ACOUSTIC REPORT

APPENDIX O

Sydney Metro City & Southwest

Pitt Street North over station development:

Acoustic Report

Applicable to:	Sydney Metro City & Southwest
Author:	Pulse Acoustic Consultancy
Owner	Sydney Metro
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1. Purpose of this report

1.1 Background

This report supports a concept State Significant Development application (concept SSD Application) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under section 4.22 of the EP&A Act.

Sydney Metro is seeking to secure concept approval for a mixed use tower above the northern portal of Pitt Street Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for a building envelope and its use for residential accommodation, visitor accommodation and commercial premises, maximum gross floor area (GFA), pedestrian and vehicular access, circulation arrangements and associated car parking as well as the strategies and design parameters for the future detailed design of development.

Sydney Metro proposes to construct the OSD as part of an integrated station development package, which would result in the combined delivery of the station, OSD and public domain improvements. The station and public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by the Minister for Planning on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for the purposes of residential or commercial premises with a Capital Investment Value of more than $30 million, the project is State Significant Development (SSD) pursuant to Schedule 1, clause 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). The full extent of the proposed development is also State Significant Development by virtue of clause 8(2) of the SRD SEPP.

This report has been prepared to respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application for Pitt Street North on 30th November 2017 which state that the Environmental Impact Statement (EIS) is to address the following requirement:

> *Amenity: noise impact assessment*

1.2 Overview of the Sydney Metro in its context

The New South Wales (NSW) Government is implementing *Sydney's Rail Future*, a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future (Transport for NSW, 2012). Sydney Metro is a new standalone rail network identified in *Sydney's Rail Future*.

Sydney Metro is Australia's biggest public transport project, consisting of Sydney Metro Northwest, which is scheduled for completion in 2019 and Sydney Metro City & Southwest, which is scheduled for completion in 2024.

Sydney Metro West is expected to be operational in the late 2020s. (Refer to **Figure 1**).

Figure 1: Sydney Metro alignment map

Sydney Metro City & Southwest includes the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and on to Bankstown through the conversion of the existing line to metro standards.

The project also involves the delivery of seven new metro stations, including at Pitt Street. Once completed, Sydney Metro will have the ultimate capacity for 30 trains an hour (one every two minutes) through the CBD in each direction - a level of service never seen before in Sydney.

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham application as a Critical State Significant Infrastructure project (reference SSI 15_7400), hereafter referred to as the CSSI Approval.

The CSSI Approval includes all physical work required to construct the CSSI, including the demolition of existing buildings and structures on each site. Importantly, the CSSI Approval also includes provision for the construction of below and above-ground structures and other

components of the future ISD (including building infrastructure and space for future lift cores, plant rooms, access, parking and building services, as relevant to each site). The rationale for this delivery approach, as identified within the CSSI Application, is to enable the ISD to be more efficiently built and appropriately integrated into the metro station structure.

The EIS for the Chatswood to Sydenham component of the Sydney Metro City & Southwest project identified that the OSD would be subject to a separate assessment process.

Since the CSSI Approval was issued, Sydney Metro has lodged four modification applications to amend the CSSI Approval as outlined below:

- Modification 1- Victoria Cross and Artarmon Substation which involves relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with inclusion of a new station entrance at this location referred to as Victoria Cross North. 52 McLaren Street would also be used to support construction of these works. The modification also involves the relocation of the substation at Artarmon from Butchers Lane to 98 – 104 Reserve Road. This modification application was approved on 18 October 2017.
- Modification 2- Central Walk which involves additional works at Central Railway Station including construction of a new eastern concourse, a new eastern entry, and upgrades to suburban platforms. This modification application was approved on 21 December 2017.
- Modification 3 - Martin Place Station which involves changes to the Sydney Metro Martin Place Station to align with the Unsolicited Proposal by Macquarie Group Limited (Macquarie) for the development of the station precinct. The proposed modification involves a larger reconfigured station layout, provision of a new unpaid concourse link and retention of the existing MLC pedestrian link and works to connect into the Sydney Metro Martin Place Station. It is noted that if the Macquarie proposal does not proceed, the modification (if approved) would be surrendered. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporated Sydenham Station and precinct works, the Sydney Metro Trains Facility South, works to Sydney Water's Sydenham Pit and Drainage Pumping Station and ancillary infrastructure and track and signalling works into the approved project. This modification application was approved on 13 December 2017.

Given the modifications, the CSSI Approval is now approved to operate to Sydenham Station and also includes the upgrade of Sydenham Station.

The remainder of the City & Southwest project (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line and the upgrade of the existing railway stations along this alignment to metro standards. This portion of the project, referred to as the Sydenham to Bankstown Upgrade, is the subject of a separate CSSI Application (No. SSI 17_8256) for which an Environmental Impact Statement was exhibited between September and November 2017 and a Response to Submissions and Preferred Infrastructure Report

was submitted to the NSW Department of Planning & Environment (DPE) in June 2018 for further exhibition and assessment.

1.3 Planning relationship between Pitt Street Station and the OSD

While the northern portal of Pitt Street Station and the OSD will form an Integrated Station Development, the planning pathways defined under the *Environmental Planning and Assessment Act 1979* require separate approval for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

For clarity, the approved station works under the CSSI Approval included the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This included but is not limited to:

- demolition of existing development
- excavation
- station structure including concourse and platforms
- lobbies
- retail spaces within the station building
- public domain improvements
- station portal link (between the northern and southern portals of Pitt Street Station)
- access arrangements including vertical transport such as escalators and lifts
- structural and service elements and the relevant space provisioning necessary for constructing OSD, such as columns and beams, space for lift cores, plant rooms, access, parking, retail and building services.

The vertical extent of the approved station works above ground level is defined by the 'transfer slab' level (which for Pitt Street North is defined by RL 48.00), above which would sit the OSD. This delineation is illustrated in **Figure 2** below.

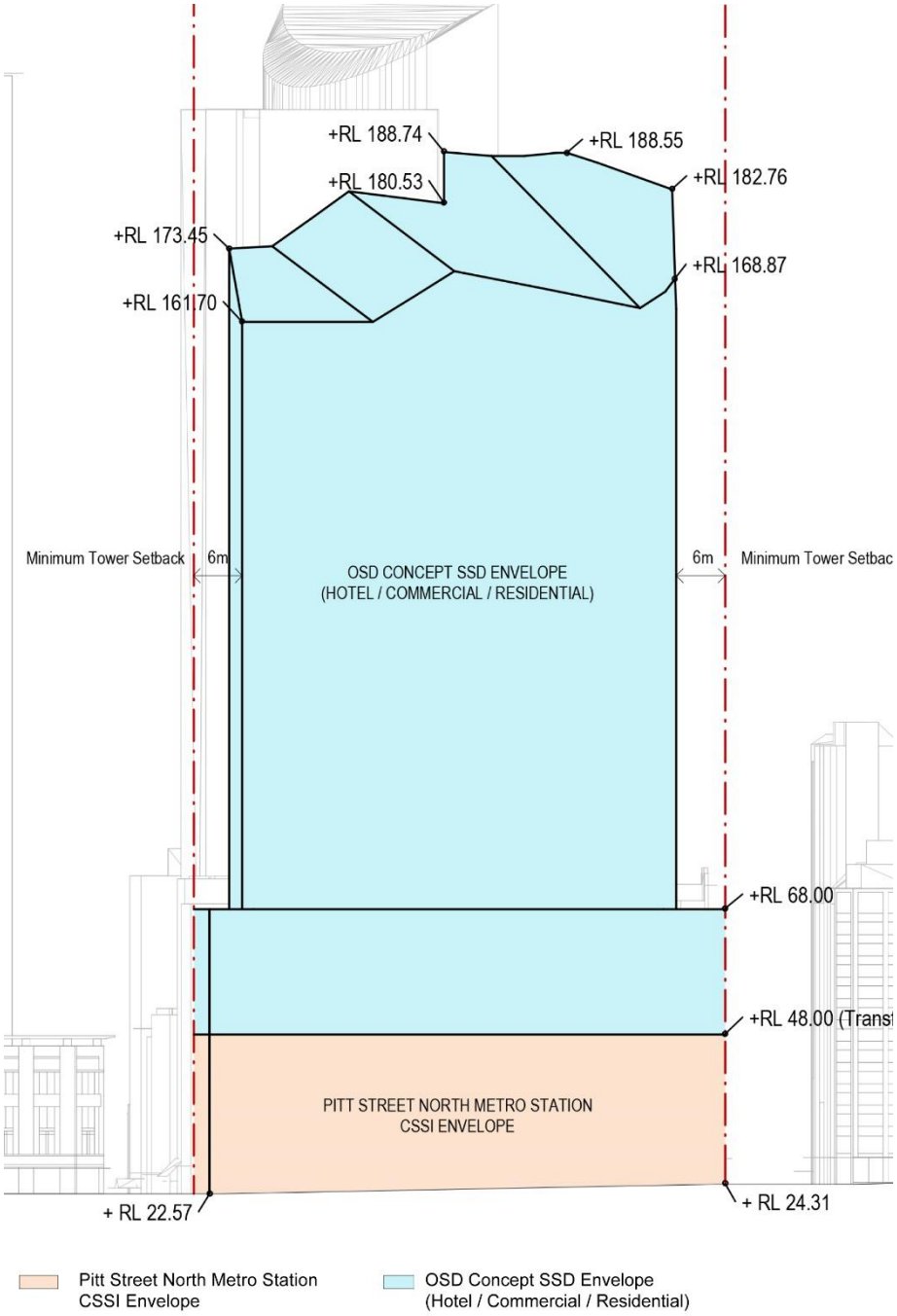

Figure 2: Delineation between station and OSD

The CSSI Approval also establishes the general concept for the ground plane of Pitt Street Station including access strategies for commuters, pedestrians and workers. In this regard, pedestrian access to the station would be from Park Street and the OSD lobbies would be accessed from Pitt Street, Park Street and Castlereagh Street.

Since the issue of the CSSI Approval, Sydney Metro has undertaken sufficient design work to determine the space planning and general layout for the station and identification of those spaces within the station area that would be available for the OSD. In addition, design work has been undertaken to determine the technical requirements for the structural integration of the OSD with the station. This level of design work has informed the concept proposal for the OSD. It is noted that ongoing design development of the works to be delivered under the CSSI Approval would continue with a view to developing an Interchange Access Plan (IAP) and Station Design Precinct Plan (SDPP) for Pitt Street Station to satisfy Conditions E92 and E101 of the CSSI Approval.

The public domain improvement works around the site would be delivered as part of the CSSI Approval.

1.4 The Site

The Pitt Street North OSD site is located at the southern portion of the Sydney CBD block bounded by Pitt Street, Park Street and Castlereagh Street, above the northern portal of the future Pitt Street Station (refer to **Figure 3** below).

Figure 3: Pitt Street Station location plan

The site is located in the City of Sydney Local Government Area. The site (refer to **Figure 4** below) is irregular in shape, has a total area of approximately 3,150 square metres and has street frontages of approximately 28 metres to Pitt Street, 81 metres to Park Street and 48 metres to Castlereagh Street.

The site address is 175-183 Castlereagh Street, Sydney and comprises the following properties:

- Lot 3 in DP 74952
- Lot 1 in DP 229365
- Lot 2 in DP 900055
- Lot 1 in DP 596474
- Lot 17 in DP 1095869
- Lot 2 in DP 509677
- Lot 1 in DP 982663
- Lot 2 in DP 982663
- Lot 3 in DP 61187
- Lot 1 in DP 74367

Figure 4: Aerial photo of Pitt Street North

1.5 Overview of the proposed development

The concept SSD Application seeks concept approval in accordance with section 4.22 of the EP&A Act for the OSD above the approved Pitt Street Station (northern portal). This application establishes the planning framework and strategies to inform the detailed design of the future OSD and specifically seeks planning approval for:

- a building envelope as illustrated at Figure 5
- a maximum building height of approximately Relative Level (RL) 189 which equates to approximately 43 storeys including a podium height of RL68 (approximately 45m), which equates to approximately 12 storeys above ground
- a maximum GFA of 49,120 square metres for the OSD component, which equates to a Floor Space Ratio (FSR) of 15.59:1, resulting in a total maximum GFA at the site (including station floorspace) of 50,309 square metres and a total maximum FSR of 15.97:1, including flexibility to enable a change in the composition of land uses within the maximum FSR sought
- conceptual use of the building envelope for a range of uses including commercial office space, visitor accommodation and residential accommodation
- use of the conceptual OSD space provisioning within the footprint of the CSSI Approval (both above and below ground), including the OSD lobby areas, podium car parking, storage facilities, services and back-of-house facilities
- car parking for approximately 50 spaces located across five levels of the podium
- loading and vehicular access arrangements from Pitt Street
- pedestrian access from Pitt Street, Park Street and Castlereagh Street
- strategies for utilities and service provision
- strategies for the management of stormwater and drainage
- a strategy for the achievement of ecologically sustainable development
- indicative signage zones
- a strategy for public art
- a design excellence framework
- the future subdivision of parts of the OSD footprint (if required)

As this concept SSD Application is a staged development pursuant to section 4.22 of the EP&A Act, future approval would be sought for detailed design and construction of the OSD. A concept indicative design, showing a potential building form outcome at the site, has been provided as part of this concept SSD Application at Appendix E.

Pitt Street Station is to be a key station on the future Sydney Metro network, providing access to the Sydney Central Business District (CBD). The proposal combines the metro station with a significant mixed use tower, contributing to the Sydney skyline. The OSD would assist in strengthening the role of Central Sydney as the key centre of business in Australia and would contribute to the diversity, amenity and sustainability of the CBD.

It is noted that Pitt Street Station southern portal OSD has been subject to a separate application, and does not form part of this concept SSD Application.

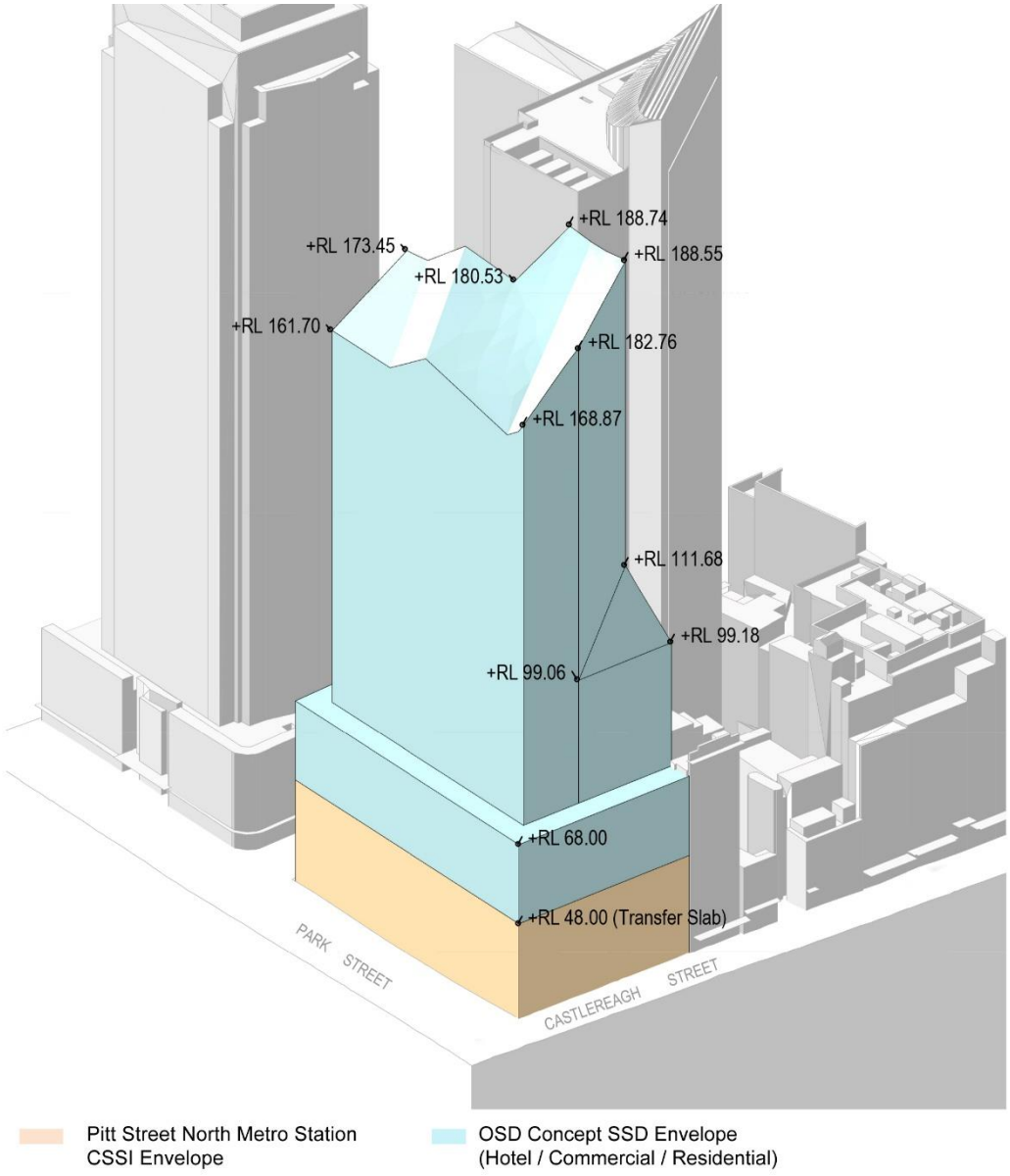

Figure 5: Pitt Street North OSD building, including OSD components (orange) and station box (grey)

Figure 6: Pitt Street North OSD indicative design, as seen from eastern, southern and western elevations

1.6 Staging and framework for managing environmental impacts

Sydney Metro proposes to procure the delivery of the Pitt Street North integrated station development in one single package, which would entail the following works:

- station structure
- station fit-out, including mechanical and electrical
- OSD structure
- OSD fit-out, including mechanical and electrical.

Separate delivery packages are also proposed by Sydney Metro to deliver the excavation of the station boxes/shafts ahead of the ISD delivery package, and line-wide systems (e.g. track, power, ventilation) and operational readiness works prior to the Sydney Metro City & Southwest metro system being able to operate.

Three possible staging scenarios have been identified for delivery of the Integrated Station Development:

1. Scenario 1 – the station and OSD are constructed concurrently by constructing the transfer slab first and then building in both directions. Both the station and OSD would be completed in 2024.
2. Scenario 2 – the station is constructed first and ready for operation in 2024. OSD construction may still be incomplete or soon ready to commence after station construction is completed. This means that some or all OSD construction is likely to still be underway upon opening of the station in 2024.
3. Scenario 3 – the station is constructed first and ready for operation in 2024. The OSD is built at a later stage, with timing yet to be determined. This creates two distinct construction periods for the station and OSD.

Scenario 1 represents Sydney Metro's preferred option as it would provide for completion of the full integrated station development and therefore the optimum public benefit at the site at the earliest date possible (i.e. on or near 2024 when the station is operational). However, given the delivery of the OSD could be influenced by property market forces, Scenarios 2 or 3 could also occur, where there is a lag between completion of the station component of the ISD (station open and operational), and a subsequent development.

The final staging for the delivery of the OSD would be resolved as part of the detailed SSD application(s).

For the purposes of providing a high level assessment of the potential environmental impacts associated with construction, the following have been considered:

- Impacts directly associated with the OSD, the subject of this SSD application
- Cumulative impacts of the construction of the OSD at the same time as the station works (subject of the CSSI Approval).

Given the integration of the delivery of the Sydney Metro City & Southwest metro station with an OSD development, Sydney Metro proposes the framework detailed in

Figure 7 to manage the design and environmental impacts, consistent with the framework adopted for the CSSI Approval, which includes:

- project design – measures which are inherent in the design of the project to avoid and minimise impacts
- mitigation measures – additional to the project design which are identified through the environmental impact assessment
- construction environmental management framework – details the management processes and documentation for the project
- construction noise and vibration strategy – identifies measures to manage construction noise and vibration
- design guidelines – provides an assurance of end-state quality
- environmental performance outcomes – establishes intended outcomes which would be achieved by the project

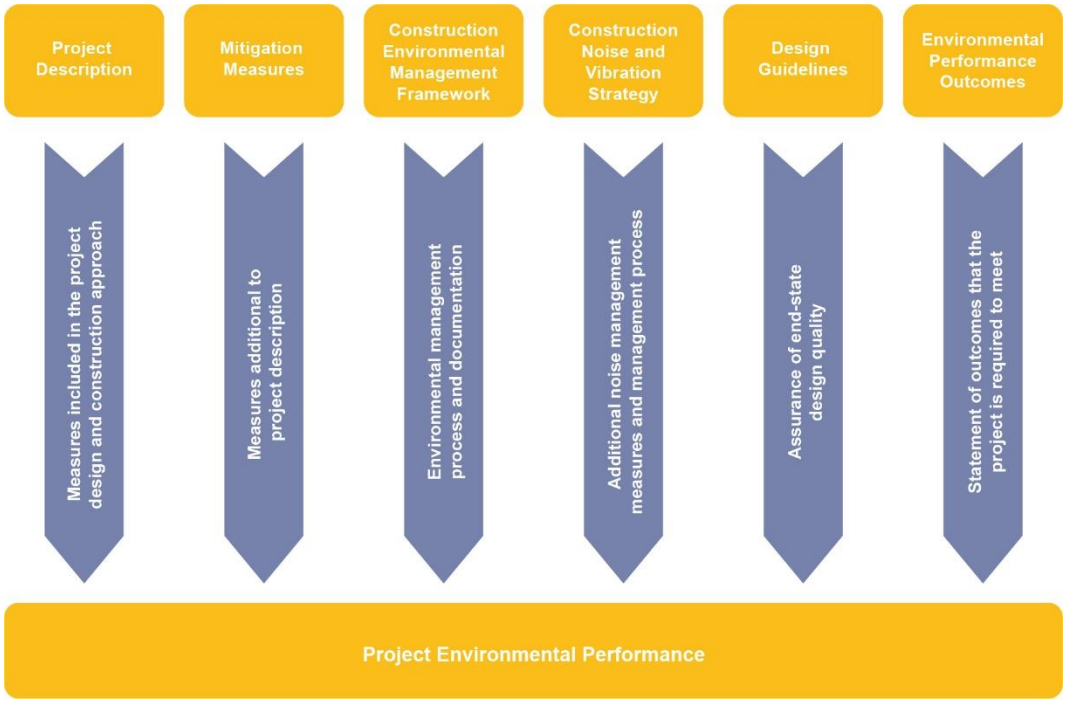

Figure 7: Project approach to environmental mitigation and management

Sydney Metro proposes to implement a similar environmental management framework where the integrated delivery of the CSSI station works and the OSD occur concurrently. This would ensure a consistent approach to management of design interface and construction-related issues.

Sydney Metro proposes this environmental management framework would apply to the OSD until completion of the station and public domain components of the integrated station development delivery contract (i.e. those works under the CSSI Approval). Should the OSD be constructed beyond the practical completion and opening of the section, standard practices for managing construction related environmental impacts would apply in accordance with the relevant guidelines and Conditions of Approval for the detailed SSD application(s).

2. Introduction

This report is prepared in response to the Secretary's Environmental Assessment Requirements (SEARs) for application number SSD 8875 (dated 30 November 2017) which comprises the conceptual design of a commercial and residential development above the station development at Pitt Street (North) station, Sydney. This station development is part of the Sydney Metro City & Southwest project.

The SEARs identifies, as a key issue, a noise impact assessment that should be conducted in order to:

- *Identify the main noise and vibration generating sources and activities from the site at all stages of operation*
- *Provide measures to minimise and mitigate potential noise and vibration impacts on surrounding occupiers*
- *Identify the noise and vibration impact from surrounding land uses, such as noise from the operation of the rail line and surrounding road networks, and management and operational arrangements or mitigation measures to protect the amenity of residents, visitors and employees*

Consequently the SEARs requests that, as part of the Environmental Impact Statement (EIS) for the project, the following documents should be provided:

- Noise report
- Construction noise and vibration report

Therefore this report has been prepared to address the key design issue mentioned above as part of the requested deliverables for the EIS.

2.1. Background Information

Sydney Metro is a new standalone railway network comprising 31 stations and more than 66 km of new rail lines. This project comprises two components: Sydney Metro City & Southwest and Sydney Metro Northwest.

The Sydney Metro City & Southwest includes two core components:

- The Sydenham to Bankstown upgrade involving the conversion and upgrades of existing rail lines and stations between Sydenham and Blacktown.
- The Chatswood to Sydenham project which involves the construction and operation of an underground rail line between Chatswood and Sydenham. This part of the Sydney Metro project is classified as Critical State Significant Infrastructure (CSSI). CSSI Approval SSI 15_7400 has been granted to undertake this project.

One of the key components of the Chatswood to Sydenham project is the construction of new train stations, of which Pitt Street Station is included. The NSW Government has identified this station as a location that can be better integrated with communities and public spaces around them. Consequently, it is proposed that the Pitt Street North over station

development (OSD) provides a single unified design above the northern portal of the station, which includes the construction of a mixed use tower.

2.2. Site Description

The project site extends over the following individual properties which front Pitt Street, Park Street and Castlereagh Street in Sydney:

- 175-183 Castlereagh Street
- 40 Park Street
- 42-46 Park Street
- 48 Park Street
- 252-254 Pitt Street
- 256 Pitt Street, Sydney

The site is located one block to the west of Hyde Park, and near Town Hall and Museum Stations. It is surrounded by residential, hotels and commercial high density buildings as shown in Figure 8 below.

Figure 8 Aerial location of the site with nearest receivers

Source: BVN, Figure 3 of report titled "Request for Secretary's Environmental Assessment Requirements, Sydney Metro City & Southwest – Pitt Street (North) Station Development", dated November 2017

2.3. Proposed Development

It is proposed that the OSD above the Pitt Street northern portal will comprise the following:

- A mixed use building with a maximum height of 189 metres and a maximum gross floor area of 48,351 m^2
- The building will be allocated for residential, hotel and commercial use
- Car parking capacity for a maximum of 50 spaces in the podium
- Loading, vehicular and pedestrian access arrangements

The podium of the building will accommodate the residential, hotel and commercial lobbies, building plant and services, and the business premises. The podium will also include the separate access to the car parking and loading dock facilities for the OSD, accessible from the Castlereagh Street frontage of the site.

Public domain works around the site will be constructed as part of the CSSI Approval. Nevertheless, the OSD will be designed to integrate with the public domain.

Refer to Figure 9 and Figure 10 for axonometric views of the development.

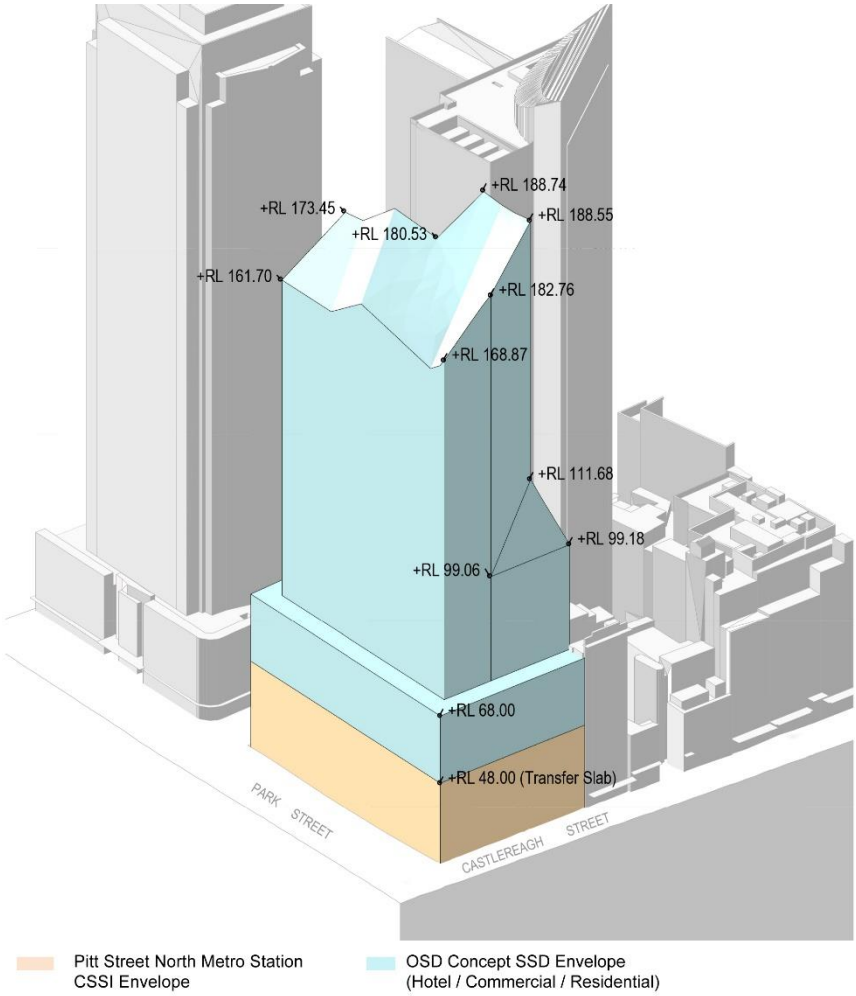

Figure 9 Axonometric view of the development

Source: Architectus, document titled "Pitt Street North OSD: Transport NSW – Planning Envelope", dated 21 June 2018

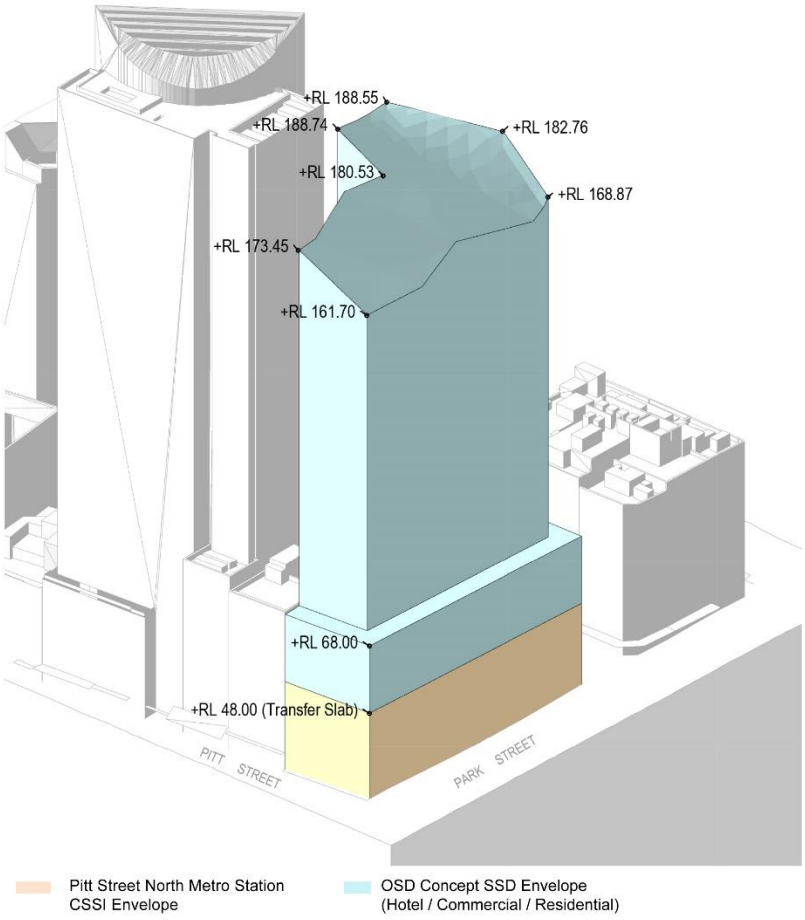

Figure 10 Axonometric view of the development

Source: Architectus, document titled "Pitt Street North OSD: Transport NSW – Planning Envelope", dated 21 June 2018

2.4. Existing Noise Environment

The existing ambient noise levels for the project site have been obtained from the Chatswood to Sydenham Environmental Impact Statement (CS EIS), Technical Paper 2: Noise and Vibration (dated May 2016). The CS EIS report has been prepared as part of the environmental impact assessment for the Sydney Metro City & Southwest project, of which the future Pitt Street station is part of. These existing ambient noise levels are summarised in Table 1 below.

These noise levels were obtained by undertaking unattended noise measurements at 260 Pitt Street, Sydney. The location of the unattended noise survey is located in the vicinity of the project site (across Park Street).

It is noted that these measurements are relatively high for ambient noise levels typical of this urban setting. Therefore it is advised that further unattended noise measurements should be undertaken at future stages of the project in order to confirm the documented noise levels.

Table 1 Existing ambient noise levels as per CS EIS Technical Paper 2

Daytime		Evening		Night time	
RBL	L_{Aeq}	RBL	L_{Aeq}	RBL	L_{Aeq}
66	71	64	70	61	68

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 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 – 8:00 am

Note 2: The RBL noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3. Operational Acoustic Criteria

3.1. External Noise Emission Criteria

3.1.1. NSW Noise Policy for Industry

In NSW, the control of noise emissions is the responsibility of Local Governments and the NSW Environment Protection Authority (NSW EPA).

Consequently, the NSW EPA has prepared a document titled Noise Policy for Industry (NSW NPI) which provides a framework and process for determining external noise criteria and subsequent assessments. The NSW NPI criteria for industrial noise sources have two components:

- Controlling the intrusive noise impacts for residents and other noise sensitive receivers in the short term; and
- Maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses.

3.1.2. Intrusive Noise Impacts

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). This is often termed the Intrusiveness Criterion.

The 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the NSW NPI. Using the rating background noise level approach results in the intrusiveness criterion being met for 90% of the time. Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point where the noise source contains annoying characteristics such as tonality or impulsiveness.

3.1.2.1. Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW NPI. That is, the ambient L_{Aeq} noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the 'Background Creep' or Amenity Criterion.

The amenity assessment is based on noise criteria specified for a particular land use and corresponding sensitivity to noise. The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. These criteria relate only to other continuous industrial-type noise and do not include road, rail or community noise. If the

existing (measured) industrial-type noise level approaches the criterion value, then the NSW NPI sets maximum noise emission levels from new sources with the objective of ensuring that the cumulative levels do not significantly exceed the criterion.

3.1.2.2. Area Classification

The NSW NPI characterises the "Urban" noise environment as an area with an acoustical environment that:

- Is dominated by "urban hum" or industrial noise source
- Has through traffic with characteristically heavy and continuous traffic flows during peak periods
- Is near commercial or industrial districts
- Has any combination of the above

…where "urban hum" means the aggregate unidentifiable sound of man and mostly due to traffic-related sound sources

The area surrounding the proposed development falls under the "Urban" area classification. For residential and non-residential receivers in an urban area, the recommended amenity criteria are shown in Table 2 below.

Table 2 NSW NPI – Recommended LAeq Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Assessment Period [1]	Recommended Amenity Noise Level [2] (L_{Aeq}, period)
Residence	Urban	Day	60
		Evening	50
		Night	45
Hotels	Urban	Day	65
		Evening	55
		Night	50
Commercial	All	When in use	65
Place of worship (internal)	All	When in use	40

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 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 – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

When the existing noise level from industrial noise sources is close to the recommended "Amenity Noise Level" (ANL) given above, noise from the new source must be controlled to preserve the amenity of the area in line with the requirements of the NSW NPI.

Where existing road traffic noise is high enough to render stationary noise sources effectively inaudible, the ANL can be modified so that the amenity criteria is not unduly stringent in an environment where road traffic noise is the dominant source of environmental noise. If all the conditions below are satisfied, the ANL becomes $L_{Aeq,traffic}$ minus 15dB(A). The conditions are:

- The road traffic noise is the dominant noise source
- The existing noise is 10dB(A) or more above the recommended ANL for the area
- It is highly unlikely the road traffic noise levels would reduce in the near future

3.1.2.3. Criteria based on the NSW Noise Policy for Industry

The intrusive and amenity criteria for industrial noise emissions derived from the measured data are presented in Table 1. These criteria are nominated for the purpose of determining the operational noise limits for mechanical plant associated with the commercial components of the development to potentially affected noise sensitive receivers. The criteria are summarised in Table 3. For each assessment period, the lower (i.e. the more stringent) of the amenity or intrusive criteria are adopted. (in this case these correspond to the amenity criteria).

Following consultation with Transport for NSW and advisors for the Sydney Metro project, it is noted that the criteria are applicable to the whole integrated station development (ISD). The ISD comprises the OSD, station development and tunnel ventilation system. Therefore the criteria corresponding to the OSD only are 5 dB less than the whole ISD criteria.

Table 3 External noise level criteria in accordance with the NSW NPI

Type of Receiver	Assessment Period 1	Project Amenity Noise Level, $L_{Aeq, period}$ (dBA) [1]	Measured $L_{A90, 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq, period}$ Noise Level (dBA)	Whole ISD Criteria		OSD criteria only (based on NPI Amenity Criteria), $L_{Aeq, 15\ min}$, [$L_{Aeq\ period}$] (dBA)
					Intrusive $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA)	Amenity $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [4]	
Residence	Day	55	66	71	71	**64**	**59 [56]**
	Evening	45	64	70	69	**63**	**58 [55]**
	Night	40	61	68	66	**61**	**56 [53]**
Hotels	Day	60	66	71	71	**64**	**59 [56]**
	Evening	50	64	70	69	**63**	**58 [55]**
	Night	45	61	68	66	**61**	**56 [53]**
Commercial	When in use	60	N/A	-	-	**63**	**58 [55]**

Type of Receiver	Assessment Period 1	Project Amenity Noise Level, $L_{Aeq, period}$ (dBA) [1]	Measured $L_{A90, 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq, period}$ Noise Level (dBA)	Whole ISD Criteria		OSD criteria only (based on NPI Amenity Criteria), $L_{Aeq, 15\ min}$, [$L_{Aeq\ period}$] (dBA)
					Intrusive $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA)	Amenity $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [4]	
Place of worship (internal)	When in use	40	N/A	-	-	**43**	**38 [35]**

Note 1: Project Amenity Noise Levels corresponding to "Urban" areas, equivalent to the Recommended Amenity Noise Levels (Table 2) minus 5 dBA

Note 2: L_{A90} Background Noise or Rating Background Level

Note 3: Project Noise Trigger Levels are shown in bold

Note 4: This is based on the assumption that the existing noise levels are unlikely to decrease in the future

3.1.2.4. Comparison with criteria from NSW Industrial Noise Policy

Based upon consultation with Transport for NSW and advisors for the Sydney Metro project, it has been agreed that the approach for deriving the OSD operational noise emission criteria will comprise the following (this approach is summarised in

Table 4 below):

- Use of the procedures discussed in the NSW Industrial Noise Policy (NSW INP) in order to define the criteria for the whole ISD.
- Then, as previously discussed in Section 3.1.2.3, a -5 dB correction will apply to the whole ISD criteria in order to account for equal contribution from the three ISD components (OSD, station development and tunnel ventilation system).

Table 4 Summary of environmental noise emission criteria for residential receivers – INP criteria are from the Resonate Acoustic Report for Pitt Street Station, and NPI Urban Amenity criteria (Period and 15-minute equivalent) have been derived by in accordance with the NSW NPI. (Background and ambient noise levels source: Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration, Criteria source: Resonate Acoustics and NSW Industrial Noise Policy)

Period	Existing		Whole Integrated Station Development		Each ISD component (OSD, Station, TVS)		OSD only
	RBL, $L_{A90\ period}$, (dBA)	Ambient $L_{Aeq\ period}$, (dBA)	Intrusiveness criteria $L_{Aeq\ 15\ min}$, (dBA)	INP Amenity criteria, $L_{Aeq\ period}$, (dBA)	Adjusted Intrusiveness criteria, $L_{Aeq\ 15\ min}$, (dBA)	Adjusted INP Amenity criteria, $L_{Aeq\ period}$, (dBA)	NPI Amenity criteria, $L_{Aeq\ 15\ min}$, [$L_{Aeq\ period}$], (dBA)

Period	Existing		Whole Integrated Station Development		Each ISD component (OSD, Station, TVS)		OSD only
	RBL, $L_{A90\ period}$, (dBA)	Ambient $L_{Aeq\ period}$, (dBA)	Intrusiveness criteria $L_{Aeq\ 15\ min}$, (dBA)	INP Amenity criteria, $L_{Aeq\ period}$, (dBA)	Adjusted Intrusiveness criteria, $L_{Aeq\ 15\ min}$, (dBA)	Adjusted INP Amenity criteria, $L_{Aeq\ period}$, (dBA)	NPI Amenity criteria, $L_{Aeq\ 15\ min}$, [$L_{Aeq\ period}$], (dBA)
Residential Receivers							
Day	66	71	71	61	66	56	**59 [56]**
Evening	64	70	69	60	64	55	**58 [55]**
Night	61	68	66	58	61	53	**56 [53]**

The following is noted from

Table 4:

- The adjusted INP amenity criteria allocated to the OSD design have been compared with the applicable NPI amenity noise criteria for the OSD (obtained from Table 3). It can be observed that the amenity criteria determined by using either the adjusted INP or the new NPI approach are identical.
- The adjusted INP intrusiveness criteria for the OSD design alone is also equivalent to the OSD criteria based on the NPI approach

3.1.2.5. External Noise Emission Criteria

The discussions provided in previous sections indicate that the external noise emission criteria should be determined by first determining the whole ISD criteria. The OSD criteria should be then be defined from equal contribution from all ISD components.

For residences, the preferable procedure to obtain the OSD criteria is the approach discussed in Section 3.1.2.4. However, as noted by comparing the NPI approach (Section 3.1.2.3) and the INP approach (Section 3.1.2.4), the obtained criteria are equivalent regardless of the adopted approach.

For non-residential receivers, it is advised the criteria summarised in Table 3 should be considered.

It is recommended that these criteria should be confirmed once further unattended noise measurements are conducted on site. As discussed in Section 2.4, it is noted that the measurement results listed in the CS EIS report could be higher than the existing ambient noise levels. This will result in more lenient criteria which are not representative of the site.

Following consultation with Transport for NSW and other advisors, it was recommended that a due diligence approach be adopted in order consider the assessment procedures

discussed in the NPI as well as in the NSW Industrial Noise Policy (NSW INP), and any differences should be examined and addressed accordingly on a case by case scenario.

3.1.2.6. Emergency Plant

For emergency plant, such as stand-by generators, which only operate occasionally (such as emergencies and maintenance operations), the NSW NPI allows for modifying factors that can be subtracted from the predicted noise levels. These modifying factors should be applied prior to assessing against the external noise level criteria. These duration modifying factors are summarised in Table 5 below.

Table 5 Modifying factors for duration

Allowable Duration of Noise (one event in any 24 hour period)	Allowable Exceedance at Receiver for the Period of Noise Event	
	Daytime and Evening (7am – 10pm)	Night time (10pm – 7am)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

Note 1: Where the duration of the noise event is smaller than the duration of the project trigger noise level (PNTL), that is, less than 15 minutes, the allowable adjusted project noise trigger level (APNTL) is derived as follows:

$$APNTL = 10\,log((10^{\frac{PNTL}{10}}\ x\ (\frac{900 - duration}{900})) + (10^{\frac{PNTL+allowable\ exceedance\ in\ table\ above}{10}}\ x\ duration))$$

3.1.2.7. Sleep Disturbance Assessment

According to the NSW NPI, the potential for sleep disturbance should be addressed if the following noise trigger levels are exceeded:

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

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.

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

- How often high noise events will occur
- 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.

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

3.1.3. City of Sydney

Standard Conditions of Development Consent issued by the City of Sydney Council, provides the following requirements regarding external noise emissions by building services:

a) *The emission of noise associated with the use of the premises including the operation of any mechanical plant and equipment shall comply with the following:*

   (i) *The $L_{Aeq,15min}$ noise level emitted from the use must not exceed the project specific noise level for that receiver as determined in accordance with the NSW Industrial Noise Policy. Noise must be measured in accordance with the Industrial Noise Policy and relevant requirements of Australian Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.*

   (ii) *Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90,\ 15\ minute}$ / rating $L_{A90,\ 15\ minute}$ process to be in accordance with the requirements for noise monitoring listed in the NSW Industrial Noise Policy and relevant requirements of Australian Standard AS1055-1997 Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.*

   (iii) *Modifying factors in Table 4.1 of the NSW Industrial Noise Policy are applicable.*

b) *An $L_{Aeq,15min}$ noise level emitted from the use must not exceed the $L_{A90,15min}$ noise level by more than 3dB in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed inside any habitable room of any affected residence provided that:*

   (i) *Where the $L_{A90,15min}$ noise level is below the threshold of hearing Tf at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 226 - Normal Equal-Loudness-Level Contours then the value of Tf corresponding to that Octave Band Centre Frequency shall be used instead.*

   (ii) *The $L_{Aeq,15min}$ noise level and the $L_{A90,15min}$ noise level shall both be measured with all external doors and windows of the affected residence closed;*

   (iii) *The relevant background noise level ($L_{A90,15\ minute}$) is taken to mean the day, evening or night rating background noise level determined in complete accordance with the methodology outlined in the NSW Industrial Noise Policy and Australian Standard AS1055.1997 Acoustics – Description and measurement of environmental noise.*

(iv) *Background noise shall be established in the absence of all noise emitted from the use but with the ventilation equipment normally servicing the affected residence operating. Background noise measurements are to be representative of the environmental noise levels at the affected location.*

(v) *Modifying factors in Table 4.1 of the NSW Industrial Noise Policy are applicable. Internal Noise measurements are not to be corrected for duration.*

3.2. Internal Noise Level Criteria

3.2.1. State Environmental Planning Policy (Infrastructure) 2007

The State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP) was introduced to assist the delivery of necessary infrastructure by improving regulatory certainty and efficiency. The Infrastructure SEPP has specific planning provisions and development controls for various types of infrastructure and also for development located adjacent to infrastructure. In order to provide guidelines for this type of assessment (noise intrusion from road and rail traffic noise), the Department of Planning of the NSW Government has prepared a document titled *"Developments Near Rail Corridors and Busy Roads – Interim Guideline"* (the Guideline).

The Guideline applies to development adjacent to rail corridors and busy roads. It can also provide a useful guide for all development that may be impacted by, or may impact on, rail corridors or busy roads. According to the Guideline, busy roads are defined as follows:

- Roads specified in Clause 102 of the Infrastructure SEPP: Freeway, tollway or a transitway or any other road with an average annual daily traffic (AADT) volume of more than 40,000 vehicles.
- Any other road is defined as roads with an average annual daily traffic (AADT) volume of more than 20,000 vehicles
- Any other road with a high level of truck movements or bus traffic.

According to Clauses 87 (rail) and 102 (road), if the development is for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded (with windows and doors closed):

- In any bedroom in the building – 35 dBA $L_{Aeq(9hour)}$ between 10:00 pm and 7:00 am
- Anywhere else in the building (other than a garage, kitchen, bathroom or hallway) – 40 dBA L_{Aeq} at any time (i.e. $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$).

If internal noise levels with windows or doors open exceed the criteria by more than 10 dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also meet the ventilation requirements of the National Construction Code (NCC).

Where windows must be kept closed, the adopted ventilation systems must meet the requirements of the NCC and the current Australian set of standards AS/NZS 1668 and AS 1668 titled "*The use of ventilation and air conditioning in buildings"*.

3.2.2. City of Sydney

The project site is located within the local area for which the requirements discussed in the Sydney Development Control Plan 2012 (Sydney DCP 2012) apply.

Consequently, the following conditions are applicable to the residential sections of the development:

4.2.3.11 Acoustic privacy

(1) A Noise Impact Assessment prepared by a suitably qualified acoustic consultant may be required when submitting a development application for commercial and retail uses which may affect the acoustic privacy of the adjacent residential use.

(2) Where necessary, a residential development is to include acoustic measures to reduce the impact of noise from existing or planned external sources (for example busy roads, adjoining industries, live music venues and public parks and plazas in which people may congregate or host live music or events).

(3) Development is to incorporate measures that reduce the entry of noise from external sources into dwellings.

(4) Where possible, the attenuation of noise at its source is preferred. Where this option is adopted, the applicant will need to demonstrate that the measures to be undertaken:

(a) have the consent of relevant parties associated with that noise source; and

(b) last for the life of the development proposal.

(7) The repeatable maximum $L_{Aeq\ (1\ hour)}$ for residential buildings and serviced apartments must not exceed the following levels:

(a) for closed windows and doors:

(i) 35 dB for bedrooms (10pm-7am); and
(ii) 45 dB for main living areas (24 hours).

(b) for open windows and doors:
(i) 45 dB for bedrooms (10pm-7am); and
(ii) 55 dB for main living areas (24 hours).

(8) Where natural ventilation of a room cannot be achieved, the repeatable maximum $L_{Aeq\ (1hour)}$ level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:

(a) 38 dB for bedrooms (10pm-7am); and

(b) 48 dB for main living areas (24 hours).

(9) These levels are to include the combined measured level of noise from both external sources and the ventilation system operating normally.

It is noted, that for noise intrusion in residential areas, the conditions discussed in the Sydney DCP 2012 are more stringent than those recommended in the Infrastructure SEPP.

Therefore, the conditions in the Sydney DCP 2012 are used as the basis for the assessment of noise intrusion in residential areas.

3.2.3. Standard AS/NZS 2107:2016

Standard AS/NZS 2107:2016 recommends a range with lower and upper levels for building interiors based on room designation and location of the development relative to external noise sources.

The levels for areas relevant to this development are given in Table 6 below. In this report we will confine our recommendations to dBA levels, however, where the background noise appears to be unbalanced, AS/NZS 2107:2016 provides direction in terms of suitable diagnostic tools that can be used to assess the spectrum distribution of the background noise.

Section 6.18 of standard AS/NZ 2107:2016 notes that the presence of discrete frequencies or narrow band signals may cause the sound level to vary spatially within a particular area and be a source of distraction for occupants. Where this occurs, the sound level shall be determined as the highest level measured in the occupied location(s).

If tonal components are significant characteristics of the sound within a measurement time interval, an adjustment shall be applied for that time interval to the measured A-weighted sound pressure level to allow for the additional annoyance. If the background sounds include spectral imbalance, then the RC (Mark II) levels indicated in Table 6 should be referenced (see also Appendix D of standard AS/NZ 2107:2016 for additional guidance).

Generally, where the final noise levels are within +/- 2 dB of the specified level given above, the design criteria will be considered met. Both the upper and lower limits will need to be satisfied especially where privacy is important or where noise intrusion to be avoided.

Table 6 AS/NZS 2107:2016: Recommended design internal sound levels

Type of Occupancy/Activity	Design sound level range ($L_{Aeq,t}$)	Project Design Noise Level	
		Approx. RC Mark II	dBA
Houses and apartments in inner city areas or entertainment districts or near major roads			
Apartment common areas (e.g. foyer, lift lobby)	45 to 50	45	50
Living areas	35 to 45	40	45
Sleeping areas (night time)	35 to 40	35	40
Work areas	35 to 45	35	40
Office buildings			
Board and conference rooms	30 to 40	35	40
Executive offices	35 to 40	35	40
Corridors and lobbies, cafeterias	45 to 50	45	50

Type of Occupancy/Activity	Design sound level range ($L_{Aeq,t}$)	Project Design Noise Level	
		Approx. RC Mark II	dBA
General office areas, open plan offices, quiet rooms, reception areas	40 to 45	40	45
Undercover carparks	< 65	60	65
Toilets	45 to 55	50	**55**

3.2.4. Emergency Operations: Standard AS/NZS 1668.1:2015

According to standard AS/NZS 1668.1:2015, internal noise levels generated by smoke control systems should comply with the following:

> *The noise level in occupied spaces during operation of the smoke control systems (including smoke exhaust fans and air pressurization fans) shall not exceed 65 dBA. Where the internal occupied ambient noise levels exceed 60 dBA, the smoke control systems shall not exceed 5 dBA above the internal occupied ambient noise levels, to a maximum level of 80 dBA.*
>
> *Noise levels in fire-isolated exits and car parks, as well as and smoke control zones served by hot layer smoke control systems shall not exceed 80 dBA.*

3.2.5. Ground-borne Noise Criteria

Ground-borne noise in the development is to be closely related with the rail operation at the new Pitt Street station. Consequently, the criteria are referenced from the *"Rail Infrastructure Noise Guideline"* (RING), issued by the NSW EPA. These criteria are summarised in Table 7 below.

Table 7 Ground-borne noise criteria according to the RING

Type of Receiver	Assessment Period	Internal Noise Trigger Levels
Residential	Day (7:00am – 10:00pm)	40 dB L_{ASmax}
	Night (10:00pm – 7:00am)	35 dB L_{ASmax}

Note 1: Specified noise levels refer to noise from heavy or light rail transportation only and do not include ambient noise from other sources.

Note 2: The noise levels represent internal noise levels and are to be assessed near to, but not at the centre of the most affected habitable room. For example, at night this may be the bedroom experiencing the highest levels of ground-borne noise, while during the day another habitable room might experience the highest levels of ground-borne noise. The triggers are relevant only where ground-borne noise levels are audible and are of a higher level than airborne noise levels from rail operations.

Note 3: 'Residential' land use typically means any residential premises and includes aged-care facilities and caravan parks incorporating long-term residential use.

Note 4: L_{ASmax} refers to the maximum noise level not exceeded for 95 per cent of rail pass-by events and is measured using the 'slow' (S) response setting on a sound-level meter

3.3. Sound Insulation Requirements

The following sound insulation requirements are applicable to the residential part of the development.

3.3.1. National Construction Code 2016

Part F5 of the National Construction Code 2016 (NCC 2016), discusses the sound insulation requirements for several internal architectural components; these are listed in Table 8 below.

Table 8 NCC 2016 sound insulation requirements

Construction	NCC 2016	
	Laboratory performance requirements	**Verification method**
Walls between sole occupancy units	$R_w + C_{tr}$ not < 50	$D_{nT,w} + C_{tr}$ not < 45
Walls between a bathroom, sanitary compartment, laundry or kitchen in one sole occupancy unit and a habitable room (other than a kitchen) in an adjoining unit	$R_w + C_{tr}$ not < 50 and **Must have a minimum 20 mm cavity between two separate leaves**	$D_{nT,w} + C_{tr}$ not < 45 "Expert Judgment" Comparison to the "Deemed to satisfy" Provisions
Walls between sole occupancy units and a plant room or lift shaft	R_w not < 50 and **Must have a minimum 20 mm cavity between two separate leaves**[1]	$D_{nT,w}$ not < 45
Walls between sole occupancy units and a stairway, public corridor, public lobby or the like, or parts of a different classification	R_w not < 50	$D_{nT,w}$ not < 45
Door assemblies located in a wall between a sole-occupancy unit and a stairway, public corridor, public lobby or the like	R_w not < 30 [2]	$D_{nT,w}$ not < 25
Floors between sole-occupancy units or between a sole-occupancy unit and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification	$R_w + C_{tr}$ not < 50 $L_{n,w}$ not > 62	$D_{nT,w} + C_{tr}$ not < 45 $L'_{nT,w}$ not > 62

Construction	NCC 2016	
	Laboratory performance requirements	Verification method
Soil, waste, water supply and stormwater pipes and ductwork to habitable rooms	$R_w + C_{tr}$ not < 40	n/a
Soil, waste, water supply and stormwater pipes and ductwork to kitchens and other rooms	$R_w + C_{tr}$ not < 25	n/a
Intra-tenancy Walls	There is no statutory requirement for airborne isolation via intra-tenancy walls.	

Note 1: A wall must be of "discontinuous construction" if it separates a sole occupancy unit from a plant room or lift shaft. Clause F5.3(c) defines "discontinuous construction" as a wall having a minimum 20 mm cavity between two separate leaves with no mechanical linkage except at the periphery.

Note 2: Clause FP5.3(b) in the NCC 2016 states that the required insulation of a floor or wall must not be compromised by a door assembly.

Note 3: Masonry walls must be laid with all joints filled solid, including those between the masonry and any adjoining construction

3.3.2. City of Sydney

The Sydney DCP 2012 includes the following requirements in regards to sound insulation performance:

4.2.3.11 Acoustic privacy

(10) To limit the transmission of noise to and between dwellings, all floors are to have a weighted standardised impact sound level (L'nT,w) less than or equal to 55 where the floor separates a habitable room and another habitable room, bathroom, toilet, laundry, kitchen, plant room, stairway, public corridor, hallway and the like.

(11) The overall design and layout of dwellings, where appropriate, is to include:

(a) a limit on window size and number where oriented towards an intrusive noise source;

(b) seals at entry doors to reduce noise transmission from common corridors or outside the building;

(c) minimisation of the number of shared walls with other dwelling units;

(d) storage, circulation areas, and non-habitable rooms to buffer noise from external sources;

(e) double or acoustic glazing; and

(f) operable acoustic screens to balconies.

(12) Mixed-use development which includes two or more dwellings is to provide separate lift access and a separate entrance for use exclusively for the dwellings.

3.4. Vibration Criteria

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AVTG) This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table **9**).
- Impulsive vibration – up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (refer to Table 10).
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to
- Table **11**).

Table 9 Continuous vibration rms velocity criteria (dB re 10^{-9} mm/s) 1 Hz-80 Hz

Location	Assessment Period	Preferred Criteria (dB re 10^{-9} mm/s)	Maximum Criteria (dB re 10^{-9} mm/s)
Residences	Daytime	106	112
	Night-time	103	109
Offices, schools, educational institutions and places of worship	Day or night-time	112	118
Workshops	Day or night-time	118	124

Table 10 Impulsive vibration rms velocity criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment Period	Preferred Criteria (dB re 10^{-9} mm/s)	Maximum Criteria (dB re 10^{-9} mm/s)
Residences	Daytime	136	142
	Night-time	126	132
Offices, schools, educational institutions and places of worship	Day or night-time	142	148
Workshops	Day or night-time	142	148

Table 11 Intermittent vibration acceleration criteria ($m/s^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

Workshops	0.80	1.60	0.80	1.60

4. Operational Acoustic Assessment

4.1. Architectural Treatment

4.1.1. Building Envelope

4.1.1.1. Commercial

For office spaces adjacent to the facade it is recommended that the façade system achieves the following preliminary sound insulation performances:

- For general office areas, open plan offices, quiet rooms, reception areas: minimum of 40 dB R_w
- For board rooms, conference rooms, executive offices: minimum of 45 dB R_w.

Hence, these performances indicate that if the façade construction comprises a glazing system, then this system should consist of double glazing units. These units should typically include interior and exterior laminated glass panels separated by an air gap with 12mm minimum width for a 40 dB R_w performance, and 25mm for a 45 dB R_w performance.

Please note these recommended performances are indicative only; and these should be confirmed once further unattended noise measurements are conducted on site (as discussed in Section 2.4).

4.1.1.2. Residential

In order to achieve the criteria for noise intrusion in residential areas (i.e. conditions as discussed in the Sydney DCP 2012), the following in-principle recommendations are advised for residential spaces adjacent to the facade:

- Bedrooms should be located behind winter gardens. Winter gardens should comprise a façade construction which achieves a minimum sound insulation performance of 25 dB R_w. If access is required between the winter garden and the bedroom, then the door and partition construction separating both spaces should achieve a minimum sound insulation performance of 30 dB R_w
- For living rooms, the façade construction should achieve a minimum sound insulation performance of 35 dB R_w. Access to balconies should be provided with doors which achieve a minimum sound insulation performance of 30 dB R_w

Typical unsealed glass windows (with 6mm monolithic glass) can achieve a sound insulation performance of 25 dB R_w. Glass constructions which achieve a sound insulation performance of 30 and 35 dB R_w typically comprise single laminated glass panels. Glass sliding doors which achieve 30 dB R_w typically includes fin seals with deep C channels as part of the door track and laminated glass panels.

Please note these recommended performances are indicative only; and these should be confirmed once further unattended noise measurements are conducted on site (as discussed in Section 2.4), and detailed room layouts become available.

4.1.2. Internal Partition, Floor and Door Constructions – Residential Areas

At this stage of the project, there is no sufficient information to provide detailed acoustic recommendations for partition, floor and door constructions in order to comply with the sound insulation requirements discussed in Section 3.3.

Therefore, it is advised that, at later design stages, inter-tenancy partition, floor and door constructions should be designed to meet these sound insulation requirements. These requirements apply to residential areas of the development (especially those classified as Class 2, 3 or 9c in accordance with the NCC 2016).

Additionally, building services should be treated in order to achieve the sound insulation requirements listed in Table 8.

4.2. Building Services

4.2.1. Outside Air Provisions (Residential Areas)

Assuming a 10 dB noise reduction for open doors and windows, the following internal noise levels are predicted:

- Daytime, 7am to 10pm: 61 dB $L_{Aeq,\ 15\ hours}$
- Night time, 10pm to 7am: 58 dB $L_{Aeq,\ 9\ hours}$

Therefore, it is noted that these internal noise levels exceed the 10 dB margin for open windows as discussed in the Infrastructure SEPP. Furthermore, assuming a 3 dB increase to convert $L_{Aeq,\ period}$ noise levels to $L_{Aeq,\ 1\ hour}$ noise levels, then the following internal $L_{Aeq,\ 1\ hour}$ noise levels are estimated:

- Daytime, 7am to 10pm: 64 dB $L_{Aeq,\ 1\ hour}$
- Night time, 10pm to 7am: 61 dB $L_{Aeq,\ 1\ hour}$

As a result, it is observed that these predicted levels will also exceed the Sydney DCP 2012 conditions for open windows and doors.

Hence, it is advised that a mechanical ventilation and AC system should be considered to provide outside air and consequently, allow windows and doors to be fully closed.

The design of this mechanical system should be undertaken at detailed design stages of the project. This system should allow for acoustic attenuation in order to mitigate noise intrusion from external noise sources. It is envisaged this system should comprise proprietary trickle vents, internally lined ductwork, acoustic louvres, etc.

4.2.2. External Noise Emissions

The detailed design of mechanical services and other noise emitting building plant (such as stand-by generators, etc.) is not available at this stage of the project.

It is advised that a detailed external noise assessment should be undertaken once the above information becomes available. Consequently, it is recommended that the criteria discussed in Section 3.1 should be considered in this assessment. Hence the following mitigation measures are recommended for consideration during detailed design stages of the project:

- Acoustic barriers around roof top plant
- Robust construction of plant rooms
- Acoustic louvres to plant room openings
- Acoustic silencers incorporated into the mechanical ventilation system
- For stand-by generators, acoustic mufflers implemented into the exhaust system and acoustic silencers in the air intake and outlet
- Internally lined ductwork as part of the mechanical ventilation system
- Selection of low noise emission plant
- Resilient isolation mounts

4.2.3. Down-Duct Noise Emissions

As discussed in Section 4.2.2, at this stage of the project there is no sufficient information of mechanical services in order to provide in-principle recommendations. Nevertheless it is advised that an assessment of down-duct noise emissions should be conducted in order to achieve the internal noise level criteria discussed in Section 3.2.

Please note that the assessment of the overall internal noise level criteria should consider the noise contribution of building services (mostly mechanical services) and the noise intrusion from external noise sources (mainly road traffic noise and external mechanical plant).

It is envisaged that the acoustic treatment for down-duct noise will typically comprise:

- Internally lined ductwork
- Acoustic silencers
- Implementation of variable speed drive units whenever possible
- Selection of “quiet” or low noise plant items.

These should be confirmed during the detailed down-duct noise assessment of mechanical services.

Additional, it is advised that all emergency plant items should be designed to achieve compliance with the emergency operational criteria discussed in Section 3.2.4.

4.3. Ground-borne Noise

Appendix E, Part B of document titled *"Sydney Metro Chatswood to Sydenham Submissions and Preferred Infrastructure Report"*, contains predicted ground-borne noise levels related to the operation of the proposed Sydney Metro line in the vicinity of the subject site. Figure 11 below shows these predicted levels and the location of the project site.

Therefore, it is observed that the predicted ground borne noise at the site location will be in the range of 36 – 40 dBA. It is also noted:

- Ground borne noise levels are predicted at Ground Level.
- The nearest residential units on the development are located in Level 6.

It is expected that there will be 1 dB attenuation per level. Consequently, it is predicted that the ground-borne noise levels at the nearest residential areas will achieve compliance with the ground borne noise criteria discussed in Section 3.2.5

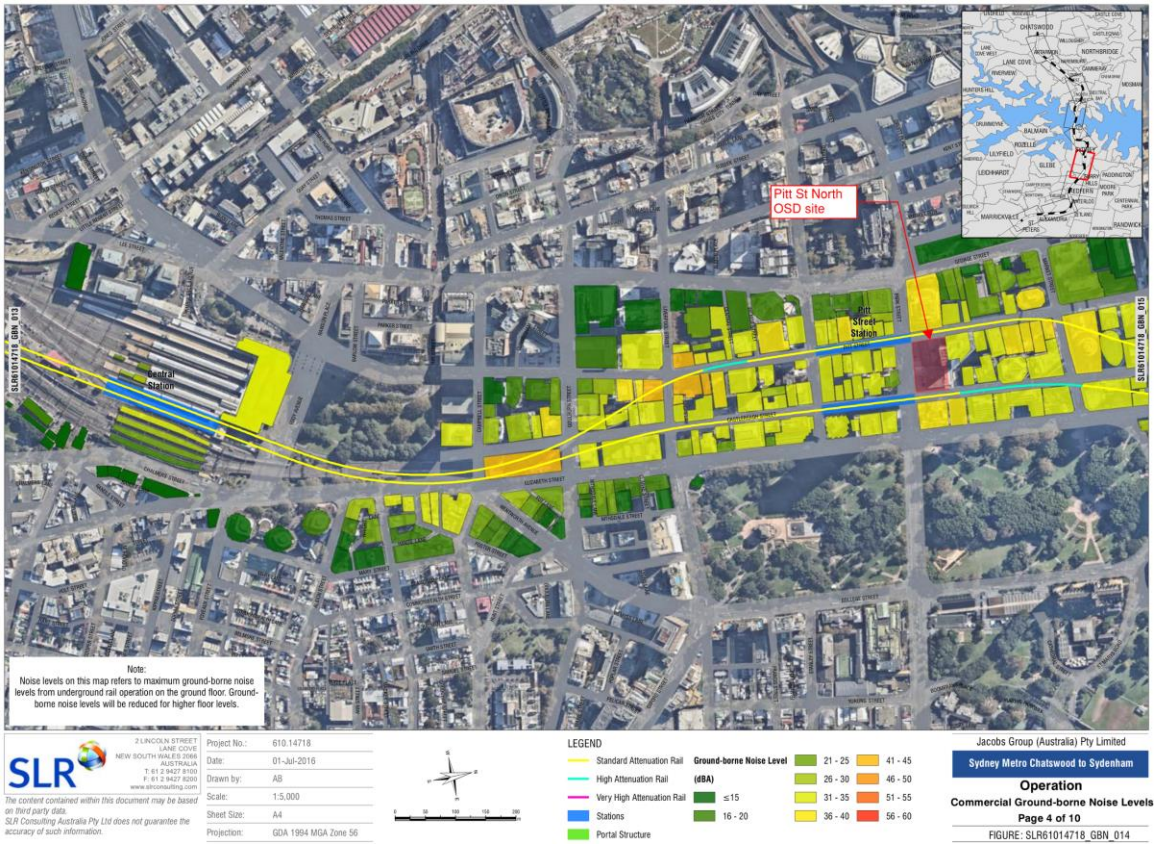

Figure 11 Predicted ground-borne noise levels

Source: Appendix E, Part B of document titled "Sydney Metro Chatswood to Sydenham Submissions and Preferred Infrastructure Report"

4.4. Ground-borne Vibration

Figure 11-2 in Chapter 11 of document titled *"Sydney Metro Chatswood to Sydenham Environmental Impact Statement"* (dated May 2016), illustrates the prediction of ground-borne vibration levels related to the operation of the proposed Sydney Metro line. This is reproduced in Figure 12 below.

From Figure 12 it is observed that the predicted vibration levels are below the most stringent vibration criterion for residences, this corresponds to continuous vibration (i.e. 103 dB re 10^{-9} mm/s, refer to Table **9**).

Therefore, it is expected that vibration levels on site will comply with the operational criteria discussed in Section 3.4.

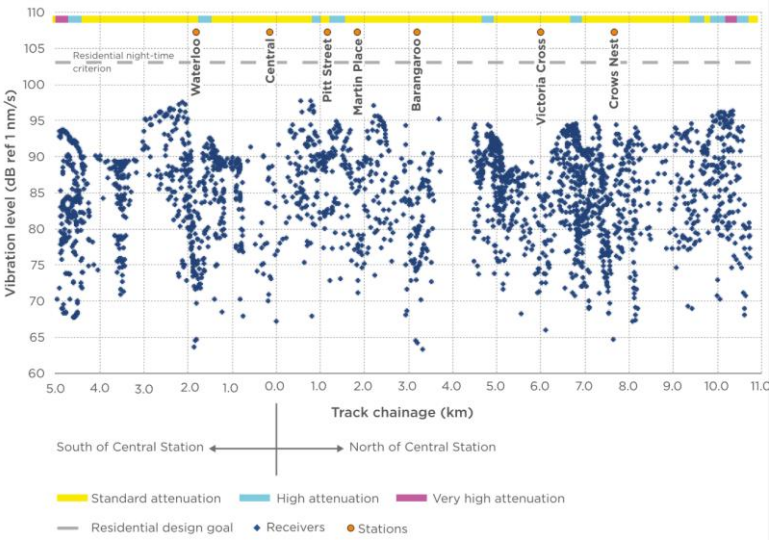

Figure 12 Predicted ground-borne vibration levels

Source: Figure 11-2 in Chapter 11 of document titled "Sydney Metro Chatswood to Sydenham Environmental Impact Statement"

5. Construction Noise & Vibration Assessment

5.1. Site Layout

The project site is currently surrounded by various noise sensitive receivers likely to be impacted by construction noise and vibration related to the development. Based upon a visual inspection of the surroundings adjacent to the project site, the following types of receiver have been identified:

- Residential and hotel buildings
- Commercial buildings, retail outlets
- Places of worship
- Active recreation areas
- Passive recreation areas
- School and educational facilities
- Child care centres
- Medical centres and surgeries

5.2. Construction Noise Criteria

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other noise sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works
- Focus on applying all “feasible” and “reasonable” work practices to minimise construction noise impacts
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for residential receivers have been reproduced from the guideline and these are listed in Table 12.

Specific non-residential receivers in the vicinity of the proposed construction site, and their recommended 'management levels', are presented in Table 13.

Table 12 NMLs for quantitative assessment at residences

Time Period	Noise Management Level $L_{Aeq\ (15\ minutes)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm 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 LAeq(15minute) 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 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 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 5 dB above the noise affected level, the proponent should negotiate with the community.

Time Period	Noise Management Level $L_{Aeq\ (15\ minutes)}$	How to Apply

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

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

Table 13 NMLs for quantitative assessment at non-residential receivers

Land Use	$L_{Aeq(15minute)}$ Construction NML
Classrooms at schools and other educational institutions	Internal noise level: 45 dBA External noise level: 55 dBA [1]
Hospital wards and operating theatres	Internal noise level: 45 dBA External noise level: 55 dBA [1]
Places of worship	Internal noise level: 45 dBA External noise level: 55 dBA [1]
Active recreation areas	External noise level: 65 dBA
Passive recreation areas	External noise level: 60 dBA
Office, retail outlets	External noise level: 70 dBA

Note 1: *External noise level criterion estimated from internal noise level criterion assuming a 10 dB noise level difference for open windows*

Therefore, based on the measured background noise levels listed in Table 1, the NMLs to be used in the assessment are summarised in Table 14. Please note these NMLs are to be confirmed based on further measurements of the existing ambient noise levels on site (as discussed in Section 2.4).

Table 14 Summary of NMLs for quantitative assessment (external noise levels)

Receiver Type	Construction NML, dB $L_{Aeq(15minute)}$	
	Standard Hours **Monday to Friday: 7 am to 6 pm** **Saturday: 8 am to 1 pm**	**Outside Standard Hours**
Residences	76	Day time (weekends only) [1]: 71 Evening [1]: 69 Night time [1]: 66
Classrooms at schools and other educational institutions	55	55

Receiver Type	Construction NML, dB $L_{Aeq(15minute)}$	
	Standard Hours **Monday to Friday: 7 am to 6 pm** **Saturday: 8 am to 1 pm**	**Outside Standard Hours**
Hospital wards and operating theatres	55	55
Places of worship	55	55
Active recreation areas	65	65
Passive recreation areas	60	60
Office, retail outlets	70	70

Note 1: For Monday to Saturday: Daytime 7:00 am – 6:00 pm, Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 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 – 8:00 am

5.3. Sleep Disturbance Criteria

An accurate representation of sleep disturbance impacts on a community from a noise source is particularly difficult to quantify mainly due to differing responses of individuals to sleep disturbance – this is found even within a single subject monitored at different stages of a single night's sleep or during different periods of sleep.

In addition the differing grades of sleep state make a definitive definition difficult, and even where sleep disturbance is not noted by the subject, factors such as heart rate, mood and performance can still be negatively affected (WHO, 1995).

An assessment of sleep disturbance should consider the maximum noise level or $L_{A1(1\ minute)}$, and the extent to which the maximum noise level exceeds the background level and the number of times this may happen during the night-time period. Factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise events will occur;
- Time of day (normally between 10.00pm and 7.00am); and
- Whether there are times of day when there is a clear change in the existing noise environment (such as during early morning shoulder periods).

Currently the information relating to sleep disturbance impacts indicates that:

- Maximum internal noise levels below 50–55 dBA are unlikely to cause an awakening from a sleep state.
- One or two noise events per night with maximum internal noise levels of 65–70 dBA are not likely to affect health and wellbeing significantly.

As such, an assessment of sleep disturbance should consider the maximum noise level or $L_{A1(1\ minute)}$, and the extent to which the maximum noise level exceeds the background level and the number of times this may happen during the night-time period.

Additionally, the NSW *Road Noise Policy* (RNP) suggests that to limit sleep disturbance event, the $L_{A1(1\ minute)}$ noise level should not exceed the $L_{A90(15\ minute)}$ noise level by more than 15 dBA. Therefore, based on measured noise levels listed in Table 1, this criterion is defined as 76 dB $L_{A1(1\ minute)}$. However, according to the RNP, this criterion does not take into account the number of events or their highest level.

Since it has already been recommended that further noise measurements of ambient noise levels should be conducted, then it is advised that the sleep arousal criterion should be defined, in the interim, as 65 dB L_{Amax}. This interim criterion should also be confirmed at future stages of the project once details of the construction program become available and the additional noise measurements on site have been undertaken.

5.4. Construction Traffic Noise Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW *Road Noise Policy* (RNP) states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person (as discussed in Section 3.4 of the RNP).

5.5. Vibration Criteria

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects.
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself.

The effect of vibration on human comfort has already been discussed in Section 3.4. The other two effects relate to impacts on the building itself and are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999).

5.5.1. Standard BS 7385 Part 2-1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 15 and illustrated in Figure 13.

Table 15 Structural damage criteria (transient vibration) as per standard DIN 4150 Part 3-1999

Line in Figure 13	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 15 relate to transient vibration which does not cause resonant responses in buildings.

Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 15 may need to be reduced by up to 50% (refer to Line 3 in Figure 13).

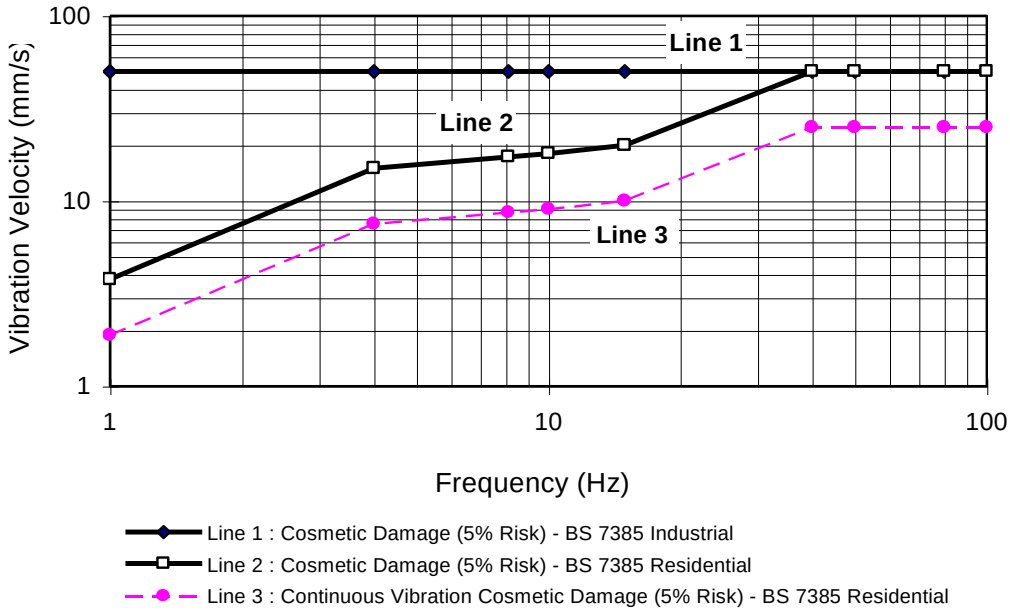

Figure 13 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 15, and major damage to a building structure may occur at values greater than four 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 values in Table 15 should not be reduced for fatigue considerations.

5.5.2. Standard DIN 4150 Part 3-1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 16. The criteria are frequency dependent and specific to particular categories of structures.

Table 16 Structural damage criteria (continuous or repetitive vibration) as per standard DIN 4150 Part 3-1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz [1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

5.5.3. Scientific and Medical Equipment

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use inside the premises, objectives for the satisfactory operation of the instrument should be sourced from manufacturer's data.

Where manufacturer's data is not available, generic vibration criterion (VC) curves may be adopted as vibration goals. These generic VC curves are presented below in Table 17 and Figure 14.

Table 17 Criteria for vibration sensitive equipment

Equipment	Curve
Bench microscopes up to 100× magnification; laboratory robots	0.102 mm/s
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 mm/s VC-A
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths	0.025 mm/s VC-B
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size	0.013 mm/s VC-C
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems	0.0054 mm/s VC-D
Non-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems	0.0032 mm/s VC-E

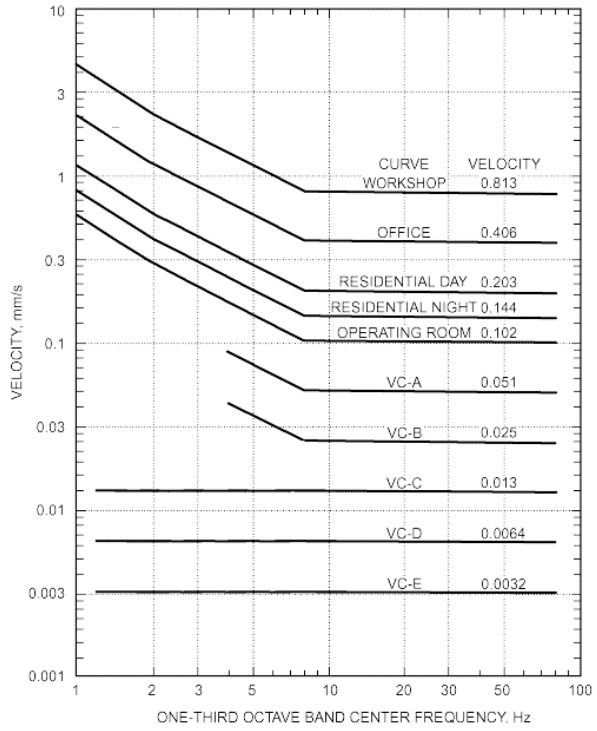

Figure 14 Criteria for vibration sensitive equipment

Source: ASHRAE 2007, HVAC Applications, Chapter 47 "Sound and Vibration Control"

5.6. Issues to Consider in the Construction Noise & Vibration Management Plan

At the time of issuing this report, detailed information of the construction program is not available and consequently, a detailed construction noise and vibration management plan (CNVMP) cannot be prepared.

Therefore, the following is proposed to be considered when preparing the CNVMP:

- If the OSD construction works take place when the Sydney Metro infrastructure is already operational, then the CNVMP should address the impact from and management of construction noise and vibration onto Sydney Metro infrastructure, staff, customers and tenants.
- If the OSD works occurs as part of the overall ISD works, the construction noise and vibration strategy (CNVS) for the Sydney Metro may need to be considered as an additional CNVS for the OSD.
- As discussed in Section 2.4, additional on-site noise monitoring is recommended in order to confirm the existing ambient noise levels. This can influence how the NMLs are established, and as a result, the management procedures to undertake
- A detailed construction program should be provided which should include the following:
    - Schedule of construction activities (classified into scenarios if applicable)
    - List of construction equipment per activity

- Location of construction equipment
- Duration of construction activities, as well as proposed construction hours

- Prepare a computer noise model to predict the noise impact at the nearest affected receivers within the affected distance as determined in Section 5.1. Assess predict noise levels in accordance with the procedures discussed in Sections 5.2. For night time works, assess the predicted noise levels in accordance with the procedures for sleep disturbance (refer to Section 5.3).
- Based on the outcome of the assessment, establish management and operational procedures to address noise and vibration mitigation measures and complaints. Refer to Section 5.6.1 for typical noise mitigation measures to be considered.
- For vibration generating equipment it is advised to establish safe working distances in order to maintain compliance with the human comfort criteria (refer to Section 3.4) as well as to minimise impact on buildings (refer to Section 5.5). Indicative safe working distances are provided in Table 18. These indicative distances should be confirmed during detailed design stages of the project by undertaking vibration validation tests involving the actual equipment to be used, and as a result producing a set of Project Specific Vibration versus Distance Curves. These validating tests should be performed at the commencement of works.

Table 18 Indicative safe working distances for vibration intensive plant (from the "*Construction Noise Strategy*", issued by the NSW Transport Construction Authority)

Plant	Rating / Description	Safe Working Distance (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
Vibratory roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 – 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800mm	2	N/A

Plant	Rating / Description	Safe Working Distance (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
Jackhammer	Hand held	1	Avoid contact with structure and steel reinforcements

- Identify heritage structures as well as vibration sensitive premises (such as those containing scientific and surgery equipment). Safe working distances from vibration generating equipment should be established in order to achieve compliance with the criteria discussed in Section 5.6.
- Identify of other vibration sensitive structures such as tunnels, gas pipelines, fibre optic cables, Sydney Water retention basins. Specific vibration goals should be determined on a case-by-case basis by an acoustic consultant which is to be engaged by the construction contractor.
- Undertake an assessment of road traffic noise generated by light and heavy vehicle movements which are associated with the development construction. For this purpose, request a traffic study report to determine the relevant traffic flows and assess the predicted road traffic noise levels in accordance with the criteria discussed in Section 5.4.

5.6.1. Noise and Vibration Mitigation Measures

The following are typical mitigation measures which can be considered in the CNVMP, these are to be confirmed once detailed information of the construction program becomes available and further noise measurements have been conducted on site:

- Undertake all feasible and reasonable measures to minimise noise impacts and achieve compliance with the NMLs
- Inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the proposal. This can be conducted as part of a community consultation process.
- A potential approach would be to schedule a respite period of one hour for every three hours of continuous construction activity, or undertaking high noise generating works to less sensitive times such as 9:00 am to 12:00 pm and / or 2:00 pm to 5:00 pm
- Undertake following operational procedures:

- Maximising the offset distance between plant items and nearby noise sensitive receivers.
- Preventing noisy plant working simultaneously and adjacent to sensitive receivers.
- Minimising consecutive works in the same site area.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.
- Minimise noise emissions from reversing alarms by maintaining occupational safety standards
- No use of PA systems on site
- Site induction training to include noise awareness component
- Site deliveries to be conducted during standard construction hours

- Conduct supplementary noise and structural damage and/or human comfort vibration monitoring in order to confirm compliance with the adopted construction noise and vibration criteria. These measurements can also be carried out in response to complaints, exceedances or for the purpose of refining construction techniques in order to minimise noise and vibration emissions.
- Establish a complaint handling procedure in order to address complaints, identify corrective action and implement if possible. The corrective action may involve supplementary monitoring in order to identify the source of the non-conformance and/or may involve modification of the construction techniques or programme to avoid any recurrence or minimise its adverse effects
- Any vibration generating plant and equipment is to be located in areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of construction plant and equipment, that is, smaller capacity plant.
- Minimise conducting vibration generating works consecutively in the same area (if applicable).
- Schedule a minimum respite period of at least 30 minutes before activities commence which are to be undertaken for a continuous 4 hour period.
- Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles at site, and monitor the profiles in use

6. Conclusions

Pulse Acoustic Consultancy has undertaken a noise and vibration assessment for the conceptual design of the mixed-use development above the station development at Pitt Street (North) station, Sydney. The assessment has considered operational conditions typical of the site as well as noise and vibration emissions produced by construction activities.

The following summarises the conclusions of the acoustic assessment.

6.1. Operational Acoustic Assessment

The façade construction for office spaces is likely to comprise a double glazing system. Indicative sound insulation performances have been provided in Section 4.1.1.1 of the report.

A mechanical ventilation system should be provided for residential areas in order to provide outside air into these spaces and consequently allow fully closed external doors and windows

Bedrooms near the façade should be situated behind winter gardens. Indicative sound insulation performances for the winter garden façade, as well as for the partition separating the winter garden and the bedroom, have been provided in Section 4.1.1.2. This indicates the glass for the bedroom is likely to comprise laminated glass panels with acoustically sealed sliding door for access to the winter garden (if required)

For living rooms, the façade construction is also likely to comprise laminated glass panels and acoustically sealed sliding doors for access to balconies (if required). Indicative sound insulation performances are also provided in Section 4.1.1.2.

Inter-tenancy partitions, floors and corridor doors should be designed to achieve the sound insulation performances discussed in the NCC 2016 and the Sydney DCP 2012. Additionally building services should be treated in order to achieve the sound insulation requirements listed in Table 8.

Noise emitting plant should be treated in order to achieve compliance with the operational external noise level criteria discussed in Section 3.1. Also, mechanical services should be assessed for down-duct noise emissions and mitigation measures should be provided in order to achieve compliance with the internal noise level criteria discussed in Section 3.2. Furthermore, all emergency plant items should be designed to achieve compliance with the emergency operational criteria discussed in Section 3.2.4.

Based on a review of documentation provided for the Sydney Metro project, it has been found that the operation of the Sydney Metro rail line will not have an impact on the development in relation to ground-borne noise and vibration.

6.2. Construction Noise & Vibration Assessment

Several noise and vibration sensitive locations have been found in the vicinity of the site and which are likely to be impacted by construction activities.

Consequently construction noise criteria have been determined for these receivers, including criteria which address sleep arousal events.

Vibration criteria have also been established, not only based on factors regarding human comfort, but also in relation to effects on building structures and the potential impact on scientific and medical equipment.

Hence it is recommended that a construction noise and vibration management plan (CNVMP) should be undertaken for the project. Issues which are likely to be considered in the CNVMP are discussed in Section 5.6, and these include typical noise and vibration mitigation measures which are to be confirmed once detailed information of the construction program becomes available.

6.3. General Comments

It is advised that additional measurements of the existing ambient noise should be undertaken to validate the measurement results listed in Table 1. This is recommended in order to confirm all acoustic criteria and treatment derived from these measurements (i.e. operational external noise level, treatment for building envelope, NMLs, sleep disturbance criteria, etc.).

6.4. Final Remarks

Based on the findings from the acoustic assessment, it is our opinion that the proposed development is capable of achieving compliance with the relevant acoustic criteria provided the conceptual recommendations discussed herein are implemented and developed further as the project design evolves into detailed design stages.