

Venues NSW

**Precinct Village and Car Park,
Moore Park**

**Noise and Vibration Impact
Assessment**

AC01

Issue 2 | 6 September 2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 282684







Arup Australia Pty Ltd ABN 76 625 912 665

Arup
Level 5
151 Clarence Street
Sydney NSW 2000
Australia
www.arup.com

ARUP

Document verification

ARUP

Job title		Precinct Village and Car Park, Moore Park		Job number 282684	
Document title		Noise and Vibration Impact Assessment		File reference AC01	
Document ref		AC01			
Revision	Date	Filename	AC01-v1_Precinct Village and Car Park NVIA.docx		
Draft 1	30 Jul 2021	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Chris Nugroho	Mathew Simon	Mathew Simon
		Signature			
Draft 2	11 Aug 2021	Filename	AC01-v2_Precinct Village and Car Park Draft NVIA.docx		
		Description	Second draft		
			Prepared by	Checked by	Approved by
		Name	Chris Nugroho	Mathew Simon	Andrew Johnson
		Signature			
Issue 1	19 Aug 2021	Filename	282684-AC01-v3_Precinct Village and Car Park NVIA.docx		
		Description	Issue 1		
			Prepared by	Checked by	Approved by
		Name	Mathew Simon	Glenn Wheatley	Andrew Johnson
		Signature			
Issue 2	6 Sep 2021	Filename	282684-AC01-v4_Precinct Village and Carpark NVIA.docx		
		Description	Updated as per review comments		
			Prepared by	Checked by	Approved by
		Name	Mathew Simon	Glenn Wheatley	Mathew Simon
		Signature			
<p align="center">Issue Document verification with document</p> <div style="text-align: right;"> <input checked="" type="checkbox"/> </div>					

Contents

	Page
1 Introduction	1
2 Precinct Village and Car Park	3
2.1 Vision	3
2.2 Location	3
2.3 Development description	4
2.4 Proposed operation	5
2.5 Delivery	6
3 Proposed approval modifications	7
4 Purpose of this report	8
5 Existing acoustic environment	11
5.1 Surrounding land-uses	11
5.2 Assessment locations	14
6 Construction noise and vibration	16
6.1 Construction noise criteria	16
6.2 Construction vibration criteria	18
6.3 Construction noise assessment	21
6.4 Construction noise mitigation measures	27
7 Operational noise	29
7.1 Overview	29
7.2 Hours of operation	30
7.3 Criteria	30
7.4 Noise assessment	33
7.5 Noise mitigation measures	40
8 Conclusion	43
8.1 Construction noise and vibration	43
8.2 Operational noise	43
9 References	45

Appendices

Appendix A

Acoustic Glossary

Appendix B

Methodology Statement - Working near Busby's Bore

1 Introduction

On 6 December 2018, the then Minister for Planning approved a concept development application and concurrent early works package (SSD 9249) to facilitate redevelopment of the Sydney Football Stadium.

The concept approval established the maximum building envelope, design and operational parameters for a new stadium with up to 45,000 seats for patrons and allowing for 55,000 patrons in concert mode. The concurrent Stage 1 works, which were completed on 28 February 2020, facilitated the demolition of the former SFS and associated buildings.

Stage 2 of the Sydney Football Stadium (SFS) Redevelopment (SSD 9835) was approved by the Minister for Planning and Public Spaces on 6 December 2019. Stage 2 provides for:

- construction of the stadium, including:
 - 45,000 seats (additional 10,000 - person capacity in the playing field in concert mode) in four tiers including general admission areas, members seating and corporate / premium seating;
 - roof cover over all permanent seats and a rectangular playing pitch;
 - a mezzanine level with staff and operational areas;
 - internal pedestrian circulation zones, media facilities and other administration areas on the seating levels;
 - a basement level (at the level of the playing pitch) accommodating pedestrian and vehicular circulation zones, 50 car parking spaces, facilities for teams and officials, media and broadcasting areas, storage and internal loading areas;
 - food and drink kiosks, corporate and media facilities; and
 - four signage zones.
- construction and establishment of the public domain within the site, including:
 - hard and soft landscaping works;
 - publicly accessible event and operational areas;
 - public art; and
 - provision of pedestrian and cycling facilities.
- wayfinding signage and lighting design within the site;
- reinstatement of the existing Moore Park Car Park 1 (MP1) upon completion of construction works with 540 at-grade car parking spaces and vehicular connection to the new stadium basement level;
- operation and use of the new stadium and the public domain areas within the site for a range of sporting and entertainment events; and
- extension and augmentation of utilities and infrastructure.

SSD 9835 has been modified on five previous occasions:

- MOD 1 amended Conditions B14 and B15 to satisfy the regulatory requirements of the Contaminated Land Management Act 1997;
- MOD 2 approved the design, construction and operation of the Stadium Fitness Facilities;
- MOD 3 approved design refinements to the western mezzanine and introduced a new condition to facilitate approval of signage details within the approved signage zones;
- MOD 4 relocated the approved photovoltaic array from the SFS roof to the Level 5 plant room roofs and revised the approved sustainability strategy; and
- MOD 5 updated plan references and dates in the Instrument of Consent.

A sixth modification which seeks approval for the fit out and operation of the SFS' eastern mezzanine for the Sydney Roosters Centre of Excellence (MOD 6) was placed on public exhibition by the Department of Planning, Industry and Environment between 19 August and 1 September 2021.

2 Precinct Village and Car Park

2.1 Vision

Venues NSW (VNSW) is proposing to introduce a village community space, event plaza and multi-level car park to complement the SFS and adjoining Moore Park and Centennial Parklands. The proposed development will facilitate the permanent closure of the EP2 on-grass parking areas within Moore Park opposite the MP1 car park and enable its use for open space purposes consistent with the Moore Park Masterplan.

The vision for the Precinct Village and Car Park is set out below:

The Precinct Village and Car Park provides a platform and canvas for an exceptional community asset and iconic design, that visually and physically connects to the adjacent Moore Park East and Kippax Lake. It provides patrons with quality café and dining experiences in an idyllic parkland setting and well-being play and relaxation nodes which engage with all ages. An event plaza, connected to the Stadium plaza provides a seamless opportunity for greater patron and community engagement through non-event and event day functions (Architectural Design Statement, Cox August 2021).

2.2 Location

The Precinct Village and Car Park is proposed to be located on the land west of the SFS, currently approved under SSD 9835 as the MP1 Car Park. It will extend to Moore Park and Driver Avenue and will adjoin the existing UTS, Rugby Australia and NRL Central buildings, all of which are to be retained and do not form part of the project site. A Location Plan is provided at Figure 1.

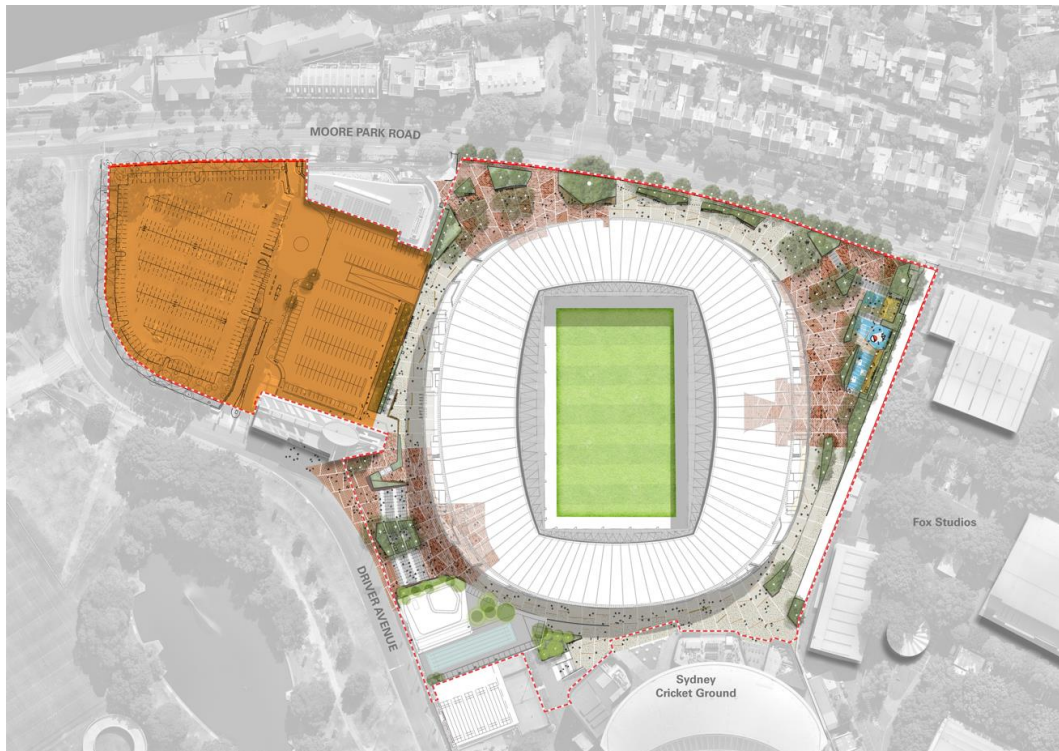


Figure 1: Precinct Village and Car Park Location

2.3 Development description

The Precinct Village and Car Park has been designed to align with the conditions and commitment established within SSD 9835, particularly relating to delivering a LEED Gold rated sustainable precinct, and will include:

- Up to a maximum of 1,500 space multilevel carpark below ground level with the following access arrangements:
 - 1 x egress point onto Moore Park Road to be used on event days only;
 - 1 x two-lane access point from Driver Ave to be used on event and non-event days; and
 - dedicated area within the car park for operation/servicing vehicles.
- Reconfiguration of the currently approved drop off requirements for the elderly and mobility impaired;
- Free flow level pedestrian access to and from the SFS concourse from Driver Ave and Moore Park Road;
- Electric car charging provision;
- A versatile and community public domain, comprising:
 - provision for 4 x north-south orientated tennis courts on non-event days with the potential to become an event platform on event days;
 - children's playground;
 - 1,500 m² cafe / retail / restaurants with associated amenities in a single storey pavilion (6 metre) low level;

- customer service office and ticket window; and
- vertical transport provisions.
- Utilities provision augmentation.

Figure 2 illustrates the proposed Precinct Village and Car Park concept. Refer to the architectural within the Architectural Design Statement (Cox, August 2021) and landscape plans (Aspect, August 2021) for further details.

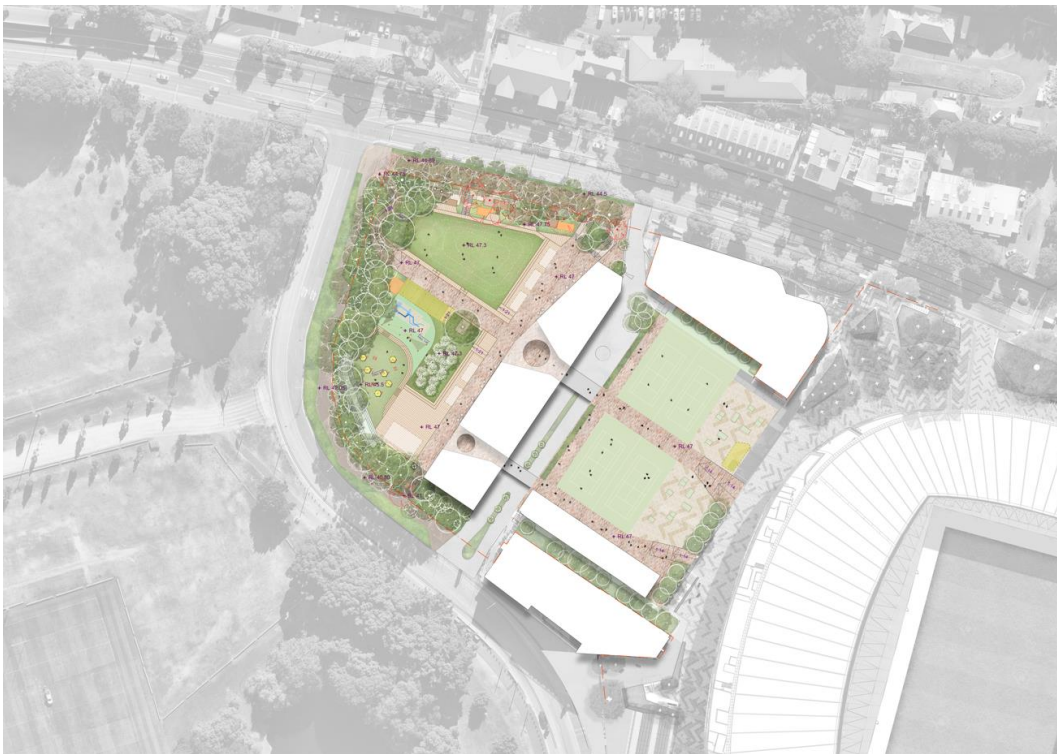


Figure 2: Precinct Village and Car Park Development

2.4 Proposed operation

The Precinct Village is proposed to be accessible from 8am to 11pm to align with the approved operating hours for the SFS.

The tennis court operating hours are proposed to be the same as the approved operating hours for the Stadium Fitness Facilities.

The car park will be automated, replicating the existing arrangements at the nearby Entertainment Quarter and will be accessible 24 hours a day, 7 days a week.

The public domain is proposed to be curated as a series of distinct, flexible and purpose specific settings for event day patrons and the general public. These inviting public places will offer rich, engaging and shared experiences. An indication of the activity types, frequencies and durations proposed within the public domain is provided in the Architectural Design Statement (Cox Architecture, August 2021) and Planning Statement (Ethos Urban, August 2021).

2.5 Delivery

The Precinct Village and Car Park is proposed to be delivered in two stages:

- Stage 1, herein referred to as the East Car Park, consists of the area between the Rugby Australia and NRL Central buildings, immediately adjacent to the SFS concourse; &
- Stage 2, herein referred to as the West Car Park, consists of the residual area immediately adjacent to the proposed East Car Park, bounded by Driver Ave and Moore Park Road.

The East Car Park is proposed to be delivered ahead of the opening of the SFS in 2022. The West Car Park is proposed to be delivered after the SFS opening, sometime in 2023.

3 Proposed approval modifications

To facilitate the Precinct Village and Car Park, SSD 9249 and SSD 9835 are required to be modified. The proposed modification to SSD 9249 (concept development application) has been submitted under separate cover. SSD 9835 is proposed to be modified to facilitate construction, fit-out and operation of Precinct Village and Car Park as described above.

4 Purpose of this report

This Acoustic Report has been prepared to support the Precinct Village and Car Park modification. This Report specifically addresses the following Secretary's Environmental Assessment Requirements (SEARs) issued in respect of SSD 9825 and as relevant to the Precinct Village and Car Park project:

Table 1: SSD 9835 SEARs

SEARs addressed	Acoustic aspect	Policy or guideline	Report section
Key Issue 20. Noise and Vibration			
Identify and provide a quantitative assessment of the main noise and vibration generating sources including details of the impacts on surrounding residences and other noise sensitive locations (including the adjoining UTS campus) during (but not limited to):	Construction and operational noise & vibration and event noise	NPfI, ICNG, AVATG	Throughout report
<ul style="list-style-type: none"> demolition of the existing slabs and footings, pavements and redundant in-ground services; 	Construction noise & vibration		Section 6
<ul style="list-style-type: none"> site preparation, piling, bulk earthworks, construction and construction-related activities and vehicle movements; 	Construction noise & vibration	ICNG, AVATG	Section 6
<ul style="list-style-type: none"> proposed on-site concrete crushing (if any) 	Construction noise & vibration	N/A – no concrete crushing proposed	
<ul style="list-style-type: none"> the likely noise impacts due to operation of the new stadium and associated facilities, particularly: <ul style="list-style-type: none"> during events involving the use of sound amplification; during pre and post event activities such as sound test, rehearsals, 'bump-in'/'bump-out', site clean-up, goods deliveries and waste collection including out-of-hours activities and vehicles accessing the basement; 	Operational noise	-	Section 7
<ul style="list-style-type: none"> the likely noise impacts of operation of the new stadium and associated facilities, in conjunction with existing facilities located on the Trust lands; and 	Operational noise	NPfI	Section 7
<ul style="list-style-type: none"> identification of key noise mitigation and management measures that would inform the final design of the new stadium. 	Operational noise		Section 7.5
Outline the likely noise impacts during events involving pyrotechnic displays and include measures to manage any adverse acoustic impact on the surrounding noise sensitive locations during such events.	N/A – no pyrotechnics proposed		

SEARs addressed	Acoustic aspect	Policy or guideline	Report section
Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land including (but not limited to) acoustic details of the stadium structure, management of events / activities within and outside the stadium structure (within the open areas of the site outside the structure), restrictions to construction hours, appropriate location of the crusher, intra-day respite periods during noisy activities, noise barriers where needed and operational hours and restrictions.	Construction and operational noise & vibration and event noise	NPfI, ICNG, AVATG	Section 6.4, 7.5
Provide a clear / plain English explanation of the adopted noise levels under the proposed new noise management framework, referred to in the development consent for SSD 9249, and how they relate to the noise levels prescribed in Notice of Preventive Action 1003904 (as at the date of the development application and as varied from time to time).	Operational noise	-	Addressed in the Stage 2 SSDA Noise and Vibration Impact Assessment [1]
Provide a justification as to why the proposed new noise management framework is the appropriate approach for the development.	Operational noise	-	
Provide a draft Construction Noise and Vibration Management Plan that outlines measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.	Construction noise & vibration	Construction Noise and Vibration Management Sub-Plan	Addressed by Construction Noise and Vibration Management Plan [2]

Key Issue 20 of the SEARs also references the following policies relevant to acoustics:

- *NSW Noise Policy for Industry*, EPA 2017 (NPfI) [3];
- *Interim Construction Noise Guideline*, DECC 2009 (ICNG) [4];
- *Assessing Vibration: A Technical Guideline*, DEC 2006 (AVATG) [5]; and
- *Development Near Rail Corridors and Busy Roads – Interim Guideline*, Department of Planning 2008 (DNRCBR) [6].

It is noted that DNRCBR [6] is not relevant to the subject development, as it relates to the assessment of noise from rail and road traffic on residential uses, places of worship, hospitals, and educational establishments or childcare centres.

This Noise and Vibration Impact Assessment Report is to be read in conjunction with the following reports and documents:

- Planning Statement prepared by Ethos Urban (August, 2021);
- Architectural plans/elevations/sections and Architectural Design Statement, prepared by Cox Architecture (August, 2021);
- Design Integrity Assessment Report prepared by Cox Architecture (August, 2021);
- Landscape plans and Landscape Design Report prepared by Aspect (August, 2021);
- Transport Assessment prepared by JMT (August, 2021);
- Stormwater and Flooding Assessment prepared by Arup (August, 2021);
- Visual Impact Assessment prepared by Ethos Urban (August, 2021);
- Social/Economic Statement prepared by Ethos Urban (August, 2021);
- Heritage Impact Statement prepared by Artefact (August, 2021);
- Sustainability Assessment prepared by LCI (August, 2021);
- Security Statement/CPTED prepared by Intelligent Risks (August, 2021);
- Contamination Assessment prepared by Douglas Partners (August, 2021);
- Aboricultural Assessment prepared by Tree IQ (August, 2021);
- Wind Assessment prepared by Arup (August, 2021);
- Infrastructure Services Strategy prepared by Arup (August, 2021);
- Geotechnical Assessment prepared by Arup (August, 2021);
- Public Domain Lighting Assessment prepared by Arup (August, 2021);
- Accessibility Statement prepared by Before Compliance (August, 2021); and
- BCA Assessment prepared by Blackett Maguire Goldsmith (August 2021).

5 Existing acoustic environment

Assessment locations and measurement data in this section are consistent with all previous acoustic impact assessments.

Traffic noise is the dominant acoustic feature of the area surrounding the SFS Site within which the Precinct Village and Car Park is proposed. The SFS 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 in the local environment are:

- Road traffic along Moore Park Road and Anzac Parade;
- CBD ‘urban hum’; and
- Aircraft noise.

The above sources generally vary in level over the day.

Infrequent event noise from the SFS, currently under construction, will also affect the local acoustic environment once operational, however will not exceed the levels nominated in the Consent Conditions.

Events have been a feature of the area for over 150 years, with Allianz Stadium constructed in 1988, which was built upon the former Sydney Sports Ground which opened in 1903. Sporting events hosted at the SFS Site over the past 150 years have included athletics, rugby league, rugby union, soccer, motorcycle and car speedway racing.

5.1 Surrounding land-uses

Residential zones are 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. Non-residential premises also surround the SFS Site, with scattered childcare centres, places of worship, educational facilities and Paddington Town Hall located in Paddington and Centennial Park, high schools located across Anzac Parade and various recreation areas nearby.



Figure 3: Noise sensitive receiver locations and NCAs

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 2. These NCAs were first established as part of the Stage 1 Concept Application and have continued to be referenced throughout the demolition and early works and more recently the Stage 2 construction works. The NCAs remain unchanged and are relevant to this noise and vibration assessment.

Table 2: NCAs and description

NCA	Description	NSW NPfI ¹ area 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	Description	NSW NPfI ¹ area classification
NCA 5	Centennial Park Lang Road and local roads	Suburban
NCA 6	Centennial Park Robertson Road and local roads	Suburban

Note:

1. Noise Policy for Industry [3]

NCA boundaries have been determined from site observations and attended measurements, conducted as part of the Stage 1 SSDA 9249 Noise and Vibration Impact Assessment (NVIA) [7]. Classifications of NCAs 1, 2, 3 and 4 as ‘Urban’ are based on on-site observations, and based on the Noise Policy for Industry [3] (NPfI), given that these areas have ‘*through-traffic with characteristically heavy and continuous traffic flows during peak periods*’. NCAs 5 and 6 are categorised as ‘Suburban’ having ‘*local traffic with characteristically intermittent traffic flows*’ and have the following characteristic: ‘*evening ambient noise levels defined by the natural environment and human activity*’ (NPfI).

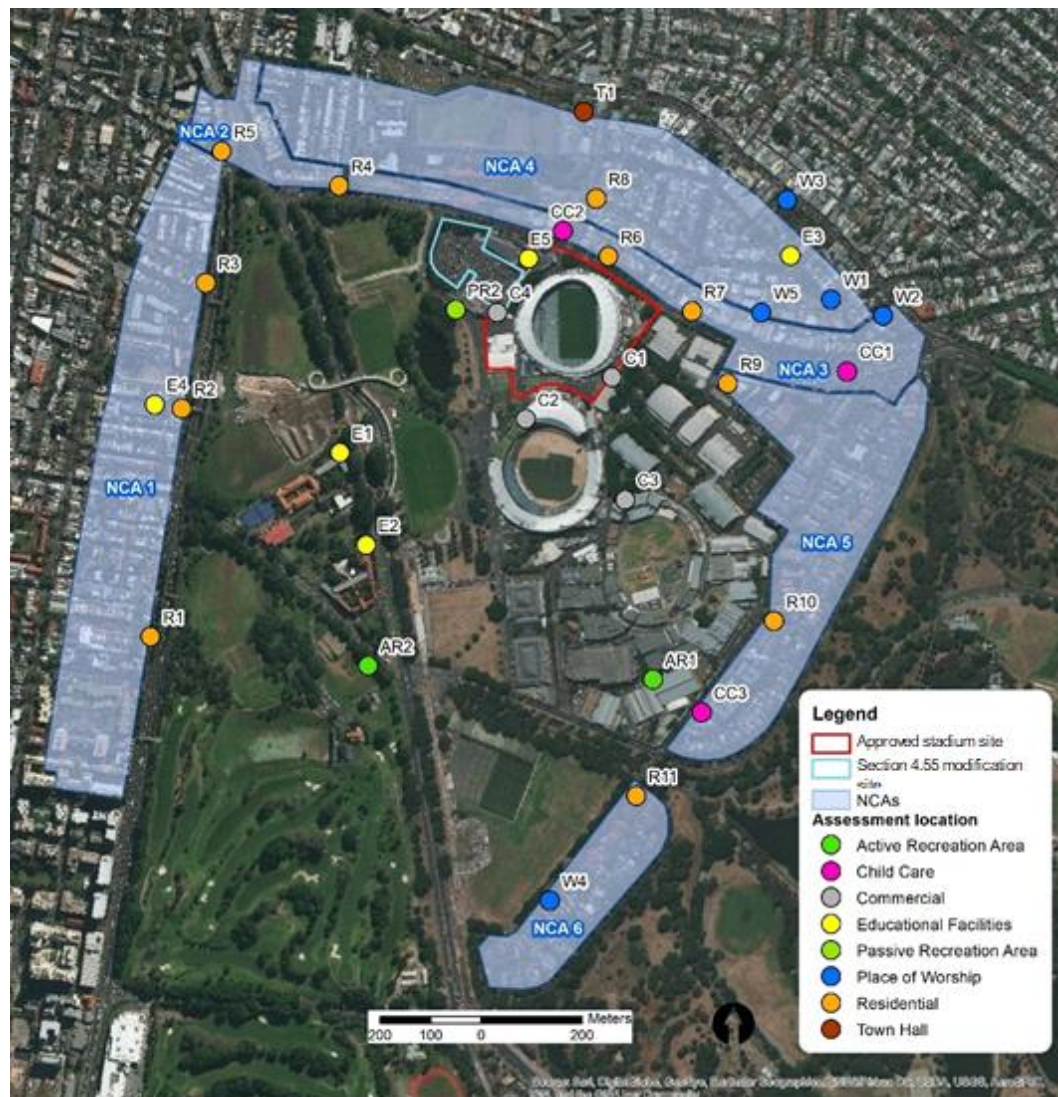


Figure 4: Assessment locations and NCAs

5.2 Assessment locations

In accordance with the NPfI, the reasonably most-affected residences have been identified in each NCA. They are also shown on Figure 4 and listed in Table 3 below. 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 3: 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
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 4.

Table 4: Non-residential receivers

Receiver ID	Name	Address	No. of floors
Active Recreation Area			
AR1	Centennial Parklands Equestrian Centre	114-120 Lang Road, Moore Park	2
AR2	Moore Park Golf Course	Cleveland Street, Moore Park	0
Commercial			
C1	Fox Studios	38 Driver Avenue, Moore Park	2
C2	Sydney Cricket Ground	Driver Avenue, Moore Park	3
C3	Entertainment Quarter	122 Lang Road, Moore Park	3
C4	NRL building	Moore Park Road and Driver Avenue, Moore Park	3
Child Care			
CC1	Gumnut Gardens Early Learning and Long Day Care Ce	61 Moore Park Road, Centennial Park	1
CC2	Kira Child Care Centre	230 Moore Park Road, Paddington	1

Receiver ID	Name	Address	No. of floors
CC3	Bambini's Child Care Centre	157/159 Cook Road, Centennial Park	2
Educational Facilities			
E1	Sydney Boys High School	556 Cleveland Street, Moore Park	3
E2	Sydney Girls High School	Corner of Anzac Parade and Cleveland Street, Surry Hills	2
E3	Paddington Public School	399-435 Oxford Street, Paddington	2
E4	Bourke Street Public School	590 Bourke Street, Surry Hills	2
E5	University of Technology Sydney Rugby Australia	Moore Park Road and Driver Avenue, Moore Park	5
Passive Recreation Area			
PR1	Moore Park	Moore Park	0
Town Hall			
T1	Paddington Town Hall	249 Oxford Street, Paddington	2
Place of Worship			
W1	St Francis of Assisi Catholic Church	64 Gordon Street, Paddington	3
W2	St Mattias Anglican Church	471-475 Oxford Street, Paddington	2
W3	Paddington Uniting Church	395 Oxford Street, Paddington	2
W4	St. Vladimir's Russian Orthodox Church	31 Robertson Rd, Centennial Park	2
W5	Kingdom Hall of Jehovah's Witnesses	20 Leinster St, Paddington	2

6 Construction noise and vibration

This section addresses the noise and vibration associated with proposed construction of the Precinct Village and Car Park.

Demolition of Allianz Stadium and associated buildings was assessed and approved as part of the Stage 1 SSD DA (SSD 9249), and construction of the new SFS was assessed and approved as part of the Stage 2 SSD DA (SSD 9835). Construction Noise and Vibration Management Plans have been approved by the Department of Planning, Industry and Environment (DPIE) for both applications and works have been undertaken in accordance with them.

Construction noise associated with the new Stadium Fitness Facilities (SFF) was assessed as part of approved modifications to SSD 9835 (MOD 2).

The Construction Noise and Vibration Management Plan approved by DPIE for SSD 9835 was subsequently updated to incorporate the SFF construction and approved by the DPIE..

6.1 Construction noise criteria

Requirements for noise management for the construction of the SFS are outlined in the SSD 9835 Development Consent [8] Condition B28, which states:

B28. Prior to the commencement of construction, the Applicant must prepare a Construction Noise and Vibration Management Sub-Plan (CNVMP). The plan must address, but not be limited to, the following:

- (a) be prepared by a suitably qualified and experienced noise expert and in consultation with the EPA;*
- (b) provide details of all the residential and non-residential receivers including the Kira Child Care Centre, University of Technology Sport Sciences Faculty Building (UTS) and Fox Studios, identified in Stage 2 SSDA – Noise and Vibration Assessment prepared by ARUP dated 30 August 2019;*
- (c) provide details of the project specific construction noise management levels (NMLs) at all the identified receivers (B28(b)) considering the noise management levels in EPA's Interim Construction Noise Guideline (DECC, 2009) (ICNG) and the relevant provisions of Australian Standard 2436 - 2010 Guide to Noise Control on Construction and Maintenance and Sites, at all identified receivers;*
- (d) identify the 'High Noise Impact works' with the associated predicted construction noise levels that would exceed the NMLs and reach or exceed the Highly Affected Noise Level of 75dB(A) LAeq(15min), at the identified the residential and non-residential receivers;*

Note: High noise impact works mean:

- jack hammering, rock breaking or hammering, pile driving, vibratory rolling, cutting of pavement, concrete or steel or other work occurring on the surface that generates noise with impulsive, intermittent, tonal or low frequency characteristics that exceed the NML; or
- continuous noisy activities where ‘continuous’ includes any period during which there is less than a 1-hour respite between ceasing and recommencing any of the work that is the subject of this condition.

A Construction Noise and Vibration Management Plan (CNVMP) [2] was prepared in accordance with Condition B28 and approved by the Planning Secretary. Noise Management Levels (NMLs) and the ‘Highly Affected Noise Level’ outlined within the CNVMP are reproduced in Table 5 and Table 6 for residential and non-residential receivers respectively.

Table 5: Approved residential Noise Management Levels during intended working hours, $\text{dBL}_{\text{Aeq 15minute}}$

Receiver ID ¹	NCA	Highly affected noise level	Noise Management Level
R1	NCA 1	75	68
R2	NCA 1	75	68
R3	NCA 1	75	68
R4	NCA 2	75	66
R5	NCA 2	75	66
R6	NCA 3	75	62
R7	NCA 3	75	62
R8	NCA 4	75	53
R9	NCA 5	75	49
R10	NCA 5	75	49
R11	NCA 6	75	57

Notes:

1. Identified in Table 3.

Table 6: Approved non-residential Noise Management Levels during intended working hours, $\text{dBL}_{\text{Aeq 15minute}}$

Usage	Rec. ID ¹	Name	Time period	External NML
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	NRL building	When in use	70
Child Care	CC1	Gumnut Gardens Early Learning and Long Day Care Ce	When in use	55

Usage	Rec. ID ¹	Name	Time period	External NML
	CC2	Kira Child Care Centre	When in use	55
	CC3	Bambini's Child Care Centre	When in use	55
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
	E5	University of Technology Sydney Rugby Australia	When in use	55
Passive recreation area	PR1	Moore Park	When in use	60
Town hall	T1	Paddington Town Hall	When in use	45
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

Notes:

1. Identified in Table 4.

6.2 Construction vibration criteria

Pertinent to construction vibration, Condition C19 of SSD 9835 [8] states:

Vibration Criteria

C19. Vibration caused by construction activities at any residence or adjoining structure including all surrounding heritage items within or outside the boundary of the site must be limited to:

- the latest version of DIN 4150-3 (1992-02) Structural vibration - Effects of vibration on structures (German Institute for Standardisation) for structural damage;*
- the acceptable vibration values set out in the Environmental Noise Management Assessing Vibration: a technical guideline (DEC 2006) (as may be updated or replaced from time to time), for human exposure; and*
- the vibration requirements of the Methodology Statement – Working Near Busby's Bore prepared by Infrastructure NSW dated September 2018 as updated by condition B22 (being part of the CNVMP in condition B28).*
- a maximum peak particle velocity of 5 mm/second in the vicinity of Shafts 9 and 10 of the Busby's Bore.*

Vibration criteria were established for the SFS construction works in the Stage 2 SSDA NVIA [1] which are in accordance with these requirements, and are presented below.

6.2.1 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is assessed in accordance with German Standard DIN4150-3 [9].

Within DIN4150-3, damage is defined as “any permanent effect of vibration that reduces the serviceability of a structure or one of its components” (p.2). The Standard also outlines:

“that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

- *cracks form in plastered surfaces of walls;*
- *existing cracks in the building are enlarged;*
- *partitions become detached from loadbearing walls or floors.*

These effects are deemed ‘minor damage.’ (DIN4150.3, 1990, p.3)

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The criteria are presented in Table 7.

Table 7: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

6.2.2 Human comfort

The NSW EPA's *Assessing Vibration – A Technical Guideline* [5] 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 [10].

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 8 and Table 9 respectively. These levels were approved as part of the SSD DA 9835 and subsequently the CNVMP that is being implemented during the construction works, which commenced in mid-March 2020.

Table 8: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s^2) 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
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 9: Acceptable vibration dose values for intermittent vibration ($\text{m/s}^{1.75}$)

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.

6.2.3 Heritage structures including Busby's Bore

Heritage structures which have been identified in the vicinity of the Precinct Village and Car Park 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'*. As the SCG and Fox Studios buildings are not considered to be structurally unsound, these heritage structures are not considered to be more vibration sensitive than other surrounding structures.

The approved Methodology Statement - Working Near Busby's Bore [11] is recommended by Artefact to be revised and updated to reflect the proposed Precinct Village and Car Park project. The currently approved Methodology Statement is provided at Appendix B and outlines the currently approved (and deemed appropriate) methodology which was developed during Stage 1 works and have been successfully implemented to date during the Stage 2 works for undertaking vibration intensive works in the vicinity of Busby's Bore to minimise the risk of structural damage. In accordance with Artefact's recommendations, the Methodology Statement will be updated prior to commencement of works to ensure that vibration intensive works in the vicinity of Busby's Bore continue to be undertaken in a manner that minimises any risk of structural damage.

Further to the requirements in the Busby's Bore Methodology Statement [11], Condition C19(d) stipulates a maximum peak particle velocity of 5 mm/second in the vicinity of Shafts 9 and 10 of the Busby's Bore.

The requirements for vibration intensive activities and impacts on heritage structures including Busby's Bore will remain for the Precinct Village and Car Park project in accordance with Condition C19(c) and C19(d) albeit as amended by the updated Methodology Statement..

6.3 Construction noise assessment

6.3.1 Program and hours of works

Construction of the Precinct Village and Car Park is split into two stages:

- Stage 1 - east Car Park to take place concurrently with the already approved SFS construction.
- Stage 2 – west Car Park to commence upon completion of the SFS.

Table 10 provides the approved hours of construction for the SFS. The Precinct Village and Car Park project, if approved, would be constructed within the same construction hours.

Table 10: SFS approved 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

If an applicable Ministerial Order is in place at the time of the Village Precinct and Car Park's construction, the extended hours are expected to be utilised by the contractor.

6.3.2 Activities and assessment

Four phases of construction are proposed as part of both Stage 1 and Stage 2 of the Precinct Village and Car Park construction activities:

Stage 1 East Car Park

- Phase 1: Civil, Substructure and Piling;
- Phase 2: Remaining Structure; and
- Phase 3: Utilities & Finishes.

Stage 2 West Car Park

- Phase 1: Civil & Piling;
- Phase 2: Bulk Excavation;
- Phase 3: Remaining Structure; and
- Phase 4: Utilities, Landscaping and Finishes.

The proposed equipment to be used as part of the Stadium Events Plaza construction are listed in Table 11.

The equipment are in line with the approved CNVMP [2], however additional items of equipment are required due to concurrent works during Stage 1.

Table 11: Construction equipment for Precinct Village and Car Park construction

Equipment	Sound Power dBL _{eq} (15min)	% of use within worst case 15-min	No. operating equipment within worst case 15-min			
			Civil works & Piling	Sub-structure works	Remain-ing Structure	Utilities, Landscaping & Finishes
Rock Breaker	118	100	2	0	0	0
50 tonne excavators	115	100	1	1	1	0
Air compressors	110	100	1	0	0	0
Angle Grinder	111	75	1	1	1	1
Bobcats	104	100	1	0	1	1
Bored Piling Rig	111	100	1	0	0	0
Bulldozer	108	100	1	0	0	0
Compactor	115	100	1	1	0	0
Concrete float / vibrators	113	60	0	1	1	1
Concrete Pumps	109	70	0	1	1	1
Concrete Trucks	109	100	0	1	1	1
Concrete Saw	122	30	1	1	0	0
Crawler cranes	115	80	1	1	0	0
Electric Saw	118	80	0	0	1	1
Front end loader	113	100	1	0	0	0
Hand tools	102	80	3	2	2	3
Jackhammering	113	75	1	1	0	0
Material/man hoists	92	100	1	0	0	0
Moxies/large truck	106	100	2	0	0	0
Roller (up to 15T)	107	100	0	0	0	1
Tower crane	99	100	3	0	1	0
Water cart	107	100	1	0	0	0

It has been assumed the Stage 1 works will be undertaken concurrently with the final phase of the Stadium and Stadium Fitness Facilities construction which includes the installation of the roof, façade, fit-out and remaining elements.

Stage 2 works will commence upon completion of the Stadium.

Predicted construction noise levels at surrounding receivers along with the relevant NML for the intended working hours are presented in Table 12 for Stage 1, and Table 13 for Stage 2.

Table 12: Stage 1 east Car Park construction noise levels (concurrent with stadium and fitness facilities final phase of construction), dBL_{Aeq} (15 min)

Receiver	NML	Stage 1 East carpark			
		Civil works & Piling	Sub-structur e works	Remain -ing Structu re	Utilities Land- scaping & Finishes
		Cumulative predicted noise level / Increase from approved construction noise level			
Residential receivers					
R1 - 749 south Dowling Street, Redfern	68	52 / 3	51 / 2	50 / 1	50 / 1
R2 - 635 south Dowling Street, Surry Hills	68	57 / 5	56 / 4	54 / 2	54 / 2
R3 - 553 south Dowling Street, Surry Hills	68	58 / 5	57 / 4	55 / 2	55 / 2
R4 - 111 Greens Rd, Paddington	66	62 / 14	60 / 13	57 / 9	56 / 8
R5 - 479 south Dowling Street, Surry Hills	66	57 / 2	57 / 2	56 / 1	56 / 1
R6 - 252 Moore Park Road, Paddington	62	75 / -	75 / -	75 / -	75 / -
R7 - 314 Moore Park Road, Paddington	62	67 / -	67 / -	67 / -	67 / -
R8 - 45 Oatley Road. Paddington	53	62 / 3	61 / 2	60 / 1	59 / 1
R9 - 5 Poate Road, Paddington	49	58 / -	58 / -	58 / -	58 / -
R10 - 107 Cook Road, Centennial Park	49	51 / -	51 / -	51 / -	51 / -
R11 - 2 Martin Road, Moore Park	57	46 / -	46 / -	46 / -	46 / -
Non-residential receivers					
AR1 - Centennial Parklands Equestrian Centre	65	37 / 2	37 / 1	36 / 1	36 / 1
AR2 - Moore Park Golf Course	65	52 / 2	51 / 2	50 / 1	50 / 1
C1 - Fox Studios	70	71 / -	71 / -	71 / -	71 / -
C2 - Sydney Cricket Ground	70	55 / 1	55 / -	55 / -	55 / -
C3 - Entertainment Quarter	70	55 / -	55 / -	55 / -	55 / -
C4 – NRL Building	70	84 / 15	82 / 13	79 / 10	78 / 9
CC1 - Gumnut Gardens Early Learning and Long Day Care Centre	55	56 / -	56 / -	56 / -	56 / -
CC2 - Kira Child Care Centre	55	70 / 1	70 / 1	69 / -	69 / -
CC3 - Bambini's Child Care Centre	55	38 / 1	37 / 1	37 / -	37 / -
E1 - Sydney Boys High School ¹	55	59 / 3	58 / 2	57 / 1	57 / 1
E2 - Sydney Girls High School ¹	55	56 / 1	55 / 1	55 / -	55 / -
E3 - Paddington Public School ¹	55	47 / 1	46 / 1	46 / -	46 / -
E4 - Bourke Street Public School ¹	55	53 / 5	52 / 4	50 / 2	50 / 2
E5 - University of Technology Sydney and Rugby Australia ²	67	84 / 13	82 / 11	79 / 8	78 / 6

Receiver	NML	Stage 1 East carpark			
		Civil works & Piling	Sub-structure works	Remaining Structure	Utilities Landscaping & Finishes
		Cumulative predicted noise level / Increase from approved construction noise level			
PR1 - Moore Park	60	71 / 11	70 / 10	67 / 7	66 / 6
T1 - Paddington Town Hall ¹	45	58 / -	58 / -	58 / -	58 / -
W1 - St Francis of Assisi Catholic Church ¹	55	49 / -	48 / -	48 / -	48 / -
W2 - St Mattias Anglican Church ¹	55	45 / -	45 / -	45 / -	45 / -
W3 - Paddington Uniting Church ¹	55	49 / 3	48 / 2	47 / 1	47 / 1
W4 - St. Vladimir's Russian Orthodox Church ¹	55	46 / -	46 / -	45 / -	45 / -
W5 - Kingdom Hall of Jehovah's Witnesses ¹	55	54 / -	54 / -	54 / -	54 / -

- Levels shaded in grey indicate a notional exceedance of NMLs based on the worst-case assumptions noted above.
- Levels in **Bold Red** indicate residential 'highly affected' noise levels of 75dBA or above. It is noted no new receivers are considered 'highly affected' by proposed works, and all highly affected receivers are already approved to occur.

1. External NML conservatively based on a 10dB noise reduction through an open window
2. External NML based on façade constructions, room and façade dimensions

Results indicate that although construction noise levels are predicted to increase by up to 14 dB at R4 - 111 Greens Rd, Paddington, these increases do not result in additional exceedances at residential receivers.

Noise levels at the majority of receivers are not predicted to increase significantly (a 2 dB increase in considered barely perceptible by the average person), due to a combination of:

- A relatively minor contribution to noise levels from works associated with the Precinct Village and Car Park due to fewer equipment items;
- A larger distance from Precinct Village and Car Park works compared to approved stadium works; &
- Shielding of construction noise due to existing buildings compared to stadium construction works.

Worst affected residences along Moore Park Road are not anticipated to experience significant increases in construction noise levels to the larger distance to, and shielding from Precinct Village and Car Park works, as compared with the previously approved stadium works.

The most significant increases and exceedances as a result of the proposed works are predicted at both the NRL and the UTS and Rugby Australia buildings, with noise levels of 84 dB $L_{Aeq(15\text{minute})}$ predicted, which represent increases of up to

15 dB over construction impacts from the stadium and exceedances of 17 dB of NMLs. The close proximity of proposed construction works and absence of shielding contribute to these exceedances.

The occurrence of the predicted noise levels would be infrequent due to the low likelihood of all the additional proposed equipment operating concurrently with construction equipment working on the stadium. Predicted noise levels therefore represent an infrequent worst-case scenario.

Table 13: Stage 2 west Car Park construction noise levels (not concurrent with stadium), dBL_{Aeq} (15 min)

Receiver	NML	Stage 2 West carpark			
		Civil works & Piling	Sub-structure works	Remaining Structure	Utilities Land-scaping & Finishes
		Predicted noise level			
Residential receivers					
R1 - 749 south Dowling Street, Redfern	68	52	50	46	45
R2 - 635 south Dowling Street, Surry Hills	68	56	55	51	50
R3 - 553 south Dowling Street, Surry Hills	68	58	57	53	52
R4 - 111 Greens Rd, Paddington	66	65	63	60	59
R5 - 479 south Dowling Street, Surry Hills	66	54	52	48	47
R6 - 252 Moore Park Road, Paddington	62	56	54	50	49
R7 - 314 Moore Park Road, Paddington	62	44	42	39	38
R8 - 45 Oatley Road, Paddington	53	50	48	44	43
R9 - 5 Poate Road, Paddington	49	40	38	34	33
R10 - 107 Cook Road, Centennial Park	49	40	38	35	34
R11 - 2 Martin Road, Moore Park	57	45	43	39	38
Non-residential receivers					
AR1 - Centennial Parklands Equestrian Centre	65	37	35	32	31
AR2 - Moore Park Golf Course	65	53	51	48	47
C1 - Fox Studios	70	41	39	36	35
C2 - Sydney Cricket Ground	70	53	51	47	46
C3 - Entertainment Quarter	70	38	36	33	32
C4 – NRL Building	70	72	70	67	66
CC1 - Gumnut Gardens Early Learning and Long Day Care Centre	55	42	41	37	36
CC2 - Kira Child Care Centre	55	58	56	53	52
CC3 - Bambini's Child Care Centre	55	35	33	30	29

Receiver	NML	Stage 2 West carpark			
		Civil works & Piling	Sub-structure works	Remaining Structure	Utilities Landscaping & Finishes
		Predicted noise level			
E1 - Sydney Boys High School ¹	55	60	58	54	53
E2 - Sydney Girls High School ¹	55	57	55	52	51
E3 - Paddington Public School ¹	55	42	40	37	36
E4 - Bourke Street Public School ¹	55	49	47	43	42
E5 - University of Technology Sydney and Rugby Australia ²	67	72	70	67	66
PR1 - Moore Park	60	73	72	68	67
T1 - Paddington Town Hall ¹	45	53	51	48	47
W1 - St Francis of Assisi Catholic Church ¹	55	39	38	34	33
W2 - St Mattias Anglican Church ¹	55	37	35	32	31
W3 - Paddington Uniting Church ¹	55	42	40	37	36
W4 - St. Vladimir's Russian Orthodox Church ¹	55	47	45	42	41
W5 - Kingdom Hall of Jehovah's Witnesses ¹	55	41	40	36	35

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

1. External NML conservatively based on a 10dB noise reduction through an open window
2. External NML based on façade constructions, room and façade dimensions

Construction noise impacts due to Stage 2 west carpark works are predicted to be more minor due to works being conducted after stadium works are complete, and due to further distance to worst affected receivers along Moore Park Road, as well as non-residential receivers NRL, UTS and Rugby Australia.

6.4 Construction noise mitigation measures

As construction noise impacts at residential receivers are not predicted to increase significantly in nature, the management of noise impacts onto on-site premises shall be a key focus. In addition to the construction noise and vibration management measures already being undertaken as part of the stadium CNVMP [2], it is recommended consultation with E5 - University of Technology Sydney and Rugby Australia and C4 – NRL Building be undertaken when developing the construction program prior to the commencement of works to understand noise sensitive periods of both premises, including exam periods at the University of Technology.

Works shall be scheduled outside of these periods where possible. Where not possible, notification shall be given to these premises as early as possible to allow the scheduling of sensitive activities outside works hours.

On-going consultation should also be undertaken, in line with that undertaken as part of the existing CNVMP [2].

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.

7 Operational noise

7.1 Overview

The Precinct Village is proposed to be curated as a series of distinct, flexible and purpose specific settings for event day patrons and the general public. These inviting public places will offer rich, engaging and shared experiences.

Condition A17 of the SSD 9835 already permits the use of the public domain areas outside the stadium footprint for use by the public for a range of events and activities. These include gathering spaces, organised temporary activities or event days, amenities, circulation purposes and active and passive outdoor recreational activities. The activities and events proposed within the Precinct Village are consistent with those approved under Condition A17.

For the purposes of this Section 4.55(2) modification, the following provides an *indication* of how the Precinct Village may be activated on event and non-event days. Consistent with Condition A18, the use of the public domain areas within the Precinct Village on event days will be documented in the Event Management Plan currently under preparation and required to be approved by the Planning Secretary.

This section addresses noise sources associated with the operation of the Precinct Village and Car Park. The Precinct Village and Car Park will be operational during both ‘event days’ and ‘non-event days’.

Typical operational activities associated with Precinct Village and Car Park include:

Event days

- Patrons entering and leaving the stadium;
- Patrons at food and beverage or merchandise retailers;
- Live site for sold out events;
- Pop up bars/tents/marquees;
- Mobile vans, ball kicking/hitting zone, etc;
- Cloaking area for concert and event patrons;
- Queuing/holding area for concerts allowing patrons who wish to arrive early to secure premium positions (e.g.: front of the stage) to enjoy the Precinct; &
- Tennis court use (organised events).

Non-event days

- Informal gatherings/picnics by families and small groups;
- Children play, sitting & eating, recreation (kicking footy, etc);

- Markets and stalls (e.g.: farmers market, book fair, etc);
- Tennis court use including personal training sessions for use by Stadium Fitness Facilities members; &
- Patrons dining outdoors at food and beverage retailers in Stage 2 west carpark area.

7.2 Hours of operation

The Precinct Village is proposed to be accessible from 8am to 11pm to align with the approved operating hours for the SFS.

The tennis court operating hours are proposed to be the same as the approved operating hours for the Stadium Fitness Facilities.

The car park will be automated, replicating the existing arrangements at the nearby Entertainment Quarter and will be accessible 24 hours a day, 7 days a week.

7.3 Criteria

Approved operational noise limits for the SFS are outlined in the SSD 9835 Development Consent [8]. Limits are provided for noise emissions during event and non-event times.

7.3.1 Event noise limits

Noise limits from sporting and concert events to be held at the stadium are addressed in SSD 9835 Development Consent Condition D48, which states:

Operational Noise Management Plan

D48. An Operational Noise Management Plan (ONMP) must be prepared prior to the commencement of operation of the stadium. The plan must:

(v) noise limits for sporting events, concerts and outdoor events with sound amplification that are consistent with the Stage 2 SSDA – Noise and Vibration Assessment prepared by ARUP dated 30 August 2019;

Noise limits for events as per the Stage 2 SSDA – Noise and Vibration Assessment [1] are reproduced in Table 14.

Table 14: Event noise limits for residential receivers

Receivers	Descriptor	Amplified sounds during concert event		Amplified sounds during sporting / other event
		dBA	1/1 octave, 63Hz dBZ	dBA
Property boundary of residential receivers	L _{eq} (5min)	70	90	60

No noise limits strictly apply to patron noise during events (sporting or concert). Nonetheless, an assessment of both patron noise and amplified sounds from the Precinct Village and Car Park against the more stringent ‘sporting event’ noise limit has been conducted to demonstrate that prior to, or following, a sporting match, noise levels from the operation of the Precinct Village are not anticipated to exceed limits which apply to amplified noise from within the stadium. This approach is considered to appropriate to assess potential amenity impacts to surrounding receivers.

The worst-case modelled patron numbers are only anticipated prior to or following an event, i.e. outside of sporting match or concert times. Therefore cumulative impacts due to the operation of the Precinct Village and amplified noise in the stadium are not anticipated to be an issue.

Should amplified sound be used during an event, cumulative noise levels from amplified sound within the stadium and from the Precinct Village and Car Park shall meet the relevant noise limits.

7.3.2 Non-event operational noise limit

Outside of event times, no noise limits within SSD 9835 Development Consent [8] strictly apply to patron noise or music. Noise limits in Condition E2 do apply to operational noise outside of event days, which states:

Non-event operational noise limit

E2. The non-event operational noise (excluding patron / crowd and music noise) generated at the premises must not exceed the noise limits at the times and locations in the Table 1 below, that apply at all residential receivers within the nominated noise catchment area (NCA) identified in the Stage 2 SSDA – Noise and Vibration Assessment prepared by ARUP dated 30 August 2019:

Table 1: Non-event operational noise limits

Noise Catchment Area	Noise limit, dBA			
	Day	Evening	Night	Night
	<i>dBL_{Aeq, 15min}</i>	<i>dBL_{Aeq, 15min}</i>	<i>dBL_{Aeq, 15min}</i>	<i>dBL_{Amax}</i>
1	58	56	55	70
2	58	53	51	66
3	57	54	52	64
4	48	46	43	56
5	44	41	38	50
6	52	45	38	60

The non-event operational noise must comply with the noise limits specified in condition E2, when the measurement is undertaken utilising the following criteria:

- (a) *the relevant noise monitoring equipment must be located at the reasonably most affected external point at the location, but no closer than 3m to a vertical reflecting surface and between 1.2 to 1.5m above ground level for single storey residences and at a height between 1.2 to 1.5m above the finished floor level for multi-storey residences;*
- (b) *noise measurements must not be undertaken where rain or wind speed at microphone level will affect the acquisition of valid measurements; and*
- (c) *the modifying factor corrections in Table C1 in Fact Sheet C of the Noise Policy for Industry (EPA, 2017) may be applied, if appropriate, to the noise measurements by the noise monitoring equipment.*

For the purpose of condition E2, non-event operational noise limits include the activities to which the Noise Policy for Industry (EPA, 2017) applies. The sources of non-event noise that apply for this premise include in principle, but are not limited to:

- (d) *mobile and fixed mechanical plant and equipment;*
- (e) *energy generation plant; and*
- (f) *vehicles on the premises.*

Non-event operational noise limits listed Condition E2 are presented in Table 15.

Table 15: Non-event noise limits for residential receivers

Noise Catchment Area (NCA)	Receivers within NCA ¹	Noise limit, dBA			
		Day	Evening	Night	Night
		dBL _{Aeq, 15min}	dBL _{Aeq, 15min}	dBL _{Aeq, 15min}	dBL _{Amax}
Approved as part of SSD 9835 ²					
1	R1, R2 and R3	58	56	55	70
2	R4 and R5	58	53	51	66
3	R6	57	54	52	64
4	R7, R8 and R9	48	46	43	56
5	R10	44	41	38	50
6	R11	52	45	38	60

Notes:

- Identified in Table 3.
- Reproduced from Condition E2 of SSD 9835 – applicable to plant and vehicle noise

7.3.3 Road noise

Regarding the increase in road traffic noise due to additional vehicles using the Precinct Village and Car Park, the Road Noise Policy [12] 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.

7.4 Noise assessment

An assessment of noise emissions generated by patron use in Stage 1 and Stage 2 has been conducted. Anticipated operations at the Precinct Village include such noise sources as:

- Patrons and music:

Event days

- Patrons at food, beverage and merchandise retailers
- Music or amplified commentary and announcements

Non-event days

- Patrons at food and beverage retailers
- Public using recreation areas
- Background music in and around retailers
- Building services noise
- Additional operational traffic generated by the Precinct Village and Car Park
- Loading and unloading activities in the loading dock

7.4.1 Patron noise and music

Noise levels from patrons in Precinct Village have been predicted using a formula established in Hayne et al. [13], being:

$$L_{WAeq} = 15 \times \log_{10}(\text{Crowd size}) + 64 \text{ dB(A)}$$

The formula assumes that people are not adversely affected by alcohol and have a random orientation, however, is considered conservative as it accounts for the Lombard effect applicable to people talking in close crowds. The increase in vocal strength is unlikely to significantly affect patrons in the Precinct Village but has been modelled as a worst-case scenario.

Spectra have been based on Cushing et al. [14] using an energy average of the male and female raised voice spectrum presented in Table 16.

Table 16: Patron vocal spectrum

Description	dB(A)	Octave band sound power level, dB							
		63	125	250	500	1 k	2 k	4 k	8 k
Vocal spectrum of single patron (raised voice)	65	48	53	61	64	61	57	51	44

Event days

The noisiest periods of operation would be during event days as patrons gather before entering and departing the Stadium, defined as pre-game and post-game. Modelled patron numbers and corresponding sound power levels are presented in Table 17.

Table 17: Patron noise modelling assumptions for event days

Description	Pre-game	Post-game
Combined number of patrons across both Stage 1 and Stage 2	7000	3500
Sound power level of patrons	125 dB(A)	120 dB(A)

Note:

1. Patron sound power levels applied as an area source across each Stage 1 and Stage 2.
2. Sound level spectra in Table 16 have been adjusted to the modelled sound power levels.

An assessment against the sporting event noise limit has been undertaken as described in Section 7.3.1. The noise limit has been split to allocate a quota to both patron noise and music which

Table 18: Event noise limits for residential receivers, $\text{dBL}_{\text{Aeq}(5\text{min})}$

Overall sporting event noise limit	Noise limit quota ¹	
	Patrons	Music
60	58	55

Note:

1. Both noise sources add logarithmically to equal 60 dBA.

An assessment of patron noise levels at surrounding receivers for event days are presented in Table 19.

Table 19: Predicted patron noise levels for event days, $\text{dBL}_{\text{Aeq}(15\text{ min})}$

Receiver	Patron noise limit	Predicted noise levels	
		Pre- Game	Post- Game
R1 - 749 South Dowling Street, Redfern	58	42	37
R2 - 635 South Dowling Street, Surry Hills	58	48	43
R3 - 553 South Dowling Street, Surry Hills	58	49	44
R4 - 111 Greens Rd, Paddington	58	58	54
R5 - 479 South Dowling Street, Surry Hills	58	45	40
R6 - 252 Moore Park Road, Paddington	58	55	50
R7 - 314 Moore Park Road, Paddington	58	37	33
R8 - 45 Oatley Road, Paddington	58	51	46
R9 - 5 Poate Road, Paddington	58	29	25
R10 - 107 Cook Road, Centennial Park	58	42	37
R11 - 2 Martin Road, Moore Park	58	42	37

Predicted noise levels comply with established patron noise limits.

It follows that music levels which comply with the prescribed noise limit quota of 55 dBA, along with predicted patron noise emissions are predicted to comply with sporting event noise limits.

Measures to manage music noise levels to maintain compliance with the 55 dBA limit are provided in Section 7.5.1.

Non-event days

Activities on non-event days are assumed to consist of patrons talking and eating at retailers in the Precinct Village. Modelled patron numbers and their sound levels can be seen in Table 20.

Table 20: Modelled noise levels for non-event days

Period	Number of patrons across both Stage 1 and Stage 2	Sound power level	Background music at retailers
Day and evening	2400	111 dBA	Anticipated to be 10 dB below patron sound power levels – suitable for background music only, not for live performances or announcements. Not considered to significantly contribute to predicted noise emissions therefore not modelled..
Night	1600	108 dBA	

Note:

Sound power level spectra in Table 15 have been adjusted to the calculated sound power levels modelled.

An assessment has been undertaken against the non-event operational noise limits as described in Section 7.3.2.

The noise limit has been split to allocate a quota to both patron noise and building services noise. An equal noise contribution from patrons and from building services has been conservatively assumed on the basis that heating, cooling and ventilation demands are not anticipated to be at their highest outside of event days, therefore building services noise emissions are likely to be well below established operational noise emission limits. Patron noise limits for non-event days have therefore been conservatively established as 3 dB lower than overall non-event operational noise limits outlined in Table 15, equivalent to attributing half the sound energy to patron noise and half to services noise.

Predicted noise levels at surrounding receivers for non-event days are presented in Table 21.

Table 21: Predicted patron noise levels for non-event days, $dB_{L_{Aeq}(15 \text{ min})}$

Receiver	Patron noise limit ¹	Predicted noise level			Comply
		Stage 1	Stage 2	Stage 1 and Stage 2 combined	
Evening ²					
R1 - 749 South Dowling Street, Redfern	53	27	33	34	Yes
R2 - 635 South Dowling Street, Surry Hills	53	35	39	40	Yes
R3 - 553 South Dowling Street, Surry Hills	53	36	39	41	Yes
R4 - 111 Greens Rd, Paddington	50	42	50	50	Yes
R5 - 479 South Dowling Street, Surry Hills	50	31	35	37	Yes
R6 - 252 Moore Park Road, Paddington	51	47	28	47	Yes
R7 - 314 Moore Park Road, Paddington	43	23	28	29	Yes
R8 - 45 Oatley Road, Paddington	43	43	31	43	Yes
R9 - 5 Poate Road, Paddington	43	19	20	22	Yes
R10 - 107 Cook Road, Centennial Park	38	15	20	21	Yes
R11 - 2 Martin Road, Moore Park	42	12	21	21	Yes
Night					
R1 - 749 South Dowling Street, Redfern	52	24	31	32	Yes
R2 - 635 South Dowling Street, Surry Hills	52	32	36	38	Yes
R3 - 553 South Dowling Street, Surry Hills	52	33	37	38	Yes
R4 - 111 Greens Rd, Paddington	48	40	47	48	Yes
R5 - 479 South Dowling Street, Surry Hills	48	29	32	34	Yes
R6 - 252 Moore Park Road, Paddington	49	44	26	44	Yes
R7 - 314 Moore Park Road, Paddington	40	20	26	27	Yes
R8 - 45 Oatley Road, Paddington	40	40	29	40	Yes
R9 - 5 Poate Road, Paddington	40	16	17	20	Yes
R10 - 107 Cook Road, Centennial Park	35	12	17	18	Yes
R11 - 2 Martin Road, Moore Park	35	10	18	19	Yes

Notes:

1- Patron noise limit established as 3dB below non-event operational noise limits to allow contribution of building services noise.

2- Compliance in the evening demonstrates compliance during the day.

Results show predicted patron noise levels due to the operation of the Stadium Precinct Village comply with established noise limits.

The acoustic design of building services which may contribute to overall operational noise levels is discussed in Section 7.4.2.

7.4.2 Building services plant noise

The location, type and size of building services plant that may emit to the surrounding environment will be the subject of further design development during detailed design stage, and indicative advice provided at this stage will be revised once the mechanical services design package is finalised.

A preliminary mechanical design has been developed which indicates the primary external mechanical plant are three carpark exhaust stacks located as shown in Figure 5.



Figure 5: Car Park exhaust stack locations

A preliminary assessment indicates acoustic attenuators will be required to mitigate car park fan noise to meet on-site noise targets to maintain acoustic amenity for users of the park and playground areas. Achieving the on-site targets will result in noise emission well below the operational noise criteria at nearest sensitive receivers.

Cumulative noise emissions shall also be assessed from building services associated with the approved stadium and patron noise from the use of the Precinct Village and Car Park.

Building services noise mitigation measures are recommended in Section 7.5.2.

7.4.3 Operational traffic noise

The additional traffic movements generated by the Precinct Village and Car Park in future years have been provided by JMT Consultants. Additional traffic movements would be as follows:

- Event days – no additional vehicles to those currently approved
- Non-event days – 1000 vehicles per day associated with the proposed retail floor space in Stage 2 West Car Park

Additional traffic would travel along either Driver Avenue / Moore Park Road or Driver Avenue / Lang Road. The most affected residential receivers along these routes are identified as:

- 32 Moore Park Road / 316 Moore Park Road – affected by traffic along Moore Park Road
- 2 Robertson Road – affected by traffic along Anzac Parade

An assessment of the noise impacts due to additional traffic is presented in Table 22.

Table 22: Additional traffic noise impacts

Residence	Nearest affecting road	Existing traffic volumes	Increase in traffic movements assuming all traffic travels either direction	Increase in noise level, dB	Criteria	Complies
32 Moore Park Road / 316 Moore Park Road	Moore Park Road	~35,000	1000	0.2 dB	2 dB	Yes
2 Robertson Road	Anzac Parade	~40,000	1000	0.2 dB	2 dB	Yes

Due to the high traffic volumes travelling along Moore Park Road and Anzac Parade, the increase in traffic noise levels due to the relatively low number of additional traffic movements is anticipated to be well below the 2 dB ‘minor impact’ criteria and to have an insignificant impact on the ambient noise environment.

7.4.4 Loading dock

The Precinct Village and Car Park will be serviced by a standalone loading dock. The location of the loading dock is on Level 0, which is one floor below ground level from Moore Park Road, connected by an inclined exit ramp shown in Figure 5.



Figure 6: Location of loading dock on level 0 of carpark

The loading dock can accommodate five service vehicles parked at any one time, including:

- One 12.5m Heavy Rigid Vehicle
- One 8.8m Medium Rigid Vehicle
- Two 6.4m Small Rigid Vehicles
- One van

The hours of operation of these activities have been assessed against criteria for all time periods.

Modelled noise sources are presented in Table 23. Noise source levels are conservative, considering truck movements will be short in duration.

Table 23: loading dock noise sources

Loading dock noise source	Sound power level, dBA	
	L _{Aeq} (15min)	L _{Amax}
Two trucks moving within loading dock for 30 seconds each to arrive, 30 seconds to depart within 15 minutes. Equivalent to four trucks arriving or departing in 15 minutes.	Sound power level of single truck – 108 dBA Time corrected level over 15 minutes – 102 dBA	112
Dropping crate	-	116
Air-brake compression release	-	116

The nearest residence to the loading dock is at 232 Moore Park Road, however residences along Oatley Road, Paddington have also been assessed, as background noise levels and hence noise criteria are lower due to the set back from Moore Park Road.

Noise impacts have also been predicted at the nearest non-residential receivers Kira Child Care and the on-site University of Technology Sydney and Rugby Australia building.

Predicted noise emissions from loading activities within the loading dock are presented in Table 24 against night-time non-event operational noise criteria, including L_{eq} criteria at both receivers and L_{max} criteria at residences to address sleep disturbance.

Table 24: Loading dock operations assessment

Receiver	Distance to loading dock	dBL _{Aeq(15min)}		dBL _{max}	
		Criteria	Predicted level	Criteria	Predicted level
Residential - 232 Moore Park, Paddington	190 m	52	44	64	52
Residential – Oatley Road, Paddington	200 m	43	39	56	47
Kira Child Care	120	45 ¹	40	-	N/A
University of Technology Sydney and Rugby Australia	20	57 ²	55	-	N/A

Notes:

1. External noise criteria based on internal NPfI [3] criteria for classrooms assuming 10dB reduction through open window
2. External noise criteria based on internal NPfI [3] criteria for classrooms and attenuation through façade construction

Noise breakout from activities within loading dock is anticipated to be low due to the distances of receivers from the loading dock and shielding of noise from the loading dock due to the sunken level of the loading dock and intermediate UTS and Rugby building. Due to the fixed façade at the UTS and Rugby Australia building, internal noise criteria are predicted to be met.

A conservative assessment predicts loading dock noise emissions will comply with night-time noise criteria, and hence noise criteria throughout the day.

7.5 Noise mitigation measures

7.5.1 Patron noise and music

Event days

Based on conservative upper patron capacity limits of 7000 patrons across both Stage 1 and Stage 2, a noise contribution of 55 dBA from amplified music or

speech at nearest residences is predicted to comply with established event noise limits.

Demonstration of compliance with this amplified sound noise limit shall be outlined in the Event Management Plan to be prepared in accordance with Condition D28 of SSD 9835.

Compliance with amplified sound noise limit may be demonstrated by:

- Modelling of proposed speaker locations and determination of sound power limits for speaker systems, which may be imposed with noise limiters.
- Monitoring at residential assessment locations or intermediate representative locations

Events shall otherwise be managed in accordance with Conditions outlined in SSD 9835.

Non-event days

Although the modelled patron numbers in this assessment represent what are anticipated to be conservative upper limits of patrons on site outside of event days and the assessment methodology is considered conservative, management of patron noise for non-event days should be addressed in the Operational Noise Management Plan to be prepared in accordance with Condition D48 of SSD 9835.

These measures should include:

- Limits on operating hours for retailers, see Section 7.2.
- Restricting music to background music in retailers.

Any music in addition to retail background music, such as live music or performances, would require assessment as part of individual retail fitout DAs.

Consent for any stand-alone events on non-event days that are not captured by Conditions A17 and the Event Management Plan will be subject of a separate future approval.

7.5.2 Building services

A preliminary assessment indicates acoustic attenuators will be required to mitigate car park fan noise to meet on-site noise targets to maintain acoustic amenity for users of the park and playground areas. A full acoustic design review shall be undertaken at detailed design stage when plant selections are finalised.

A review of cumulative noise emissions shall be conducted including:

- building services noise from both the Precinct Village and Car Park and the approved stadium; and
- patron noise from the use of the Precinct Village and Car Park.

Services noise emissions shall consider the time of day, and therefore operating speed and capacity when assessing cumulative noise emissions. Acoustic

treatment or operational constraints shall be implemented to maintain compliance with non-event operational noise limits outlined in Section 7.3.2.

8 Conclusion

Based on the assessments detailed above, it is concluded that the cumulative construction and operational noise emissions associated with the Precinct Village and Car Park are predicted to comply with the criteria approved under SSD 9835.

The assessment has covered the following issues and concluded:

8.1 Construction noise and vibration

An assessment of cumulative impacts of construction of the Precinct Village and Car Park and the approved stadium has been conducted. Increases in noise levels at residential receivers due to the contribution of proposed works are predicted to be minor (generally 2 dB or less), or are not anticipated to result in exceedance of NMLs.

Construction noise impacts at non-residential receivers are predicted to increase as a result of the proposed works at C4 – NRL Building and E5 - University of Technology Sydney and Rugby Australia due to the close proximity and direct line of sight to the works. Construction noise and vibration management measures are recommended in Section 6.4.

Vibration impacts due to the construction of the Precinct Village and Car Park shall be managed as per the stadium CNVMP including the Methodology Statement - Working near Busby's Bore.

Requirements outlined in the CNVMP [2] will be adhered to during Stadium Fitness Facilities construction works.

8.2 Operational noise

Operation noise criteria have been established for noise emissions from sources associated with the Precinct Village and Car Park, which include:

- Patron noise and music during event and non-event days
- Building services plant
- Additional operational traffic
- Loading dock operations

Noise mitigation measures are provided in Section 7.5 pertaining to patron noise, music and building services. Mitigation measures which relate to patron noise and music on non-event days shall be captured in the Operational Noise Management Plan, as required in Condition D48 of SSD 9835. Mitigation measures relating to patron noise and music on event days shall be captured in the Event Management Plan, as required in Condition D28 of SSD 9835.

Consent for any stand-alone events on non-event days that are not captured by Conditions A17 and the Event Management Plan will be subject of a separate future approval.

Operational noise emissions from Precinct Village and Car Park are predicted to comply with existing operational noise criteria as outlined in approved operational conditions in SSD 9835 [8], and therefore compliance with the existing Notice of Prevention Preventative Action [15].

9 References

- [1] Arup, “AC04-v5_SFSR Stage 2 NVIA,” Arup, Sydney, 2019.
- [2] Arup, “AC09-v7 SFSR Stage 2 CNVMSP, Issue 5,” Arup, Sydney, 2020.
- [3] NSW Environment Protection Authority, “NSW Noise Policy for Industry,” NSW Environment Protection Authority, Sydney, 2017.
- [4] Department of Environment and Climate Change NSW, “Interim Construction Noise Guideline,” Department of Environment and Climate Change NSW, Sydney, 2009.
- [5] Department of Environment and Conservation (NSW), “Assessing Vibration: A technical guideline,” Department of Environment and Conservation (NSW), Sydney, 2006.
- [6] Department of Planning NSW, “Development Near Rail Corridors and Busy Roads – Interim Guideline,” Department of Planning NSW, Sydney, 2008.
- [7] Arup, “2018-06-05 - AC01-v5_SFSR_Noise and Vibration Impact Assessment,” Arup, Sydney, 2018.
- [8] Department of Planning, Industry and Environment, “Development Consent, As modified by SSD-9835-Mod-1 –03.04.2020,” Department of Planning, Industry and Environment, Consent Authority: Minister for Planning and Public Spaces, Sydney, 2020.
- [9] German Institute for Standardisation, “DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure',” German Institute for Standardisation, 1999.
- [10] British Standards, “BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting,” British Standards, 2008.
- [11] Infrastructure NSW, “Methodology Statement - Working Near Busby’s Bore,” Infrastructure NSW, Sydney, 2018.
- [12] Department of Environment, Climate Change and Water NSW, “NSW Road Noise Policy,” NSW Environmental Protection Authority, Sydney, 2011.
- [13] M. Hayne, J. Taylor, R. Rumble and D. Mee, “Prediction of Noise from Small to Medium Sized Crowds,” in *Acoustics 2011*, Gold Coast, 2011.
- [14] I. R. Cushing, F. F. Li, T. J. Cox, K. Worrall and T. Jackson, “Vocal effort levels in anechoic conditions,” *Applied Acoustics*, vol. 72, pp. 695-701, 2011.
- [15] Environment Protection Authority, “Notice of Preventative Action 1003904,” Environment Protection Authority, Sydney, 2017.
- [16] H. Rindel, “Acoustical capacity as a means of noise control in eating establishments,” in *Joint Baltic-Nordic Acoustics Meeting*, Lyngby, 2012.

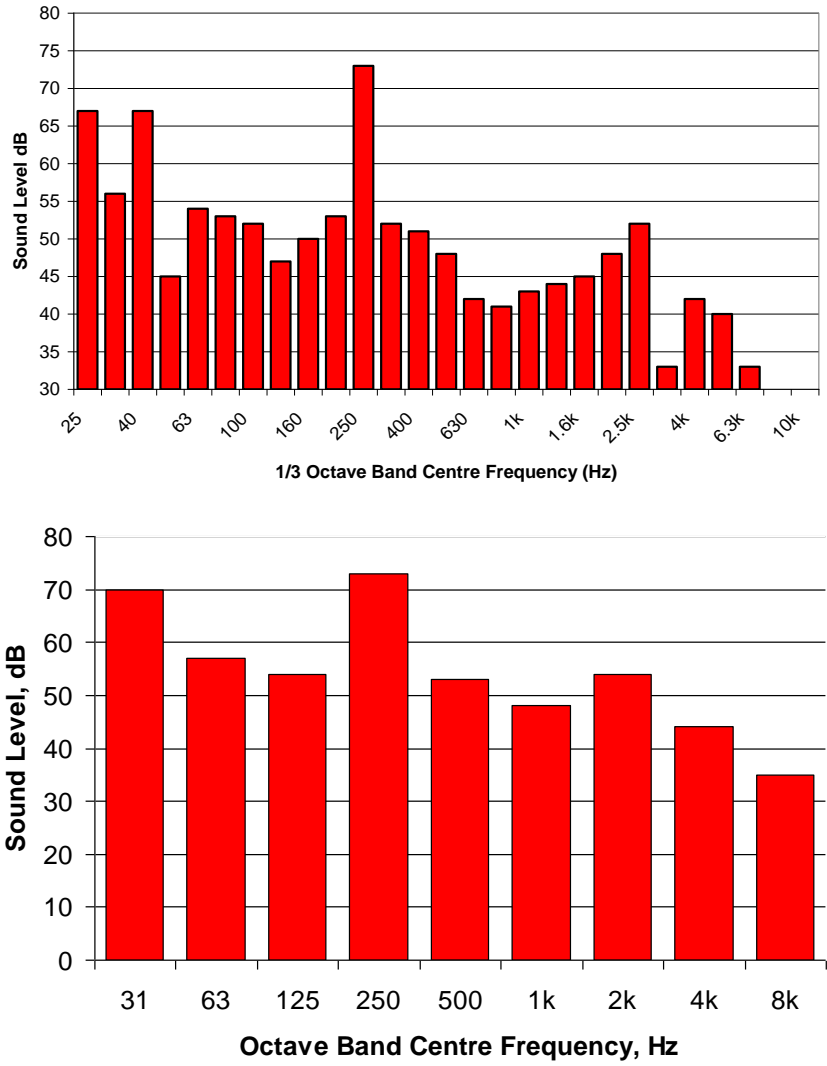
Appendix A

Acoustic Glossary

A1 Acoustic Glossary

Term	Definition
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	<p>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.</p> <p>Assessment Background Level (ABL)</p> <p>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 LA90 noise levels – i.e. the measured background noise is above the ABL 90% of the time.</p> <p>Rating Background Level (RBL / min LA90,1hour)</p> <p>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 LA90,1hour in QLD.</p>
Decibel	<p>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.</p> <p>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.</p>
dBA	<p>dBA denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level.</p> <p>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.</p>

Term	Definition																														
	<p>Some typical dBA levels are shown below.</p> <table> <tr> <th>Sound Pressure Level dBA</th><th>Example</th></tr> <tr><td>130</td><td>Human threshold of pain</td></tr> <tr><td>120</td><td>Jet aircraft take-off at 100 m</td></tr> <tr><td>110</td><td>Chain saw at 1 m</td></tr> <tr><td>100</td><td>Inside nightclub</td></tr> <tr><td>90</td><td>Heavy trucks at 5 m</td></tr> <tr><td>80</td><td>Kerbside of busy street</td></tr> <tr><td>70</td><td>Loud stereo in living room</td></tr> <tr><td>60</td><td>Office or restaurant with people present</td></tr> <tr><td>50</td><td>Domestic fan heater at 1m</td></tr> <tr><td>40</td><td>Living room (without TV, stereo, etc.)</td></tr> <tr><td>30</td><td>Background noise in a theatre</td></tr> <tr><td>20</td><td>Remote rural area on still night</td></tr> <tr><td>10</td><td>Acoustic laboratory test chamber</td></tr> <tr><td>0</td><td>Threshold of hearing</td></tr> </table>	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
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	<p>The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.</p> <p>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.</p>																														
L_{10}	<p>The L_{10} statistical level is often used as the “average maximum” level of a sound level that varies with time.</p> <p>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.</p>																														
L_{90}	<p>The L_{90} statistical level is often used as the “average minimum” or “background” level of a sound level that varies with time.</p> <p>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.</p>																														
L_{eq}	<p>The ‘equivalent continuous sound level’, L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.</p> <p>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 LAeq. Often the measurement duration is quoted, thus LAeq,15 min represents the dBA weighted energy-average level of a 15 minute measurement.</p>																														

Term	Definition
L _{max}	<p>The L_{max} statistical level can be used to describe the “absolute maximum” level of a sound or vibration level that varies with time.</p> <p>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.</p> <p>Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.</p>
Frequency	<p>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”.</p>  <p>1/3 Octave Band Centre Frequency (Hz)</p> <p>Octave Band Centre Frequency, Hz</p>
Peak Particle Velocity (PPV)	<p>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.</p> <p>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.</p>

Term	Definition
Sound Power and Sound Pressure	<p>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.</p>
Vibration	<p>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.</p> <p>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.</p> <p>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.</p>

Appendix B

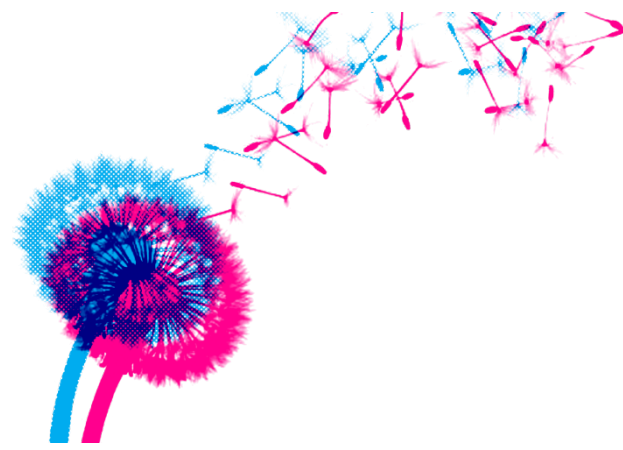
Methodology Statement - Working near Busby's Bore

SFS Response to Submissions

(SSD9249)

Attachment 8- Methodology Statement-
Working Near Busby's Bore

September 2018



This methodology has been developed to support demolition and construction around Busby's Bore. It has been developed with the input of Arup (acoustics and vibration), Curio Project (heritage and archaeology) and Aver (construction and demolition management). In particular it has been developed to respond to the comment DPE12:

While the proposal is for a concept building envelope, it is considered that further assessment regarding the protection of Busby's Bore during demolition and construction works would be required. The report should include a methodology of how the bore would be identified, protected, assessed and monitored throughout the demolition and construction works. The method should be included in detail in an updated Construction Management Plan, supported by the HIA. This document should be submitted for further consideration.

This methodology also addresses comment COS34:

The site is affected by a State Heritage Listing and General Terms of Approval should be obtained from the Heritage Council. There is a potential that the demolition works through vibration could impact Busby's Bore.

It is noted that approval for construction works is not being sought as part of the Stage 1 SSDA, however it is considered the principles contained within this methodology will be applicable to those works. Adjustments may be made to this methodology to support the construction as part of the Stage 2 application when further detail regarding the construction methodology is known.

1. Identification and Assessment

Prior to the commencement of demolition, investigations will be undertaken in an effort to determine the condition of the bore through the site. This will entail access through the existing shafts on site with known locations (Shafts 9 and 10). The exact path as the Bore crosses beneath the site, and the precise locations of Shafts 11 and 'Intervening Shaft 4' remain unknown.

The steps to be followed will include:

- Land owners consent for access and support for the methodology for the investigative works to be obtained from Sydney Water prior to seeking approval from the NSW Heritage Division to undertake investigative works of the Bore.
- If land owners consent is provided, then a Section 57 (2) Heritage Exemption will be prepared by qualified historical archaeologist and submitted to the NSW Heritage Division in accordance with the requirements of the NSW Heritage Act (1977) to undertake investigation works.
- Safe Work Method Statement for access to be developed.

The results of the investigation works will be utilised to determine the current state of the Bore, where possible to further inform the design and management of impacts to known and potential sections of the Bore during Stage 1 demolition works and future Stage 2 construction works.

Figure 1, below, demonstrates the location of the known shafts and an indicative path of the tunnel beneath the site, with reference to the proposed indicative footprint of the new stadium envelope.

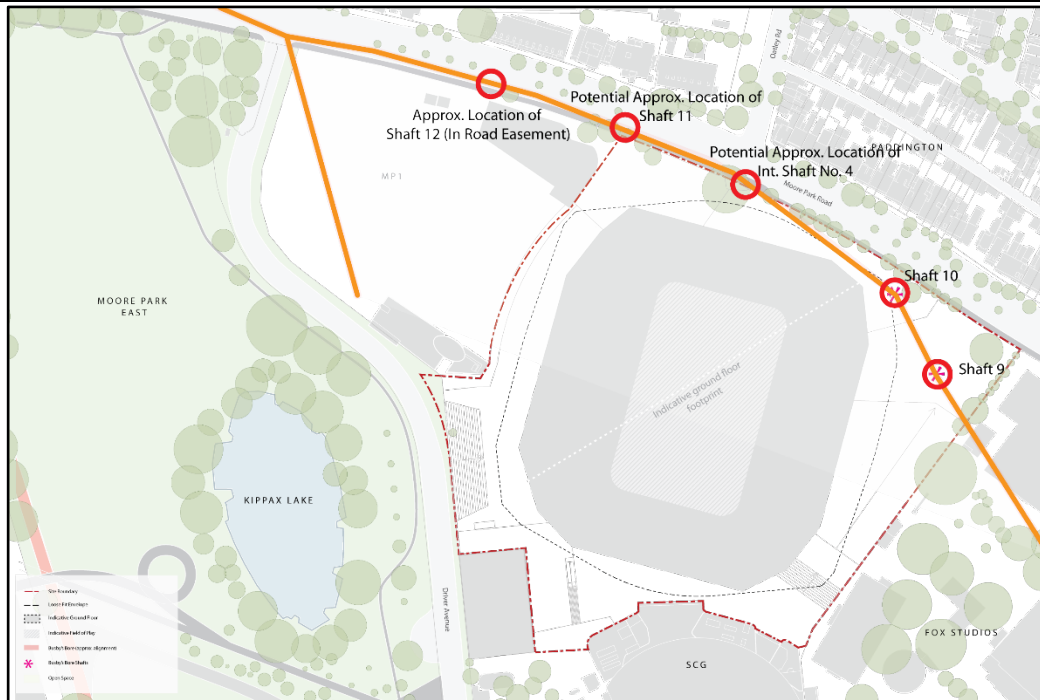


Figure 1: Locational Map of known and possible Busby's Bore shafts within SFS Redevelopment Site (Source: SJB Architects with Curio Additions 2018)

2. Protection

A physical exclusion zone will be maintained around the existing shafts and the Bore (if found during investigation works). The project archaeologist and the Site Manager will liaise regarding the best location for these barriers.

Vibration monitoring devices will be installed within the shafts of Busby's Bore in a location agreed by the project archaeologist, structural engineer and acoustic consultant. A conservative vibration criterion of 3mm/s, based on structural damage criterion for 'sensitive structures' in DIN 4150 – Part 3¹ will be applied. The vibration monitors will be calibrated to generate real-time alerts (SMS messages and/or flashing lights) when vibration criterion is exceeded.

3. Monitoring

In the event that the vibration criterion is exceeded by works on site an alert will be sent to the Site Manager. This alert will trigger a cessation of works and the project archaeologist and structural engineering advisor will be notified and requested to attend site. A visual inspect of the pits and/or Bore will be undertaken to determine whether any damage has been sustained.

An exceedance of the vibration criterion will necessitate a change in demolition and/or construction methodology. This could include:

- Re-evaluation of the vibration criterion based on results of the initial condition investigation and inspections of the structure following the commencement of works.
- Maintain vibration monitoring throughout Stage 1 and Stage 2 works.

¹ German Standard DIN 4150-Part 3 'Structural vibration in buildings – Effects on Structure'

-
- Reduce the size of demolition and construction equipment and develop alternative methodologies to minimise vibration.
 - Use less vibration emitting demolition methods such as concrete pulverisers and smaller percussive hammers if necessary closer to Busby's Bore.
 - Use rubber tracked excavators and machinery if necessary closer to Busby's Bore.
 - Balance variable speed vibrating plant and operate at speeds that do not produce resonance.
 - Ensure all fixed plant at the site are appropriately selected (on a risk assessment approach), and where necessary, fitted with vibration attenuation measures.
 - Position vibrating plant and equipment as far apart as it practicable from each other and consider whether orientation and location of the plant can reduce vibration impacts at sensitive receivers such as Busby's Bore.
 - Use non-percussive piling techniques for all piles where practicable.
 - Ensure that vibratory compactors must not be used closer than 30 meters from sensitive receivers unless vibration monitoring confirms compliance with the vibration criteria specified.
 - Maintain machinery and equipment.
 - If necessary plan traffic flow, parking, loading/unloading areas to minimise movements within the area of Busby's Bore.