling Street, Surry Hills	3	1
R3	553 South Dowling Street, Surry Hills	3	1

Receiver ID	Address	No. of floors	NCA
R4	111 Greens Rd, Paddington	2	2
R5	479 South Dowling Street, Surry Hills	3	2
R6	252 Moore Park Road, Paddington	2	3
R7	314 Moore Park Road, Paddington	2	3
R8	45 Oatley Road. Paddington	2	4
R9	5 Poate Road, Paddington	2	5
R10	107 Cook Road, Centennial Park	2	5
R11	2 Martin Road, Moore Park	3	6

A list of all non-residential noise sensitive receivers within the study area is presented in Table 3.

Table 3: Non-residential receivers

Receiver ID	Usage	Name	Address	No. of floors
AR1	Active Recreation Area	Centennial Parklands Equestrian Centre	114-120 Lang Road, Moore Park	2
AR2	Active Recreation Area	Moore Park Golf Course	Cleveland Street, Moore Park	0
C1	Commercial	Fox Studios	38 Driver Avenue, Moore Park	2
C2	Commercial	Sydney Cricket Ground	Driver Avenue, Moore Park	3
C3	Commercial	Entertainment Quarter	122 Lang Road, Moore Park	3
C4	Commercial	University of Technology Sydney Rugby Australia and NRL building	Moore Park Road and Driver Avenue, Moore Park	5
CC1	Child Care	Gumnut Gardens Early Learning and Long Day Care Ce	61 Moore Park Road, Centennial Park	1
CC2	Child Care	Kira Child Care Centre	230 Moore Park Road, Paddington	1
CC3	Child Care	Bambini's Child Care Centre	157/159 Cook Road, Centennial Park	2
E1	Educational Facilities	Sydney Boys High School	556 Cleveland Street, Moore Park	3
E2	Educational Facilities	Sydney Girls High School	Corner of Anzac Parade and Cleveland Street, Surry Hills	2
E3	Educational Facilities	Paddington Public School	399-435 Oxford Street, Paddington	2
E4	Educational Facilities	Bourke Street Public School	590 Bourke Street, Surry Hills	2
E4	Educational Facilities	UNSW Art & Design	Corner Oxford Street & Greens Road, Paddington	4
PR2	Passive Recreation Area	Moore Park	Moore Park	0
T1	Town Hall	Paddington Town Hall	249 Oxford Street, Paddington	2
W1	Place of Worship	St Francis of Assisi Catholic Church	64 Gordon Street, Paddington	3
W2	Place of Worship	St Mattias Anglican Church	471-475 Oxford Street, Paddington	2
W3	Place of Worship	Paddington Uniting Church	395 Oxford Street, Paddington	2
W4	Place of Worship	St. Vladimir's Russian Orthodox Church	31 Robertson Rd, Centennial Park	2
W5	Place of Worship	Kingdom Hall of Jehovah's Witnesses	20 Leinster St, Paddington	2

2.4 Measurement of existing noise levels

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

2.5 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or if a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The short-term and long-term measurement locations are outlined in Table 4 and shown in Figure 5.

Table 4: Measurement summary

ID	NCA	Measurement location	Measurement type	Comment on location suitability
Meas. 1	1	587 South Dowling Street	Long and short term	Noise from South Dowling Street was noted as consistent along the length of NCA 1, therefore this location is considered representative of background noise levels at the worst affected receivers within NCA 1.
Meas. 2	2	24 Moore Park Road	Long and short term	Considered representative of reasonably most-affected residences, at south-eastern corner of NCA 2.
Meas. 3	3	256 Moore Park Road	Long and short term	Considered representative of reasonably most-affected residences, directly opposite the SFSR site along Moore Park Road.
Meas. 4	4	43 Stewart Street	Long and short term	Monitoring location was considered representative of reasonably most-affected residences within NCA 4. Noise levels along Stewart Street were observed as consistent, being shielded from Moore Park Road by intervening buildings. Measured noise levels may be slightly lower than those at the western end of Stewart Street, however this would result in slightly conservative RBL based criteria.

ID	NCA	Measurement location	Measurement type	Comment on location suitability
Meas. 5	5	11 Furber Road	Long and short term	Monitoring location was considered representative of reasonably most-affected residences within NCA 5. Noise levels throughout NCA 5 were observed as consistent, being shielded from Moore Park Road by intervening buildings. Measured noise levels may be slightly lower than those at the western end of NCA 5, however this would result in slightly conservative RBL based criteria.
Meas. 6	6	17 Robertson Road	Long and short term	Considered representative of reasonably most-affected residences, at a similar distance from Anzac Parade.
Meas. 7	-	Sydney Boys High School	Long and short term	-

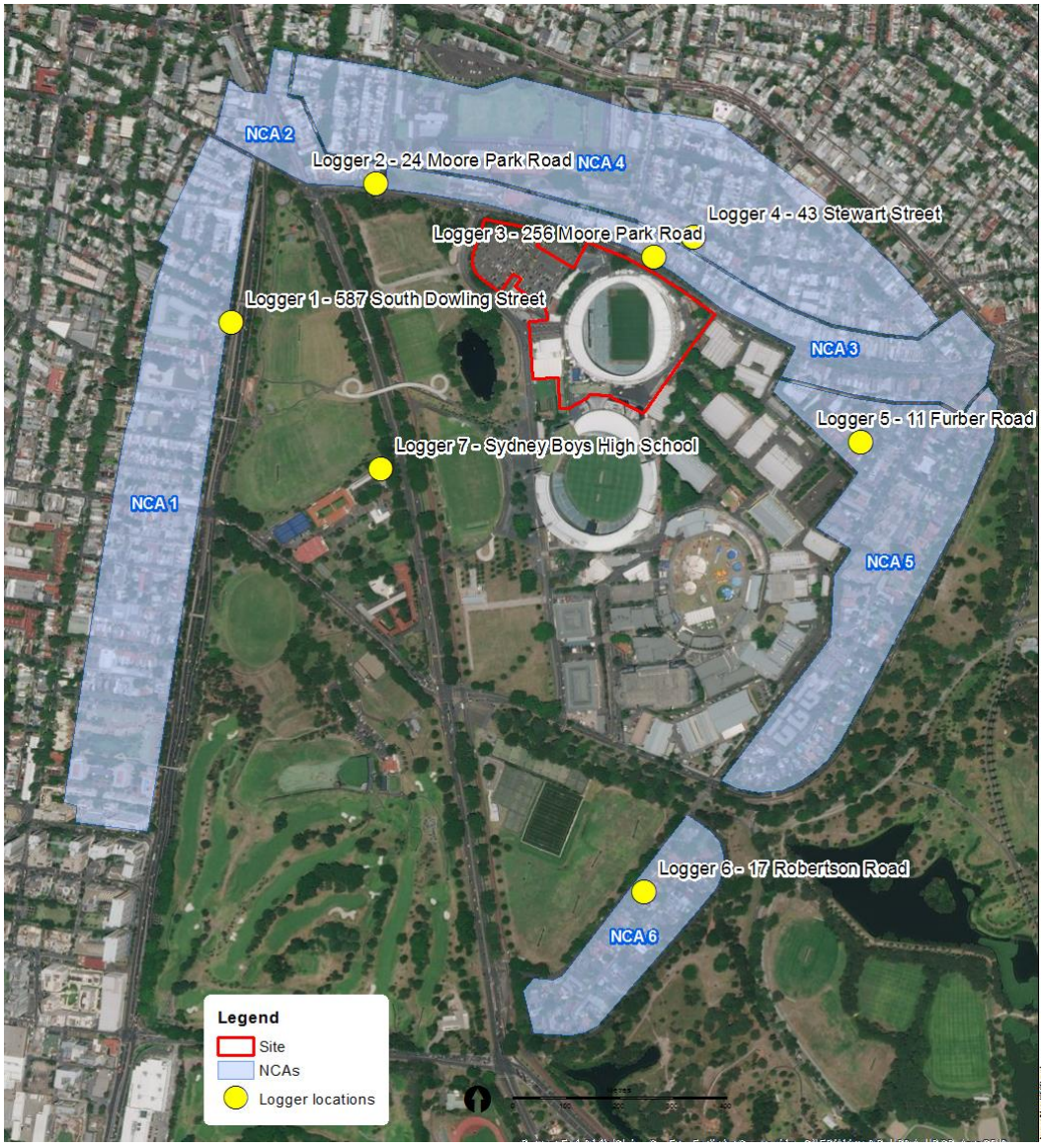

Figure 5: Measurement locations and NCAs

2.6 Long-term unattended noise measurement results

Long-term noise monitoring was carried out from Wednesday 21 February 2018 to Monday 5 March 2018 by Arup. Monitoring was conducted in accordance with Appendix B1 of the NPI [1]. The NPI separates the 24-hour day into three different time periods – day, evening and night. These time periods are detailed below in Table 5.

Table 5: Standard NPI time periods

Period	Day of Week	Time period
Day	Monday-Saturday Sunday, Public Holidays	7:00 am-6:00 pm 8:00 am-6:00 pm
Evening	Monday-Sunday	6:00 pm -10:00 pm
Night	Monday-Saturday Sunday, Public Holidays	10:00 pm -7:00 am Operating times of the stadium are limited to 11:00 pm, therefore RBLs have been calculated based on this period, see Table 6. 10:00 pm -8:00 am

The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix C.

Table 6 presents the overall single RBLs and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the NPI.

Table 6: Long-term noise monitoring results

ID	NCA	Location	Time period	RBLs[1], dBL_{A90}	Ambient $dBL_{Aeq(period)}$
Meas. 1	NCA 1	587 South Dowling Street	Day	58	69
			Evening	56	68
			Night[1]	55	67
Meas. 2	NCA 2	24 Moore Park Road	Day	56	67
			Evening	52	65
			Night[1]	51	62
Meas. 3	NCA 3	256 Moore Park Road	Day	52	68
			Evening	49	66
			Night[1]	49	64
Meas. 4	NCA 4	43 Stewart Street	Day	43	57
			Evening	41	55
			Night[1]	41	46
Meas. 5	NCA 5	11 Furber Road	Day	39	60
			Evening	36	56
			Night[1]	35	43
Meas. 6	NCA 6	17 Robertson Road	Day	47	57

ID	NCA	Location	Time period	RBLs[1], dBL_{A90}	Ambient $dBL_{Aeq(period)}$
			Evening	47	57
			Night[1]	45	49
Meas. 7	-	Sydney Boys High School	Day	60	72
			Evening	56	70
			Night[1]	56	67

1 - Night-time RBLs have been calculated based on the operational time of the SFS from 10:00pm to 11:00pm.

2.7 Short-term attended noise measurement results

Short-term operator attended noise measurements were conducted on Monday, 5 March 2017 by Arup at each logger location. Noise measurements were conducted over a 15-minute period. Weather conditions were warm, still and clear during measurements.

It should be noted no industrial noise contribution was noted at any of the measurement locations.

Table 7 presents the measured L_{90} and L_{eq} noise levels for at each measurement locations, determined in accordance with the NPI.

Table 7: Short-term noise monitoring results

ID	Location	Date / Time	dBL_{Aeq}	dBL_{A90}	dBL_{Amax}	Description of noise environment
Meas. 1	587 South Dowling Road	5/03/18 11:55AM	68	60	79	Traffic noise dominant Heavy vehicles passing intermittently Drilling / jack hammer from road construction works across South Dowling Street very regular (approx 50m away) Construction generators and vehicles constant in background as well
Meas. 2	24 Moore Park Road	5/03/18 1:09 PM	65	56	82	Traffic noise dominant with significant heavy traffic Bird noise noted
Meas. 3	256 Moore Park Rd	5/03/18 1:33 PM	67	51	85	Traffic noise dominant with significant heavy traffic
Meas. 4	43 Stewart street	5/03/18 1:59 PM	46	39	66	Local traffic only, intermittent Occasional noise from residences and passing foot traffic

Meas. 5	11 Furber Street	5/03/18 2:55 PM	46	38	77	Local traffic only, intermittent Some occasional construction noise - drilling, jack hammer and sawing in background
Meas. 6	17 Robertson Road	5/03/18 3:21 PM	50	43	72	Local traffic only, intermittent Occasional noise from residences and passing foot traffic Bird noise noted
Meas. 7	Sydney Boys School	5/03/18 12:31 PM	70	57	83	Traffic noise dominant on Anzac Parade, including many buses. Construction noise in open area next door to school on northern side of fence - drilling and jack hammer

3 Construction Noise and Vibration

3.1 Overview

Early works construction is being assessed as part of the Stage 1 SSDA. A preliminary early works programme has been prepared by Aver for the SFS redevelopment. The assessment in this report assesses the components of this work, including establishment works and demolition works.

3.2 Construction noise criteria

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all 'feasible and reasonable' work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 8 and other sensitive receivers in Table 9 below.

Table 8: Construction noise management levels at residential receivers

Time of day	**Management level** [1] **$L_{Aeq\ (15\ min)}$**	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

1 - Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 9: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Noise Management level $L_{Aeq(15\ min)}$[1]
Passive recreation areas	External noise level	60 dBA
Active recreation areas	External noise level	65 dBA
Educational institutions	Internal noise level	45 dBA
Place of worship	Internal noise level	45 dBA
Town hall	Internal noise level	45 dBA[2]
Commercial premises	External noise level	70 dBA

1 - Noise management levels apply when properties are in use.

2 - Based on AS/NZS2107:2016 max design level for Municipal building – function area

3.2.1 Project construction noise targets

Construction noise criteria are set based on noise catchment areas relative to proposed construction works. These catchment areas are defined for the project in Section 2.3.

Measured noise data obtained at the logger location most representative of each noise catchment area has been used to derive appropriate noise management levels for the project. These are summarised in Table 10.

Table 10: Residential Noise Management Levels during intended working hours

Location	NCA	Time Period	RBL, dBA	Noise Management Level, $dBL_{Aeq\ 15minute}$	
				Noise affected	Highly noise affected
Residences					
R1	NCA 1	Day	58	68	75
		Evening	56	61	75
		Night	55	60	75
R2	NCA 1	Day	58	68	75
		Evening	56	61	75
		Night	55	60	75
R3	NCA 1	Day	58	68	75
		Evening	56	61	75
		Night	55	60	75
R4	NCA 2	Day	56	66	75
		Evening	52	57	75
		Night	51	56	75
R5	NCA 2	Day	56	66	75
		Evening	52	57	75
		Night	51	56	75
R6	NCA 3	Day	52	62	75
		Evening	49	54	75
		Night	49	54	75
R7	NCA 3	Day	52	62	75
		Evening	49	54	75
		Night	49	54	75
R8	NCA 4	Day	43	53	75
		Evening	41	46	75
		Night	41	46	75
R9	NCA 5	Day	39	49	75
		Evening	36	41	75
		Night	35	40	75
R10	NCA 5	Day	39	49	75
		Evening	36	41	75
		Night	35	40	75
R11	NCA 6	Day	47	57	75
		Evening	47	52	75

Location	NCA	Time Period	RBL, dBA	Noise Management Level, $dBL_{Aeq\ 15minute}$	
				Noise affected	Highly noise affected
		Night	45	50	75

Table 11: Non-residential Noise Management Levels during intended working hours

Usage	Receiver ID	Name	Time period	NML, $dBL_{Aeq\ 15minute}$
Active recreation area	AR1	Centennial Parklands Equestrian Centre	When in use	65
	AR2	Moore Park Golf Course	When in use	65
Commercial premise	C1	Fox Studios	When in use	70
	C2	Sydney Cricket Ground	When in use	70
	C3	Entertainment Quarter	When in use	70
	C4	University of Technology Sydney Rugby Australia and NRL building	When in use	70
Child Care	CC1	Gumnut Gardens Early Learning and Long Day Care Ce	When in use	70
	CC2	Kira Child Care Centre	When in use	70
	CC3	Bambini's Child Care Centre	When in use	70
Educational institution	E1	Sydney Boys High School	When in use	55
	E2	Sydney Girls High School	When in use	55
	E3	Paddington Public School	When in use	55
	E4	Bourke Street Public School	When in use	55
	E4	UNSW Art & Design	When in use	55
Passive recreation area	PR2	Moore Park	When in use	60
Town hall	T1	Paddington Town Hall	When in use	55
Place of worship	W1	St Francis of Assisi Catholic Church	When in use	55
	W2	St Mattias Anglican Church	When in use	55
	W3	Paddington Uniting Church	When in use	55
	W4	St. Vladimir's Russian Orthodox Church	When in use	55
	W5	Kingdom Hall of Jehovah's Witnesses	When in use	55

3.3 Construction vibration criteria

Vibration criteria for construction works are established in the following sections. Vibration management measures have been recommended in Section 6.2.

3.3.1 Human comfort

The NSW EPA's *Assessing Vibration – A Technical Guideline* [3] provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472-1:2008 [5].

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV considers both the magnitude of vibration events and the number of instances of the vibration event. Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as 'impulsive' sources for the purposes of assessment.

As noted in the Guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 12 and Table 13 respectively.

Table 12: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	0.10	0.071	0.20	0.14

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.64	0.46	1.28	0.92

1. Criteria for sensitive areas are only indicative, and have been provided as guidance to acceptable vibration levels for the use of sensitive equipment, eg. camera equipment at Fox Studios.

Table 13: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas[1]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

1. Criteria for sensitive areas are only indicative, and there may be a need to assess intermittent vibration against impulsive or continuous criteria.

3.3.2 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with BS7385-2 [6]. BS7385-1 [7], defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of BS7385-2 sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component*

particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.

3.3.2.1 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 14 sets out the BS7385-2 criteria for cosmetic, minor and major damage.

A number of heritage structures have been identified in the vicinity of the SFSR, which include Busby's Bore, sections of the SCG, and some buildings within Fox Studios. Regarding heritage buildings, BS7385-2 notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 14: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures. Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

1 - Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2 - Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

3.4 Noise sources

3.4.1 Construction activities

Assumed construction equipment to be used for redevelopment works are provided in Table 15 (refer to Construction Management Plan).

Equipment sound power levels have been determined by reference to AS2436 [8], DEFRA [9], and Arup's measurement database. The equipment below has been assumed to operate concurrently and continuously over a full 15-minute period (a typical worst case assumption).

The locations of equipment have been based on the locations of the demolition and construction works around the precinct.

Table 15: Construction equipment usage and associated sound power levels (Lw)

Stage	Approx. duration	Description of noise intrusive works in sub-stage	Equipment	Number of units operating on site within worst case 15-minutes	Sound Power Lw, dBA
1 - Procurement & establishment	30 Days	Establishment of project office compound. Installation of sedimentation fencing and erosion controls. Installation of perimeter hoardings, fences and signage.	Trucks	3	98
			Chainsaw	2	114
			Mulcher / chipper	1	116
			50 tonne mobile crane	1	106
			Boom lift	1	97
			Light vehicles	3	90
2 Ancillary building demolition works	190 days	Removal of classified hazardous materials. Removal of internal fitout. Demolition of roof structure. Demolition of concrete structural components. Breaking up of concrete. Removal of light towers.	Long reach excavators	2	98
			Hand tools (electric)	3	102
			40 tonne excavator	3	115
			Jackhammers / Rockbreakers	3	108
			250 tonne crane	1	106
			Boom lift	1	97
			Water tank - generator	3	93
			Re-fuelling tank - generator	2	93
			Bobcats	5	104
			Dump trucks	3	98
			Concrete crusher	1	118
			Light vehicles	3	90
3 - Stadium demolition works	240 days	Removal of classified hazardous materials. Removal of internal fitout. Demolition of roof structure. Demolition of concrete structural components. Breaking up of	Long reach excavators	2	98
			Hand tools (electric)	3	102
			40 tonne excavator	3	115
			Jackhammers / Rockbreakers	3	113
			250/450 tonne crane	1	106
			Boom lift	1	97

Stage	Approx. duration	Description of noise intrusive works in sub-stage	Equipment	Number of units operating on site within worst case 15-minutes	Sound Power Lw, dBA
		concrete. Removal of light towers.	Water tank - generator	3	93
			Re-fuelling tank - generator	2	93
			Bobcats	5	104
			Dump trucks	3	98
			Concrete crusher	1	118
			Light vehicles	3	90

3.4.2 Hours of construction

General demolition and construction works will be undertaken within the hours outlined in Table 16, in accordance with ICNG standard hours of construction.

Table 16: Preferred Hours of Construction

Day	Proposed construction hours
Monday to Friday	7.00 am to 6:00 pm
Saturdays	8.00 am to 1:00 pm
Sundays or Public Holidays	No construction

In some cases, after-hours permits may be sought from the relevant authorities where special requirements exist, for example oversized deliveries.

3.4.3 Modelling methodology

Noise emissions from early works demolition and construction activities associated with the SFSR have been assessed to criteria outlined in Section 3.2.

Noise emissions have been modelled using SoundPlan 8 in accordance with ISO9613-2 algorithms. The model included:

- Construction noise sources listed in Section 3.4.1;
- SFS and surrounding buildings;
- Receivers listed in Table 2; and
- Ground terrain and absorption.

3.4.4 Noise prediction results

Predicted construction noise levels at surrounding receivers are presented in Table 17, along with the relevant NML for the intended working hours (as presented in Table 10).

Table 17: Predicted construction noise levels

Receiver	*NML*	Construction stage		
		1. Procurement & establishment	2. Ancillary building demolition	3. Stadium demolition
		Highest predicted noise level, dBA		
Residential receivers				
R1 - 749 South Dowling Street, Redfern	***68***	42	49	48
R2 - 635 South Dowling Street, Surry Hills	***68***	44	53	52
R3 - 553 South Dowling Street, Surry Hills	***68***	47	56	54
R4 - 111 Greens Rd, Paddington	***66***	50	60	57
R5 - 479 South Dowling Street, Surry Hills	***66***	38	52	50
R6 - 252 Moore Park Road, Paddington	***62***	60	62	71
R7 - 314 Moore Park Road, Paddington	***62***	42	41	64
R8 - 45 Oatley Road. Paddington	***53***	50	60	60
R9 - 5 Poate Road, Paddington	***49***	35	37	55
R10 - 107 Cook Road, Centennial Park	***49***	28	40	48
R11 - 2 Martin Road, Moore Park	***57***	29	45	44
Non-residential receivers				
AR1 - Centennial Parklands Equestrian Centre	***65***	28	37	35
AR2 - Moore Park Golf Course	***65***	45	51	49
C1 - Fox Studios	***70***	49	42	72
C2 - Sydney Cricket Ground	***70***	55	65	64
C3 - Entertainment Quarter	***70***	36	40	54
C4 - University of Technology Sydney Rugby Australia and NRL building	***70***	66	76	73
CC1 - Gumnut Gardens Early Learning and Long Day Care Centre	***70***	31	37	53
CC2 - Kira Child Care Centre	***70***	51	63	66
CC3 - Bambini's Child Care Centre	***70***	26	35	35
E1 - Sydney Boys High School	***55***	48	57	56

Receiver	*NML*	Construction stage		
		1. Procurement & establishment	2. Ancillary building demolition	3. Stadium demolition
		Highest predicted noise level, dBA		
E2 - Sydney Girls High School	***55***	50	57	56
E3 - Paddington Public School	***55***	35	40	45
E4 - Bourke Street Public School	***55***	42	55	52
E4 - UNSW Art & Design	***55***	42	55	52
PR2 - Moore Park	***60***	49	74	67
T1 - Paddington Town Hall	***55***	49	56	59
W1 - St Francis of Assisi Catholic Church	***55***	35	40	49
W2 - St Mattias Anglican Church	***55***	31	40	44
W3 - Paddington Uniting Church	***55***	40	44	47
W4 - St. Vladimir's Russian Orthodox Church	***55***	34	46	44
W5 - Kingdom Hall of Jehovah's Witnesses	***55***	34	39	53

- Levels shaded in grey indicate a notional exceedance of NMLs based on the worst case assumptions noted above.

Results show some exceedances of up to 9 dB are predicted at the most affected receivers located along Moore Park Road and the local streets of Paddington. No residences are predicted to be 'highly affected', i.e. experience noise levels of 75 dBA or above.

The highest levels are predicted to occur during the early works, during use of equipment such as the mulcher, concrete crusher, excavator and rock breakers. These items are typically used over short durations and therefore may not be in operation concurrently as assumed in the predictions. Therefore, the noise levels predicted in Table 17 are expected to represent a conservative worst-case 15-minute period of each construction stage. In practice, noise levels during each stage are expected to be significantly lower than that predicted above.

Noise levels at the on-site UTS Rugby Australia and NRL building, located adjacent to the existing member's car park, are predicted to be up to 6 dB over NMLs for commercial premises. Although the 'highly affected' status only applies to residential receivers, high noise levels predicted at the UTS Rugby Australia and NRL building may be problematic. Potential disturbance to occupants is more likely during use of equipment such as the concrete crusher, and therefore siting of such equipment should give due regard to the nearest potential affected locations.

Other non-residential receivers are predicted to marginally exceed NMLs, such as Fox Studios, Sydney Boys and Sydney Girls High Schools and Paddington Town Hall, however exceedances are conservatively predicted to be within 2 – 3 dB of NMLs. As noise predictions are considered to be conservative with respect to number of concurrent operating plant and durations, significant disturbance to these locations is not expected.

At Moore Park, noise levels from construction activity could significantly exceed passive recreation management levels, however these only apply when this area is in use. It is noted that any event to be held at this park will require a DA and coordination between event organisers and the Contractor is recommended.

Construction noise mitigation and management measures are discussed in Section 6.1.

3.5 Construction traffic

Trucks will be used to remove demolition and construction waste from the site, with the driveway along Moore Park Road proposed for access.

Construction works will generate vehicle trips primarily along Moore Park Road and Driver Avenue. Demolition works are anticipated to generate 30 - 40 truck movements per day for approximately 10-11 months, with 5 movements per day expected during site establishment.

The RNP states:

> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

Considering the existing traffic numbers along Moore Park Road (approximately 20,000 vehicles per day) and the small number of construction generated vehicles, the additional construction traffic created by construction is predicted to increase noise levels by less than 1 dB, and therefore represent an insignificant short-term effect on the ambient noise environment.

3.6 Construction Vibration

Construction vibrations have the potential to impact buildings and structures located close to demolition activities.

The location of heritage listed structures potentially directly beneath the demolition works may result in adverse vibration impacts. Construction vibration mitigation measures presented in 6.2 should be implemented to minimise impacts of early works.

Should rockbreaking be required in proximity to the UTS Rugby Australia building, located adjacent to the site, there is potential to exceed human comfort criteria, and to a lesser extent, cause cosmetic building damage. Recommended minimum work distances and construction vibration management

recommendations are provided in Section 6.2 to minimise the risk of adverse impacts.

No adverse vibration impacts are expected to occur and other receiver buildings due to the distances involved, either in terms of cosmetic damage or impacts on human comfort.

4 Operational noise – Excluding events

4.1 Overview

Primary operational noise sources associated with SFS, excluding special events (addressed in Section 5), include:

- External mechanical plant and equipment;
- Staff carpark activities; and
- Loading dock operations & waste and recycling collection.

4.2 Criteria

Operational noise emissions from the SFS have been assessed in accordance with the NPI [1], which is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses.

The NPI sets out the procedure to determine the project noise trigger levels relevant to an industrial development. The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so 'trigger' a management response.

4.2.1 Intrusive noise trigger level

The intrusiveness noise trigger level is applicable to residential premises only and is summarised as follows:

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

  (where $L_{Aeq,15minute}$ represent the equivalent continuous noise level of the source)

4.2.2 Recommended and project amenity noise level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from **all** industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPI where feasible and reasonable. An extract from the policy pertinent to this assessment is given below in Table 18.

Table 18: NPI Recommended Amenity Noise Levels (RANLs)

Receiver	Noise amenity area	Time of Day[1]	Recommended amenity noise levels (RANLs) L_{Aeq}, dBA
Residential	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60

Receiver	Noise amenity area	Time of Day[1]	Recommended amenity noise levels (RANLs) L_{Aeq}, dBA
		Evening	50
		Night	45
School classroom - internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Place of worship – internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65

- The recommended amenity noise levels (RANLs) refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

1 - The NPI defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays;
- Evening: the period from 6 pm to 10 pm; and
- Night: the remaining period.

(These periods may be varied where appropriate. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$

The recommended amenity noise levels (RANLs) represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level (PANL) represents the objective for noise from a single industrial development at a receiver location.

To ensure that any new industrial source of noise is within the RANLs for an area, the PANL applies for each new source of industrial noise as follows:

- *Project Amenity Noise Level (PANL) = Recommended Amenity Noise Level (RANL) minus 5 dBA*

The NPI also provides the following exceptions to the above method for deriving the project amenity noise level:

1. *In areas with high traffic noise levels.*
2. *In proposed developments in major industrial clusters.*
3. *Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it*

can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

4. *Where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.*

The area surrounding the site can be categorised as Urban and Suburban in accordance with the NPI, discussed in Section 2.3. According to attended measurements summarised in Table 7, the ambient noise levels at the majority of sensitive receivers is controlled by traffic. The NPI sets the PANLs to $L_{Aeq(period(traffic))}$ minus 15 dBA in the case that the level of transport $L_{Aeq(period(traffic))}$ exceeds the RANL by 10 dB or more.

Table 19 summarises the RANLs and the PANLs applicable for the project.

Table 19: NPI RANLs and PANLs

NCA	Indicative Noise Amenity Area	Time of day[1]	Recommended Amenity Noise Level (RANL) $L_{Aeq(period)}$	Existing Traffic $L_{Aeq(period)}$ [2]	Project Amenity Noise Level (PANL) $L_{Aeq(period)}$
NCA 1	Urban	Day	60	69	55
		Evening	50	68	53[2]
		Night	45	66	51[2]
NCA 2	Urban	Day	60	67	55
		Evening	50	67	52[2]
		Night	45	62	47[2]
NCA 3	Urban	Day	60	68	55
		Evening	50	66	51[2]
		Night	45	62	47[2]
NCA 4	Urban	Day	60	57	55
		Evening	50	54	45
		Night	45	49	40
NCA 5	Suburban	Day	55	60	50
		Evening	45	56	41[2]
		Night	40	45	35
NCA 6	Suburban	Day	55	57	50
		Evening	45	59	44[2]
		Night	40	50	35[2]

1 - The NPI defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays;
- Evening: the period from 6 pm to 10 pm; and
- Night: the remaining period.

2 - Traffic noise is the dominant source of noise at the receiver location:

a. the existing traffic noise is 10 dBA or more above the ANL for the area; and

b. it is unlikely that traffic noise will reduce over time.

4.3 Sleep disturbance

The NSW NPI recommends the following screening criteria for the assessment of potential sleep disturbance, for the period between 10 pm and 7 am:

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

4.4 NPI Project specific noise levels

Based on the background and ambient noise monitoring, Table 20 summarises the derived project specific noise levels based on the NPI.

Table 20: NPI Project specific noise levels

Receiver	Time Period	Project Specific Noise Levels		
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) $L_{Aeq,period}$	Sleep Disturbance $L_{Amax(night)}$
R1	Day	63	55	N/A[2]
	Evening	61	53	N/A[2]
	Night	52	51	62
R2	Day	63	55	N/A[2]
	Evening	61	53	N/A[2]
	Night	52	51	62
R3	Day	63	55	N/A[2]
	Evening	61	53	N/A[2]
	Night	52	51	62
R4	Day	61	55	N/A[2]
	Evening	57	52	N/A[2]
	Night	47	47	57
R5	Day	61	55	N/A[2]
	Evening	57	52	N/A[2]
	Night	47	47	57
R6	Day	57	55	N/A[2]
	Evening	54	51	N/A[2]
	Night	42	47	52
R7	Day	57	55	N/A[2]
	Evening	54	51	N/A[2]
	Night	42	47	52
R8	Day	48	55	N/A[2]
	Evening	46	45	N/A[2]
	Night	42	40	52
R9	Day	44	50	N/A[2]
	Evening	41	41	N/A[2]
	Night	37	35	52
R10	Day	44	50	N/A[2]
	Evening	41	41	N/A[2]
	Night	37	35	52
R11	Day	52	50	N/A[2]

Receiver	Time Period	Project Specific Noise Levels		
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) $L_{Aeq,period}$	Sleep Disturbance $L_{Amax(night)}$
	Evening	51	44	N/A[2]
	Night	46	35	56

1 - The NPI defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays;
- Evening: the period from 6 pm to 10 pm; and
- Night: the remaining period.

2 - N/A Not Applicable

4.4.1 Emergency equipment

The NPI allows increases to the environmental noise limits for events of short durations where no more than one event occurs in any 24-hour period. This is to allow for short and intermittent operation of equipment during testing and/or emergencies such as stair pressurisation fans. The allowances are summarised in Table 21.

Table 21: Adjustments to environmental noise limits for duration

Duration of Noise (one event in any 24-hour period)	Increase in acceptable noise level at receptor, dBA	
	Daytime and Evening 7am-10pm	Night 10pm-7am
1-2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
less than 1.5 minutes	20	10

For the purposes of design, it is assumed that smoke exhaust fan tests would fall in the 15 minutes to 1 hour band during the daytime, and thus attract an allowable increase of 5 dBA to the limiting noise criteria for typical building daytime operation.

The scheduled testing of smoke exhaust fans would also be limited to occur on Saturdays during the daytime hours to avoid disruption to occupants within the building.

4.5 Operational noise considerations

- External mechanical plant and equipment;
- Staff carpark activities; and
- Loading dock operations & waste and recycling collection.

It should be noted that no change in operational noise is proposed as part of the redevelopment, therefore the noise impacts from the above sources is not anticipated to change from current levels.

Mechanical plant selections and accordingly, the associated noise levels are not typically available at the project application stage, particularly for a Stage 1 Concept Application. Similarly, operational car park activities and loading dock operations and waste & recycling collection are yet to be determined at this Stage 1 Concept Phase. The project will however be subject to more detailed assessment at the Stage 2 Environmental Assessment, and following during the detailed design stage of the project. These operational noise sources are to be further considered as part of the Stage 2 Environmental Assessment.

5 Event noise

5.1 Overview

The existing Allianz Stadium is a multi-purpose sporting and entertainment venue which hosts a range of events throughout the year.

A comparison of the proposed SFS with the existing Allianz Stadium is presented in Table 22.

Table 22: Allianz Stadium and Sydney Football Stadium comparison

Description	Allianz Stadium (current)	Sydney Football Stadium (proposed)
Capacity	45,000	45,000
Stadium shape	Saddle shape	Bowl shape

The proposed SFS will retain a capacity of 45,000 however due to an improved acoustically performing stadium shape, changing from the current 'saddle' stadium shape to the proposed 'bowl' shape with higher facades to the north and south, noise egress from within the stadium is predicted to reduce.

The SFS is anticipated to host 49-52 events per year, including up to 6 concerts.

Significant noise sources emanating from the new stadium are expected to include:

- Music and announcements from sound amplification systems during sporting and concert events; and
- Crowd noise during sporting and concert events.

5.2 Noise criteria

In accordance with the Noise Guideline for Local Government (NGLG) [10], the Protection of the Environment Operations Act 1997 (POEO Act) [11] and the Protection of the Environment Operations (Noise Control) Regulation 2008 (Noise Control Regulation) [12] provide the main legal framework and basis for managing unacceptable noise.

The NGLG presents guidance on the management of entertainment noise from '*outdoor concerts, festivals and cinematic or theatrical events using sound amplification equipment with 200 or more people at venues designated under cl. 90 of the POEO General Regulation*'. As a venue designated under cl. 90, the Sydney Football Stadium is required to have a Noise Management Plan (NMP). Details on the composition of the NMP are provided in Section 6.3.

Regarding large outdoor events, the NGLG states:

> *There are no hard and fast rules to apply when developing noise limits for these types of events, and what is appropriate will depend upon the particular circumstances. Typically, unless the venue is very remote, it is not possible to*

establish noise limits that prevent annoyance at every residence. However, noise limits can prevent the noise levels from being any higher than necessary.

The impact on the residents is not just a function of the noise level but is also a function of, for example:

- *the length of the event;*
- *the commencement and finishing times; and*
- *the number of similar events held per year.*

These can all be juggled and need to be considered collectively when establishing the noise limit. Therefore, the length of the event and commencement and finishing times etc. that were originally proposed may need to be revisited. The impact on residents needs to be weighed up against the cultural, social and economic needs/expectations of the broader community to determine if the venue is suitable and if the event should proceed.

In establishing appropriate noise limits for the proposed SFS and expanding on the guidance from the NGLG, the following factors have been considered:

- Time limits / length of events;
- Noise limits for similar venues;
- Noise descriptor / measurement time period;
- Assessment method;
- Minimum functional requirements for events; and
- Community expectation.

5.2.1 Times limits and length of events

Time limits of sporting, concert and other events and not proposed to change from those which currently apply to events at Allianz Stadium, outlined in the existing NMP [13]. A summary of proposed event time limits is provided in Table 23.

Table 23: Event time limits

Descriptor	**Time limits**			**Maximum length of event**
	Not to commence before	**Not to finish after**	**If delayed outside of the Trust's control, may continue till**	
Sporting events	8:00 AM	10:30 PM	11:00 PM	-
Concerts	10:00 AM	10:30 PM	11:00 PM	5 hours
Rehearsals	10:00 AM	7:00 PM	-	Kept to absolute minimum

Descriptor	Time limits			Maximum length of event
	Not to commence before	Not to finish after	If delayed outside of the Trust's control, may continue till	
Sound tests	10:00 AM	7:00 PM	-	Kept to absolute minimum
Other outdoor event with sound amplification – days preceding working days	10:00 AM	8:00 PM	-	-
Other outdoor event with sound amplification – days **not** preceding working days	10:00 AM	10:30 PM	-	-

5.2.2 Review of noise limits for similar venues

A review of existing noise limits for the existing Allianz Stadium and similar venues which host large outdoor events has been conducted in order to establish appropriate noise limits for the proposed SFS. Noise limits for events at Allianz Stadium as well as similar venues to the proposed SFS in Sydney and across Australia is presented in Appendix D. A summary is provided in Table 24.

Table 24: Summary of noise limits for similar venues

Venue	Source	Descriptor[1]	Noise limit[1]
Allianz Stadium, Sydney	Sporting events sound amplification equipment	L_{Amax}	60 dBA
	Concert noise	L_{Amax}	80 dBA
		L_{Cmax}	100 dBC
Western Sydney Stadium, Sydney	Major sporting events	$L_{Aeq,15min}$	RBL+10
		$L_{Ceq,15min}$	RBL+25
	Major concert events	$L_{Aeq,15min}$	RBL+15
		$L_{Ceq,15min}$	RBL+30
Sidney Myer Music Bowl (SMMB), Melbourne	Outdoor venues	$L_{Aeq,15min}$	65 dBA
Docklands Stadium, Melbourne	Outdoor events	$L_{Aeq,15min}$	65 dBA
Sydney Botanic Gardens and Domain, Sydney	cinematic outdoor entertainment activity, 200 – 2000 people	L_{Amax}	55 dBA or RBL+5
	commercial outdoor entertainment activity, 2000 – 10000 people	L_{Amax}	55 dBA
		L_{Cmax}	70 dBC
		L_{Amax}	70 dBA

Venue	Source	Descriptor[1]	Noise limit[1]
	outdoor entertainment activity, >10000 people	L_{Cmax}	90 dBC
SOH	Outdoor events	$L_{Aeq5min}$ and $L_{Ceq5min}$	Dependent on stage configuration and event duration
Walsh Bay Arts and Cultural Precinct	Precinct wide events	$L_{Aeq,15min}$	Day & eve 55 dBA Night 50 dBA
		$L_{Ceq,15min}$	Day & eve 70 dBC Night 65 dBC
Centennial Parklands, Sydney	Event tests, rehearsals and concerts	L_{Amax}	65 dBA
		L_{Cmax}	85 dBC
Barangaroo, Sydney	Major events	$L_{Aeq,10min}$	10am – 10pm 65 dBA Other times 55 dBA
		$L_{Ceq,10min}$	10am – 10pm 75 dBC Other times 65 dBC

1 - Presented are a summary of descriptors and noise limit values without detailed conditions under which limits apply. See Appendix D for details.

From this summary, the most commonly adopted noise limit descriptors are L_{max} and $L_{eq.}$, with levels either set values or based of measured RBLs.

5.2.3 Noise descriptor and period

The L_{max} descriptor is not considered ideal in assessing noise at nearby receivers due to its limitation in describing the noise exposure at receivers due to its higher variability when compared to an L_{Aeq}, and susceptibility to influence from extraneous noise.

The L_{eq} descriptor presents a better representation of on-going noise exposure over the course of an event. This descriptor represents the average noise energy over the relevant period of measurement and takes account of peak noise levels as well as the degree of noise fluctuation. This descriptor is most widely correlated with the subjective effect of noise (Miedema and Vos [14]).

When using an L_{Aeq} to assess noise exposure, the time period of averaging becomes relevant. Typically, as per the intrusiveness noise assessment, a measurement period of 5-minutes is considered representative of the type of noise generated by the SFSR. This shorter measurement period will also facilitate a quicker assessment – response process, allowing quicker remediation of noise exceedances.

To capture the low-frequency component of noise emissions, a C-weighting criteria is also used in conjunction with the A-weighted criteria. A L_{Ceq} level 20 dB higher than the L_{Aeq} is considered appropriate based on current noise limits for Allianz Stadium, and reflects an acceptable low-frequency level for music played within the stadium.

5.2.4 Assessment method

To avoid the need for onerous attended noise monitoring at nearby receivers to determine event noise emissions, the use of permanent noise monitors within the site boundary, specifically on or near the stadium façade or roof, could be considered. Noise monitors located close to or within the stadium envelope can be established, with noise limits adjusted based on their closer proximity and relationship to the site. Such monitoring can provide indication of levels at receivers, while minimising the influence of extraneous noise such as pedestrians and passing traffic at the receivers.

The application of this assessment method is discussed further in Section 6.3.2.1.

5.2.5 Community expectation

Regarding the cultural, social and economic needs/expectations of the broader community, the long history of the site as a venue for sporting events should be considered. Various sporting events have been hosted at the site for over a century, as described in Section 2.2.

Crowd noise is considered to be less 'offensive' than music noise, as crowd noise, such as cheering, is characterised as mid to high-frequency, and is not impulsive in nature. This is as opposed to music noise which typically has a large low-frequency component and may be impulsive.

5.2.6 SFSR proposed event noise limits

Event noise limits are proposed in the form of $L_{eq(5min)}$ levels based on the considerations presented in the Sections above.

Due to the infrequent nature of events, intermittent nature of event noise and their typical occurrence after business hours or on weekends, event noise limits have only been established for residential receivers.

Event noise limits for residential receivers are presented in Table 25.

Table 25: Event noise limits for residential receivers

Receivers	**Time Period**	**Concert event**		**Amplified sounds during sporting / other event**	
		dBL$_{Aeq5min}$	**dBL$_{Ceq5min}$**	**dBL$_{Aeq5min}$**	**dBL$_{Ceq5min}$**
Property boundary of all residences	All periods	70	90	60	80

Noise limits from concert events of 70 dBL$_{Aeq5min}$ and 90 dBL$_{Ceq5min}$ are proposed based on a -10 dB conversion of existing L_{max} noise limits for Allianz Stadium. A 10 dB difference between L_{max} and L_{eq} noise levels are demonstrated by

measurement data from recent concerts at Allianz Stadium and is typical for music noise.

Noise limits for sporting events or other events have been established for noise from amplified sound systems. This reflects the community's sensitivity to amplified noise, as well as the capacity to control amplified noise, as opposed to crowd noise.

The methodology for assessing noise from amplified sound systems, including distinguishing amplified noise from crowd noise, is described in Section 6.3.

5.3 Noise sources

To give an indication of potential noise emission from the SFSR, significant event noise sources have been modelled. The significant sporting and concert event noise sources have been identified as:

Sporting events

- Crowds talking and cheering within the stadium; and
- Announcements and music over the in-house Public Address (PA) system.

Concert events

- Crowds talking and cheering within the stadium; and
- Music playing over concert sound system (separate from in-house PA system).

Pyrotechnics displays also occasionally take place during large events at the SFS. Noise management measures from these displays are recommended to be part of the Noise Management Plan, with measures provided in Section 6.3 in the form of notification to the SCG Trust, community notification and time limits.

Noise measurements were conducted by Arup at the existing Allianz Stadium. A summary of measured event noise levels is presented in Table 26.

Table 26: Event noise measurement summary

Venue	Event	Description of measured noise	Duration	Highest measured sound pressure level within crowd	
				dBL_{Aeq}	dBL_{Ceq}
Sporting event					
Allianz Stadium, Sydney	Rugby Union match 24 Feb 2018	Included crowd cheering and music / announcements over PA	10 mins	83	86
	Rugby League match 16 Mar 2018	Included crowd cheering after try and music / announcements over PA	15 mins	87	87

Venue	Event	Description of measured noise	Duration	Highest measured sound pressure level within crowd	
				dBL_{Aeq}	dBL_{Ceq}
Sporting event					
	Anzac Day Rugby League match 25 Apr 2018	Included crowd cheering after try and music / announcements over PA	15 mins	89	90
		Half time music and announcements, no crowd cheering	15 mins	84	87
Concert event					
Allianz Stadium, Sydney	Coldplay - concert 12 Feb 2016	Included crowd noise and music. Loudest recorded 15 minutes during concert	15 mins	97	110
	Coldplay - concert 13 Feb 2016		15 mins	101	110
	Coldplay - concert 14 Feb 2016		15 mins	102	109
	Sia - rehearsal 1 Dec 2017		15 mins	88	105
	Sia - concert 2 Dec 2017		15 mins	94	108

5.4 Stadium design and operation

The proposed SFS would be a three-tiered bowl design, with a capacity of 30,000 seats on the lower and mid tiers, and 15,000 seats on the upper tier, with a total capacity of 45,000.

The stadium will incorporate a ring-style roof which will cover the seating areas. The roof material is yet to be finalised, but may be an acoustically transparent material, such as fabric.

No roof has been included in the noise model of the stadium, conservatively assuming they are acoustically transparent and provide no shielding effect. An investigation into the influence on noise levels with and without a solid roof with a 5 metre gap between the roof and the upper tier seating showed noise levels at the nearest affected receivers changed by less than 2 dB, barely perceptible to the average person.

A detailed description of the acoustic modelling is given in Section 5.5.1.

5.4.1 Operational modes – Sporting events

The SFS is proposed to operate in two modes when hosting events; championship mode and club mode. When in championship mode, all three seating tiers, upper, mid and lower tier seats, are available, with a combined capacity of 45,000. When

in club mode, the upper tier seating is not open to the public, lowering the capacity of the stadium to 30,000.

5.4.2 Operational modes – Concert events

Promoters / producers for concert events to take place at the SFS are anticipated to provide their own audio systems. Notional configurations of a concert sound system have been used for modelling the noise impact. In the typical configuration during concert events, speakers are located at the north facing south, away from the worst affected receivers along Moore Park Road. Two non-typical configurations have also been modelled, with speakers located at the centre and south of the stadium. All configurations are presented in Figure 6 below.

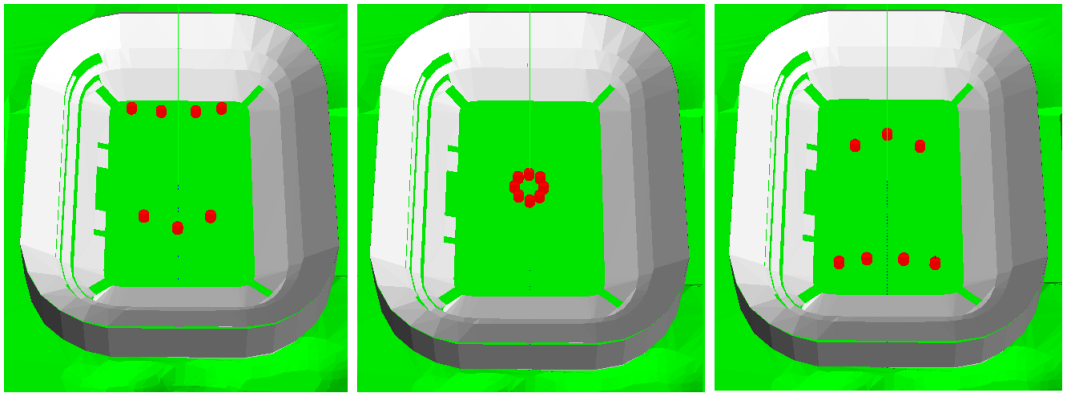

Figure 6: Speaker configuration located north facing south (left), centre facing outwards (middle) and south facing north (right)

In both the north and south scenario, four front of house speakers have been placed at the stage with three delay speakers located further back in the crowd, indicative of a typical sound system configuration for a large arena style concert.

The capacity of the stadium during concert events is 55,000, comprising 45,000 in the tiered seating and 10,000 on the pitch

5.5 Modelling methodology

Noise emissions from events taking place at the SFS have been assessed to noise limits outlined in Section 5.2.

Noise emissions have been modelled using SoundPlan 8 using the CONCAWE algorithm. The model included:

- Event noise sources listed in Section 5.3;
    - Crowd noise sources have been modelled as area sources extending over the entire lower and middle tier of the SFS, and including the upper tier for Championship mode events. The area sources were adjusted in the model to give representative sound levels within the crowd itself – see Section 5.5.1;

    - Concert noise sources have been modelled as point sources shown in Section 5.4.2, and adjusted in the model to give representative sound levels within the crowd itself;
- SFS and surrounding buildings;
- Receivers listed in Table 2; and
- Ground terrain and absorption.

A 3D rendering of the noise model is presented in Figure 7.

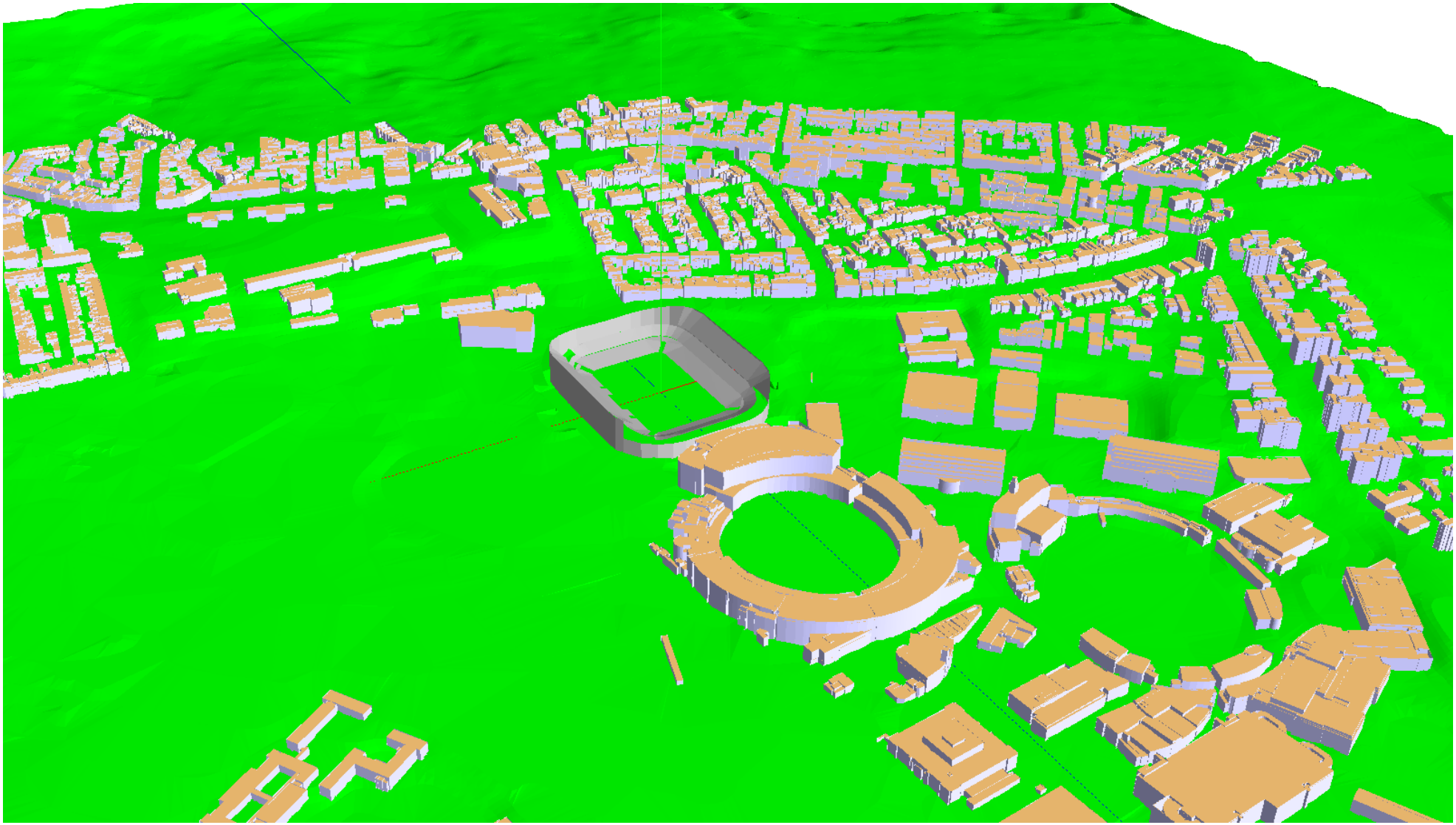

Figure 7: 3D rendering of noise model

5.5.1 Modelled scenarios

Noise source spectra used in modelling of events is presented in Table 27, based on the loudest measured noise level for each source in Table 26. Sound power levels of each source have been set, such that sound pressure levels within the crowd match those presented in Table 28 below.

Table 27: Modelled event noise source spectra dBL_{eq5min}

Noise source	Overall		Octave Band Centre Frequency, Hz							
			63	125	250	500	1k	2k	4k	8k
	dBA	dBC	Sound pressure level, dB							
Concert noise spectrum, including capacity crowd and music (Coldplay concert – Allianz Stadium)	102	113	113	96	97	97	99	94	87	81
Capacity crowd noise & PA noise spectrum (Rugby League match – Allianz Stadium)	89	90	73	72	74	84	87	81	73	62
PA noise during half time (Rugby League match – Allianz Stadium)	84	88	78	80	80	82	80	77	71	60

The following event scenarios have been modelled to capture typical sporting and concert events which may take place at the SFS.

Table 28: Modelled event scenarios and crowd noise levels

Event type	Modelled noise sources	Mode	Sound pressure level in crowd	
			dBL_{Aeq}	dBL_{Ceq}
Sporting	Area source covering the upper, mid and lower tiers representing crowds	Championship mode	89	90
	Area source covering the mid and lower tiers representing crowds	Club mode	88	89
	Area source covering the upper, mid and lower tiers representing PA noise coverage	PA only	84	88
Concert	Directional point sources representing speaker arrays representing amplified music	Speakers located north facing south	102	113
		Speakers located centre facing outwards	102	113
		Speakers located south facing north	102	113

5.6 Results

Predicted noise levels have been assessed to established noise limits below. Noise emission has been predicted under neutral weather conditions (no wind) and worst case weather conditions (3 m/s source to receiver winds).

Results are shown graphically in noise contour maps presented in Appendix F.

5.6.1 Concert events

5.6.1.1 Typical operational mode – Speakers north facing south

Predicted noise levels from concert events are presented in Table 29 and Table 30 below.

Table 29: Concert event noise assessment – $dBL_{Aeq5min}$

Representative receiver	**Typical concert mode**		
	Noise limit	**Predicted noise level[1]**	
		Neutral weather	**Worst weather**
R1 - 749 South Dowling Street, Redfern	***70***	54	57
R2 - 635 South Dowling Street, Surry Hills	***70***	53	56
R3 - 553 South Dowling Street, Surry Hills	***70***	54	56
R4 - 111 Greens Rd, Paddington	***70***	50	52
R5 - 479 South Dowling Street, Surry Hills	***70***	57	59
R6 - 252 Moore Park Road, Paddington	***70***	71	72
R7 - 314 Moore Park Road, Paddington	***70***	64	65
R8 - 45 Oatley Road. Paddington	***70***	66	66
R9 - 5 Poate Road, Paddington	***70***	62	64
R10 - 107 Cook Road, Centennial Park	***70***	62	65
R11 - 2 Martin Road, Moore Park	***70***	56	59

1 - Noise levels shaded in grey indicate an exceedance of noise limit

Results show that during concert events, when speakers are located at the north of the stadium, all locations comply except for a 2 dB exceedance of the $L_{Aeq15min}$ noise limit at the representative receiver R6 - 252 Moore Park Road. This is considered a minor exceedance.

Table 30: Concert event noise assessment – $dBL_{Ceq5min}$

Representative receiver	Typical concert mode		
	Noise limit	Predicted noise level	
		Neutral weather	Worst weather
R1 - 749 South Dowling Street, Redfern	***90***	71	73
R2 - 635 South Dowling Street, Surry Hills	***90***	70	72
R3 - 553 South Dowling Street, Surry Hills	***90***	71	73
R4 - 111 Greens Rd, Paddington	***90***	68	70
R5 - 479 South Dowling Street, Surry Hills	***90***	75	77
R6 - 252 Moore Park Road, Paddington	***90***	88	90
R7 - 314 Moore Park Road, Paddington	***90***	81	83
R8 - 45 Oatley Road. Paddington	***90***	80	82
R9 - 5 Poate Road, Paddington	***90***	78	80
R10 - 107 Cook Road, Centennial Park	***90***	77	79
R11 - 2 Martin Road, Moore Park	***90***	72	73

Results show that during concert events, $L_{Ceq15min}$ levels are predicted to comply with noise limits during worst case and neutral weather conditions at all receivers.

5.6.1.2 Non-typical operational mode – Middle / South speaker configuration

As part of the modelling process, alternative speaker locations were assessed to investigate flexible event scenarios. Two additional non-typical speaker layouts were assessed, speakers located in the middle of the stadium facing outwards, and speakers located at the south of the stadium facing north, as described in section 5.4.2.

In non-typical loudspeaker configurations the following can be observed:

- $L_{Aeq5min}$ criteria - exceedances of up to 10 dB are predicted at two receivers under worst case weather conditions and 9 dB under neutral conditions; and
- $L_{Ceq5min}$ criteria - exceedances of up to 10 dB are predicted at two receivers under worst case weather conditions and 8 dB under neutral conditions.

The above results represent the worst-case results based upon all investigated configurations. It should be noted that middle and southern speaker configurations are unlikely.

Notwithstanding the above, it may be possible to operate with non-typical speaker configurations while complying with event noise limits should care be taken to adequately control noise emission through implementation of mitigation measures, outlined in Section 6.3.

5.6.2 Sporting events

5.6.2.1 PA noise

Predicted noise impacts from PA noise during sporting events are presented in Table 33 and Table 34 below.

Table 31: PA noise assessment – $dBL_{Aeq5min}$

Representative receiver	*Noise limit*	**Predicted noise level**	
		Neutral weather	**Worst weather**
PA noise			
R1 - 749 South Dowling Street, Redfern	*60*	40	42
R2 - 635 South Dowling Street, Surry Hills	*60*	44	45
R3 - 553 South Dowling Street, Surry Hills	*60*	46	47
R4 - 111 Greens Rd, Paddington	*60*	43	45
R5 - 479 South Dowling Street, Surry Hills	*60*	49	50
R6 - 252 Moore Park Road, Paddington	*60*	58	58
R7 - 314 Moore Park Road, Paddington	*60*	56	56
R8 - 45 Oatley Road. Paddington	*60*	52	53
R9 - 5 Poate Road, Paddington	*60*	51	52
R10 - 107 Cook Road, Centennial Park	*60*	44	46
R11 - 2 Martin Road, Moore Park	*60*	42	44

Table 32: PA noise assessment – $dBL_{Ceq5min}$

Representative receiver	*Noise limit*	**Predicted noise level**	
		Neutral weather	**Worst weather**
PA noise			
R1 - 749 South Dowling Street, Redfern	*80*	45	47
R2 - 635 South Dowling Street, Surry Hills	*80*	49	51
R3 - 553 South Dowling Street, Surry Hills	*80*	51	53
R4 - 111 Greens Rd, Paddington	*80*	49	50
R5 - 479 South Dowling Street, Surry Hills	*80*	55	56
R6 - 252 Moore Park Road, Paddington	*80*	64	64
R7 - 314 Moore Park Road, Paddington	*80*	61	61
R8 - 45 Oatley Road. Paddington	*80*	57	58
R9 - 5 Poate Road, Paddington	*80*	57	57
R10 - 107 Cook Road, Centennial Park	*80*	50	51
R11 - 2 Martin Road, Moore Park	*80*	47	49

Results show both L_{Aeq} and L_{Ceq} noise levels comply with established noise limits.

5.6.2.2 Crowd noise

Predicted noise emission from crowds at sporting events are presented in Table 33 and Table 34 below. As no noise limits are proposed for crowd noise, results are presented to illustrate expected noise levels, as opposed to assess compliance.

Results for sporting events in both club mode and championship mode are presented, see Section 5.4.1 for definitions. Measured existing night-time ambient $L_{Aeq5min}$ levels are also presented for context.

Table 33: Crowd noise predictions – $dBL_{Aeq5min}$

Representative receiver	***Existing night-time ambient L_{Aeq}***	**Predicted noise level**	
		Neutral weather	**Worst weather**
Club mode (30,000 patrons)			
R1 - 749 South Dowling Street, Redfern	*67*	31	35
R2 - 635 South Dowling Street, Surry Hills	*67*	36	39
R3 - 553 South Dowling Street, Surry Hills	*67*	39	41
R4 - 111 Greens Rd, Paddington	*62*	35	37
R5 - 479 South Dowling Street, Surry Hills	*62*	41	43
R6 - 252 Moore Park Road, Paddington	*64*	58	58
R7 - 314 Moore Park Road, Paddington	*64*	49	50
R8 - 45 Oatley Road. Paddington	*43*	51	52
R9 - 5 Poate Road, Paddington	*43*	46	48
R10 - 107 Cook Road, Centennial Park	*43*	36	39
R11 - 2 Martin Road, Moore Park	*49*	34	37
Championship mode (45,000 patrons)			
R1 - 749 South Dowling Street, Redfern	*67*	45	47
R2 - 635 South Dowling Street, Surry Hills	*67*	49	50
R3 - 553 South Dowling Street, Surry Hills	*67*	51	52
R4 - 111 Greens Rd, Paddington	*62*	48	50
R5 - 479 South Dowling Street, Surry Hills	*62*	54	55
R6 - 252 Moore Park Road, Paddington	*64*	63	63
R7 - 314 Moore Park Road, Paddington	*64*	61	61
R8 - 45 Oatley Road. Paddington	*43*	57	58
R9 - 5 Poate Road, Paddington	*43*	56	57
R10 - 107 Cook Road, Centennial Park	*43*	49	51
R11 - 2 Martin Road, Moore Park	*49*	47	49

Results show that during sporting events in club mode, noise levels of up to 58 dBA are predicted. These predicted noise levels relate to the loudest 5-minute period during a sporting match, as presented in Table 28, and include contributions from crowd noise and from the PA system.

It should be noted that predicted noise levels at the worst affected assessment locations along Moore Park Road are below existing measured $L_{Aeq15min}$ ambient

noise levels, which is otherwise largely controlled by traffic, measured at every assessment location.

Noise levels of up to 63 dBA are predicted during sporting events in championship mode. Similarly to club mode, predicted event noise levels at the reasonably most-affected assessment locations are below measured ambient noise levels.

Table 34: Crowd noise predictions – $dBL_{Ceq5min}$

Receiver	Predicted noise level	
	Neutral weather	Worst weather
Club mode (30,000 patrons)		
R1 - 749 South Dowling Street, Redfern	34	37
R2 - 635 South Dowling Street, Surry Hills	38	41
R3 - 553 South Dowling Street, Surry Hills	41	44
R4 - 111 Greens Rd, Paddington	37	40
R5 - 479 South Dowling Street, Surry Hills	43	45
R6 - 252 Moore Park Road, Paddington	60	60
R7 - 314 Moore Park Road, Paddington	51	52
R8 - 45 Oatley Road. Paddington	53	54
R9 - 5 Poate Road, Paddington	48	50
R10 - 107 Cook Road, Centennial Park	38	41
R11 - 2 Martin Road, Moore Park	36	40
Championship mode (45,000 patrons)		
R1 - 749 South Dowling Street, Redfern	47	49
R2 - 635 South Dowling Street, Surry Hills	51	53
R3 - 553 South Dowling Street, Surry Hills	53	55
R4 - 111 Greens Rd, Paddington	51	52
R5 - 479 South Dowling Street, Surry Hills	57	58
R6 - 252 Moore Park Road, Paddington	66	66
R7 - 314 Moore Park Road, Paddington	63	63
R8 - 45 Oatley Road. Paddington	59	60
R9 - 5 Poate Road, Paddington	59	59
R10 - 107 Cook Road, Centennial Park	52	53
R11 - 2 Martin Road, Moore Park	49	51

Results show that during sporting events in both club and championship mode, L_{Ceq} noise levels of up to 66 dBC are predicted at all receivers.

5.6.3 Comparison of noise emission from existing Allianz Stadium and proposed SFS

A comparison of the noise emission from the existing Allianz Stadium and the proposed SFS development has been carried out.

Noise emission at the reasonably most-affected receivers has been calculated using the following parameters:

- Measured internal noise levels in stadium. See Section 5.3;
- Acoustic performance of Allianz stadium's envelope, predicted using simultaneous measurements taken within stadium and at 252 Moore Park Road; and
- Acoustic performance of SFS's envelope, simulated using noise modelling, see Section 5.5.

Table 35 presents the predicted noise levels at existing Allianz Stadium and proposed SFS at the worst affected receiver.

Table 35: Existing Allianz and proposed SFS development noise impact at reasonably most-affected receiver - $dBL_{Aeq5min}$

Assessment Location	**SPL in Stadium**	**Predicted noise levels**	
		Existing Allianz Stadium	**Future SFS development**
Worst affected receiver -R6 – 252 Moore Park Road	89	66	63

Assessment indicates an improvement from the proposed SFS's building envelope design, resulting in a 3 dBA reduction in noise level at the reasonably most-affected receiver. In a practical sense, noise emission from proposed SFS are not likely not to increase.

5.6.4 Double header sporting events – SCG and SFS

Predictions have been carried out to quantify the cumulative noise emission from simultaneous events occurring at both the SCG and proposed SFS.

Predicted noise levels at selected reasonably most-affected receivers are provided in Table 36 below.

Table 36: Sporting event noise predictions for SCG and SFS – $dBL_{Aeq5min}$

Receiver	**Predicted noise level**					
	SCG - Club mode (30,000 patrons)		**SFS - Club mode (30,000 patrons)**		**Double header – events at SCG & SFS together**	
	Neutral weather	**Worst weather**	**Neutral weather**	**Worst weather**	**Neutral weather**	**Worst weather**
R6 - 252 Moore Park Road, Paddington	44	44	58	58	58	58
R8 - 45 Oatley Road. Paddington	40	41	51	52	51	52

Results indicate predicted noise levels from the SCG are 10 dB below those predicted from SFS. Therefore, the contribution from events at the SCG during a double header are considered negligible.

In practice, the infrequency of double headers, along with the low likelihood of crowds cheering from both venues simultaneously mean the likelihood of cumulative impacts is very low.

5.7 Discussion

5.7.1 Overview

In assessing the predicted impacts of the proposed SFS, the following factors should be taken into consideration:

- Event noise is a feature of the area, with Allianz Stadium and the Sydney Cricket Ground both currently operational. The area has hosted sporting events for over 150 years;
- The proposed SFS will retain the same number of seats as the existing Allianz Stadium;
- Changes to the shape of the stadium, namely from the ‘saddle’ shape to a more traditional ‘bowl’ with a higher façade at the north of the stadium, is expected to result in a reduction in current event noise levels to surrounding receivers;
- Currently 49-52 events are scheduled to take place at the SFS per year, which equates to approximately one per week;
- No changes to current event time limits for Allianz Stadium are proposed. Events are not to finish after 10:30pm, with a possible extension to 11:00pm if events are delayed outside of the Trust’s control, as presented in Table 23; and
- No changes to sporting event or concert event operations are proposed.

It follows that no increases to current noise emission are predicted as a result of the SFS redevelopment, and a slight reduction in overall event noise may occur.

In addition, a number conservative assumptions have been made in this assessment methodology which are likely to result in noise impacts being lower in reality than predicted in this assessment. These include:

- The omission of a roof in the noise model. These features may not only shield some noise leaving the stadium, but also may absorb some noise from sources in the stadium, reducing reverberant noise levels within the stadium;
- Predicted noise levels are modelled off worst-case scenarios, based off highest measured noise levels during both concerts and sporting events. In practice, noise levels during these events are likely to be lower than predicted;
- A full capacity venue has been modelled for sporting events in both club and championship modes. Match attendances for the previous twelve months, provided in Appendix E, shows that typical attendances for sporting events at the existing Allianz Stadium are approximately 16,000 patrons. Lower patron numbers would result in lower source noise levels, and in addition patrons at

less-than-capacity events would likely sit lower in the bowl closer to the field, therefore increasing the shielding effect from the stadium façade; and

- Worst-case weather conditions have been modelled, which includes 3m/s source to receiver winds. Worst-case weather conditions are not typical, and would not affect all receivers at the same time, as has been conservatively modelled.

5.7.2 Concert events

Noise limits have been established based on the considerations discussed in Section 5.2 to provide achievable levels of event noise which reflect the needs of the community, as well as considering the context of the project.

Predicted L_{Aeq} noise levels are generally predicted to comply with proposed noise limits, with some minor exceedances of 2 dB or less, predicted for reasonably most-affected receivers along Moore Park Road. No exceedances of L_{Ceq} noise limits, which reflect low-frequency noise, have been predicted.

Under a non-typical speaker configuration where speakers are not located at the north of the stadium facing south away from worst affected receivers, noise emission is expected to increase by up to 10 dB. Under these configurations, noise mitigation measures are required to comply with noise limits, and are outlined in Section 6.3.

Predicted noise levels from the SFSR have been compared with the exiting Allianz Stadium, and results indicate noise levels at the reasonably most- affected receivers, could slightly decrease for the proposed SFS.

No significant contribution from event noise at the SCG are predicted at worst affected receivers during double headers.

To manage noise levels during concerts, mitigation measures are provided in Section 6.3, which should be incorporated into a Noise Management Plan for the SFSR. It is expected that these will be further developed during the Stage 2 Project Application.

5.7.3 Sporting events

An assessment of noise emission from PA systems indicates compliance is predicted with the established L_{Aeq} and L_{Ceq} noise limits. To manage noise levels from PA systems, recommendations are provided in Section 6.3.

No noise limits are proposed for crowd noise, as it is generally considered less intrusive than music or PA announcement noise, and is not readily managed or mitigated. Predictions of noise from crowds at sporting events indicate noise levels are generally similar or below existing ambient noise levels due to traffic at the reasonably most-affected receiver locations.

5.7.4 Overall impacts

Considering the SFS redevelopment is not expected increase noise emission, compared with the current Allianz Stadium, no additional or significant acoustic issues are expected. This is supported by predictions indicating compliance with established noise limits for concerts and PA noise during sporting events. In addition, crowd noise from sporting events are generally no louder than existing ambient traffic noise.

Regarding proposed noise limits, noise emission which exceed these levels are not necessarily an issue, however do indicate where noise management measures should be implemented. Recommended event noise mitigation measures are provided in Section 6.3.

6 Recommended mitigation and management measures

6.1 Construction noise mitigation measures

The contractor will have a key role in managing the noise and vibration levels during the works to reduce noise and vibration as far as is reasonably practicable. This will include:

6.1.1 Noise and vibration management plan

A noise management and vibration plan shall be prepared. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities.

6.1.2 Staffing

- Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration;
- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise;
- Ensuring good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable;
- Avoid the use of radios or stereos outdoors; and
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.

6.1.3 Plant and equipment

- Some construction activities proposed for use as part of the early works are identified as being potentially ‘annoying’ or intrusive to residents in Section 4.5 of the ICNG [2]. These activities include the use of chainsaws, mulchers, excavators and the concrete crusher, which are also identified as the noisiest equipment in Table 15. Intrusive stationary equipment, such as the mulcher and concrete crusher, should be located to the south of the site as far from receivers as possible. Where possible stationary equipment should be located behind structures such as demountable buildings or stockpiles to maximise shielding to receivers;
- Turn off all vehicles, plant and equipment when not in use; and
- Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.

6.1.4 Scheduling

- Ensure that the Responsible Person controls the working hours on site to ensure that work is only done during the acceptable periods (7am to 6pm on

weekdays and 8am to 1pm on Saturdays. No work on Sundays or public holidays);

- Intrusive activities identified in Section 6.1.3 above should be:
  - undertaken after 8am;
  - only undertaken over continuous periods not exceeding 3 hours with at least a 1-hour respite period in between; and
  - Not undertaken during designated 'rest' times for Kira Child Care Centre, 230 Moore Park Road, Paddington.

6.1.5 Community liaison

- Ensuring that the Responsible Person keeps the local community advised on expected activities and coordinates scheduling and locations of noisy works around any critical user events where practicable. This shall include face to face meetings with nearby receivers if requested and a letter box drop, and shall include close liaison with neighbours during construction, including Fox Studios, NRL and Rugby Australia; and
- Maintaining appropriate records of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with the Responsible Person.

6.2 Construction vibration management

The following guidance provides recommended minimum working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 37 below for reference.

Table 37: Recommended minimum working distances for vibration intensive plant

Plant Item	Rating / Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration Guideline)
Small rock breaker	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium rock breaker	(900 kg – 12 to 18t excavator)	7 m	23 m
Large rock breaker	(1600 kg – 18 to 34t excavator)	22 m	73 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

- More stringent conditions may apply to sensitive areas such as Fox Studios, based on sensitive equipment vibration criteria, and sensitive heritage structures, dependent on dilapidation surveys.

The safe working distances presented are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Mitigation will need to be considered where sensitive receivers are located closer to the construction work zone than these 'safe working distances'. It is noted that focus is on mitigating cosmetic damage.

This should be considered when conducting rock breaking near receiver C4 - University of Technology Sydney Rugby Australia and NRL building and Busby's Bore. Keeping to these distances will minimise risks of adverse impacts.

Heritage buildings and structures should be considered in the construction vibration plan. Dilapidation surveys may be required for heritage items to determine the appropriate vibration mitigation measures. The requirements for dilapidation surveys should be identified in the construction vibration plan once further details on the works (eg. Location, types, magnitudes) and receivers (eg. Existence, location) is available, with the aim of complying with vibration criteria presented in Section 3.3. In the case of Busby's Bore this will be dependent upon whether the Bore can be located, its existing condition (i.e. some sections are known to have collapsed) and whether safe access can be gained to the Bore. Other identified heritage listed items that may be affected by vibration include sections of the SCG and some buildings within Fox Studios.

The contractor will be required to manage vibration as well as noise and make use of best practice in the management of vibration using simple and practicable techniques such as avoiding dropping heavy items.

Where vibration intensive works are required within the minimum working distances outlined in Table 37, vibration monitoring at the nearest potential affected building should be considered, where real-time alerts can be generated when measured vibration levels exceed criteria.

Given the large distances between other receivers and the demolition works, vibration damage is not considered a significant risk for any other vibration sensitive buildings.

6.3 Event noise

As a venue designated under clause 90 of the POEO General Regulation, the Sydney Football Stadium is required to have a NMP in place. These comprise three elements:

- Preventive management – details of mitigation of noise impact prior to the event such as stage orientation, barriers, sound limitation devices etc. and effective community consultation before the event;
- Reactive management – noise monitoring in real time (travellers and fixed locations), use of trigger levels set below limits, modes of communication between monitors and operators, noise mitigation in real time, complaints handling in real time and communication modes between complaints handling and operators; and
- Review – assessing the performance of: – community consultation (before/during /after) – monitoring in real time – mitigation, to inform the

development and implementation of recommendations that will improve performance over time (continuous improvement).

The review, update and implementation of the current Sydney Cricket Ground and Allianz Stadium NMP [13] is therefore recommended, to apply to all events taking place at the proposed SFS.

The SFS NMP should include the mitigation and management measures outlined in this section.

6.3.1 Preventative management

6.3.1.1 Design considerations

At this early stage of design, noise spill from the stadium bowl has been considered in the preliminary design on the stadium envelope. The height of the stadium façade has been maximised and penetrations in the façade have been minimised.

The predicted noise levels in this assessment are based on a conservative modelling approach, as discussed in Section 5.7.1, where no roof has been modelled.

6.3.1.2 Requirements on limits to the days and times of events

Restrictions to the number of events per year will provide respite for nearby receivers. Time limits should be applied to the use of the PA system and event sound systems, as well as pyrotechnic displays.

No changes to existing event time limits are proposed, presented in Section 5.2.1, and these time restrictions have been considered in establishing noise limits.

6.3.1.3 Requirement for notice to consent authorities

The current Allianz Stadium NMP [13] requires the SCG Trust to notify the EPA Manager Metropolitan Infrastructure of details of upcoming concert(s) at least 28 days before concerts, sound tests and rehearsals.

It is recommended SFS NMP include requirements to inform consent authorities of:

- the nature (description) and size of (expected crowd attendance) an event;
- the date and time (duration) of the event, including sound tests and/or rehearsals;
- the name and contact details of a general liaison person for the purposes of communication with the EPA in connection with any concerts, sound tests and rehearsals; and

- the name and contact details of a person appointed as the SCG Trust's representative specifically for the duration of any concerts, sound tests and rehearsals.

The EPA will be notified of any changes to the details provided above at least 7 days prior to the commencement date of the concerts, sound tests and rehearsals or immediately after receipt of the information.

In addition, the NMP should include requirements for a risk management plan to be provided by the event manager to the SCG Trust addressing noise impacts of pyrotechnic displays on local residents and wildlife. A pre-start checklist may also be provided by the SCG Trust, for completion by the event manager.

6.3.1.4 Notification to community

The current NMP [13] requires the SCG trust to make all reasonable efforts to ensure that residents and sensitive receivers, likely to be significantly impacted upon by noise (i.e. mainly receivers located north and south of Oxford street, west of Centennial park, and north and east of Bourke street and north and south of Cleveland street), are given adequate written notification of a concert, sound test and rehearsal.

The current NMP [13] assumes that sporting events do not require written notification as they are already widely publicised through various media, including television and the SCG Trust website.

It is recommended that, following from current requirements, written notification of concerts, sound tests and rehearsals be distributed by a letterbox drop between 5 to 14 days prior to the event.

The notice to the sensitive receivers will advise of:

- a nature (description) and size of (expected crowd attending) a major event;
- a date and time (duration) of the event, including preliminary practice sessions and/or rehearsals;
- a date and time (duration) of any planned pyrotechnics displays; and
- the telephone number and operating hours of the SCG trust information Hot Line for lodgement of noise complaints.

6.3.1.5 Use of permanent noise monitors

The use of permanent noise monitors is recommended to manage noise emissions from the SFSR.

The advantages of using a permanent noise monitoring system made up of several loggers installed within the site boundary are:

- Removing the need for onerous attended noise monitoring;

- Allowing prediction of noise impacts at multiple assessment locations simultaneously;
- Minimising the influence of extraneous noise, eg. traffic noise or pedestrian noise, affecting measurements;
- Allowing more accurate prediction of noise impacts at receivers than front of house measurements by reducing the predictions needed for propagation and shielding effects;
- Allowing more accurate prediction of noise impacts at receivers than front of house measurements by measuring all noise sources within the stadium, not just one or two; and
- Allow for real-time feedback and a direct display of measurement levels by potentially integrating the monitoring system into in-house data system.

Noise monitors are recommended to be located within the site boundary, specifically on or near the stadium façade or roof. The details of the monitoring system should be carefully considered as part of the NMP. The NMP should outline:

- Number and location of the noise monitors – this should take into account exposure to extraneous noise, prediction of noise impacts at receivers, accessibility / maintenance, exposure to weather effects;
- Specifications of the noise monitors – required measurement parameters (L_{Aeq} and L_{Ceq} as a minimum), power requirements, data access requirements (integration into in-house system) and maintenance and calibration requirements;
- Validation procedure – how to determine the transfer function which correlates noise limits at the stadium façade with noise limits at receivers, and an on-going calibration methodology to ensure transfer functions remain accurate; and
- Consideration of weather effects.

The specifications and design of the noise monitoring system should be developed early in the stadium design process to allow for the system to be incorporated into the stadium design while allowing considering of all the above factors.

6.3.1.6 Setup of sound amplification systems

An optimal setup of sound amplification systems should be sought in consultation with suitably qualified acoustic consultants to minimise noise impacts at potential worst affected receivers.

It is recommended that the proposed monitoring system be used to allow close monitoring and control of noise levels at receivers by adjustment of sound amplification system outputs.

Sound systems may also include noise limiters to prevent exceedance of established noise limits at nearby receivers, or trigger levels as indication of exceedances of noise limits. The setting of these systems will require consultation with suitably qualified acoustic and AV consultants.

To comply PA system noise limits during sporting events, it is recommended that testing of the PA system be conducted prior to a sporting event in the absence of crowd noise. The noise monitoring system should be used to establish an upper noise limit which shall not be exceeded during the sporting match. This upper limit may change from day to day based on weather conditions or other variables, and should be calibrated regularly.

6.3.1.7 Noise limits during events

The current Allianz Stadium NMP [13] recommends that during the entire concert, sound tests and rehearsals, a SCG Trust employee or agent be present at the sound-mixing desk to provide direction to control noise levels in accordance with the noise levels measured by the acoustic consultant.

Compliance with the noise monitoring location limits shall indicate compliance with noise limits at surrounding receivers, and any exceedances shall be actively managed by staff at the sound mixing desk.

Receivers predicted to exceed these event noise limits should be eligible for the reactive management measures presented in Section 6.3.2.

6.3.2 Reactive management

6.3.2.1 Noise monitoring requirements

It is recommended that the noise monitoring system monitor noise during the entire duration of an event. It is recommended that noise measurements would be undertaken as follows:

- For each concerts, rehearsals or sound tests; and
- Upper noise limits for PA use during sporting events should be calibrated at least 4 times every calendar year.

Reporting requirements for noise monitoring during noisy events should be outlined in the NMP and should include:

- Measured noise levels at the monitoring system;
- Predicted noise levels at worst affected receiver locations;
- Activities occurring at the SFS and around the SFS;
- Weather at the time of the measurement;
- Instrumentation;
- Monitoring times;
- Noise descriptors and corresponding measured noise levels; and

- Personnel qualifications.

An outline to reporting requirements should also be included, providing information required in the report, such as confirmation of conditions being met.

6.3.2.2 Complaints handling

During all noisy events, the SCG trust information Hot Line should to be contactable at all times.

The SCG Trust's representative should notify without delay the acoustical consultants carrying out event noise emissions measurements who should immediately follow complaints with noise measurements carried out at locations of complainants.

A complaints register will be maintained by the SCG Trust.

Information recorded in the complaints register with respect to each complaint will include:

- Date and time of complaint and corresponding event;
- Name, address and telephone number of complainant;
- Nature of complaint; and
- Response action taken to date.

The SCG Trust's representative, during event periods, communicate and attempt to resolve matters with residents in an amicable basis.

6.3.3 Review mechanism

6.3.3.1 Community feedback

Occupants of noise sensitive receivers should be encouraged to express their opinion on the impact of noise emanating from noisy events held at SFS and provide suggestions on minimising the impact through letter box drops. The general public should similarly be encouraged through a website and in local newspapers.

6.3.3.2 Noise Management Plan publicly available

The NMP should be made publicly available on a website alongside information on upcoming noisy events.

6.3.3.3 Review of Noise Management Plan

This NMP shall be reviewed annually or on "as needs" basis and recommendations from any interested parties will be made to SCG Trust for any changes to be made to the NMP. The SCG Trust may then determine to make changes to the NMP to improve the management of the site.

The regular review and update of the NMP should take into account:

- complaints regarding noise;
- results of the community consultation; and
- recommendations from the consent authorities and acoustical consultants engaged in monitoring of noise during the events.

7 Conclusion

Based on the assessments detailed above, it is concluded that the development will not have any significant additional noise impacts on the nearby noise sensitive receivers or the environment around the development site. The noise assessment has included a complete set of noise surveys to update assumptions regarding the existing noise climate.

The assessment has covered the following issues and concluded:

7.1 Construction noise

Predictions have been made of noise generated from the various activities during early works, which include procurement and establishment and demolition of ancillary buildings and stadium. This has been informed by guidance from the project Construction Consultant.

The most significant noise impacts are predicted during demolition works, where the use of noisy equipment such as concrete crushers, excavators and rock breakers are predicted to generate noise impacts above construction NMLs.

Noise impacts may affect occupants in the University of Technology Sydney Rugby Australia and NRL building, and scheduling of works and consultation is recommended should these buildings remain operational during demolition works.

Mitigation will need to be considered where sensitive receivers are located closer to the construction work zone than these ‘safe working distances’ presented in Table 37. This should be considered when conducting rock breaking near vibration sensitive receivers such as receiver C4 - University of Technology Sydney Rugby Australia and NRL building and potentially heritage listed buildings or structures.

It should be noted that no residential receivers are predicted to be ‘highly affected’, i.e. over 75 dBA.

Detailed recommendations are given for the control of construction noise for the periods where exceedances are predicted of relevant Noise Management Levels.

7.2 Operational noise excluding events

Operation noise criteria have been established for noise emissions excluding events, which include:

- External mechanical plant and equipment;
- Staff carpark activities; and
- Loading dock operations & waste and recycling collection.

Since details of these noise sources are not available at this stage of the project, the assessment of noise emissions from these sources shall be conducted at Stage 2 Development Application.

7.3 Sporting and concert events

Noise impacts from sporting and concert events have been predicted at nearby residential receivers. Noise limits have been established based on L_{eq5min} noise levels for both concert noise and PA noise during sporting events.

It should be noted, noise impacts from events at the proposed SFS are expected to decrease from existing impacts from Allianz Stadium, as the stadium shape will improve noise shielding to nearby receivers from the existing stadium.

The following event scenarios have been modelled:

Sporting events:

- Club mode – 30,000 patrons; and
- Championship mode – 45,000 patrons.

Concert events:

- Typical speaker configuration; located north facing south; and
- Non-typical speaker configuration; located centre facing outwards and located south facing north.

Noise impacts have been predicted using a noise model, with the following conservative assumptions:

- No roof has been included in the model;
- For sporting events, the stadium is at full capacity in both modes; and
- Modelled internal noise levels are based on the highest measured levels taken during events at the existing Allianz Stadium.

Results show predicted noise impacts during concert events generally comply with noise limits when in typical speaker configuration, and comply with PA noise limits during sporting events. It is noted that noise impacts from sporting events are generally similar to ambient L_{eq} levels from road traffic.

Overall, event noise impacts are expected to be similar or slightly lower than current event noise impacts, and no additional significant acoustic issues are predicted as a result of the project. No significant cumulative effect from sporting events at the SCG are expected.

Noise and vibration mitigation measures have been recommended, and should be included in a NMP to be implemented for concert and sporting events.

Appendix A

References

References

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Appendix B

Acoustic Glossary

B1 Acoustic Glossary

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / min$L_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and min$L_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dBA

dBA denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dBA.

Some typical dBA levels are shown below.

Sound Pressure Level dBA	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc.)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dBA or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an

example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dBA or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dBA or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dBA weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dBA weighted energy-average level of a 15 minute measurement.

L_{max}

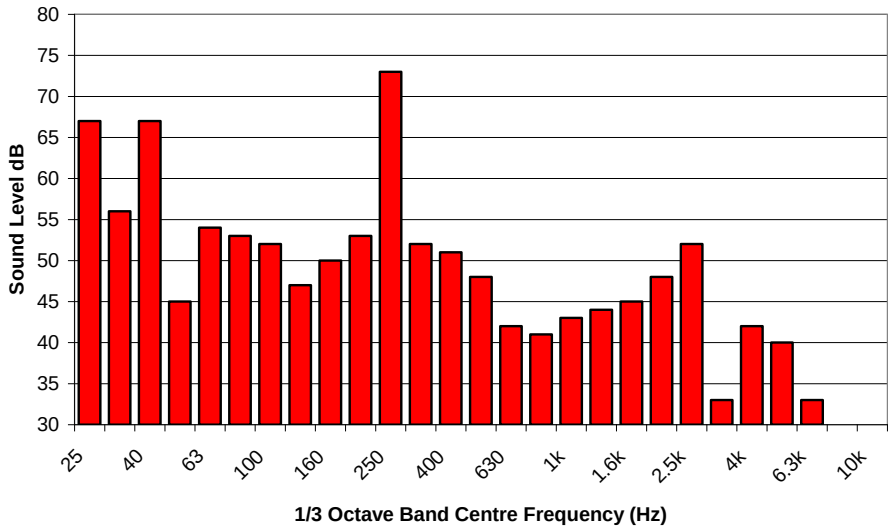
The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

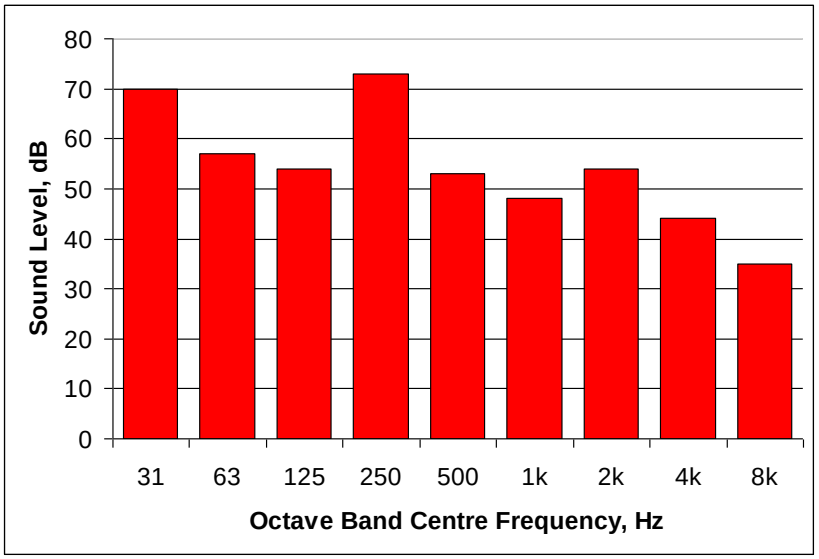
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dBA during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".





Peak Particle Velocity (PPV)

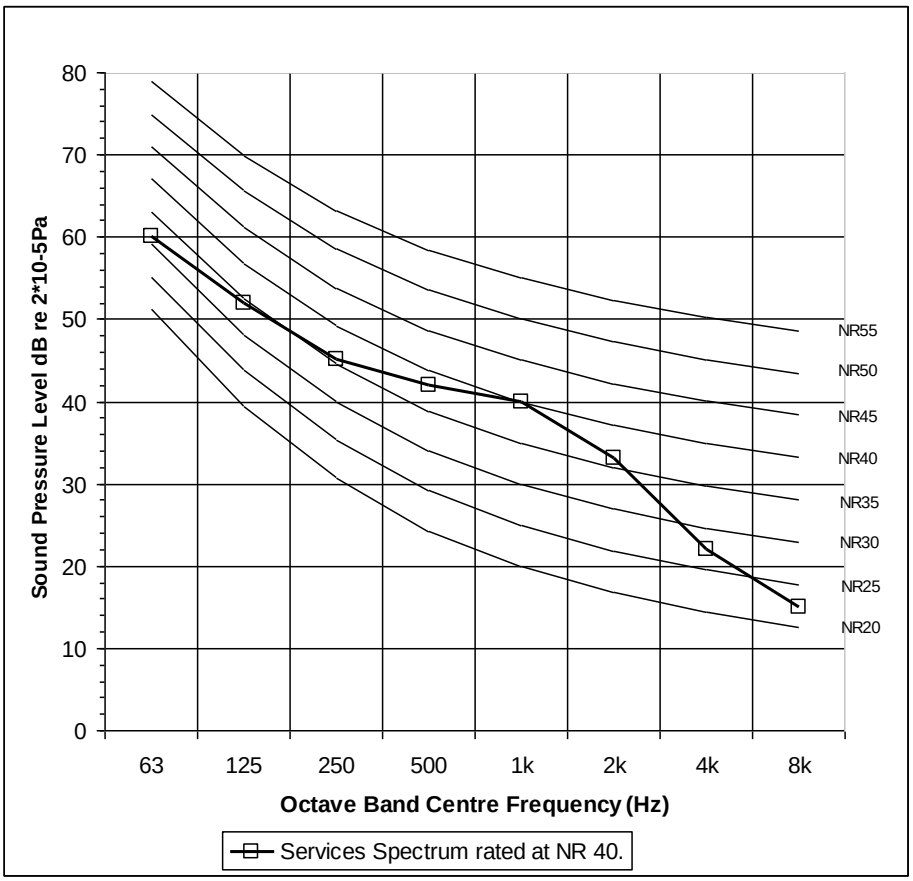
Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criterion, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Noise Rating (NR) Curves

Noise rating (NR) curves are a set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The NR value of a noise

is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a plant noise spectrum that is equivalent to NR 40.



Sound Level Difference (D)

Sound level difference is used to quantify the sound insulation between two spaces, and is equal to the difference in sound level between the two rooms at a particular frequency (e.g. if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB). The weighted sound level difference, D_w, (as defined in AS/NZS ISO 717.1) is commonly used to provide a single-number descriptor to describe the overall performance of a partition across a wider frequency range.

The terms used to describe the airborne sound insulation rating of a building element when tested on-site are the weighted normalised level difference ($D_{n,w}$), which corrects the measured sound level difference to a reference absorption area in the receiving room, or the weighted standardized level difference ($D_{nT,w}$), which corrects the measurements to a reference reverberation time in the receiving room. These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s²) or else using a decibel scale.

Appendix C

Measurement Methodology and Results

C1 Noise Monitoring Methodology and Results

C1.1 Noise monitoring equipment

Unattended and attended monitoring was carried out using the following equipment:

Monitoring	Measurement location	Equipment/model	Serial No.	SLM Type
Unattended long-term	Meas. 1	Ngara (ARL)	878 07b	Class 1
	Meas. 2	Ngara (ARL)	878 000	Class 1
	Meas. 4	Ngara (ARL)	878 0E6	Class 1
	Meas. 5	Ngara (ARL)	878 042	Class 1
	Meas. 6	Ngara (ARL)	878 0EA	Class 1
	Meas. 7	Ngara (ARL)	878 0D1	Class 1

Notes: All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and designated either Class 1 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Class 4231 calibrator. No significant drift in calibration was observed.

C1.2 Long-term measurement methodology

C1.2.1 Extraneous/weather affected data

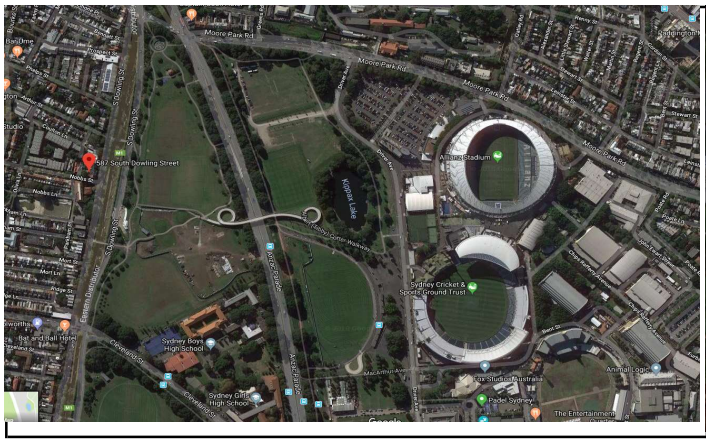
Measurement samples affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Appendix B of the NPI [1].

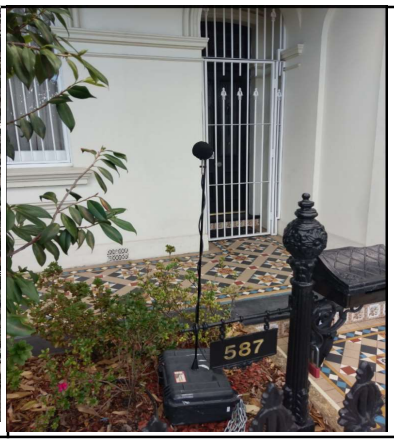
Data was provided by the Bureau of Meteorology (BOM) collection station at Sydney Observatory Hill. Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

ARUP

587 South Dowling St (Free Field)

Additional detail:





Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		56	45		67	65
Thursday-22-February-2018	57	56	44	68	67	65
Friday-23-February-2018	58	57	46	68	68	66
Saturday-24-February-2018	57	56		67	67	
Sunday-25-February-2018						
Monday-26-February-2018	60	56	47	70	69	67
Tuesday-27-February-2018	58	57	49	68	70	66
Wednesday-28-February-2018	57	57	50	69	68	66
Thursday-01-March-2018	58	57	49	69	68	67
Friday-02-March-2018	57	56		70	68	
Saturday-03-March-2018						
Representative Weekday[5]	**58**	**56**	**47**	**69**	**68**	**66**
Representative Weekend[5]	**57**	**56**	**#NUM!**	**67**	**67**	**#DIV/0!**
Representative Week[5]	**58**	**56**	**47**	**69**	**68**	**66**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	67	65	69	69
Thursday-22-February-2018	68	65	68	69
Friday-23-February-2018	68	66	68	69
Saturday-24-February-2018	67	68	68	70
Sunday-25-February-2018	70	70	74	72
Monday-26-February-2018	70	67	71	72
Tuesday-27-February-2018	69	66	70	69

Wednesday-28-February-2018	68	66	70	69
Thursday-01-March-2018	69	67	72	70
Friday-02-March-2018	70	66	0	68
Saturday-03-March-2018				
Representative Weekday[3]	**69**	**66**	**69**	**70**
Representative Weekend[3]	**69**	**69**	**72**	**71**
Representative Week[3]	**69**	**67**	**70**	**70**

Notes:

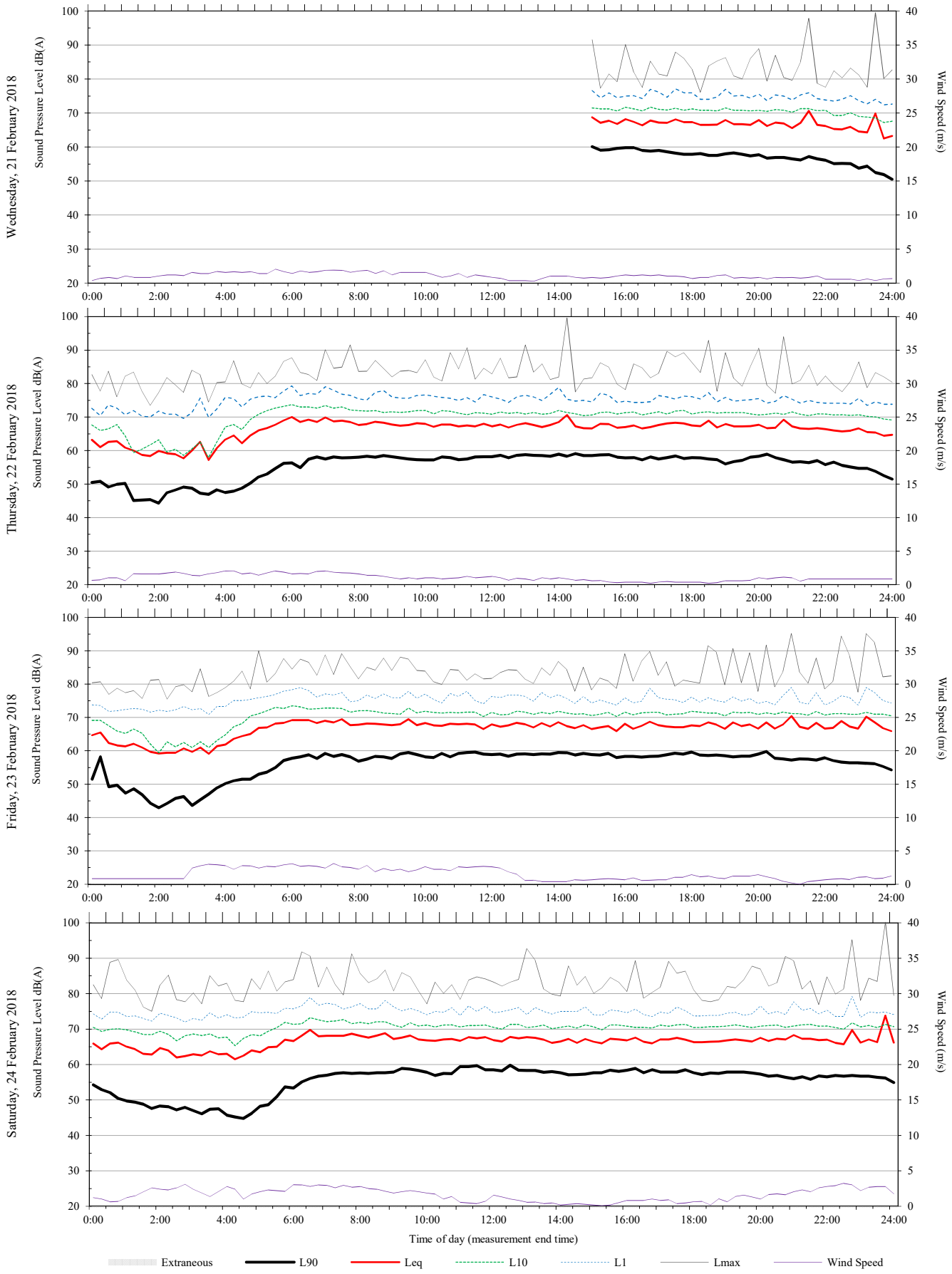
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

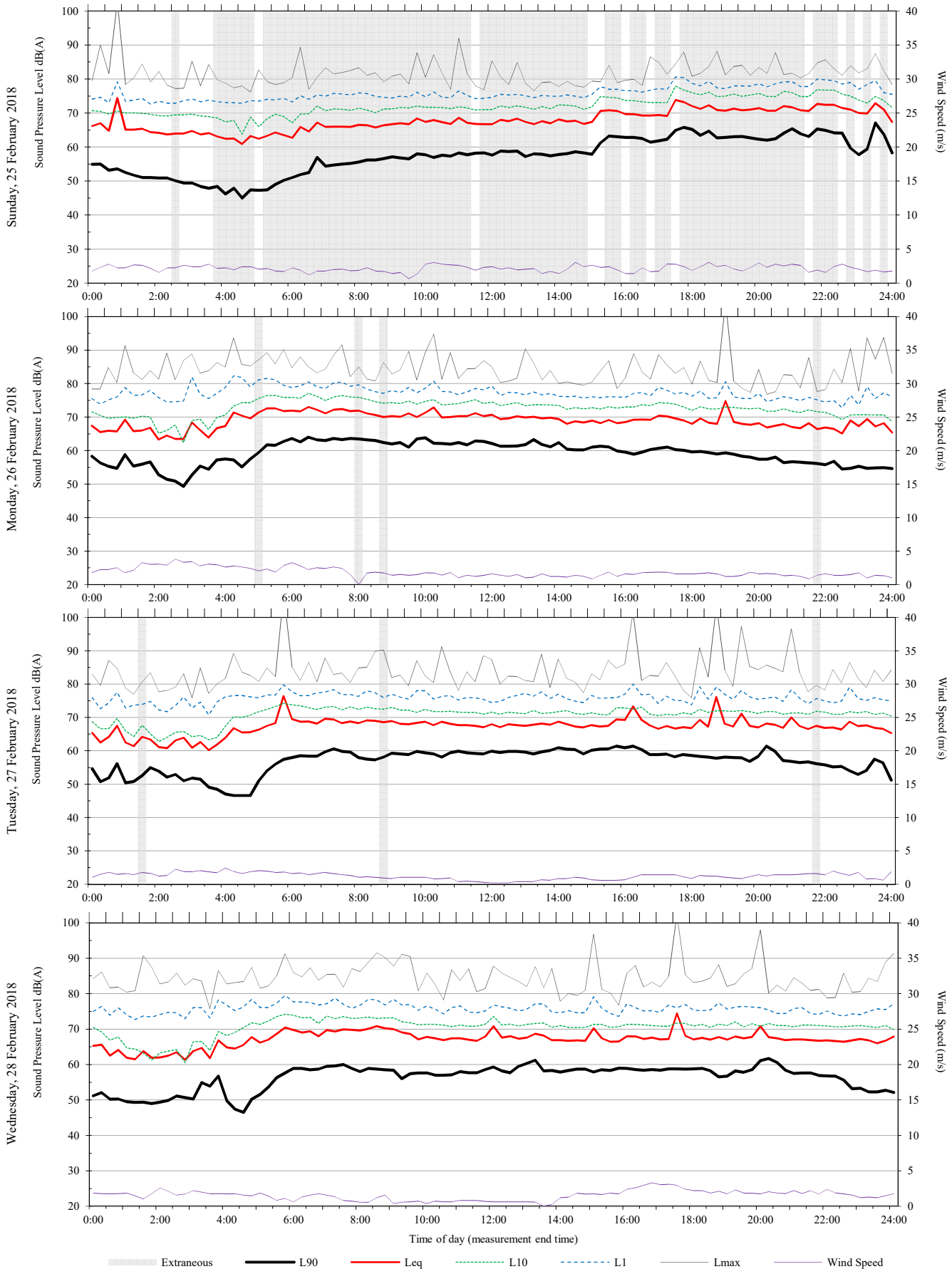
Unattended monitoring: 587 South Dowling St (Free Field)

ARUP



Unattended monitoring: 587 South Dowling St (Free Field)

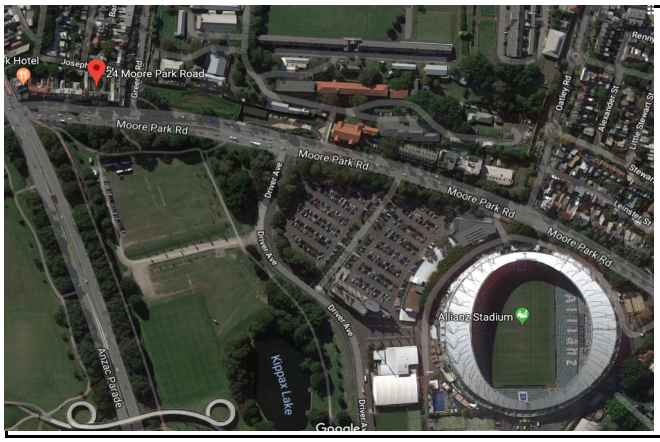
ARUP



ARUP

24 Moore Park Road, Paddington (Free Field)

Additional detail:



Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		52	38		64	61
Thursday-22-February-2018	56	51	39	66	65	61
Friday-23-February-2018	57	52	39	66	64	60
Saturday-24-February-2018	54	52		66	64	
Sunday-25-February-2018						
Monday-26-February-2018	58	52	42	69	67	61
Tuesday-27-February-2018	56			66		
Wednesday-28-February-2018						
Representative Weekday[5]	**56**	**52**	**39**	**67**	**65**	**61**
Representative Weekend[5]	**54**	**52**	**#NUM!**	**66**	**64**	**#DIV/0!**
Representative Week[5]	**56**	**52**	**39**	**67**	**65**	**61**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	65	61	66	66
Thursday-22-February-2018	66	61	67	67
Friday-23-February-2018	66	60	67	64
Saturday-24-February-2018	65	62	66	64
Sunday-25-February-2018	69	65	72	69
Monday-26-February-2018	69	61	70	66
Tuesday-27-February-2018	67		67	
Wednesday-28-February-2018				
Representative Weekday[3]	**67**	**61**	**68**	**66**
Representative Weekend[3]	**67**	**64**	**70**	**67**

Representative Week[3]	**67**	**62**	**69**	**66**

Notes:

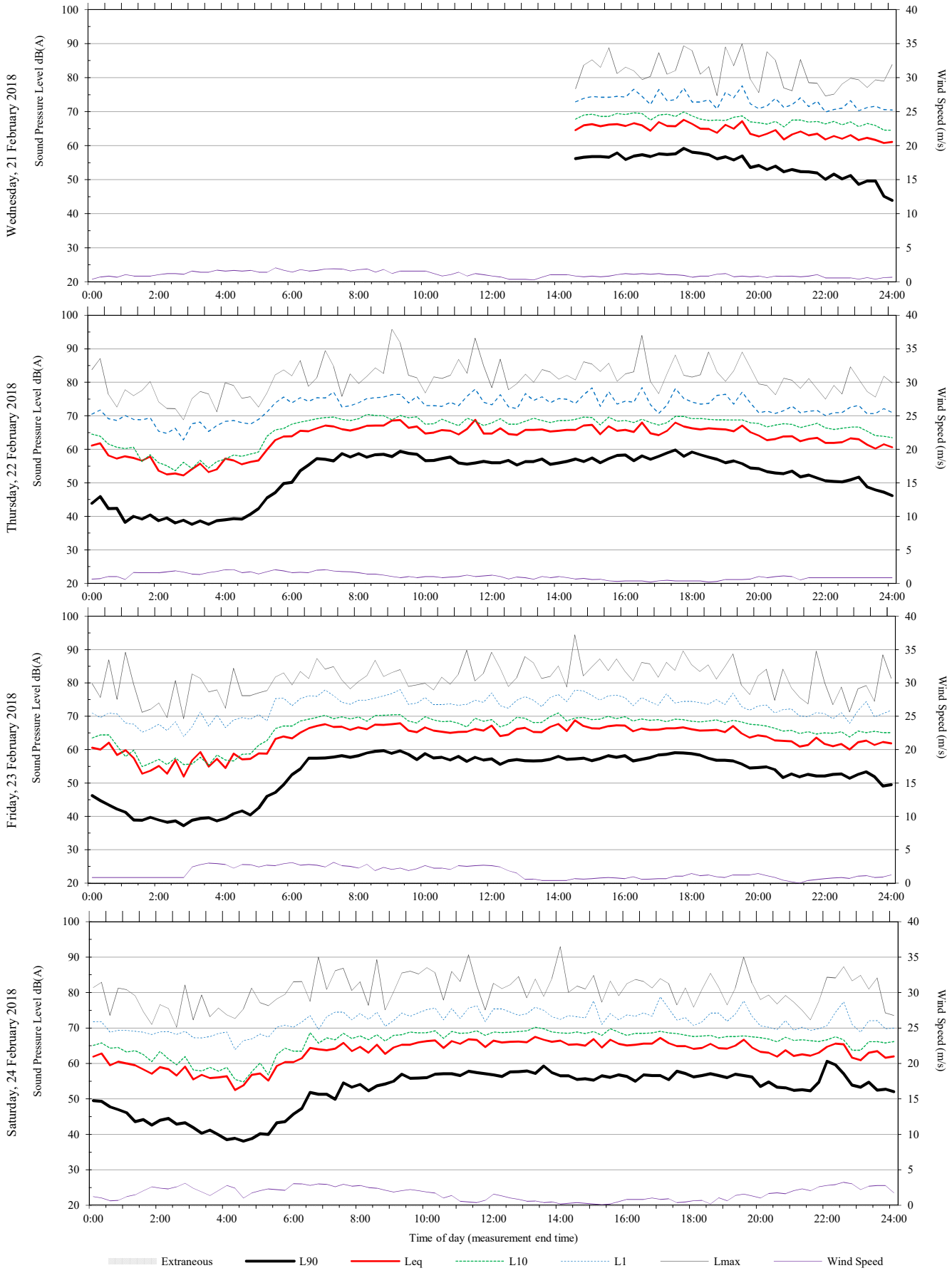
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

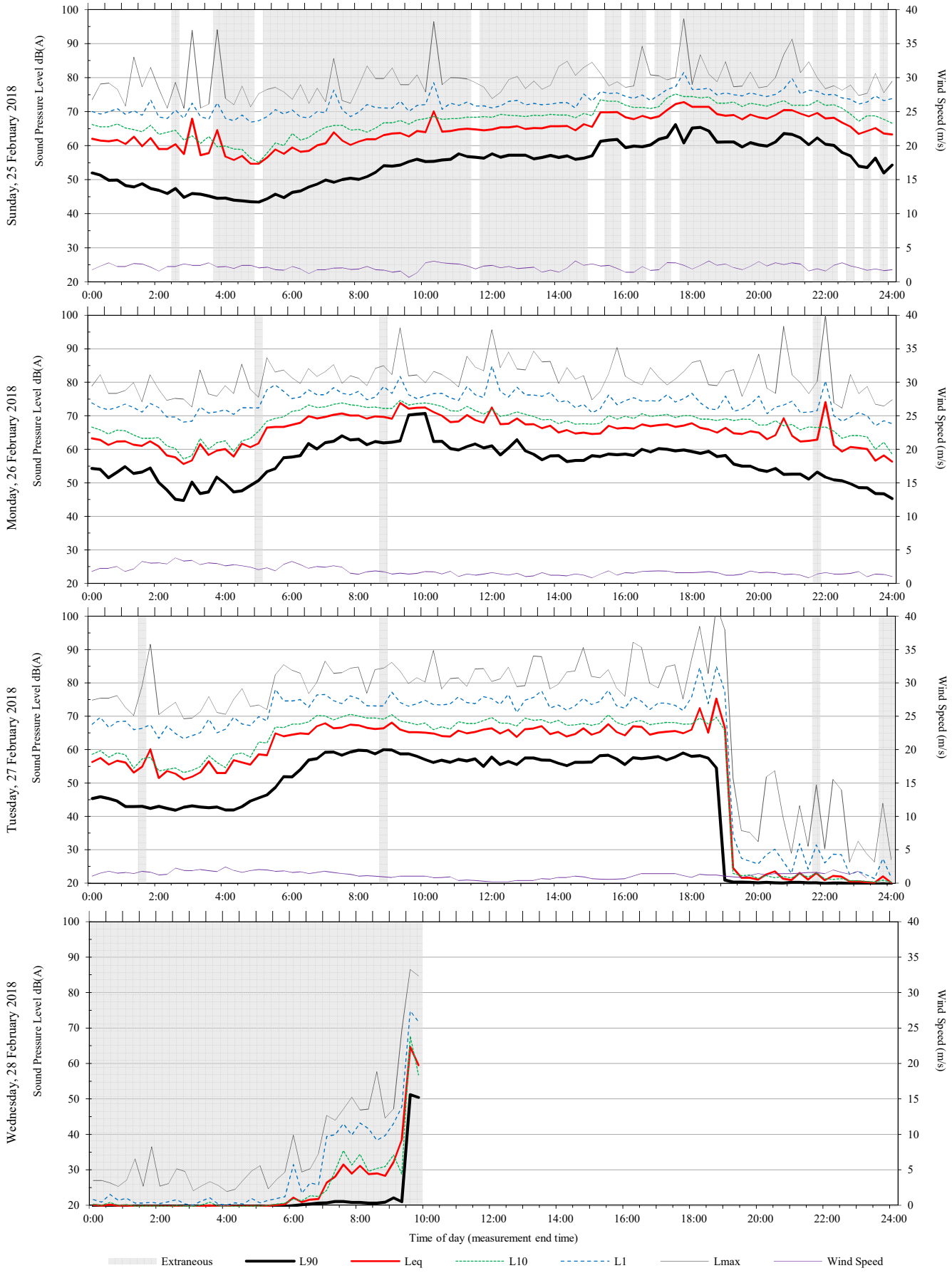
Unattended monitoring: 24 Moore Park Road, Paddington (Free Field)

ARUP



Unattended monitoring: 24 Moore Park Road, Paddington (Free Field)

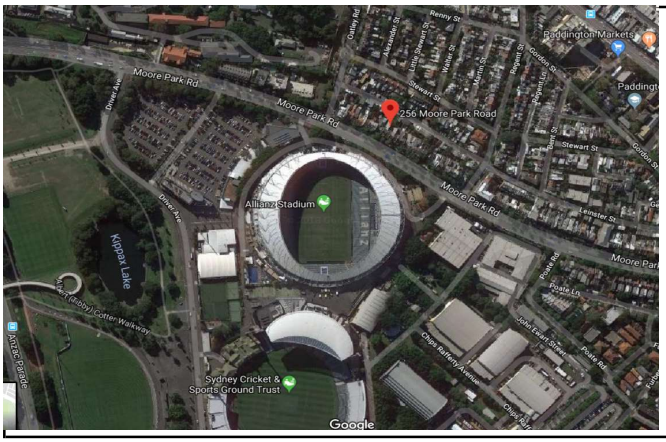
ARUP

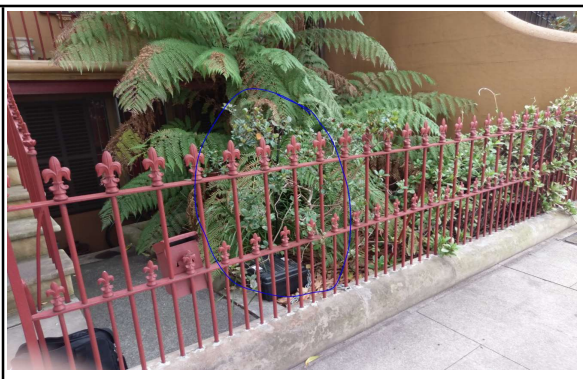


ARUP

256 Moore Park Rd (Free Field)

Additional detail:





Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		49	37		66	62
Thursday-22-February-2018	52	50	37	67	67	63
Friday-23-February-2018	53	49	38	68	66	61
Saturday-24-February-2018	52	54		66	65	
Sunday-25-February-2018						
Monday-26-February-2018	53	48	38	69	66	61
Tuesday-27-February-2018	52	50	37	67	66	62
Wednesday-28-February-2018	52	50	41	68	67	62
Thursday-01-March-2018	52	51	38	68	68	62
Friday-02-March-2018	52	49	37	68	66	63
Saturday-03-March-2018	50	49		69	65	
Sunday-04-March-2018						
Representative Weekday[5]	**52**	**49**	**37**	**68**	**67**	**62**
Representative Weekend[5]	**51**	**51**	**#NUM!**	**68**	**65**	**#DIV/0!**
Representative Week[5]	**52**	**49**	**37**	**68**	**66**	**62**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	67	62	68	67
Thursday-22-February-2018	67	63	70	68
Friday-23-February-2018	67	61	68	64
Saturday-24-February-2018	66	62	67	64
Sunday-25-February-2018	71	67	72	72
Monday-26-February-2018	69	61	72	68

Tuesday-27-February-2018	67	62	68	69
Wednesday-28-February-2018	68	62	69	68
Thursday-01-March-2018	68	62	69	69
Friday-02-March-2018	67	63	0	66
Saturday-03-March-2018	68	62	71	65
Sunday-04-March-2018				
Representative Weekday[3]	**68**	**62**	**69**	**68**
Representative Weekend[3]	**69**	**64**	**70**	**69**
Representative Week[3]	**68**	**63**	**69**	**68**

Notes:

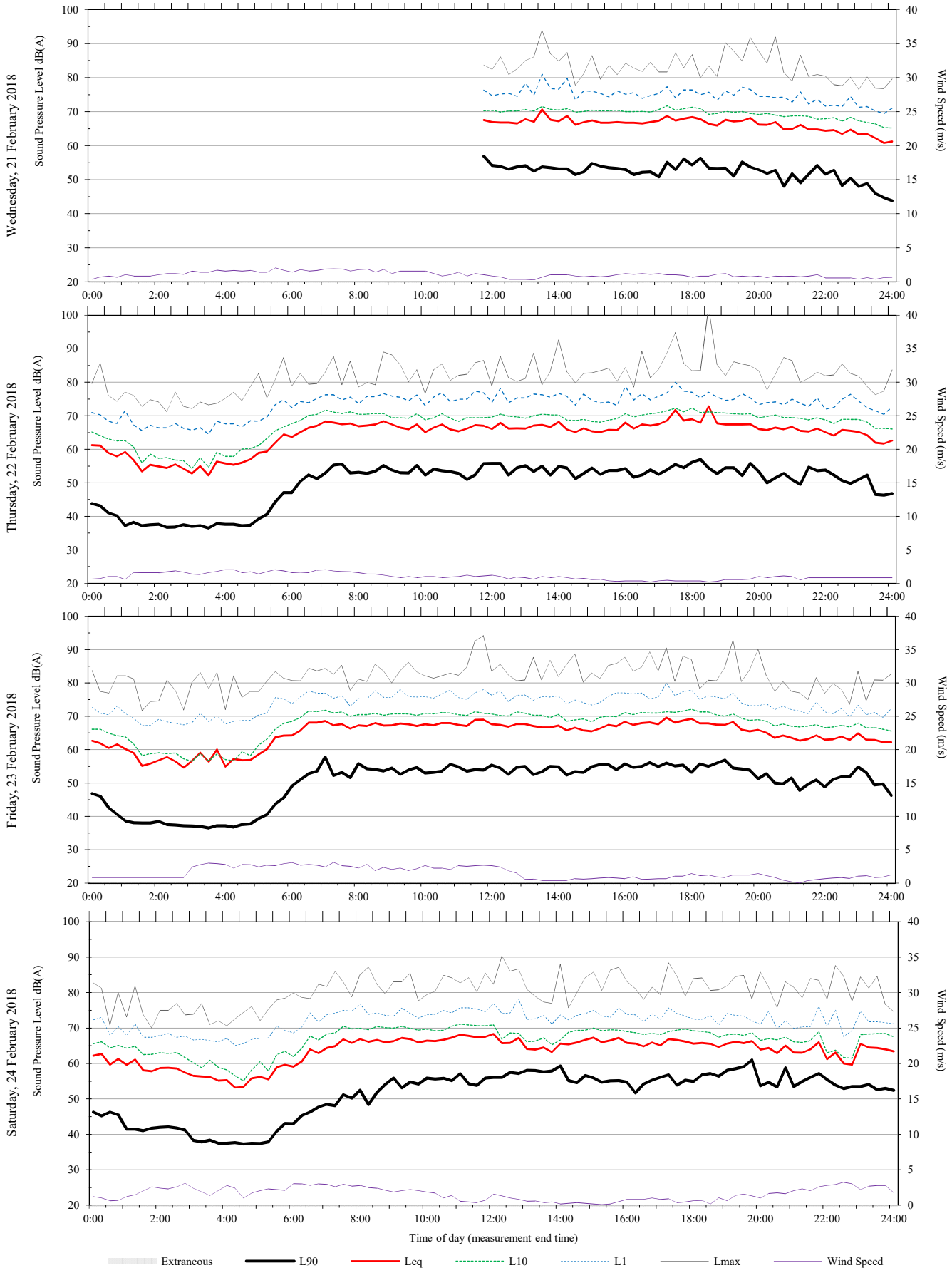
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

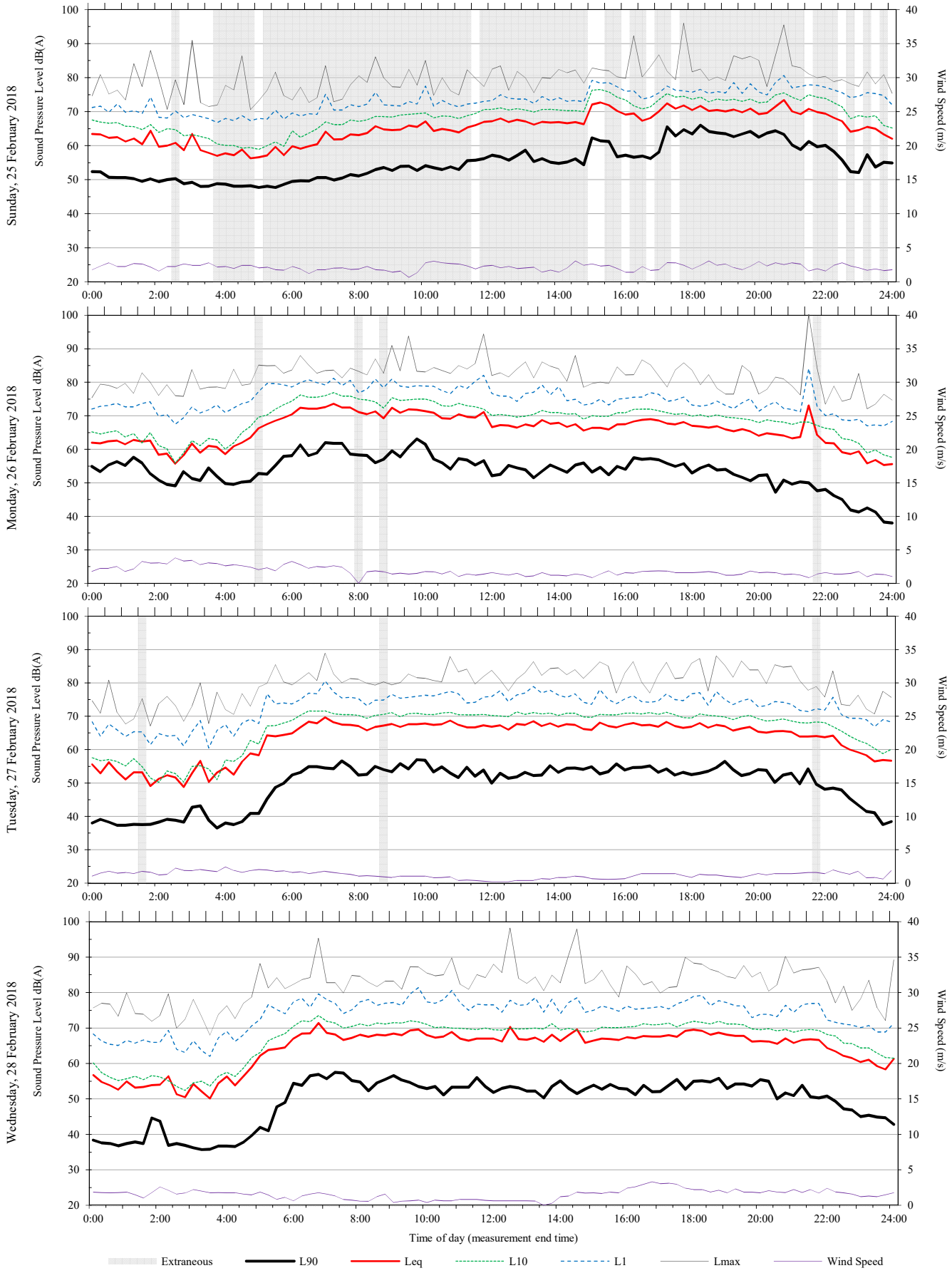
Unattended monitoring: 256 Moore Park Rd (Free Field)

ARUP



Unattended monitoring: 256 Moore Park Rd (Free Field)

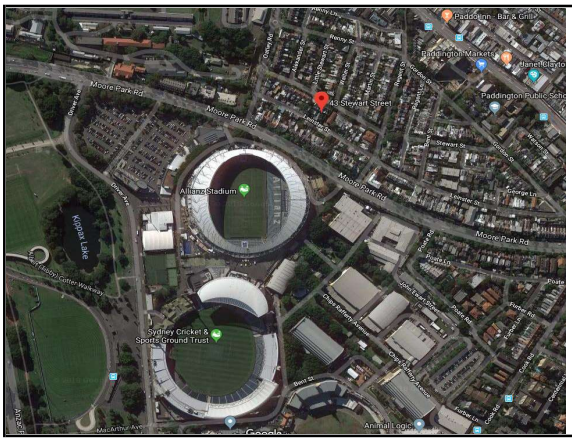
ARUP



ARUP

43 Stewart St (Free Field)

Additional detail:



Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		39	37		53	49
Thursday-22-February-2018	40	40	37	60	55	44
Friday-23-February-2018	43	44	38	58	57	49
Saturday-24-February-2018	43	46		57	56	
Sunday-25-February-2018						
Monday-26-February-2018	45	42	38	57	53	46
Tuesday-27-February-2018	41	38	37	54	56	47
Wednesday-28-February-2018	43	45	41	59	56	53
Thursday-01-March-2018	42	40	38	60	53	46
Friday-02-March-2018	40	38	37	55	50	47
Saturday-03-March-2018	40	46	38	56	57	50
Sunday-04-March-2018	45	41	37	58	51	46
Monday-05-March-2018						
Representative Weekday[5]	**42**	**40**	**37**	**58**	**54**	**49**
Representative Weekend[5]	**43**	**46**	**38**	**57**	**55**	**48**
Representative Week[5]	43	41	**37**	**57**	**55**	**49**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	52	49	54	58
Thursday-22-February-2018	59	44	60	50
Friday-23-February-2018	57	49	58	55
Saturday-24-February-2018	57	51	59	57
Sunday-25-February-2018	59	55	65	57

Monday-26-February-2018	56	46	58	51
Tuesday-27-February-2018	55	47	56	56
Wednesday-28-February-2018	58	53	58	58
Thursday-01-March-2018	59	46	63	51
Friday-02-March-2018	54	47	0	55
Saturday-03-March-2018	56	50	57	55
Sunday-04-March-2018	56	46	60	52
Monday-05-March-2018	55		57	
Representative Weekday[3]	**57**	**49**	**58**	**55**
Representative Weekend[3]	**57**	**51**	**61**	**56**
Representative Week[3]	**57**	**50**	**59**	**55**

Notes:

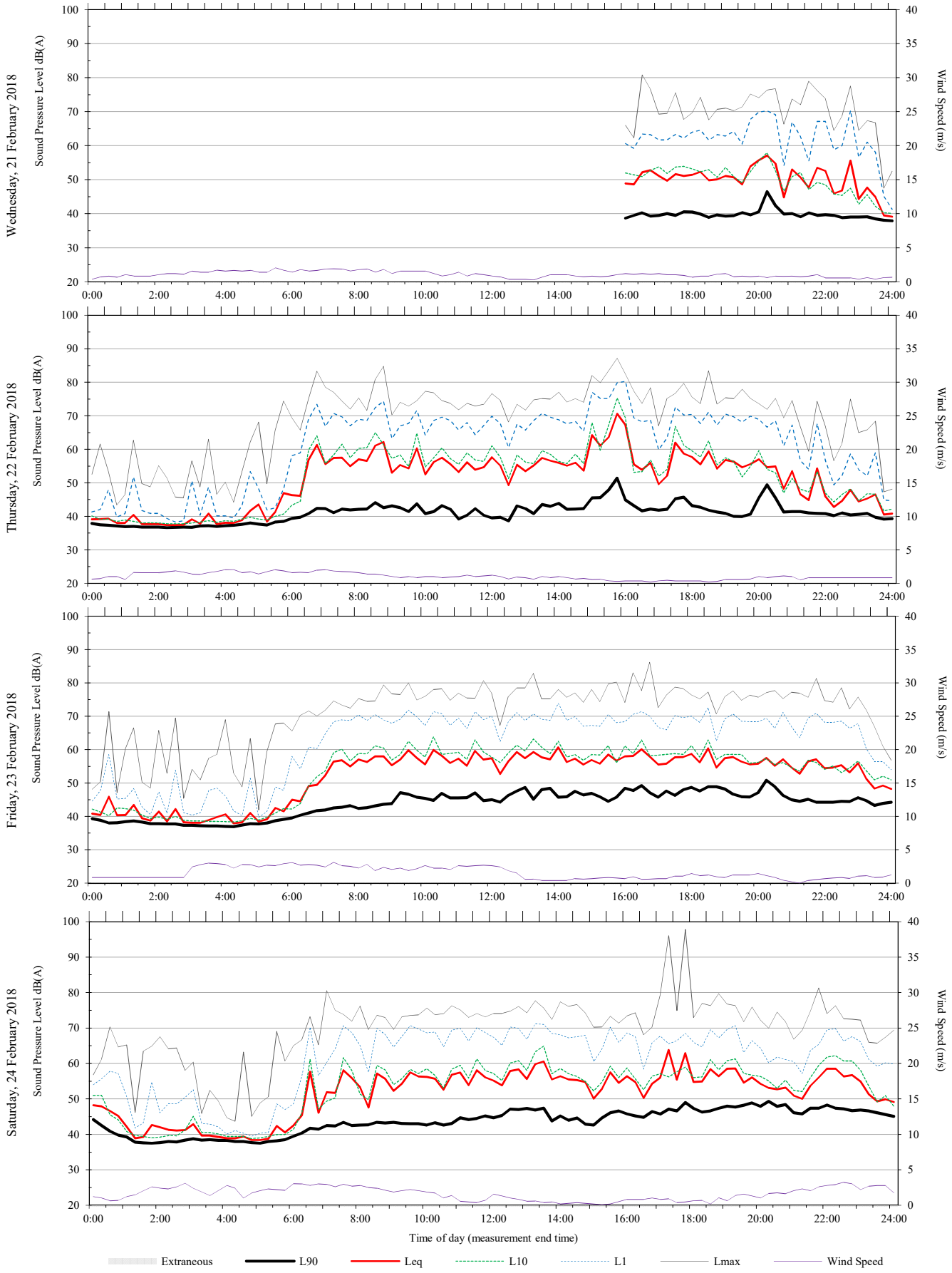
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

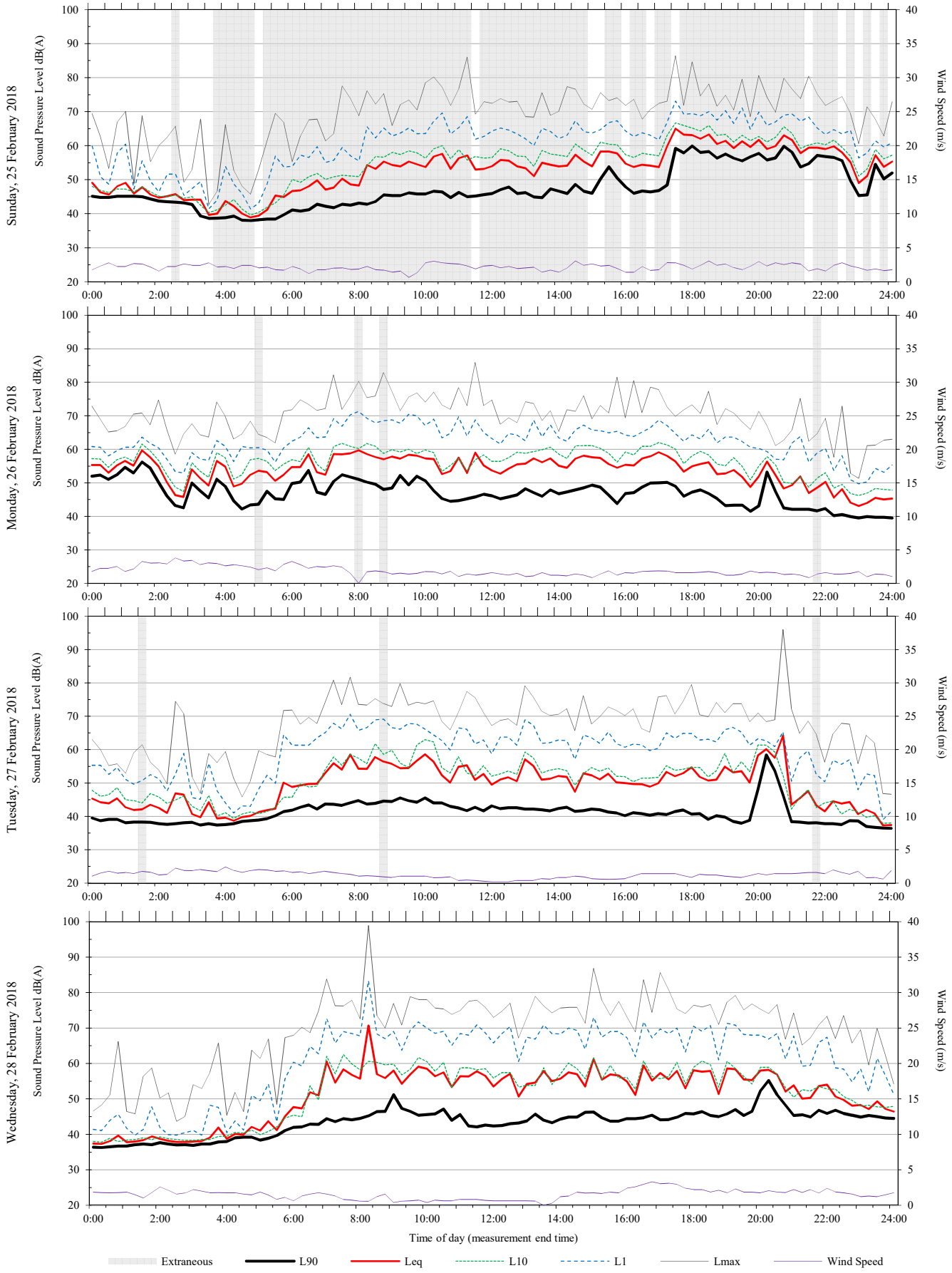
Unattended monitoring: 43 Stewart St (Free Field)

ARUP



Unattended monitoring: 43 Stewart St (Free Field)

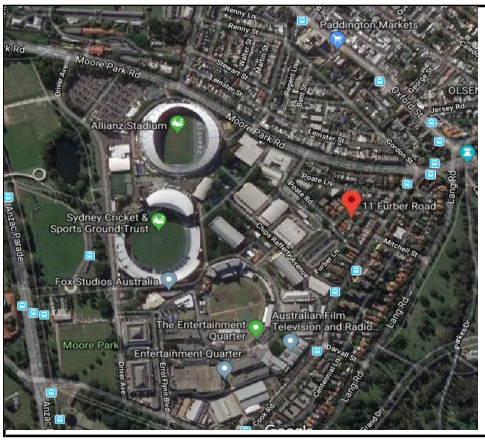
ARUP

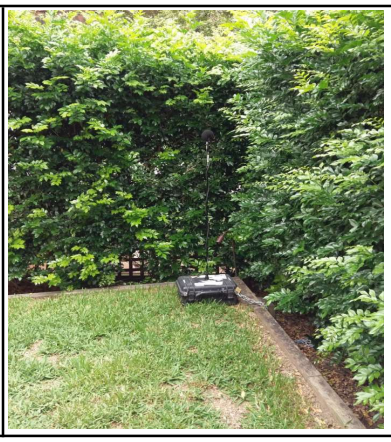


ARUP

11 Furber Rd (Free Field)

Additional detail:





Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		36	28		52	45
Thursday-22-February-2018	38	37		56	54	
Friday-23-February-2018						
Saturday-24-February-2018		43			52	
Sunday-25-February-2018						
Monday-26-February-2018	41	36	29	51	55	42
Tuesday-27-February-2018	38	35	30	54	56	40
Wednesday-28-February-2018	40	42	37	57	59	45
Thursday-01-March-2018	39	35	33	54	54	40
Friday-02-March-2018	37	32	30	49	52	44
Saturday-03-March-2018	37	43	34	68	60	47
Sunday-04-March-2018	40	36	29	51	51	39
Monday-05-March-2018						
Representative Weekday[5]	**39**	**36**	**30**	**54**	**55**	**43**
Representative Weekend[5]	**39**	**43**	**32**	**65**	**56**	**45**
Representative Week[5]	**39**	**36**	**30**	**60**	**56**	**43**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	52	45	53	52
Thursday-22-February-2018	55	41	57	41
Friday-23-February-2018				
Saturday-24-February-2018	53	46	59	51
Sunday-25-February-2018	56	49	61	52

Monday-26-February-2018	53	42	56	49
Tuesday-27-February-2018	55	40	59	45
Wednesday-28-February-2018	58	45	62	49
Thursday-01-March-2018	54	40	57	45
Friday-02-March-2018	50	44	0	52
Saturday-03-March-2018	67	47	72	54
Sunday-04-March-2018	51	39	54	44
Monday-05-March-2018	51		53	
Representative Weekday[3]	**54**	**43**	**57**	**49**
Representative Weekend[3]	**61**	**47**	**66**	**51**
Representative Week[3]	**58**	**45**	**63**	**50**

Notes:

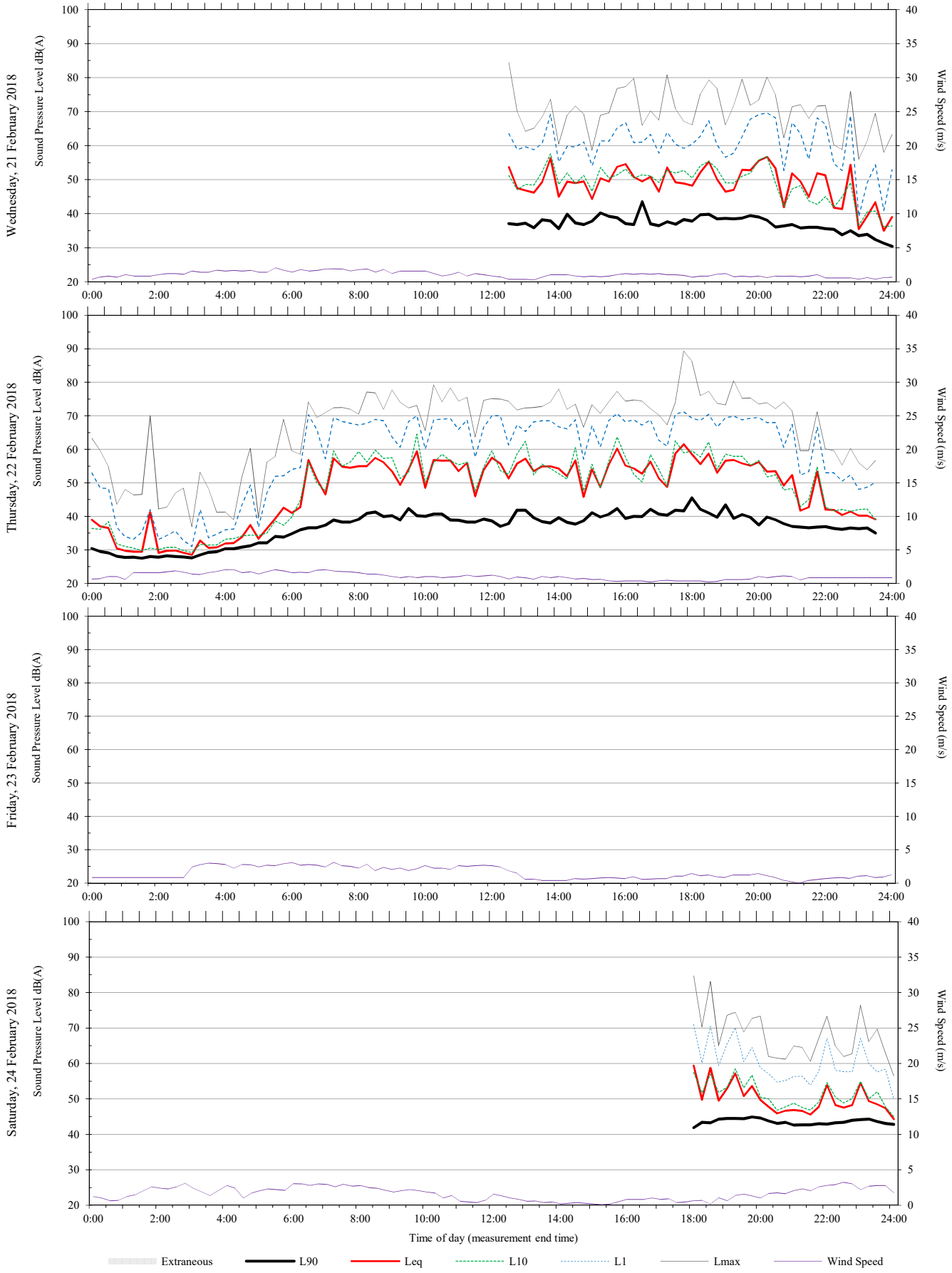
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

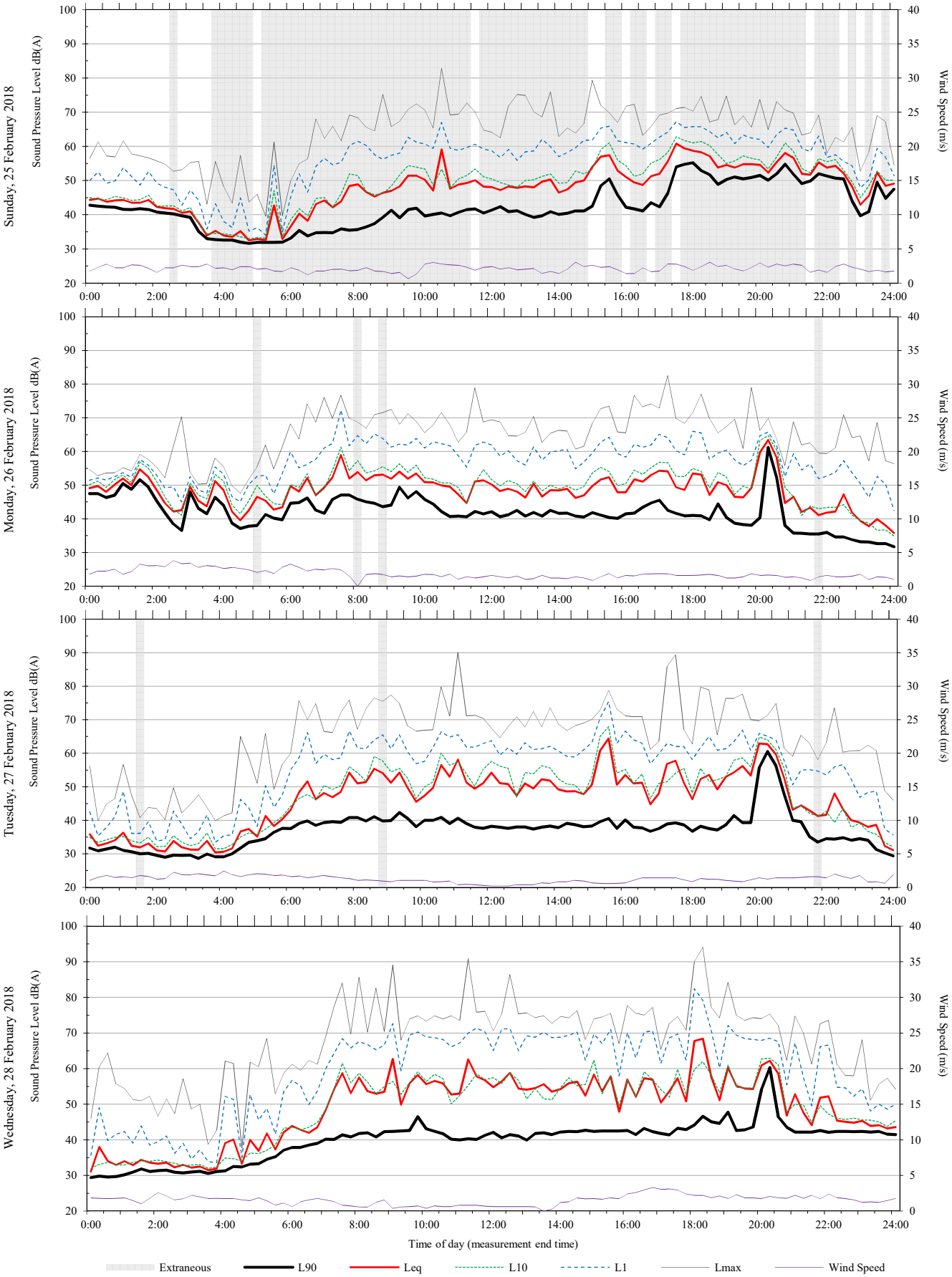
Unattended monitoring: 11 Furber Rd (Free Field)

ARUP



Unattended monitoring: 11 Furber Rd (Free Field)

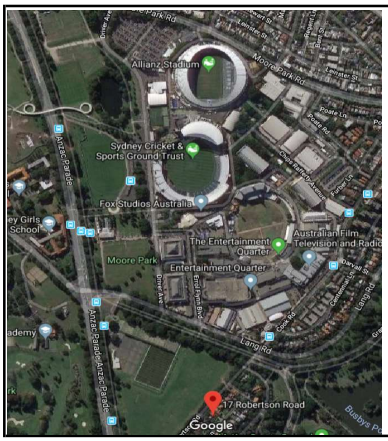
ARUP



ARUP

17 Robertson Rd (Free Field)

Additional detail:



Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-21-February-2018		45	41		57	50
Thursday-22-February-2018	47	48	43	58	58	50
Friday-23-February-2018	50	47	40	59	57	50
Saturday-24-February-2018	48	49		57	55	
Sunday-25-February-2018						
Monday-26-February-2018	47		39	55		47
Tuesday-27-February-2018	45		42	54		51
Wednesday-28-February-2018	47	49	43	58	61	50
Thursday-01-March-2018	45		40	55		48
Friday-02-March-2018	44	43	41	55	54	49
Saturday-03-March-2018	47			57		
Representative Weekday[5]	**47**	**47**	**41**	**57**	**58**	**49**
Representative Weekend[5]	**48**	**49**	**#NUM!**	**57**	**0**	**#DIV/0!**
Representative Week[5]	**47**	**47**	**41**	**57**	**0**	**49**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Wednesday-21-February-2018	56	50	60	56
Thursday-22-February-2018	58	50	60	54
Friday-23-February-2018	59	50	60	55
Saturday-24-February-2018	57	50	58	52
Sunday-25-February-2018	58	52	64	56
Monday-26-February-2018	54	47	57	53
Tuesday-27-February-2018	54	51	55	56

Wednesday-28-February-2018	59	50	60	52
Thursday-01-March-2018	55	48	58	53
Friday-02-March-2018	55	49	0	55
Saturday-03-March-2018	57			
Representative Weekday[3]	**57**	**49**	**58**	**55**
Representative Weekend[3]	**0**	**51**	**62**	**54**
Representative Week[3]	**0**	**50**	**59**	**55**

Notes:

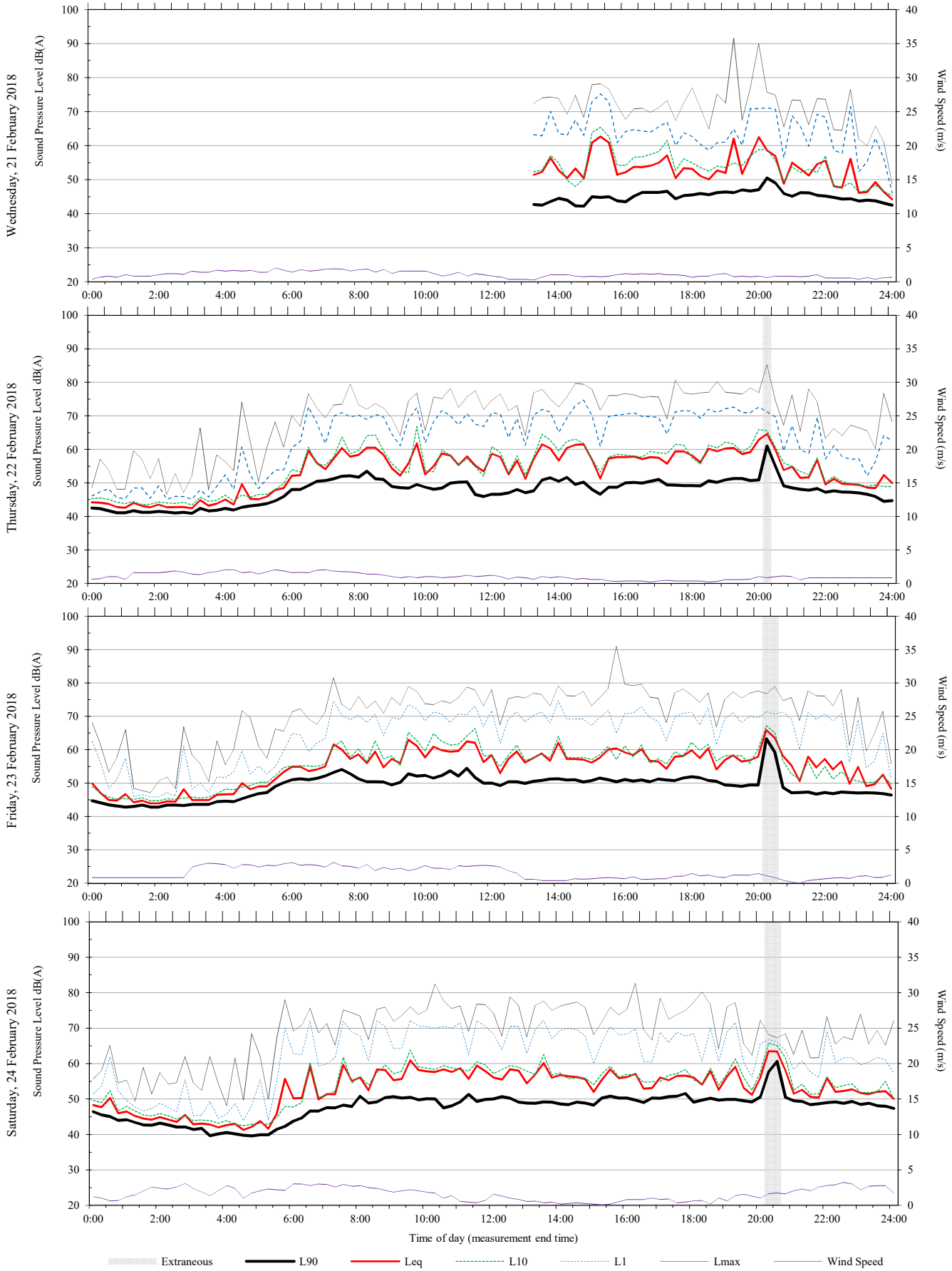
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

Unattended monitoring: 17 Robertson Rd (Free Field)

ARUP



Unattended monitoring: 17 Robertson Rd (Free Field)

ARUP