Sydney Cricket Ground and Sports Trust

Stadium Fitness Facilities

Noise and Vibration Assessment

AC01

Issue 6 | 11 November 2020

Job number 274301

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Contents

Appendices

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 a new stadium with up to 45,000 seats (55,000 capacity in concert-mode), including playing pitch, grandstands, sports and stadium administration areas, food and drink kiosks, corporate facilities and all other aspects of a modern stadium;
- Operation and use of the stadium and surrounding site area for a range of sporting and entertainment events;
- Vehicular and pedestrian access and circulation arrangements, including excavation to deliver a partial basement level for storage, internal loading and servicing at the playing pitch level;
- Reinstatement of the MP1 car park following the completion of construction, including enhanced vehicle rejection facilities and direct vehicular connection to the new stadium basement level;
- Public domain improvements within the site boundary, including hard and soft landscaping, to deliver a range of publicly accessible, event and operational areas;
- Provision of new pedestrian and cycling facilities within the site;
- Signage, including building identification signage, business identification signage and a wayfinding signage strategy; and
- Extension and augmentation of physical infrastructure/ utilities for the development within the site.

2 Stadium Fitness Facilities

The Sydney Cricket Ground and Sports Trust (SCGST) is proposing to integrate new Stadium Fitness Facilities into the SFS Redevelopment. This will reinstate the facilities that operated in conjunction with the former, demolished stadium in a new location on the site.

The Stadium Fitness Facilities are to be partially located underneath the western concourse with a low level pavilion building, swimming pools and cabanas located behind the southern entry abutment wall at the primary site entry at Driver Avenue. It will extend to the former Indoor Cricket Centre and include part of the Sydney Cricket Ground's (SCG) practice area, part of a tennis court, and the wall extending south along Driver Avenue, south of the Driver Avenue main entry stair. A Location Plan is provided at Figure 1.

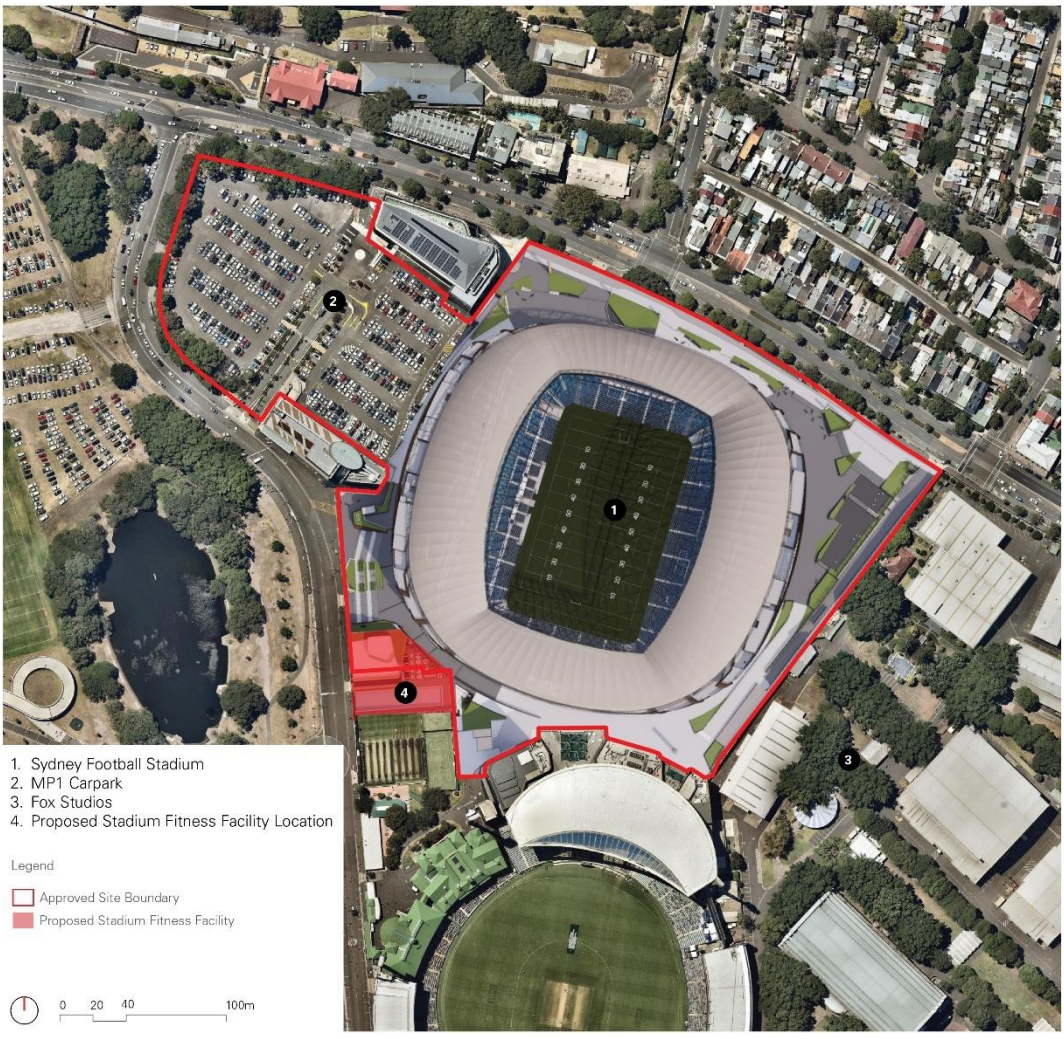


Figure 1: Stadium Fitness Facilities Proposed Location (Source: Cox Architecture, July 2020)

The Stadium Fitness Facilities will include:

- A low level pavilion building located behind the southern entry abutment wall and a basement level structure, largely integrated into

the under croft space beneath the approved SFS entry stairs to accommodate:

  - a gymnasium, training area and three group fitness training areas;
  - two squash courts;
  - sauna, spa, steam area;
  - wet and dry change rooms; and
  - day spa and treatment rooms.

- A café with indoor and outdoor seating.
- A 25m long and a 50m long open-air swimming pool and surrounding areas including design, installation and commissioning of all pool deck finishes;
- Basement level to accommodate plant and equipment;
- Associated site landscaping; and
- Services and associated plant rooms.

The Stadium Fitness Facilities will be accessible to existing and future SCSGT Members and guests, with typical utilisation across the facility of 500 people at any one time, however recognising that the facility has a maximum functional capacity of approximately 1,000 persons (rounded up from 993).

For ease of operation across both the Stadium Fitness Facilities and the main stadium, operating hours are proposed to be generally aligned, noting an earlier opening time is proposed for the Stadium Fitness Facilities to facilitate gym access.

The typical operating hours are proposed to be:

- 5.30am and 11.30pm Monday to Friday;
- 6am and 11.30pm on Saturdays; and
- 7am and 11pm on Sundays.

Access to the facilities is available from an entrance near the approved DDA lifts and reinstated MP1 carpark or from the concourse via the approved stairs.

Architectural and landscape plans are appended to the Planning Statement prepared by Ethos Urban, dated July 2020.

3 Proposed Modifications

To facilitate the Stadium Fitness Facilities, SSD 9249 and SSD 9835 are required to be modified.

The proposed modification to SSD 9249 (concept development application) is limited to a revision to the project boundary to capture the land on which the Stadium Fitness Facilities is proposed to be constructed. No other modifications are proposed.

SSD 9835 is proposed to be modified to facilitate construction, fit-out and operation of the new Stadium Fitness Facilities described in Section 2.

It is emphasised that the Stadium Fitness Facilities will not amend or otherwise compromise the approved design of the stadium including the location and design of site entries and circulation paths.

4 Purpose of this Report

This Noise and Vibration Report has been prepared to support the Stadium Fitness Facilities modification. This Report specifically considers:

- Construction noise and vibration impacts;
- Operational noise impacts; and
- Noise generated by additional traffic.

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

- Planning Statement prepared by Ethos Urban (November, 2020);
- Architectural Design Statement Addendum and plans prepared by Cox (November, 2020);
- Landscape and Public Domain Report Addendum and plans prepared by Aspect (November, 2020);
- Traffic and Transport Addendum prepared by JMT (November, 2020);
- Stormwater and Flooding Addendum, prepared by Arup (November, 2020);
- Accessibility Review prepared by Before Compliance (July, 2020).

A noise and vibration assessment is not required to support the modification to SSD 9249 MOD 5 to the Stage 1 Development Approval given the administrative change of the proposal. In addition, the Department of Planning, Industry and Environment has not requested a noise and vibration assessment for SSD 9249 MOD 5.

This version of this report (Issue 3) is an update to the public exhibited version (Issue 1) and has been updated to specifically address feedback received in submissions from the EPA and the DPIE. In particular, the following feedback has been addressed through this report:

- clarification on the proposed nature and frequency of functions;
- confirmation that no plant/equipment is proposed on the external facades of the building;
- reiteration of the Trust's commitment to continue to operate in accordance with the statutory Notice of Prevention Action 1003904 issued under the Protection of the Environment Operations Act 1997.

This report should be read in conjunction with the following documents which have been prepared to respond to consultation outcomes following the public exhibition of the modification:

- Planning Statement prepared by Ethos Urban (October, 2020);
- Architectural Design Statement Addendum and plans prepared by Cox (October, 2020);

- Landscape and Public Domain Report Addendum and plans prepared by Aspect (October, 2020);
- Traffic and Transport Addendum prepared by JMT (October, 2020); and
- Stormwater and Flooding Assessment prepared by Arup (October, 2020).

5 Existing acoustic environment

Traffic noise is the dominant acoustic feature of the area surrounding the SFS Site within which the Stadium Fitness Facilities is proposed to be constructed. 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’;
- Aircraft noise; and
- General activity noise from users of the existing facilities.

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.

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 child cares, 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.

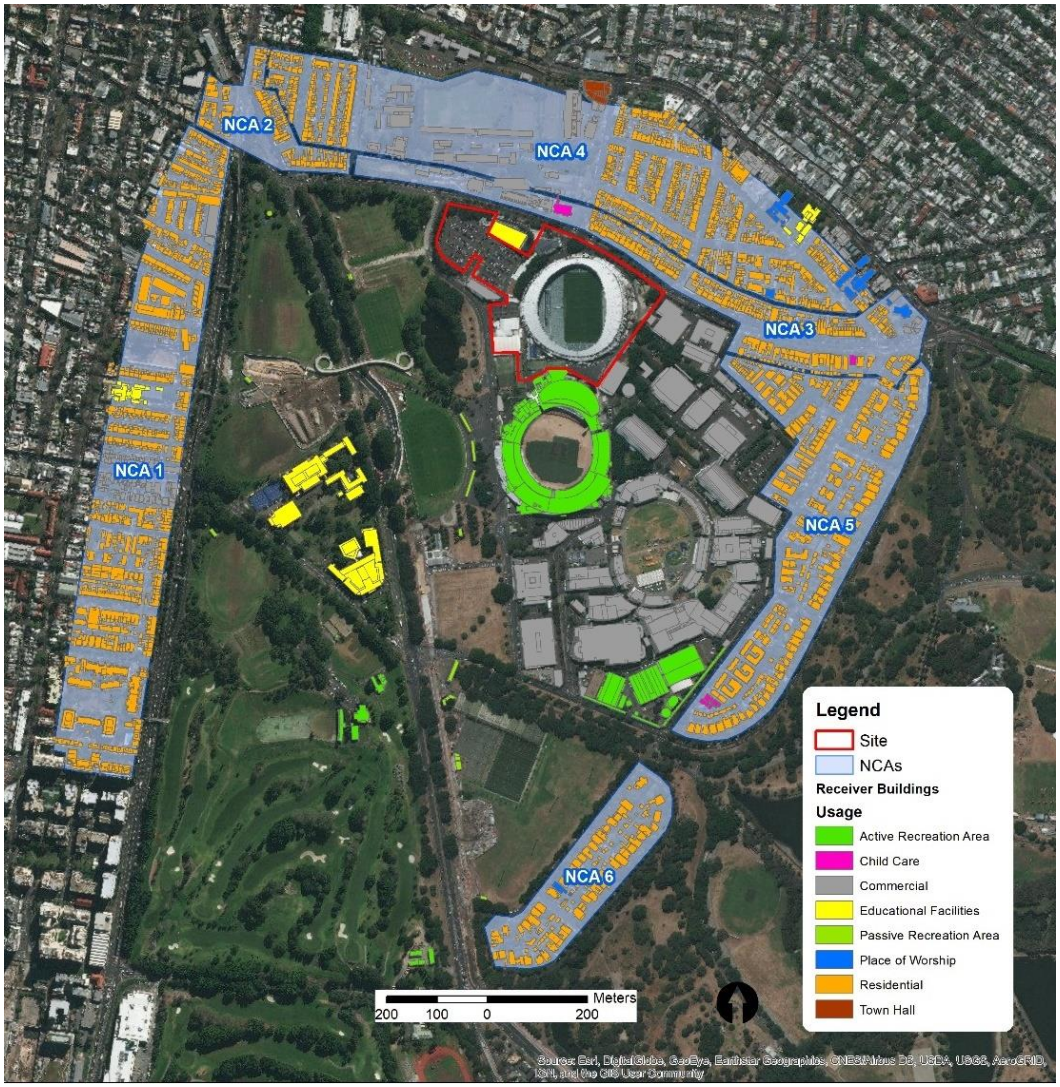


Figure 2: Noise sensitive receiver locations and NCAs

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 2 and described in Table 1. 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 1: 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 [1]

NCA boundaries have been determined from site observations and attended measurements, conducted as part of the Stage 1 SSDA Noise and Vibration Impact Assessment (NVIA) [2]. Classifications of NCAs 1, 2, 3 and 4 as 'Urban' are based on on-site observations, and based on the 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 [1]).

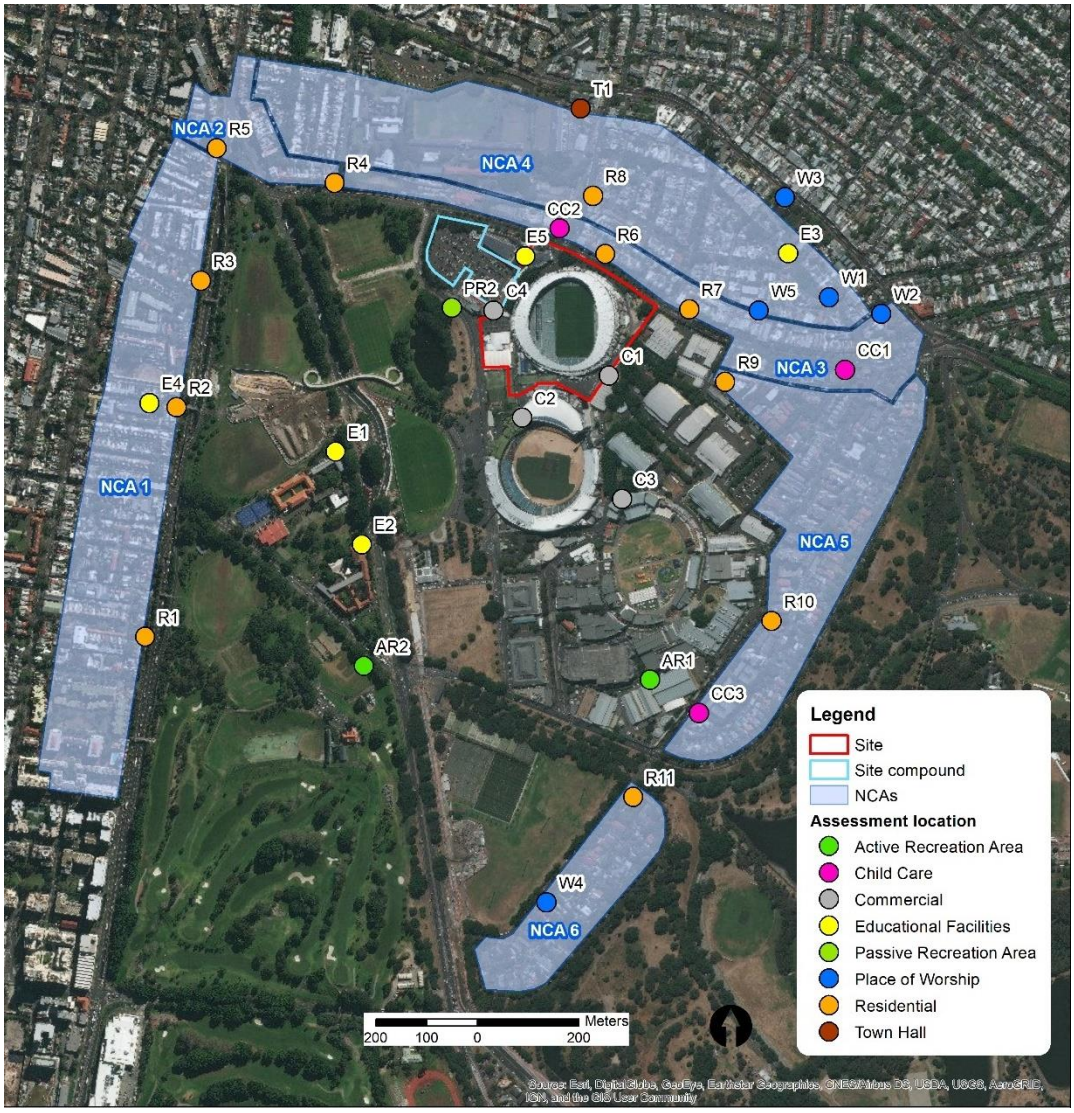


Figure 3: Assessment locations and NCAs

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 3 and listed in Table 2 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 2: Reasonably most-affected residential receivers

Receiver ID	Address	No. of floors	NCA
R1	749 South Dowling Street, Redfern	2	1
R2	635 South Dowling Street, Surry Hills	3	1
R3	553 South Dowling Street, Surry Hills	3	1
R4	111 Greens Rd, Paddington	2	2
R5	479 South Dowling Street, Surry Hills	3	2
R6	252 Moore Park Road, Paddington	2	3
R7	314 Moore Park Road, Paddington	2	3
R8	45 Oatley Road. Paddington	2	4
R9	5 Poate Road, Paddington	2	5
R10	107 Cook Road, Centennial Park	2	5
R11	2 Martin Road, Moore Park	3	6

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

Table 3: Non-residential receivers

Receiver ID	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 report addresses the noise and vibration associated with proposed construction of the new Stadium Fitness Facilities. Demolition of Allianz Stadium and associated buildings was assessed and approved as part of the Stage 1 SSD DA, and construction of the new SFS was assessed and approved as part of the Stage 2 SSD DA. Construction Noise and Vibration Management Plans have been approved for both applications and works have been undertaken in accordance with them.

6.1 Construction noise criteria

Requirements for noise management for the construction of the SFS are outlined in the SSD 9835 Development Consent [3] 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) [4] 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 4 and Table 5 for residential and non-residential receivers respectively.

Table 4: Approved residential Noise Management Levels during intended working hours, $dBL_{Aeq\ 15minute}$

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 2.

Table 5: Approved non-residential Noise Management Levels during intended working hours, $dBL_{Aeq\ 15minute}$

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
	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

Usage	Rec. ID[1]	Name	Time period	External NML
	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 3.

6.2 Construction vibration criteria

Pertinent to construction vibration, Condition C19 of SSD 9835 [3] 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:*
>
> *(a) the latest version of DIN 4150-3 (1992-02) Structural vibration - Effects of vibration on structures (German Institute for Standardisation) for structural damage;*
>
> *(b) 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*
>
> *(c) 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).*
>
> *(d) 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 [5] 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 [6].

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 6.

Table 6: 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* [7] 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 [8].

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 7 and Table 8 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 7: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	**Period**	**Preferred Values**		**Maximum Values**	
		z-axis	**x- and y-axes**	**z-axis**	**x- and y-axes**
Continuous Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	0.10	0.071	0.20	0.14
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 8: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	**Daytime 0700-2200 h**		**Night-time 2200-0700 h**	
	Preferred Value	**Maximum Value**	**Preferred Value**	**Maximum Value**
Critical areas[1]	0.10	0.20	0.10	0.20

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
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 SFS Site 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.

Regarding Busby's Bore, a methodology statement, 'SFS Response to Submissions (SSD9249) Attachment 8 – Methodology Statement – Working Near Busby's Bore' [9], outlines the methodology developed during Stage 1 works for undertaking vibration intensive works in its vicinity to minimise the risk of structural damage and is presented in Appendix B.

Further to the requirements in the Busby's Bore Methodology Statement [9], 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 Stage 2 construction works in accordance with Condition C19(c) and C19(d), and throughout the construction of the Stadium Fitness Facilities.

6.3 Construction noise assessment

6.3.1 Hours of works

Construction of the Stadium Fitness Facilities is to take place concurrently with the already approved SFS construction.

Table 9 provides the approved hours of construction for the SFS.

Table 9: 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

An Order has been made by the Minister for Planning and Public Spaces under section 10.17 of the *Environmental Planning and Assessment Act* 1979 to protect the health, safety and welfare of members of the public during the COVID-19 pandemic, as it will facilitate social distancing by extending construction work over additional days in a week. The Order states:

> *6. Construction work days*
>
> *(1) The carrying out of any building work or work, or the demolition of a building or work on a Saturday, Sunday or public holiday is development specified for this Order.*
>
> *(2) The conditions specified for the development are that the development must –*
>
> *(a) be the subject of a development consent, and*
>
> *(b) comply with all conditions of the consent other than any condition that restricts the hours of work or operation on a Saturday, Sunday or public holiday, and*
>
> *(c) for work or operation on a Saturday, Sunday or public holiday –*
>
> *i. Comply with the conditions of the consent that restricts the hours of work or operation on any other day as if the conditions applied to work or operation on a Saturday, Sunday or public holiday, and*
>
> *ii. not involve the carrying out of rock breaking, rock hammering, sheet piling, pile driving or similar activities during the hours of work or operation that would not be permitted but for this Order, and*
>
> *iii. take all feasible and reasonable measures to minimise noise.*

The proposed extended construction hours in accordance with the Order are presented in Table 10.

Table 10: Proposed extended hours of construction

Day	Proposed construction hours
All days, including public holidays	7.00 am to 6:00 pm

6.3.2 Activities and assessment

Stadium Fitness Facilities construction activities would generally utilise the equipment proposed as part of the approved CNVMP [4], however two additional items of equipment are required as part of the Stadium Fitness Facilities construction, which are listed in Table 11.

Table 11: Additional construction equipment for Stadium Fitness Facilities construction

Equipment	Total number of units additional to SFS construction	No. operating within worst case 15-min	Sound Power $dBL_{eq\ (15min)}$
Mobile concrete pumps	2	1	113
Mobile Crane	1	1	113

It has been conservatively assumed the additional equipment may be operational during any phase of the SFS construction.

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

Table 12: Predicted cumulative construction noise levels due to the construction of the SFS and Stadium Fitness Facilities, $dBL_{Aeq\ (15\ min)}$

Receiver	NML	Construction phase				
		CC1 – Site Excavation and Earthwork	CC2 – Stadium Sub-structure	CC3 – Basement to concourse level	CC4 – Above concourse level works	CC5 – Roof, façade, fit-out and remaining
		Cumulative predicted noise level / Increase from SFS construction noise level				
Residential receivers						
R1 - 749 South Dowling Street, Redfern	**68**	55 / -	53 / -	49 / -	49 / 1	49 / 1
R2 - 635 South Dowling Street, Surry Hills	**68**	58 / -	56 / -	52 / -	52 / 1	52 / 1
R3 - 553 South Dowling Street, Surry Hills	**68**	59 / -	57 / -	54 / 1	53 / -	53 / 1
R4 - 111 Greens Rd, Paddington	**66**	54 / 1	52 / 1	48 / -	48 / 1	48 / 1
R5 - 479 South Dowling Street, Surry Hills	**66**	61 / -	59 / -	55 / -	55 / 1	55 / 1
R6 - 252 Moore Park Road, Paddington	**62**	**80** / -	**79** / 1	**75** / -	**75** / 1	**75** / 1
R7 - 314 Moore Park Road, Paddington	**62**	72 / -	71 / 1	67 / -	67 / 1	67 / 1
R8 - 45 Oatley Road. Paddington	**53**	64 / -	62 / -	59 / 1	58 / -	58 / -
R9 - 5 Poate Road, Paddington	**49**	64 / -	62 / -	59 / 1	58 / -	58 / -
R10 - 107 Cook Road, Centennial Park	**49**	56 / -	54 / -	51 / 1	51 / 1	51 / 1
R11 - 2 Martin Road, Moore Park	**57**	52 / -	50 / -	46 / -	46 / 1	46 / 1
Non-residential receivers						
AR1 - Centennial Parklands Equestrian Centre	**65**	41 / -	39 / -	36 / 1	35 / -	35 / -
AR2 - Moore Park Golf Course	**65**	55 / -	53 / -	50 / 1	49 / -	49 / -
C1 - Fox Studios	**70**	**76** / -	74 / -	71 / 1	71 / 1	71 / 1
C2 - Sydney Cricket Ground	**70**	60 / -	58 / -	55 / 1	54 / -	54 / -

Receiver	NML	Construction phase				
		CC1 – Site Excavation and Earthwork	CC2 – Stadium Sub-structure	CC3 – Basement to concourse level	CC4 – Above concourse level works	CC5 – Roof, façade, fit-out and remaining
		Cumulative predicted noise level / Increase from SFS construction noise level				
C3 - Entertainment Quarter	**70**	61 / -	59 / -	55 / -	55 / 1	55 / 1
C4 – NRL Building	**70**	**75** / 1	73 / 1	69 / -	69 / 1	69 / 1
CC1 - Gumnut Gardens Early Learning and Long Day Care Centre	**55**	62 / -	60 / -	56 / -	56 / 1	56 / 1
CC2 - Kira Child Care Centre	**55**	**75** / -	73 / -	69 / -	69 / 1	69 / 1
CC3 - Bambini's Child Care Centre	**55**	42 / -	40 / -	37 / 1	37 / 1	37 / 1
E1 - Sydney Boys High School[1]	**55**	62 / -	60 / -	56 / -	56 / 1	56 / 1
E2 - Sydney Girls High School[1]	**55**	60 / -	58 / -	55 / 1	54 / -	54 / -
E3 - Paddington Public School[1]	**55**	51 / -	49 / -	46 / 1	45 / -	45 / -
E4 - Bourke Street Public School[1]	**55**	53 / -	52 / 1	48 / -	48 / 1	48 / 1
E5 - University of Technology Sydney and Rugby Australia[1]	**55**	**77** / -	**75** / -	72 / 1	71 / -	71 / -
PR1 - Moore Park	**60**	66 / -	64 / -	60 / -	60 / 1	60 / 1
T1 - Paddington Town Hall[1]	**45**	63 / -	61 / -	58 / 1	58 / 1	58 / 1
W1 - St Francis of Assisi Catholic Church[1]	**55**	54 / -	52 / -	49 / 1	48 / -	48 / -
W2 - St Mattias Anglican Church[1]	**55**	51 / -	49 / -	45 / -	45 / 1	45 / 1
W3 - Paddington Uniting Church[1]	**55**	52 / -	50 / -	46 / -	46 / 1	46 / 1
W4 - St. Vladimir's Russian Orthodox Church[1]	**55**	51 / -	49 / -	46 / 1	45 / -	45 / -
W5 - Kingdom Hall of Jehovah's Witnesses[1]	**55**	59 / -	58 / 1	54 / -	54 / 1	54 / 1

- Levels shaded in grey indicate a notional exceedance of NMLs based on the worst-case assumptions noted above.
- Levels in **Bold Red** indicate 'highly affected' noise levels of 75dBA or above.

1. External NML conservatively based on a 10dB noise reduction through an open window

Results show additional works associated with the Stadium Fitness Facilities construction marginally increase predicted noise levels by 1 dB at some receivers. Increases of 1dB are considered imperceptible to the average person.

The occurrence of the predicted noise levels would also be infrequent due to the low likelihood of the additional concrete pump truck and mobile crane operating concurrently with all other modelled construction equipment. Predicted noise levels therefore represent an infrequent worst-case scenario.

Due to the minor nature of cumulative increases to overall construction noise impacts, and the unlikely nature of cumulative impacts occurring, the increase in

disturbance to the community due to the construction of the Stadium Fitness Facilities is considered low, therefore no additional noise mitigation is considered necessary.

Since mobile concrete pumps and cranes do not generate significant vibration impacts, adverse vibrations due to the use of mobile concrete pump or cranes are anticipated insignificant, therefore no additional vibration management measures are considered necessary.

7 Operational noise

7.1 Overview

This section addresses noise sources associated with the operation of the Stadium Fitness Facilities. The Stadium Fitness Facilities will be occupied exclusively by Sydney Cricket and Sports Ground Trust Members.

Typical operational noise sources associated with Stadium Fitness Facilities include:

- Patron noise and music from pool and outdoor café seating area
- Operational traffic generated by the Stadium Fitness Facilities

No additional external mechanical plant or equipment is proposed as part of the Stadium Fitness Facilities.

The operating hours of the Stadium Fitness Facilities, including fitness activities and functions, are proposed to be:

- 5.30am and 11.30pm Monday to Friday;
- 6am and 11.30pm on Saturdays; and
- 7am and 11pm on Sundays.

Functions to be held at the Facilities would take place within these operating hours. Fitness activities would not take place concurrently with functions.

Noise emissions from the Facilities have been assessed in isolation from noise from the main SFS stadium. In order to demonstrate the noise from the Facilities would not result in any cumulative exceedance of approved noise limits, noise emissions have been assessed to a more stringent criteria, as outlined in Section 7.2.

7.2 Criteria

Approved operational noise limits for the SFS are outlined in the SSD 9835 Development Consent [3]. Limits are provided for noise emissions during event and non-event times.

In relation to the loudest anticipated activities which are expected to be functions to be held at the facilities, this assessment recognises that they could occur on any day of the year that the facility is open, however it also adopts the important assumption that there will not be a function held every day. For this reason, functions have been assessed as occurring on any day (which would include non-event days) and have been assessed as generating to 10dB less than what is already approved for the main stadium on non-event days. This is to demonstrate a negligible contribution from the Stadium Fitness Facilities to the overall permitted impacts from the SFS, since the addition of a secondary noise contribution 10 dB lower than a primary noise source is mathematically insignificant (eg. 50 dB plus 60 dB equals 60 dB rounded to the nearest dB).

7.2.1 Non-event operational noise limit

Outside of event times, no noise limits within SSD 9835 Development Consent [3] 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***
	$dBL_{Aeq, 15min}$	***$dBL_{Aeq, 15min}$***	***$dBL_{Aeq, 15min}$***	***dBL_{Amax}***
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.

In the absence of applicable noise limits, a conservative assessment has been conducted against criteria 10 dB lower than non-event operational noise limits in Condition E2. This is considered to demonstrate a negligible impact due to the Stadium Fitness Facilities.

Non-event operational noise limits listed Condition E2 are presented in Table 13.

Table 13: 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}**
SFS – 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
Stadium Fitness Facilities – Mod 2[3]					
1	R1, R2 and R3	48	46	45	60
2	R4 and R5	48	43	41	56
3	R6	47	44	42	54
4	R7, R8 and R9	38	36	33	46
5	R10	34	31	28	40
6	R11	42	35	28	50

Notes:

1. Identified in Table 2.
2. Reproduced from Condition E2 of SSD 9835 – applicable to plant and vehicle noise
3. 10 dB lower than SFS limits to demonstrate a negligible contribution to overall impacts

7.2.2 Road Noise

Regarding the increase in road traffic noise due to additional vehicles using the Stadium Fitness Facilities, the Road Noise Policy [11] 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.*

7.3 Noise assessment

7.3.1 Patron noise from pool and outdoor areas

An assessment of noise emissions generated by patron use of outdoor areas and the pool has been conducted, as well as amplified music which may be played over a speaker system.

Typical daily operations of the Stadium Fitness Facilities would include such activities as;

- Gymnasium and pool use by members
- Patrons talking and eating at the café

The noisiest periods of operation would be during functions held in the Stadium Fitness Facilities, which may occur on event days or non-event days. These may include member functions such as Christmas Party, member club gatherings, corporate partner functions, sports partner functions, high-teas, lunches, networking functions and BBQs.

Noise emissions from internal activities are anticipated to be insignificant due to noise reduction through building envelope, therefore have not been assessed.

Noise levels from patrons in the outdoor café, rooftop and pool area have been predicted using a formula established in Hayne et al. [12], being:

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

The formula assumes that people are not adversely affected by alcohol, and have a random orientation. Spectra have been based on Cushing et al. [13] using an energy average of the male and female raised voice spectrum presented in Table 14. This also assumes one-third of the patrons are talking at any one time. Music noise spectrum is based on the Arup measurement database.

Table 14: Contribution sound power level spectra.

Description	**dB(A)**	**Octave band sound power level, dB**							
		63	**125**	**250**	**500**	**1 k**	**2 k**	**4 k**	**8 k**
Vocal spectrum of 200 patrons (raised voices)	99	81	86	94	97	94	90	84	77
Speaker system playing music at 79dBA at 5 metres	101	95	100	97	99	97	92	86	78

Sound power level spectra in Table 14 have been adjusted to the calculated sound power levels listed in Table 15.

Table 15: Modelled noise levels

Description	**Outdoor location**			
	Café	**Rooftop terrace**	**Pool and pool deck**	**TOTAL**
Music level at 5m from speaker[1]	81 dBA	79 dBA	-	**83 dBA**

Description	Outdoor location			
	Café	Rooftop terrace	Pool and pool deck	TOTAL
Number of patrons	284 people	200 people	104 people	**588 people**
Combined sound power level[2]	104 dBA	103 dBA	94 dBA	**107 dBA**

Note:

1. Music noise levels are adjusted to appropriate level for crowd size based on Rindell [14].
2. Combined music and patron sound power levels applied as an area source across each space.

Predicted noise levels at surrounding receivers are presented in Table 16.

Table 16: Predicted operational noise levels, $dBL_{Aeq\ (15\ min)}$

Receiver	Function	
	Noise limit[1]	Highest predicted noise level
R1 - 749 South Dowling Street, Redfern	45	31
R2 - 635 South Dowling Street, Surry Hills	45	35
R3 - 553 South Dowling Street, Surry Hills	45	36
R4 - 111 Greens Rd, Paddington	41	40
R5 - 479 South Dowling Street, Surry Hills	41	35
R6 - 252 Moore Park Road, Paddington	42	22
R7 - 314 Moore Park Road, Paddington	33	19
R8 - 45 Oatley Road. Paddington	33	23
R9 - 5 Poate Road, Paddington	33	21
R10 - 107 Cook Road, Centennial Park	28	16
R11 - 2 Martin Road, Moore Park	28	28

Notes:

1. Functions have been assessed to the most stringent night-time limits. Compliance with these limits demonstrate compliance at all periods of the day.

Results show predicted worst case noise levels due to the operation of the Stadium Fitness Facilities comply with the event and non-event Stadium Fitness Facilities noise limits, established as 10 dB below noise limits for the main stadium. This demonstrates noise impacts due to the Stadium Fitness Facilities operation are predicted to be insignificant.

7.3.2 Operational traffic noise

The additional traffic movements generated by members attending the Stadium Fitness Facilities in future years have been provided by JMT Consultants. Additional traffic movements would be as follows:

- Weekday AM peak hour – 43 traffic movements
- Weekday PM peak hour – 36 traffic movements

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

Due to the high traffic volumes travelling along Moore Park Road and Anzac Parade, the increase in traffic noise levels due to the 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.

7.3.3 Conditions of Consent

In approving SSD 9835, the Minister for Planning and Public Spaces imposed a number of conditions to mitigate noise and vibration impacts during the construction and operational phases of the SFS. These conditions remain valid in their entirety to the proposed Stadium Fitness Facilities. Should the Stadium Fitness Facilities modification be approved, the various management plans required to be prepared under the existing consent and associated implementation and monitoring measures should be integrated to apply to the Stadium Fitness Facilities.

The CNVMP [4] that has been prepared to facilitate commencement of construction will need to be updated to accommodate the Stadium Fitness Facilities. A suitably worded condition of consent can reinforce this requirement.

Relevant operational conditions in Sections A, D and E of SSD 9835 [3] will also apply to the Stadium Fitness Facilities where applicable. It is not anticipated that these conditions require modification as they refer to the 'development' as defined by the consent. Under this proposed modification, development will include the main Stadium and the Stadium Fitness Facilities.

8 Conclusion

Based on the assessments detailed above, it is concluded that the reinstatement of the Stadium Fitness Facilities will not generate any significant additional construction or operational noise impacts on the nearby noise sensitive receivers or the environment around the SFS Site.

Cumulative construction and operational noise emissions 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 SFS and the Stadium Fitness Facilities has been conducted. Increases in noise levels due to the

contribution of works associated with the Stadium Fitness Facilities are predicted to be marginal (up to 1 dB), and no noticeable additional disturbances to the community are anticipated.

No additional adverse vibration impacts are anticipated due to the construction of the Stadium Fitness Facilities.

Requirements outlined in the CNVMP [4] will be adhered to during Stadium Fitness Facilities construction works.

8.2 Operational noise excluding events

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

- Patron noise and music from pool, rooftop terrace and outdoor café seating areas
- Operational traffic generated by the Stadium Fitness Facilities

Operational noise emissions from Stadium Fitness Facilities are predicted to generate insignificant contributions to noise emissions from the approved SFS. No significant adverse acoustic impacts are anticipated. This demonstrates compliance with the approved operational conditions in SSD 9835 [3], and therefore compliance with the existing Notice of Prevention Preventative Action [10]. It follows that noise from the Stadium Fitness Facilities is not predicted to generate additional adverse noise impacts to overall Precinct noise emissions. On this basis, a Precinct Noise Plan is not required as there are already several statutory mechanisms in place to mitigate and monitor noise from the precinct for the full range of activities proposed.

It is not anticipated that these operational conditions in SSD 9835 [3] require modification as they refer to the ‘development’ which, under this proposed modification, will include the main Stadium and the Stadium Fitness Facilities.

9 References

[1] NSW Environment Protection Authority, "NSW Noise Policy for Industry," NSW Environment Protection Authority , Sydney, 2017.

[2] Arup, "2018-06-05 - AC01-v5_SFSR_Noise and Vibration Impact Assessment," Arup, Sydney, 2018.

[3] 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.

[4] Arup, "AC09-v7 SFSR Stage 2 CNVMSP, Issue 5," Arup, Sydney, 2020.

[5] Arup, "AC04-v5_SFSR Stage 2 NVIA," Arup, Sydney, 2019.

[6] German Institute for Standardisation, "DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure'," German Institute for Standardisation, 1999.

[7] Department of Environment and Conservation (NSW), "Assessing Vibration: A technical guideline," Department of Environment and Conservation (NSW), Sydney, 2006.

[8] British Standards, "BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting," British Standards, 2008.

[9] Infrastructure NSW, "Methodology Statement - Working Near Busby's Bore," Infrastructure NSW, Sydney, 2018.

[10] Environment Protection Authority, "Notice of Preventative Action 1003904," Environment Protection Authority, Sydney, 2017.

[11] Department of Environment, Climate Change and Water NSW, "NSW Road Noise Policy," NSW Environmental Protection Authority, Sydney, 2011.

[12] M. Hayne, J. Taylor, R. Rumble and D. Mee, "Prediction of Noise from Small to Medium Sized Crowds," in *Acoustics 2011*, Gold Coast, 2011.

[13] I. R. Cushing, F. F. Li, T. J. Cox, K. Worral and T. Jackson, "Vocal effort levels in anechoic conditions," *Applied Acoustics*, vol. 72, pp. 695-701, 2011.

[14] H. Rindel, "Acoustical capacity as a means of noise control in eating establisments," in *Joint Baltic-Nordic Acoustics Meeting*, Lyngby, 2012.

[15] British Standards, "BS 7385-1:1990 - Evaluation and measurement for vibration in buildings. Guide for measurement of vibrations and evaluation of their effects on buildings," British Standards, 1990.

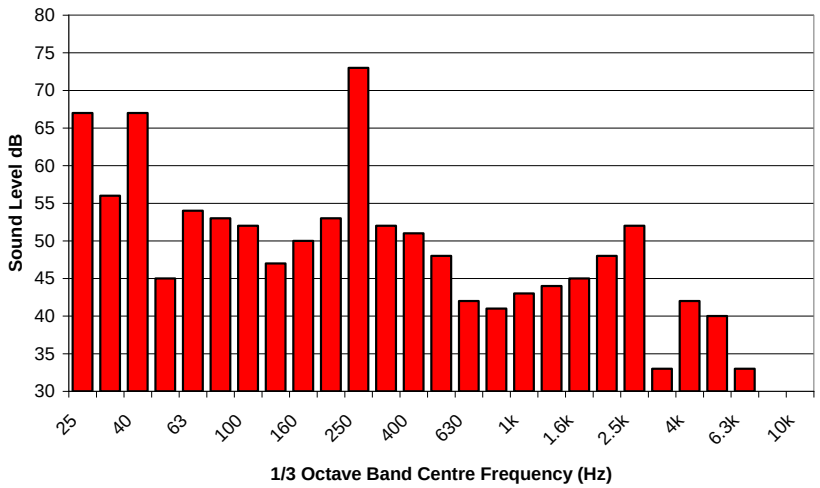
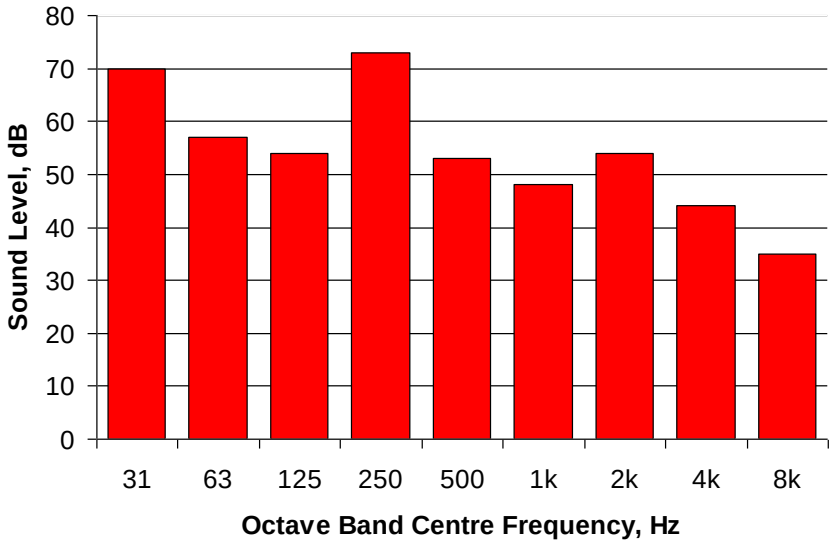
Appendix A

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	The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects. **Assessment Background Level (ABL)** A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background LA90 noise levels – i.e. the measured background noise is above the ABL 90% of the time. **Rating Background Level (RBL / min $L_{A90,1hour}$)** A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and min $L_{A90,1hour}$ in QLD.
Decibel	The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore, a logarithmic scale, the decibel (dB) scale, is used to describe sound levels. An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.
dBA	dBA denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level. The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dBA.

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td></td><td>Some typical dBA levels are shown below.
<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></td></tr>
<tr><td>L_1</td><td>The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.
Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dBA or higher for 1% of the 15 minute measurement period.</td></tr>
<tr><td>L_{10}</td><td>The L_{10} statistical level is often used as the “average maximum” level of a sound level that varies with time.
Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dBA or higher for 10% of the 18 hour measurement period.</td></tr>
<tr><td>L_{90}</td><td>The L_{90} statistical level is often used as the “average minimum” or “background” level of a sound level that varies with time.
Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dBA or higher for 90% of the 15 minute measurement period.</td></tr>
<tr><td>L_{eq}</td><td>The ‘equivalent continuous sound level’, Leq, is used to describe the level of a time-varying sound or vibration measurement.
Leq 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.</td></tr>
</table>

Term	Definition
L_{max}	The Lmax statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time. Mathematically, Lmax is the highest value recorded during the measurement period. As an example, 94 dB LAmax is a highest value of 94 dBA during the measurement period. Since Lmax is often caused by an instantaneous event, Lmax levels often vary significantly between measurements.
Frequency	Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".  
Peak Particle Velocity (PPV)	Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure root mean squared (RMS) values; it is common to approximate the PPV based on an RMS measurement. PPV is commonly used as a vibration criterion, and is often interpreted as a PPV based on the Lmax or Lmax,spec index.

Term	Definition
Sound Power and Sound Pressure	The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.
Vibration	Waves in a solid material are called "vibration", as opposed to similar waves in air, which are called "sound" or "noise". If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage. A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space. Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Methodology Statement - Working near Busby's Bore

B1

Insert Methodology Statement pdf