NOISE AND VIBRATION IMPACT ASSESSMENT REPORT

APPENDIX N

Sydney Metro City & South West: Victoria Cross Over Station Development

Noise and vibration impact assessment report

Applicable to:	Sydney Metro City & Southwest
Author:	AECOM Australia Pty Ltd
Owner	Transport for NSW
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1.0 Introduction

1.1 Purpose of this report

This report supports a concept State Significant Development application (concept SSD Application) submitted to the Department of Planning and Environment (DP&E) 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.

Transport for NSW (TfNSW) is seeking to secure concept approval for a commercial office tower above the Victoria Cross Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for a building envelope and its use as a commercial premises (office, business and retail), maximum building height, maximum gross floor area, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of development.

TfNSW proposes to procure the construction of 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 DP&E on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for commercial premises with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

This report has been prepared to outline the acoustic and vibration impacts and specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 30th November 2017 which states that the Environmental Impact Statement (EIS) is to address the following requirements:

- a noise impact assessment identifying:
  - the main noise and vibration generating sources and activities from the site at all stages of operation
  - measures to minimise and mitigate potential construction and operational noise and vibration impacts on surrounding occupiers
  - the impacts of likely noise and vibration from surrounding land uses, such as noise from the operation of the rail line and surrounding road networks, including Pacific Highway and management and operational arrangements or mitigation measures to protect the amenity of residents/ visitors/ employees.
- include a noise and vibration report.

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 (Stage 1), which is due for completion in 2019 and Sydney Metro City & Southwest (Stage 2), which is due for completion in 2024 (Refer to **Figure 1**).

Figure 1: Sydney Metro alignment map

Stage 2 of Sydney Metro 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 (7) new metro stations, including at North Sydney. 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 lodged by TfNSW 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 OSD (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 OSD to be more efficiently built and appropriately integrated into the metro station structure.

The EIS for the Chatswood to Sydenham component of the 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 original station design remains approved. 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 Stage 2 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 part of the project, referred to as the Sydenham to Bankstown Upgrade, is the subject of a separate CSSI Application (Application No. SSI 17_8256) which is currently being assessed by the DP&E.

1.3 Planning relationship between Victoria Cross Station and the OSD

While the Victoria Cross Station and OSD will form an Integrated Station Development, the planning pathways defined under the *Environmental Planning & 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 includes but is not limited to:

- Demolition of existing development
- Excavation
- Integrated station and OSD structure (including concourse and platforms)
- Lobbies
- Retail spaces within the station building
- Public domain improvements
- Pedestrian through-site link
- Access arrangements including vertical transport such as escalators and lifts
- Space provisioning and service elements necessary to enable the future development of the OSD, such as lift cores, plant rooms, access, parking, retail, utilities connections and building services.

The vertical extent of the approved station works above ground level is defined by the 'transfer level' level (which for Victoria Cross is defined by RL 82), above which would sit the OSD. This delineation is illustrated in **Figure 2**.

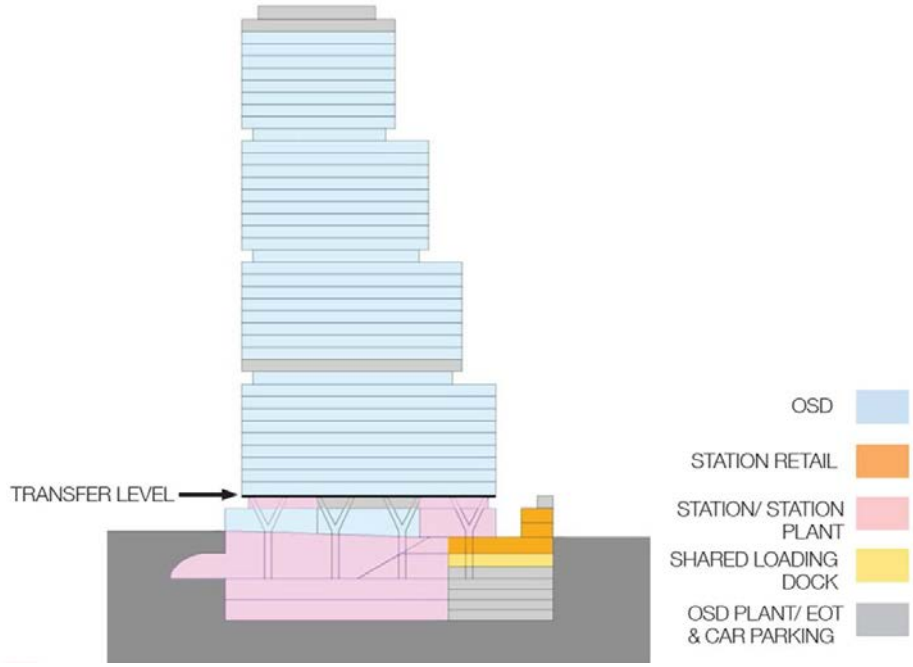


Figure 2: Delineation between the Metro station and OSD

The CSSI Approval also establishes the general concept for the ground plane of Victoria Cross Station including access strategies for commuters, pedestrians and workers. In this regard, pedestrian access to the station would be from Miller and Denison Streets and the commercial lobby would be accessed from Miller Street. Retail uses (approved under the CSSI Approval) would be located on the ground floor of the development at both the Miller Street and Denison Street levels activating the through-site link. Separate consent would be sought in the future for the fit-out and specific use of this retail space.

Since the issue of the CSSI Approval, TfNSW 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 Victoria Cross 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 Victoria Cross OSD site is located at the southeast corner of the intersection of Miller and Berry Streets, North Sydney, above the southern portal of the future Victoria Cross Station (refer to **Figure 3**). The site is located in North Sydney CBD, which is identified as part of Sydney's "Harbour CBD" (along with Sydney CBD) in the *Greater Sydney Region Plan (2018).* It is the third largest office market in Sydney and is a key component of Sydney's Global Economic Corridor.

Figure **3:** Victoria Cross Station location plan

The site is located in the North Sydney Local Government Area approximately 3km north of Sydney CBD, 5km southeast of Chatswood and 2km southeast of St Leonards.

The site (refer to **Figure 4**) is irregular in shape, has a total area of approximately 4,815 square metres and has street frontages of approximately 37 metres to Berry Street, 34 metres to Denison Street and 102 metres to Miller Street.

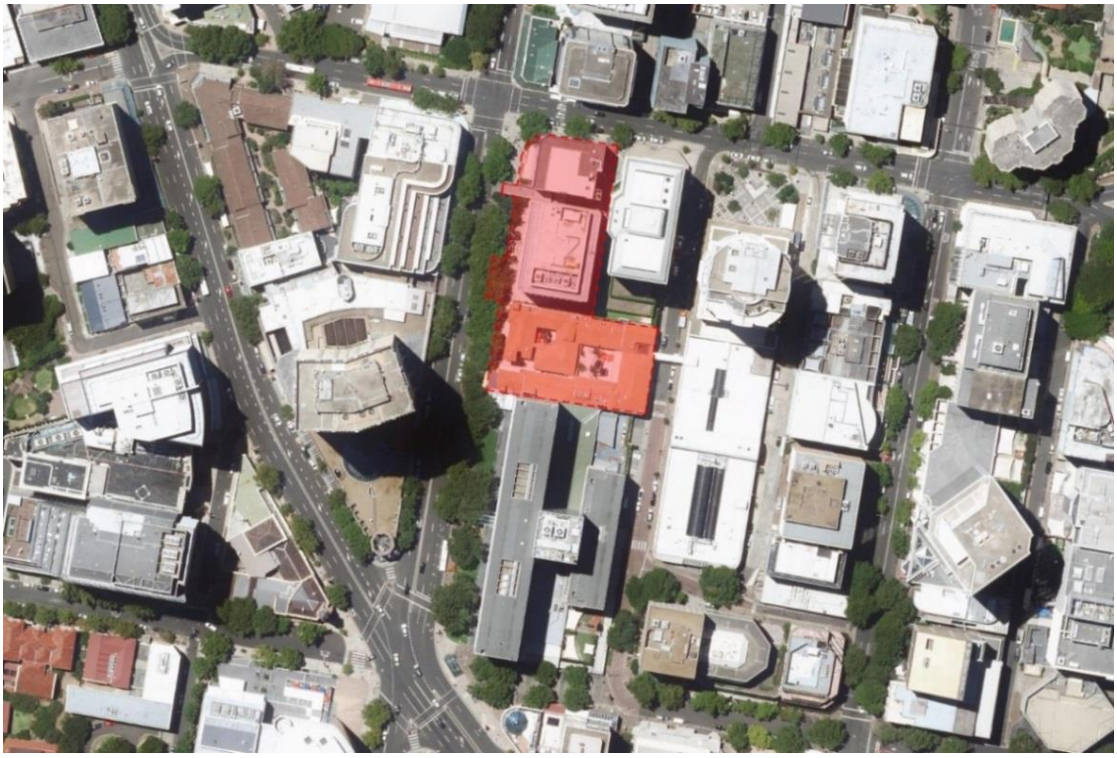


Figure 4: The Site

The site comprises the following properties:

- 155–167 Miller Street — SP 35644 (formerly Tower Square)
- 181 Miller Street — Lot 15 in DP 69345, Lot 1 & Lot 2 DP 123056 and Lot 10 in DP 70667
- 187 Miller Street — Lot A in DP 160018
- 189 Miller Street — Lot 1 in DP 633088
- Formerly part 65 Berry Street — Lot 1 in DP 1230458

1.5 Overview of the proposed development

This concept SSD Application comprises the first stage of the Victoria Cross OSD project. It will be followed by a detailed SSD Application for the design and construction of the OSD to be lodged by the successful contractor who is awarded the contract to deliver the Integrated Station Development.

This concept SSD Application seeks approval for the planning and development framework and strategies to inform the future detailed design of the OSD. It specifically seeks approval for the following:

- A building envelope as illustrated in **Figure 5**

- A maximum building height of RL 230 or 168 metres (approximately 42 storeys) for the high rise portion of building envelope and RL 118 or 55 metres (approximately 13 storeys) for the lower rise eastern portion of the building envelope
- A maximum gross floor area (GFA) of 60,000 square metres for the OSD component, which is equivalent to a floor space ratio of 12.46:1
- Use of the building envelope area for commercial premises including commercial office, retail and business premises
- Use of the conceptual OSD space provisioning within the footprint of the CSSI Approval (both above and below ground), including the OSD lobby and associated retail space, basement parking, end-of-trip facilities, services and back-of-house facilities
- Car parking for a maximum of 150 parking spaces over four basement levels with an additional 11 parking spaces allocated to the station retail approved under the terms of the CSSI Approval
- Loading, vehicle and pedestrian access arrangements from Denison Street
- Strategies for utility and services 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).

The total GFA for the Integrated Station Development including the station GFA (i.e. retail, station circulation and associated facilities) and the OSD GFA is 67,000 square metres and is equivalent to a FSR of 13.9:1.

A drawing illustrating the proposed building envelope is provided in **Figure 5**. The concept SSD Application includes an indicative design for the OSD to demonstrate one potential design solution within the proposed building envelope (refer to **Figure 6**).

Victoria Cross Station is to be a key station on the future Sydney Metro network, providing access to the growing North Sydney Central Business District (CBD). The proposal combines the Metro station with a significant commercial office tower, contributing to the North Sydney skyline. The OSD would assist in strengthening the role of North Sydney as a key component of Sydney's global economic arc and would contribute to the diversity, amenity and commercial sustainability of the CBD.

It is noted that Victoria Cross northern services building and new station entrance at Victoria Cross North do not form part of the concept SSD Application.

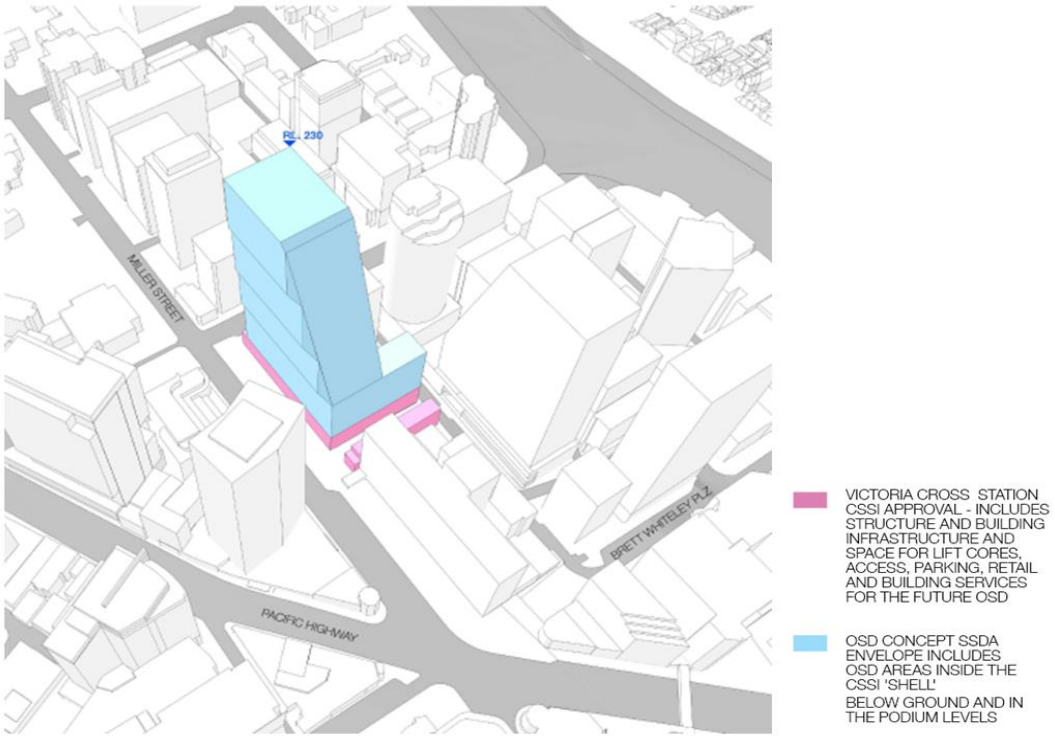


Figure 5: Proposed Victoria Cross OSD building

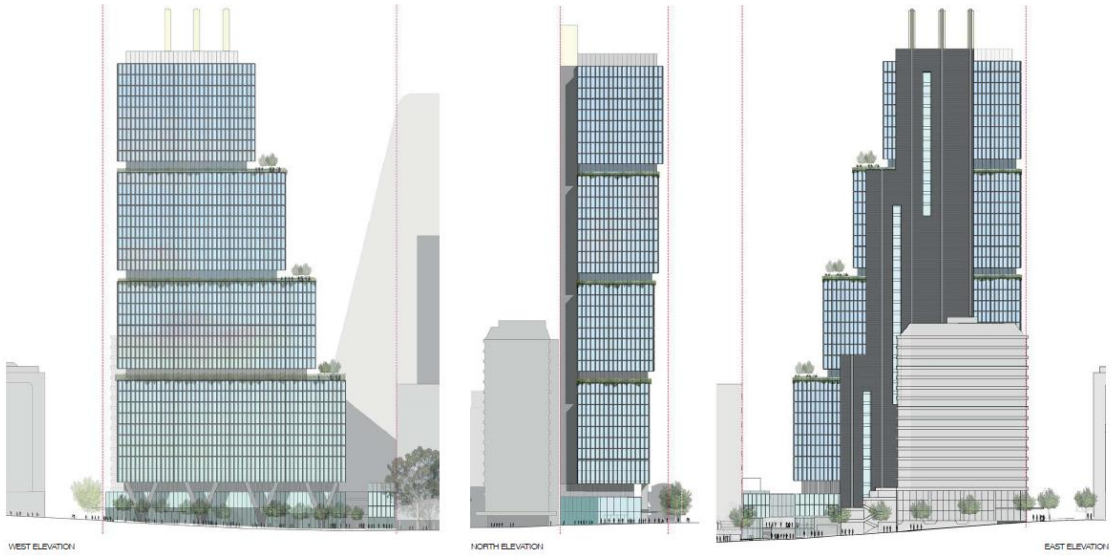


Figure 6: Victoria Cross OSD indicative design

1.6 Staging and framework for managing environmental impacts

TfNSW proposes to procure the delivery of the Victoria Cross Integrated Station Development in one single package, which would entail the following works:

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

Separate delivery packages are also proposed by TfNSW to deliver the excavation of the station boxes/shafts ahead of the Integrated Station Development delivery package, and linewide 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 TfNSW'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, TfNSW proposes the framework detailed in **Figure 7** to manage the

design and environmental impacts, in relation to noise and vibration, consistent with the framework adopted for the CSSI Approval.

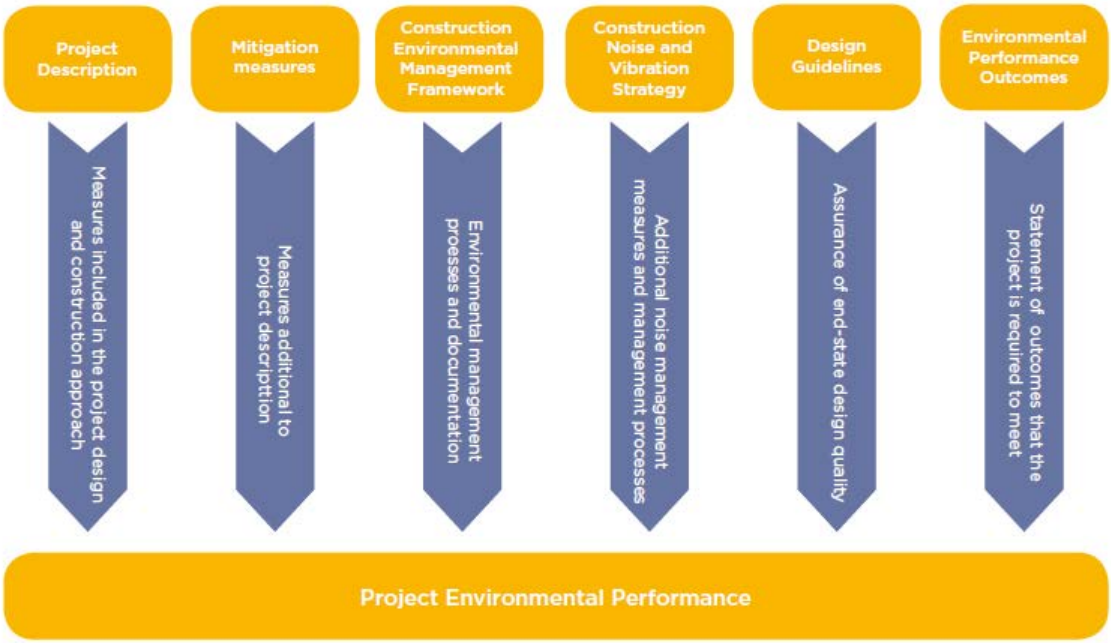


Figure 7: Project approach to environmental mitigation and management

This approach would be implemented until such time as practical completion of the station works (i.e. works under the CSSI Approval) is achieved. Beyond that point, standard construction environmental management practices would be implemented by the OSD developer in accordance with relevant guidelines and any conditions of approval.

2.0 Scope of assessment

This report documents an acoustic and vibration assessment that has been undertaken for the OSD concept drawings provided by Bates Smart (hereafter referred to as the OSD). It discusses the existing noise and vibration environment and assesses the impact of the OSD's construction and operation on the precinct. The impact of noise and vibration generated by the station and the precinct on the OSD is also considered.

Owing to the OSD's location above the CSSI approved station, a series of collaboration workshops have been undertaken with TfNSW's Stage 1 Design Team (METRON) and their specialist acoustic adviser (Resonate Acoustics). This occurred as METRON advanced towards their Stage 1 design deliverable (approximately a 40% level of definition).

The information set out in this report is for information only to ensure a compliant and functional building and does not reflect the final design for the constructed building. Further development of calculations and treatment strategies should be determined during future detailed design phases of the development.

Appropriate operational environmental noise emission criteria for the development have been established in this report and are based upon measured background noise levels, North Sydney Council Policy, the NSW Environment Protection Authority (EPA) NSW *Industrial Noise Policy* (INP, 2000), its successor the *Noise Policy for Industry* (NPfI, 2017), the NSW *Road Noise Policy* (RNP) and other Standards and guidelines outlined in **Section 3.0**.

Construction noise management levels and vibration criteria have been determined using the EPA's *Interim Construction Noise Guideline* (ICNG, 2009), NSW *Assessing Vibration. A Technical Guideline* (AVATG, 2006) and other Standards and guidelines outlined in **Section 3.0**.

The outcomes of the operational and construction noise and vibration assessment, and the proposed noise and vibration control measures required to achieve compliance with the established criteria are outlined in this report.

3.0 Relevant standards and guidelines

The following standards and guidelines are considered applicable to this project and have been utilised or referenced where appropriate.

3.1 Operation

- *Sydney Metro City & Southwest Chatswood to Sydenham Design Guidelines*, Transport for NSW June 2017.
- Australia/New Zealand Standard AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors*.
- Australian Standard AS 2670.2 1990 *Evaluation of human exposure to whole-body vibration. Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)*.
- International Standard ISO 14837-1, 2005 *Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance*.
- *Protection of the Environment Operations Act* 1997, NSW Planning and Environment, 2016.
- *Noise Policy for Industry*, NSW Environment Protection Authority, 2017.
- NSW *Industrial Noise Policy*, NSW Environment Protection Authority, 2000.
- Application notes to the NSW Industrial Noise Policy, NSW Environment Protection Authority, 2013.
- NSW *Road Noise Policy*, Department of Climate Change, Environment and Water, 2011.
- *Assessing Vibration: A Technical Guideline*, NSW Department of Environment and Conservation, 2006.
- *Rail Infrastructure Noise Guideline*, NSW Environment Protection Authority, 2013.
- *North Sydney Development Control Plan*, North Sydney Council 2013.
- *State Environmental Planning Policy (Infrastructure)* 2007, NSW Planning and Environment, 2016.
- *Chatswood to Sydenham Environmental Impact Statement*, Technical Paper 2: Noise and vibration, Version: Final, May 2016.
- Information for OSD DA Team (AECOM), Resonate Acoustics, 7 November 2017.
- *Guideline for Child Care Centre Acoustic Assessment*, Association of Australian Acoustical Consultants, October 2013.

3.2 Construction

- Australian Standard AS 2436-2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*.
- *Interim Construction Noise Guideline*, Department of Environment and Climate Change, 2009.
- *Assessing Vibration: A Technical Guideline*, NSW Department of Environment and Conservation, 2006.
- NSW *Road Noise Policy*, Department of Environment, Climate Change and Water, 2011.
- *Construction Noise Strategy*, Transport Construction Authority, 2011.
- German Standard DIN Standard 4150: Part 3 1999 *Structural Vibration in Buildings - Effects on Structures*, 1999.
- British Standard 7385: Part 2 1993 *Evaluation and Measurement of Vibration in Buildings*, 1993.
- British Standard 6472: Part 1 2008 *Evaluation of Human Exposure to Vibration in Buildings*, 2008.
- *Chatswood to Sydenham Environmental Impact Statement*, Technical Paper 2: Noise and vibration, Version: Final, May 2016.
- *Sydney Metro City & Southwest Construction Noise and Vibration Strategy*, Sydney Metro, 2016.

3.3 NSW Industrial Noise Policy / Noise Policy for Industry

The *NSW Industrial Noise Policy* (INP) was superseded by the *Noise Policy for Industry* (NPfI) on 27 October 2017. The main difference between the NPfI and the INP is that the project specific Amenity criterion is more stringent in the NPfI. The derivation of the Intrusiveness criterion remains the same.

The '*Implementation and Transitional Arrangement for the Noise Policy for Industry (2017)'* (EPA October 2017) allows for the ongoing use of the INP under certain circumstances. They are replicated below:

1. The *NSW Noise Industrial Noise Policy* (2000) is withdrawn and is replaced by the *Noise Policy for Industry* (2017) except as described in points 2 and 3 below.
2. The *Noise Policy for Industry* (2017) will take effect immediately upon its release and should be referenced in relevant Secretary's Environmental Assessment Requirements (SEARs) for new industrial development issued after the policy release date. Where SEARs were issued before the release of the new policy, and have not

been modified, the assessment requirements referenced in the SEARs will apply for a period of two (2) years from the date of the issue of the SEARs consistent with the provisions in the *Environmental Planning and Assessment Regulation* 2000, Schedule 2, Part 2, 3 (7).

3. In situations where SEARs are not issued (that is, development consent that is not State Significant Development or Infrastructure), however a proponent can demonstrate that the environmental assessment substantially commenced before release of the new policy, planning and regulatory authorities may choose to determine the application based on the *NSW Industrial Noise Policy* (2000) for a period of up to one (1) year from the date of release on the *Noise Policy for Industry* (2017).

The Sydney Metro portion of the works has been approved prior to the publication of the NPfI, and the INP applies to that portion of the work. However the OSD is to be approved under a separate planning approval, after the publication of the NPfI. The design of the OSD portion is at concept phase and noise controls have not yet been designed.

Noise emission for the site applies to the cumulative noise levels from all aspects of the OSD and Sydney Metro Projects as a whole development as follows:

- All operational aspects of the OSD including mechanical services plant, car parking, loading docks etc. (OSD portion).
- The Victoria Cross station mechanical and electrical plant for the continual operation of the station and associated retail concessions (Sydney Metro portion).
- The train tunnels require large fans for exhaust and ventilation. This includes the following sub-systems (Sydney Metro portion):
    - Tunnel Ventilation System (TVS)
    - Trackway Exhaust System (TES)
    - Draft Relief (DR) shafts are also required for train passbys.

Resonate Acoustics has advised that the components relating to the Sydney Metro Project (station and tunnels) utilise the INP for the assessment of environmental noise emission with an adjustment applied to the criteria to allow for contribution from the OSD. The Sydney Metro Project was subject to a Critical State Significant Infrastructure (CSSI) process and has been conceptually approved. The SEARs for the Sydney Metro Project were issued prior to the release of the new NPfI and therefore, in accordance with the implementation arrangements, the INP is the relevant document to employ for the Sydney Metro portions of the project. It should also be considered that the assessment of the Sydney Metro Project (station, station retail and tunnels) has substantially commenced and has progressed significantly further than the OSD component.

This assessment has considered the differences between applying the INP and the NPfI to the OSD component. The aim for the whole development is to ensure that noise emissions from Sydney Metro and OSD development, when combined, should meet the applicable Conditions of Approval for the Sydney Metro CSSI portion of works. This has involved applying an allocation of allowable noise emissions for the three main aspects of the project described above, with each assigned noise emissions criteria set to 5 dB below the applicable INP target.

Sydney Metro considers that the OSD design is at a stage where it can accommodate the requirements of the NPfI, and that it is appropriate to acknowledge the current Policy in the assessment of the OSD. In addition, the cumulative noise emissions from Sydney Metro and OSD portions of the development should meet the INP noise criteria in accordance with the CSSI approval.

The allocation of the allowable noise emissions from the OSD does not change, regardless of whether the INP or the NPfI is applied. This is because the NPfI approach for deriving the project-specific Amenity criterion results in a 5 dB more stringent Amenity criterion than the now-superseded INP. A 5 dB adjustment has already been applied for the noise allocation approach for the total development emissions, and therefore in terms of allowable noise emissions, the two approaches result in equal noise criteria for the OSD.

Therefore the noise emissions criteria for the OSD has taken a two-step approach:

1. Establish adjusted noise emissions criteria for the three main components of the Sydney Metro and OSD, such that the CSSI Approval conditions would be met by the whole development.

2. Compare the OSD adjusted criteria against the NPfI, to ensure that the adjusted criteria are no higher than the NPfI and therefore meet the intent of the new Policy.

The INP has been adopted for the assessment of environmental noise emission from the OSD with a similar adjustment to the criteria to allow for contribution from the Sydney Metro Project (station and tunnel). The adjusted criteria derived for the OSD portion of the development have then been compared with the NPfI noise emissions criteria. This approach has been adopted to:

- Ensure that the CSSI noise emissions criteria (based on INP) are met by the whole development.
- Provide consistency across the assessment of noise emission from all sources located on the site (i.e. station, tunnels and OSD).
- Provide rational distribution of criteria between components (i.e. station, tunnel and OSD).

- Ensure that the intent of the updated NSW NPfI is met by the OSD portion of the design, particularly in relation to the approach for preserving acoustic amenity for noise-sensitive receivers.

Acoustic terminologies used in this report are explained in **Appendix A.**

4.0 Existing noise and vibration environment

Noise sensitive receivers surrounding the site have been grouped into two Noise Catchment Areas (NCAs) based on similar background noise levels. NCA 1 comprises receivers south of Berry Street. NCA 2 comprises receivers north of Berry Street.

The NCA boundaries are shown in **Figure 8**.

4.1 Noise Catchment Area 1

NCA 1 comprises predominantly high-rise commercial and residential receivers along Miller Street, Berry Street, Mount Street, Arthur Street and Walker Street. The site is located within NCA 1 and the nearest commercial receivers border the site in all directions. The nearest residential receiver is approximately 15 metres away, across Denison Street in the residential high rise building. There is a childcare centre at 65 Berry Street, directly facing the OSD site. The noise environment within NCA 1 is considered urban and is dominated by road traffic noise.

NCA 1 comprises commercial core zones (B3) as classified by the North Sydney Local Environmental Plan 2013 - Land Zoning Map – Sheet LZN_002A, refer to **Appendix B.**

4.2 Noise Catchment Area 2

NCA 2 comprises predominantly mixed use premises with a number of single and double storey semi-detached houses and multi storey residential units, there are also a number of educational and commercial establishments. The nearest commercial receiver is across Berry Street from the site. The nearest residential receivers, multi-level residences along Berry Street, are located approximately 150 metres east of the site. The noise environment within NCA 2 is urban and dominated by road traffic noise.

NCA 2 comprises a combination of medium density (R3) and high density (R4) residential zones as well as a number of infrastructure (SP2), commercial core (B3) and mixed use (B4) zones as classified by the North Sydney Local Environmental Plan 2013 - Land Zoning Map – Sheet LZN_002A. A public recreation zone (RE1) also exists in NCA 2.

Figure 8: NCA boundaries

4.3 Noise monitoring

Noise monitoring was conducted in the study area surrounding the site between 1 September 2015 and 15 September 2015. The noise monitoring was conducted as part of the EIS for the Sydney Metro City & Southwest Chatswood to Sydenham project (Sydney Metro Project) and comprised of long term unattended noise logging supplemented by attended noise measurements. (Refer to **Figure 8** for noise monitoring locations).

The noise monitoring data from 2015 are applicable because they are not affected by the various construction projects which are currently underway.

Noise monitoring for the Sydney Metro Project is detailed in the report titled: *Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration* dated 28 April 2016

(Technical Paper 2: Noise and Vibration). The noise monitoring was carried out at three locations:

- **Location 1** - Unit 3004, 77-81 Berry Street North Sydney, located on the northern façade of the building. This logger was representative of receivers located adjacent to the OSD and is dominated by road traffic noise in the general area. Thus the results of this logger were used to quantify the road traffic noise in the vicinity of the development site. Noise levels at this logger location are representative of receivers in NCA 1. This logger was designated as B16 in the Technical Paper.

- **Location 2** - 237 Miller Street, North Sydney, located on the western wall of the pool area in the residential apartment building. The ambient noise environment at this location was dominated by road traffic noise from Miller Street and McLaren Street. Noise levels at this logger location are representative of residential receivers in NCA 2. This logger was designated as B18 in the Technical Paper 2: Noise and Vibration.

- **Location 3** – 12-16 Berry Street, North Sydney, located to the west of Pacific Highway. While this location is approximately 200m distant from the Victoria Cross Sydney Metro site, the ambient noise environment is considered to be similar to receivers located off the main road, such as to the rear of the development on Denison Street. Noise levels at this logger location are considered representative of residential receivers off the main road in NCA 1 and NCA 2. During the design development of the OSD, the applicable ambient and background noise levels, particularly for rear-facing receivers, should be confirmed and reviewed as required. This logger was designated as B17 in the Technical Paper 2: Noise and Vibration.

Noise monitoring data from Unit 3004, 77-81 Berry Street and 237 Miller Street and 12-16 Berry Street have been used to develop criteria for the OSD.

'Urban hum' was also observed at all logger locations and is deemed to be constant in the North Sydney region.

4.3.1 Unattended noise monitoring results

A summary of the L_{Aeq} noise levels representing traffic noise levels incident on the proposed development is presented in **Table 1**, and Rating Background Levels (RBLs) and existing L_{Aeq} ambient noise levels representing surrounding receivers are presented in **Table 2**.

Table 1: Existing traffic (L_{Aeq}) noise levels
Source: Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration

	Day $L_{eq, (1\ hour)}$[1]	Night $L_{eq, (1\ hour)}$[1]	Day $L_{eq, (15\ hour)}$[1]	Night $L_{eq, (9\ hour)}$[1]
Location 1 – Unit 3004, 77 – 81 Berry Street, North Sydney				
Log Average L_{Aeq}	-[2]	-[2]	67	62
Location 2 – 237 Miller Street, North Sydney				
Log Average L_{Aeq}	-[2]	-[2]	74	67

Notes:

1. In accordance with the EPA's NSW Road Noise Policy (DECC 2011):
   - Day is defined as 7:00 am to 10:00 pm.
   - Night is defined as 10:00 pm to 7:00 am.
   - $L_{eq, (1\ hour)}$ represents the loudest 1 hour L_{eq} within the period.
   - $L_{eq, (15\ hour)}$ and $L_{eq, (9\ hour)}$ represent the L_{eq} of the entire day or night-time period respectively.
2. Data not provided in Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration.

Table 2: Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels
Source: Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration

	Background L_{A90} and ambient noise levels L_{Aeq}, dB(A)		
	Day[1]	Evening[1]	Night[1]
Location 1 – NCA 1:Unit 3004, 77-81 Berry Street North Sydney			
Rating background level	65	63	52
Log Average L_{Aeq}	68	65	62
Location 2 – NCA 2: 237 Miller Street, North Sydney			
Rating background level	65	57	51
Log Average L_{Aeq}	74	71	67
Location 3 – NCA 1 and 2 receivers off main road: 12-16 Berry Street, North Sydney[2]			
Rating background level	55	50	44
Log Average L_{Aeq}	61	55	51

Notes:

1. In accordance with the INP:
   - Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
   - Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday & Public Holidays.
   - Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays.
2. During the design development of the OSD, the applicable ambient and background noise levels, particularly for rear-facing receivers, should be confirmed and reviewed as required.

4.3.2 Attended noise monitoring

Attended noise monitoring is also presented in the Technical Paper 2: Noise and Vibration. The attended measurements were conducted on 15 September 2015 to quantify noise sources affecting the area. The noise levels for the 15 minute measurements for the measured locations are presented in **Table 3**.

Table 3: Attended noise measurement results
Source: Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration

Location		Date / Time	Details	Measured noise level, dB(A)	
				L_{Aeq}	L_{A90}
1	Unit 3004, 77-81 Berry Street North Sydney	15 September 2015 7:40 pm - Evening	Local traffic dominant. "City hum" observed and deemed to be constant in North Sydney.	65	62
2	237 Miller Street, North Sydney	15 September 2015 9:53 am - Day	Traffic along Miller Street and McLaren Street dominant. Tree rustling (wind) contributed to the L_{A90}. Constant "City hum" was observed.	72	59

5.0 Assessment criteria

5.1 Operational noise criteria

This section presents relevant criteria in order to address the following acoustical issues:

- Noise emitted from additional traffic generated by the site.
- Noise intrusion requirements from road and rail traffic and other ambient noise sources (e.g. building services from other nearby developments).
- External environmental noise emission levels for building services.
- Regenerated noise and vibration from trains.

5.1.1 Road traffic noise emission criteria

Noise from traffic movements to and from the site including truck and car movements was assessed using the EPA's document *NSW Road Noise Policy* (RNP). Vehicle access point to the development would be via Denison Street.

Denison Street is classified as a local road. The northern end is proposed to be converted into a two-way road up to the development's loading dock entry. The southern end of Denison Street would be converted to a pedestrian zone in the longer term.

Table 4 presents the RNP's road traffic noise assessment criteria for residential/commercial land use developments with potential to create additional traffic on existing roads. The external criteria are assessed at 1 metre from the affected residential building façades and at a height of 1.5 metres from the floor.

Table 4: Road traffic noise assessment criteria for residential land uses
Source: NSW Road Noise Policy, EPA

Road category	Type of project/land use	Assessment criteria - dB(A)	
		Day (7 am – 10 pm)	Night (10 pm – 7 am)
Freeway / arterial / sub-arterial roads	Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,\ (15\ hour)}$ 60 (external)	$L_{Aeq,\ (9\ hour)}$ 55 (external)
Local roads	Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,(1\ hour)}$ 50 (external)

In cases where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person (refer RNP Section 3.4).

5.1.2 External noise intrusion

5.1.2.1 Air-borne noise

Internal noise levels in the commercial tenancy spaces would mainly be contributed by vehicles using surrounding streets, including Miller Street and Berry Street, and by the building's air conditioning and mechanical ventilation plant.

The subject development was assessed for road traffic noise intrusion by addressing the EPA's RNP. The RNP states that "*For commercial and industrial developments, information on desirable noise levels is contained in AS/NZS 2107: 2000"* which has been superseded by AS/NZS 2017:2016.

Combined internal noise levels due to external noise intrusion and internal mechanical services such as air conditioning and mechanical ventilation plant should not exceed the upper level of the range recommended in AS/NZS 2107:2016.

The Standard recommends a range of internal noise levels for building interiors, the given ranges have been found to be acceptable by most people for the space under consideration. When the sound level is greater than the upper level of the range, most people occupying the space would become dissatisfied with the level of sound. When the sound level is below the lower level of the range, the inadequacy of background sound to provide masking sound can become problematic, for example, by allowing other intermittent noise sources to cause distraction, annoyance, or lack of privacy.

Internal noise levels due to road traffic noise intrusion should be controlled to meet AS/NZS 2107:2016 recommended design sound levels less 3 dB. This allows for an equal contribution from mechanical services servicing the development.

The relevant criteria for road traffic noise intrusion are presented in **Table 5**. The recommended noise levels are given in terms of equivalent continuous A-weighted noise levels (L_{Aeq}).

Table 5: Road traffic noise intrusion criteria
Source: AS/NZS 2017:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors

Space	Design sound level, L_{Aeq}, dB(A) AS/NZS 2107:2016 less 3 dB
Retail	
Small retail stores (general)	< 47
Shopping malls	< 52
Show rooms	< 47
Speciality shops (where detailed discussion is necessary in transactions)	< 42
Supermarkets	< 52
Cafeterias	37 to 47
Food courts	42 to 52
Coffee shops	37 to 47
Restaurants	37 to 47
Commercial	
Board and conference rooms	27 to 37
Corridors and lobbies	42 to 47
Executive offices	32 to 37
General office areas	37 to 42
Meeting room (small)	37 to 42
Open plan office	37 to 42
Public spaces	37 to 47
Quiet rooms	37 to 42
Reception areas	37 to 42

5.1.3 Environmental noise emission

Environmental noise emission criteria have been developed by Resonate Acoustics based upon the *Technical Paper 2: Noise and Vibration* which references the INP.

In addition, the North Sydney Development Control Plan 2013 (NSDCP 2013) provides criteria for developments within the North Sydney Council boundaries.

5.1.3.1 INP environmental noise emission criteria summary

A summary of Rating Background Levels (RBLs), intrusive and amenity criteria specific to this project is given in **Table 6** and **Table 7**. The environmental noise criteria have been established in collaboration with Resonate Acoustics based on the *Technical Paper 2: Noise and Vibration*. The noise criteria have been adjusted by Resonate Acoustics to allow for an

equal distribution of the INP noise criteria between the OSD and the Sydney Metro Projects as follows:

- All operational aspects of the OSD including mechanical services plant, car parking, loading docks etc. – OSD portion
- The Victoria Cross Station mechanical and electrical plant for the continual operation of the station and associated retail concessions. – Sydney Metro portion, approved
- The train tunnels require large fans for exhaust and ventilation. This includes the following sub-systems: – Sydney Metro portion, approved:
    - Tunnel Ventilation System (TVS)
    - Trackway Exhaust System (TES)
    - Draft Relief (DR) shafts are also required for train passbys.

An equal distribution of the INP intrusiveness noise criteria between the OSD and Sydney Metro Projects results in each component (station, tunnel and OSD) being able to have an equal contribution to noise emission levels from the site but maintain compliance with the overall cumulative noise criteria.

The amenity criteria apply to environmental noise emissions from sources such as building services plant as these sources would run continuously and therefore would have the potential to contribute to background noise creep. The amenity criteria apply over the entire daytime, evening or night-time period, whereas intrusive criteria apply over any 15 minute period. All criteria must be applied at the most affected receiver boundaries.

The adjusted INP noise Amenity criteria allocated to the OSD have also been compared with the applicable NPfI Amenity noise criteria for the OSD. The Period Amenity criteria are identical taking the adjusted INP and the new NPfI approach. The adjusted INP Intrusiveness criteria for the OSD are 5 dB below the NPfI approach for the OSD alone – that is, the “whole of development” approach which has been adopted for the OSD is 5 dB more stringent than if the NPfI had been applied to the OSD on its own.

The adjusted INP criteria allocation ensures that the combined noise emissions from the OSD and the Sydney Metro station and tunnel-related portion of the project would meet the controlling overall CCSI criterion for the approved Sydney Metro project.

The noise data obtained for the EIS should be supplemented as the OSD design progresses, to ensure that noise emission criteria for residential receivers considers local variations in existing ambient noise due to shielding from road traffic noise by existing buildings, exposure to existing industrial-type noise sources such as rooftop plant, for example.

These criteria apply to environmental noise emissions from the development including mechanical services and other plant noise, loading dock noise and car parking noise.

Table 6: Summary of environmental noise emission criteria for residential receivers – INP
Source: Resonate Acoustics and NSW Industrial Noise Policy, and derived Amenity criteria in accordance with the NSW *NPfI*

Period[2]	Existing RBL, L_{A90}, dB(A)	Existing ambient, L_{Aeq}, dB(A)	Overall cumulative development criteria[1]		OSD only criteria	
			Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	Amenity criteria, $L_{Aeq\ period}$, dB(A)	Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	Amenity criteria, $L_{Aeq\ period}$, dB(A)
NCA 1 – residential receivers facing main road						
Day	65	68	70	58[3]	65	53
Evening	63	65	68	55	63	50
Night	52	62	57	52	52	47
NCA 2 – residential receivers facing main road						
Day	65	74	70	64	65	59
Evening	57	71	62	61	57	56
Night	51	67	56	57	51	52
NCA 1 and 2 – residential receivers off the main road (rear-facing)[4]						
Day	55	61	60	60	55	55
Evening	50	55	55	50	50	45
Night	44	51	49	45	44	40

Notes:

1. The overall cumulative development criteria applies to the combined noise emission from all sources associated with the Sydney Metro Project including, but not limited to, tunnel ventilation, station and OSD.
2. In accordance with the INP and NPfI:
   - Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
   - Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday & Public Holidays.
   - Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays.
3. Amenity Criterion has been derived conservatively assuming that existing ambient noise levels are dominated by industrial-type noise, rather than road traffic noise. This assumption should be confirmed during OSD design development.
4. Indicative criteria: during the design development of the OSD, the applicable ambient and background noise levels for rear-facing receivers should be confirmed and reviewed as required.

Table 7: Summary of environmental noise emission criteria for non-residential receivers
Source: Resonate Acoustics and NSW Industrial Noise Policy, and derived Amenity criteria in accordance with the NSW *NPfI*

Type of receiver	Indicative noise amenity area	Time of day	Recommended L_{Aeq} noise level, dB(A)	
			Overall development criteria	OSD only criteria
Commercial	All	When in use	65	60
School classroom (applies also to child care educational facilities) (external)	All	Noisiest 1 hour period when in use	50	45

5.1.3.2 Sleep disturbance

The INP Application Notes and the NPfI discuss sleep disturbance and its assessment, to minimise the risk of sleep disturbance as a result of industrial type operations during the night-time period (10.00pm to 7.00pm).

The INP sleep disturbance assessment compares the L_{Amax} or the $L_{A1,1minute}$ against the sleep disturbance screening level which is set equal to the measured RBL + 15 dB.

The NPfI recommends that the L_{Amax} noise level outside a bedroom window should not exceed 52 dB(A) or the L_{A90} background noise level by more than 15 dB(A), whichever is greater, and the $L_{Aeq,15min}$ should not exceed 40 dB(A) or RBL + 5, whichever is greater. If either of these screening criteria are found to be exceeded, then a more detailed analysis must be undertaken.

The Project-Specific NPfI $L_{Aeq,15min}$ Sleep disturbance screening level is equal to the Intrusiveness criterion given in **Table 6**, and this would be one of the design criteria applied to intermittent and quasi-continuous type noise at night.

The Project-Specific NPfI L_{Amax} sleep disturbance screening level is 15 dB is applicable to this project as it is greater than 52 dB(A). This is the same as the INP Sleep Disturbance Screening Level.

Applying the INP approach, there is an option to assess the $L_{A1,1minute}$ instead of the L_{Amax}. During design development, the OSD design should examine in more detail whether the assessment approach using $L_{A1,1minute}$ or L_{Amax} from intermittent noise sources results in different outcomes. While the INP approach is applicable to the entire development, the NPfI approach should also be considered for the design controls required to manage sleep disturbance.

The INP and NPfI reference the RNP for some guidance in assessing the potential for sleep disturbance. It concludes that having considered the results of research to date that, *'Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions'*. Given that an open window provides approximately 10 dB in noise attenuation from outside to inside (if open sufficiently to provide natural ventilation), external noise levels of 60-65 dB (A) are unlikely to result in awakening reactions.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented **Table 8**.

Table 8: Sleep disturbance criteria
Source: NSW INP Application Notes and NSW Road Noise Policy

Noise catchment area	Night RBL (L_{A90}), dB(A)	Sleep disturbance criteria, L_{Amax}, dB(A)	
		Screening level	Awakening reaction
NCA 1 – residential receivers facing main road	52	67	65
NCA 2 – residential receivers facing main road	51	66	65
NCA 1 and NCA 2 – residential receivers off the main road (rear-facing) (to be confirmed during design development)	44	59	65

The sleep disturbance was assessed against the awakening reaction noise criteria as a more conservative approach for receivers on the main road.

5.1.3.3 Emergency operations

In the absence of any relevant NSW guideline for emergency generators and equipment, it is recommended that noise limits for emergency plant equipment be relaxed by 5 dB, in accordance with the duration correction in Table 4.1 of the INP.

Adjustments to the level of noise predicted (or measured) at the assessment location may be applied in accordance with Section 4 of the INP to account for the subjective effects of specific noise characteristics including tonality, low frequency content, intermittency, impulsiveness and duration.

Table 9 presents emergency operations noise criteria. As noted previously, the OSD design should be developed with more detailed reviews of local variations in ambient noise, due to varying exposure to road traffic and rooftop plant noise in this built up area.

Table 9: Emergency operations noise criteria (*Source: Resonate Acoustics and NSW INP)*

Period	Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	Emergency operations noise criteria, $L_{Aeq\ 15\ min}$, dB(A)
NCA 1 – residential receivers facing main road		
Day	65	70
Evening	63	68
Night	52	57
NCA 2 – residential receivers facing main road		
Day	65	70
Evening	57	62
Night	51	57

Period	Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	Emergency operations noise criteria, $L_{Aeq\ 15\ min}$, dB(A)
NCA 1 and NCA 2 (indicative) – residential receivers off the main road (rear-facing)		
Day	55	60
Evening	50	55
Night	44	49

5.1.3.4 North Sydney Development Control Plan

Clause 11 of the SRD SEPP states that development control plans do not apply to State significant development. Accordingly, NSDCP 2013 does not apply to this concept proposal. Nonetheless, the underlying objectives of NSDCP 2013 have informed and influenced this assessment.

Section 2.3.2 of the NSDCP 2013 provides criteria which are not directly applicable to this State Significant development, but should be considered for the OSD design. These NSDCP requirements are provided below in italics:

P1 Noise emission associated with the operation of non-residential premises or non-residential components of a building must not exceed the maximum 1 hour noise levels ($L_{Aeq,\ 1hour}$) specified in Table B-2.3.

Table B-2.3 – Noise Emission Limits			
Time Period			***Max 1 hour noise level ($L_{Aeq,\ 1hour}$)***
Day	***Week***	***Time***	
Weekday	*Day*	*7am – 6pm*	*60 dB(A)*
	Evening	*6pm – 10pm*	*50 dB(A)*
	Night	*10pm – 7am*	*45 dB(A)*
Weekend	*Day*	*8am - 7pm*	*60 dB(A)*
	Evening	*7pm - 10pm*	*50 dB(A)*
	Night	*10pm - 8am*	*45 dB(A)*

Notes: *$L_{Aeq,\ 1hour}$ readings are to be measured during the noisiest 1 hour period between Day 7/8am to 6/7pm, Evening – 6/7pm – 10pm and Night – 10pm to 7/8am.*

P2 In terms of determining the maximum noise levels as required by P1 above, the measurement is to be taken at the property boundary of the nearest residential premises. Within a mixed use development, the boundary is taken to be the nearest floor ceiling or wall to a residential dwelling on the site.

P3 Despite P1 above, the noise emission associated with the operation of non-residential premises of non-residential components of a building must not exceed 5 dB(A) above the background maximum 1 hour noise level ($L_{Aeq,\ 1hour}$) during the day and evening and not exceeding the background level at night when measured at the boundary of the property.

P4 Council may require the submission of an Acoustic Report to ensure compliance with P1 above.

P5 Plant and machinery should incorporate noise reduction measures to minimise their impacts.

P6 Development should be designed and/or incorporate features that reduce noise transmission.

P7 Where practical, development should incorporate adequate measures for tonal, low frequency, impulsive or intermittent noise.

P8 Developments must comply with the EPA Industrial Noise Policy 2000 in particular the modification required for acceptable noise level (ANL).

A summary of the NSDCP 2013 criteria is presented in **Table 10.**

Table 10: Summary of environmental noise emission criteria for residential receivers
Source: Resonate Acoustics and NSDCP 2013

Period		Existing RBL, L_{A90}, dB(A)	Existing ambient, L_{Aeq}, dB(A)	Overall cumulative development criteria		OSD only criteria	
Day	Time			P1	P3	P1	P3
NCA 1 – residential receivers facing main road							
Weekday	Day (7am – 6pm)	65	68	60	73	55	68
	Evening (6pm – 10pm)	63	65	50	70	45	65
	Night (10pm – 7am)	52	62	45	62	40	57
Weekend	Day (8am – 7pm)	65	68	60	73	55	68
	Evening (7pm – 10pm)	63	65	50	70	45	65
	Night (10pm – 8am)	52	62	45	62	40	57
NCA 2 – residential receivers facing main road							
Weekday	Day (7am – 6pm)	65	74	60	79	55	74
	Evening (6pm – 10pm)	57	71	50	76	45	71
	Night (10pm – 7am)	51	67	45	67	40	62
Weekend	Day (8am – 7pm)	65	74	60	79	55	74
	Evening (7pm – 10pm)	57	71	50	76	45	71
	Night (10pm – 8am)	51	67	45	67	40	62
NCA 1 and 2 – residential receivers off the main road (rear-facing)[2]							
Weekday	Day (7am – 6pm)	55	61	60	66	55	61
	Evening (6pm – 10pm)	50	55	50	60	45	55
	Night (10pm – 7am)	44	51	45	51	40	46
Weekend	Day (8am – 7pm)	55	61	60	66	55	61
	Evening (7pm – 10pm)	50	55	50	60	45	55

Period		Existing RBL, L_{A90}, dB(A)	Existing ambient, L_{Aeq}, dB(A)	Overall cumulative development criteria		OSD only criteria	
Day	Time			P1	P3	P1	P3
	Night (10pm – 8am)	44	51	45	51	40	46

Notes:

1. The overall cumulative development criteria applies to the combined noise emission from all sources associated with the Sydney Metro Project including, but not limited to, tunnel ventilation, station and OSD.
2. Indicative criteria: during the design development of the OSD, the applicable ambient and background noise levels for rear-facing receivers should be confirmed and reviewed as required.

5.2 Regenerated noise

The NSW Government Department of Planning guideline, *'Development Near Rail Corridors and Busy Roads – Interim Guideline*' was referred to for assessing the impact of regenerated noise. The regenerated noise trigger levels contained within the guideline are provided in **Table 11**.

Table 11: Ground-borne (internal) noise trigger levels
Source: Development Near Rail Corridors and Busy Roads – Interim Guideline

Receiver	Time of day	Noise criteria, $L_{Amax\ slow}$ dB(A)
Residential	Day (7 am – 10 pm)	40
	Night (10 pm – 7 am)	35
Schools, educational institutions, places of worship	When in use	40
Places of Worship	When in use	40
Hospitals- Wards	When in use	35
Hospitals - Other noise sensitive areas	When in use	45

For commercial/retail spaces a value of 45-50 $L_{Amax(slow)}$ is typically adopted.

5.3 Operational vibration criteria

Vibration criteria are set primarily according to whether the particular activities of interest are continuous in nature or intermittent, whether they occur during the daytime or night-time and the type of receiver to be assessed e.g. commercial or residential.

The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed, i.e. human disturbance or discomfort.
- Those in which the integrity of the building or the structure itself may be prejudiced.

- Those where the building contents may be affected.

For the operation of the OSD, levels of vibration should meet human comfort criteria. Higher vibration levels which may affect the building structure or contents would not be relevant to the operational phase.

5.3.1 Tactile vibration

5.3.1.1 Assessing vibration – A technical guideline

The EPA's *Assessing vibration: A Technical Guideline* (AVTG) has been designed to be used in evaluating and assessing the effects on amenity of vibration emissions from industry, transportation and machinery. The guideline is used in assessment of vibration impacts caused by the construction and operation of new developments.

The guideline distinguishes between continuous, intermittent and impulsive vibration and provides a set of different vibration goals for each of these activities (**Table 12**).

Table 12: Examples of types of vibration
Source: Assessing Vibration: A Technical Guideline

Continuous	Impulsive	Intermittent
Continuous uninterrupted for a defined period (usually throughout day-time and/or night-time	A rapid build-up to a peak followed by a damped decay. The duration is typically less than 2 seconds.	Defined as interrupted periods of continuous vibration or repeated periods of impulsive vibration.
Steady road traffic, continuous construction activity (e.g. tunnel boring), machinery	Activities that create up to 3 distinct vibration events in an assessment period (e.g. occasional dropping of heavy equipment)	Trains, concrete breakers, impact pile driving

Continuous and impulsive vibration

Preferred and maximum vibration levels for different receivers for continuous and impulsive vibration are provided in **Table 13** and **Table 14**.

Table 13: Preferred and maximum weighted root mean square (rms) vibration levels for continuous vibration acceleration (m/s^2) in the vertical direction
Source: Assessing Vibration: A Technical Guideline

Location	Daytime		Night-time	
	Preferred	Maximum	Preferred	Maximum
Critical areas	0.005	0.010	0.005	0.010
Residences	0.010	0.020	0.007	0.014
Offices, schools, educational institutions and places of worship	0.020	0.040	0.020	0.040
Workshops	0.040	0.080	0.040	0.080

Table 14: Preferred and maximum weighted root mean square (rms) vibration levels for impulsive vibration acceleration (m/s^2) in the vertical direction.
Source: Assessing Vibration: A Technical Guideline

Location	Daytime		Night-time	
	Preferred	Maximum	Preferred	Maximum
Critical areas	0.005	0.010	0.005	0.010
Residences	0.030	0.060	0.100	0.200
Offices, schools, educational institutions and places of worship	0.640	1.280	0.640	1.280
Workshops	0.640	1.280	0.640	1.280

The guideline states:

> '*there is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Activities should be designed to meet the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum value may be used if they can be justified. For values beyond the maximum value, the operator should negotiate directly with the affected community. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short term duration'.*

Intermittent vibration

The assessment of intermittent vibration outlined in the EPA guideline is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the day-time and night-time periods.
Maximum and preferred VDVs for are listed in **Table 15**.

Table 15: Preferred and maximum vibration dose values for intermittent vibration ($m/s^{1.75}$)
Source: Assessing Vibration: A Technical Guideline

Location	Daytime		Night-time	
	Preferred	Maximum	Preferred	Maximum
Critical areas	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

5.3.1.2 British Standard 6472-1:2008

The impact of tactile vibration is assessed against BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting". BS 6472-1:2008 assesses the probability of adverse comment from vibration by means of Vibration Dose Values (VDVs).

The probability of adverse comment from occupants exposed to a particular level of vibration is given in **Table 16.**

Table 16: Vibration dose value ranges which might result in various probabilities of adverse comment within commercial buildings
Source: BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting

Place and time	Low probability of adverse comment ($ms^{-1.75}$)	Adverse comment possible ($ms^{-1.75}$)	Adverse comment probable ($ms^{-1.75}$)
Residential - Day	0.2 to 0.4 (same as AVTG "preferred" to "maximum")	0.4 to 0.8	0.8 to 1.6
Residential – Night	0.1 to 0.2 (same as AVTG "preferred" to "maximum")	0.2 to 0.4	0.4 to 0.8
Offices	0.4 to 0.8 (same as AVTG "preferred" to "maximum")	0.8 to 1.6	1.6 to 3.2

BS 6472-1:2008 acknowledges that there is widely differing susceptibility to vibration in the community and accordingly, ranges rather than discrete values are provided.

5.4 Construction noise and vibration criteria

5.4.1 Construction noise management levels

The NSW EPA's *Interim Construction Noise Guideline* (ICNG) is the principal guidance for the assessment and management of construction noise in NSW.

The ICNG recommends that a quantitative assessment is carried out for all 'major construction projects that are typically subject to the EIA process'. Noise levels due to construction activities are predicted at nearby receivers using environmental noise modelling software and compared to the levels provided in Section 4 of the ICNG.

Where an exceedance of the management levels is predicted the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practises to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details.

Where construction noise levels reach 75 dB(A) residential receivers can be considered as 'highly noise affected' and the proponent should, in consultation with the community, consider restricting hours to provide respite periods.
The ICNG defines what is considered to be feasible and reasonable as follows:

Feasible

A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.

Reasonable

Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

The construction noise management levels (NMLs) for the residential and other sensitive land uses in proximity to the site are detailed below.

5.4.1.1 Construction hours

Standard construction hours are defined in the ICNG. No work is generally expected to be required outside of standard construction hours. Construction hours are defined as:

- Standard Hours: 7 am to 6 pm Monday to Friday and 8 am to 1 pm Saturday;
- Out of Hours: before 7 am and after 6 pm Monday to Friday, before 8 am and after 1 pm Saturday, and all Sunday and public holidays.

In addition to the ICNG standard construction hours noted above, North Sydney Council allows for work hours on construction sites as follows:

- Monday to Friday: 7 am to 5 pm
- Saturday: 8 am to 1 pm
- Sunday and Public Holidays: no work is permitted.

It should however be noted that applications can ordinarily be made to North Sydney Council to conduct works outside of these hours. Out of hours works may be considered if there is a strong justification for it.

5.4.1.2 Residential receivers

Guidance for setting construction NMLs for residential receivers are summarised in **Table 17.**

Table 17: Setting and applying noise management levels at residences
Source: Interim Construction Noise Guideline

Time of day	NML, $L_{Aeq,15min}$, dB(A)[1]	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 $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise.

Time of day	NML, $L_{Aeq,15min}$, dB(A)[1]	How to apply
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 (ICNG).

Notes:

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

5.4.1.3 Other sensitive land uses and commercial receivers

NMLs for non-residential receivers located adjacent to the site have been determined using the recommended levels in the ICNG for other sensitive land uses and commercial buildings. The ICNG does not specify noise criteria for childcare centres. The NMLs for childcare centres are provided by the Association of Australian Acoustical Consultants *Guideline for Child Care Centre Acoustic Assessment* dated October 2013. This guideline recommends $L_{Aeq,1\ hour}$ noise limits which have been adopted as $L_{Aeq,15min}$ NMLs. The NMLs are presented in **Table 18**.

Table 18: Construction noise management levels sensitive land uses (other than residences) and commercial buildings
Source: Interim Construction Noise Guideline

Land use	Noise levels, $L_{Aeq,15min}$ (applies when properties are in use)
Monte Sant' Angelo Mercy College classrooms	45 dB(A) Internal
Monte Sant' Angelo Mercy College gymnasium	50 dB(A) Internal
Australian Catholic University	45 dB(A) Internal

Land use	Noise levels, $L_{Aeq,15min}$ (applies when properties are in use)
Only About Children Childcare Walker Street Early Learning Centre Tree Tops Childcare Centre	40 dB(A) Internal 55 dB(A) Outdoor play areas or activity area
Mary Mackillop Memorial Chapel	45 dB(A) Internal
Commercial Premises (including: Café, offices, restaurants and retail stores)	70 dB(A) external

5.4.1.4 Site specific construction noise management levels

Construction NMLs for the most affected residential receivers are shown in **Table 19**. It should be noted that these NMLs indicate levels "*above which there may be some community reaction to noise*". They do not represent strict criteria. The highly noise affected level of 75 dB(A) represents "*the point above which there may be a strong community reaction to noise*".

NMLs for out of hours works periods have also been presented for information.

Table 19: Construction noise management levels - Residential receivers
Source: Resonate Acoustics and Interim Construction Noise Guideline

Catchment area	Period	RBL, L_{A90} dB(A)	Noise management levels, $L_{Aeq\ (15\ min)}$ dB(A)
NCA 1 – residential receivers facing main road	Day (standard hours)	65	75
	Day (out of hours)	65	70
	Evening	63	68
	Night	52	57
NCA 2 – residential receivers facing main road	Day (standard hours)	65	75
	Day (out of hours)	65	70
	Evening	57	62
	Night	51	56
NCA 1 and 2 – residential receivers off the main road (rear-facing) (to be confirmed during design development)	Day (standard hours)	55	65
	Day (out of hours)	55	60
	Evening	50	55
	Night	44	49

5.4.1.5 Sleep disturbance

Works are generally not proposed to be conducted outside of standard construction hours; therefore a sleep disturbance assessment is not required.

However, for information, the applicable criteria would be sleep disturbance screening levels of RBL + 15dB, and 65dB(A) sleep awakening levels (assuming bedroom windows can be kept open sufficiently for natural ventilation).

5.4.2 Construction vibration and structural damage

The German Standard DIN 4150-Part 3 'Structural vibration in buildings – Effects on Structures' provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. If cosmetic damage is avoided then structural damage would not occur. These levels are presented in **Table 20.** Receivers classified as Group 1, Group 2 and Group 3 have been identified as being potentially affected by construction vibration.

Table 20: Structural damage vibration criteria
Source: DIN 4150 – Part 3 Structural vibration in buildings – Effects on Structures

Group	Type of structure	Guideline values for velocity in mm/s			
		Vibration at the foundation			Vibration at the horizontal plane of highest floor at all frequencies
		1 H to 10 Hz	10 H to 50 Hz	50 H to 100 Hz	
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20-40	40-50	40
2	Dwellings and buildings of similar design and/or use	5	5-15	15-20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under Group 1 or 2 and are of great intrinsic value (e.g. listed buildings under a preservation order)	3	3-8	8-10	8

5.4.3 Construction road traffic noise criteria

The ICNG does not provide direct reference to an appropriate criterion to assess the noise arising from construction traffic on public roads.

Given the relative short duration of most construction activities and taking into consideration the RNP which provides guidance when assessing relative increases in criteria, namely:

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

Thus, the criterion applied to traffic movements on public roads generated during the construction phase of the project is an increase in existing road traffic noise of no more than 2 dB(A).

The requirements of the ICNG have been addressed in **Section 0** of this report.

6.0 Operational noise and vibration emission assessment

The assessment of operational noise and vibration emission is detailed in this section of the report with regard to the established criteria detailed in **Section 5.0**.

6.1 Road traffic noise due to operation

The proposed development includes a car park with space for 161 vehicles. Predicted percent increase in peak hourly traffic flow at critical intersections due to the operation of the OSD has been provided in the document, *Metron Internal Technical Memorandum Victoria Cross OSD Modelling Assessment NWRLSRT-MET-SRT-TI-REP-000017*.

A summary of the traffic flow percentage increases is presented in **Table 21**.

Table 21: % Increase in peak hourly traffic flow at critical intersections due to OSD
Source: Metron Technical Memorandum

Intersection	AM peak (%)	PM peak (%)
Miller Street / McLaren Street	0.2	0.0
Miller Street / Berry Street	0.2	0.0
Miller Street / Pacific Highway	0.0	0.0
Berry Street / Denison Street	1.0	5.1
Berry Street / Walker Street	0.4	2.5

The maximum percentage increase in traffic flow corresponds to an increase of less than 1 dB(A), complying with the RNP criteria. Therefore, the impact of noise from vehicles arriving at and leaving the development is considered to be insignificant. AECOM's Traffic and Transport Report (EIS Appendix P) has identified that the development of the OSD would not have a significant impact to the operation of the surrounding road. For increases in road traffic flow to have an acoustic impact (i.e. 2 dB increase in noise levels), traffic flows would have to increase by 60%.

6.2 Building services noise and vibration emission

The environmental noise emissions from the OSD building's services plant should be assessed against the environmental criteria presented in **Section 5.1.3**. This should be addressed during the design of the commercial building within the concept SSD Application envelope and assessed as part of the EIS for the detailed SSD Application (or applications), and appropriate acoustic treatment incorporated, where required, to comply with the criteria.

The main noise and vibration emitting sources from the development would include:

- Air cooled and/or water cooled chillers and/or cooling towers
- Pumps
- Ventilation fans

- Emergency generators

It is expected that standard acoustic treatments would be sufficient to meet the established criteria. These would likely include the following:

- Acoustic barriers around roof top plant
- Robust construction of plant rooms
- Acoustic louvres to some plant room openings
- Acoustic attenuators incorporated into mechanical ductwork
- Acoustic mufflers incorporated into generator exhaust systems
- Internal lining of ductwork
- Selection of low-noise plant
- Acoustic isolation mounts.

6.3 Sleep disturbance assessment

Sleep disturbance due to the operation of the OSD should be assessed against the criteria presented in **Section 5.1.3** during the detailed SSD Application (or applications). Appropriate reasonable and feasible acoustic treatments should be incorporated into the OSD design as required to minimise sleep disturbance.

It is expected that standard acoustic treatments would be sufficient to minimise sleep disturbance. Mitigation measures would likely include:

- Testing of emergency equipment, such as generators, during day-time periods.

6.4 Emergency operations

Emergency operations of the OSD should be assessed against the criteria presented in **Section 5.1.3.3** during the detailed SSD Application (or applications). Acoustic treatments, such as attenuators, acoustic louvres and mufflers, should be incorporated into the design as required to meet the emergency operations noise emission criteria.

6.5 Car park noise emission

All car parking associated with the proposed development would be located in basement carparks. Noise emission from vehicle movements within the car park would be sufficiently attenuated by the proposed development structure to comply with the relevant criteria presented in **Section 5.1.3**.

Based upon the existing traffic flows and net increase in traffic flows, the maximum number of vehicle movements through the Denison Street carpark entry would be 109 during the peak one hour in the daytime. This is an approximate value and the impact of car park noise

emission should be further reviewed during the detailed SSD Application (or applications) when the traffic study is finalised.

Predicted $L_{Aeq,15min}$ noise contributions from cars entering and exiting the car parks are presented in **Table 22**, these values have been compared against the relevant criteria presented in **Section 5.1.3**. The car park entrance faces receivers to the East in Denison Street North, it is expected that the OSD building structure and existing buildings would provide adequate shielding to receivers in the adjacent NCA 2.

Table 22: Summary of noise contribution from car park
Source: AECOM

Noise catchment area	Receiver	Noise contribution from the carpark, dB(A)	Intrusiveness Criteria, Day/Evening/Night
NCA 1 – residential receivers facing main road	Residential	32	53/50/47
	Commercial	45	60
NCA 2 – residential receivers facing main road	Residential	< 30	59/55/51
	Commercial	< 30	60
NCA 1 and 2 – residential receivers off the main road (rear-facing) (to be confirmed during design development)	Residential	< 30	55/50/44
	Commercial	< 30	60

In order to minimise environmental noise emission from the use of the car park entries, AECOM recommends consideration of the following noise mitigation measures during the detailed design stage:

- Should entry/exit warning systems be required for safety purposes, the use of audible warning devices should be avoided and visual warning devices used.
- Any metal drainage grates should be mounted on resilient pads to reduce impact noise as vehicles pass over them.
- Other potential noise sources, such as speed humps, floor surfaces and tyre squeal, boom gates, should be considered further during detailed design.

6.6 Loading dock noise emission

Access to the loading docks would be from Denison Street. Denison Street is shielded from main road traffic noise and is considered to have a lower RBL than receivers facing Miller and Berry Streets. The applicable noise criteria at this location should be further investigated during design development. The loading dock is proposed at Level 1 of the basement, accessed via a ramp from street level. Noise emission from the loading dock would be

sufficiently attenuated by the proposed development structure to comply with the relevant criteria presented in **Section 5.1.3**.

6.7 Operational vibration assessment

The operational vibration levels of the site should be managed in order to achieve the acoustic and vibrational amenity to the commercial and retail tenancies within the development and also to ensure that the development does not adversely affect the surrounding land usages.

6.7.1 Internal vibration levels

All major equipment, installed as part of the OSD, should be mounted on isolation mounts.

The following measures should be adopted for mounting of mechanical plant:

- Isolation mounts and connections should be provided for all reciprocating and rotating equipment, pipework and ductwork.
- Selection of suitable vibration isolation systems should be made based on the design minimum isolation efficiency, floor static deflection, and plant/equipment mass, rotational/reciprocating speeds and power requirements etc.
- The method of vibration isolation should be selected for each particular application.
- A minimum clearance of 50 mm between vibrating and rotating equipment and nearby building structure and 25 mm between the underside of a concrete inertia block or machine base and the top of a concrete floor slab should be achieved. Contractors must ensure that any debris between items of plant and the building structure is removed.
- Unless otherwise specified the manufacturers' recommendations for installation of vibration isolation mounts and flexible connections should be strictly observed.
- Where metal (coil) springs are required they should be provided with neoprene pads in series fixed to the base of the springs.
- All rotary machinery should be accurately balanced both statically and dynamically.

7.0 Noise and vibration impact upon development

7.1 Traffic noise intrusion

The facade of the future OSD building, within the concept envelope, is likely to have glazing as the main component. Therefore, the glazing and associated framing system must be capable of preventing unnecessary noise intrusion from outside noise sources. Noise levels incident on the building façade were determined from noise measurements as detailed in **Section 4.3**. Noise levels measured at 237 Miller Street were considered representative of traffic noise incident on the worst affected façade of the proposed development i.e. the west façade which is adjacent to Miller Street. Noise levels measured at Unit 3004, 77-81 Berry Street were 6 dB lower than those measured at 237 Miller Street. However, this location is set back a considerable distance from Berry Street hence noise levels measured at 237 Miller Street are considered more representative of proposed façade noise levels. 15 hour average noise levels have been used in line with the RNP.

As the proposed OSD development would only contain commercial occupants, only the daytime ambient noise level was utilised. Indicative glazing constructions are presented in **Table 23**.

Table 23: Preliminary glazing requirements
Source: AECOM

Space	Minimum R_w performance	Indicative glazing construction
Open offices, corridors and lobbies	42	• 10.38 mm laminated glass • 12 mm air gap • 6 mm monolithic glass

Note that specified glazing thicknesses only address the acoustic requirements and do not take into account other requirements such as structural, safety or other considerations. These additional considerations may require the glazing thicknesses to be increased beyond the acoustic requirement.

Additional glazing systems, such as jockey sashes, may be required where acoustically critical spaces, such as boardrooms and video-conferencing facilities, are located on the building perimeter.

7.2 Sydney Metro Project noise intrusion

7.2.1 Ground-borne and structure-borne rail noise and vibration

Resonate Acoustics has confirmed that it can be assumed that the isolation of noise and vibration from the Metro trains would occur at the source and would adequately attenuate structure-borne rail-induced noise and vibration in the station and OSD to acceptable levels.

7.2.2 Air-borne noise

Resonate Acoustics has confirmed that it can be assumed that the isolation of noise from the Sydney Metro Project (station and tunnel), such as public address systems, engine noise

and emergency and ventilation equipment, would occur at the station level (e.g. building fabric) and would adequately attenuate air-borne noise in the OSD to acceptable levels.

8.0 Construction noise and vibration assessment

A Construction Noise and Vibration Management Plan (CNVMP) should be developed by the builder in consultation with the stakeholders and acoustic engineer during the detailed design stage prior to construction activities commencing on site. The CNVMP should be developed in accordance with ICNG, as referenced in **Section 5.3.1.2** in order to manage impacts on nearby receivers.

8.1 Construction stages and scheduling

Construction works to take place as part of the site have been assumed and are outlined in **Table 24**. Works have been grouped in two indicative construction stages.

It is assumed that demolition, site establishment and excavations would be conducted as part of the Sydney Metro early works package.

Table 24: Construction stages and scheduling
Source: AECOM

Construction scenario activities	Construction hours
Construction - Podium	Day – Standard hours
Construction - Tower	Day – Standard hours

8.2 Plant and equipment noise levels

Table 25 presents the typical sound power levels of the construction equipment used in this assessment. These sound power levels are typical values taken from data provided in Australian Standard AS 2436-2010, "*Guide to noise and vibration control on construction, demolition and maintenance sites*" and the UK Department for Environment, Food and Rural Affairs (DEFRA) "*Update of noise database for prediction of noise on construction and open sites*" noise database and assume equipment is modern and in good working order.

For the noise assessment, only the worst case construction scenarios have been considered. The modelled scenario includes all equipment that could be reasonably assumed to be operating at the same time for an entire 15 minute period. **Table 25** shows the construction equipment for each construction scenario and their sound power levels.

Table 25: Typical sound power levels of construction equipment
Source: AS 2436-2010 and DEFRA

Phase	Equipment / Activity	Qty	'A' weighted total SWL dB(A)
Podium construction	Diesel tower cranes	2	99
	Electric Concrete placing boom	1	103
	Electric formwork hoist	2	82
	Diesel Manitou at ground	1	92
	Forklift	1	101
	Delivery trucks of various sizes at ground	1	98
	Rubbish removal trucks at ground	1	98
	Diesel Mobile cranes at ground	1	104
Tower construction	Diesel tower cranes	2	99
	External Man and Material Hoist	2	94
	Electric Concrete placing boom	1	103
	Electric formwork hoist	2	82
	Diesel Manitou at ground	1	92
	Forklift	1	101
	Delivery trucks of various sizes at ground	1	98
	Rubbish removal trucks at ground	1	98
	Diesel Mobile cranes at ground	1	104

8.3 Modelling

In order to assess noise impact from the site during construction, a noise model was created to represent 'reasonable' worst periods of construction activities.

The construction of the project was modelled in SoundPLAN Version 7.3.

Noise emissions from the site were modelled using an implementation of the ISO 9613-2:1996 propagation algorithm. Neutral weather conditions were assumed. Barrier reflections and ground absorption coefficients of 0 for hard surfaces and 0.6 for soft ground was included in the model. It can be expected that noise levels measured during construction may at times be lower than those predicted due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment and acoustic shielding.

8.4 Construction site noise assessment

At the time of writing this report, the commencement and duration of the main construction activities had not been developed. The predicted impact from the assumed 'reasonable'

worst case 15 minute period of each phase of construction works was assessed. Works to take place outside ICNG standard construction hours would require prior approval.

The assessment assumes no noise mitigation during construction. Predicted construction noise impacts during the proposed construction hours are shown in **Table 26.**

Noise results for each construction scenario are presented in **Appendix C** as noise contour layers over aerial maps. The noise contours have been calculated at 1.5 metres above ground level. The contours are indicative only and should not be used to determine noise levels at specific receivers.

Table 26: Predicted daytime construction noise impacts, dB(A)
Source: AECOM

Receiver	Address	NML	Construction phase					
			Podium			Tower		
			SPL	Worst affected level	Exceedance	SPL	Worst affected level	Exceedance
Residential receivers								
R1	77 Berry Street	75	70	F 2	-	70	F 3	-
R2	169 Berry Street	75	56	F 11	-	56	F 11	-
R3	231 Miller Street	75	47	F 15	-	47	F 15	-
R4	173 Walker Street	75	46	F 1	-	46	F 1	-
R5	37 McLaren Street	75	32	F 12	-	32	F 12	-
Non-residential receivers								
N1	65 Berry Street	70	81	F 5	11	81	F 5	11
N2	53 Berry Street	70	68	F 2	-	68	F 2	-
N3	Rag & Famish	70	71	F 1	1	71	F 1	1
N4	177 Pacific Highway	70	58	F 13	-	59	F 11	-
N5	Monte Sant Angelo Mercy College	55	58	F 4	3	58	F 4	3
N6	Monte Sant Angelo Mercy College Gym/Pool southern façade	70	62	GF	-	62	GF	-
N7	Monte Sant Angelo Mercy College Gym/Pool eastern façade	70	63	GF	-	62	GF	-
N8	173 Pacific Highway	70	55	F 3	-	55	F 3	-
N9	Walker Street Early Learning Centre	55	52	F 2	-	52	F 2	-
N10	65 Berry Street (Childcare)	55	75	F 1	20	74	F 1	19
N11	Tree Tops Childcare Centre	55	65	GF	10	65	GF	10

Compliance is achieved across all residential receivers for both construction scenarios. A number of exceedances have been predicted for non-residential receivers. These exceedances should be managed by the contractor through the implementation of work practices and equipment selection. Furthermore, the assumption that all equipment would be running at the same time means that the predicted levels are worst case and are unlikely to occur. Also, the construction scenarios modelled are indicative only and the impacts of construction noise should be further reviewed when the selection of a contractor is finalised and the construction program and associated equipment has been identified in order to check consistency with the assumptions in this assessment.

Affected non-residential receivers such as the Child Care Centre at 65 Berry Street (should it remain in operation at the time of OSD construction) should be assessed in more detail by the contractor. The assessment would include consideration of existing noise controls for the outdoor play area.

Significant variation in the assumptions from this assessment may require a review of potential noise impacts against the noise criteria presented in **Section 5.3.1.2**.

8.5 Construction traffic assessment

A traffic assessment was conducted to determine the noise impacts of traffic generated by construction of the project.

8.5.1 Existing traffic volumes

Traffic counts were provided in *Sydney Metro City & Southwest Chatswood to Sydenham Technical Paper 1: Traffic and Transport Working Paper, February 2016 by Jacobs*. Only peak hourly volumes were available.

Peak hourly traffic volumes are presented in **Table 27.**

Table 27: Peak hourly traffic volumes 2015
Source: Jacobs Technical Paper

Road	Location	Peak hourly traffic volumes[1]	
		AM	PM
Pacific Highway	Between McLaren Street and Berry Street (southbound)	1,390	1,060
	Between McLaren Street and Berry Street (northbound)	1,000	790
Pacific Highway	Between Berry Street and Miller Street (southbound)	520	620
	Between Berry Street and Miller Street (northbound)	1,210	1,160
Miller Street	Between McLaren Street and Berry Street (southbound)	630	530
	Between McLaren Street and Berry Street (northbound)	470	500
Miller Street	Between Berry Street and Pacific Highway (southbound)	540	370
	Between Berry Street and Pacific Highway (northbound)	550	640
McLaren Street	Between Pacific Highway and Miller Street (eastbound)	240	190
	Between Pacific Highway and Miller Street (westbound)	290	250
Berry Street	Between Pacific Highway and Miller Street (eastbound)	1,220	940
	Between Miller Street and Walker Street (eastbound)	1,280	1,700
Walker Street	Between Arthur Street and Mount Street (southbound)	160	100
	Between Arthur Street and Mount Street (northbound)	1,170	940

Notes:
1. Counts taken 2015, one-way data.

8.5.2 Construction generated traffic volumes

An assumed worst-case scenario of traffic passing the worst affected residential premise in a one hour period has been considered. In the absence of construction generated traffic volumes, 60 delivery vehicles over the ICNG standard construction hour day (7 am to 6 pm) has been assumed for the purpose of this assessment. This represents a total of 12 movements in a one hour period (i.e. six vehicles in and six vehicles out in one hour). Considering the high volume of traffic along Berry Street (the nearest residential receiver) the impact of noise from construction delivery vehicles arriving at and leaving the site is considered to be insignificant, and requires no further assessment. Construction traffic noise should be reassessed during the detailed design stage when the construction methodology has developed further.

8.6 Construction vibration assessment

Typical safe working distances for the construction equipment that may be part of this project are provided in **Table 28.** These safe working distances are developed to meet the recommended levels of vibration levels of British Standard 6472-1992 and DIN 4150 and are based upon the safe working distances presented in the CNS and AECOM's library of vibration data.

Safe working distances should be adhered to when operating this equipment near on-site buildings in order to minimise the risk of discomfort to occupants and structural damage.

Table 28: Recommended safe working distances for vibration intensive equipment (*Source: BS 6472-1992 and DIN 4150)*

Plant	Rating/Description	Safe working distance	
		Cosmetic damage	Human response
Vibratory Roller	< 50 kN (Typically 1-2T)	5 m	15-20 m
	< 100 kN (Typically 2-4T)	6 m	20 m
	< 200 kN (Typically 4-6T)	12 m	40 m
	< 300 kN (Typically 7-13T)	15 m	100 m
	> 300 kN (Typically 13-18T)	20 m	100 m
	> 300 kN (> 18 T)	25 m	100 m
Small Hydraulic Hammer	(300 kg – 5-12T excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12-18T excavator)	7 m	23 m
Large Hydraulic Hammer	(1,600 kg – 18-34T excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2–20 m	20 m
Pile Boring	≤ 800 mm	2 m	N/A
Jackhammer	Handheld	1 m nominal	Avoid contact with structure

The distances in **Table 28** assume individual items of plant operating independently. Concurrent operation of vibration intensive equipment should be avoided, however if it is necessary to operate multiple items of plant concurrently close to the safe working distance then vibration monitoring is recommended.

The safe working distances for cosmetic damage are generally considered to be conservative and working within them would not necessarily result in damage, however as factors such as work practices and intervening ground conditions can affect vibration levels, vibration monitoring is recommended within these distances, and should be undertaken at the beginning of the project in order to refine the safe working distances for site specific conditions.

8.7 Construction noise and vibration mitigation

8.7.1 Standard mitigation measures

All construction activities associated with the project should be subject to the standard noise and vibration mitigation measures described below:

The contractor should, where reasonable and feasible, apply best practice noise mitigation measures including:

- Turn off plant that is not being used.
- Ensure plant is regularly maintained, and repair or replace equipment that becomes noisy.
- Schedule more noisy activities during less noise sensitive periods.
- Minimise reversing alarm noise through a dedicated effort on the part of all construction equipment drivers to minimise, wherever feasible, the amount of reversing of their vehicles.
- Wherever feasible, turning circles should be created at the end points of vehicle work legs, which should allow trucks to turn and avoid the need for reversing.
- Emphasis should be placed during driver training and site induction sessions on the potential adverse impact of reversing alarms and the need to minimise their use.

8.7.2 Local road traffic – heavy vehicles noise mitigation

The following mitigation measures are proposed in order to minimise the impact of heavy vehicles on local roads at residential receiver locations:

- All trucks should be fitted with mufflers and any other noise control equipment in good working order.
- Pick-ups and deliveries should be conducted during standard construction hours.
- As far as practical and safety consideration, truck drivers should avoid:
  - Heavy acceleration and braking
  - Compression braking
  - Reversing as far as practicable
  - High speeds
  - Idling outside noise sensitive receivers.
- Truck routes to and from the worksites should be via major roads where possible.

8.7.3 Vibration mitigation measures

For vibration intensive activities that occur within the safe working distances, management methods to mitigate should include:

- Use of less vibration intensive methods of construction or equipment.
- All equipment should be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.

- Works scheduling can often be adopted to effectively manage construction vibration impacts and in particular to limit potential impacts. Wherever possible, vibration intensive works should be limited to the least sensitive times of the day. Respite periods should be negotiated with the community for construction activities expected to generate high levels of vibration.

- If vibration intensive equipment is to be used within the safe working distances for cosmetic damage, presented in **Table 28,** then it is recommended that attended vibration measurements are undertaken when work commences, to determine site specific safe working distances.

- Vibration intensive work should not proceed within the site specific safe working distances unless a permanent vibration monitoring system is installed, to warn operators (via flashing light, audible alarm, SMS etc.) when vibration levels are approaching the peak particle velocity objective. If alarms are triggered work should then be temporarily halted, the item of plant that triggered the alarm should be identified and alternative work methods should be considered (for example using non-vibratory rollers in place of vibratory rollers or using lighter rated equipment).

- For work scheduled to occur near a building, within the safe working distance for human response but outside the safe working distance for cosmetic damage, it is considered that the measures highlighted in **Section 8.7.1** would be sufficient to mitigate the vibration impact at nearby residential receivers. Therefore vibration monitoring would not be required at these properties.

The requirements of the ICNG have been addressed above. It is expected that the requirements for construction road traffic noise, as presented in the ICNG, would be met with no additional acoustic treatments. As standard construction hours are expected, sleep disturbance has not been considered.

NMLs have been established for the site in accordance with the ICNG requirements and reasonable and feasible mitigation measures should be incorporated into the construction practices to meet the NMLs where possible. Reasonable and feasible mitigation measures should be determined during the detailed design stages of the project when the construction methodology has progressed.

9.0 Conclusion

This report presents the results of an acoustic and vibration assessment of the OSD above the proposed Victoria Cross Station located at the corner of Miller Street and Berry Street North Sydney.

This report has been prepared to outline the acoustic and vibration impacts of the OSD and to specifically respond to the SEARs issued for the concept SSD Application.

Operational noise and vibration criteria for the OSD have been established based upon the SEARs.

Major noise and vibration emitting sources from the OSD have been identified, such as traffic and plant, and should be treated to meet the established criteria with the use of standard acoustic treatments.

Noise intrusion to the development from noise sources in the vicinity of the site, such as rail traffic and road traffic from Berry and Miller Streets and the Pacific Highway, has been assessed in principle and standard glazing systems would result in compliance with the established criteria.

Noise and vibration intrusion to the OSD from the station and tunnel, from sources such as rail induced noise and vibration, public address systems, engine noise and emergency and ventilation equipment, is expected to be controlled at the source and within the station and tunnel envelopes.

It is expected that the implementation of standard acoustic mitigation measures would be sufficient to meet all operational noise and vibration criteria established in this report in line with the SEARs.

Indicative construction scenarios applicable to the OSD have been modelled and construction noise levels at nearby sensitive receivers have been predicted and comply with the established noise management levels at residential receivers. Exceedances of the noise management levels are expected at some non-residential receivers due to proximity to the site. A Construction Noise and Vibration Management Plan (CNVMP) should be developed in order to manage and minimise potential impacts on nearby receivers.

Appendix A

Glossary of Acoustic Terminology

The following is a brief description of acoustic terminology used in this report.

Sound power level	The total sound emitted by a source
Sound pressure level	The amount of sound at a specified point
Decibel [dB]	The measurement unit of sound
A Weighted decibels [dB(A])	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows: 0dB(A) Threshold of human hearing 30dB(A) A quiet country park 40dB(A) Whisper in a library 50dB(A) Open office space 70dB(A) Inside a car on a freeway 80dB(A) Outboard motor 90dB(A) Heavy truck pass-by 100dB(A) Jackhammer/Subway train 110 dB(A) Rock Concert 115dB(A) Limit of sound permitted in industry 120dB(A) 747 take off at 250 metres
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
L_{max}	The maximum sound pressure level measured over the measurement period
L_{min}	The minimum sound pressure level measured over the measurement period
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.

L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays.
Evening	The period from 1800 to 2200 h Monday to Sunday and Public Holidays.
Night	The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays.
Assessment background level [ABL]	The overall background level for each day, evening and night period for **each day** of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the **entire length** of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*, the EPA's NSW Industrial Noise Policy and Road Noise Policy.

Appendix B

North Sydney Local Environmental Plan 2013 - Land Zoning Map

North Sydney Local Environmental Plan 2013

Land Zoning Map
- Sheet LZN_002A

Zone

B1	Neighbourhood Centre
B3	Commercial Core
B4	Mixed Use
E2	Environmental Conservation
E4	Environmental Living
IN2	Light Industrial
IN4	Working Waterfront
R2	Low Density Residential
R3	Medium Density Residential
R4	High Density Residential
RE1	Public Recreation
RE2	Private Recreation
SP1	Special Activities
SP2	Infrastructure
UL	Unzoned Land

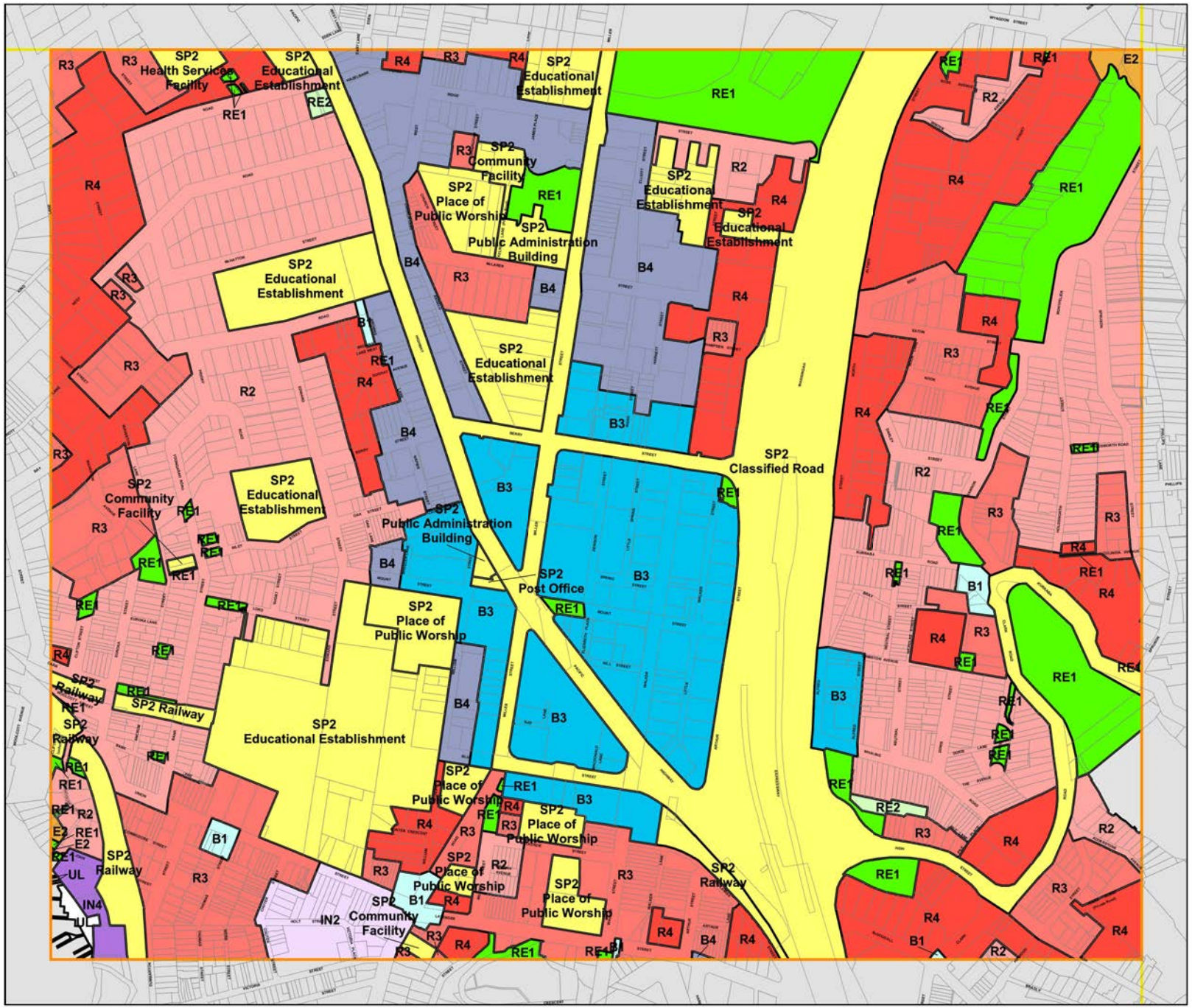
Cadastre

Cadastre 07/06/13 © North Sydney Council

N
W
E
S
0
metres
250
Scale: 1:5000 @ A3

Projection GDA 1994
MGA Zone 56

Map identification number:
5950_COM_LZN_002A_005_20130607



Appendix C

Construction Noise Contours

AECOM

Legend

- Assessment locations
- Previous logged location
- NCA
- Roads

L_{Aeq}, dB(A)

55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Sydney Metro OSD Victoria Cross

Podium construction noise contours at 1.5 m above ground, L_{Aeq}, dB(A)

NOV 2017

60519745

0 50 100 200 m

Fig. **C1**

AECOM

Legend

- Assessment locations
- Previous logged location
- NCA
- Roads

L_{Aeq}, dB(A)

55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Sydney Metro OSD Victoria Cross

Tower construction noise contours at 1.5 m above ground, L_{Aeq}, dB(A)

NOV 2017

60519745

0 50 100 200 m

Fig. **C2**

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