Sydney Metro City & Southwest:
Crows Nest
Over Station Development

Noise and vibration impact report

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Executive Summary

This report supports a concept State Significant Development application (concept SSD Application) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act. The Secretary's Environmental Assessment Requirements (SEARs) for the concept proposal were issued by DPE on 26 September 2018.

The Sydney Metro Authority (Sydney Metro) is seeking to secure concept approval for a mixed-use development comprising four buildings above the Crows Nest Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for building envelopes and land uses, maximum building heights, maximum gross floor areas, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of the development.

This report documents a noise and vibration assessment that has been undertaken for the OSD concept drawings prepared by Sydney Metro for the OSD at Crows Nest. This is for the purpose of establishing the noise and vibration criteria and standards required for the future detailed SSD application. The report discusses the existing noise and vibration environment and assesses the impact of the concept OSD's construction and operation on the precinct.

The information set out in this report demonstrates that reasonable and feasible design methodologies and mitigation measures are available such that a building compliant with the relevant SEARs requirements could be constructed. Further development of calculations and treatment strategies should be determined during future detailed design phases of the development.

Operational noise and vibration

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.

The potential operational noise and vibration impact of the proposal on the surrounding environment has been undertaken. Noise emissions associated with building services plant and equipment, car parking, road traffic generated by the development and operation of loading docks and site access points have been reviewed. Noise and vibration control

strategies have been recommended such that the concept proposal could comply with the established criteria.

An assessment of potential noise and vibration impacts on the proposal has also been undertaken. This included a review of the existing acoustic environment and potential constraints this may have on the proposal. A review of future potential rail related ground-borne noise and vibration has also been conducted. Noise and vibration control strategies have been recommended such that the concept proposal could comply with the established criteria.

Construction noise and vibration

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.

Exceedances of the daytime NMLs are predicted in all noise catchment areas. NML exceedances are predominantly predicted to occur at residential and commercial receiver locations facing onto Pacific Highway. Exceedances of the established vibration criteria may occur due to the proximity of the works to sensitive receivers including the Sydney Metro Station.

As such, a suite of noise and vibration mitigation strategies have been presented to aid in controlling potential impacts on sensitive receivers located adjacent to the proposal. Construction noise and vibration impacts and mitigation strategies should be further assessed as the design and construction methodology progresses.

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 (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act.

Sydney Metro is seeking to secure concept approval for a mixed use development comprising four buildings above the Crows Nest Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for building envelopes and land uses, maximum building heights, maximum gross floor areas, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of the development.

Sydney Metro 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 DPE on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for commercial premises and residential accommodation 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). The development is therefore, State significant development for the purposes of Section 4.36 of the EP&A Act.

This report has been prepared to specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 26 September 2018 which states that the Environmental Impact Statement (EIS) is to address the following requirements:

Reference	SEARs Requirement	Where Addressed in Report
9. Noise and Vibration	The EIS shall include a noise impact assessment identifying: • measures to minimise and mitigate potential noise and vibration impacts of the proposal on surrounding developments. • 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 and mitigation measures to protect amenity	Section 6.0 (Operational noise and vibration emission assessment) Section 7.0 (Noise and vibration impact upon development) Section 8.0 (Construction noise and vibration assessment)
Plans and Documents	Noise and vibration report	This report

1.2 Overview of Sydney Metro in its context

Sydney Metro is Australia's biggest public transport project. A new standalone metro railway system, this 21st century network will deliver 31 metro stations and 66km of new metro rail for Australia's biggest city — revolutionising the way Sydney travels. Services start in the first half of 2019 on Australia's first fully-automated railway.

Sydney Metro was identified in *Sydney's Rail Future*, as an integral component of the *NSW Long Term Transport Master Plan*, a plan to transform and modernise Sydney's rail network so it can grow with the city's population and meet the future needs of customers. In early 2018, *the Future Transport Strategy 2056* was released as an update to *the NSW Long Term Transport Master Plan* and *Sydney's Rail Future*. Sydney Metro City & Southwest is identified as a committed initiative in the *Future Transport Strategy 2056*.

Sydney Metro is comprised of three projects, as illustrated in **Figure 1**:

- **Sydney Metro Northwest** — formerly the 36km North West Rail Link. This $8.3 billion project is now under construction and will open in the first half of 2019 with a metro train every four minutes in the peak.

- **Sydney Metro City & Southwest** — a new 30km metro line extending the new metro network from the end of Sydney Metro Northwest at Chatswood, under Sydney Harbour, through the CBD and south west to Bankstown. It is due to open in 2024 with an ultimate capacity to run a metro train every two minutes each way through the centre of Sydney.

- **Sydney Metro West** – a new underground railway connecting the Parramatta and Sydney central business districts. This once-in-a-century infrastructure investment will double the rail capacity of the Parramatta to Sydney CBD corridor and will establish future capacity for Sydney's fast growing west. Sydney Metro West will serve five key precincts at Westmead, Parramatta, Sydney Olympic Park, The Bays and the Sydney CBD. The project will also provide an interchange with the T1 Northern Line to allow faster connections for customers from the Central Coast and Sydney's north to Parramatta and the Sydney CBD.

Sydney's new metro, together with signalling and infrastructure upgrades across the existing Sydney suburban rail network, will increase the capacity of train services entering the Sydney CBD – from about 120 an hour currently to up to 200 services beyond 2024. That's an increase of up to 60 per cent capacity across the network to meet demand.

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

The project also involves the delivery of six (6) new metro stations, including at Crows Nest, together with new underground platforms at Central. Once completed, Sydney Metro will have the ultimate capacity for a train every two minutes through the CBD in each direction - a level of service never seen before in Sydney.

Figure 1: Sydney Metro alignment map

On 9 January 2017, the Minister for Planning (the Minister) 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 alignment 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 five modification applications to amend the CSSI Approval as outlined below:

- **Modification 1** - Victoria Cross and Artarmon Substation which involves the relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with the inclusion of a new station entrance at this location referred to as Victoria Cross North. 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.

- **Modification 5** - Blues Point acoustic shed modification which involves the installation of a temporary acoustic shed at Blues Point construction site and retrieval of all parts of the tunnel boring machines driven from the Chatswood dive site and Barangaroo through the shaft at the Blues Point temporary site. This modification application was approved on 2 November 2018.

The CSSI Approval as modified allows for all works to deliver Sydney Metro between Chatswood and Sydenham Stations and also includes upgrade of Sydenham Station.

The remainder of the City & Southwest alignment (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line from west of Sydenham Station to Bankstown 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) for which an EIS was exhibited between September and November 2017, and a Submissions

and Preferred Infrastructure Report was exhibited in June and July 2018. This application is currently being assessed by DPE.

1.3 Planning relationship between Crows Nest Station and the OSD

While Crows Nest Station and the 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, above which would sit the OSD. This delineation is illustrated in **Figure 2**.

The CSSI Approval also establishes the general concept for the ground plane of Crows Nest Station including access strategies for commuters, pedestrians, workers, visitors and residents.

Since the issue of the CSSI Approval, Sydney Metro has undertaken sufficient design work to determine the space planning and general layout for the station and identification of those spaces within the station area that would be available for the OSD. In addition, design work has been undertaken to determine the technical requirements for the structural integration of the OSD with the station. This level of design work has informed the concept proposal for the Crows Nest 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 Crows Nest Station to satisfy Conditions E92 and E101 of the CSSI Approval.

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

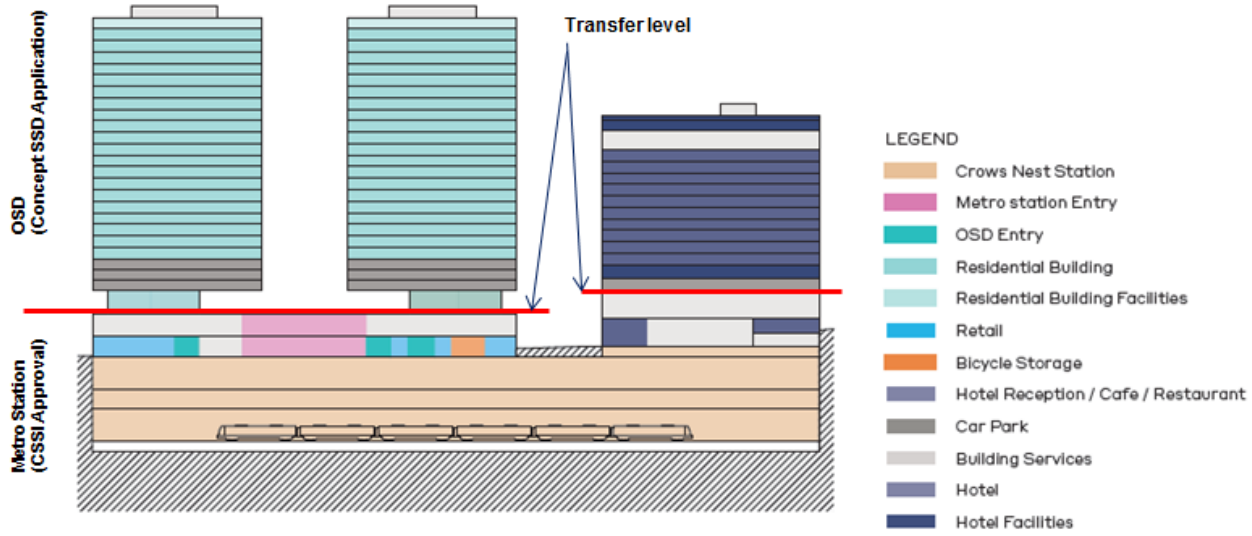

Figure 2: Delineation between the Metro station and OSD (based on indicative OSD design)

1.4 The strategic planning context

DPE is currently undertaking strategic planning investigations into revitalising the area surrounding St Leonards railway station and the metro station at Crows Nest. In August 2017, DPE released the *St Leonards and Crows Nest Station Precinct Interim Statement* and in October 2018 DPE released the *St Leonards and Crows Nest 2036 Draft Plan* (2036 Draft Plan) and supporting documents which detail recommended changes to land use controls in the precinct. These documents recommend new developments be centred around the Pacific Highway corridor and the Crows Nest Station while protecting the amenity of Willoughby Road.

In October 2018, DPE also placed on public exhibition the *Crows Nest Sydney Metro Site Rezoning Proposal* (Planning Proposal). The Planning Proposal outlines the State led rezoning of the subject site, on the basis that the current planning controls in the *North Sydney Local Environmental Plan 2013* do not reflect the opportunities for improved accessibility associated with the new metro station enabling people to live, work and spend time close to public transport. This concept SSD Application is aligned with the planning controls proposed in the Planning Proposal.

1.5 The site

Crows Nest Station precinct is located between the Pacific Highway and Clarke Street (eastern side of the Pacific Highway) and Oxley Street and south of Hume Street, Crows Nest (**Figure 3**).

The site is located within the North Sydney Local Government Area.

The Crows Nest Station precinct is divided into three separate sites as illustrated in **Figure 4** and described below:

- **Site A:** Six lots in the block bound by the Pacific Highway, Hume Street, Oxley Street and Clarke Lane (497-521 Pacific Highway, Crows Nest)
- **Site B:** Three lots on the southern corner of Hume Street and Pacific Highway (477-495 Pacific Highway, Crows Nest)
- **Site C:** One lot on the north-western corner of Hume Street and Clarke Street (14 Clarke Street, Crows Nest).

Sites A, B and C have a combined site area of 6,356 square metres.

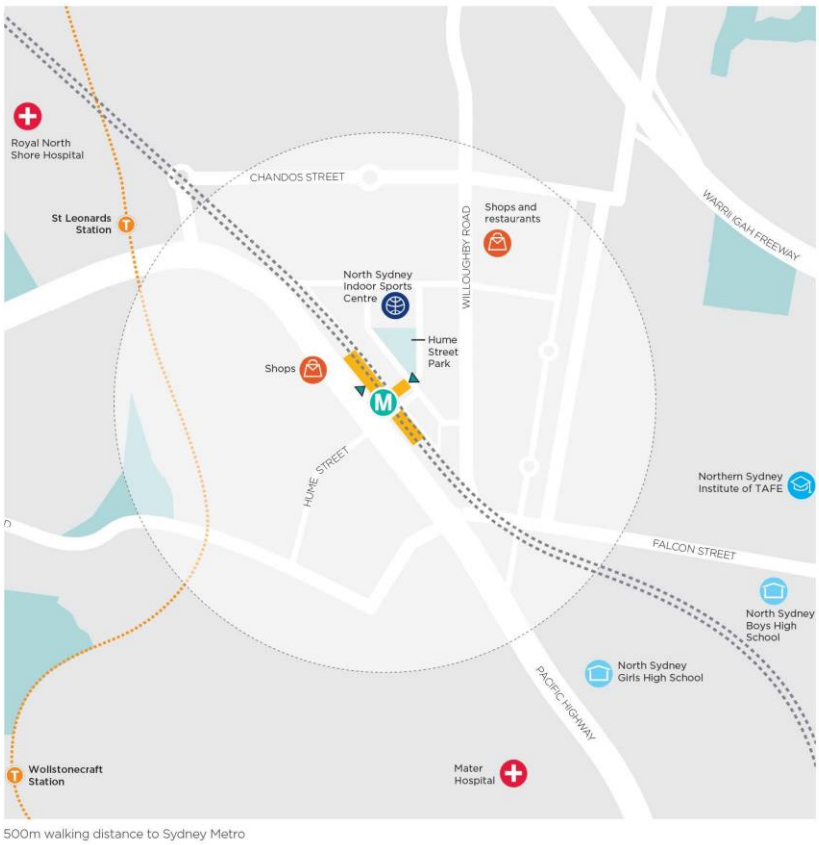

Figure 3: Crows Nest Station location plan

Figure 4: The subject site

The site comprises the following properties:

- **Site A:**
  - 497 Pacific Highway (Lot 2 in DP 575046)
  - 501 Pacific Highway (Lot 1 in DP 575046)
  - 503-505 Pacific Highway (Lot 3 in DP 655677)
  - 507-509 Pacific Highway (Lot 4 in DP 1096359)
  - 511-519 Pacific Highway (SP 71539)
  - 521-543 Pacific Highway (Lot A and Lot B in DP 374468)
- **Site B:**
  - 477 Pacific Highway (Lot 100 in DP 747672)
  - 479 Pacific Highway (Lot 101 in DP 747672)
  - 491-495 Pacific Highway (Lot 100 in DP 442804)
- **Site C:**
  - 14 Clarke Street (Lot 1 in SP 52547)

1.6 Overview of the proposed development

This concept SSD Application comprises the first stage in the Crows Nest 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 Crows Nest OSD.

The concept SSD Application specifically seeks approval for the following:

- maximum building envelopes for Sites A, B and C, including street wall heights and setbacks as illustrated in the plans prepared by Foster + Partners for Sydney Metro
- maximum building heights:
    - **Site A:** RL 183 metres or equivalent of 27 storeys (includes two station levels and conceptual OSD space in the podium approved under the CSSI Approval)
    - **Site B:** RL 155 metres or equivalent of 17 storeys (includes two station levels and conceptual OSD space approved under the CSSI Approval)
    - **Site C:** RL 127 metres or 8 storeys (includes two station levels and conceptual OSD space approved under the CSSI Approval)

      Note 1: the maximum building heights defined above are measured to the top of the roof slab and exclude building parapets which will be resolved as part of future detailed SSD Application(s)
    - maximum height for a building services zone on top of each building to accommodate lift overruns, rooftop plant and services:
        - **Site A:** RL 188 or 5 metres
        - **Site B:** RL 158 or 3 metres
        - **Site C**: RL 132 or 5 metres

      Note 1: the use of the space within the building services zone is restricted to non-habitable floor space.

      Note 2: for the purposes of the concept SSD Application, the maximum height of the building envelope does not make provision for the following items, which will be resolved as part of the future detailed SSD Application(s):

        - communication devices, antennae, satellite dishes, masts, flagpoles, chimneys, flues and the like, which are excluded from the calculation of building height pursuant to the standard definition in NSLEP 2013
        - architectural roof features, which are subject to compliance with the provisions in Clause 5.6 of NSLEP 2013, and may exceed the maximum building height, subject to development consent.
- maximum gross floor area (GFA) of 55,400sqm for the OSD comprising the following based on the proposed land uses:
    - **Site A:** Residential accommodation - maximum 37,500 square metres (approximately 350 apartments)
    - **Site B:** Hotel / tourist accommodation and associated conference facilities or commercial office premises GFA - maximum of 15,200 square metres (approximately 250 hotel rooms)
    - **Site C:** Commercial office premises GFA - maximum of 2,700 square metres
    - **Site A or C**: social infrastructure GFA inclusive of the GFA figures nominated above for each site, with provision optional as follows:
        - Site A: podium rooftop (approximately 2,700 square metres)

- Site C: three floors and rooftop (approximately 1,400 square metres)

Note 1: GFA figures exclude GFA attributed to the station and station retail space approved under the CSSI Approval

- a minimum non-residential floor space ratio (FSR) for the OSD across combined Sites A, B and C of 2.81:1 or the equivalent of 17,900 square metres
- the use of approximate conceptual areas associated with the OSD which have been provisioned for in the Crows Nest station box (CSSI Approval) including areas above ground level (i.e. OSD lobbies and associated spaces)
- a maximum of 150 car parking spaces on Sites A and B associated with the proposed commercial, hotel and residential uses
- loading, vehicular and pedestrian access arrangements
- strategies for utilities and services provision
- strategies for managing stormwater and drainage
- a strategy for the achievement of ecological sustainable development
- a public art strategy
- indicative signage zones
- a design excellence framework
- the future subdivision of parts of the OSD footprint, if required.

As this is a staged development pursuant to section 4.22 of the EP&A Act, future approval would be sought for the detailed design and construction of the OSD.

The proposed location of the buildings on the site is illustrated in the location plan provided at **Figure 5**.

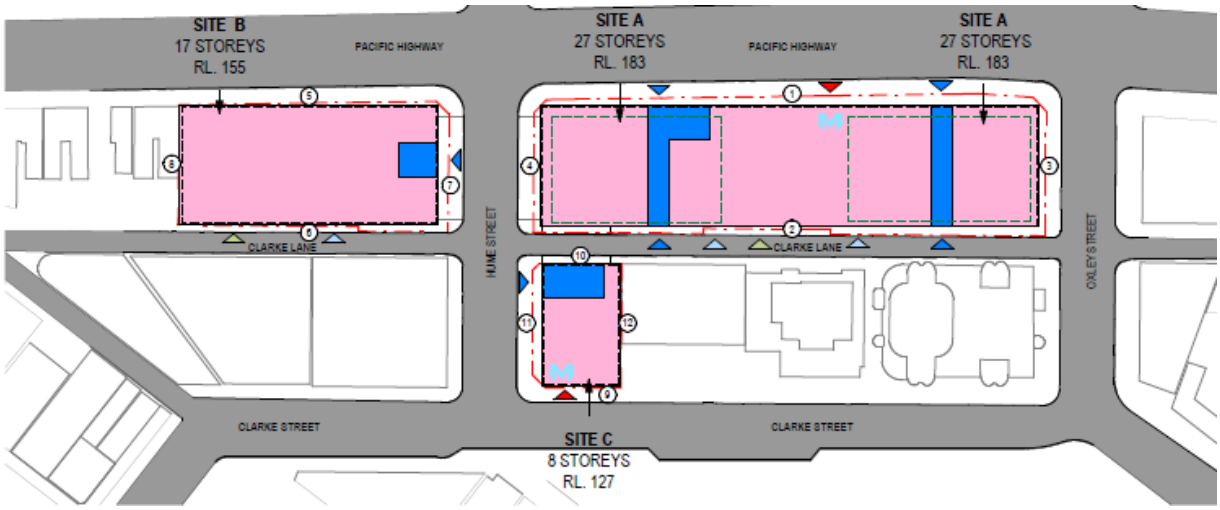

Figure 5 – Proposed location of buildings on the

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 60,400 square metres, equivalent to a floor space ratio (FSR) of 9.5:1.

The concept proposal includes opportunities for community uses in the development on either Site A or Site C. This space has the potential to be used for a range of uses including community facilities, child care centre, recreational area/s, library, co-working space, which can take advantage of the sites accessibility above the metro station.

Through design development post the CSSI Approval, pedestrian access to the metro station is proposed from the Pacific Highway and from Clarke Street, opposite the Hume Street Park. Vehicular access to the site including separate access to the loading docks and parking is proposed from Clarke Lane.

Public domain works around the site would be delivered as part of the CSSI Approval. Notwithstanding, the OSD will be appropriately designed to complement the station and activate the public domain. Provision for retail tenancies to activate the public domain are included in the ground floor of Sites A, B and C, as part of the CSSI Approval. Future detailed development applications will seek approval for the fitout and specific use of this retail space.

Drawings illustrating the proposed building envelopes are provided in Figures 6A and 6B. 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 7).

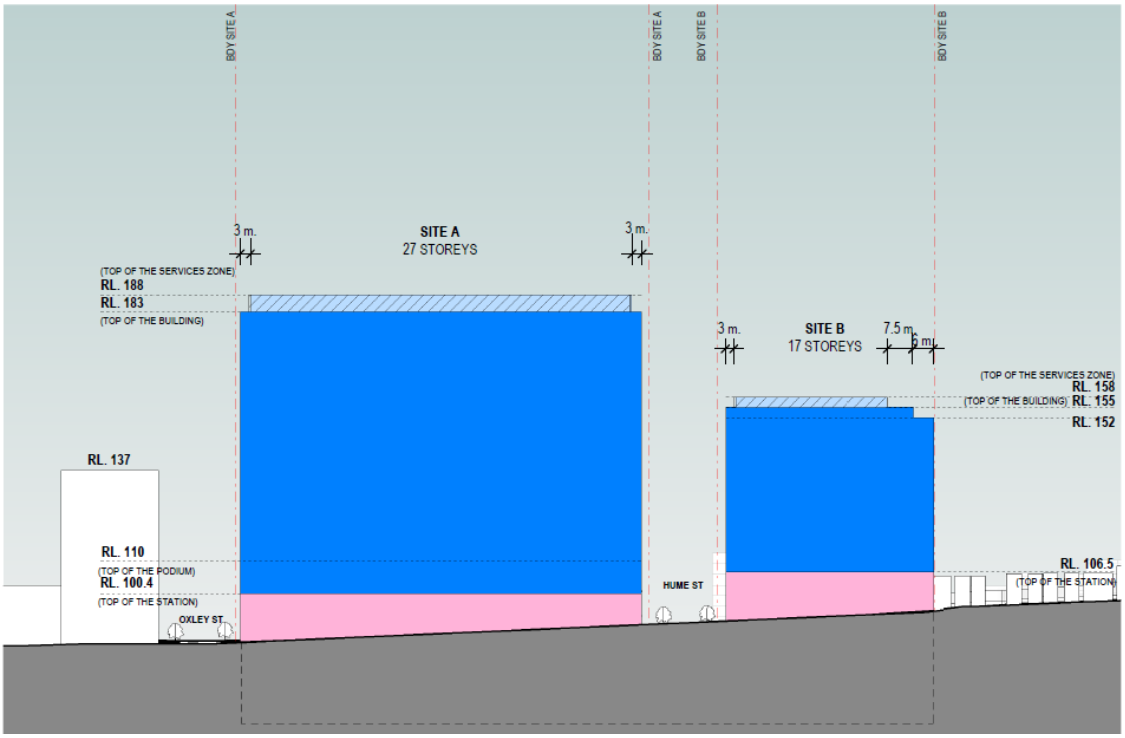

Figure 6A: Proposed Crows Nest OSD building envelopes – west elevation (Pacific Highway)

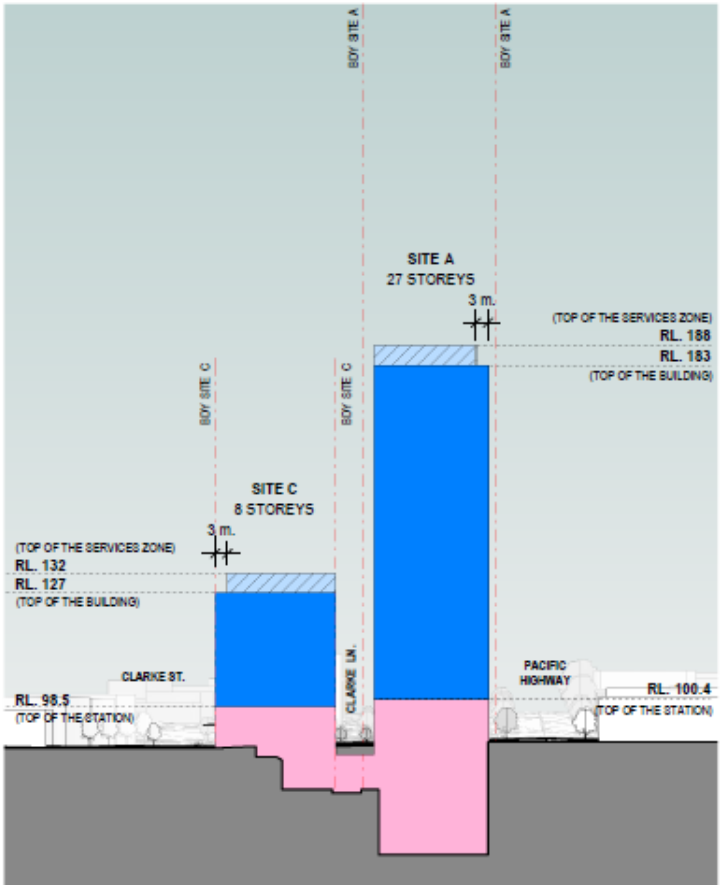

Figure 6B: Proposed Crows Nest OSD building envelopes – cross section through the site (east-west)

Figure 7: Crows Nest OSD indicative design

1.7 Staging and framework for managing environmental impacts

Sydney Metro proposes to procure the delivery of the Crows Nest 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 Sydney Metro 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/s, with timing yet to be determined. This creates at least two distinct construction periods for the station and OSD.

Scenario 1 represents Sydney Metro 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 future detailed SSD Application(s).

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

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

Given the integration of the delivery of the Sydney Metro City & Southwest metro station with an OSD development, Sydney Metro proposes the framework detailed in Figure **8** to

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

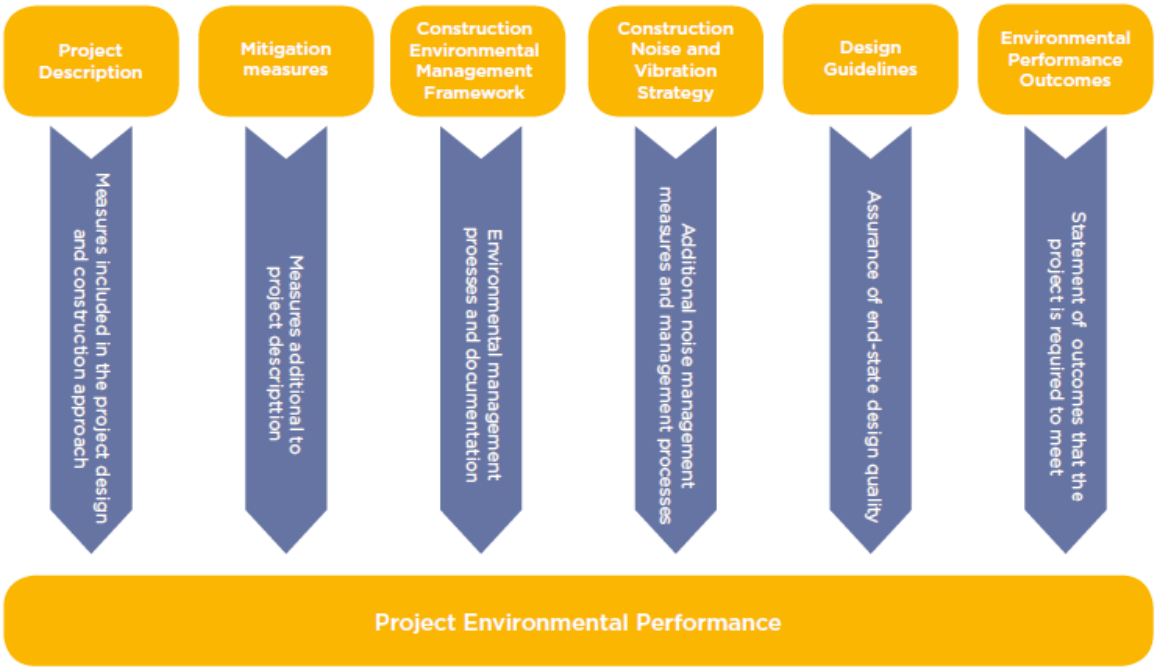

Figure 8: Project approach to environmental mitigation and management

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 a noise and vibration assessment that has been undertaken for the OSD concept prepared by Sydney Metro for the OSD at Crows Nest. The report discusses the existing noise and vibration environment and assesses the impact of the OSD's construction and operation on the precinct.

The information set out in this report demonstrates that reasonable and feasible design methodologies and mitigation measures are available such that a building compliant with the relevant SEARs requirements could be constructed. 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.

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

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 Operational

- *Noise Policy for Industry*, NSW Environment Protection Agency, 2017
- *NSW Industrial Noise Policy*, NSW Environment Protection Agency, 2017
- *Application notes to the NSW Industrial Noise Policy*, NSW Environment Protection Authority, 2013.
- *Assessing Vibration: A Technical Guideline*, NSW Department of Environment and Conservation, 2006
- *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.
- *NSW Road Noise Policy*, Department of Climate Change, Environment and Water, 2011.
- *Rail Infrastructure Noise Guideline*, NSW Environment Protection Authority, 2013.
- *North Sydney Development Control Plan*, North Sydney Council 2013.
- *National Construction Code, Building Code of Australia 2016*, Australian Building Codes Board, 2016.
- *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.
- *Crows Nest Station Acoustics, Noise and Vibration Report Stage 1 Design Underground Stations Design & Technical Services* for Sydney Metro, 18 January 2018

3.2 Construction

- *Interim Construction Noise Guideline,* Department of Environment and Climate change, 2009
- Australian Standard *AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites*.
- UK Department for Environment, Food and Rural Affairs (DEFRA) "*Update of noise database for prediction of noise on construction and open sites*" noise database.
- *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 for New South Wales, 2017.
- 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.
- *ISO 9613-2:1996: Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*.
- Chatswood to Sydenham Environmental Impact Statement, *Technical Paper 2: Noise and vibration*, Version: Final, May 2016.
- *Crows Nest Station Acoustics, Noise and Vibration Report Stage 1 Design Underground Stations Design & Technical Services* for Sydney Metro, 18 January 2018.
- *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 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 if a proponent can demonstrate that the environmental assessment substantially commenced before the release of the new policy, planning and regulatory authorities may choose to determine the application based on the *NSW Industrial Nosie 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 Crows Nest 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)

- Draught Relief (DR) shafts are also required for train passbys.

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 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 (OSD, station, tunnels), with each assigned noise emission 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 emission 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.OSD, station and tunnels).
- 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.

4.0 Existing noise and vibration environment

Noise sensitive receivers surround the site and have been grouped into three Noise Catchment Areas (NCA) for the purpose of describing potential noise impacts from the proposal. A site map identifying the NCAs and nearest noise sensitive receiver locations is provided in **Figure 9**.

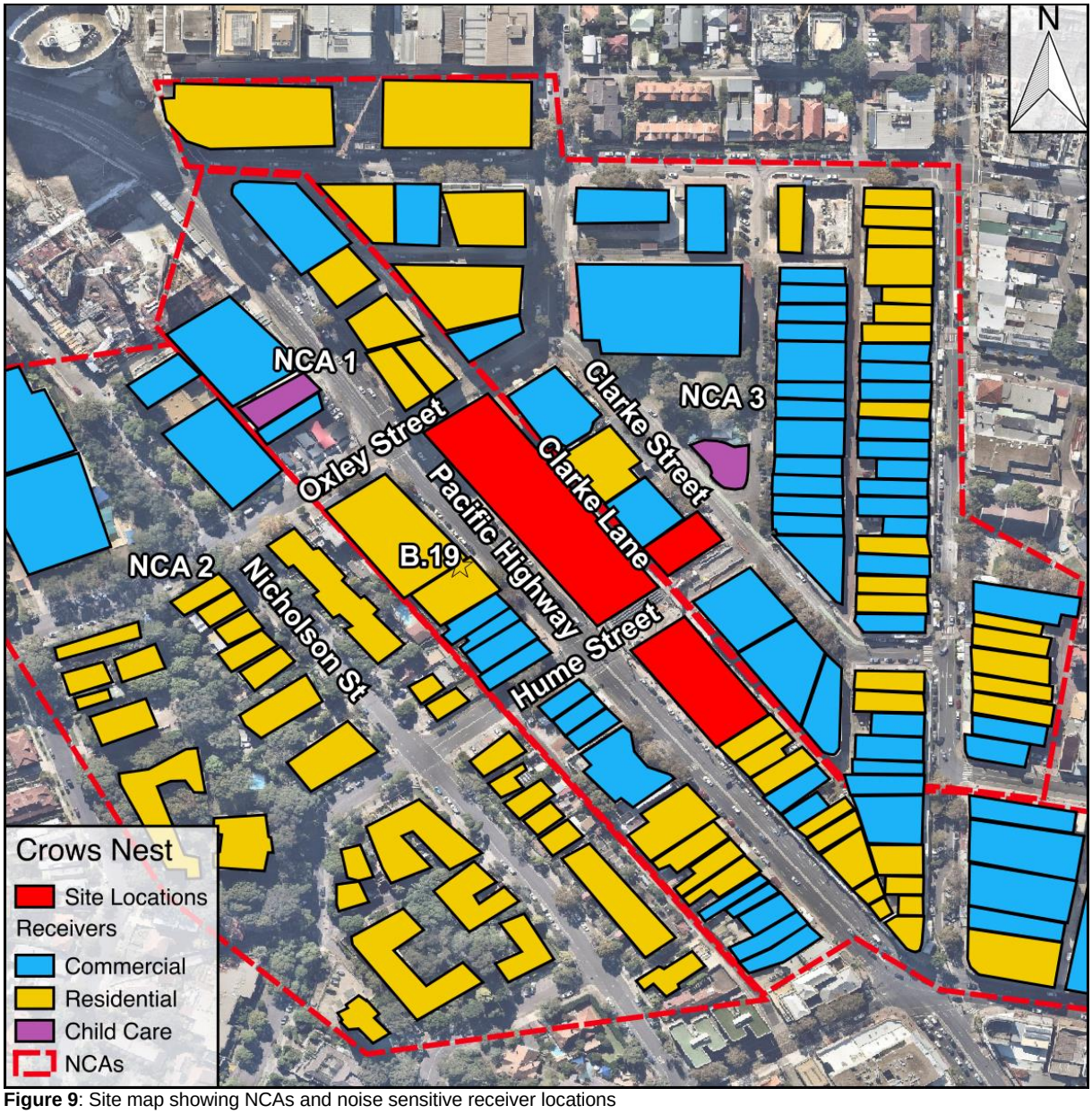

Figure 9: Site map showing NCAs and noise sensitive receiver locations

4.1 Noise Catchment Areas

A description of each NCA is provided below.

4.1.1 Noise Catchment Area 1

NCA 1 comprises predominantly commercial premises with a spread of mixed-use receivers along Pacific Highway. Froebel Early Learning Centre is located near the north west corner of the Oxley Street and Pacific Highway intersection. The nearest commercial receivers border the site to the north and south. The noise environment within NCA 1 is considered urban and is dominated by traffic noise from Pacific Highway and Willoughby Road.

4.1.2 Noise Catchment Area 2

NCA 2 generally comprises single and double storey semi-detached houses and multi storey residential units, with some scattered commercial premises. The nearest receivers, residences along Nicholson Street, are located approximately 70 m south west of the site. The noise environment in NCA 2 is urban and dominated by traffic noise, from local roads and Pacific Highway. However, NCA 2 is shielded from Pacific Highway traffic noise by building structures located on Pacific Highway. The North Shore Railway line is also located to the west of NCA 2.

4.1.3 Noise Catchment Area 3

NCA 3 comprises predominantly commercial premises with a spread of mixed use receivers along Willoughby Road. Kelly's Place Children's Centre is located at the corner of Clarke Street and Hume Street, Crows Nest. The nearest commercial receivers border the site to the east. The noise environment within NCA 3 is considered urban and is dominated by traffic noise from Pacific Highway and Willoughby Road.

A number of receivers are located on Clarke Lane, Clarke Street and Pacific Highway which may have a particular sensitivity to noise and vibration associated with the construction and operation of the proposal. These include medical practices, a day surgery, an eye surgery and recording studios.

4.2 Unattended noise monitoring results

Noise monitoring was conducted in the study area surrounding the site between 19 June 2015 and 1 July 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 9** for the noise monitoring location).

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

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 one location:

- Location 1 - 420 Pacific Highway, Crows Nest, located on the north eastern façade on the roof located directly across the Pacific Highway from the development site. This logger was representative of receivers located adjacent to Pacific Highway and is dominated by road traffic noise in the general area. Thus, the results of this logger location were used to quantify the road traffic noise in the vicinity of the development site. This logger was designated as B19 in the Technical Paper 2: Noise and Vibration.

The existing noise levels at the measurement location are presented in **Table 1** for the time periods required by the INP.

Table 1: Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels in dB(A)

Noise Descriptor	Noise Levels dB(A)		
	Daytime 7:00-1800	Evening 18:00-22:00	Night-time 22:00-7:00
RBL	59	55	50
L_{Aeq}	68	67	62

The existing noise road traffic noise levels at the measurement location are presented in **Table 2** for the time periods required by the NSW *EPA's Road Noise Policy*.

Table 2: Existing road traffic noise levels (L_{Aeq}) noise levels in dB(A)

Noise Descriptor	Noise Levels dB(A)	
	Daytime 7:00-22:00	Night-time 22:00-7:00
L_{Aeq}	68	62

5.0 Assessment Criteria

5.1 Operational noise criteria

This section presents relevant criteria in order to assess the potential impacts the following noise and vibration sources:

- 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 Environmental noise emission

A summary of environmental noise emission criteria for residential receivers derived in accordance with the INP and the NPfI Suburban Amenity criteria (Period and 15-minute equivalent) are presented in **Table 3**.

Table 3: Summary of environmental noise emission criteria for residential receivers

	Existing		Whole Integrated Station Development		Each ISD component (OSD, Station, TVS)		OSD only
	RBL, $L_{A90\ period}$, dB(A)	Ambient $L_{Aeq\ period}$, dB(A)	Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	INP Amenity criteria, $L_{Aeq\ period}$, dB(A)	Adjusted Intrusiveness criteria, $L_{Aeq\ 15\ min}$, dB(A)	Adjusted INP Amenity criteria, $L_{Aeq\ period}$, dB(A)	NPI Amenity criteria, $L_{Aeq\ period}$, [$L_{Aeq\ 15\ min}$], dB(A)
All NCAs – residential receivers facing main road – based on B.19 420 Pacific Highway							
Day	59	68	64	58	59	53	53 [56]
Evening	55	67	60	57	55	52	52 [55]
Night	50	62	55	52	50	47	47 [50]
All NCAs – residential receivers off the main road (rear-facing)1– based on short term attended measurements at Clarke Lane, indicative only							
Day	TBC	TBC	TBC	TBC	TBC	TBC	TBC
Evening	51[1]	63[1]	55[1]	50-53[2]	51	45-48[2]	45-48 [48-53][2]
Night	46[1]	58[1]	51[1]	45-48[2]	46	40-43[2]	40-43 [43-48][2]

Note 1: An adjustment to the intrusiveness criteria for rear facing residential receivers was made on the basis of attended noise measurements undertaken in Crows Nest in a location shielded from Pacific Highway. The measurements were conducted during the evening and early night-time period. Daytime noise measurements were not conducted for this stage of the project. The measured L_{A90} and L_{Aeq} noise levels were determined to be approximately 4 dB below those for a Pacific Highway facing receiver.

Note 2: INP Amenity assumes that road traffic noise is not dominant at rear-facing receivers, and therefore no modification has been applied. The range presented for rear-facing receivers is based on an unmodified Amenity Noise Level (lower end of the range) and the modified Amenity Noise Level which assumes that the existing noise is dominated by industrial type noise (upper end of the range). The rear-facing receiver noise emissions criteria are indicative and would be confirmed during the next stages in the OSD design, using long duration noise survey data in representative receiver locations.

The North Sydney Council noise criteria for the Crows Nest OSD are to be considered in addition to the INP / NPI approach. In addition, the North Sydney Development Control Plan 2013 (NSDCP 2013) provides criteria for developments within the North Sydney Council boundaries.
Environmental noise emission criteria for other sensitive land uses are presented in **Table 4**.

Table 4: Nearby sensitive receiver operational criteria

Receiver categories	Time of day	Recommended L_{Aeq} noise emission criteria dB(A)	
		Overall development	Indicative OSD component
Commercial	When in use	65	60
Child care centres [1] (educational external)	Noisiest 1 hour period when in use	50	45
Active recreation (e.g. school playground)	When in use	55	50
Places of worship (external)	When in use	50	45
Passive recreation	When in use	50	45

Note 1: The external criteria for Child Care Centres and Places of Worship is based on the internal requirement of 40 dBA for areas already subject to industrial noise. The equivalent external noise level was determined assuming a 10 dB outside to inside noise level difference (i.e. windows open).

5.1.1.1 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 dB, 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 provided in **Table 3**, 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 65 dB and 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 *Road Noise Policy* 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 5**.

Table 5: Sleep disturbance criteria

Receiver categories	Night-time RBL dB(A)	Recommended L_{Aeq} noise emission criteria dB(A)	
		Overall development	Indicative OSD component
Residential	50	65	65

5.1.1.2 Emergency operations

There are no specific relevant NSW guidelines for the assessment of noise emissions associated with the operation of emergency equipment. Therefore, it is recommended that preliminary noise targets aligning with a 5 dB to 10 dB relaxation of the established INP criteria be adopted. This is in acknowledgement that emergency operations are rare events that would not present a continuous emission to the surrounding environment. Notwithstanding, two appropriate references will be used to finalise the selection of criteria during detailed design factoring in the selection and operational characteristics of emergency equipment and sensitivity of the surrounding environment.

5.1.1.3 North Sydney Development Control Plan (NSDCP 2013) – Environmental Noise Emission

Clause 11 of the NSW State Environmental Planning Policy (State and Regional Development) states that Development Control Plans do not apply to State Significant Development. Hence, the NSDCP 2013 does not technically 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 details provisions relating to environmental noise emission which are not directly applicable to this State Significant Development, but will be considered in the OSD design. These NSDCP 2013 requirements are provided below in italics:

P1 *Noise emission associated with the operation of non-residential premises or residential components of a building must not exceed the maximum 1 hour noise levels -($L_{Aeq\ 1\ Hour}$) 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 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 or non-residential components of a building must not exceed 5 dBA above the background maximum 1 hour noise level ($L_{Aeq\ 1\ Hour}$) 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 *Developments 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 EPA Industrial Noise Policy 2000 in particular the modification required for acceptable noise level (ANL).*

5.1.2 Internal acoustic privacy

5.1.2.1 Building Code of Australia 2016 – Acoustic requirements

Part F5 of the Building Code of Australia 2016 (BCA) details requirements for the acoustic separation of sole occupancy units. These requirements must be incorporated as part of the design development of the OSD.

5.1.2.2 North Sydney Development Control Plan (NSDCP 2013) – Acoustic privacy

Clause 11 of the NSW State Environmental Planning Policy (State and Regional Development) states that Development Control Plans do not apply to State Significant Development. Hence, the NSDCP 2013 does not apply to this concept proposal. Nonetheless, the underlying objectives of NSDCP 2013 have informed and influenced this assessment.

Section 1.3.8 and Section 1.3.9 of the NSDCP 2013 details provisions relating to internal acoustic and vibration privacy for residential dwellings which are not directly applicable to this State Significant Development, but will be considered in the OSD design. These NSDCP 2013 requirements are provided below in italics:

1.3.8 Acoustic Privacy

P1 *New dwellings shall be designed and constructed to comply with the criteria specified in Table B-1.2 for all noise intrusion from external noise sources (including mechanical services noise from within the development itself), with windows and doors closed.*

Table B-1.2: Noise intrusion criteria from external sources

Time Period		Max 1 hour noise level ($L_{Aeq, 1hour}$)
Internal Space	**Time Period**	
Living Areas	Day or Night	≤ 40 dB(A)
Sleeping Areas	Day or Night	≤ 35 dB(A)

Notes: *Readings are to be $L_{Aeq\ (1hour)}$, when measured during the noisiest 1 hour period between Day 7am to 10pm; and Night – 10pm to 7am.*

P2 *Where multiple dwellings are provided within the same building, the building shall be designed and constructed to comply with the requirements in Table B-1.3 regarding acoustic insulation of walls and floors.*

Table B-1.3: Internal acoustic insulation criteria

Building element	
Item	**Criteria**
Field Sound Reduction Index R'w of walls, floors services and ducts	BCA as amended. Except that Field Noise Reduction Index of all inter- tenancy walls shall be designed to achieve ≥R'w55 and the intent of the BCA requirements.
Field Sound Reduction Index R'w of Doors	Any door (including the effects of its frame and any edge gaps) in a wall between a dwelling and a stairwell or other internal common area shall be designed to achieve an ≥R'w28.
Field Impact Isolation Class (FICC) of Floors	Where the floor of a dwelling separates a habitable room of one dwelling and a habitable room, bathroom, toilet, laundry, kitchen, plant room, stairway, public corridor, hallway and the like of a separate tenancy, the floor shall be designed to achieve a Field Impact Insulation Class of FIIC ≥55.

P3 *An acoustic report prepared by a certified acoustic consultant must be submitted and address the requirements to P1 where the proposal involves the construction of 4 or more new dwellings.*

P4 *Buildings are to be designed and rooms positioned to reduce noise transmission within and between dwellings.*

P5 *Bedrooms should be designed so that wardrobes provide additional sound buffering between rooms within the dwelling or between adjoining dwellings over and above the requirements in P2 above.*

P6 *Windows and doors should be located away from external noise sources, or buffers used where separation cannot be achieved.*

P7 *Materials with low noise penetration properties should be used where practical.*

P8 *Locate bedrooms and private open spaces away from noise sources such as garages, driveways, mechanical equipment and recreation areas.*

P9 *Mechanical equipment, such as pumps, lifts or air conditioners should not be located adjacent to bedrooms or living rooms of dwellings on adjoining properties.*

P10 *Where dwellings are located on busy roads the following construction techniques are to be considered for incorporation into the design of the development to reduce traffic noise within the dwelling:*
(a) cavity brick walls;
(b) double glazing;
(c) solid core doors;
(d) concrete floors; and
(e) recessed balconies.

P11 *Where possible, avoid the use high brick fences on busy roads. High fences present a harsh*

and bland appearance to the street, obstruct views from the footpath to gardens and dwelling entries, reduce amenity for pedestrians and reduce casual surveillance of the street. Try to reduce acoustic impacts through other acoustic reduction measures.

P12 Development on land which is on or is within 100m of a railway corridor, a road corridor for a freeway, a tollway, a transit way or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RMS) must consider the requirements of the DoP's Development Near Rail Corridors and Busy Roads – Interim Guideline (19 December 2008) in accordance with cl.87(2) and cl.102(2) of SEPP (Infrastructure) 2007. An acoustic report may be required to be prepared to demonstrate compliance with this Guideline and the acoustic requirements within cl.87(3) and cl.102(3) of the SEPP (Infrastructure) 2007.

1.3.9 Vibration

P1 Development on land which is on or is within 60m of a railway corridor, or is adjacent to a road corridor for a freeway, a tollway, a transit way or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RMS) must consider the requirements of the DoPI's Development Near Rail Corridors and Busy Roads – Interim Guideline (19 December 2008) in accordance with cl.87(2) and cl.102(2) of SEPP (Infrastructure) 2007. In particular, consideration should be given to the vibration criteria contained within the Department of Environment Climate Change and Water's Assessing Vibration: a technical guideline. A vibration assessment report may be required to be prepared to demonstrate compliance with these Guidelines.

5.1.3 Road traffic noise emission criteria

Table 6 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 6: Road traffic noise criteria

Road category	Night-time RBL dB(A)	Assessment criteria dB(A)	
		Daytime (7am – 10 pm)	Night-time (10pm – 7am)
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).

5.1.4 External noise intrusion

5.1.4.1 Air-borne noise

Internal noise levels in the residences, hotel and commercial tenancy spaces will mainly be contributed by vehicles using Pacific Highway and by the building's air conditioning and mechanical ventilation plant.

The subject development will be assessed for road traffic noise intrusion by addressing the 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 AS/NZS 2107:2016 recommends a range of internal noise levels for building interiors, the given ranges have been found to be acceptable by most people for a particular type of occupancy/activity under consideration. When the sound level is greater than the upper level of the range, most people occupying the space will 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 traffic noise, for residential receivers, must also comply with the State Environmental Planning Policy (Infrastructure) 2007 (SEPP 2007) and the DP&E's document 'Development near Rail Corridors and Busy Roads – Interim Guidelines'. It should be noted that the criteria detailed in the SEPP 2007 are identical to those in the Interim Guidelines.

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 7**.

Table 7: External noise intrusion criteria

Type of occupancy/activity	Design Sound Level, L_{Aeq} dB(A)	
	AS2107:2016	SEPP 2007
Residential		
Apartment common areas (e.g. foyer, lift lobby)	42 to 47	-
Living areas	32 to 42	40
Sleeping areas	32 to 37	35
Hotel		
Bar and lounges	< 47	-
Dining rooms	37 to 42	-
Foyers and recreation areas	42 to 47	-
Kitchen laundry and maintenance areas	< 52	-
Sleeping areas (night time) near major roads	32 to 37	35
Washrooms and toilets	42 to 52	-
Retail		
Small retail stores (general)	< 47	-
Shopping malls	< 52	-
Show rooms	< 47	-
Speciality shop (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	-
Executives 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	-

Type of occupancy/activity	Design Sound Level, L_{Aeq} dB(A)	
	AS2107:2016	SEPP 2007
Education[1]		
Open plan teaching spaces	35 to 45	-
Primary schools	35 to 45	-
Secondary schools	35 to 45	-

Note 1: There are no criteria for community and child care centres presented within AS 2107:2016. The Association of Australasian Acoustical Consultants (AAAC) Guideline Child Care Centre Acoustic Assessment provides additional recommendations in relation to acoustic considerations for child care centre design. The proposed uses and types of spaces to be included in the community and child care centres should be further investigated during the detailed design of the proposal.

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 8**.

Table 8: 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 9**).

Table 9: 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 10** and **Table 11**.

Table 10: 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 11: 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 12**.

Table 12: 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 13.**

Table 13: 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

Construction noise in New South Wales is assessed using the Department of Environment & Climate Change (now Environment Protection Authority (EPA)) *Interim Construction Noise Guideline* (ICNG). The ICNG is also defined as the relevant guideline for construction noise by the SEARs issued by the DPE.

The ICNG aims to manage noise from construction works regulated by the EPA. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment.

The ICNG prescribes $L_{eq,15min}$ Noise Management Levels (NMLs) for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

5.4.2 Residential land uses

The NMLs prescribed for residential land uses by the ICNG are presented in **Table 14**. The levels apply at the most exposed property boundary of the noise sensitive receiver at a height of 1.5 metres above ground level.

5.4.3 Other sensitive land uses

The ICNG also prescribes NMLs for other sensitive land uses, including educational buildings. The NMLs for relevant land uses are summarised in **Table 15** and apply only when those land uses are in use.

For those receivers where an internal NML applies, it is common to assume an outdoor-to-indoor noise reduction of 10 dB(A). This is based on a standard commercial building facade with windows kept open to allow sufficient natural ventilation. Therefore, for this assessment, an external NML of 55 dB(A) $L_{eq,15min}$ will be used for the educational and place of worship sensitive land uses surrounding the development site.

5.4.4 Commercial and industrial premises

The ICNG prescribes specific NMLs for commercial land uses for commercial and industrial premises in three categories:

- Industrial premises: external $L_{Aeq,15min}$ 75 dB(A)
- Offices, retail outlets: external $L_{Aeq,15min}$ 70 dB(A)
- Other businesses that may be very sensitive to noise, where the noise level is project specific should be assessed on a project-by-project basis.

These criteria apply when the buildings are in use.

5.4.4.1 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.

5.4.4.2 Residential receivers

Table 14: ICNG noise management levels for residential land uses

Time of day	Noise Management Level, Leq,15 min	Application notes
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	May be some community reaction to noise. Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected 75 dB(A)	May be strong community reaction to noise. Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. Respite activities would be determined considering times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Outside recommended standard hours 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 + 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 affected noise level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the affected noise level, the proponent should negotiate

Time of day	Noise Management Level, Leq,15 min	Application notes
		with the affected community.
	Noise affected RBL + 10 dB	May be some community reaction to noise. Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.

5.4.4.3 Other sensitive land uses and commercial receivers

Table 15: ICNG noise management levels for other sensitive land uses

Land use	Noise Management Level, $L_{eq,15\ min}$ [1]
Classrooms at schools and other educational institutions Outdoor play areas (e.g. child care centres) Based on indoor target less 10 dB	Internal noise level 45 dB(A) Outdoor noise level 55 dB(A)[2]
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities that generate their own noise or focus for participants, making them less sensitive to external noise intrusion).	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation).	External noise level 65 dB(A)

Note 1: Applies when properties are being used.

Note 2: Based on indoor target less 10 dB

5.4.4.4 Site specific construction noise management levels

Table 16 summarises the NMLs applicable to sensitive land uses around the project site during the construction phase. The NMLs are based on the background levels measured for the purposes of this report.

Table 16: Project specific Noise Management Levels

Land use	Noise Management Level, dB(A)			
	Standard Working Hours	Outside of Standard Working Hours		
		Day	Evening	Night
Residential land uses (NCA 1)	69	64	60	55
Residential land uses (NCA 2)	65	60	56	51
Residential land uses (NCA 3)	65	60	56	51
Educational buildings (external)	55	55	55	55
Places of worship (external)	55	55	55	55
Sporting ovals	65	65	65	65
Commercial buildings (external)	70	70	70	70

5.4.4.5 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).

5.4.5 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).

5.4.6 Construction vibration and structural damage

Ground vibration generated by construction can have a range of effects on buildings and building occupants. The main effects are generally classified as:

- human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- effects on building structures – vibration which may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on buildings. Building occupants will normally feel vibration readily at levels well below those which may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[1]
- Human comfort: *Assessing Vibration – A Technical Guideline* (the Vibration Guideline)

5.4.7 Cosmetic and structural damage

DIN 4150-3 summarises structural and cosmetic damage assessment criteria for different types of buildings, which are presented in **Table 17**, which are widely used for the assessment of construction vibration effects on buildings in Australia. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

Table 17: DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	< 10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

[1] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

With respect to the project site, there are no neighbouring State heritage sites on the NSW Office & Environment Heritage Register. The St Leonards Centre is located on the corner of Clarke Lane and Oxley Street. This building is locally listed in the North Sydney Local Environmental Plan, 2013.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended would not necessarily result in damage. Rather, it recommends these values as maximum levels of short-term construction vibration at which experience has shown damage reducing the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if:

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

5.4.8 Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Vibration Guideline).

The vibration assessment criteria defined in the Vibration Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction activities as part of the proposed works would be expected to be continuous or intermittent in nature.

Table 18 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted RMS vibration

velocity levels. The Vibration Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 18: RMS velocity management levels for continuous and impulsive vibration

Land use	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Preferred
Critical areas[1]	0.1	0.2	0.1	0.2
Residences – daytime[2]	0.2	0.4	6.0	12.0
Residences – night time[3]	0.14	0.28	2.0	4.0
Offices, schools	0.4	0.8	13.0	26.0
Workshops	0.8	1.6	13.0	26.0

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in **Table 19**

Table 19: VDV management levels for intermittent vibration

Land use	VDV – intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Critical areas[1]	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4
Residences and hospital wards – night time[3]	0.13	0.26
Offices, schools	0.4	0.8
Workshops	0.8	1.6

1. Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.
2. Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.
3. Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

5.4.9 Receivers with a particular sensitivity to vibration

A number of receivers are located on Clarke Lane, Clarke Street and Pacific Highway which may have a particular sensitivity to noise and vibration associated with the construction and operation of the proposal. These include medical practices, a day surgery, an eye surgery and recording studios.

Specific vibration criteria may be applicable to these locations depending on the specific sensitivity of the work conducted within the spaces. A detailed review of these locations would be required in order to select appropriate criteria and mitigation measures appropriate to the construction works associated with the OSD. Appropriate vibration criteria may be developed on the basis of the VC curves provided in the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) Chapter 48, Noise and Vibration Control.

5.5 Impact on Crows Nest Sydney Metro Station during OSD construction

Appropriate noise and vibration management levels for assessing the potential impact of OSD construction on the operational Sydney Metro station should be further developed in consultation with the future station operators and should include consideration of the following:

- ICNG and AS2107 for recommended noise management levels in station areas
- Sydney Metro station design criteria for recommended noise management levels in station areas
- ASA guidelines for developers near rail corridors for noise and vibration impacts on operational railways
- Commitment to work with Sydney Metro to determine applicable noise and vibration criteria for station and operational rail
- Commitment to coordinate timing of works with Sydney Metro's operations in order to manage operational impacts

Once more specific information regarding the proposed construction methodology, equipment and staging is known, it is recommended that the managing contractor produces a comprehensive Construction Noise and Vibration Management Plan incorporating the mitigation and management strategies recommended above, developed through consultation with the surrounding community and local authority that is also in accordance with the framework for compliance established in this report.

When completing these assessments reference should be made to the requirements and criteria defined in the *Chatswood to Sydenham Construction Noise and Vibration Strategy* (Sydney Metro, 2017).

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.

6.1 Road traffic noise due to operation

The pre-existing site incorporated 138 car parking spaces spread across Sites A, B and C. The concept plan for the site is applying for up to 150 car parking spaces spread across the proposal area. The indicative design that fits within the approval envelope incorporates 121 car parking spaces.

The previous land use (predominantly commercial) incorporating bulky goods shops generated a higher intensity trip generation due to the continual turnover of car parking spaces.

The new land use proposal which will be predominantly residential would generate a lower intensity trip generation because most movements would occur during the morning and afternoon peak periods with less trips on average throughout the day. Also noting the future option to utilise the new Sydney Metro train services.

In the event that the maximum number of car parking spaces are realised in the final design, the net increase in noise level would be less than 0.5 dB(A). As such no specific additional mitigation measures are recommended as part of this Stage 1 concept approval.

Notwithstanding, opportunities to minimise future potential impacts should continue to be explored as the design progresses.

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 development 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 but not be limited to:

- Testing of emergency equipment, such as generators, during day-time periods.
- Implementation of measures identified in Section 6.2.

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 above ground multi-story parking spread across Site A and Site B.

The pre-existing site incorporated 138 car parking spaces spread across Sites A, B and C. The concept plan for the site is applying for up to 150 car parking spaces spread across the proposal area. The indicative design that fits within the approval envelope incorporates 121 car parking spaces. Whilst the potential increase in the total number of car spaces is considered minor, the following options for noise control would be further investigated as the design develops:

- Acoustically enclose the car park façades such that compliance with the environmental noise emission criteria is achieved.
- Installation of automatic hinged gates operated by hydraulic pistons instead of metal roller shutters. Hours of operation of the gates should be minimised to most secured hours only. Use of boom gates should be considered for majority of the time of

operation.

- 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.
- Car lifts should be chosen with consideration of noise emission levels.

6.6 Loading dock noise emission

The proposed loading docks for the OSD sites will be shared with the station site.

The future servicing vehicles will gain access to Site A (station and OSD) and Site B (OSD only) via Clarke Lane and there are no formalised loading dock areas proposed for Site C where loading is proposed to occur from the street.

Prior to demolition there were 32 service vehicle access points down Clarke Lane, however due to the combination of the Sydney Metro station and OSD projects, this number will be reduced to 26.

The following factors should also be noted:

- The pre-existing usage of Clarke Lane and associated access roads was predominantly utes, trucks in loading docks and waste removal. Most of the pre-existing developments used Clarke Lane for waste removal.
- The shift in land use to predominantly residential is likely to change the mix of vehicles to a higher proportion of private light vehicles.

Therefore, no net increase to the ambient acoustic environment is predicted due to noise emissions associated with the use of loading docks and site access points.

Notwithstanding, opportunities to minimise future potential impacts should continue to be assessed as the design progresses.

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 building, of which the main component is glazing, will control external noise intrusion. Therefore, the glazing and associated framing system must be capable of preventing unnecessary noise intrusion from external noise sources. Noise levels incident on the building façade were determined from noise measurements as detailed in Section 4. Noise levels measured at 420 Pacific Highway 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 Pacific Highway.

Both the daytime and night time ambient noise levels were utilised. Indicative glazing constructions are presented in **Table 20**.

Table 20: Indicative glazing requirements

Type of occupancy/activity	Minimum R_W performance	Indicative glazing construction (double glazed option)
Open offices, corridors and lobbies	40	• 10 mm monolithic glass • 12 mm air gap • 6.38 mm laminated glass
Sleeping areas (residential)	40	• 10 mm monolithic glass • 12 mm air gap • 6.38 mm laminated glass
Living areas (residential)	40	• 10 mm monolithic glass • 12 mm air gap • 6.38 mm laminated glass
Sleeping areas (hotel)	40	• 10 mm monolithic glass • 12 mm air gap • 6.38 mm laminated glass

Note that specified glazing thicknesses only address the acoustic requirements and do not consider 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. The glazing constructions are indicative only and will need to be reviewed during the detailed design stage.

7.1.1.1 Ventilation

It is commonly accepted that a window that is open to provide ventilation to a room provides 10 dB(A) noise reduction from outside to inside.

The external road traffic noise levels would not allow for the internal noise design targets to be achieved with windows open. Consequently, windows must be closed to ensure internal noise criteria can be satisfied. This is likely to be required on all levels of all facades of each building however a detailed study of acoustic façade and fresh air ventilation performance will be required as part of the detailed design. Optimisation of the building façade performance would occur as part of this process.

It is therefore recommended that an alternative means of ventilation be provided for residential spaces on road traffic noise affected facades. An alternative means of ventilation may take the form of:

- Air conditioning with an outside/fresh air component (not a conventional 'split' system).
- Mechanical ventilation drawn from a 'quiet' side of the building and/or with an acoustically attenuated intake path.

The design of fresh air ventilation for the proposal should consider and incorporate the requirements of the BCA and the State Environmental Planning Policy No 65 - Design Quality of Residential Apartment Development (SEPP 65).

7.2 Sydney Metro Project Noise intrusion

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

A detailed assessment of ground-borne noise and vibration due to railway operations was undertaken as part of the EIS for the CSSI (Sydney Metro City and South West Railway Project).

The predicted ground-borne vibration and noise levels for the project alignment are reproduced in Figure 10 and Figure 11 respectively.

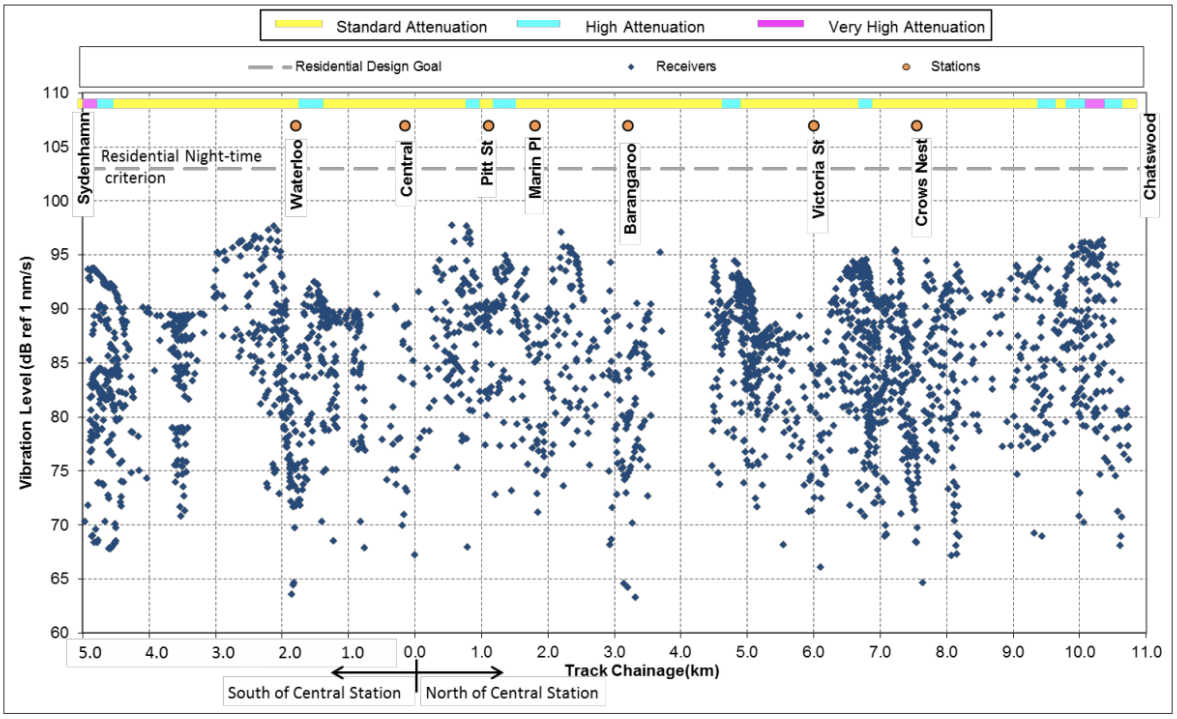

Figure 10: Reproduction of Figure 34 from CSSI Noise and Vibration technical paper (ground-borne vibration level predictions)

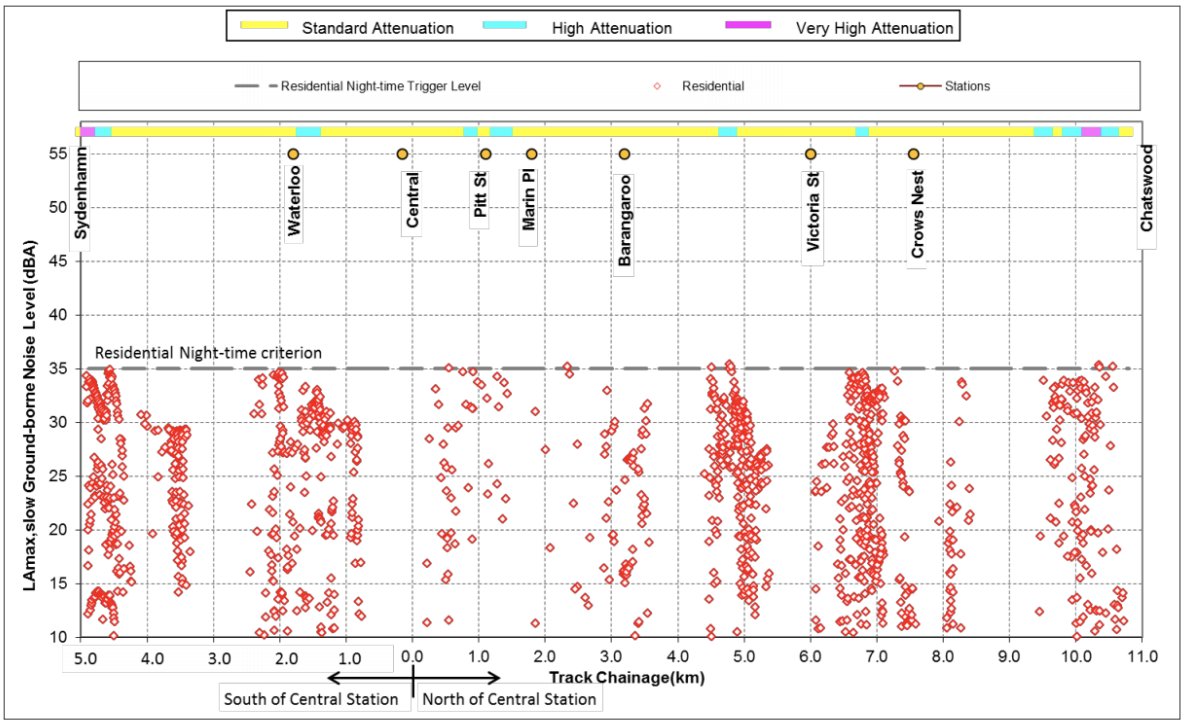

Figure 11: Reproduction of Figure 40 from CSSI Noise and Vibration technical paper (ground-borne noise level predictions)

The predicted levels demonstrate compliance with the established criteria for residential sensitive receiver locations.

Further investigation of the impacts from trains on the Over Station Development would be completed as the project progresses, and the developers would work closely with Sydney Metro to ensure the impacts are adequately assessed and mitigated. It is anticipated that the operational rail ground borne noise criteria can be met through the use of resilient trackforms, building isolation in the form of bearings at the base of the buildings, or a combination of both.

7.2.2 Air-borne noise

Sydney Metro's strategy for managing noise emissions from the station, track and OSD is that each component will contribute equally to the overall environmental noise criteria for the ISD. For planning and design purposes, the OSD is treated as a sensitive receiver and noise emissions from the OSD, station and track systems would be designed such that the environmental noise criteria are met at noise sensitive areas of the ISD.

The environmental noise criteria for industrial noise sources associated with the ISD are in the order of 10 dB lower than the existing ambient road traffic noise that will control the noise intrusion design (i.e. control the acoustic design of the façade as detailed in Section 7.1).

7.3 Summary of operational noise and vibration mitigation measures

A summary of the noise and vibration mitigation measures relevant to the operation of the proposal is provided in Table 21. The list of measures will be reviewed and refined as part of the detailed design such that the operational noise and vibration requirements are met.

Table 21: Indicative glazing requirements

Operational consideration	Mitigation measures
Road traffic noise due to operation	No specific additional mitigation measures are recommended as part of this Stage 1 concept approval. Notwithstanding, opportunities to minimise future potential impacts should continue to be explored as the design progresses.
Building services noise and vibration emission	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

Operational consideration	Mitigation measures
	• Selection of low-noise plant • Acoustic isolation mounts.
Sleep disturbance assessment	It is expected that standard acoustic treatments would be sufficient to minimise sleep disturbance. Mitigation measures would likely include but not be limited to: • Testing of emergency equipment, such as generators, during day-time periods. • Implementation of measures identified in Section 6.2.
Emergency operations	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.
Car park noise emission	The following options for noise control should be further investigated as the design develops: • Acoustically enclose the car park façade facing the nearest residential receivers on Clarke Lane. • Installation of automatic hinged gates operated by hydraulic pistons instead of metal roller shutters. Hours of operation of the gates should be minimised to most secured hours only. Use of boom gates should be considered for majority of the time of operation. • 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. • Car lifts should be chosen with consideration of noise emission levels.
Loading dock noise emission	No net increase to the ambient acoustic environment is predicted due to noise emissions associated with the use of loading docks and site access points. Notwithstanding, opportunities to minimise future potential impacts should continue to be assessed as the design progresses such that the compliance with the established criteria is achieved.
Operational vibration	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

Operational consideration	Mitigation measures
	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.
Traffic noise intrusion	Indicative glazing thicknesses have been provided and only address the acoustic requirements and do not consider 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. The glazing constructions are indicative only and will need to be reviewed during the detailed design stage.
Ventilation	It is therefore recommended that an alternative means of ventilation be provided for residential spaces on road traffic noise affected facades. An alternative means of ventilation may take the form of: • Air conditioning with an outside/fresh air component (not a conventional 'split' system). • Mechanical ventilation drawn from a 'quiet' side of the building and/or with an acoustically attenuated intake path. The design of fresh air ventilation for the proposal should consider and incorporate the requirements of the BCA and the State Environmental Planning Policy No 65 - Design Quality of Residential Apartment Development (SEPP 65).
Ground-borne and structure-borne rail noise and vibration	It is anticipated that the operational rail ground borne noise criteria can be met through the use of resilient trackforms, building isolation in the form of bearings at the base of the buildings, or a combination of both.

Operational consideration	Mitigation measures
Airborne noise	The environmental noise criteria for industrial noise sources associated with the ISD are in the order of 10 dB lower than the existing ambient road traffic noise that will control the noise intrusion design (i.e. control the acoustic design of the façade as detailed in Section 7.1).

8.0 Construction noise and vibration assessment

8.1 Construction stages and scheduling

A detailed construction staging design will be completed as the design of the ISD progresses. The OSD component would be completed in two main stages:

- Podium construction.
- Tower construction.

8.2 Modelling

In order to quantify noise emissions from the proposed construction works, noise modelling software (SoundPLAN v7.4) has been utilised to predict the $L_{Aeq(15\text{-}minute)}$ noise levels at nearby receivers. The calculations include: the source noise levels of the anticipated equipment, the location of selection of nearby sensitive receivers, the number of plant items likely to be operating at any given time and the distance between the equipment and the receivers.

Table 22 summarises the assumed sound power levels (L_w) for the major construction noise sources which would reasonably be expected to be on site during each phase. The sound power levels have been based on data obtained from previous measurements conducted by Sydney Metro's Technical Advisor, data from Roads and Maritime's *Construction Noise and Vibration Guideline* and those within the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*. An overall sound power level for each phase has also been assumed based on the loudest typical source(s) operating for each works phase

In practice, the noise levels will vary because plant will move around the worksites and will not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the works.

Table 22: Construction noise source sound power levels

Stage	Typical plant items	Assumed sound power level, dB(A)
Podium construction	Diesel tower cranes	99
	Electric Concrete placing boon	103
	Electric formwork hoist	82
	Diesel Manitou at ground	92
	Forklift	101
	Delivery Trucks of various sizes at ground	98
	Rubbish removal trucks at ground	98
	diesel Mobile cranes at ground	104
	Concrete truck/ agitator	109
	Typical overall sound power level	**112**
Tower Construction	Diesel tower cranes	99

Stage	Typical plant items	Assumed sound power level, dB(A)
	Electric Man and Material Hoist	94
	Electric Concrete placing boon	103
	electric formwork hoist	82
	Diesel Manitou at ground	92
	Forklift	101
	Delivery Trucks of various sizes at ground	98
	Rubbish removal trucks at ground	98
	diesel Mobile cranes at ground	104
	Concrete truck/ agitator	109
	Typical overall sound power level	**112**

8.3 Construction site noise assessment

$L_{Aeq(15minute)}$ noise levels have been predicted for the nominated construction scenarios. The results are presented as noise contours in **Figure 12** and **Figure 13** for podium and tower construction scenarios respectively.

Exceedances of the daytime NMLs are predicted in all noise catchment areas. NML exceedances are predominantly predicted to occur at residential and commercial receiver locations facing onto Pacific Highway.

A number of receivers are located on Clarke Lane, Clarke Street and Pacific Highway which may have a particular sensitivity to noise and vibration associated with the construction of the proposal. These include medical practices, a day surgery, an eye surgery and recording studios.

Some of these receiver locations are predicted to be highly noise affected by the works (i.e. noise levels above 75 dB(A). Additional mitigation considerations may be required at these locations when factoring in the potential sensitivity of these locations to high noise levels.

It should be noted that construction noise levels vary significantly with time and the predicted noise levels presented in this report assume that all plant are operating simultaneously.

Construction noise impacts should be further assessed as the design and construction methodology progresses. These assessments should incorporate more detailed construction noise and vibration impact statements with specific review of the particularly sensitive receivers including the recording studios and medical practices.

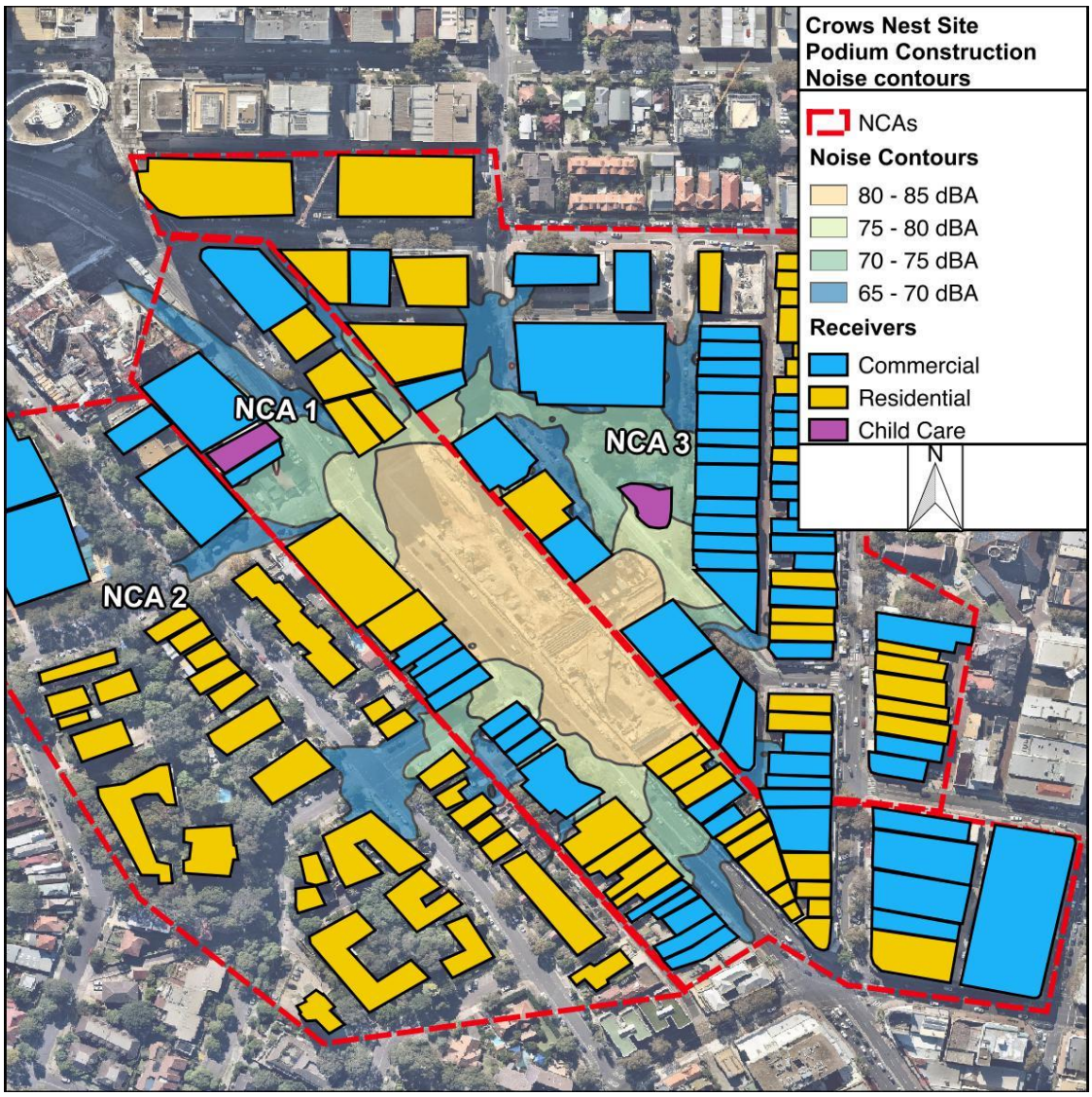

Figure 12: Predicted podium construction noise levels

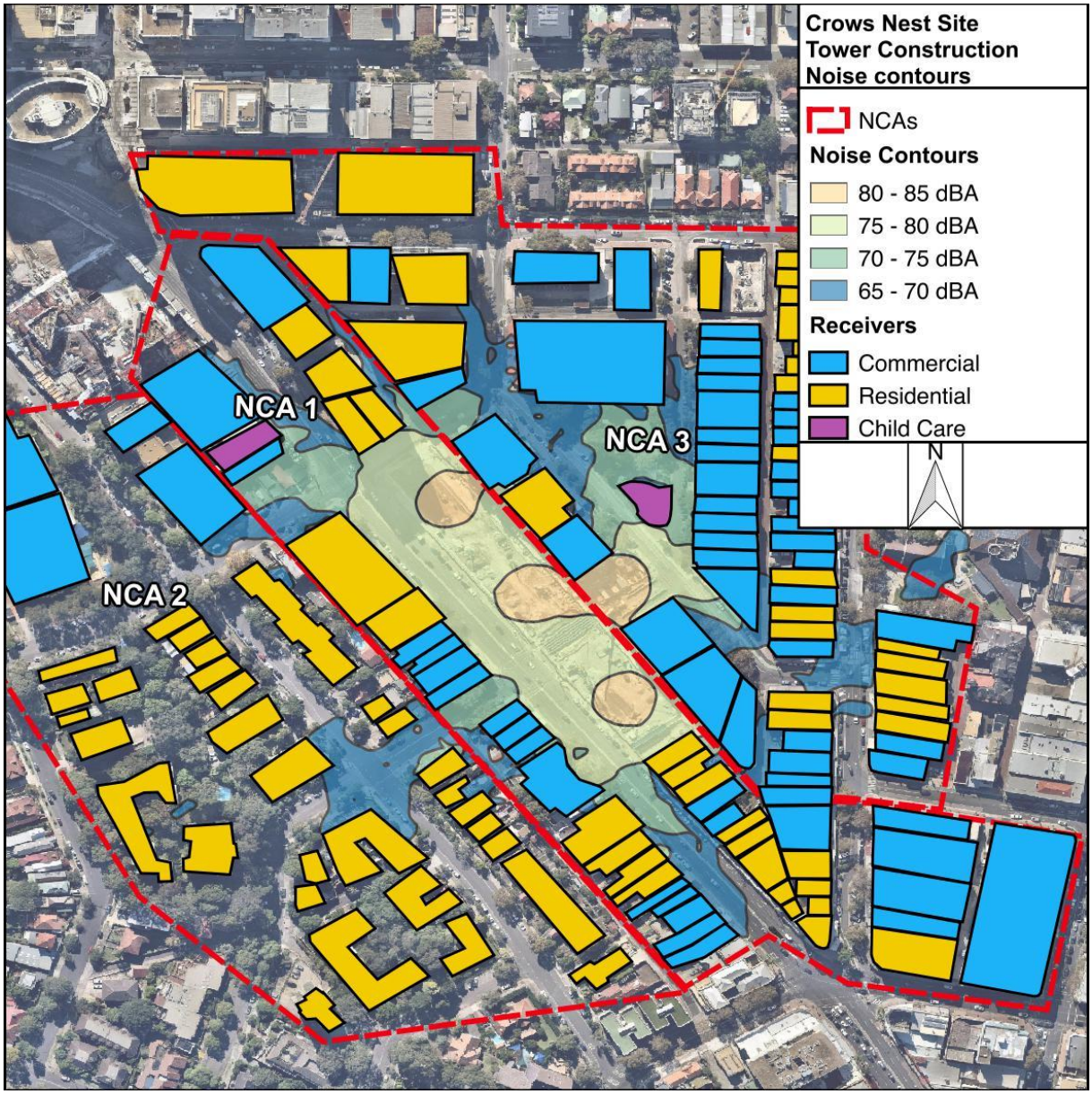

Figure 13: Predicted tower construction noise levels

8.4 Construction traffic assessment

8.4.1 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 prepared by Jacobs*. Only Peak hourly volumes were available.

The peak hourly traffic volumes are present in the Table 23 below

Table 23: Crows Nest existing peak hour traffic volumes by direction (2015)

Source: Jacobs Technical Paper

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Pacific Highway	Between Oxley Street and Hume Street (southbound)	1,340	1,360
	Between Oxley Street and Hume Street (northbound)	1,480	1,410
Pacific Highway	Between Hume Street and Falcon Street (northbound)	1,290	1,290
	Between Hume Street and Falcon Street (southbound)	1,480	1,400
Hume Street	East of Pacific Highway (westbound)	150	190
	East of Pacific Highway (eastbound)	140	140
Oxley Street	East of Pacific Highway (eastbound)	225	145
	East of Pacific Highway (westbound)	145	150

8.4.2 Construction generated traffic volumes

In the absence of construction generated traffic volumes, an estimate based upon a total of 60 delivery vehicles over an ICNG standard construction hour day (7am to 6am) has been assumed. This number has been derived from recent project experience and other OSD developments. This represents a total of 12 movements in a one-hour period (six vehicles in and six vehicles out in one hour) Considering the high existing volume of traffic on the adjacent roads as per Table 23 above, the noise impact generated by construction delivery vehicles arriving and leaving the site would result in an increase in road traffic noise levels of less than 2 dB which is in compliance with the established criteria. Notwithstanding the predicted compliance on main project access roads, potential construction traffic noise impacts should be reassessed during the detailed design stage when the construction methodology has developed further.

8.5 Construction vibration assessment

Roads and Maritime's *Construction Noise and Vibration Guideline* provides guidance for minimum working distances for vibration-intensive activities with respect to the stated standards and guidelines. The minimum working distances for building damage should be complied with at all times. The distances are noted as being indicative and are likely to vary depending on the particular item of plant and local geotechnical conditions. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.
In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

Table 24 presents the recommended minimum working distances for vibration intensive plant.

Table 24: Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

A number of receivers are located on Clarke Lane, Clarke Street and Pacific Highway which may have a particular sensitivity to vibration associated with the construction of the proposal. These include medical practices, a day surgery, an eye surgery and recording studios.

Specific vibration criteria may be applicable to these locations depending on the specific sensitivity of the work conducted within the spaces. A detailed review of these locations would be required in order to select appropriate criteria and mitigation measures appropriate to the construction works associated with the OSD. Appropriate vibration criteria may be developed on the basis of the VC curves provided in the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) Chapter 48, Noise and Vibration Control. Baseline vibration monitoring is recommended at these locations prior to commencement of construction works.

8.6 Construction noise and vibration mitigation

To manage the potential impact of noise and vibration during construction, feasible and reasonable management measures and work practices should be implemented as detailed below.

8.6.1 Construction Noise and Vibration Management Plan

Prior to the commencement of major construction works the contractor should develop a Construction Noise and Vibration Management Plan (CNVMP). The CNVMP should:

- identify relevant construction noise and vibration criteria as detailed in this report
- identify neighbouring sensitive land uses for noise and vibration
- summarise key noise and vibration generating construction activities and the associated predicted levels at neighbouring land uses
- identify reasonable and feasible work practices to be implemented during the works
- summarise stakeholder consultation and complaints handling procedures for noise and vibration.

8.6.2 Stakeholder consultation

Nearby stakeholders should be consulted prior to the works and kept regularly informed of potential noise and vibration impacts from the works.

A noise and vibration complaints handling procedure and register should be developed and implemented during construction.

8.6.3 Work programming

Construction stage programming should be implemented such that works, and particularly noisy works, occur during standard working hours wherever feasible, namely:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 1 pm
- No work on Sundays or public holidays.

If high noise works are to occur outside of these times, then the CNVMP should define an approval process for undertaking out of hours works that identifies feasible and reasonable mitigation measures to be implemented. Such measures might include, but not be limited to:

- taking delivery of loud plant and equipment during the Standard Hours periods
- undertaking high-impact noise generating construction works prior to 12 am
- implementing localised noise barriers or hoarding around work areas for the duration of the out of hours work
- stakeholder consultation, as above, to determine local sensitivity to out of hours works and implementation of feasible and reasonable measures based on community feedback.

8.6.4 Truck movements and site access

Truck movements during long term construction projects have the potential to cause annoyance for sensitive receivers, even where trucks may be travelling on sealed roads. The

design and selection of site access routes shall consider the potential disturbance to residents. In particular:

- site access and delivery points shall be located as far away from residences as possible
- truck movements shall use arterial roads and be diverted away from residential streets where feasible
- deliveries to/from site shall not occur during the night time period where possible.

8.6.5 Site management

Site management procedures should include the following:

- processes that generate lower noise levels should be selected where feasible
- noisy plant should be located as far away from residences as is practical to allow efficient and safe completion of the task
- the potential shielding provided by site topography and intervening buildings should be considered in locating equipment
- site compounds should be located as far away as possible from residences
- equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use
- works should be planned to minimise the reduce the noise from reversing signals
- warning horns should not be used as signalling devices
- two-way radios should be set to the minimum effective volume
- noise associated with packing up plant and equipment at the end of works should be minimised.

8.6.6 Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment where possible
- equipment should be well maintained
- equipment should have quality mufflers and silencers installed where relevant
- equipment not in use on site should be shut down
- tasks should be completed using the minimum feasible power and equipment

8.6.7 Vibration mitigation measures

The potential impacts from vibration are to be considered in the site-specific Construction Noise and Vibration Management Plans, to be developed during the detailed design phase when more information is available on the schedule for the works and the equipment to be used.

The safe working distances should be maintained, with distances between works and sensitive receivers maximised wherever possible. The following should be implemented where reasonable and feasible to do so:

- All plant should be properly maintained.
- Low vibration alternatives for plant should be implemented where possible.
- Plant that have high and low vibration operating settings should be run on the lowest effective vibration setting.

- Vehicle movements along uneven surfaces should be restricted to minimum speed adjacent to vibration sensitive receivers.
- Baseline vibration monitoring is recommended at receivers that may have a particular sensitivity to vibration.

9.0 Conclusion

This report presents the results of a noise and vibration assessment of the OSD above the proposed Crows Nest Station. This report has been prepared to outline the noise 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 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 dated 26 September 2018.

Indicative construction scenarios applicable to the OSD have been modelled and construction noise levels at nearby sensitive receivers have been predicted to exceed the established noise management levels at some residential and commercial receivers due to their 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.

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm as defined in the INP.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Evening	Between 6 pm and 10 pm as defined in the INP.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 to 20,000 Hz.
INP	New South Wales *Industrial Noise Policy*, 2000.
Intrusive Noise	Noise emission that when assessed at a noise-sensitive receiver (principally the boundary of a residence) is greater than 5 dB(A) above the background noise level.
L_{10}	Noise level exceeded for 10% of the measurement time. The L_{10} level is commonly referred to as the average maximum noise level.
L_{90}	Noise level exceeded for 90% of the measurement time. The L90 level is commonly referred to as the background noise level.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{max}	Maximum measured sound pressure level in the time period.
mm/s	Millimetres per second—units of vibration velocity.
$m/s^{1.75}$	Units of VDV.
Night-time	Between 10 pm on one day and 7 am on the following day as defined in the INP.
Noise Management Level (NML)	Construction noise management level. Where the construction noise levels are above the NML, additional consideration of feasible and reasonable noise mitigation is required.
Peak Particle Velocity (PPV)	The maximum speed of a particle in a particular component direction due to vibration during a measurement.

Rating Background Level (RBL)	Overall single-figure A-weighted background level representing an assessment period (Day/Evening/Night). For the short-term method, the RBL is simply the measured $L_{90,15min}$ noise level. For the long-term method, it is the median value of all measured background levels during the relevant assessment period.
Vibration	Refers to the oscillation of an object back and forth, normally the ground.
Vibration Dose Value (VDV)	A measure used to assess the level of vibration over a defined time period, such as a day, evening or night. Often used for the assessment of intermittent construction vibration that may rise and fall across a day.