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SYDNEY FLIGHT TRAINING CENTRE, 28-30 BURROWS ROAD, ST PETERS

Noise & Vibration Impact Assessment

27 September 2022

LOGOS Development Management Pty Ltd

TM727-01F01 28-30 Burrows Rd NVIA (r2).docx

35 1982-2017 ACOUSTIC ENGINEERING EXCELLENCE

Sydney Melbourne Brisbane Gold Coast Kuwait Singapore
Renzo Tonin & Associates ABN 29 117 462 861
Level 1/418A Elizabeth St SURRY HILLS NSW 2010 | PO Box 877 STRAWBERRY HILLS NSW 2012
P (02) 8218 0500 F (02) 8218 0501 sydney@renzotonin.com.au www.renzotonin.com.au

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1 Introduction

1.1 Overview and purpose of report

Renzo Tonin & Associates (RT&A) has been engaged by LOGOS Development Management Pty Ltd (Logos) to prepare this report to undertake an operational and construction noise and vibration impact assessment (NVIA) in accordance with the technical requirements of the Secretary's Environmental Assessment Requirements (SEARs), and in support of the State Significant Development Application (SSD 47601708) for the proposed Sydney Flight Training Centre at 28-30 Burrows Road, St Peters.

The noise and vibration assessment has been carried out in accordance with the policies, guidelines and standards presented in Section 3 of this report addressing construction noise and vibration and operational noise, respectively.

1.2 Secretary's environmental assessment requirements

The Department of Planning and Environment (DPE) issued Secretary's environmental assessment requirements (SEARs) relating to the project on 12 September 2022.

These requirements are addressed in this report, as outlined in Table 1-1.

Table 1-1: Secretary's environmental assessment requirements – Noise and vibration

Secretary's environmental assessment requirements	Where addressed
Noise and vibration	
A noise and vibration impact assessment undertaken by a suitably qualified acoustic consultant in accordance with the relevant Environment Protection Authority guidelines and Australian Standards which includes: • a description of all potential noise and vibration sources during the construction and operational phases of the development, including proposed management and mitigation measures to adequately manage identified noise impacts.	Section 1.5 - Nearby noise and vibration sensitive receivers Section 3 – Details of relevant EPA guidelines and objectives Section 4 – Construction Section 3.4 – Operational Road traffic Section 5 – Operational – Site noise emissions and sleep disturbance
Infrastructure requirements	
• identification of any existing infrastructure or future easements on or off the site which may be impacted or created by construction or operation of the development, including, any new easements to be created or existing Sydney Water and Council stormwater easements. Details such as measures to be implemented to address any impacts to the infrastructure or easements is to be included • endorsement and/or approval from Sydney Water to ensure the proposed development does not adversely impact on Alexandra Canal. It is recommended that a feasibility or out of scope building application is lodged directly with Sydney Water as soon as possible.	Section 3.2 – Construction vibration objectives Section 4.4 – Construction vibration assessment and management measures

1.3 Project overview

1.3.1 Location

The site is located at 28-30 Burrows Road, St Peters and comprises land known as Lot 2 of DP 212652 and Lot 15 of DP 32332. The Project location is shown in Figure 1 below.

The site is surrounded by a variety of uses, including:

- North: The site has a direct road frontage to Burrows Road, close to the intersection with Campbell Road. Directly opposite the site to the north is the Westconnex Transurban MCC Main Office which comprises car parking facilities for motorists at the St Peters interchange. Sydney Park is further north on the opposite side of Campbell Parade. The nearest residences are located approximately 250 metres to the north of the Project on Campbell Road.
- East: The immediately adjoining site to the east comprises industrial development. Campbell Road and Campbell Road Bridge are further east, with additional industrial land uses on the opposite side of Alexandra Canal, including Alexandria and Rosebery. Campbell Road connects the site to the broader Westconnex road network.
- South: The site is bound to the south by Alexandra Canal, a State Significant Heritage Item. Additional industrial land uses are located across the canal to the south, primarily comprising warehouse and distribution centres. Gardeners Road and Bourke Street provide access to Mascot and Eastlakes. Sydney Kingsford Smith Airport (the Airport) is further south.
- West: The immediately adjoining land comprises industrial development. The St Peters WestConnex Interchange is located to the north-west, with the Princes Highway beyond. Further west is low density residential and industrial land uses in the suburb of Sydenham. Sydenham Train Station is approximately 1.5km west of the site, providing services to the Sydney CBD.

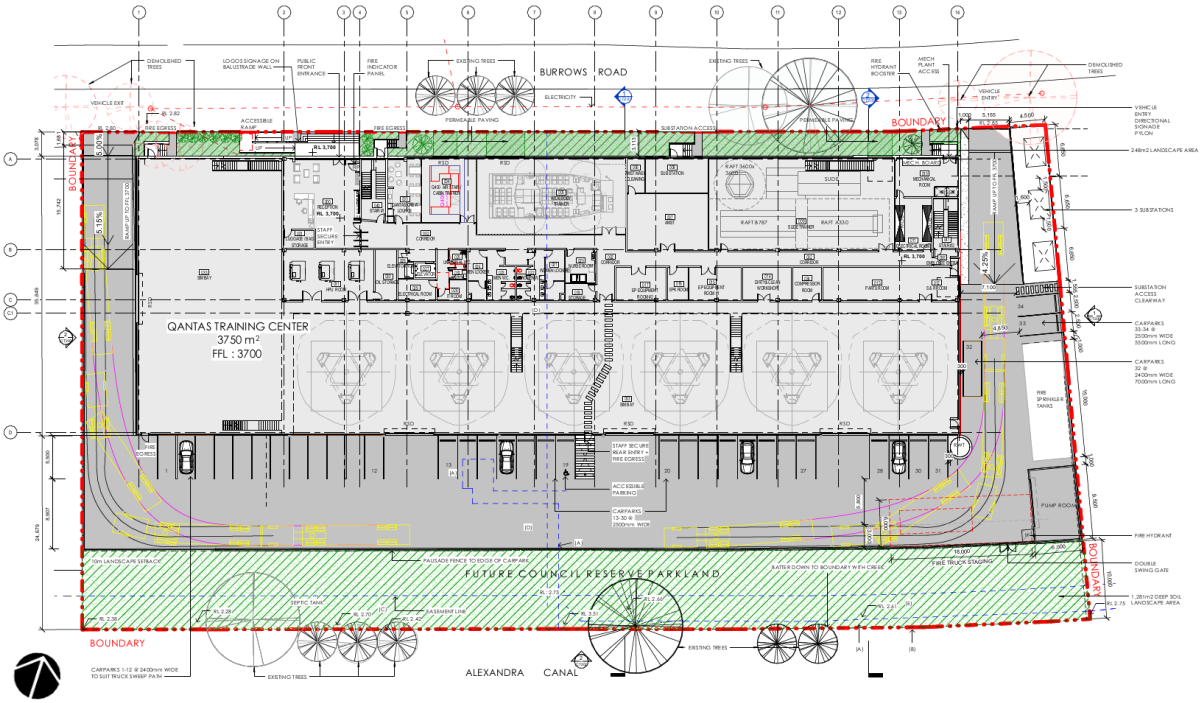
1.3.2 Site key features

The key features of the Project site are as follows:

- The site is approximately 7,961sqm and is rectangular in shape. The primary frontage to Burrows Road is approximately 123 metres in length and the site maintains a depth of approximately 63.5 metres.
- The site is currently occupied by two industrial / warehouse buildings with a large hardstand area for vehicle parking and deliveries. Alexandra Canal runs along the southern boundary of the site. A Site Survey Plan accompanies the application which details the topographic characteristics of the site.
- Limited vegetation is located along both the road frontage and the canal. The proposed development is to include a setback of 10 metre along the southern boundary to align with the City of Sydney's vision for a pedestrian and cycling network along the water's edge.
- Vehicular access to the site from the local road network is available from Burrows Road which links the site to the WestConnex road network in the north and Sydney Airport to the west.
- Industrial land uses extend along Burrows Road and Euston Road. St Peters railway station is approximately 1.5km from the site. The nearest residential neighbours south of the site are about 300 metres away and are separated by industrial warehouse buildings and the Alexandra Canal.
- The site is located within the City of Sydney LGA.

The layout of the Project is shown in Figure 1.

Figure 1: Project layout



1.3.3 Project operations

The proposed flight training facility will enable pilots and flight crews from Qantas and other airlines to undertake periodic training and testing to meet regulatory requirements by simulating both aircraft and emergency procedural environments. The flight training centre will be situated within a three-storey industrial warehouse and will include:

- Flight simulator hall:
  - 8 x simulator bays. State of the art full motion flight simulators with visual fidelity, motion and sound. This allows crew to be trained in all aspects of normal and non-normal operations, including instrument approaches and landings in all weather conditions.
  - The proposed simulators will complement the flight training facilities in other states.
- Emergency procedures component including:
  - Cabin evacuation emergency trainer. Full-scale cabin mock-up is used as practical training device. These facilities allow emergency situations to be accurately portrayed and allow pilots and cabin crew to handle emergency situations in both wide and narrow-bodied aircraft.
  - Slide descent tower. Enables realistic training of deployment and use of slides to evacuate aircraft for pilots and cabin crew.
  - Door trainers. Enables realistic training of use of emergency exits to evacuate aircraft for pilots and cabin crew.
- Ancillary spaces (administration and training areas) including:
  - Equipment room. Storage of emergency equipment (oxygen tanks, defibrillators etc.) that supports the training and assessment of cabin crew and pilots of aviation medicine.
  - Pilots lounge. Area for pilots to wait prior to simulator sessions
  - Meeting rooms and lunch room.
  - Reception area.
  - Toilets, plant, loading dock.

1.3.4 Project hours

The Project hours of operation is to be 24 hours, 7 days per week.

1.4 Assessment objectives

The assessment objectives are to determine the potential levels of noise and vibration at sensitive receivers located near the Project and determine the levels of mitigation that would be required to enable compliance with the current NSW requirements.

As part of preparing this assessment, the following policies, guidelines and standards have been considered:

- NSW *Approved methods for measurement and analysis of environmental noise in NSW* (NSW Approved Methods) (EPA, 2022)
- Australian Standard AS 1055:2018 *Acoustics—Description and measurement of environmental noise*
- NSW *Noise Policy for Industry* (NPfI) (EPA 2017)
- NSW *Road Noise Policy* (RNP) (DECCW 2011)
- NSW *Interim Construction Noise Guideline* (ICNG) (DECC 2009)
- NSW *Assessing Vibration – A Technical Guideline* (AVTG) (DEC 2006)
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA 1999)
- NSW *Noise Guide for Local Government* (NGLG) (EPA 2013).

In undertaking the assessments, attended and unattended noise monitoring was conducted to measure noise from the existing acoustic environment and potential noise sources.

1.5 Acoustic terms & quality

This report is technical in nature and uses acoustic terminology throughout. A summary and explanation of the common acoustic terms that have been used in this report is presented in APPENDIX A Section A.1. Some of the key acoustic concepts used in this report are outlined in APPENDIX A Section A.3.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

1.6 Nearby noise and vibration sensitive receivers

1.6.1 Site and surrounding land use

The Project site is located at 28-30 Burrows Road, St Peters in the City of Sydney LGA.

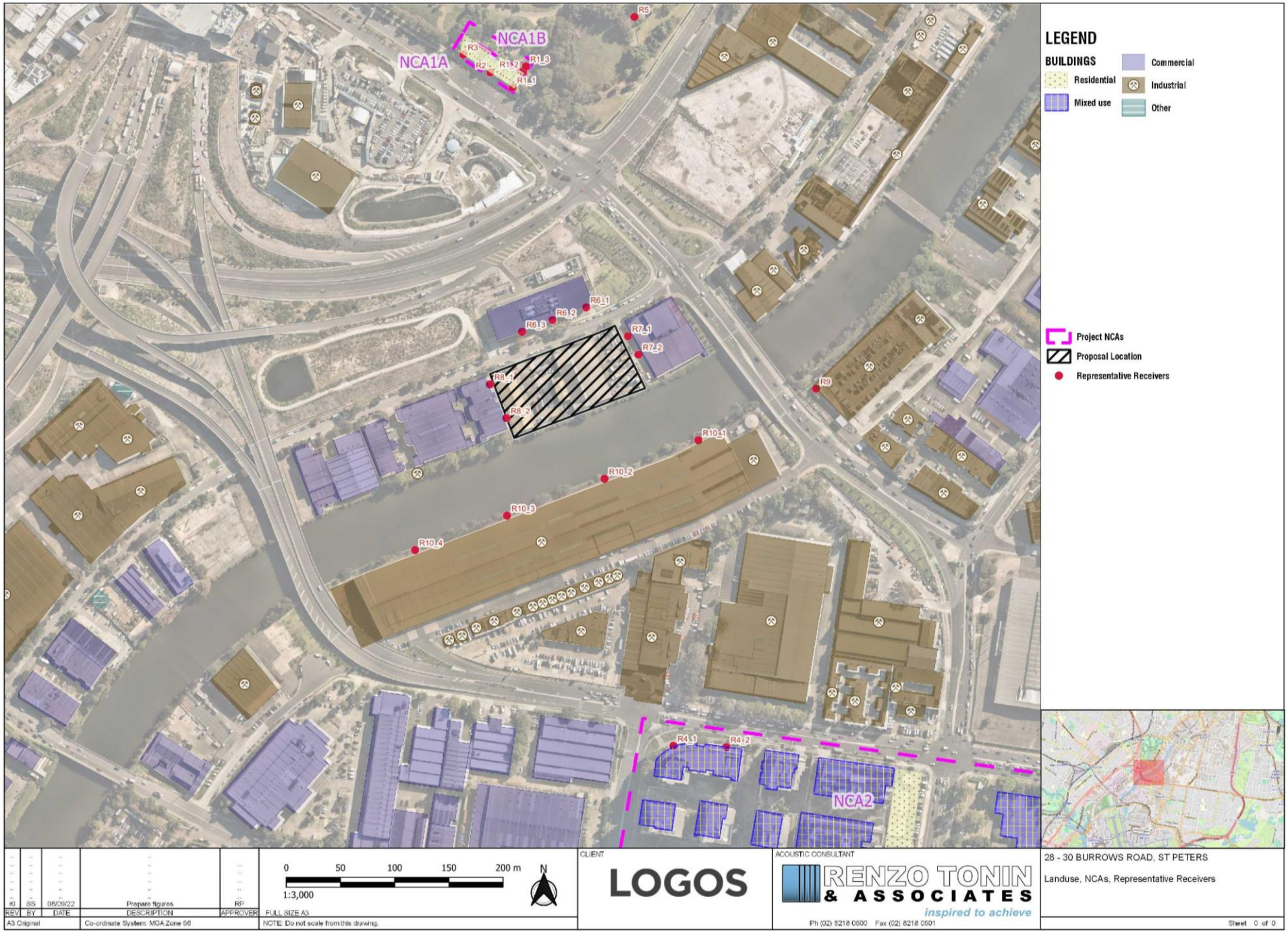
There are commercial receivers adjacent to the eastern and western boundaries of the site on Burrows Road. Directly opposite the site to the north is the WestConnex Transurban MCC Main Office.

The nearest residential receivers to the site are approximately 250 metres to the north on Campbell Road. There are residences located approximately 320 metres to the south-east in multistorey residential apartment complexes in Mascot, with the nearest residences on the corner of Gardeners Road and Kent Road.

Along the southern boundary of the Project site is the Alexandra Canal, a listed heritage item.

The nearby noise sensitive receivers are presented in Figure 2. The extent of receiver buildings that have been included in the assessment modelling for the NPfI assessment is presented in Figure 2. Given the large number of nearby receivers, a set of representative receiver locations have been selected and are presented in Figure 2 and described in detailed in Section 1.6.3.

Figure 2: Site location, nearby noise sensitive receivers, land uses and NCAs



1.6.2 Noise catchment areas

As the existing acoustic environment varies at the nearby residential receivers, these residential receivers have been grouped into Noise Catchment Areas (NCAs) based upon areas with similar acoustic environments. This has been done to logically group the receivers to assist with the assessment and allocate the appropriate project noise trigger levels or management levels to each receiver. The locations of these noise catchment area boundaries are also shown in Figure 2. NCA1 has been subdivided into NCA1A and NCA1B for residences on Campbell Road as the acoustic environment changes between the front the rear of these properties, where is NCA1A fronts Campbell Road and NCA1B is the rear yard area.

1.6.3 Representative receivers

Noise levels have been modelled to all nearby and potentially impacted noise sensitive receiver locations, however for the purpose of simplifying the tabling of results in this report, the results from 10 identified representative receivers at a total of 20 assessment locations have been included. The locations of the representative receiver locations are presented in Table 1-2 below.

Table 1-2: Representative receiver locations

Residential noise catchment area (NCA)	Receiver ID	Address	Location	Receiver type	Approximate distance to the Project, metres
NCA1A	R1_1	34 Campbell Road, Alexandria	Front facade First floor	Residential	250
NCA1B	R1_2	34 Campbell Road, Alexandria	Rear facade First floor	Residential	260
NCA1B	R1_3	34 Campbell Road, Alexandria	Rear yard	Residential	260
NCA1A	R2	20 Campbell Road, Alexandria	Front facade First floor	Residential	265
NCA1A	R3	20 Campbell Road, Alexandria	Front facade First floor	Residential	285
NCA2	R4_1	671 Gardeners Road, Mascot	North-western facade Top floor	Residential	320
NCA2	R4_2	671 Gardeners Road, Mascot	Northern facade Top floor	Residential	320
-	R5	Sydney Park	Sydney Park	Active recreation	310
-	R6_1	33 Burrows Road, St Peters	Southern facade Eastern end	Commercial	30
-	R6_2	33 Burrows Road, St Peters	Southern facade Central	Commercial	30
-	R6_3	33 Burrows Road, St Peters	Southern facade Western end	Commercial	30

Residential noise catchment area (NCA)	Receiver ID	Address	Location	Receiver type	Approximate distance to the Project, metres
-	R7_1	32 Burrows Road, St Peters	Western facade Northern end	Commercial	10
-	R7_2	32 Burrows Road, St Peters	Western facade Central	Commercial	10
-	R8_1	24-26 Burrows Road, St Peters	Eastern facade Northern end	Commercial	5
-	R8_2	24-26 Burrows Road, St Peters	Eastern facade Central	Commercial	5
-	R9	67 Bourke Road, Alexandria	Western facade Northern end	Industrial	180
-	R10_1	697 Gardeners Road, Alexandria	Northern facade Eastern end	Industrial	75
-	R10_2	697 Gardeners Road, Alexandria	Northern facade Central - east	Industrial	75
-	R10_3	697 Gardeners Road, Alexandria	Northern facade Central – west	Industrial	75
-	R10_4	697 Gardeners Road, Alexandria	Northern facade Western end	Industrial	75

2 Existing noise environment and noise monitoring

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

As the noise environment of an area almost always varies over time, background and ambient noise levels need to be determined for the operational times of the proposed development. Background noise varies over the course of any 24-hour period, typically from a minimum at 3:00am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NSW Environment Protection Authority (EPA) *Noise Policy for Industry* (NPfI) (EPA 2017) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. Fact Sheet B of the NPfI outlines the methods for determining the background noise level of an area.

The typical time periods in accordance with the NPfI are as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Sunday & Public Holidays.

Shoulder periods

Fact Sheet B of the NPfI outlines the methods for determining the background noise level of an area. The NPfI also outlines methods for assessing 'shoulder periods' being shorter periods on either side of a standard period, where the standard period noise levels are not well represented. For example, a 'shoulder period' may be warranted for 5:00am-7:00am or 10:00pm-12:00am during which the night-time period background noise level is not well represented. Fact Sheet A, Section A3 of the NPfI outlines suitable methods to determine the shoulder period background noise level.

Because the nearby arterial roads (Campbell Road and Euston Road for NCA01 and Gardeners Road and Bourke Road for NCA02) dominate the ambient noise environment at nearby residential receivers, and these roads have steadily rising traffic noise levels during the early morning period, it is appropriate to establish a morning shoulder period in accordance with NPfI Section A3.

Accordingly, the time periods established for the assessment in accordance with the NPfI are as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 5:00am, Monday to Sunday & Public Holidays.

- **Morning shoulder** is defined as 5:00am to 7:00am, Monday to Saturday and 5:00am to 8:00am Sundays & Public Holidays.

2.1 Environmental noise monitoring

Noise measurements have been carried out at both the nearest and potentially most affected locations surrounding the Project. This has included residential receiver locations on Campbell Road, in addition to receivers located on the multi-storey apartment complexes on Gardeners Road.

These monitoring locations were adopted to determine the variation in background and ambient noise level at all potentially impacted nearby receivers.

2.1.1 Existing noise environment - unattended noise monitoring

Fact Sheet B of the NSW EPA NPfI outlines two methods for determining the background noise level of an area, being 'B1 – Determining background noise using long-term noise measurements' and 'B2 – Determining background noise using short-term noise measurements'. This assessment has used long-term noise monitoring to determine background noise levels, supported by short-term noise measurements.

To quantify the existing noise environment, data from unattended long-term noise monitoring that was carried out at four locations has been adopted. This monitoring was undertaken for continuous periods measuring the ambient and background noise levels. For NCA1 (Location L1 to L3), noise monitoring was conducted at three locations in June 2022. For NCA2 (Location L4), noise monitoring was conducted at one location in November and December 2021. The noise monitoring for NCA2 was conducted as part of SSD-32489140 (520 Gardeners Road, Alexandria) and is presented in the NVIA for that project [ref: Renzo Tonin & Associates, TM455-01F01 520 Gardeners Road NVIA (r7)] on the NSW Planning Portal. The noise monitoring data used for NCA2 was selected to represent the most conservative assessment point potentially impacted by the Project on the residential towers along Gardeners Road, Alexandria.

Long-term noise monitoring was conducted using the instrumentation presented in Table 2-1. The noise level-vs-time graphs of the data are included in APPENDIX B. Long-term noise monitoring was conducted in general accordance with Fact Sheet B of the NSW EPA NPfI.

The equipment used for noise measurements were NTi Audio Type XL2 precision sound level analysers which are a Class 1 instruments having accuracy suitable for field and laboratory use. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

Table 2-1: Unattended noise monitoring equipment

Reference location	Address	Location	Logger reference	Monitoring period
L1	34 Campbell Road, Alexandria	Front yard	RTA06-007	15/06/2022 – 28/06/2022
L2	34 Campbell Road, Alexandria	Rear yard (3.5m high)	RTA06-003	15/06/2022 – 28/06/2022
L3	34 Campbell Road, Alexandria	Rear yard (1.5m high)	RTA06-004	15/06/2022 – 28/06/2022
L4	659 Gardeners Road, Mascot	Level 12, roof terrace, north facade	RTA06-002	19/11/2021 – 12/12/2021

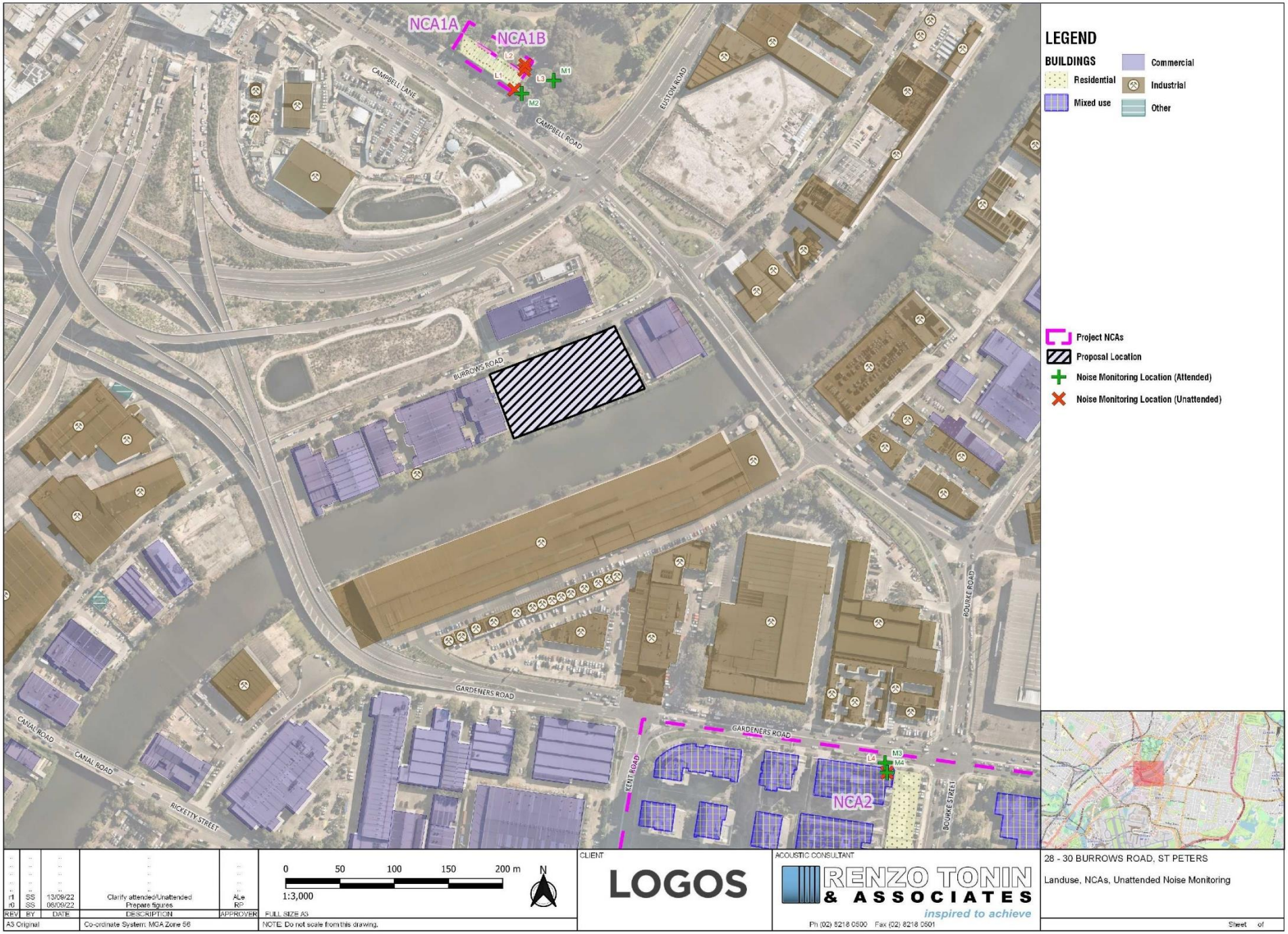
The equipment calibration was field checked as per NSW Approved Methods prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator, with no significant calibration drift observed. Noise monitoring locations L2 to L4 were undertaken in the free field, and representative of the ambient noise environment for the associated residential receivers. For noise monitoring location L1, free field monitoring was not possible given the site constraints of the front yard area at 34 Campbell Road, Alexandria. A correction for the measured ambient noise levels to account for facade reflections is detailed in Section 2.1.2.

The unattended noise monitoring locations and observed noise environment are summarised in the Table 2-2 below. The locations of the unattended long-term noise monitoring are presented in Figure 3.

Table 2-2: Unattended noise monitoring locations

Reference location	Address and location description	Observed noise environment
L1/L2/L3	34 Campbell Road, Alexandria Three locations on the property were monitored, because the acoustic environment changes between the front the rear of this property. As noise emissions from the site could impact both the front and rear of the yard, multiple locations were monitored to ensure that the assessment was at the potentially reasonably most affected receiver location, as per NPfI Section 2.6 and Fact Sheet B1. L1: Front yard L2: Rear yard (3.5m high) (above the rear yard fence) L3: Rear yard (1.5m high)	The ambient noise level was contributed to by road traffic on Campbell Road, distant traffic movements along Euston Road and aircraft noise. Background noise controlled by natural sources (birds etc.) and distant traffic noise from Euston Road.
L4	659 Gardeners Road, Mascot Representative of upper floor apartments adjacent to Gardeners Road. Location was selected as being elevated it has line of sight to the Project location, and represents the residential towers along Gardeners Road, Alexandria potentially impacted by the Project. Noise logger was located adjacent to the northern glass balustrade on the roof podium. Microphone was located 2.3 metres above ground level, elevated 0.6 metre above the glass parapet to measure in the free field and have line of sight to Gardeners Road.	Day: Controlled by constant road traffic on Gardeners Road and Bourke Road. Occasional aircraft fly over, and distant aircraft noise. Night: Controlled by intermittent road traffic on Gardeners Road, Bourke Road and Campbell Road with contributions from nearby industrial activities and mechanical plant.

Figure 3: Noise monitoring locations



The monitored existing ambient and background noise levels measured are presented Table 2-3 below. A summary of the unattended noise monitoring results along with a graphical recorded output from the long-term noise monitoring is included in APPENDIX B. The graphs in APPENDIX B were analysed to determine an assessment background level (ABL) for each day, evening and night period in each 24-hour period of noise monitoring. Based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NPfI. The RBL values for the morning shoulder period (5:00am to 7:00am) were established in accordance with Fact Sheet A, Section A3 of the NPfI.

Noise measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NPfI. Determination of extraneous meteorological conditions was based on data provided by the nearest Bureau of Meteorology (BOM) station, which was the Sydney Airport AMO weather station (Station 066037) approximately 3.5 km from the Project site. This is considered representative of the noise monitoring locations in accordance with the NPfI. The long-term noise monitoring data was reviewed and all extraneous noise events (eg nearby local noise events and extraneous meteorological conditions) that were identified as not a usual feature of the area, were excluded as shown by the 'greyed' out areas of the graphs presented in APPENDIX B of this report.

For NCA1B, the monitoring data at from L3 (1.5m above ground) was adopted as a conservative approach for this NCA for all assessments.

Table 2-3: Measured existing background and ambient noise levels, dB(A)

Ref	Address	Location description	Rating background noise levels (RBL), $L_{A90,\ 15\ minute}$				Ambient noise levels[5], $L_{Aeq,\ 15\ minute}$			
			Day[1]	Eve[2]	Night[3]	Shoulder[4,6]	Day[1]	Eve[2]	Night[3]	Shoulder[4]
L1	34 Campbell Road, Alexandria	Front yard	59	57	50	53	67[7]	65[7]	62[7]	66[7]
L2	34 Campbell Road, Alexandria	Rear yard (3.5m high)	53	52	46	49	62	60	57	60
L3	34 Campbell Road, Alexandria	Rear yard (1.5m high)	49	47	41	45	58	56	52	56
L4	659 Gardeners Road, Mascot	Level 12, roof terrace, north facade	56	51	47	49	63	60	56	59

Notes:
1. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
2. Evening: 6.00pm to 10.00pm Monday to Sunday & Public Holidays
3. Night: 10.00pm to 5.00am Monday to Sunday & Public Holidays
4. Morning shoulder: 5.00am to 7.00am Monday to Saturday and 5.00am to 8.00am Sundays & Public Holidays
5. As required by the NPfI, the external ambient noise levels presented are free-field noise levels. [ie. no facade reflection]
6. Shoulder period RBL levels determined as per NPfI Fact Sheet A3
7. Free field correction applied as detailed in Section 2.1.2

2.1.2 Existing noise environment - attended noise monitoring

Additionally, attended short-term noise monitoring was undertaken to confirm and characterise the existing ambient noise environment at the receiver locations. The locations of the attended noise monitoring are presented in Figure 3.

Attended short-term noise measurements were undertaken nearby the potentially affected receivers and the unattended noise monitoring locations (where accessible at the time) in order to supplement the long-term noise monitoring and provide greater detail about the noise sources that make up the existing noise environment. A summary of the attended noise measurement results is presented in Table 2-4 below.

The equipment used for attended noise measurements included a NTi Audio Type XL2 precision sound level analysers, which are Class 1 instruments having accuracy suitable for field and laboratory use. The instruments were field checked as per NSW Approved Methods for calibration prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

As noted in Section 2.1.1 above, a free field correction to account for reflections from nearby surfaces (building facade, awning etc.) has been applied to the long term noise monitor installed at the front yard area of 34 Campbell Road, Alexandria when quantifying the L_{Aeq} noise level. The correction was obtained by conducting a short term attended fifteen minute measurement at location M2 in the free field near Harber Street. The short term measurement was in line with the long term noise monitor, at the same setback distance from Campbell Road. The measured L_{Aeq} noise level at the short term attended location was compared with the corresponding L_{Aeq} noise level measured during the same period at the long term unattended noise monitor. This resulted in a correction of -2.8dB which has been applied to the ambient and traffic noise levels for the long term unattended monitor (L1) location at the front of 34 Campbell Road logger for all time periods. As per AS 1055:2018, no correction is applied to the monitored L_{A90} noise levels.

Table 2-4: Short-term attended noise monitoring results

ID	Location / Time	Measured noise level, dB(A)						Comments on measured noise levels
		L_{Amax}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	L_{Amin}	
M1	Sydney Park (in line with logger RTA06-003 in the backyard of 34 Campbell Road) 4:23pm – 4:38pm 15 June 2022	73	71	65	61	58	53	The background L_{A90} was controlled by natural noise sources (i.e. birds) and distant traffic noise from Euston Road to the West (~ 56-58 dB(A)). The ambient L_{Aeq} noise level was contributed to by road traffic on Campbell Road, distant traffic movements along Euston Road and aircraft noise (~ 58-62 dB(A)). Road traffic noise – intermittent traffic on Campbell Road was the main source with a mix of light and heavy vehicles. High noise events were from loud vehicle passbys along Campbell Road (~ 68-70 dB(A)).
M2	Harber Street (in line with logger RTA06-007 on the front landing of 34 Campbell Road) 4:45pm – 5:01pm 15 June 2022	80	75	71	67	61	55	The background L_{A90} was controlled by natural noise sources (i.e. birds) and distant traffic noise from Euston Road to the South-East (~ 56-57 dB(A)). The ambient L_{Aeq} noise level was contributed to by road traffic on Campbell Road, distant traffic movements along Euston Road and aircraft noise (~ 65-68 dB(A)). Road traffic noise – intermittent traffic on Campbell Road was the main source with a mix of light and heavy vehicles. High noise events were from loud heavy vehicle (e.g. cement agitators, double bogie trucks) passbys along Campbell Road (~ 74-75 dB(A)).
M3	659 Gardeners Road (footpath) 5:08am – 5:23am 14 December 2021	84	78	71	66	50	45	The background L_{A90} was controlled by road traffic noise from Gardeners Road and Bourke Road and Industrial activity from Gardeners Distribution Centre from 546-548 Gardeners Road ~ 47 dB(A). The ambient L_{Aeq} noise level was contributed to by road traffic on Gardeners Road and the intersection with Bourke Road including heavy vehicle braking and engine noise (~ 76 dB(A)). Road traffic noise – intermittent traffic on Gardeners Road and heavy vehicles leaving the distribution centre were the main sources with a mix of light and heavy vehicles. Heavy vehicles slowing at the Gardeners Road intersection were up to 68 dB(A). High noise events were from loud vehicle passbys along Gardeners Road.
M4	Level 12, 659 Gardeners Road 2:45am – 3:00am 14 December 2021	*Measurement saving issue. However observations and notes were made of the noise environment.*						The background L_{A90} was controlled by natural noise sources (i.e. wind gusts), distant road traffic noise from Gardeners Road and Campbell Road and Industrial activity from Gardeners Distribution Centre at 312 deg from 546-548 Gardeners Road ~ 49 dB(A). The ambient L_{Aeq} noise level was contributed to by road traffic on Gardeners Road and distant traffic movements from Campbell Road to the intersection of Gardeners Road and Bourke Road (~ 56 dB(A)). Vehicle activity from the distribution centre contributed to the ambient noise levels. Road traffic noise – intermittent traffic on Gardeners Road and the intersection of Gardeners Road and Bourke Road was the main source with a mix of light and heavy vehicles. High noise events were from loud vehicle passbys along Gardeners Road.

2.2 Measured road traffic noise levels

At each of the noise monitoring locations, road traffic noise dominated the existing noise environment. The existing traffic noise levels were monitored and the results are summarised in Table 2-5. Noise levels are described in accordance with the requirements of the *NSW Road Noise Policy* (RNP) (*Department of Climate Change and Water, 2011*).

As Campbell Road, Gardeners Road and Bourke Road are arterial/sub-arterial roads, the relevant descriptors for traffic noise are $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$, which represent the existing day and night traffic noise levels, respectively.

A +2.5 dB(A) correction has been applied to the measured road traffic noise levels to represent an equivalent road traffic noise level at one metre from a building facade, in accordance with the requirements of the RNP.

Table 2-5: Measured road traffic noise levels

Ref	Address	Location description	Measured road traffic noise level, dB(A)	
			Day $L_{Aeq,15hour}$ (7:00am to 10:00pm)	Night $L_{Aeq,9hour}$ (10:00pm to 7:00am)
L1	34 Campbell Road, Alexandria	Front yard	69[2]	65[2]
L2	34 Campbell Road, Alexandria	Rear yard (3.5m high)	64	60
L3	34 Campbell Road, Alexandria	Rear yard (1.5m high)	57	52
L4	659 Gardeners Road, Mascot	Level 12, roof terrace, north facade	64	58

Notes:
1. Noise levels presented are representative of road traffic noise level at one metre from a building facade, as per RNP.
2. Consistent with the approach presented in 2.1.2 to account for reflections from nearby surfaces (building facade, awning etc.), the noise levels have been converted to representative of road traffic noise level at one metre from a building facade, as per RNP.

3 Noise and vibration objectives

3.1 Construction noise objectives

3.1.1 Construction hours

3.1.1.1 Standard construction hours

The NSW *Interim Construction Noise Guideline* (DECCW, 2009) (ICNG) defines standard hours as detailed in Table 3-2.

Whilst the standard construction hours are not mandatory, limiting construction works to within standard construction hours as much as practicable assists in managing noise or vibration impact by limiting potentially noisy and vibration causing activities to the day time, when background noise levels are higher, and by providing respite from construction noise and vibration during the evening, overnight, and on weekends.

3.1.1.2 Works outside of standard construction hours

The ICNG identifies that there are five categories of work that typically may be required to be carried out outside of the standard construction hours:

1. The **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
2. **Emergency work** to avoid imminent injury or the loss of life or damage to property, or to prevent environmental harm
3. **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard construction hours
4. **Public infrastructure works** that shorten the length of the project and are supported by the affected community
5. Works where a proponent demonstrates and justifies **a need to operate outside the recommended standard construction hours**.

In the last two categories, the proponent should provide the relevant authority with clear justification for reasons other than convenience, such as to sustain operational integrity of road, rail and utility networks.

This report proposes some construction activities outside of standard construction hours (OOH), and as such addresses the reasons as to why these works are required to take place outside of outside of standard construction hours.

3.1.1.3 Summary of construction hours

A summary of the construction hours for the Project are detailed in Table 3-1.

Table 3-1: Construction hours

Construction hours	Monday to Friday	Saturday	Sunday/ Public holiday
Recommended standard construction hours			
Standard hours	7am to 6pm	8am to 1pm	No work
Outside recommended standard construction hours			
Out-of-Hours Work (Day)	N/A	1pm to 6pm	8am to 6pm
Out-of-Hours Work (Evening)	6pm to 10pm	6pm to 10pm	6pm to 10pm
Out-of-Hours Work (Night)	10pm to 5am	10pm to 5am	10pm to 5am
Out-of-Hours Work (Morning shoulder)	5am to 7am	5am to 8am	5am to 8am

3.1.2 Noise management levels (NMLs)

The NSW *Interim Construction Noise Guideline* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Identify and minimise noise from construction works
- Encourage construction during normal working hours only, unless approval is given for works that cannot be undertaken during these hours
- Use of 15 minute average ($L_{Aeq(15min)}$) as the descriptor for measuring and assessing construction noise.
- The establishing of "Noise Management Levels". These are noise levels which if exceeded, trigger the need to consider the application of feasible and reasonable noise mitigation. They are not intended to act as a prohibition on an activity if the trigger level is expected to be exceeded.
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods described for the assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration and involves the measurement and prediction of noise levels and assessment against set criteria. A qualitative assessment is recommended for small projects

with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification. Given the scale and duration of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

Table 3-2 reproduced from the ICNG, sets out the airborne noise management levels and how they are to be applied for residential receivers.

Table 3-2: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before/ after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see *ICNG* section 7.2.2.

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

3.1.3 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over more than two consecutive nights, maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL should be considered.

In line with the ICNG, further guidance is taken from the NSW *Road Noise Policy* (Department of Climate Change and Water, 2011) (RNP), as this document has superseded the NSW *Environmental Criteria for*

Road Traffic Noise (ECRTN) (Environment Protection Authority 1999). The potential for both sleep disturbance and awakenings should be considered in the assessment.

To assess the likelihood of sleep disturbance, an initial screening level of $L_{Amax} < L_{A90(15min)} + 15$ dB(A) is used. This is an external noise level, while receivers will be located inside when there is potential for sleep disturbance impacts. In situations, where this results in an internal screening levels of less than 45 dB(A) (internal), a minimum internal screening level of 45 dB(A) is set.

When considering awakening reactions, the RNP includes a review of internal sleep arousal research and concluded that:

- LAmax (the maximum A-weighted noise level) internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep (corresponding to approximately 60-65 dB(A) external noise level with an open window)
- One or two noise events per night, with maximum internal noise levels of 65–70 dB(A) (corresponding to approximately 75–80 dB(A) external noise level assuming an open window), are not likely to affect health and wellbeing substantially.

Typically when considering internal noise impacts using a conservative 10 dB(A) reduction from external noise levels to internal noise levels is assumed considering an open window in line with the ICNG, which is not always the case and could be greater especially in the case that the receivers have a closed windows/facade. Sealed facades or facades with windows closed can provide external to internal noise reductions much greater than 10 dB(A). Noise reductions greater than 20–25 dB(A) are achievable where facades consist of standard to thick glazing and heavy facade construction (eg. brick construction).

Where there are noise events found to exceed the initial screening level, further analysis is then made to identify:

- The likely number, nature, distribution and frequency of events above the screening level that might occur during the night assessment period
- Whether events exceed an 'awakening reaction' level of 55 dB(A) L_{Amax} (internal) (that equates to an external NML of L_{Amax} 75 dB(A), assuming closed windows).

3.1.4 Non-residential receiver construction noise management levels

Table 3-3 sets out the ICNG noise management levels for non-residential receivers.

Table 3-3: Noise management levels at other noise sensitive land uses

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 55 dB(A)
Hospital wards and operating theatres	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 55 dB(A)

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Places of worship	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 55 dB(A)
Active recreation areas	When in use	Outdoor noise level	65 dB(A)
Passive recreation areas	When in use	Outdoor noise level	60 dB(A)
Commercial premises	When in use	Outdoor noise level	70 dB(A)
Industrial premises	When in use	Outdoor noise level	75 dB(A)

Notes:

1. Outdoor noise level based on internal noise level in ICNG and assumes 10 dB loss through an open window
2. Noise management levels apply when receiver areas are in use only.

3.1.5 Summary of construction noise management levels

Table 3-4 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 2. The assessment locations and nearby sensitive receivers for the construction assessment are identified in Figure 2.

Table 3-4: Construction noise management levels

NCA	Receiver type	Noise management level $L_{Aeq(15min)}$[1]					Sleep disturbance screening level, L_{Amax}[3]	
		Day (Standard)	Day (OOHW)	Evening	Night	Shoulder	Night	Shoulder
NCA1A	Residential	69	64	62	55	58	65	68
NCA1B	Residential	59	54	52	46	50	56	60
NCA2	Residential	66	61	56	52	54	62	64
-	Commercial premises	70[2]	70[2]	70[2]	70[2]	70[2]	-	-
-	Industrial premises	75[2]	75[2]	75[2]	75[2]	75[2]	-	-

Notes:

1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
2. Noise management levels apply when receiver areas are in use only.
3. Noise management level applies at the facade of the dwelling
4. Construction hours for the Project are detailed in Table 3-1.

3.2 Construction vibration objectives

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings, and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The International System of Units (SI unit) for distance is the metre (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared (m/s^2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

3.2.1 Disturbance to buildings occupants

The acceptable vibration values to assess the potential for human annoyance from vibration are set out in the NSW '*Environmental Noise Management Assessing Vibration: A Technical Guideline*' (AVTG).

The guideline provides criteria which are based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 3-5 provides definitions and examples of each type of vibration.

Table 3-5: Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

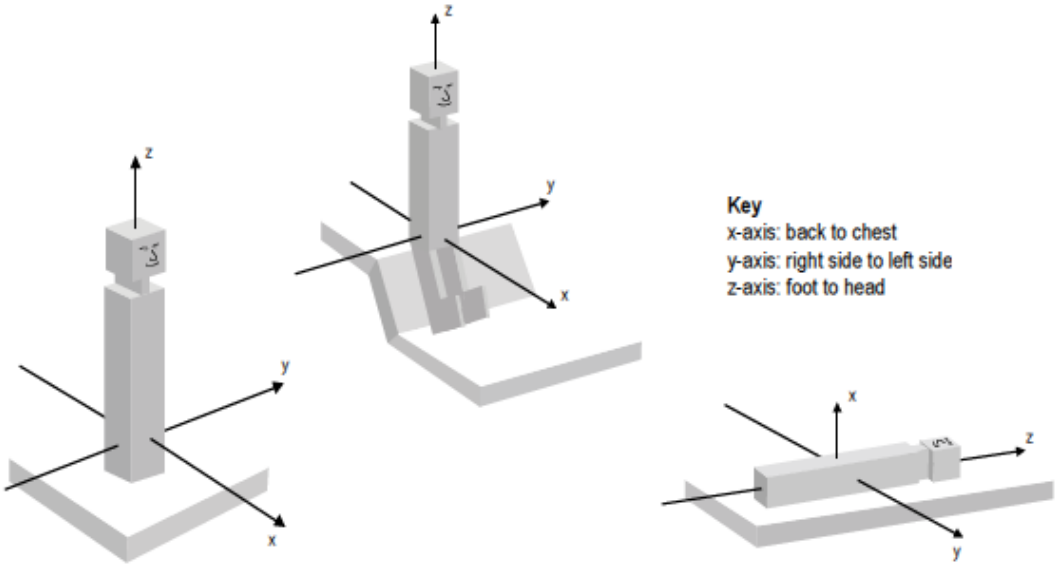
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 4. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 4: Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 3-6.

Table 3-6: Preferred and maximum levels for human comfort

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	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
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	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
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. The screening test is based on the continuous vibration velocity (i.e. vibration that continues uninterrupted for a defined period). If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (i.e. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

The initial screening test values and VDVs recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected, are presented in Table 3-7. The 'Low probability of adverse comment eVDV' represent the preferred and maximum value presented in the AVTG.

Table 3-7: Vibration management levels for disturbance to building occupants

Place and Time	Initial screening test Velocity, PEAK, mm/s (>8Hz)	Low probability of adverse comment eVDV $m/s^{1.75}$	Adverse comment possible eVDV $m/s^{1.75}$	Adverse comment probable eVDV $m/s^{1.75}$
Critical areas (day or night)[1]	0.28	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Residential buildings 16 hr day[2]	0.56	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night[2]	0.40	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices, schools, educational institutions and places of worship (day or night)	1.10	0.4 to 0.8	0.8 to 1.6	1.6 to 2.4
Workshops (day or night)	2.20	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

Notes:

1. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above

2. Daytime is 7am to 10pm and night-time is 10pm to 7am

3.2.2 Cosmetic damage to building structures

3.2.2.1 Cosmetic damage to building structures

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard BS 7385 Part 2 and German Standard DIN 4150 Part 3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 times higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

BS 7385-2 sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) from *BS 7385-2* for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 3-8.

Table 3-8: BS 7385 structural damage criteria

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

Notes:
1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. PPV values increase between specified frequencies as detailed in BS7385-2
3. Values referred to are at the base of the building, as per Section 6.3 of BS7385-2

BS 7385-2 states that the guide values in Table 3-8 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 3-8 may need to be reduced by up to 50%.

BS 7385-2 goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 3-8 and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 3-8 should not be reduced for fatigue considerations. It is noteworthy that, extra to the guide values nominated in Table 3-8, the standard states that:
"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."

3.2.2.2 Heritage structures and items

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. It should be noted that British Standard BS 5228-2:2009 states that *'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*' (p.39) when compared to other structures.

As part of the identification of noise and vibration sensitive receivers discussed in Section 1.6 potentially impacted heritage receivers nearby to the construction works areas are identified. Included in the vibration assessment in Section 4.4 are the nearby identifies nearby heritage items and structures that are subject to heritage conservation as designated by the relevant NSW environmental planning

instrument (EPI) under the *Environmental Planning and Assessment Act 1979*. Heritage conservation areas are not included in the assessment. At detailed design a further review of potentially impacted vibration-sensitive heritage receivers should be undertaken to ensure that vibration intensive construction activities are appropriately mitigated and managed.

Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for works to not further damage the structure. As stated previously, German Standard DIN 4150 - Part 3 (2016) '*Vibration in buildings - Effects on Structures*' (DIN 4150-3:2016) provides guidance for structures that are sensitive to vibration (eg. structurally unsound).

A conservative vibration damage screening level of 2.5 mm/s has been adopted as a screening level for heritage structures. This does not necessarily reflect that there would be a vibration impact on the structure if this level is exceeded, instead it is a suitable vibration level that is used as part of the construction vibration management process to trigger further investigation.

Any heritage structure predicted to exceed the screening level would be further investigated during detailed design, and appropriate vibration criteria for the structure adopted.

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Carry out a structural engineering report on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. **Where the item is confirmed as 'structurally sound',** adopt the recommended screening vibration level from the structural engineer, which may be adopting the appropriate level from BS7385 Part 2 with additional consideration for frequency or other recommended vibration management limit, or
4. **Where the item is confirmed as 'structurally unsound',** adopt the vibration limits presented in DIN 4150-3: (2016) Table 1 Line 3 with additional consideration for frequency.

The project is adjacent to the Alexandra Canal. It is required by the SEARs that potential vibration impacts during the construction phase are appropriately managed. As such, specific appropriate vibration management limits and management measures should be determined in consultation with Sydney Water.

3.2.2.3 Vibration damage to buildings screening criteria

In accordance with *BS 7385-2 and DIN 4150-3*, a conservative vibration damage screening level (peak component particle velocity) per receiver type is outlined below:

The limits presented in Table 3-8 above relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Conservatively it is assumed that

dynamic magnification due to resonance could occur, and so the guide values in Table 3-8 have been reduced by up to 50 percent to establish the below vibration screening criteria.

On this basis, consistent a conservative vibration screening criteria per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s
- Heritage structures (structurally unsound): 2.5 mm/s.

These levels do not necessarily reflect that there would be a vibration impact on the structure if this level is exceeded but are established as suitable vibration levels to be used as part of the construction vibration management process to trigger further investigation.

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable vibration limit to manage the vibration intensive works.

3.2.3 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for such equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment specific data provided by manufacturers, there are generic vibration criteria that can be used to assess the impact of vibration generating activities on buildings housing vibration sensitive equipment. For example, the Vibration Criteria (VC) curves are often referred to as they are generic and apply to all tools/ equipment types within each category. The VC curves are defined over the frequency range 8 to 100 Hz.

Table 3-9 below summarises a range of suitable and conservatively stringent vibration limits that are applicable to buildings housing vibration sensitive equipment which may potentially be affected by construction vibration.

Table 3-9: Acceptable vibration limits for vibration measured on building structure housing sensitive equipment

Equipment Requirements	Vibration Limit[1] mm/s,		Description of Use[3]
	RMS[4]	Peak [5]	
Computer Areas[2]	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.
Medical[2, 3]	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A[3]	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc

Notes: 1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment.

2. Based on AS 2834 Computer Accommodation

3. Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment

4. Root Mean Square value representing the average value of a signal

5. In the absence of Peak limits, RMS limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414

3.2.4 Damage to buried services

Section 5.3 of DIN 4150-3:2016 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 3-10 below.

Table 3-10: DIN 4150-3:1999 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For long-term vibration the guideline levels presented in Table 3-10 should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not.

It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out. This may include a specific vibration impact statement addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

3.3 Operational noise objectives

The operational assessment objectives are to determine the potential levels of noise and vibration at sensitive receivers located near the Project and determine the levels of mitigation that would be required to enable compliance with the current NSW requirements.

The SEARs relating to the Project detail the assessment requirements for the SSD project, which are presented in Section 1.2.

As the Project site is located within the boundary of the City of Sydney this is also addressed in Section 3.3.1.

3.3.1 City of Sydney - Sydney Development Control Plan 2012 (SDCP 2012)

The City of Sydney Council DCP 2012 does not outline provisions specifically applicable for controlling noise from industrial facilities.

However, it does identify a number of applicable requirements for noise for the Project, including:

- controlling environmental impacts such as noise to achieve design excellence (Clause 6.21)
- reviewing development in areas subject to aircraft noise (Clause 7.17) (see Section 3.5)
- noise management in the Southern Employment Lands (Clause 5.8.6.3), which states:
  - *A development application for a new building or for a change of use of an existing building, for a land use that is likely to generate external noise, must be accompanied by a Noise Impact Assessment prepared by a suitably qualified acoustic consultant. The Noise Impact Assessment is to include mitigation strategies, which must be implemented, to mitigate the impacts of noise generated by the new development on other activities in the vicinity. Mitigation strategies may include, for example, landscape buffers, sound locks, the use of specific building materials or sound walls.*
- Acoustic Privacy (Clause 4.2.3.11 and 4.2.5.3).

By assessing potential noise impacts against the NSW EPA guidelines required by the SEARs, as detailed in Section 1.2 and 1.4, this will also achieve the outcomes as required by the City of Sydney DCP for this type of development, including assessing impacts against the provisions of the NSW Environment Protection Authority (EPA) *Noise Policy for Industry* (NPfI). Refer to see Section 3.5 in regard to aircraft noise.

3.3.2 NSW EPA Noise Policy for Industry

This assessment aims to quantify the potential operational noise emissions from the Project in accordance with the NPfI. The assessment procedure has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the project noise trigger level which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

3.3.2.1 Intrusive noise levels

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq,15min}$ descriptor) does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

$L_{Aeq,15minute}$ Intrusiveness noise level = Rating Background Level ('RBL') plus 5 dB(A)

For the purposes of assessing operational noise impacts, rating background noise levels representative of the nearby affected residential receivers were described and presented in Section 2.1.1. The intrusiveness noise levels for residential receivers are reproduced in Table 3-11 below.

Table 3-11: Intrusiveness noise levels

Receiver (see Figure 2 for locations)	Logger	Intrusiveness noise level, $L_{Aeq,15min}$			
		Day	Evening	Night	Shoulder period (morning)[4]
NCA1A	L1	59 + 5 = 64	57 + 5 = 62	50 + 5 = 55	53 + 5 = 58
NCA1B	L3	49 + 5 = 54	47 + 5 = 52	41 + 5 = 46	45 + 5 = 50
NCA2	L4	56 + 5 = 61	51 + 5 = 56	47 + 5 = 52	49 + 5 = 54

Notes:
1. Day: 7:00am to 6:00pm Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays
2. Evening: 6:00pm to 10:00pm Monday to Sunday & Public Holidays
3. Night: 10:00pm to 5:00am Monday to Sundays & Public Holidays
4. Shoulder period 5:00am to 7:00am Monday to Saturday and 5:00am to 8:00am Sundays & Public Holidays

3.3.2.2 Amenity noise levels

The project amenity noise levels for different time periods of day are determined in accordance with Section 2.4 of the NPfI. The NPfI recommends amenity noise levels ($L_{Aeq,period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for total industrial noise experienced at a receiver location. However, when assessing a single industrial development and its impact on an area then "project amenity noise levels" apply.

The recommended amenity noise levels applicable for the subject receiver areas are reproduced from the NPfI Table 2.2 in Table 3-12 below.

Table 3-12: Recommended amenity noise levels

Type of receiver	Noise amenity area	Time of day	Recommended amenity noise level, L_{Aeq}, dB(A)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom (internal)	All	Noisiest 1-hour period when in use	35[5]
Hospital ward	All		
- Internal		Noisiest 1-hour	35
- External		Noisiest 1-hour	50
Place of worship (internal)	All	When in use	40
Passive recreation (e.g. national park)	All	When in use	50
Active recreation (e.g. school playground, golf	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	When in use	Add 5 dB(A) to recommended noise amenity area

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
4. The recommended amenity noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated
5. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable LAeq noise level may be increased to 40 dB LAeq(1hr)

3.3.2.2.1 Residential amenity category

Table 2.3 "*Determining which of the residential receiver categories applies*" of the NPfI provides guidance on assigning residential receiver noise categories.

Recent guidance from NSW EPA in the journal Acoustics Australia (Volume 50, No. 3, September 2022) provided clarification on how to use the table to determine the noise amenity category for residential receivers.

The first step in the process was to determine the land use zoning of the potentially affected residential receiver, before considering other factors detailed in NPfI Table 2.3. This would then be the basis of the adopted residential receiver amenity category, unless there is strong justification for a different residential receiver amenity category.

The residences located in NCA01 are located in areas zoned R1 'General residential', and the residences located in NCA02 are located in areas zoned B4 'Mixed use'. In both cases, the applicable receiver amenity category based upon this zoning is **Urban residential** from column 1 of NPfI Table 2.3.

As such, these residential receivers have been categorised as **urban**.

3.3.2.2.2 Project amenity noise levels

To ensure that the total industrial noise level (existing plus new) remains within the recommended amenity noise levels for an area, the project amenity noise level should apply for each new industrial noise source is determined as follows:

$L_{Aeq,period}$ Project amenity noise level = $L_{Aeq,period}$ Recommended amenity noise level – 5 dB(A)

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$L_{Aeq,15minute}$ = $L_{Aeq,period}$ + 3dB(A)

The project amenity noise levels ($L_{Aeq,\ 15min}$) applied for the Project are reproduced in Table 3-13.

Table 3-13: Project amenity noise levels

Type of receiver	Noise amenity area	Time of day	Recommended noise level, dB(A)	
			$L_{Aeq,\ Period}$	$L_{Aeq,\ 15min}$
Residence	Urban	Day	60 – 5 = 55	55 + 3 = 58
		Evening	50 – 5 = 45	45 + 3 = 48
		Night[1]	45 – 5 = 40	40 + 3 = 43
Commercial Premises	All	When in use	65 – 5 = 60	60 + 3 = 63
Industrial premises	All	When in use	70 – 5 = 65	65 + 3 = 68

Notes:
1. Daytime 7:00am to 6:00pm; Evening 6:00pm to 10:00pm; Night-time 10:00pm to 5:00am, and Morning-shoulder 5:00am - 7:00am. On Sundays and Public Holidays, Daytime 8:00am - 6:00pm; Evening 6:00pm - 10:00 pm; Night-time 10:00pm - 5:00am, Morning-shoulder 5:00am - 7:00am.
2. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
3. Based upon recently guidance from NSW EPA in the journal Acoustics Australia (Volume 50, No. 3, September 2022) it details that the NSW EPA expects that where a morning shoulder period has been justified that the corresponding day-time period amenity level would be applicable.

3.3.2.2.3 Amenity noise levels in areas of high traffic noise

Where the levels of transport noise, in particular road traffic noise are high enough to make noise from an industrial source effectively inaudible, even though the L_{Aeq} noise level from that industrial noise source may exceed the project amenity noise level, the NPfI sets out criteria to take this into account.

In such cases NPfI Section 2.4.1 details that the project amenity noise level may be derived from the $L_{Aeq,\ period(traffic)}$ minus 15 dB(A). It is noted that in a similar manner to the derivation of the project amenity noise level in Section 3.3.2.2.2, this minus 15 dB(A) includes a 5 dB(A) reduction to take into account cumulative other industrial noise contributions, to ensure that the total industrial noise level (existing plus new) remains within the recommended amenity noise levels for an area.

This high traffic project amenity noise level may be applied only if all the following apply:

- traffic noise is identified as the dominant noise source at the site
- the existing traffic noise level (determined using the procedure outlined in A2, Fact Sheet A, that is, measuring traffic instead of industrial noise) is 10 dB or more above the recommended amenity noise level for the area
- it is highly unlikely traffic noise levels will decrease in the future.

The applicability of these traffic noise provisions needs to be determined for each assessment period (that is, day, evening and night).

Due to the dominance of the surrounding arterial and sub-arterial roads to the ambient noise levels at the nearby residential receivers, presented in Section 2.1.2, amenity noise levels in areas of high traffic noise are applicable for a number of receiver locations during different assessment periods for this NVIA. With considering the nearby recent road projects that have recently commenced operation and the road traffic projections detailed in the associated EIS documentation, such as the Westconnex M8, it is highly unlikely that traffic noise will reduce on these arterial roads over time.

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$$\mathbf{L_{Aeq,15minute} = L_{Aeq,period} + 3dB(A)}$$

Therefore, Table 3-14 reviews and determines where applicable, that the high traffic noise provisions in the Noise Policy for Industry, Section 2.4.1 should be adopted to derive the project amenity trigger levels.

Table 3-14: High traffic project amenity noise level

NCA	Existing traffic noise levels[1], $L_{Aeq, 15\ minute}$				Existing traffic noise levels 10 dB(A) or more above ANL?				High traffic project amenity noise level[2], $L_{Aeq, 15\ minute}$			
	Day[1]	Eve[2]	Night[3]	Shoulder[4]	Day[1]	Eve[2]	Night[3]	Shoulder[4]	Day[1]	Eve[2]	Night[3]	Shoulder[4]
NCA1A	67	65	62	66	No	Yes	Yes	No	-3	53	50	-3
NCA1B	58	56	52	56	No	No	No	No	-3	-3	-3	-3
NCA2	63	60	56	59	No	Yes	Yes	No	-3	48	44	-3

Notes:
1. Noise levels measured as per NPfI Section 2.4.1, which noted that the traffic noise levels are to be determined using the procedure outlined in A2, Fact Sheet A, that is, measuring traffic instead of industrial noise
2. High traffic project amenity noise level is existing traffic levels minus 15 dB(A) plus 3 dB(A) to convert from a period level to a 15-minute level.
3. High traffic project amenity noise level does not apply

3.3.2.3 Project noise trigger levels

In accordance with the NPfI the project noise trigger levels (PNTL) the project noise trigger level is the lower (that is, the more stringent) value of the project intrusiveness noise level and project amenity noise levels, after conversion to $L_{Aeq\ 15min}$ values. The PNTL for the Project are presented in Table 3-15 below.

Table 3-15: Summary of project noise trigger levels (PNTL)

Receiver location	$L_{Aeq, 15min}$ Project noise trigger levels, dB(A)			
	Day	Evening	Night	Morning shoulder
Residential receivers[3]				
NCA1A	58	53	50	58
NCA1B	54	48	43	50
NCA2	58	48	44	54
Other sensitive receivers[2,4]				
Commercial	63	63	63[2]	63[2]
Industrial	68	68	68[2]	68[2]

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 5.00 am, Morning-shoulder 5.00 am - 7.00 am. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 5.00 am, Morning-shoulder 5.00 am -7.00 am.
2. Project noise trigger level is only applicable when the receiver type is in use.
3. For a residence, the project noise trigger level and maximum noise levels are to be assessed at the reasonably most-affected point on or within the residential property boundary up to 30m, as per the NPfI.
4. For commercial or industrial premises, the noise level is to be assessed at the reasonably most-affected point on or within the property boundary.

3.3.2.4 Cumulative industrial noise

The management of cumulative operational noise is required by the NPfI and SEARs. By addressing cumulative noise impacts consistent with the NPfI, this will also sufficiently address cumulative impacts in accordance with the DPIE guideline "*Cumulative Impact Assessment Guidelines for State Significant Projects*" (DPIE, 2021) as detailed in Section 3.5 of that document.

As stated in Section 2.1 of the NPfI "*The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses.*".

The NPfI amenity noise criteria derived in Section 3.3.2.2 aims to control the total industrial noise level (existing plus new) with the aim for it to remain within the recommended amenity noise levels for the area. As such, the potential cumulative noise impacts as a result of the development have been considered in the assessment through the derivation of criteria in accordance with the NPfI, and assessment against these levels.

3.3.2.5 Sleep disturbance noise levels

The potential for sleep disturbance due to maximum noise level events from the Project site during the night-time period needs to be considered. In accordance with NPfI, a detailed maximum noise level event assessment should be undertaken where the subject development night-time noise levels at a residential location exceed the following noise trigger levels:

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

The sleep disturbance noise trigger levels for the Project are presented in Table 3-16 below.

Table 3-16: EPA NPfI Sleep disturbance assessment trigger levels

Receiver location	Night (10:00pm to 5:00am)		Morning shoulder period (5:00am to 7:00am)	
	Assessment level $L_{Aeq,15min}$	Assessment level L_{AFmax}	Assessment level $L_{Aeq,15min}$	Assessment level L_{AFmax}
NCA1A	50 + 5 = 55	50 + 15= 65	53 + 5 = 58	53 + 15 = 68
NCA1B	41 + 5 = 46	41 + 15= 56	45 + 5 = 50	45 + 15 = 60
NCA2	47 + 5 = 52	47 + 15= 62	49 + 5 = 54	49 + 15 = 64

Notes:
1. As per NPfI Section 2.5, minimum screening level is the greater of L_{Aeq} 40 dB(A) or RBL + 5dB.
2. As per NPfI Section 2.5, minimum screening level is the greater of L_{AFmax} 52 dB(A) or RBL + 15dB.

The detailed assessment should consider all feasible and reasonable noise mitigation and management measures with a goal of achieving the sleep disturbance noise trigger levels. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the RNP (see Section 3.3.2.5.1).

Other factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events will occur
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the subject development

- whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods)
- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night (see Section 3.3.2.5.1).

Maximum noise level event assessments should be based on the L_{AFmax} descriptor on an event basis under 'fast' time response.

3.3.2.5.1 Current reference literature on sleep disturbance

NSW RNP

In relation to maximum noise level events, the NSW RNP identifies in its summary on sleep disturbance research to date that:

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

The above references identify that internal noise levels of 50 to 55 dB(A), are unlikely to cause awakenings. On the assumption that there is a 10 dB(A) outside-to-inside noise loss through an open window (see Section 2.6 of the NPfI, p15), this indicates that external noise levels of L_{Amax} 60 to 65 dB(A) are unlikely to cause awakening reactions. Given the equivalent external noise levels and considering the second point above, an L_{Amax} 65 dB(A) has then been used as the assessment noise level to determine the potential for awakening reactions.

World Health Organisation reports

As stated in the NPfI, other factors that may be important in assessing the extent of impacts on sleep, includes current scientific literature regarding the impact of maximum noise level events at night. The organisation that reports on the current scientific literature pertaining to night-time impacts on sleep is the World Health Organisation (WHO).

The latest guidelines produced by the WHO relating to night-time impacts on sleep, were produced in 2009 and 2018. These reports mainly focus on sleep disturbance from transportation noise sources, such as aircraft, road and rail, with the 2018 guideline also providing recommendations for wind turbine and leisure noise sources. As stated in the later report, it does not provide specific recommendations for industrial activity noise due to lack of information and data.

However, given that some of the proposed operations of the Project, may have a similar nature and character of noise to road traffic noise, guidance and limits relating to road traffic noise are referred to in this NVIA to assess potential sleep disturbance from site operations and activities.

Following the publication of community noise guidelines in 1999, the WHO released the *Night Noise Guidelines for Europe (WHO 2009)* in 2009, which uses $L_{night\ (outside)}$ as a primary measure of night-time noise. The $L_{night\ (outside)}$ is an A-weighted noise level at the most exposed facade outdoors over all night periods determined as a long-term average over a year, and is roughly equivalent to the external $L_{Aeq,9hour}$ night-time descriptor.

The report recommends a long-term $L_{night\ (outside)}$ noise guideline level of 40 dB(A), with an interim $L_{night\ (outside)}$ target level of 55 dB(A). The interim target is only intended as an intermediate step in localised situations as health impacts, particularly on vulnerable groups, are apparent at this noise level. The report notes:

1. For $L_{Aeq(9hour)}$ (external) levels above 55 dB(A), adverse health effects occur frequently, and a sizeable proportion of the population is highly annoyed and sleep disturbed.

2. For $L_{Aeq(9hour)}$ (external) levels between 40 dB(A) and 55 dB(A), adverse health effects are observed and vulnerable groups are more severely affected.

The WHO released the latest research into sleep in 2018 as the *Environmental Noise Guidelines for the European Region: A systematic Review on Environmental Noise and Effects on Sleep* (WHO 2018). The WHO 2018 guideline recommends reducing noise levels produced by road traffic during night-time to below 45 dB(A) $L_{night\ (outside)}$, as night-time road traffic noise above this level is associated with adverse effects on sleep.

The WHO 2018 guideline does not recommend criteria in terms of single-event noise indicators or maximum sound pressure levels (eg L_{Amax}), because the assessment of the relationship between different types of single-event noise indicators and long-term health outcomes at the population level remains tentative. The WHO guideline therefore makes no recommendations for single-event noise indicators. Thus, the WHO guideline is restricted to long-term health effects during night time and therefore only includes recommendations about average noise indicators, e.g. $L_{night\ (outside)}$.

enHealth

The enHealth Council (2004) report "*The health effects of environmental noise – other than hearing loss*", which is also quoted in the RNP, includes the following statement from the enHealth Council (2004) report, which is the summary of the research findings and states:

> *'as a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) LA, (Max) more than 10 or 15 times per night'.*

This internal noise level of 45 dB(A) L_{Amax} would be equivalent to 55 dB(A) L_{Amax} external, if the receivers have their windows open. If the windows are closed however, the noise reduction will be greater than the assumed 10 dB(A) outside to inside. As per Section 2.3 of the Australian Department of Health enHealth Council (2018) report "*The health effects of environmental noise*" which reviews updates and revises the referenced 2004 enHealth Australia report on the non–auditory effects of environmental

noise, notes that "*Single and double window glazing can reduce noise by up to 30 and 35 dB(A) when closed.*"

Typically, noise reductions greater than 20 – 25 dB(A) are achievable where facades are substantial, and consist of standard to thick glazing and heavy facade construction (eg brick construction).

Noting that this is already included in Section 5.4 "*Sleep disturbance*" of the RNP the above issues have already been addressed when assessing the requirements as per the RNP.

3.3.2.5.2 Sleep disturbance assessment noise levels

In accordance with the NPfI and current scientific literature, the sleep disturbance project assessment noise levels, are presented in Table 3-17 below.

Table 3-17: Sleep disturbance project assessment noise levels

Receiver location	Sleep disturbance project assessment noise levels, dB(A)					
	EPA NPfI sleep disturbance assessment levels, L_{Amax}		Awakening reaction[3], L_{Amax}	EPA NPfI sleep disturbance assessment levels, $L_{Aeq,15min}$		WHO 2018 $L_{Aeq,15min}$[2]
	Night[1]	Morning shoulder period[1]		Night[1]	Morning shoulder period[1]	
NCA1A	65	68	65	50	58	48
NCA1B	56	60	65	43	50	48
NCA2	62	64	65	44	54	48

Notes:
1. Night-time 10:00pm to 5:00am. The morning shoulder period is 5:00am to 7:00am.
2. As per Section 2.2 of the NPfI, the WHO 45 dB(A) Lnight (outside) has been converted to a LAeq,15minute level by adding 3 dB(A).
3. As per the NSW RNP, as detailed in Section 3.3.2.5.1.

3.4 Road traffic noise (construction and operational)

Noise impacts from the potential increases in traffic on the surrounding road network due to construction and operational activities from the Project are assessed in accordance with the RNP. The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impacts and determining mitigation measures for sensitive receivers that are potentially affected by road traffic noise associated with the construction and operation of the subject site, with the aim of preserving the amenity appropriate to the land use.

The Project will be using sub-arterial / arterial roads and not local roads. Therefore, for existing residences affected by additional traffic on existing sub-arterial / arterial roads generated by land use developments, the following RNP road traffic noise criteria would apply.

Table 3-18: RNP road traffic noise criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment criteria, dB(A)	
		Day 7am – 10pm	Night 10pm – 7am
Freeway/arterial/sub-arterial roads	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 60 (external)	$L_{Aeq,(9\ hour)}$ 55 (external)

Further to the above, the RNP states the following for land use developments generating additional traffic:

> *"For existing residences and other sensitive land uses affected by* **additional traffic on existing roads generated by land use development***, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'."*

The RNP states that 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.

3.5 Aircraft noise intrusion

As required by the City of Sydney DCP, Proposed developments potentially impacted by aircraft noise should be assessed to determine that they can achieve the noise level requirements of *Australian Standards AS2021 – Acoustics Noise Intrusion – Building Siting and Construction*.

Based on the Sydney Airport ANEF 2039 chart the Project site is located within the ANEF 20 to 25 contours.

3.5.1 AS2021-2015 - aircraft noise intrusion

Aircraft noise intrusion from take-off, landing and circuit training operations at civil aerodromes or military airfields is assessed using Australian Standard A2021-2015 – '*Acoustics – Aircraft Noise Intrusion – Building Siting and Construction*' ('AS2021'). This section of the report outlines the application of AS2021. The scope of AS2021-2015 is stated as:

> *This standard, together with the relevant Australian Noise Exposure Forecast (ANEF) chart provides guidelines for determining-*
>
> *a. whether the extent of aircraft noise intrusion makes building sites 'acceptable', 'unacceptable' or 'conditionally acceptable' for the types of activity to be, or being, undertaken (Clause 2.3);*
>
> *b. for 'conditionally acceptable' sites, the extent of noise reduction required to provide acceptable noise levels indoors for the types of activity to be, or being, undertaken; and*
>
> *c. the type of building construction necessary to provide a given noise reduction, provided that external windows and doors are closed.*

3.5.2 Building site acceptability

AS2021 contains advice on the acceptability of building sites based on Australian Noise Exposure Forecast (ANEF) zones. The ANEF chart provides a predicted cumulative exposure to aircraft flyover noise in communities near aerodromes. The chart presents zones represented by noise contours overlaid on a locality map specific to an airport. The ANEF system was developed as a land use planning tool aimed at controlling encroachment on airports by noise sensitive buildings.

Table 2.1 of AS2021 sets acceptability zones for different building types and land uses. Table 3-19 reproduces the sections of AS2021 Table 2.1 relevant to the Project and given it is situated between the 20 and 25 contour it is classified as acceptable.

Table 3-19: Building site acceptability based on ANEF zones (Table 2.1 of AS2021)

Building type	ANEF zone of site		
	Acceptable	Conditional	Unacceptable
Commercial building	Less than ANEF 25	25 to 35 ANEF[2]	Greater than 35 ANEF
Light industrial	Less than ANEF 30[1]	30 to 40 ANEF[2]	Greater than 40 ANEF
Other industrial	Acceptable in all ANEF zones		

Section 2.3 of AS2021 details the actions resulting from the acceptability determination. Table 3-20 presents the outcomes as a result of the Project building being classified as acceptable.

Table 3-20: Description of building site acceptability

Zone	Description
Acceptable	If from Table 2.1, the building site is classified as 'acceptable', there is usually no need for the building construction to provide protection specifically against aircraft noise. However, it should not be inferred that aircraft noise will be unnoticeable in areas outside the ANEF 20 contour. (See Notes 1, 2 and 3 of AS2021:2015 Table 2.1.)

3.5.3 Site consideration

Based on the Sydney Airport ANEF 2039 chart the Project site is located within the ANEF 20 to 25 contours. As such the Project has been assessed as acceptable and it is determined that no further assessment is required to address the requirements of AS2021:2015.

4 Construction noise and vibration assessment

4.1 Background

Construction activities associated with the proposed development will result in increased noise levels during construction hours. The works undertaken in the various stages consist of a mixture of both high and low noise activities. This assessment identifies potentially noisy activities, their impacts on surrounding receivers and outlines management strategies to control the impacts of noise and vibration during the construction stages of the project.

4.2 Construction noise and vibration activities and assumptions

4.2.1 Construction works and activities

An assessment of the potential level of construction noise and vibration impact has been carried out to determine whether mitigation would be required, and to determine appropriate management controls. Specific construction equipment requirements are not yet known. The type and number of plant and equipment associated with the proposed works was assumed based upon experience with similar noise assessments.

Prior to the commencement of construction, the final construction details should be reviewed against the assumptions in this report to ensure that the mitigation and management measures that will be implemented remain consistent with these assumptions, and appropriate for the project. Demolition works of the existing structures have been included in the assessment for completeness, however it is understood that these works will be completed under a complying development certificate (CDC).

The approximate phases and duration of works are presented in Table 4-1 below.

Table 4-1: Construction phases

Construction phase	Construction activities
Site establishment works	• Installation of enviro controls • Establishment of construction facilities
Demolition works	• Demolition of existing structures and hardstand
Utility, stormwater, infrastructure and services augmentation works	• Utility modification works • Stormwater civil works • Infrastructure and services augmentation works
Piling works	• Piling works

Construction phase	Construction activities
Surface preparation works	• Surface preparation works • Excavation and levelling of site
Building construction	• Construction of the main building structure
Building fit-out	• Internal fitout within the building • Deliveries

4.2.2 OOHW construction works

4.2.2.1 Proposed construction works

It is understood that the proposal is seeking approval for construction works to occur during OOHW periods for certain types of works, this would include:

Table 4-2: Proposed OOH construction works

Proposed OOH construction works	Proposed OOHW periods
Impact piling and demolition works	OOHW day and evening period
Concrete pours	OOHW morning shoulder period OOHW evening period
Internal fitout works, including deliveries	All periods

4.2.2.2 Justification for extended and OOHW construction hours

As per the requirements of the ICNG, the justifications for undertaking these construction works outside of the standard construction hours during the proposed time periods are as follows:

Table 4-3: Justification for proposing to undertake construction works outside of the standard construction hours

Proposed OOH construction works	Justifications for proposing to undertake construction works outside of the standard construction hours
Impact piling and demolition works	Given the close proximity of the nearby commercial receivers to the proposal, it is likely that impacts from construction noise and human comfort vibration impacts would potentially exceed the relevant noise and vibration management levels. There are limited alternative techniques, source mitigation or path mitigation options for the driven piles because of sight specific factors (ie. contamination). One effective approach to manage the overall impacts from the proposal would be to undertake these high noise and vibration generating activities during periods when the adjacent commercial receivers are not in use, considering there is a substantial distance between the site and nearby residences. It is recommended that by extending the construction hours for the demolition works and impact piling works over the weekend day periods, or into the evening period could allow for more effective management of noise and vibration impacts from these works.

Proposed OOH construction works	Justifications for proposing to undertake construction works outside of the standard construction hours
Concrete pours	For concrete pours during hotter months, they are proposed to commence during the early morning period (from 5:00am) to avoid the hottest time of the day when concrete pours are not able to occur. Large concrete slabs require an extended time period to complete, and as such this would require commencing early in the morning period to complete during the day. This would also be for worker welfare. For the same reason detailed above, concrete pours have been assessed during the evening period from 6:00pm to 10:00pm as they may need to extend into this period to be completed. To mitigate potential impacts during these OOHW periods, for the assessment of concrete pours during OOHW periods it has been assumed that the concrete truck can be setup so that there is no direct line of sight to the residences on Campbell Road (i.e., the WestConnex Transurban MCC Main Office or the proposal building can provide shielding to the residences of the concrete truck).
Internal fitout works, including deliveries	Fitout works are proposed to occur during out of hours periods once the building shell has been completed. This would occur inside the building within and therefore noise impacts are not expected, however deliveries may be required. This would assist with reducing the overall construction program, and potentially reduce the construction intensity during standard hours, and as such reduce the potential construction impacts and nearby sensitive receivers.
Oversized deliveries	Some larger deliveries may occur also after hours. This is due to road restrictions for oversized deliveries.

Given that the nearest residence to the proposal is located approximately 250 metres to the north and all potentially impacted residences are subject to high traffic noise levels from surrounding major roads, there is an opportunity to extend the standard construction hours for the proposal whilst complying with the relevant construction noise management levels at these nearby residences.

Therefore, with exception of the demolition works and impact piling, the noise assessment prepared in this report demonstrates the feasibility of the proposed OOH construction works to achieve the relevant noise management levels at nearby residences during the proposed OOH periods, providing further justification for these works to occur during OOHW periods.

4.2.3 Construction traffic

The worksite will generate additional traffic movements in the form of:

- Light vehicle movements generated by construction personnel travelling to and from work
- Heavy vehicle movements generated by:
  - Trucks removing construction waste from the site
  - Delivery vehicles bringing raw materials, plant, and equipment to the site

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 4.2.1. When construction-related traffic moves on the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as additional road traffic on public roads rather than as part of the construction site's activities.

The estimated daily number of heavy vehicles accessing the site during intensive construction periods will be up to 50 trucks per day during peak periods or an average of 5 per hour, over a standard 10 hour work day.

The proposal site is located on Burrows Road and would be accessed from either Campbell Road or Canal Road. Campbell Road and Canal Road are sub-arterial roads that carry high existing traffic volumes which will increase over time, particularly when the WestConnex St Peters Interchange becomes fully operational. Based on available data, traffic volumes on both Canal Road and Campbell Road currently exceed 20,000 AADT.

As there are no assessment receivers for road traffic noise on Burrows Road, and Canal Road and Campbell Road carry high existing traffic volumes, road traffic noise with the operation of the proposal would not cause any exceedance of the RNP noise goals. No further assessment of construction related road traffic has been considered.

4.2.4 Construction noise sources

The schedule of items of plant and equipment likely to be used during the construction phases of the Project is presented in Table 4-4 below.

Table 4-4: Typical construction equipment & sound power levels

Plant item	Individual source/activity sound power level (Lw re. 1pW), $L_{Aeq,15min}$, dB(A)	Individual source/activity sound power level (Lw re. 1pW), L_{Amax}, dB(A)
Site establishment works		
Tracked excavator with bucket	103	115
Hand tools	107	111
Elevated work platform	106	110
Small truck	104	115
Franna crane	99	115
Truck with Hiab	96	117
Assumed activity noise level	**108**[2]	-[1]
Demolition works		
Franna crane	99	115
Franna crane	99	115
Truck with Hiab	96	117
Hand tools	107	111
Tracked excavator with bucket	103	115
Truck	108	120
Tracked excavator with rock breaker attachment	122[5]	126
Assumed activity noise level	**122**[3]	-[1]

Plant item	Individual source/activity sound power level (Lw re. 1pW), $L_{Aeq,15min}$, dB(A)	Individual source/activity sound power level (Lw re. 1pW), L_{Amax}, dB(A)
Utility and services augmentation works		
Concrete saw	119[5]	119
Vacuum truck	108	112
Hand tools	107	111
Tracked excavator with bucket	103	115
Franna crane	99	115
Truck with Hiab	96	117
Elevated Work Platform (EWP)	106	110
Concrete truck	108	120
Concrete pump	103	106
Assumed activity noise level	**119[3]**	-[1]
Piling		
Impact piling	131[5]	-[1]
Assumed activity noise level	**131[3]**	-[1]
Surface preparation works		
Tracked excavator with bucket	103	115
Hand tools	107	111
Concrete pump	103	108
Concrete truck	108	118
Padfoot roller	109	112
Truck	108	120
Franna crane	99	115
Assumed activity noise level	**110[2]**	**120**
Building construction		
Mobile crane	105	115
Concrete trucks	108	120
Delivery trucks	108	120
Hand tools	107	111
Bobcat	102	110
Concrete pump	102	106
Concrete vibrator	99	99
Non-powered hand tools	98	111
Assumed activity noise level	**110[2]**	**120**

Plant item	Individual source/activity sound power level (Lw re. 1pW), $L_{Aeq,15min}$, dB(A)	Individual source/activity sound power level (Lw re. 1pW), L_{Amax}, dB(A)
Building fit-out		
Delivery trucks	108	120
Hand tools	107[3]	111
Bobcat	102[3]	110
Scissor lift	99[3]	105
Non-powered hand tools	98[3]	111
Assumed activity noise level	**108[4]**	**120**

Notes:

1. No works during OOHW night period
2. Based upon the 2 (noisiest) plant operating concurrently and considering corrections for typical usage time in a 15-minute period.
3. Works are dominated by the loudest equipment item, which has been modelled.
4. Assumed to take place within the completed building shell. Delivery activities assumed to occur externally.
5. In accordance with the ICNG, a 5 dBA 'penalty' is applied for activities identified as particularly annoying, such as rock hammer, impact piling and concrete saw.

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the Interim Construction Noise Guideline (ICNG), information from past projects and/or information held in the Renzo Tonin & Associates library files.

4.3 Construction noise assessment

4.3.1 Predicted noise levels

Noise levels at any receiver location resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Noise emissions were determined by modelling the noise sources, receiver locations, and operating activities, based on the information presented in Section 4.2.1.

Table 4-5 to Table 4-11 presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site.

Noise levels were calculated using the modelling approach detailed in Section 5.3.1.

A 5 dB(A) penalty in accordance with the ICNG has been factored into the noise modelling levels where applicable to allow for particularly annoying activities, such as rock hammering, impact piling, saw cutting and jack hammering.

The predicted level range is based upon when works are at the closest point or furthest point within the construction site to each receiver. While in practice, noise intensive construction works would occur at different locations throughout the work area, resulting in differing noise levels at each receiver. This means that predicted noise levels are only likely to occur when works are at the closest point to each receiver. The noise impacts may be lower than predicted as the construction activities move around or progress around the construction site.

Table 4-5: Predicted standard hours $L_{Aeq(15min)}$ noise levels for construction plant and activities, dB(A)

Receiver			NML	Predicted construction noise level, $L_{Aeq,15min}$													
NCA	NCA ID	Address		Site establishment		Demolition		Utilities		Piling		Surface preparation		Building construction		Building fitout	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
NCA01A	R1_1	34 Campbell Road, Alexandria	69	52	35	66	49	63	46	**76**	57	54	37	55	36	39	39
NCA01B	R1_2	34 Campbell Road, Alexandria	59	44	31	58	45	55	42	**67**	54	46	33	46	33	33	33
NCA01B	R1_3	34 Campbell Road, Alexandria	59	53	36	**67**	50	**64**	47	**76**	58	55	38	55	37	41	41
NCA01A	R2	20 Campbell Road, Alexandria	69	51	34	65	48	62	45	**70**	56	53	36	49	35	39	39
NCA01A	R3	4 Campbell Road, Alexandria	69	51	34	65	48	62	45	65	56	53	36	44	35	37	37
NCA02	R4_1	671 Gardeners Road, Mascot	66	50	44	64	58	61	55	**73**	**70**	52	46	52	49	51	51
NCA02	R4_2	671 Gardeners Road, Mascot	66	49	43	63	57	60	54	**72**	**70**	51	45	51	49	50	50
Active recreation	R5	Sydney Park	65	51	36	65	50	62	47	**75**	57	53	38	54	36	44	44
Commercial	R6_1	33 Burrows Road, St Peters	70	70	58	**84**	**72**	**81**	69	**94**	**82**	**72**	60	**73**	61	54	54
Commercial	R6_2	33 Burrows Road, St Peters	70	70	59	**84**	**73**	**81**	70	**93**	**84**	**72**	61	**72**	63	48	48
Commercial	R6_3	33 Burrows Road, St Peters	70	**72**	63	**86**	**77**	**83**	**74**	**96**	**87**	**74**	65	**75**	66	47	47
Commercial	R7_1	32 Burrows Road, St Peters	70	**81**	62	**95**	**76**	**92**	**73**	**99**	**86**	**83**	64	**78**	65	65	65
Commercial	R7_2	32 Burrows Road, St Peters	70	**80**	62	**94**	**76**	**91**	**73**	**98**	**87**	**82**	64	**77**	66	66	66
Commercial	R8_1	24-26 Burrows Road, St Peters	70	**86**	63	**100**	**77**	**97**	**74**	**104**	**86**	**88**	65	**83**	65	50	50
Commercial	R8_2	24-26 Burrows Road, St Peters	70	**87**	62	**101**	**76**	**98**	**73**	**103**	**86**	**89**	64	**82**	65	66	66
Industrial	R9	67 Bourke Road, Alexandria	75	55	35	69	49	66	46	**77**	58	57	37	56	37	56	56
Industrial	R10_1	697 Gardeners Road, Alexandria	75	65	58	**79**	72	**76**	69	**85**	**81**	67	60	64	60	64	64
Industrial	R10_2	697 Gardeners Road, Alexandria	75	66	59	**80**	73	**77**	70	**87**	**82**	68	61	66	61	66	66
Industrial	R10_3	697 Gardeners Road, Alexandria	75	65	50	**79**	64	**76**	61	**86**	74	67	52	65	53	62	62
Industrial	R10_4	697 Gardeners Road, Alexandria	75	61	36	75	50	72	47	**81**	59	63	38	60	38	59	59

Notes:

1. **Bold** indicates exceedance of NML

Table 4-6: Predicted OOHW (daytime) $L_{Aeq(15min)}$ noise levels for construction plant and activities, dB(A)

Receiver			NML	Predicted construction noise level, $L_{Aeq,15min}$													
NCA	NCA ID	Address		Site establishment[2]		Demolition		Utilities[2]		Piling[2]		Surface preparation		Building construction		Building fitout	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
NCA01A	R1_1	34 Campbell Road, Alexandria	64	-	-	**66**	49	-	-	**76**	57	-	-	-	-	39	39
NCA01B	R1_2	34 Campbell Road, Alexandria	54	-	-	**58**	45	-	-	**67**	54	-	-	-	-	33	33
NCA01B	R1_3	34 Campbell Road, Alexandria	54	-	-	**67**	50	-	-	**76**	**58**	-	-	-	-	41	41
NCA01A	R2	20 Campbell Road, Alexandria	64	-	-	**65**	48	-	-	**70**	56	-	-	-	-	39	39
NCA01A	R3	4 Campbell Road, Alexandria	64	-	-	**65**	48	-	-	**65**	56	-	-	-	-	37	37
NCA02	R4_1	671 Gardeners Road, Mascot	61	-	-	**64**	58	-	-	**73**	**70**	-	-	-	-	51	51
NCA02	R4_2	671 Gardeners Road, Mascot	61	-	-	**63**	57	-	-	**72**	**70**	-	-	-	-	50	50
Active recreation	R5	Sydney Park	65	-	-	65	50	-	-	**75**	57	-	-	-	-	44	44
Commercial	R6_1	33 Burrows Road, St Peters	70	-	-	**84**	**72**	-	-	**94**	**82**	-	-	-	-	54	54
Commercial	R6_2	33 Burrows Road, St Peters	70	-	-	**84**	**73**	-	-	**93**	**84**	-	-	-	-	48	48
Commercial	R6_3	33 Burrows Road, St Peters	70	-	-	**86**	**77**	-	-	**96**	**87**	-	-	-	-	47	47
Commercial	R7_1	32 Burrows Road, St Peters	70	-	-	**95**	**76**	-	-	**99**	**86**	-	-	-	-	65	65
Commercial	R7_2	32 Burrows Road, St Peters	70	-	-	**94**	**76**	-	-	**98**	**87**	-	-	-	-	66	66
Commercial	R8_1	24-26 Burrows Road, St Peters	70	-	-	**100**	**77**	-	-	**104**	**86**	-	-	-	-	50	50
Commercial	R8_2	24-26 Burrows Road, St Peters	70	-	-	**101**	**76**	-	-	**103**	**86**	-	-	-	-	66	66
Industrial	R9	67 Bourke Road, Alexandria	75	-	-	69	49	-	-	**77**	58	-	-	-	-	56	56
Industrial	R10_1	697 Gardeners Road, Alexandria	75	-	-	**79**	72	-	-	**85**	**81**	-	-	-	-	64	64
Industrial	R10_2	697 Gardeners Road, Alexandria	75	-	-	**80**	73	-	-	**87**	**82**	-	-	-	-	66	66
Industrial	R10_3	697 Gardeners Road, Alexandria	75	-	-	**79**	64	-	-	**86**	74	-	-	-	-	62	62
Industrial	R10_4	697 Gardeners Road, Alexandria	75	-	-	75	50	-	-	**81**	59	-	-	-	-	59	59

Notes:

1. **Bold** indicates exceedance of NML

2. Activity not proposed during OOHW period

Table 4-7: Predicted OOHW (evening) $L_{Aeq(15min)}$ noise levels for construction plant and activities, dB(A)

Receiver			NML	Predicted construction noise level, $L_{Aeq,15min}$													
NCA	NCA ID	Address		Site establishment[2]		Demolition		Utilities[2]		Piling		Surface preparation		Building construction		Building fitout	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
NCA01A	R1_1	34 Campbell Road, Alexandria	62	-	-	**66**	49	-	-	**76**	57	46	37	46	37	39	39
NCA01B	R1_2	34 Campbell Road, Alexandria	52	-	-	**58**	45	-	-	**67**	**54**	39	34	39	34	33	33
NCA01B	R1_3	34 Campbell Road, Alexandria	52	-	-	**67**	50	-	-	**76**	**58**	50	38	50	38	41	41
NCA01A	R2	20 Campbell Road, Alexandria	62	-	-	**65**	48	-	-	**70**	56	44	36	44	36	39	39
NCA01A	R3	4 Campbell Road, Alexandria	62	-	-	**65**	48	-	-	**65**	56	44	36	44	36	37	37
NCA02	R4_1	671 Gardeners Road, Mascot	56	-	-	**64**	**58**	-	-	**73**	**70**	52	47	52	47	51	51
NCA02	R4_2	671 Gardeners Road, Mascot	56	-	-	**63**	**57**	-	-	**72**	**70**	51	47	51	47	50	50
Active recreation	R5	Sydney Park	65	-	-	65	50	-	-	**75**	57	53	37	53	37	44	44
Commercial	R6_1	33 Burrows Road, St Peters	70	-	-	**84**	**72**	-	-	**94**	**82**	**72**	62	**72**	62	54	54
Commercial	R6_2	33 Burrows Road, St Peters	70	-	-	**84**	**73**	-	-	**93**	**84**	**72**	63	**72**	63	48	48
Commercial	R6_3	33 Burrows Road, St Peters	70	-	-	**86**	**77**	-	-	**96**	**87**	**74**	65	**74**	65	47	47
Commercial	R7_1	32 Burrows Road, St Peters	70	-	-	**95**	**76**	-	-	**99**	**86**	**75**	65	**75**	65	65	65
Commercial	R7_2	32 Burrows Road, St Peters	70	-	-	**94**	**76**	-	-	**98**	**87**	**74**	65	**74**	65	66	66
Commercial	R8_1	24-26 Burrows Road, St Peters	70	-	-	**100**	**77**	-	-	**104**	**86**	**78**	65	**78**	65	50	50
Commercial	R8_2	24-26 Burrows Road, St Peters	70	-	-	**101**	**76**	-	-	**103**	**86**	**79**	65	**79**	65	66	66
Industrial	R9	67 Bourke Road, Alexandria	75	-	-	69	49	-	-	**77**	58	56	39	56	39	56	56
Industrial	R10_1	697 Gardeners Road, Alexandria	75	-	-	**79**	72	-	-	**85**	**81**	65	60	65	60	64	64
Industrial	R10_2	697 Gardeners Road, Alexandria	75	-	-	**80**	73	-	-	**87**	**82**	68	64	68	64	66	66
Industrial	R10_3	697 Gardeners Road, Alexandria	75	-	-	**79**	64	-	-	**86**	74	66	61	66	61	62	62
Industrial	R10_4	697 Gardeners Road, Alexandria	75	-	-	75	50	-	-	**81**	59	61	42	61	42	59	59

Notes:

1. **Bold** indicates exceedance of NML

2. Activity not proposed during OOHW period

Table 4-8: Predicted OOHW (night) $L_{Aeq(15min)}$ noise levels for construction plant and activities, dB(A)

Receiver			NML	Predicted construction noise level, $L_{Aeq,15min}$													
NCA	NCA ID	Address		Site establishment[2]		Demolition[2]		Utilities[2]		Piling[2]		Surface preparation		Building construction		Building fitout	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
NCA01A	R1_1	34 Campbell Road, Alexandria	55	-	-	-	-	-	-	-	-	-	-	-	-	39	39
NCA01B	R1_2	34 Campbell Road, Alexandria	46	-	-	-	-	-	-	-	-	-	-	-	-	33	33
NCA01B	R1_3	34 Campbell Road, Alexandria	46	-	-	-	-	-	-	-	-	-	-	-	-	41	41
NCA01A	R2	20 Campbell Road, Alexandria	55	-	-	-	-	-	-	-	-	-	-	-	-	39	39
NCA01A	R3	4 Campbell Road, Alexandria	55	-	-	-	-	-	-	-	-	-	-	-	-	37	37
NCA02	R4_1	671 Gardeners Road, Mascot	52	-	-	-	-	-	-	-	-	-	-	-	-	51	51
NCA02	R4_2	671 Gardeners Road, Mascot	52	-	-	-	-	-	-	-	-	-	-	-	-	50	50
Active recreation	R5	Sydney Park	65	-	-	-	-	-	-	-	-	-	-	-	-	44	44
Commercial	R6_1	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	54	54
Commercial	R6_2	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	48	48
Commercial	R6_3	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	47	47
Commercial	R7_1	32 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	65	65
Commercial	R7_2	32 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	66	66
Commercial	R8_1	24-26 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	50	50
Commercial	R8_2	24-26 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	-	-	-	-	66	66
Industrial	R9	67 Bourke Road, Alexandria	75	-	-	-	-	-	-	-	-	-	-	-	-	56	56
Industrial	R10_1	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	-	-	-	-	64	64
Industrial	R10_2	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	-	-	-	-	66	66
Industrial	R10_3	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	-	-	-	-	62	62
Industrial	R10_4	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	-	-	-	-	59	59

Notes:

1. **Bold** indicates exceedance of NML

2. Activity not proposed during OOHW period

Table 4-9: Predicted OOHW (morning shoulder) $L_{Aeq(15min)}$ noise levels for construction plant and activities, dB(A)

Receiver			NML	Predicted construction noise level, $L_{Aeq,15min}$													
NCA	NCA ID	Address		Site establishment[2]		Demolition[2]		Utilities[2]		Piling[2]		Surface preparation		Building construction		Building fitout	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
NCA01A	R1_1	34 Campbell Road, Alexandria	58	-	-	-	-	-	-	-	-	46	37	46	37	39	39
NCA01B	R1_2	34 Campbell Road, Alexandria	50	-	-	-	-	-	-	-	-	39	34	39	34	33	33
NCA01B	R1_3	34 Campbell Road, Alexandria	50	-	-	-	-	-	-	-	-	50	38	50	38	41	41
NCA01A	R2	20 Campbell Road, Alexandria	58	-	-	-	-	-	-	-	-	44	36	44	36	39	39
NCA01A	R3	4 Campbell Road, Alexandria	58	-	-	-	-	-	-	-	-	44	36	44	36	37	37
NCA02	R4_1	671 Gardeners Road, Mascot	54	-	-	-	-	-	-	-	-	52	47	52	47	51	51
NCA02	R4_2	671 Gardeners Road, Mascot	54	-	-	-	-	-	-	-	-	51	47	51	47	50	50
Active recreation	R5	Sydney Park	65	-	-	-	-	-	-	-	-	53	37	53	37	44	44
Commercial	R6_1	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**72**	62	**72**	62	54	54
Commercial	R6_2	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**72**	63	**72**	63	48	48
Commercial	R6_3	33 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**74**	65	**74**	65	47	47
Commercial	R7_1	32 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**75**	65	**75**	65	65	65
Commercial	R7_2	32 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**74**	65	**74**	65	66	66
Commercial	R8_1	24-26 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**78**	65	**78**	65	50	50
Commercial	R8_2	24-26 Burrows Road, St Peters	70	-	-	-	-	-	-	-	-	**79**	65	**79**	65	66	66
Industrial	R9	67 Bourke Road, Alexandria	75	-	-	-	-	-	-	-	-	56	39	56	39	56	56
Industrial	R10_1	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	65	60	65	60	64	64
Industrial	R10_2	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	68	64	68	64	66	66
Industrial	R10_3	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	66	61	66	61	62	62
Industrial	R10_4	697 Gardeners Road, Alexandria	75	-	-	-	-	-	-	-	-	61	42	61	42	59	59

Notes:

1. **Bold** indicates exceedance of NML

2. Activity not proposed during OOHW period

Table 4-10: Predicted OOHW (Night) L_{Amax} noise levels for construction plant and activities, dB(A)

Receiver				Predicted construction noise level, $L_{Aeq,15min}$						
NCA	NCA ID	Address	NML	Site establishment[2]	Demolition[2]	Utilities[2]	Piling[2]	Surface preparation[2]	Building construction[2]	Building fitout
NCA01A	R1_1	34 Campbell Road, Alexandria	65	-	-	-	-	-	-	51
NCA01B	R1_2	34 Campbell Road, Alexandria	56	-	-	-	-	-	-	45
NCA01B	R1_3	34 Campbell Road, Alexandria	56	-	-	-	-	-	-	53
NCA01A	R2	20 Campbell Road, Alexandria	65	-	-	-	-	-	-	51
NCA01A	R3	4 Campbell Road, Alexandria	65	-	-	-	-	-	-	49
NCA02	R4_1	671 Gardeners Road, Mascot	62	-	-	-	-	-	-	62
NCA02	R4_2	671 Gardeners Road, Mascot	62	-	-	-	-	-	-	61

Notes:

1. **Bold** indicates exceedance of NML
2. Activity not proposed during OOHW period

Table 4-11: Predicted OOHW (Shoulder) L_{Amax} noise levels for construction plant and activities, dB(A)

Receiver				Predicted construction noise level, $L_{Aeq,15min}$						
NCA	NCA ID	Address	NML	Site establishment[2]	Demolition[2]	Utilities[2]	Piling[2]	Surface preparation	Building construction	Building fitout
NCA01A	R1_1	34 Campbell Road, Alexandria	68	-	-	-	-	58	58	51
NCA01B	R1_2	34 Campbell Road, Alexandria	60	-	-	-	-	51	51	45
NCA01B	R1_3	34 Campbell Road, Alexandria	60	-	-	-	-	62	62	53
NCA01A	R2	20 Campbell Road, Alexandria	68	-	-	-	-	56	56	51
NCA01A	R3	4 Campbell Road, Alexandria	68	-	-	-	-	56	56	49
NCA02	R4_1	671 Gardeners Road, Mascot	64	-	-	-	-	64	64	62
NCA02	R4_2	671 Gardeners Road, Mascot	64	-	-	-	-	63	63	61

Notes:

1. **Bold** indicates exceedance of NML
2. Activity not proposed during OOHW period

4.3.2 Discussion of construction noise results

4.3.2.1 Standard daytime hours

4.3.2.1.1 Residential receivers

The predicted noise levels presented above indicate that the noise levels during standard daytime hours are generally predicted to comply with the NMLs for nearby affected receivers. However, where high noise generating plant and equipment is in use such rock breakers and impact piling, noise levels predicted to be up to 8 dB(A) and 17 dB(A) above the NMLs respectively. This would only occur where there is direct line of sight to the residences on Campbell Road. For a large portion of the site, the WestConnex Transurban MCC Main Office provides shielding to these residences. Therefore, impacts would typically be less than the worst case scenario presented. For residences in NCA02 on Gardeners Road, with the exception of impact piling, noise levels are predicted to comply with the NMLs.

4.3.2.1.2 Non-residential receivers

The commercial and industrial receivers surrounding the site are generally predicted to experience construction noise above the relevant NMLs for most construction activities. Impacts would be greatest during demolition, utility works and impact piling. During the worst case scenario for impact piling near the boundaries of the site, noise levels are predicted to be more than 30 dB(A) above the NML at the adjacent commercial receivers.

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise. Further details on construction noise mitigation and management measures are provided in Section 4.3.4 below.

As detailed in Section 4.2.2, given the large exceedances predicted at the nearby commercial receivers, to manage these impacts there is an opportunity to conduct these high noise generating activities outside standard hours on the weekend and in the evening periods. However, this would cause higher impacts to surrounding residences should construction works take place during these OOH periods. Predicted OOH impacts have been assessed in the following sections.

4.3.2.2 Outside of standard construction hours

4.3.2.2.1 OOHW (daytime)

Demolition, impact piling and building fitout works have been assessed during the OOHW daytime period.

For the demolition works, noise levels are predicted to be up to 13 dB(A) above the NML for the worst case scenario at residences in NCA01, and 3 dB(A) above the NML for residences in NCA02. However,

when these works take place at other locations within the construction site, the noise levels are predicted to comply with the OOH (daytime) NML.

For the impact piling works, noise levels are predicted to be up to 22 dB(A) above the NML for the worst case scenario at residences in NCA01, and 12 dB(A) above the NML for residences in NCA02.

Building fitout works have been assessed assuming deliveries may be required for the works. Noise levels at all residential receivers during these works are predicted to comply with the OOH (daytime) NMLs.

4.3.2.2.2 OOHW (evening)

Demolition, impact piling, concrete pours associated with surface preparation, building construction and building fitout works have been assessed during the OOHW evening period.

For the demolition works, noise levels are predicted to be up to 15 dB(A) above the NML for the worst case scenario at residences in NCA01, and 8 dB(A) above the NML for residences in NCA02. For the impact piling works, noise levels are predicted to be up to 24 dB(A) above the NML for the worst case scenario at residences in NCA01, and 17 dB(A) above the NML for residences in NCA02. Substantially lower noise levels are predicted when works take place at other locations within the construction area when there is acoustic shielding, such as the Transurban MCC Main Office between the source and receiver.

Concrete pours associated with the surface preparation and building construction have been assumed to occur with no direct line of sight to the residences in NCA01 on Campbell Road. Management of these key noise sources so that there is acoustic shielding would likely be both reasonable and feasible. Assuming no line of sight, noise levels are predicted to comply with the NMLs at all receivers in NCA01. Noise levels are also predicted to comply with the OOH (evening) NML at all residences in NCA02.

Building fitout works have been assessed assuming deliveries may be required for the works. Noise levels at all residential receivers are predicted to comply with the OOH (evening) NMLs.

4.3.2.2.3 OOHW (night)

Building fitout works have been assessed during the OOHW night period. Building fitout works have been assessed assuming deliveries may be required for the works. Noise levels at all residential receivers are predicted to comply with the NMLs.

Maximum noise levels have been assessed and are predicted to comply with the night-time sleep disturbance screening levels at all residential receivers.

4.3.2.2.4 OOHW (shoulder period)

Concrete pours associated with surface preparation and building construction and building fitout works have been assessed during the OOHW morning shoulder period.

Concrete pours associated with the surface preparation and building construction have been assumed to occur with no direct line of sight to the residences in NCA01 on Campbell Road. Management of these key noise sources so that there is acoustic shielding would likely be both reasonable and feasible. Assuming no line of sight, noise levels are predicted to comply with the NMLs at all receivers in NCA01. Noise levels are also predicted to comply at all residences in NCA02.

Building fitout works have been assessed assuming deliveries may be required for the works. Noise levels at all residential receivers are predicted to comply with the NMLs.

Maximum noise levels have been assessed and are predicted to comply with the morning shoulder period sleep disturbance screening levels at all residential receivers.

4.3.2.2.5 Summary of proposed impacts outside of standard construction hours

A number of construction works are proposed to take place outside of standard construction hours due to the reason detailed in Section 4.2.2. This section has assessed the associated potential noise impacts as a result of these works.

Generally, across the proposed demolition, concrete pours associated with surface preparation, building construction and building fitout works, where the construction works take place at the worst case locations within the construction area, the works are predicted to exceed the relevant NML. However, where the works are managed so as to occur in acoustically shielded locations, the impacts can generally be managed so as to achieve the NMLs at nearby residential receivers. This demonstrates that the use of OOH periods to manage impacts to adjacent non-residential receivers should be considered further as part of further design development during the construction stage.

Similarly for impact piling, noise impacts are generally predicted to exceed the OOH NML at nearby noise sensitive receivers. However, noting that level of exceedance predicted at the adjacent receivers, use of OOH periods to manage impacts to adjacent receivers should be considered further as part of further design development during the construction stage. However, this should be balanced with increased impacts at nearby residences.

4.3.3 Cumulative noise impacts

A number of construction projects are taking place in the vicinity of the Project with the potential impact similar noise and vibration sensitive receivers. The following construction projects presented in Table 4-12 have been identified as potentially undertaking noise generating works during the construction of the Project:

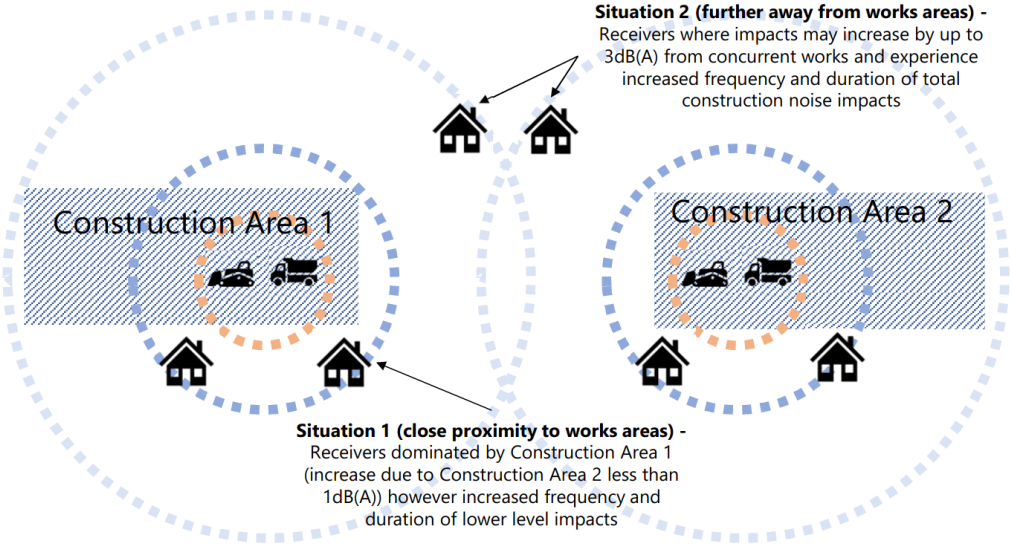
Table 4-12: Nearby projects with the potential for cumulative construction impacts

Site	Application Reference	Project	Comments
Sydney Gateway Road Project	SSI-9737	New, toll-free connection from St Peters Interchange to improve journey times to Sydney Airport, the M5 and Eastern Distributor	Under construction. Proposed opening 2024.

Site	Application Reference	Project	Comments
Botany Rail Duplication	SSI-9714	Duplicating of an existing 2.9 kilometres long freight only rail single track single rail track between Mascot and Botany, increasing capacity of the line.	Under construction. Proposed opening 2024.
WestConnex	SSI-6788	M4 & M5 tunnels	Under construction. Proposed opening 2023.
1-3 Burrows Road	SSD-35962232	Four storey warehouse and distribution centre	Prepare EIS stage.
84 Burrows Road (Alexandria Transfer Station)	SSD-35784535	Proposed putrescible waste transfer station that handles up to 180,000 tonnes per annum (tpa) of waste from commercial and industrial (C&I) and municipal solid waste (MSW) markets	Prepare EIS stage.
520 Gardeners Road	SSD-32489140	Construction, fit out and operation of a new three-level warehouse and distribution centre.	Currently at assessment stage. Construction is proposed to be completed 2023.
76-82 Burrows Road	D/2022/234	Proposed alterations and additions to Alexandria Material Recovery Facility.	Currently at assessment stage.
45 Burrows Road (also known as 202-212 Euston Road, Alexandria)	D/2020/625	Two double storey warehouse buildings.	Under construction.

Typically, while impacts from one project or one construction site may be relatively short-term or noise intensive periods intermittent, when multiple construction projects are occurring at the same time near to a particular receiver cumulative construction noise impacts can occur. This can mean that construction noise impacting a sensitive receiver may be louder than from an individual set up works [by up to 3 dB(A)], the overall duration of construction impacts may be overall longer or impacts more frequent. Typically, concurrent projects can impact nearby receiver locations in one of two ways, as also shown in Figure 4-2.

Figure 5: Cumulative construction



As there is potential for cumulative noise impacts from the Project combined with other concurrent construction projects it is recommended that mitigation and management measures are implemented to minimise cumulative impacts, as detailed in Section 4.3.4. In addition, the following measures are to be used to mitigate and manage cumulative noise impacts along with potential construction fatigue:

- Coordinating work between construction sites to minimise cumulative noise impacts, where feasible and reasonable (ie. to ensure that multiple sites are not undertaking noise intensive works concurrently with direct line-of-sight to receivers, construction impacts from one construction site impact the same receiver that is experiencing a respite period from another project).

- Community consultation to gauge key noise impacts and issues and identify any unknown impacts from concurrent or consecutive sets of constructions works.

- Consideration of cumulative construction noise impacts during the development of noise mitigation and management measures for the worksites, including coordination between construction projects, where reasonable and feasible.

These mitigation measures would be included in the CNVMP or CEMP and would include how the above measures would be incorporated during the works.

4.3.4 Construction noise mitigation measures

4.3.4.1 Noise management measures

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. **These should be considered and implemented where feasible and reasonable where there is potential for the noise management levels presented in Section 3.1 to be exceeded by the construction works either individually or cumulatively**.

Taking into account the predicted noise levels set out in Section 4.3.1 the following noise management are recommended for consideration by a contractor and implemented where feasible and reasonable. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table 4-13 summarises actions that can be applied to manage the potential for noise to impact on sensitive receivers near the Project construction works, which are to be applied where reasonable and feasible.

Table 4-13: Noise mitigation and management measures

Action required	Applies to	Details	Estimated noise benefit
At-source mitigation measures			
Equipment selection	Airborne noise Vibration	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable. Where loud plant and/or equipment are being used in construction works, where feasible and reasonable the selection of alternative quieter plant and/or equipment should be considered for tasks.	Variable. Minimise noise impact and reduce risk of annoyance.
Equipment noise and vibration levels	Airborne noise Vibration	Plant and equipment must be properly maintained. Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.	Variable. Minimise noise impact and reduce risk of annoyance.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions, with quieter and less noise/vibration emitting construction methods where feasible and reasonable.	Variable. Minimise noise impact and reduce risk of annoyance.
Use and siting of plant	Airborne noise Vibration	• Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. • The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. • Plant used intermittently to be throttled down or shut down. • Noise-emitting plant to be directed away from sensitive receivers. • Any equipment not in use for extended periods during construction work must be switched off.	Up to 20 dB reduction + reduce vibration
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.	5-10 dB reduction
Minimise disturbance arising from delivery of goods	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers if possible. Delivery vehicles to be fitted with straps ratherthan chains for unloading, wherever possible.	Variable. Reduce noise/ vibration impact + risk of annoyance.
Silencers on mobile plant	Airborne noise	Where possible reduce noise from mobile plant through additional fittings including: - Residential grade mufflers - Air Parking brake engagement is silenced. Ensure plant including the silencer is well maintained.	0-20 dB reduction Reduce annoyance + sleep disturbance.
Prefabrication of materials off-site	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.	5-20 dB reduction Reduce noise/ vibration impact + risk of annoyance

Action required	Applies to	Details	Estimated noise benefit
Engine compression brakes	Airborne noise	Limit the use of engine compression brakes in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.	5-20 dB reduction
Reversing alarms	Airborne noise	Use of broadband "quacker" type of reverse/movement alarms instead of the tonal 'beeping" type.	Minimise noise impact and reduce risk of annoyance.
Path mitigation measures			
Construction hoarding as noise barrier	Airborne noise	Any construction hoarding shall be installed on each worksite shall be constructed as a noise barrier, where practicable to provide shielding to the nearest affected receivers.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Site sheds	Airborne noise	Site sheds to be strategically located to provide shielding to nearby residences.	Receiver **with** line of site of the works area: 5-10 dB reduction
Laydown and stockpiling	Airborne noise	Locate laydown and staging areas within the construction area as far from residences as practicably possible.	Variable. Minimise noise impact and reduce risk of annoyance.
Shield stationary noise sources such as pumps, compressors etc	Airborne noise	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.	5-10 dB reduction
Use temporary noise barriers around work area	Airborne noise	Where works are to be completed as OOHW outside the construction hoarding area, relocatable noise barriers e.g. acoustic blankets hung from temporary construction fencing would be used, where practicable.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Mobile noise screens	Airborne noise	Where practicable, a mobile noise screen/tent would be used to reduce noise from moving plant items e.g. concrete saw. Mobile noise screens utilise aluminium mobile scaffold (or similar), with acoustic blanket/ quilt (e.g. Echo-barrier, FlexShield or similar) attached on up to 4 sides (including the top, where no solid platform). Mobile noise screens can provide 5 to 10 dB noise reduction, where they can break line of sight between the source and the receiver.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Management measures			
Construction Environmental Management Plan update	Airborne noise Vibration	The CEMP including at minimum relevant section for construction noise and vibration management must be prepared prior to the commencement of construction and regularly updated to account for changes in noise management issues and strategies.	-

Action required	Applies to	Details	Estimated noise benefit
Implement stakeholder consultation measures	Airborne noise	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted to notify the community of upcoming works: • Project Specific Website • Project Infoline • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings.	Keeps stakeholders informed of the likely impact. Community may identify solution to assist in managing impacts.
Register of noise and vibration sensitive receivers	Airborne noise Vibration	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document.	Assists with keeping stakeholders informed of the likely impact. Assists with planning and reducing potential noise/ vibration impact + risk of annoyance
Site inductions	Airborne noise Vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Keeps construction workforce informed of actions required to minimise noise and vibration impact.
Construction hours and scheduling	Airborne noise Vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise levels and vibration intensive plant identified within minimum working distances for human response should be scheduled during less sensitive time periods, such as after 8 am and before 6 pm. If the work cannot be undertaken during the day, it should be completed before 11 pm.	Minimise noise and vibration impact and reduce risk of annoyance.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.	0-20 dB reduction Reduce annoyance

Action required	Applies to	Details	Estimated noise benefit
Heavy vehicle routes	Airborne noise	Construction heavy vehicles and delivery vehicles should be scheduled during standard construction hours where feasible and reasonable.	Minimises noise impacts
Verification monitoring	Airborne noise	In response to noise complaints, a noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan (CNVMP) or CEMP and any approval conditions.	Minimises noise impacts
Complaints management	Airborne noise Vibration	See Section 4.5 for further details. In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.	Minimise noise impact and reduce risk of annoyance.

Additionally, implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 '*Guide to Noise Control on Construction, Demolition and Maintenance Sites*', are expected to reduce predicted construction noise levels. Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

4.3.4.2 Highly noise affected receivers

Some residential receivers nearest to the construction work areas may be 'highly noise affected' [ie exposed to noise levels that exceed 75 dB(A)] as a result of high noise generating works (ie. impact piling) in close proximity.

As such, where construction noise is likely to be above the 'highly noise affected' level, respite periods should be considered where feasible and reasonable. The following potential respite periods would be considered:

- High noise impact activities carried out in continuous blocks of up to three hours. Respite provided between each block of high noise impact activities for at least one hour. No high noise impact activities carried out during this one hour respite period.
- Where an alternative approach to the above is preferable, a respite period can be agreed upon with the potentially impacted receivers if the premises are occupied during the construction period. Potential respite periods would limit the use of high impact activities, such as hammering or impact piling, to say 9:00am to 5:00pm with a one hour break during this period.

4.3.4.3 Noise impacts to nearby commercial and industrial receivers

The surrounding commercial and industrial receivers nearest to the proposal are predicted to experience construction noise that significantly exceeds the NMLs. In particular, the commercial tenancies to the 24-26 Burrows Road, to the east at the 32 Burrows Road, and across the road to the north at 33 Burrows Road.

As such, for construction activities with high noise generating plant and equipment, such as hydraulic hammers and impact piling, periods of high noise, consultation with affected receivers should be conducted to determine all feasible and reasonable mitigation measures. The following types of management measure could be considered to manage impacts:

- Respite periods throughout the day from high noise impact activities. Typically respite periods should be at least 1 hour long. During these periods no high noise impact activities should be carried out.

- High noise construction activities when potentially impacted commercial tenancies are not in use (ie. outside recommended standard hours) to better manage the overall impacts of construction noise and vibration. It is highly recommended that consideration be given to alternative construction hours for high noise and vibration generating plant and equipment. This is further discussed in Section 4.3.4.4 below.

4.3.4.4 Construction works outside standard hours

As discussed in Section 4.2.2 and 4.3.2, this assessment has considered the impacts of high generating noise and vibration activities during outside standard hours. Given the impacts to nearby commercial receivers during standard construction hours, conducting certain activities outside standard hours could assist with minimising noise impacts to surrounding commercial receivers. However, this would lead to higher exceedances at nearby residential receivers during these time periods, as detailed in Section 4.3.2 which would require further management.

In addition, this assessment has also considered various types of low impact construction works such as concrete pours and deliveries during outside standard hour. The results presented indicate that there is scope to perform certain types of construction activities outside of the standard construction hours with compliance of the relevant noise goals at nearby residential receivers predicted.

It is therefore recommended that undertaking construction works outside of standard construction hours be considered to manage potential noise impacts, with all relevant stakeholders consulted with to negotiate construction hours for the Project to manage the overall construction noise impacts.

4.3.4.5 Noise monitoring

The following approach could be adopted with regard to noise monitoring procedures during the construction works.

- In the event of a sustained complaint, noise monitoring may be carried out to examine noise impacts.
  - Reasonable and feasible noise reduction measures must be investigated, where necessary.
  - Typically, short term (attended) noise monitoring would be undertaken to investigate a complaint as opposed to ongoing noise logging as this will enable a faster response time.
  - In the event that short term (attended) noise measurements cannot produce a suitable outcome, long term noise monitoring will be considered. Typically, long term monitoring is useful primarily as a means to check if start/finish times or respite periods have been adhered to. Given this limitation, they are not typically proposed in the first instance.

As part of further design development, when a contractor is appointed and the specific construction methodology is known and the likely construction equipment are also known, the potential construction impacts are to be reviewed to determine that they are consistent with those presented in this SSDA NVIA and that the associated mitigation and management measures are appropriate.

4.4 Construction vibration assessment

4.4.1 Vibration sources

The pattern of vibration radiation is very different to the pattern of airborne noise radiation and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration, and the receiver structure.

The recommended minimum working distances for vibration intensive plant are presented in Table 4-14 and Table 4-15. Site specific minimum working distances for vibration intensive plant items must be measured on site where plant and equipment are likely to operate close to or within the minimum working distances for cosmetic damage, as detailed in Table 4-14.

Unlike noise, vibration cannot be readily predicted. There are many variables from site to site, such as soil type and conditions, sub surface rock, building types and foundations, and actual plant on site.

The data relied upon in this assessment (tabulated below) is taken from a database of vibration levels measured at various sites or obtained from other sources (such as BS5228-2:2009). They are not specific to this proposal as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

As such, potential vibration impacts are to be further reviewed during the construction design, planning stages to determine if the final selected plant and equipment could be located within the minimum working distances and/or result in vibration levels about the applicable vibration limits. Where then identified, and feasible and reasonable mitigation and management would be implemented to achieve the applicable vibration limits.

Table 4-14: Minimum working distances (m) for cosmetic damage (continuous vibration)

Plant item	Minimum working distance (m)[5]		
	Reinforced or framed structures (e.g. commercial buildings)[1,3]	Unreinforced or light framed structures (e.g. residential buildings)[1,3]	Sensitive structures (e.g. heritage structures)[2,4]
Place compactor/Wacker packer	5	5	5
Truck-mounted drill rig / bored piling	5	5	10
Light hydraulic hammer (up to 5t)	5	5	10
10-15t excavator with hydraulic hammer attachment	5	5	10
Smooth drum roller (13t) - High vibration	5	5	15
Smooth drum roller (13t) - Low vibration	5	5	10
Piling rig (driven)[6]	20	50	70

Notes
1. Criteria referenced from British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings'.
2. Criteria referenced from DIN 4150 Part 3, Structural Damage - Safe Limits for Short-term Building Vibration.
3. Initial screening test criteria reduced by 50% due to potential dynamic magnification in accordance with BS7385.
4. A site inspection should determine whether a heritage structure is structurally unsound.
5. Minimum working distances are in 5m increments only to account for the intrinsic uncertainty of this screening method.
6. Based upon Junttan PM26 impact piling rig in use.

Table 4-15: Minimum working distances (m) for human annoyance (continuous vibration)

Plant item	Minimum working distances (m)				
	Critical areas[2,3] 0.28 mm/s	Residences		Offices[2] 1.1 mm/s	Workshops[2] 2.2 mm/s
		Day[1] 0.56mm/s	Night[1] 0.40 mm/s		
Place compactor/Wacker packer	20	10	15	5	5
Truck-mounted drill rig / bored piling	30	20	20	10	10
Light hydraulic hammer (up to 5t)	25	20	20	15	10
10-15t Excavator with hydraulic hammer attachment	30	20	25	15	10
Smooth drum roller (13t) - High vibration	105	55	75	30	15
Smooth drum roller (13t) - Low vibration	75	40	55	20	10
Piling rig (driven)[4]	380	230	-[5]	140	80

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Appliable when in use
3. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992
4. Based upon Junttan PM26 impact piling rig in use.
5. Not proposed during the night period

4.4.2 Vibration assessment

4.4.2.1 Cosmetic damage

4.4.2.1.1 Adjacent commercial buildings

For impact piling, the minimum working distance for cosmetic damage for a reinforced framed building is 20 metres. Based on a desktop review of the site, it is anticipated that all surrounding commercial buildings adjacent to the site would be classified as reinforced structures. For the piling works, the nearest building is located to the west at 24-26 Burrows Road and is approximately 10 metres from the building footprint and so would be located within the minimum working distance.

For the demolition and surface works activities where a hydraulic hammer and drum roller would be required, the minimum working distance for cosmetic damage for reinforced framed buildings is five metres. The existing hardstand for the Project site would be demolished during the demolition phase of works. This would mean that the demolition works could need to occur within the minimum working distance for 24-26 Burrows Road. As such, vibration mitigation and management measures may be required for these works as outlined in Section 4.4.3.

4.4.2.1.2 Alexandra Canal

The Alexandra Canal is located directly south of the site. This is a water-related infrastructure asset owned by Sydney Water.

As part of the SEARs, Sydney Water identified that the proponent should ensure that satisfactory steps/measures are taken to protect existing stormwater assets including the Alexandra Canal, which would include this canal. Additionally, this canal is a listed heritage item. As such, care should be taken to appropriately manage potential construction vibration impacts on the canal structure.

The existing hardstand would be demolished and is directly adjacent to the Alexandra Canal. The use of hydraulic hammers during the breakout of the hardstand would therefore be within the minimum working distance for an unsound heritage structure of 10 metres.. In addition, the minimum working distance for a drum roller is between 10 to 15 metres for an unsound heritage structure. Vibration mitigation and management measures may be required for these works as outlined in Section 4.4.3.Driven piles will be required to construct the foundations for the building. Based on the proposed footprint of the Project building, the Alexandra Canal is approximately 25 to 30 metres from the footing impact piling locations. This distance is less than the minimum working distance for an unsound heritage structure for impact piling works.

It is understood that impact piling is required as the soil under the proposal site is potentially contaminated with asbestos and other harmful substances. Other piling methodologies such as bored piles would create potentially harmful spoil waste that would need to be disposed of, potentially put working and surrounding receivers at risk. Given that impact piling is required, the determination of a suitable vibration limit for the Alexandra Canal, along with suitable management measures where this

limit cannot be practicably achieved, should be determined in consultation with Sydney Water to appropriately manage potential construction vibration impacts on the canal structure.

It should be noted that as this structure is not a building, and is fully supported, and so the applicable vibration limits for building structures as detailed in BS 7385 and DIN 4150 may not be appropriate for suitable management of vibration impacts as different opportunities to rectify cosmetic damage are potentially available. Additionally, the condition of the canal varies along the extent of the Project boundary. Considering these points, it is recommended that a structural engineering report is undertaken of the canal to confirm the structural integrity of the building, confirm if the item is 'structurally sound', and to determine appropriate vibration criteria that could be used to manage vibration impacts.

It is recommended that these items, along with the suitable standards for cosmetic damage impacts are considered in consultation with Sydney Water when determining appropriate vibration criteria that could be used to manage vibration impacts.

Following the determination of suitable vibration limits, where site specific measurements show that works are likely to occur within the minimum working distances for cosmetic damage, recommendations for the mitigation and management of vibration have been provided in Section 4.4.3.

4.4.2.2 Human annoyance

The nearest residence is approximately 250 metres from the proposal. The minimum working distance for impact piling is 230 metres. Based on this distance, there are no residences within the minimum working distance for human comfort.

The adjacent commercial receivers to the proposal on Burrows Road, along with the WestConnex Transurban MCC Main Office are within the minimum working of up to 140m metres for impact piling to commercial receivers.

Given that it is likely the human comfort levels will likely be exceeded at the nearby commercial receivers during the bulk of the demolition and piling phases of work, potential human annoyance impacts should be reviewed and appropriate feasible and reasonable management measures implemented when vibration intensive works are proposed to take place within the minimum working distances.

As previously discussed, the potential to conduct these high vibration works (demolition with rock breakers and impact piling) during outside standard hours to reduce impacts to the nearby commercial receivers should be further investigated.

4.4.3 Vibration management measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest receivers:

4.4.3.1 Cosmetic damage

1. Where construction activities occur in close proximity to sensitive receivers/structures or on material that will likely cause vibration to any identified receiver/structure, vibration testing of actual equipment on site should be carried out prior to their commencement of site operation to determine site specific acceptable minimum working distance to the nearby sensitive receiver/structures location/s.

   Undertake attended vibration measurements at the commencement of vibration-generating activities to establish site-specific minimum working distances and re-assess potential impacts (if required). This may include further detailed analysis based on the frequency content of the vibration levels.

2. If vibration intensive work is proposed to occur within the site specific acceptable minimum working distance, then the following would be carried out:

   d. Evaluate whether alternative construction methods, plant or equipment can be utilised for the works and re-assess potential impacts (if required).

   e. If there is any risk of exceeding the vibration objectives after all of the above options have been considered, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the structural/cosmetic damage limits. It is recommended that for the operator alerts, that multiple alert levels are set. Typically, this would be an alert trigger level at 75% of the vibration criteria (ie. amber alert), and an alert trigger level at 100% of the vibration criteria (ie. red alert).

   f. A management procedure would be developed prior to the works taking place to determine the response to each trigger level. It is recommended that this includes a pause and management measures for an alert trigger level at 75% of the vibration criteria, and stop work at an alert trigger level at 100% of the vibration criteria. Where stop work is triggered, it is recommended that the following are undertaken:

      Stop works actions

      i. Investigate cause of exceedance

      ii. Visual inspection of the vibration sensitive building/structure/item including photos

      iii. If no cosmetic damage is found, works and vibration monitoring can be resumed

      iv. If cosmetic damage has been identified, repair damage or undertake any specific required action and a different construction method with lower source vibration levels is to be used.

   g. If works are proposed within the cosmetic damage minimum working distance, prior to starting work a building/structure condition survey would be carried out on items within the minimum working distances and vibration limits determined to manage cosmetic damage.

3. Dilapidation surveys must be conducted at all receivers and structures within the vibration minimum working distances for the construction site for cosmetic damage prior to commencement of activities with the potential to cause property damage.

4.4.3.2 Human annoyance

Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures. At properties near the construction works, nearby receivers may be able to feel vibration when vibration-generating equipment is being utilised. For this reason, it is appropriate identify properties where there is a probability of adverse comment so that impacts can be managed.

1. A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Attended vibration measurements for human annoyance should be carried out as required to appropriately manage the works. The proximity of neighbouring residences will be communicated to subcontractors highlighting the relevant vibration restrictions and criteria for the area. This information will also be communicated during pre-tender meetings, start-up meetings and site inductions of personnel.

4. Notification by letterbox drop would be carried out for all buildings in the vicinity of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property. Notification is to be provided to all occupants prior to any works that may cause vibration.

5. Implement community consultation measures, including direct consultation with potentially impacted receivers.

4.4.3.3 Specific additional vibration management measures – Impact piling and hydraulic hammering construction works

4.4.3.3.1 Cosmetic damage

Due to the proximity of vibration sensitive structures (including nearby commercial receivers and the heritage listed Alexandra Canal structure) to the impact piling and hydraulic hammering construction

works, there is the potential for cosmetic damage to these structures if mitigation and management measures are not implemented.

This is of importance when considering the use of impact piling, which can generate high levels of vibration. Ground resistance varies as the pile is driven into the ground, causing vibration from impact piling to change over the course of the piling driving. Considering this, it is important that the potential worst-case vibration impacts are used when reviewing the piling methodology and potential vibration levels, and why continuous vibration monitoring will be important to appropriately manage potential vibration impacts.

The management of vibration impacts from piling would require specific review of the methodology and assessment of potential impacts during detailed design to be used by the construction contractor to minimise impacts from vibration. Where vibration levels are likely to be higher than the acceptable limits, further investigation of alternative piling techniques, scheduling and further management measures are to be considered. These measures may also assist in reducing the airborne noise impacts on the surrounding receivers.

Once the vibration intensive works methodologies are determined, site-specific minimum working distances for all vibration-intensive activities (e.g. hydraulic hammering and impact piling) that may impact vibration sensitive structures must be measured on site where plant and equipment are likely to operate close to or within the minimum working distances prior to the vibration intensive construction works commencing. These would also help inform and update the appropriate methodology to adopt to manage and mitigate impacts from the vibration intensive works. Unless specifically managed, vibration intensive works would take place outside of site-specific buffer distances to comply with relevant vibration limits for cosmetic damage for each vibration sensitive structure/item.

In addition, it is recommended that a dilapidation survey of the existing Alexandra Canal wall within the identified minimum working distances be conducted prior to construction.

4.4.3.3.2 Human annoyance

There is a high risk for adverse comment from the nearby commercial receivers with use of hydraulic hammers and impact piling within the minimum working distances for human comfort. The adjacent commercial receivers, including the WestConnex Transurban MCC Main Office will be exposed to vibration that is likely to be annoying when piling is occurring, or when hydraulic hammering is occurring nearby.

Given that it is likely the human comfort levels will likely be exceeded at the nearby commercial receivers during the bulk of the demolition and piling phases of work, potential human annoyance impacts should be reviewed when vibration intensive works are proposed to take place within the minimum working distances.

It is recommended that consultation be conducted with all commercial tenancies identified within the minimum working distances for impact piling to determine all feasible and reasonable methods for reducing vibration impacts. This could involve conducting impact piling and other vibration generating

works outside the regular business hours, or providing respite periods throughout the day. It is also recommended that consideration be given to piling during outside standard construction hours, as has been detailed and assessed in Section 4.3.

4.5 Complaints management

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

The contractor is responsible for ensuring that all reasonable and feasible mitigation and management measures are implemented such as the provision of a Noise and Vibration Complaints Program, to minimise the generation of excessive noise and/or vibration levels from the site to nearby sensitive areas.

Owners and occupants of nearby affected properties are to be informed by direct mail/email or a direct telephone line and contact person to either make a noise and/or vibration complaint or request information.

Nearby development should be notified of the proposed works.

The notification should outline:

- Detail of a site point of contact.
- The anticipated duration of the project.
- Identify the duration of the Demolition Stages.

Identify what stages will have greatest potential impact on each nearby sensitive receiver. This will provide much clearer information for each party about how the site work will impact them specifically (the duration over which the greatest noise impact will occur).

All noise and/or vibration complaints associated with the construction works shall be investigated in accordance with the Noise / Vibration Complaint Management Procedure identified in APPENDIX D.

5 Operational noise assessment

5.1 Operations noise sources

To undertake a noise and vibration assessment for the facility, the NPfI requires a comprehensive assessment of the potential operational noise emissions from the Project. The basis of these noise emissions is what would be the "reasonable worst case 15-minute period" noise emissions for each of the assessment periods (day, evening, night and morning shoulder).

The proposed operations are unlikely to significantly vary, and so will be similar 24/7. Details of the various activities associated with the operations of the Project are detailed in Section 1.3.3.

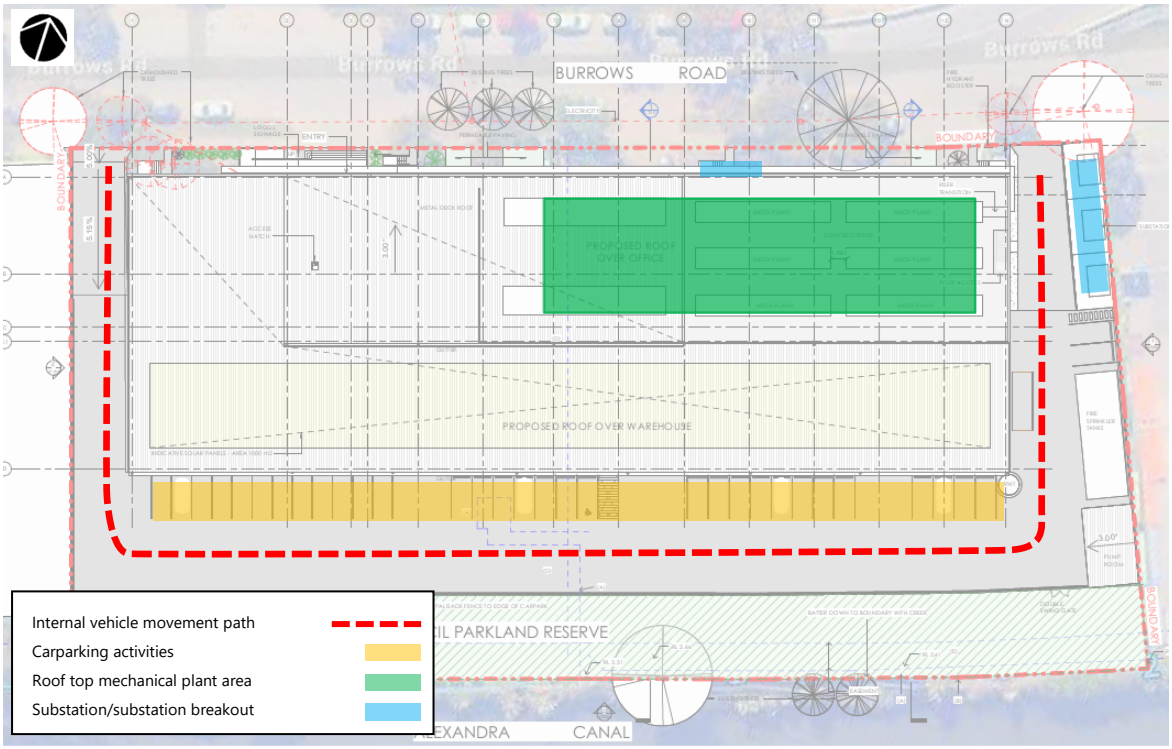
The key noise generating areas of the Project can be separated into the following categories:

- building services and mechanical plant and equipment
- bus and passenger vehicle movements and car parking

5.2 Key proposal noise sources

Figure 6 presents the Project plans showing the assumed locations of noise generating activities as part of the noise modelling based upon the operational information provided by the client and project team in preparation of this NVIA.

Figure 6: Indicative modelled noise generating components diagram



5.2.1 Mechanical plant and equipment

To carry out a quantitative assessment of mechanical equipment, a complete specification of equipment is required. At this stage of the project appropriate detail for mechanical plant and equipment is not available, and so preliminary indicative plant and equipment has been selected as part of the assessment. The key mechanical plant and equipment noise sources that have been considered for the noise assessment are detailed in Table 5-1 below.

Table 5-1: Key mechanical plant and equipment noise sources

Noise source	Number of units	Individual source/activity sound power level (L_w re. 1pW), $L_{Aeq,15min}$	Location	Mitigation
Chiller	2	90	Rooftop[1]	Acoustic screen to RL 20.515[2]
Water pump	3	90	Rooftop[1]	Acoustic screen to RL 20.515[2]
Water pump	2	82	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-G-01	1	89	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-G-02	1	80	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-F-01	1	89	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-F-02	1	87	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-S-01	1	89	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-S-02	1	89	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-G01	2	71	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-G03	1	65	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-F01	1	71	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-F02	1	70	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-F03	1	64	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-S01	2	71	Rooftop[1]	Acoustic screen to RL 20.515[2]
CU-ACU-S03	1	67	Rooftop[1]	Acoustic screen to RL 20.515[2]
Air handling unit	4	85	Rooftop[1]	1m rectangular duct with 90 degree elbow and 25mm lining on ductwork to external
Internal fans	10	58	Discharge on eastern facade	-
Transformer	3	80	Substation building	-
Transformer	1	80	Ground floor plant room	-

Notes:

1. All rooftop plant conservatively assessed at RL 20.715 (200mm above acoustic screen)
2. Noise screen included along the northern facade of roof to RL 20.515 (proposed height of parapet wall)

5.2.2 Vehicle movements and carparking

The carpark noise sources that have been considered for the noise assessment are detailed in Table 5-2 below.

Table 5-2: Key carpark noise sources

Noise source	Number of movements / events per 15 minutes	Reference sound power level (L_w re. 1pW)	Individual source/activity sound power level (L_w re. 1pW)
$L_{Aeq,15min}$ assessment			
Door slam	31	$L_{Aeq,15min}$	71
Car starts	8	$L_{Aeq,15min}$	83
Car movement up-ramp (entrance or exit)	8 movements (to or from carpark), approx., 40 metres distance travel into carpark from street	$L_{Aeq,t}$ Moving point source (10km/h)	83
Car movement on grade	8 movements (to or from carpark), approx., 60 metres travel in carpark	$L_{Aeq,t}$ Moving point source (10km/h)	79
Private bus (37 seater)	1 movement through the site	$L_{Aeq,t}$ Moving point source (10km/h)	96
L_{Amax} (sleep disturbance) assessment			
Door slam	-	L_{Amax}	96
Car starts	-	L_{Amax}	97

There would also be infrequent heavy vehicle movements associated with the operations of the project for deliveries and waste collection. As they would be infrequent and not be part of typical operations for the facility, they have not been included in the reasonable worst case 15 minute assessment of operational noise.

5.2.3 Emergency plant and equipment

The following noise generating plant are proposed to be included in the Project:

1. Two fire sprinkler pumps, located within a dedicated plant room in the south-east corner of the Project site.

Due to the infrequent and non-typical operating nature of these emergency plant and equipment items, they do not operate as part of normal reasonable worst-case operations as they are for emergency and stand-by usage only. For this reason and in the absence of any directly relevant NSW guideline or specific guidance for emergency and stand-by equipment, they do not form part of the reasonable worst case 15-minute scenario modelling.

However, feasible and reasonable mitigation and management should be implemented in accordance with the NPfI in order to minimise the potential noise impacts on nearby sensitive receivers. The project

trigger levels presented in Section 3.3.2.2.3 are not directly suitable or applicable to the stand-by and emergency plant but can serve as a guide for reviewing selections and feasible and reasonable mitigation and management at detailed design.

As such, the following recommendations should be incorporated:

1. For selection and installation of the fire sprinkler pumps, they are to be located within a ventilated structure, designed to minimise noise impacts at the nearest residential receivers directly south across Gardeners Road during testing and maintenance procedures.

2. All emergency plant and equipment are to be tested and maintained during the daytime weekday period (7:00 am to 6:00 pm).

3. All noise mitigation and management measures should generally be selected to not substantially increase the cumulative site noise emissions during testing [ie. not increase total site noise emissions by more than 5 dB(A)].

4. The design of noise levels from emergency plant and equipment should consider the internal noise level requirements during emergencies detailed in Section 4.6 of AS/NZS 1668:2015.

5.3 Noise prediction methodology

5.3.1 Modelling overview

Modelling and assessment of airborne noise impacts from the Project were determined by modelling the noise sources, receiver locations and topographical features, and possible noise mitigation measures using a 3D noise modelling package, CadnaA (Version 2021 MR 1). Noise modelling algorithms were used to calculate the contribution of each noise source at each identified sensitive receiver location and to predict the total noise from the site for the various reasonable worst-case scenarios developed for the Project.

The noise prediction model considers:

- Location of noise sources and sensitive receiver locations (including multi-storey buildings).
- Heights of sources and receivers referenced to digital ground contours (1 metre contour intervals) or relative to the Project building structure.
- Noise source levels of individual plant and equipment.
- Separation distances between sources and receivers.
- Ground type and reflections between sources and receivers (ground absorption value of 0 has conservatively been applied for all areas)
- Attenuation from barriers, buildings and structures (natural terrain and purpose built).

- Atmospheric losses and meteorological conditions.
- Feasible and reasonable noise mitigation/treatments and management measures that have been determined for the Project.

The CONCAWE noise propagation algorithm was implemented for assessing potential noise impacts because:

- As the potentially nearest residential receivers are located at distances of 250 metres from the Project, this algorithm allows for prevailing noise enhancing weather conditions to be included and accounted for in the assessment.
- CONCAWE allows for the meteorological conditions presented in NPfI Fact Sheet D to be directly considered.
- The CONCAWE algorithm at the receiver distances relevant to this assessment provides for a conservative assessment.

5.3.2 Meteorological factors

In accordance with the NPfI, the noise assessment considers the effects of adverse meteorological conditions such as wind and temperature inversions.

Noise modelling has conservatively considered temperature inversions and worst case source to receiver wind using the CONCAWE noise modelling algorithm implementing noise-enhancing meteorological conditions presented in NPfI Fact Sheet D.

5.3.3 Annoying noise characteristics adjustments

Where the character of the industrial noise is assessed as particularly annoying at a receiver location (i.e., if the resulting noise level at a receiver location is tonal, low frequency or is intermittent at night), then an adjustment would be added to penalise the predicted noise for its potential increase in annoyance. The Fact Sheet C of the NPfI provides definitive procedures for determining whether a modifying factor should be applied which is assessed as part of the Project. The corrections are to be added to the predicted noise levels at the receiver before comparison with the project noise trigger levels.

5.3.3.1 Tonality

There are 3 transformers located in the substation building at the eastern end of the site and one transformer located on the ground floor plant room on the northern facade of the proposal. These noise sources have been identified as tonal at source. To determine if a tonality penalty for the proposal is required in accordance with the NPfI, the noise contribution from the transformers was compared to the overall predicted noise levels from all sources from the proposal at the assessed receivers. Through the process, it was found that the overall predicted noise level from the proposal does not exceed the

screening test for tonality when all noise sources are operating. Based on this, a tonality penalty is required for the proposal noise emissions.

5.3.3.2 Low frequency

The proposed operations do not support or expect to have any sources that could result in low-frequency noise levels at nearby receivers, therefore noise emissions do not require a low-frequency noise penalty as identified in the NPfI.

5.3.3.3 Intermittent noise

The NPfI details that the test for intermittent noise that applies during the night period to be *"The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible."* and *"…where the level suddenly drops/increases several times during the assessment period…"*. During the environmental assessment stage it is not possible to listen and subjectively assess the noise at the receiver as required by the guideline. However, only where all of the following tests are met shall a penalty be applicable to the predicted noise level at the relevant receiver:

- the noise level fluctuates / cycles by more than 5 dB(A);
- this difference relates to a 'sudden' drop/increase in the activity noise level;
- this activity may occur multiple times during a 15-minute assessment period; and
- the predicted noise level from the subject source at a receiver is clearly audible over the ambient noise environment.

There are no intermittent noise sources for the proposal, therefore no intermittent penalty has been applied.

5.4 Noise predictions

5.4.1 Predicted operational noise levels $L_{Aeq,15min}$

The predicted operational $L_{Aeq,15min}$ noise levels for the proposal are presented in Table 5-3 below. The results presented include both calm and adverse meteorological conditions and provides results with and without the inclusion of a 1.8 metre high screen on the roof at the northern facade of the building. The noise levels have been assessed against the night-time PNTL, as this is the most stringent noise goal as the proposed operational noise emissions are unlikely to significantly vary over a typical day.

Noise contour maps at 1.5 metres above the local ground level for each of the scenarios assessed are presented in APPENDIX C.

Table 5-3: Predicted operational noise levels – $L_{Aeq,15min}$ dB(A)

Receiver				PNTL (Night)	Predicted noise level, $L_{Aeq\ 15min}$, dB(A)				Exceedance, dB(A)			
					Without 1.8m rooftop screen		With 1.8m rooftop screen		Without 1.8m rooftop screen		With 1.8m rooftop screen	
NCA	ID	Address	Receiver type		Standard	Noise-enhancing	Standard	Noise-enhancing	Standard	Noise-enhancing	Standard	Noise-enhancing
NCA01A	R1_1	34 Campbell Road, Alexandria	Residential	50	43	47	38	42	-	-	-	-
NCA01B	R1_2	34 Campbell Road, Alexandria	Residential	43	27	31	27	31	-	-	-	-
NCA01B	R1_3	34 Campbell Road, Alexandria	Residential	43	42	46	38	42	-	3	-	-
NCA01A	R2	20 Campbell Road, Alexandria	Residential	50	42	46	37	41	-	-	-	-
NCA01A	R3	4 Campbell Road, Alexandria	Residential	50	41	45	36	41	-	-	-	-
NCA02	R4_1	671 Gardeners Road, Mascot	Residential	44	40	44	40	44	-	-	-	-
NCA02	R4_2	671 Gardeners Road, Mascot	Residential	44	39	44	39	44	-	-	-	-
-	R5	Sydney Park	Active recreation	55	42	46	37	42	-	-	-	-
-	R6_1	33 Burrows Road, St Peters	Commercial	65	59	59	51	52	-	-	-	-
-	R6_2	33 Burrows Road, St Peters	Commercial	65	59	60	51	52	-	-	-	-
-	R6_3	33 Burrows Road, St Peters	Commercial	65	61	62	54	54	-	-	-	-
-	R7_1	32 Burrows Road, St Peters	Commercial	65	54	54	53	54	-	-	-	-
-	R7_2	32 Burrows Road, St Peters	Commercial	65	56	57	56	57	-	-	-	-
-	R8_1	24-26 Burrows Road, St Peters	Commercial	65	59	59	59	59	-	-	-	-
-	R8_2	24-26 Burrows Road, St Peters	Commercial	65	61	61	61	61	-	-	-	-
-	R9	67 Bourke Road, Alexandria	Industrial	70	44	48	44	48	-	-	-	-
-	R10_1	697 Gardeners Road, Alexandria	Industrial	70	52	54	52	54	-	-	-	-
-	R10_2	697 Gardeners Road, Alexandria	Industrial	70	54	56	54	56	-	-	-	-
-	R10_3	697 Gardeners Road, Alexandria	Industrial	70	51	54	51	54	-	-	-	-
-	R10_4	697 Gardeners Road, Alexandria	Industrial	70	47	51	47	51	-	-	-	-

5.4.2 Predicted operational noise levels L_{Amax}

The assessment as considered operations within the carpark in the night period for consideration of sleep disturbance. The noise sources considered at door slams and car starts. It has been assumed that this could occur at any location within the carpark. The results of the sleep disturbance assessment are detailed in Table 5-4 below.

Table 5-4: Predicted operational noise levels – L_{Amax} dB(A)

Receiver				PNTL (Night)	Predicted noise level, $L_{Aeq\ 15min}$, dB(A)				Exceedance, dB(A)			
					Without 1.8m rooftop screen		With 1.8m rooftop screen		Without 1.8m rooftop screen		With 1.8m rooftop screen	
NCA	ID	Address	Receiver type		Standard	Noise-enhancing	Standard	Noise-enhancing	Standard	Noise-enhancing	Standard	Noise-enhancing
NCA01A	R1_1	34 Campbell Road, Alexandria	Residential	65	39	30	38	30	-	-	-	-
NCA01B	R1_2	34 Campbell Road, Alexandria	Residential	56	38	30	37	29	-	-	-	-
NCA01B	R1_3	34 Campbell Road, Alexandria	Residential	56	44	43	44	43	-	-	-	-
NCA01A	R2	20 Campbell Road, Alexandria	Residential	65	38	31	38	31	-	-	-	-
NCA01A	R3	4 Campbell Road, Alexandria	Residential	65	38	30	37	30	-	-	-	-
NCA02	R4_1	671 Gardeners Road, Mascot	Residential	62	53	43	53	43	-	-	-	-
NCA02	R4_2	671 Gardeners Road, Mascot	Residential	62	53	43	53	43	-	-	-	-

5.4.3 Discussion of results

The noise levels predictions provided in Section 5.4.1 above indicate that with the inclusion of a 1.8 metre high solid screen on the rooftop along the northern facade of the building, noise levels are predicted to comply with the NPfI noise goals at all nearby assessment receivers for all assessment periods.

Without the inclusion of the 1.8 metre high screen, there is a predicted exceedance of up to 4 dB(A) during adverse meteorological conditions at 34 Campbell Road, Alexandria.

Operations from use of the carpark at night (including door slams and car starts) at predicted to comply with the NPfI noise goals for sleep disturbance.

5.4.4 Recommended operational mitigation and management measures

5.4.4.1 In principle building services and mechanical plant and equipment measures

Building services and mechanical plant and equipment associated with the development has the potential to impact on nearby noise sensitive properties if not designed or selected correctly. At the SSD assessment stage of the project appropriate detail for mechanical plant is not available, and so indicative plant and equipment has been assumed as part of the assessment with indicative mitigation as detailed in Section 5.2.1.

The following in-principle noise management measures should be considered during detailed design:

- Acoustic assessment of mechanical services equipment should be undertaken during the detailed design phase of the development to ensure that the cumulative noise of all noise generating items and operations as part of typical operations (ie. building services and mechanical plant cumulatively with other noise sources such as trucks and loading activities) does not exceed the applicable noise criteria. This includes the detailed specification and location of mechanical plant on site.
- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - procurement of 'quiet' plant
  - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
  - commercially available acoustic attenuators for air discharge and air intakes of plant
  - acoustically lined and lagged ductwork

  - acoustic barriers between plant and sensitive neighbouring premises
  - partial or complete acoustic enclosures over plant
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery – Mechanical Vibration*'.

5.4.4.2 Noise barriers and enclosures

Noise barriers and enclosures are either proposed as part of the noise mitigation measures incorporated into the Project or may be required during detailed design. The extent and heights of noise barriers and areas of enclosures are indicative only at the SSD assessment stage. The final extents and quantities of noise barriers, enclosures and materials required, will largely depend on the performance of the preferred materials selected by the designers and the outcomes of a design review / optimisation process. The construction of a noise barrier can be made from any durable material with sufficient mass to prevent direct noise transmission (eg. masonry, steel, fibrous-cement, timber, acrylic or polycarbonate) selected to withstand weather elements.

In addition to the above, all noise barriers should give regard to the following to maintain acoustic integrity and to perform effectively as noise barriers:

- any penetrations through the fabric of the fence should be sealed airtight
- all joints and gaps between fence panels and adjacent structures should be sealed airtight
- any gaps between the fence and the ground / retaining walls should be filled to ensure that the fence provides appropriate noise attenuation

5.5 Operational related road traffic

The current plans for the proposal indicate that the carpark will include a total of 35 spots with a relatively low turnover through the day. The development is expected to generate between 15 to 20 vehicles per hour morning and afternoon peak periods.

Heavy vehicles generated by the proposal will be rigid trucks, including medium (8.8 metre) and large rigid trucks (12.5 metres). The heavy vehicle movements to the site would be infrequent for deliveries and waste collection. On occasion an articulated vehicle will need to access the flight training centre (to install or replace fight simulators). This is anticipated to occur once or twice a year.

In addition, we have been advised that the proposal would generate up to two bus movements per hour (34 drop offs per day over 17 hours) taking people back and forth between Qantas Headquarters (and potentially Sydney Airport)and the facility.

The proposal site is located on Burrows Road and would be accessed from either Campbell Road or Canal Road. Campbell Road and Canal Road are sub-arterial roads that carry high existing traffic volumes which will increase over time, particularly when the WestConnex St Peters Interchange becomes

fully operational. Based on available data, traffic volumes on both Canal Road and Campbell Road currently exceed 20,000 AADT.

As there are no assessment receivers for road traffic noise on Burrows Road, and Canal Road and Campbell Road carry high existing traffic volumes, additional road traffic noise associated with the operation of the proposal would not cause any exceedance of the RNP noise goals. No further assessment or operational related road traffic has been considered.

6 Conclusion

Renzo Tonin & Associates (RT&A) has been engaged by LOGOS Development Management Pty Ltd(Logos) to undertake an operational and construction noise and vibration impact assessment (NVIA) to accompany the State Significant Development (SSD 47601708) for the proposed flight training centre at 28-30 Burrows Road, St Peters.

This report assesses noise and vibration impacts during the construction and operational phases for the Project. It proposes mitigation and management measures to reduce potential noise emissions and resulting noise impacts during the construction and operation phases of the Project. The report has been prepared to address the requirements of the Secretary of the Department of Planning and Environment (DPIE) ('the Secretary's environmental assessment requirements') (SEARs).

6.1 Operational noise assessment

Operational noise impacts from the Project have been assessed, potential noise impacts identified and feasible and reasonable mitigation measures recommended and/or incorporated into the Project design to minimise noise emissions and potential impacts on sensitive receivers nearby to the Project site.

The assessment has reviewed the existing noise environment and established the noise emission objectives in accordance with the NSW *Noise Policy for Industry* (NPfI) (EPA 2017).

The assessment has predicted the potential noise impacts from the reasonable worst case site operations under noise-enhancing meteorological conditions in accordance with the NPfI. With the inclusion of acoustic screening on the northern rooftop facade of the building, operational noise levels are predicted to comply with the relevant NPfI noise goals at all assessed receivers.

Potential increases in road traffic noise by vehicles generated by the Project on public roads has been reviewed. The road traffic noise level contributions from the vehicle movements associated with the Project are not expected to increase existing traffic noise levels by more than 2 dB(A) and so would meet the NSW *Road Noise Policy* requirements.

The Project site is located within the Sydney Airport ANEF 2039 chart 20 to 25 contours. As such, the Project has been assessed in accordance with AS 2021:2015 and determined as acceptable and so no further assessment was required.

6.2 Construction noise and vibration assessment

An assessment of construction noise impact from the Project construction works has been undertaken. Noise emissions from the proposed construction works have been predicted and assessed against the relevant noise management levels set by the NSW Interim Construction Noise Guideline (ICNG) (DECC 2009) during the recommended standard hours for construction.

Noise levels are surround residential commercial and industrial receivers are predicted to exceed the NMLs throughout the construction phase. Noise impacts would be greatest during periods of high noise generating activities (such as hydraulic hammering during demolition and impact piling).

Additionally, it is understood that the proposal is seeking approval for a number of construction activities to occur outside of the standard construction hours, including works concrete pours, internal fitout works, including deliveries, oversized deliveries and impact piling and demolition. Justifications for why it is proposed to undertake construction works outside of the standard construction hours, along with the potential impacts, and the ways that impacts can feasibly and reasonably be managed are detailed in the report.

There are a number of potential construction projects nearby to the Project that may be taking place concurrently, and so cumulative impacts should be considered during further design development.

Construction related road traffic noise is expected to achieve the requirements of the NSW *Road Noise Policy* and is not expected to cause any adverse impacts at nearby receivers.

The expected construction noise levels have been predicted and presented in Section 4.3. Noise mitigation and management measures have been presented in Section 4.3.4 to aid in providing additional noise reduction benefits where exceedance of the objectives occurs. Noise mitigation includes the potential for construction to occur during outside standard hours to minimise noise impacts to the adjacent commercial receivers.

A number of vibration intensive construction activities are likely to be required such as impact piling and hydraulic hammers. Due to the close proximity to nearby commercial receivers and the Alexandra Canal, a further review of potential vibration impacts and construction methodology, along with mitigation and management approaches to appropriately manage potential impacts, would be required during further design development phases to ensure that potential vibration impacts are adequately mitigated and managed.

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APPENDIX A Technical terms and concepts

A.1 Glossary of terminology - Noise

The following is a brief description of the technical terms used to describe noise and to assist in understanding the technical issues presented.

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our environment:

	threshold of hearing	0 dB	The faintest sound we can hear, defined as 20 micro Pascal
		10 dB	Human breathing
	almost silent	20 dB	
		30 dB	Quiet bedroom or in a quiet national park location
	generally quiet	40 dB	Library
		50 dB	Typical office space or ambience in the city at night
	moderately loud	60 dB	CBD mall at lunch time
		70 dB	The sound of a car passing on the street
	loud	80 dB	Loud music played at home
		90 dB	The sound of a truck passing on the street
	very loud	100 dB	Indoor rock band concert
		110 dB	Operating a chainsaw or jackhammer
	extremely loud	120 dB	Jet plane take-off at 100m away
	threshold of pain	130 dB	
		140 dB	Military jet take-off at 25m away
dB(A)	A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter is denoted as dB(A). Practically all noise is measured using the A filter.		
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications.		
Deemed-to-Satisfy Provisions	The Deemed-to-Satisfy Provisions are an optional means of achieving compliance with the mandatory Performance Requirements of the National Construction Code. (also see Alternate Solution)		
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.		
DIN	German Standard		
Discontinuous Construction	A wall system having a minimum 20mm cavity between two separate leaves, where, for other than masonry there is no mechanical linkage between leaves except at the periphery.		
DnT,w	Weighted Standardised Field Level Difference A measure of sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in-situ. It is a field measurement that relates to the Rw laboratory measured value but is not equal to it because an in-situ space is not of the same quality as a laboratory space. The value is indicative of the level of speech privacy between spaces. The higher its value the better the insulation performance.		
ECRTN	Environmental Criteria for Road Traffic Noise, 1999		
ENMM	Environmental Noise Management Manual, Roads and Maritime Services (Transport for NSW)		
EPA	Environment Protection Authority		
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.		

FIIC	Field Impact Isolation Class. A measure of the noise impact performance of a floor. The value indicates the resistance of the floor to the transmission of impact sound and is measured using a standard tapping machine. It is measured in-situ and is therefore subject to the inherent accuracies involved in such a measurement. The term is defined in ASTM E492 and E1007. It is a field measure of the level of impact sound transmitted to a space via a floor. The equivalent measurement in a laboratory is termed the IIC. The higher the value the better the performance.
Flanking	Flanking is the transfer of sound through paths around a building element rather than through the building element material directly. For example, sound travelling through a gap underneath a door or a gap at the top of a wall.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
FSTC	Field Sound Transmission Class A measure of the sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in the field and is therefore subject to the inherent inaccuracies involved in such a measurement. The term was referred to in older superseded versions of the Building Code of Australia and has now been replaced with the term DnT,w.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects DEC 2007
IIC	Impact Isolation Class A measure of the noise impact performance of a floor. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from the operation a standard tapping machine placed on the floor. The term is defined in ASTM E492 and E1007. The higher the number the better the performance.
Impact Noise	The noise in a room, caused by impact or collision of an object onto the walls or the floor. Typical sources of impact noise are footsteps on the floor above a tenancy and the slamming of doors on cupboards mounted on the common wall between tenancies.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
INP	NSW Industrial Noise Policy, EPA 1999
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation.
Intertenancy wall	Walls that separate buildings or units within a building. They may provide sound resistance or serve as a fire wall. Synonymous with 'party wall'.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).

ISEPP	State Environmental Planning Policy (Infrastructure), 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Ln,w	Weighted Normalised Impact Sound Pressure Level A measure of the sound level transmitted from impacts on a floor to a tenancy below. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from a standard tapping machine. A lower value indicates a better performing floor.
LnT,w	Weighted Standardised Field Impact Sound Pressure Level As for Ln,w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The equivalent measurement in a laboratory is the Ln,w. A lower value indicates a better performing floor.
Laboratory Test	The performance of a building element when measured in a laboratory. The sound insulation performance of a building element installed in a building however can differ from its laboratory performance for many reasons including the quality of workmanship, the size and shape of the space in which the measurement is conducted, flanking paths and the specific characteristics of the material used which may vary from batch to batch.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially similar.
NCG	Noise Criteria Guideline, Roads and Maritime Services (Transport for NSW)

NMG	Noise Mitigation Guideline, Roads and Maritime Services (Transport for NSW)
Noise	Unwanted sound
Normalised	A method of adjusting the measured noise indices in a laboratory so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the Ln,w impact sound pressure level measured in a laboratory is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the sound absorption in the receiving room is set at 10m2. This enables all laboratories to report the same value when measured under slightly different conditions. See also 'Standardised'.
NRC	Noise Reduction Coefficient. A measure of the ability of a material to absorb sound. The NRC is generally a number between 0 and 1 but in some circumstances can be slightly greater than 1 because of absorption at the edges of the material. A material with an NRC rating of 1 absorbs 100% of incoming sound, that is, no sound is reflected back from the material. The NRS is the average of the absorption coefficient measured in the octave bands 250Hz, 500Hz, 1kHz & 2kHz which correspond to the predominant frequencies associated with the human voice.
Partition wall	A wall dividing two rooms.
Party wall	A wall dividing two tenancies. Synonymous with 'Intertenancy Wall'.
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
RBL	Rating Background Level is the representative LA90 background noise level for a period, as defined in the NSW EPA's noise policies.
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, May 2013
RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australia. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sole-occupancy Unit	An area within a building for the exclusive use of the owner or occupier.
Sound	A fluctuation of air pressure which is propagated as a wave through air.

Sound absorption	The ability of a material to absorb sound energy by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 micro Pascal.
Spoil	Soil or materials arising from excavation activities.
Standardised	A method of adjusting the measured noise indices in-situ so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the L'n,w impact sound pressure level measured in a room is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the reverberation time in the receiving room is set at 0.5 seconds. This enables the same value to be reported independent of whether the room contains carpet and furnishings and the like. See also 'Normalised'.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w.

A.2 Glossary of terminology - Vibration

The following is a brief description of the technical terms used specifically to describe vibration and to assist in understanding the technical issues presented.

Acceleration	The rate of change of velocity, often measured in m/s2 or g's. 1 g = 9.81 m/s2. Commonly used to assess human response to vibration and for machine condition monitoring.
Accelerometer	A vibration transducer sensor that is used to measure acceleration.
ANC	The Association of Noise Consultants, UK.
Ambient vibration	The all-encompassing vibration occurring at a given location, at a given time, composed of all vibration sources near and far.

Amplification	Vibration amplification refers to an increase in vibration. Amplification may occur due to resonance, when an object or structure is excited at its natural frequency.
Attenuation	Attenuation refers to a reduction in vibration. This may occur due to damping of a vibration system, the inclusion of attenuating devices or, in the case of ground vibration, during propagation through the ground. Ground attenuation is determined by the dynamic properties of the site's soil and rock.
AVTG	Assessing Vibration: A Technical Guideline. NSW Department of Environment and Conservation's (DEC) 2006 guideline for assessing human responses to vibration. Based on BS 6472–1992.
Axis	A fixed reference line for the measurement for the measurement of vibration in a particular direction. Vibration is commonly measured in transverse (T), longitudinal (L) and vertical (V) axes (or X, Y and Z).
Background vibration	The underlying level of vibration present in the ambient environment, measured in the absence of the vibration sources of interest.
Blasting	Excavation or demolition using explosives.
Borehole transducer	A geophone transducer rigidly mounted at the bottom of a borehole (either permanently or temporarily) to measure underground vibration.
Broadband vibration	The overall vibration level which encompasses a wide range of frequencies. As opposed to vibration levels for specific frequency bands (see Octave) or narrowband vibration levels as produced by FFT.
BS	British Standard.
Continuous vibration	Vibration that continues uninterrupted over a defined period.
Cosmetic damage	Damage to a structure due to vibration that only affects the appearance of the structure and can be easily repaired, e.g. hairline cracks in mortar joints of brick or concrete constructions, or cracks in plasterwork.
Coupling loss	The change in vibration level when vibration is transmitted from the ground to a building's foundations.
Crest factor	The ratio of the peak value of a vibration event to the RMS value of a vibration event.
Damping	Reduction of vibrational energy due to friction or other forces.
DEC	NSW Department of Environment and Conservation, now the Department of Planning, Industry and Environment.
Decibel [dB]	The logarithmic unit used to represent sound and vibration levels. A vibration level in dB equals 20 times the logarithm to the base 10 of the ratio of the vibration level relative to the reference level. For vibration velocity, the reference level is commonly 1 nm/s. For vibration acceleration, the reference level is commonly 1 $\mu m/s^2$. Other reference values are commonly used. The reference value should always be stated.
DIN	German Standard.
Displacement	Change in position of a body from a reference point. Usually measured in m or mm.
EPA	Environment Protection Authority.
eVDV	Estimated Vibration Dose Value. See also VDV.
Filter	An electrical circuit that allows signals of certain frequency ranges to pass through, and blocks all other frequencies. Types of filters include low pass filters, high pass filters, and band pass filters.
FFT	Fast Fourier Transform. An algorithm that converts a signal from the time domain to the frequency domain.
Frequency	In the case of vibration, frequency is the number of oscillations that occurs per second. Frequency is measured in units of Hertz (Hz).
Geophone	A vibration transducer sensor that is used to measure velocity.

Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Ground spike	A metal stake with a flat top that is driven into the ground and used to mount a vibration transducer to measure vibration levels.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Intermittent vibration	Either interrupted periods of continuous vibration or repeated periods of impulsive vibration.
Impulsive vibration	Vibration that rapidly builds up to a peak followed by a damped decay. May consist of multiple impulsive events, typically less then 2 seconds in duration.
Isolation	The process of reducing the vibrational energy transmitted to an object, such as a piece of equipment or building, from the source of vibrations.
Minor damage	Damage to a structure due to vibration that affects the serviceability of residential style buildings or other sensitive structures but does not affect the structural elements. E.g. cracks in plastered or rendered surfaces, existing cracks enlarged or partitions detached.
Mode	A mode of vibration is a characteristic pattern or shape in which a mechanical system will vibrate. The actual vibration of a structure is a combination of all the vibration modes, but to varying degrees, depending on the vibration source.
Natural frequency	The frequency at which a system tends to oscillate in the absence of any driving or damping force.
Noise floor	The residual level of unwanted signal measured by an instrumentation system. The signal of interest must be above the noise floor to be measured accurately. See also Signal to noise ratio.
Octave	An octave represents a doubling or halving in frequency. Noise or vibration levels across a frequency spectrum are commonly given in octave or one-third octave frequency bands.
Peak-to-peak	The difference between the highest positive peak level and the lowest negative peak of a vibration event.
Peak vibration velocity	The absolute maximum value of the vibration velocity signal measured in the X, Y or Z axis during a given time interval. Also referred to as the peak component particle velocity.
PPV	Peak Particle Velocity. The absolute maximum value of the vibration velocity signal measured in any axis during a given time interval.
PVS	Peak Vector Sum. The vector sum of the peak vibration velocities measured in the three orthogonal axes.
Resonance	The phenomenon of increased amplitude that occurs when the frequency of an applied force is equal or close to the natural frequency of the system.
RMS	Root Mean Square value representing the average value of a signal.
Sampling rate	The number of samples per second taken from a continuous signal to make a discrete or digital signal. Measured in Hertz. To accurately record the signal and determine the spectrum, the sampling rate must two or more times the maximum frequency of interest.
Settlement	The movement of soil due to vibration or other forces, often in relation to a building's foundations. The indirect effect of settlement and ground movement may cause building damage, separately from the direct of effect of building vibration.
Signal to noise ratio	A ratio of the level of a desired signal to the level of the background, often expressed in decibels.
Source vibration	A source that generates vibration. Can be quantified by the amplitude, frequency content and duration of the vibration. Common sources of vibration include rail and road traffic, construction and demolition activities and blasting.
Spectrum	The result of transforming a signal from the time domain to the frequency domain.

Structural damage	Damage to a structure due to vibration that may affect its serviceability due to damage to structural elements. May result in the reduced stability of the building and/or reduction in load-bearing capacities.
Structural fatigue	The weakening of a material caused by cyclic loading that results in progressive and localised structural damage and the growth of cracks.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft.
Tactile vibration	Vibration of a level that can be felt by humans, dependant on the amplitude and frequency of the source. Note that vibration may also be perceived through indirect effects such as ground-borne noise or the shaking of building elements.
Transducer	A device that converts energy from one form to another. Vibration transducers convert either acceleration, velocity or displacement to an electrical signal that is processed by the monitoring system.
Triaxial	Three axes. Measurement systems often consist of three vibration transducers arranged triaxially – oriented at 90° from each other.
VDV	Vibration Dose Value. A measure of tactile vibration levels used to assess intermittent vibration.
Velocity	The rate of change of vibration displacement, usually measured in mm/s.
Vibration	A mechanical phenomenon whereby oscillations occur about an equilibrium point; a periodic back-and-forth motion of an elastic body or medium, commonly resulting when almost any physical system is displaced from its equilibrium condition.
Vrms	Root mean square (RMS) vibration level for the train passby, typically expressed in mm/s
Waveform	A graphical representation of a vibration event in the time domain, showing the measured vibration levels for each sample.

A.3 Acoustic concepts

A.3.1 Sound and noise

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound. Sound is a vibration that travels as an audible wave of pressure through the air from a source to a receiver location such as the human ear. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) is a unit of measurement used to express the ratio of a quantity to another on a logarithmic scale to make the wide range of sound pressure more manageable.

Sound power is the rate at which a source emits acoustic energy and is unaffected by the environment. It is a property of the source that is emitting acoustic energy.

In contrast, **sound pressure** is the effect, and it is affected by factors associated with the built and natural environment such as distance, direction, obstacles etc. The sound pressure is the acoustic energy or 'noise level' at a distance away from the noise source. The relationship between sound power and sound pressure can be explained by considering the analogy of an electric heater, which radiates heat into a room and temperature is the effect. Like sound pressure, temperature also reduces with distance from the source following the inverse square law.

In this technical working paper, **sound power level** is identified by the symbols **SWL** or $\mathbf{L_w}$, while **sound pressure level** is represented by **SPL** or $\mathbf{L_p}$, and both have the same scientific unit in dB.

A.3.2 Individual's perception of sound

The loudness of sound depends on its sound pressure level. The A-weighted decibel [dB(A)] is generally used for the purposes of environmental noise impact assessment as it has been adjusted to account for the varying sensitivity of the human ear to different frequencies of sound. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dB(A) is a good measure of the loudness of environmental noise to the human ear as it considers this frequency dependant sensitivity.

Different noise sources having the same dB(A) level generally sound equally loud. However, the frequency of a sound is what gives it a distinctive pitch or tone – for example, the rumble of distant thunder is an example of a low frequency sound and a whistle is an example of a high frequency sound. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 to 90 dB(A). The following table provide some points of reference, measured in dB(A), of familiar sounds and those from construction activities.

Table A-1 Perception of sound - familiar sounds and construction noise

Common sounds	Construction noise	Sound pressure level
Leaf blower at operator's ear	Concrete saw or jack hammer 7 metres away	90 dB(A)
Airplane cabin during cruise (Airbus 321)	Excavator (with bucket) 7 metres away	80 dB(A)
General traffic noise kerbside next to Military Road	Towable compressor 7 metres away	75 dB(A)
Normal conversation at 1 metre		60 dB(A)
Outdoor air conditioning unit 1 metre away	Towable compressor 50 metres away	55 dB(A)
General office		50 dB(A)
Inside private office	Ground-borne noise from road header tunnel excavation between depths of 20 metres to 50 metres	40 dB(A)
Inside bedroom		30 dB(A)

In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect, whilst a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However, individuals may perceive the same sound differently since many factors can influence an individual's response, including:

- The specific characteristics of the noise (eg. frequency, intensity, duration of the noise event)
- Time of day noise events occur
- Individual sensitivities and lifestyle
- Reaction to an unfamiliar sound
- Understanding of whether the noise is avoidable and the notions of fairness.

A.3.3 Environmental noise assessment indicators

Environmental noise is an accumulation of noise pollution that occurs outside and is most commonly attributed to various modes of transport as well as industrial and construction activities. Environmental noise has been shown to have an adverse effect on the quality of life, especially following long-term exposure. The focus of the present technical assessment is on annoyance and sleep disturbance as they constitute most of the burden related to the impact of environmental noise on health outcomes. Noise annoyance is defined by the World Health Organization as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. Sleep disturbance relates to difficulty with sleep initiation, consolidation as well as awakening and reduced quality of sleep.

In New South Wales, contemporary environmental noise assessment criteria for addressing noise annoyance and sleep disturbance are specified by the Environment Protection Authority (EPA). Potential

road traffic noise impact is assessed in accordance with the NSW Road Noise Policy. For motorway and ventilation facilities that are permanently fixed, and associated noise emissions are long-term in nature, noise criteria have been adopted in accordance with the Noise Policy for Industry. For enabling construction activities which are temporary in nature and highly variable, EPA's Interim Construction Noise Guideline provides the underlying assessment principles for the determination of potential construction noise impact. Each policy/guideline is discussed in detail in the body of this report:

- Section 3.4 details the NSW Road Noise Policy
- Section 3.3.2 details the Noise Policy for Industry
- Section 3.1 details the EPA's Interim Construction Noise Guideline.

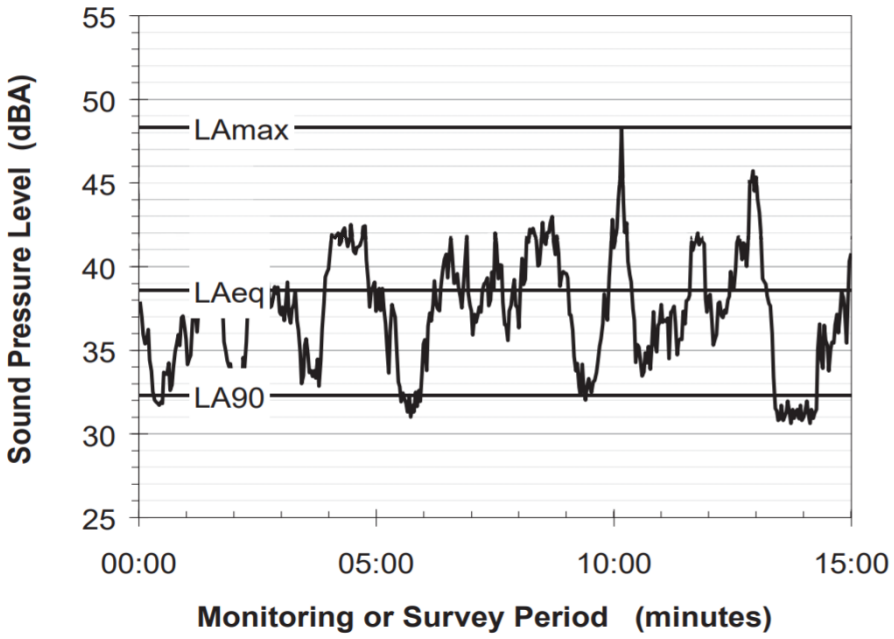
L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as L_{Aeq}. The L_{Aeq} indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence over the L_{Aeq} level than do quieter ones, and activities that last longer in time have greater L_{Aeq} than do shorter ones. An increase in the number of events also increases the L_{Aeq}. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} - It is important to note that L_{Aeq} levels are numerically lower than maximum noise levels (denoted as L_{Amax}). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short-term awakening reaction, potential impact is assessed using the L_{Amax} indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 per cent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

These three noise indicators of L_{Amax}, L_{Aeq} and L_{A90} are presented in Figures A-1 for a sample noise monitoring survey period showing the sound pressure level of a varying noise environment such as environmental noise.

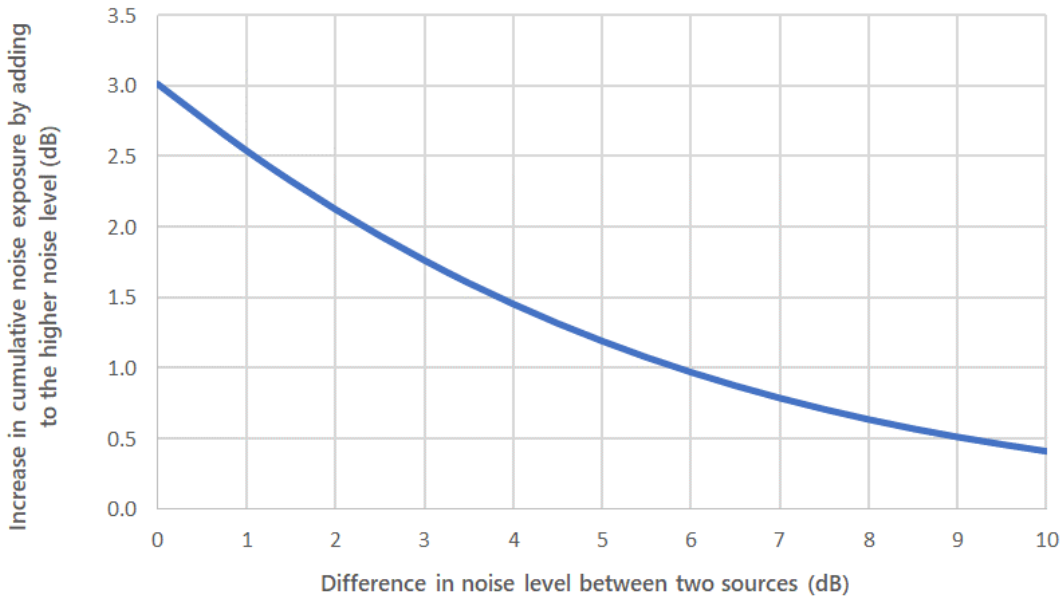
Figure A-1: Environmental noise assessment indicators



A.3.4 Cumulative sound exposure

As illustrated in Figure A-2, for two activities that result in the same amount of acoustical energy or noise level at a receiver location, the cumulative sound exposure level would be 3 dB higher than the level of just one single activity. This is because the decibel (dB) scale is logarithmic. Conversely, if the activity closer to your home results in noise exposure level that is 10 dB higher than the activity occurring further away, the quieter works would contribute very little to the cumulative noise exposure level.

Figure A-2: Difference in noise level between two sources



APPENDIX B Existing acoustic environement

B.1 Unattended monitoring

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sydney@renzotonin.com.au
www.renzotonin.com.au

Monitoring ID: L1
Address: 34 Campbell Road, Alexandria
Description: Front landing

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels				L_{Aeq} Ambient Noise Levels			
	Day[1]	Evening[2]	Night[3]	Shoulder[4,6]	Day[1]	Evening[2]	Night[3]	Shoulder[4]
Representative Week[5]	59	57	50	53	67	65	62	66

Notes:

1. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
2. Evening: 6.00pm to 10.00pm Monday to Sunday & Public Holidays
3. Night: 10.00pm to 5.00am Monday to Sunday & Public Holidays
4. Shoulder period: 5:00am to 7:00am
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}
6. Shoulder period RBL levels determined as per NPfI Fact Sheet A3

Road Monitoring Results (at one metre from façade[4])

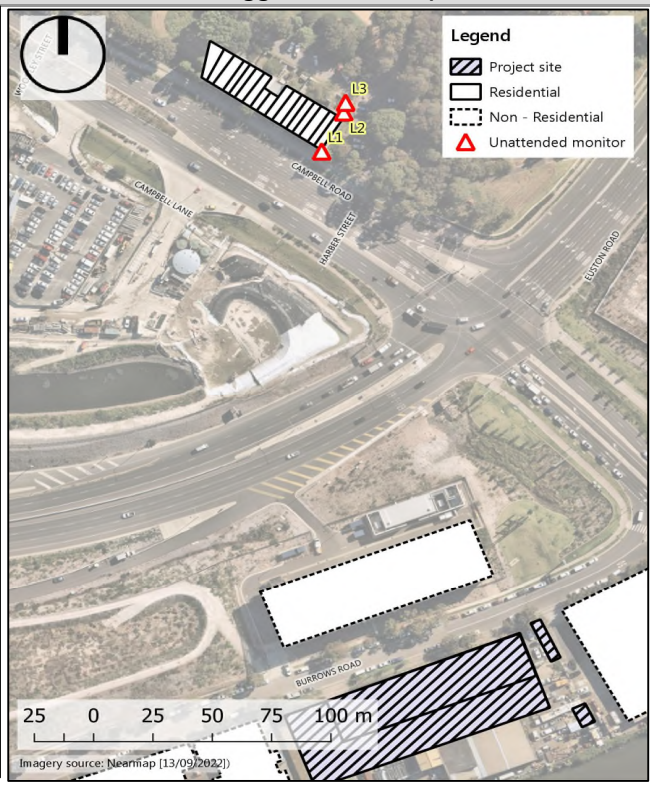
	L_{Aeq} Noise Levels[4]	
	Day[1]	Night[2]
Representative Week[3]	69	65

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Median of daily L_{Aeq}
4. Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field

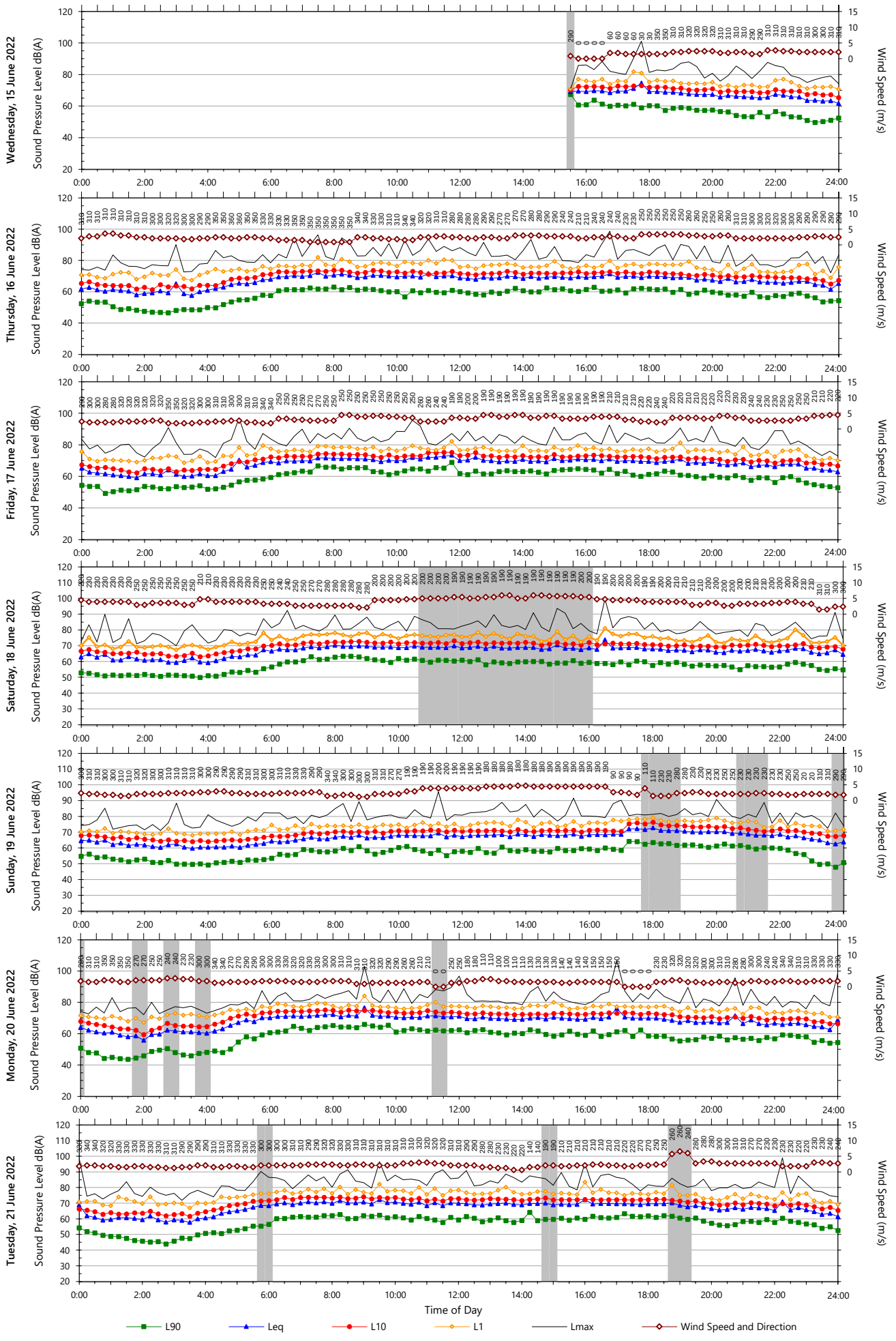
Logger location photograph

Logger location map



Unattended Monitoring Results

Location: Front landing



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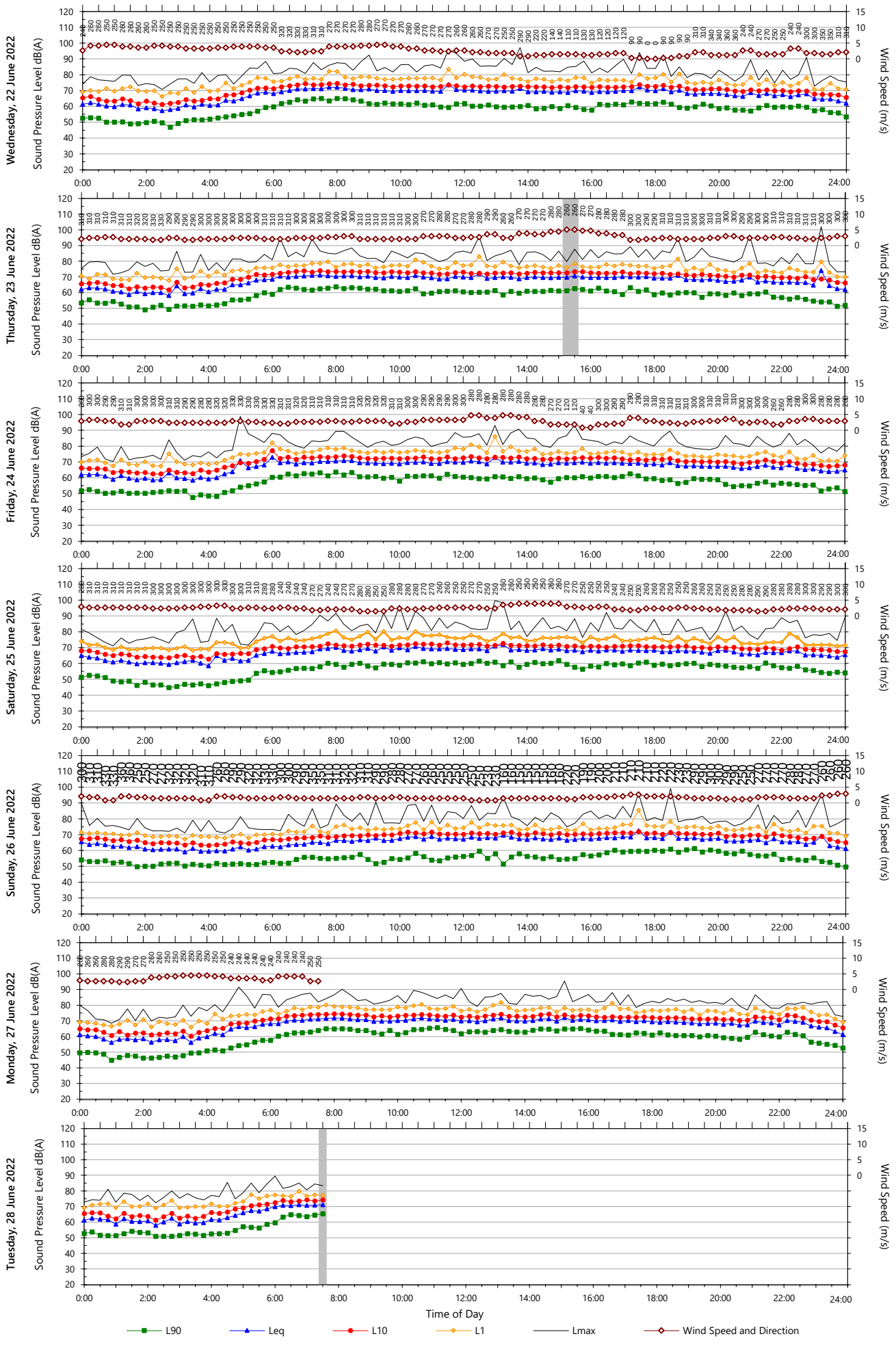
Template: QTE-26 Logger Graphs Program (r40)



Data File: 2022-06-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r40)

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sydney@renzotonin.com.au
www.renzotonin.com.au

Monitoring ID: L2
Address: 34 Campbell Road, Alexandria
Description: Backyard (3.5m)

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels				L_{Aeq} Ambient Noise Levels			
	Day[1]	Evening[2]	Night[3]	Shoulder[4,6]	Day[1]	Evening[2]	Night[3]	Shoulder[4]
Representative Week[5]	53	52	46	49	62	60	57	60

Notes:

1. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
2. Evening: 6.00pm to 10.00pm Monday to Sunday & Public Holidays
3. Night: 10.00pm to 5.00am Monday to Sunday & Public Holidays
4. Shoulder period: 5:00am to 7:00am
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}
6. Shoulder period RBL levels determined as per NPfI Fact Sheet A3

Road Monitoring Results (at one metre from façade[4])

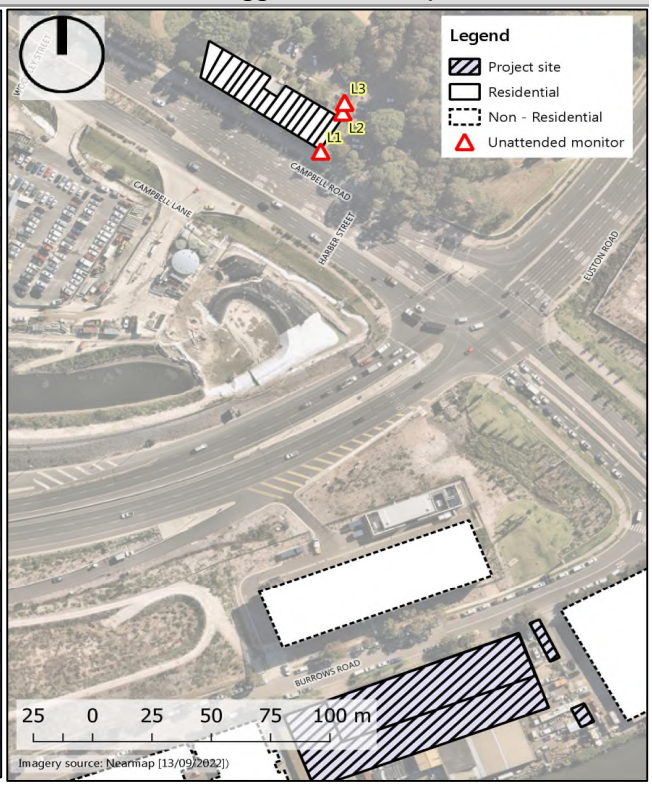
	L_{Aeq} Noise Levels[4]	
	Day[1]	Night[2]
Representative Week[3]	64	60

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Median of daily L_{Aeq}
4. Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field

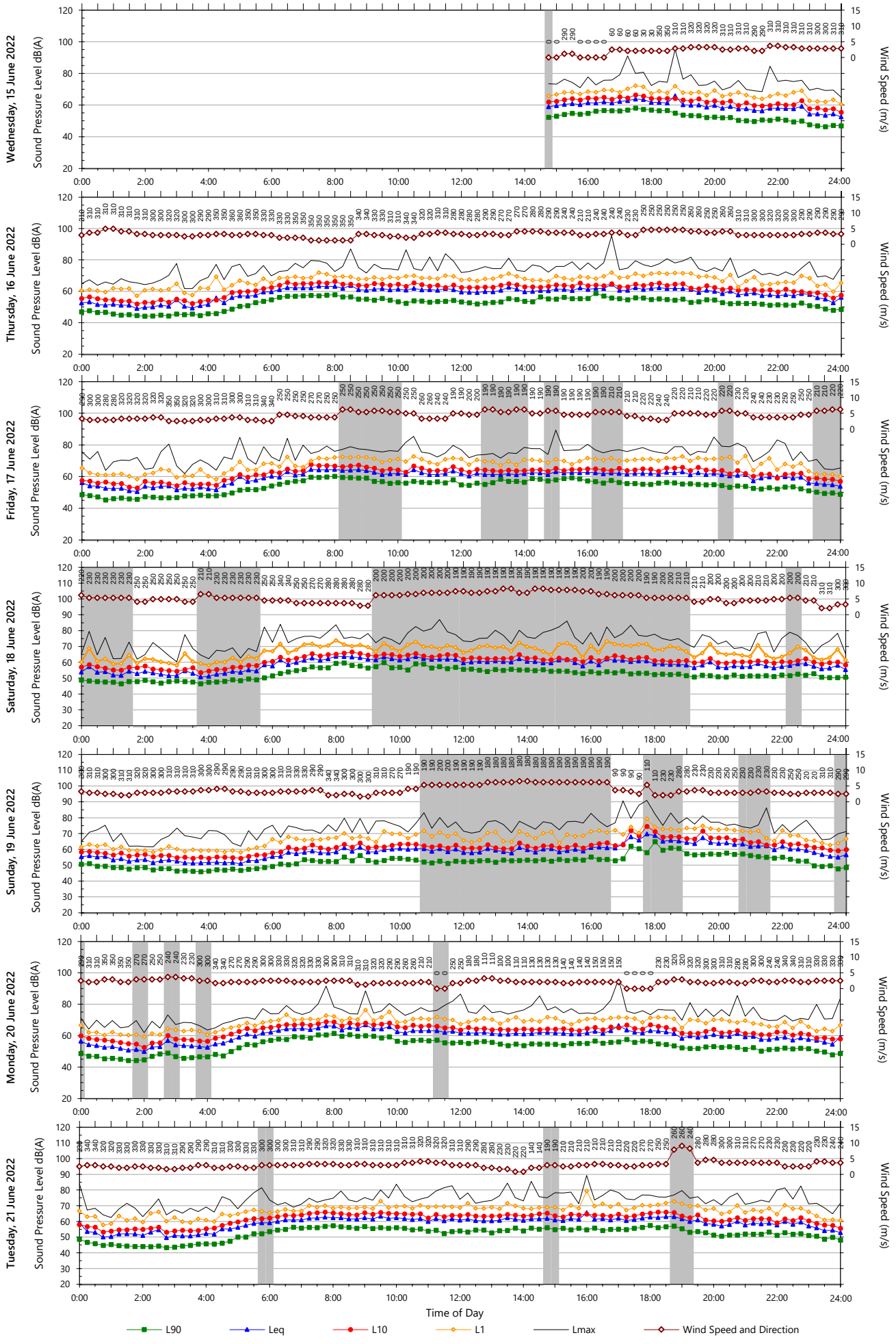
Logger location photograph

Logger location map



Unattended Monitoring Results

Location: Backyard (3.5m)

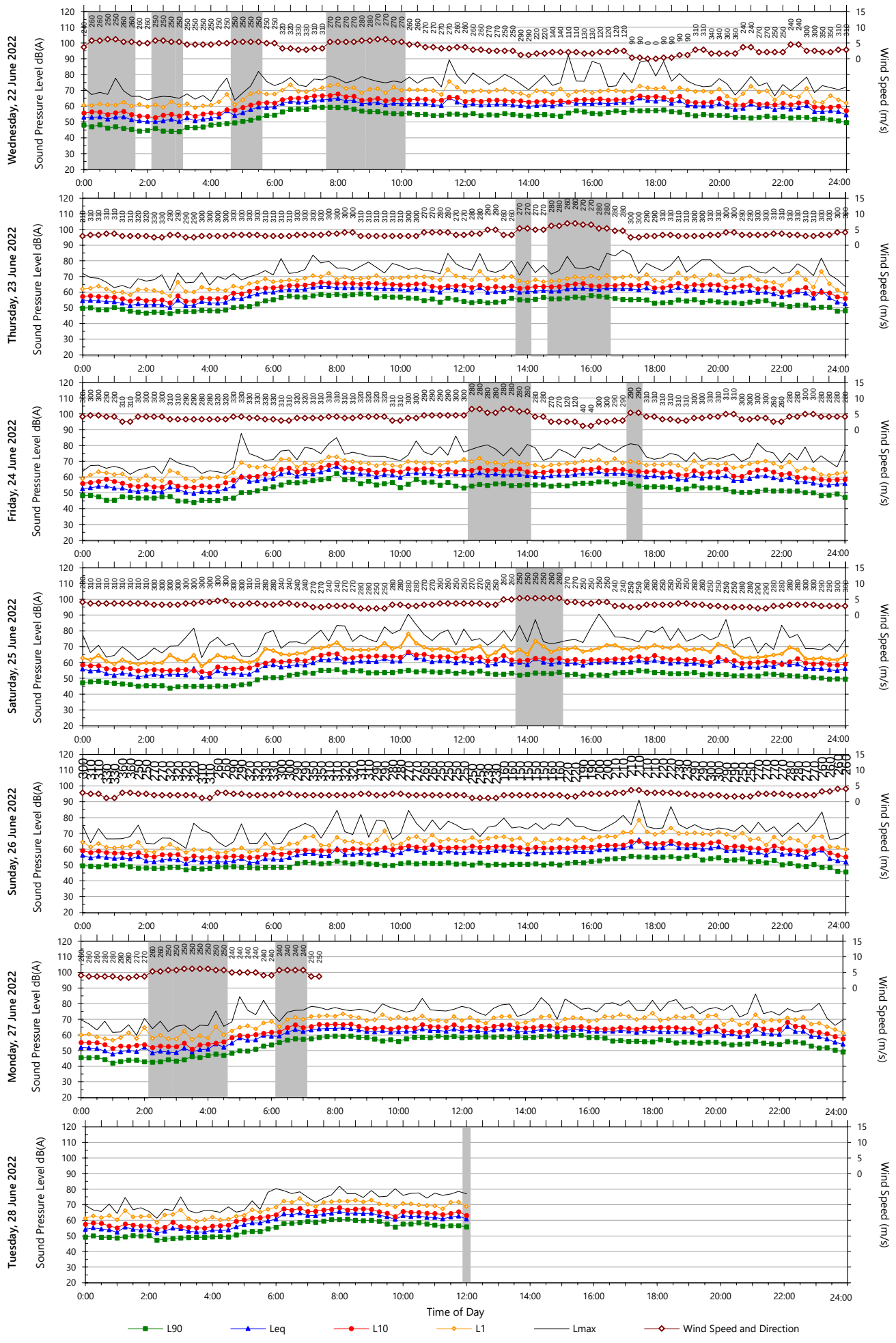


Data File: 2022-06-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r40)

Unattended Monitoring Results

Location: Backyard (3.5m)



Data File: 2022-06-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r40)

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sydney@renzotonin.com.au
www.renzotonin.com.au

Monitoring ID: L3
Address: 34 Campbell Road, Alexandria
Description: Backyard (1.5m)

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels				L_{Aeq} Ambient Noise Levels			
	Day[1]	Evening[2]	Night[3]	Shoulder[4,6]	Day[1]	Evening[2]	Night[3]	Shoulder[4]
Representative Week[5]	49	47	41	45	58	56	52	56

Notes:

1. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
2. Evening: 6.00pm to 10.00pm Monday to Sunday & Public Holidays
3. Night: 10.00pm to 5.00am Monday to Sunday & Public Holidays
4. Shoulder period: 5:00am to 7:00am
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}
6. Shoulder period RBL levels determined as per NPfI Fact Sheet A3

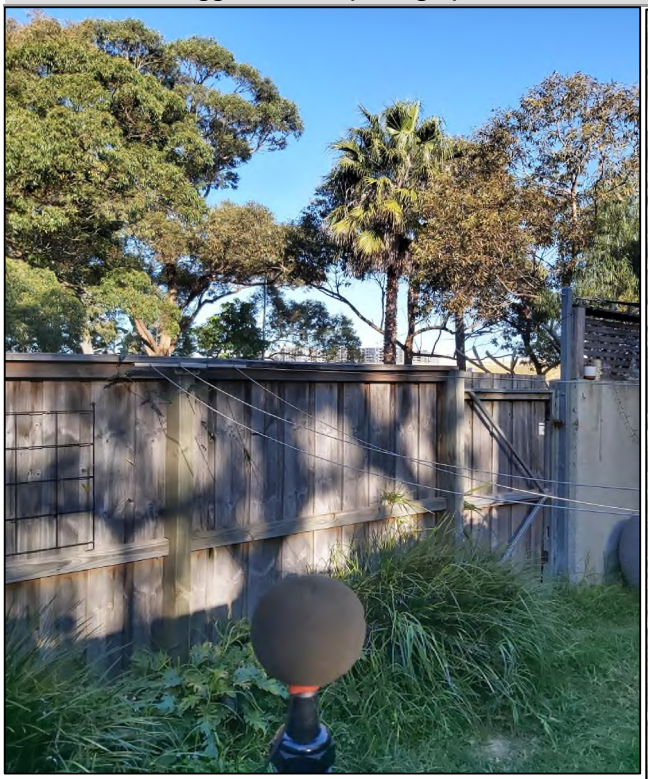
Road Monitoring Results (at one metre from façade[4])

	L_{Aeq} Noise Levels[4]	
	Day[1]	Night[2]
Representative Week[3]	60	55

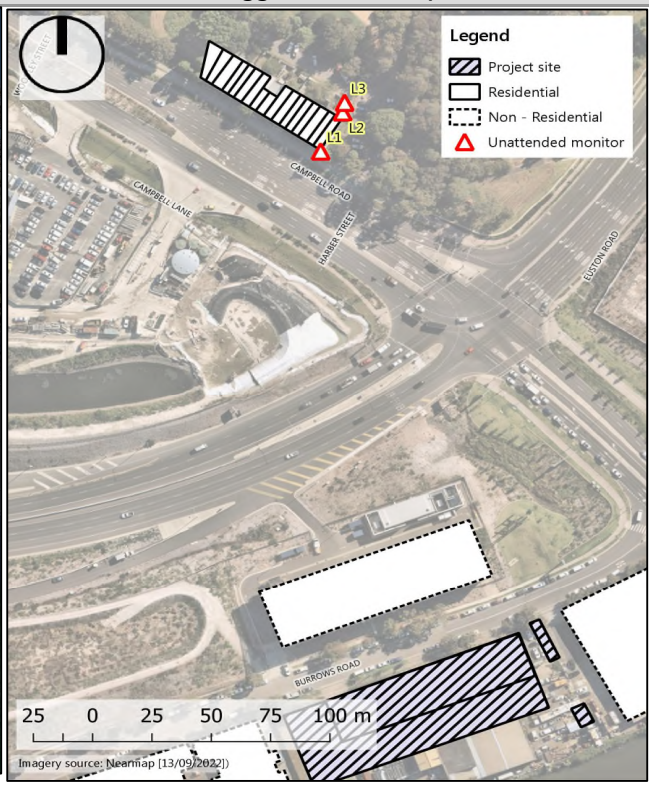
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Median of daily L_{Aeq}
4. Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field

Logger location photograph

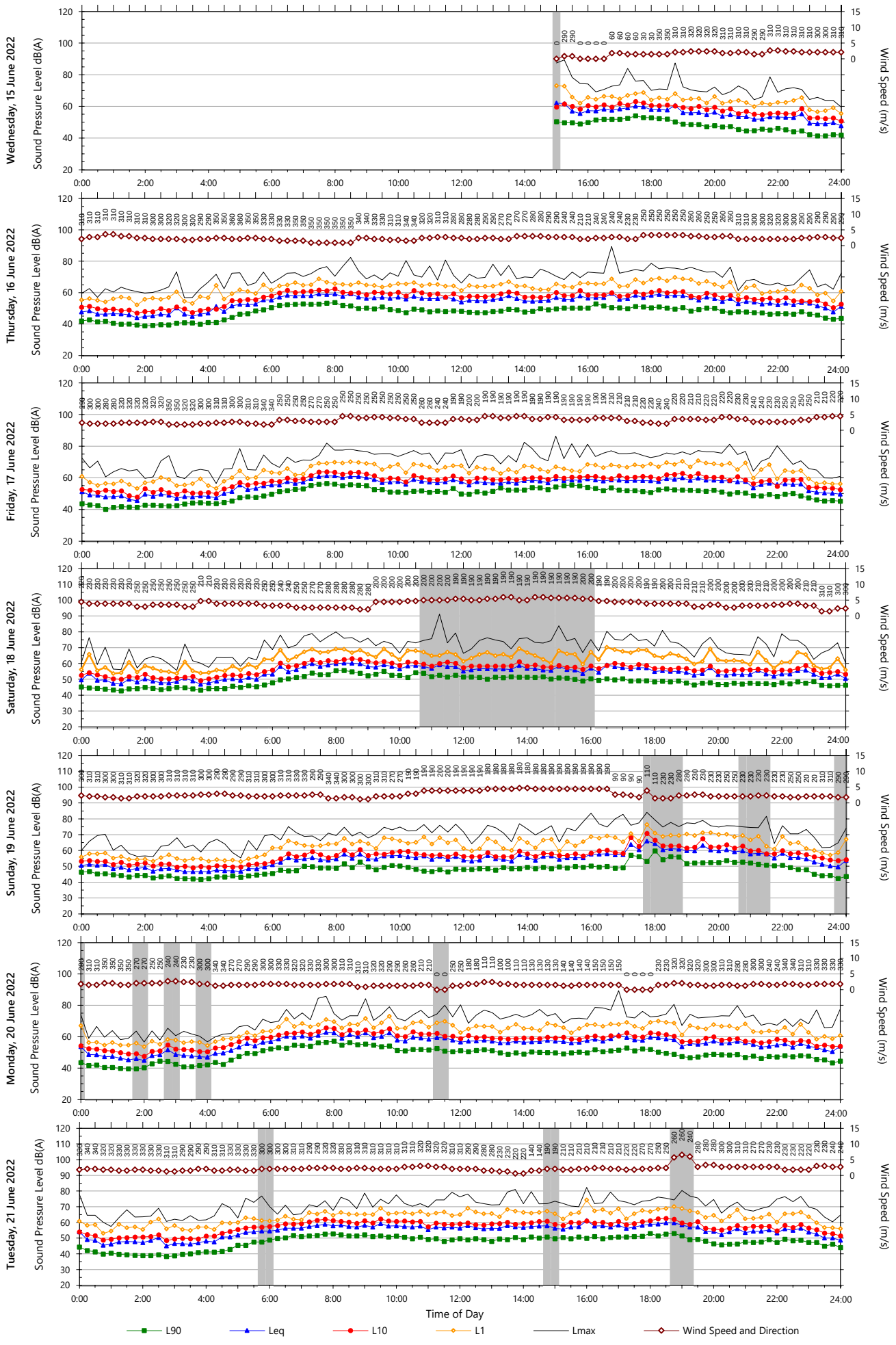


Logger location map



Unattended Monitoring Results

Location: Backyard (1.5m)

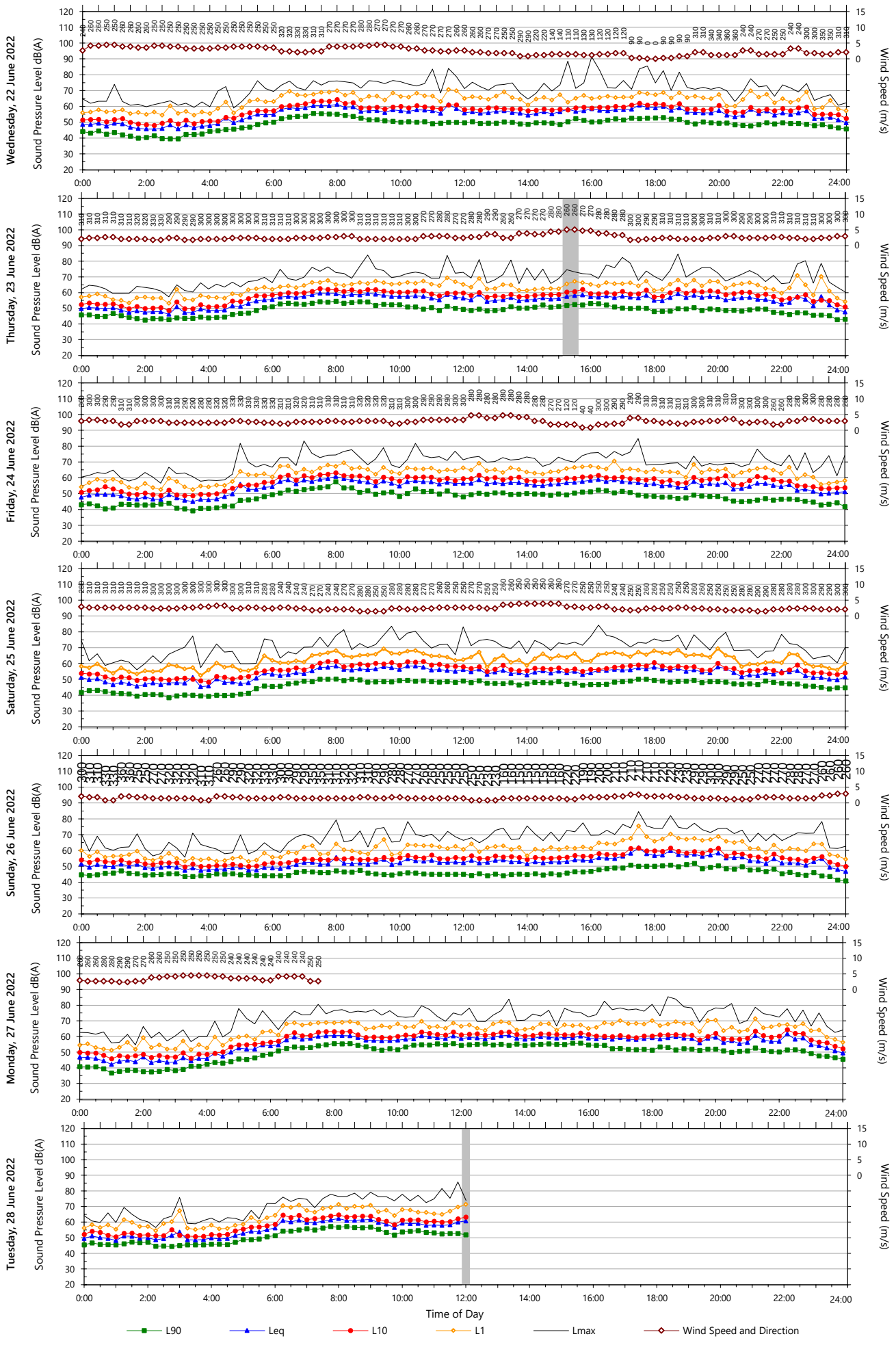


Data File: 2022-06-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r40)

Unattended Monitoring Results

Location: Backyard (1.5m)



Data File: 2022-06-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r40)

APPENDIX C Predicted operational noise contours

C.1 Predicted operational noise levels, $L_{Aeq,15minute}$

Plotted: 27/09/22 - 14:31 Layout: TM727 Noise contours template
C:\Users\Public\Projects\TM727 - TM750\TM727 and 28-30 Burrows Road, St Peters\T1 SSD NMA\5 Calcs\TM727 - SS.qgz

CHURCH STREET
CAMPBELL STREET
ALBERT STREET
VICTORIA STREET
PRINCES HIGHWAY
CAMPBELL LANE
CAMPBELL ROAD
EUSTON ROAD
BURROWS ROAD
ORCHARD ROAD
BOURKE ROAD
CANAL ROAD
GARDENERS ROAD
KENT ROAD
RICKETTY STREET
GALLOWAY STREET
MULLER LANE
BOURKE STREET

LEGEND

BUILDINGS copy

- Residential
- Non - Residential
- Site Buildings

Noise Contours During Operations
Without mitigation
Standard meteorological conditions
in dB(A) Leq (15 mins)

- < 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- > 60

REV	BY	DATE	DESCRIPTION	APPROVED
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
r2	SS	27/09/22	Noise Barrier Details	RP
r1	SS	13/09/22	Modify Contours	ALe
r0	SS	08/09/22	Prepare figures	RP

A3 Original
Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 m
1:3,900 at A3
FULL SIZE A3
NOTE: Do not scale from this drawing.

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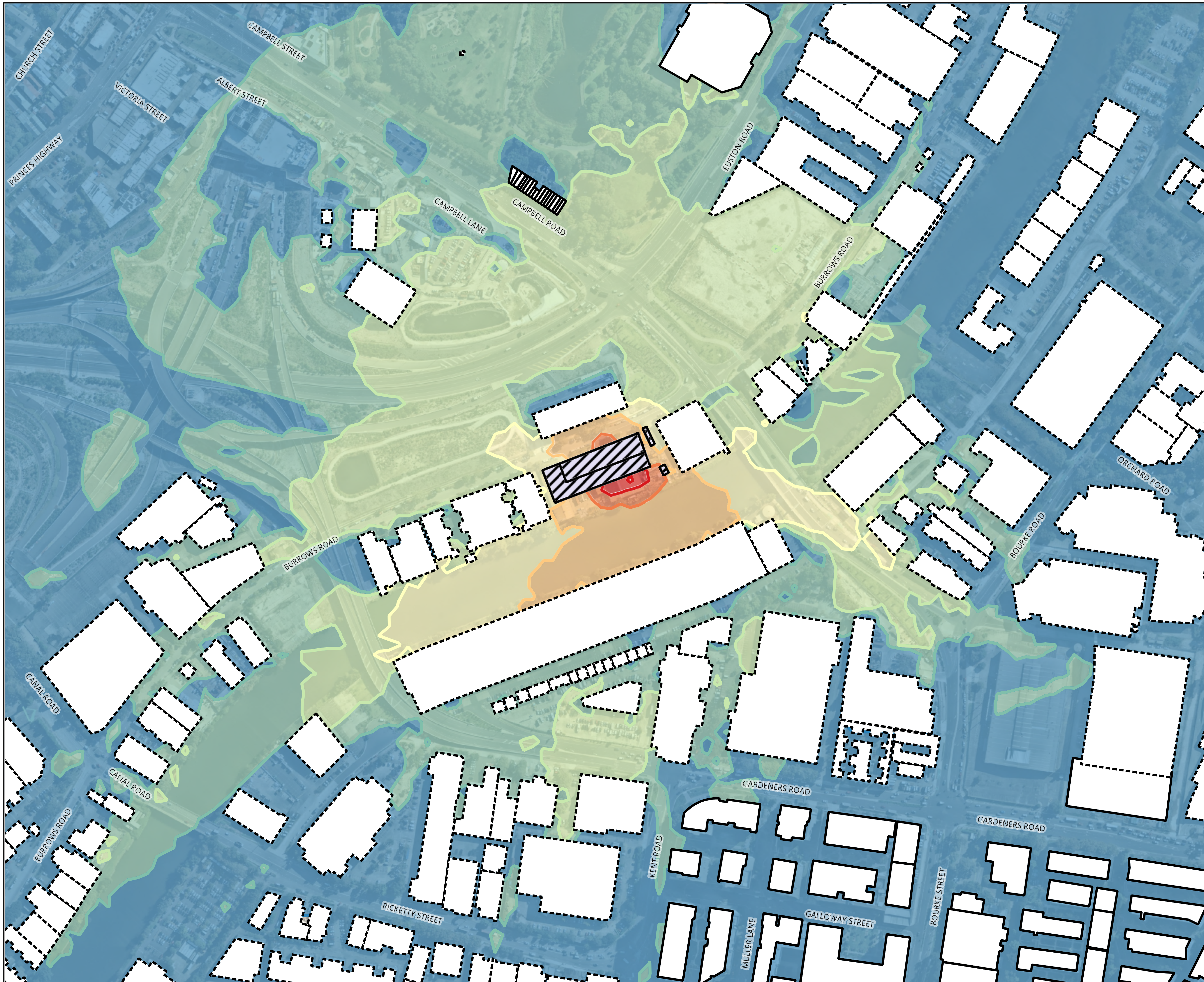
Operational Noise Assesment
Without mitigation,Standard meteorological conditions

Sheet 1 of 4

Plot Date: 27/09/22 - 14:31   Layout: TM727 Noise contours template



LEGEND

BUILDINGS copy

- Residential
- Non - Residential
- Site Buildings

Noise Contours During Operations
Without mitigation
Noise-Enhancing meteorological conditions
in dB(A) Leq (15 mins)

- < 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- > 60

REV	BY	DATE	DESCRIPTION	APPROVER
..	..	..	..	..
r2	SS	27/09/22	Noise Barrier Details	RP
r1	SS	13/09/22	Modify Contours	ALe
r0	SS	08/09/22	Prepare figures	RP

A3 Original   Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 m
1:3,900 at A3
FULL SIZE A3
NOTE: Do not scale from this drawing.

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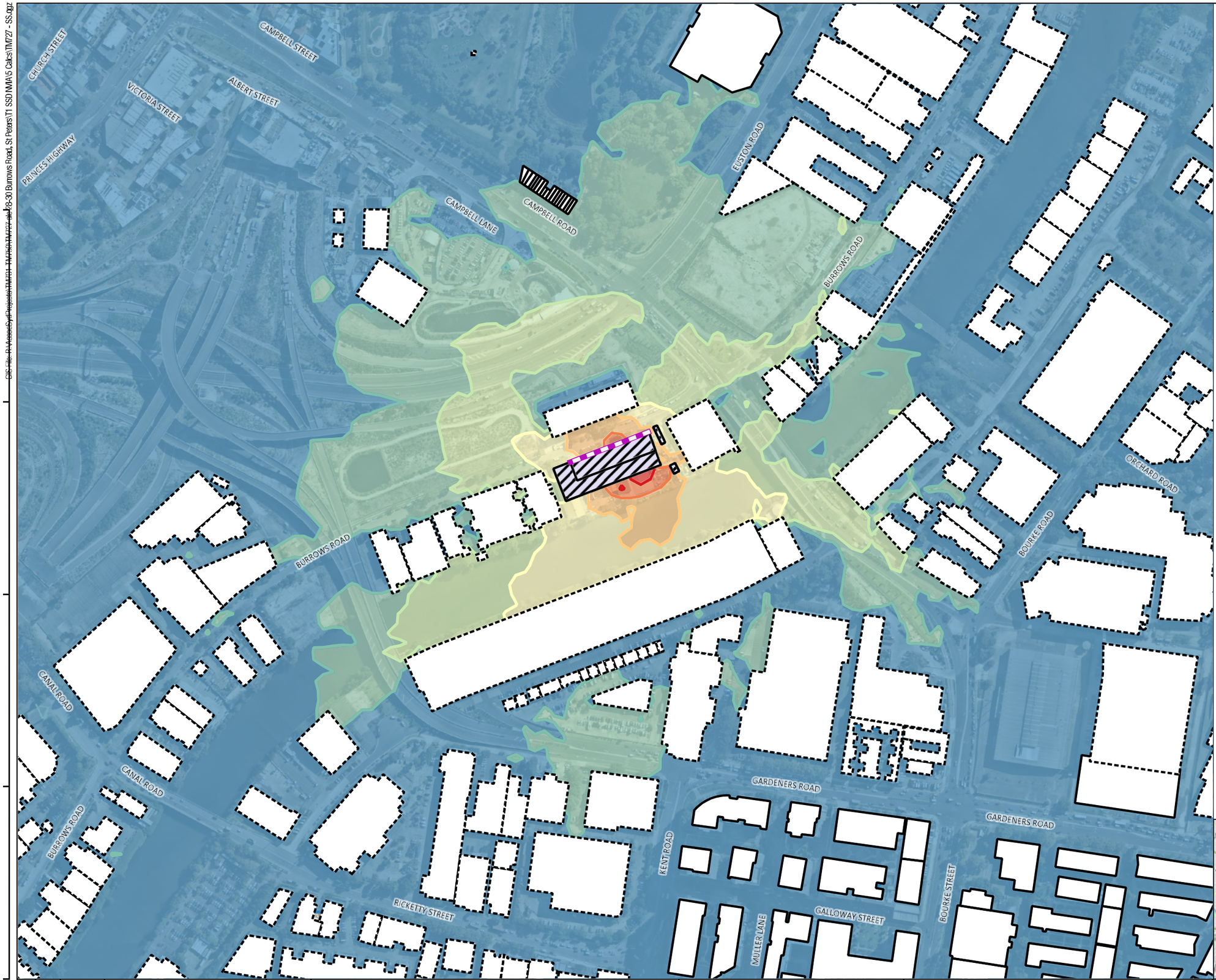
28 - 30 BURROWS ROAD, ST PETERS

Operational Noise Assesment
Without mitigation,Noise-Enhancing meteorological conditions

Plotted: 27/09/22 - 14:31 Layout: TM727 Noise contours template
C:\Users\Public\Projects\TM727 - TM750\TM727 - 28-30 Burrows Road, St Peters\T1 SSD NMA\5 Calcs\TM727 - SS.ogz



LEGEND

BUILDINGS copy
- Residential
- Non - Residential

- Acoustic screen (RL 20.515)
- Site Buildings

Noise Contours During Operations
With mitigation
Standard meteorological conditions
in dB(A) Leq (15 mins)
- < 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- > 60

REV	BY	DATE	DESCRIPTION	APPROVER
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
r2	SS	27/09/22	Noise Barrier Details	RP
r1	SS	13/09/22	Modify Contours	ALe
r0	SS	08/09/22	Prepare figures	RP

0 50 100 150 200 250 m
1:3,900 at A3
FULL SIZE A3

N

A3 Original
Co-ordinate System: MGA Zone 56
NOTE: Do not scale from this drawing.

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28 - 30 BURROWS ROAD, ST PETERS

Operational Noise Assesment
With mitigation,Standard meteorological conditions

Plotted: 27/09/22 - 14:31 Layout: TM727 Noise contours template
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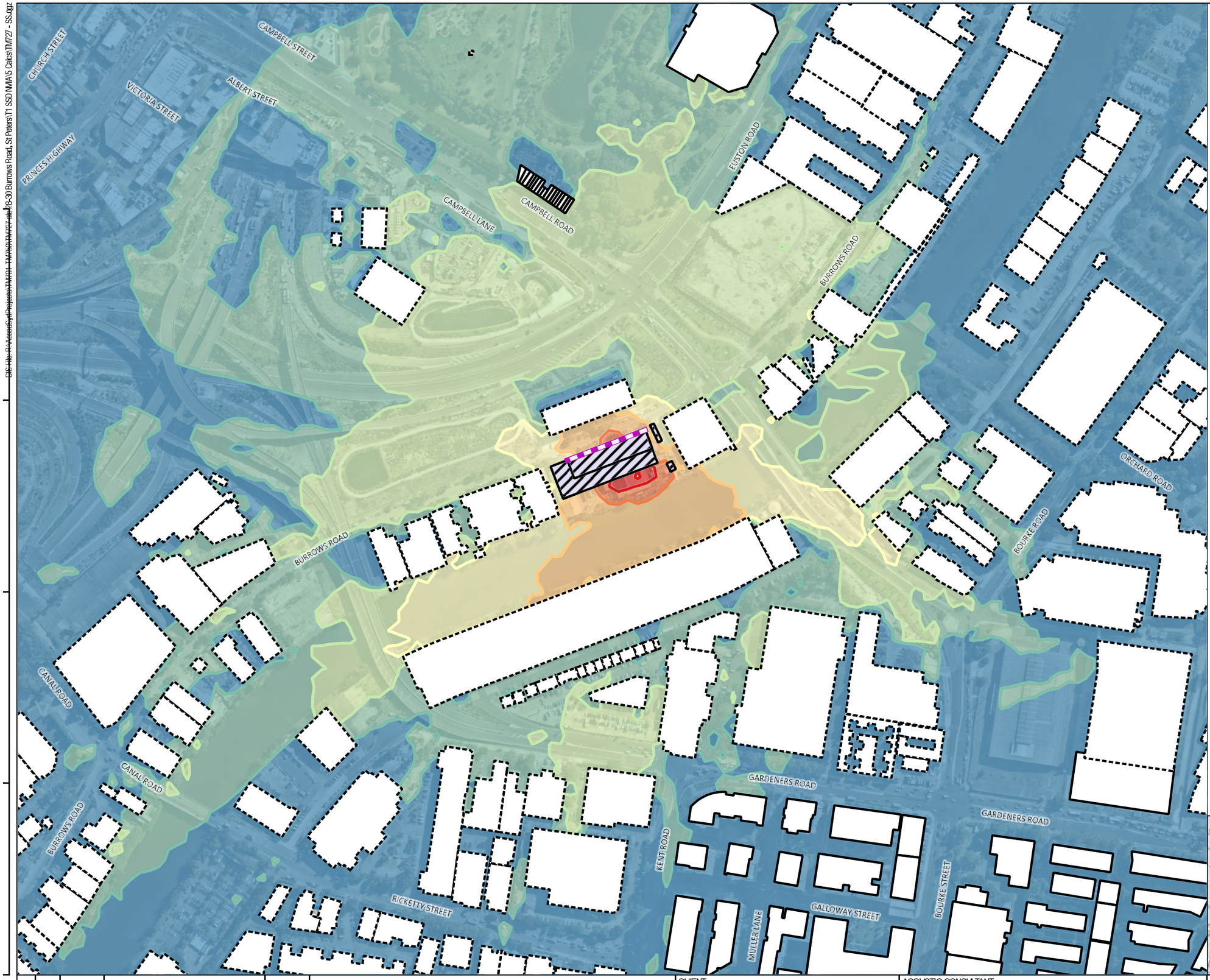

LEGEND

BUILDINGS copy

- Residential
- Non - Residential

- Acoustic screen (RL 20.515)
- Site Buildings

Noise Contours During Operations
With mitigation
Noise-Enhancing meteorological conditions
in dB(A) Leq (15 mins)

- < 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- > 60

REV	BY	DATE	DESCRIPTION	APPROVER
r2	SS	27/09/22	Noise Barrier Details	RP
r1	SS	13/09/22	Modify Contours	ALe
r0	SS	08/09/22	Prepare figures	RP

A3 Original | Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 m

1:3,900 at A3

FULL SIZE A3

NOTE: Do not scale from this drawing.

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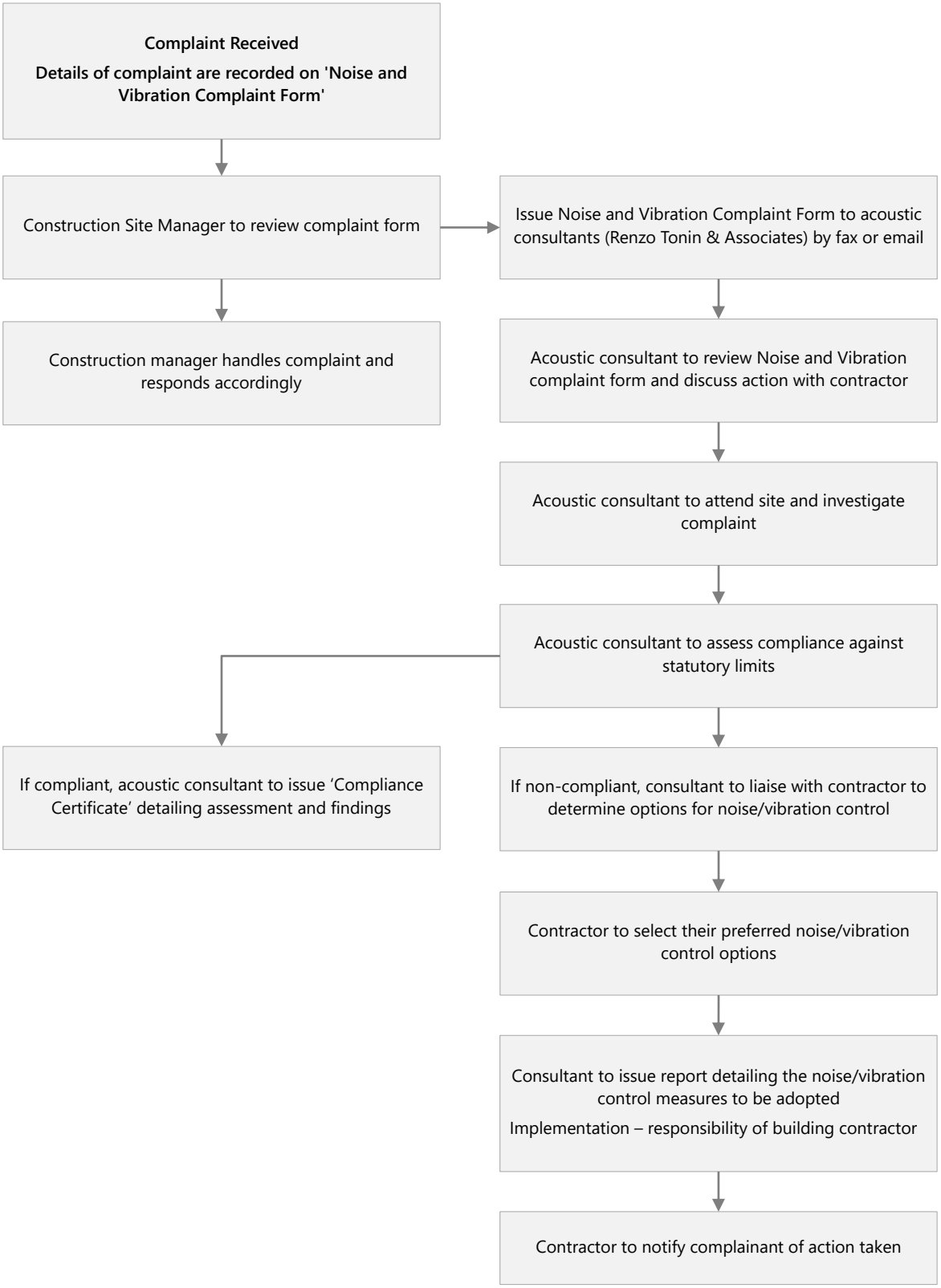
Ph (02) 8218 0500 Fax (02) 8218 0501

28 - 30 BURROWS ROAD, ST PETERS

Operational Noise Assesment
With mitigation,Noise-Enhancing meteorological conditions

APPENDIX D Noise / vibration complaint management procedure



NOISE/ VIBRATION COMPLAINT FORM

Project title: _____ **Date:** _____

Site contractor: _____ **Phone:** _____

Site contact: _____ **Email:** _____

Complaint details

Received by (circle): Phone / Email / In person / Other: _____

Name: _____ H Ph: _____

Address: _____ W Ph _____

Email: _____ M Ph _____

Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise/vibration:

Investigation

Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:

Following approval from the Project Manager, email/fax this form to Renzo Tonin & Associates