Construction Noise and Vibration Monitoring Program

Sydney Terminal Building Revitalisation Project

Stage 1

Gartner Rose Pty Ltd
Level 3, 15 Blue Street
NORTH SYDNEY NSW 2060

Reference: 24265.1.3.R1R0
Issue Date: 29 July 2025

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Quality Management

Status	Date	Prepared	Checked	Authorised	Comments
Draft 1	27 June 2025	Joe McNamara	Olivia Madesta	Sam Demasi	-
Draft 2	7 July 2025	Joe McNamara	Sam Demasi	Sam Demasi	TfNSW Comments
Draft 3	15 July 2025	Joe McNamara	Sam Demasi	Sam Demasi	ER Comments
Draft 4	22 July 2025	Joe McNamara	Sam Demasi	Sam Demasi	ER Comments
Draft 5	25 July 2025	Joe McNamara	Sam Demasi	Sam Demasi	Table 18 Amendment
Revision 0	29 July 2025	Joe McNamara	Sam Demasi	Sam Demasi	Updated noise and vibration predictions. City of Sydney review.

This Report by VMS Australia Pty Ltd is prepared for Gartner Rose Pty Ltd and is based on the objective, scope, conditions and limitations as agreed. The Report presents only the information that VMS Australia Pty Ltd believes, in its professional opinion, is relevant and necessary to describe the issues involved. The Report should not be used for anything other than the intended purpose. All surveys, forecasts, projections, and recommendations contained in or associated with this report are made in good faith and on the basis of information supplied to VMS Australia Pty Ltd at the date of this report, and upon which VMS Australia Pty Ltd relied.

This report in its finalised version has been prepared, checked, and authorised by suitably qualified and experienced personnel from VMS Australia Pty Ltd, who hold memberships with the Australian Acoustical Society (AAS). Draft versions of this report may not be subject to this qualification.

VMS Australia Pty Ltd does not accept any liability or responsibility to any party with respect to the information and opinions contained in this report.

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1 Introduction

The Sydney Terminal Building Revitalisation Project (STBRP) was declared a State Significant Infrastructure (SSI) and was granted approval by the Minister of Planning on 17 November 2023 with conditions outlined in the *Sydney Terminal Building Revitalisation Condition of Approval*, Application No.: SSI-45421960 (CoA).

Transport for NSW (Transport) has engaged Gartner Rose Pty Ltd (the Contractor) as the Design and Construct Contractor for Stage 1 of STBRP (the Project).

VMS Australia Pty Ltd (VMS) has been engaged by the Contractor to prepare a Construction Noise and Vibration Monitoring Program (Monitoring Program) for the proposed demolition, excavation and construction works associated with the Project.

This Monitoring Program is designed to satisfy the requirements of CoA C9 as reproduced below.

> *'The Proponent must engage a suitably qualified and experienced person to prepare a Construction Noise and Vibration Monitoring Program (CNVMP). The program must be prepared in consultation with the City of Sydney Council and include, but not be limited to:*
>
> *(a) noise and vibration monitoring at representative locations adjacent to construction activities (including at the most / worst affected residences) to confirm construction noise and vibration levels;*
>
> *(b) noise monitoring during the day, evening and night-time periods throughout the construction period, covering the range of activities (including worst-case construction noise levels) being undertaken;*
>
> *(c) method and frequency for reporting of monitoring result;*
>
> *(d) procedures to identify and implement additional mitigation measures where results of monitoring indicate noise levels in excess of predicted noise levels and / or vibration levels in excess of vibration criteria; and*
>
> *(e) any consultation to be undertaken in relation to the monitoring program.'*

Reference is made to the *Construction Noise and Vibration Management Plan* (CNVMP) (ref. 24265.1.2.R1R5, dated 29 July 2025) prepared by VMS, in the determination of potential noise and vibration impacts associated with the Project.

Specific acoustic terminology is used in this report. An explanation of common acoustic and air quality terms is provided in **Appendix A**.

CoA and Mitigations Measures relevant to Noise and Vibration are reproduced in **Table 1**.

Table 1 Project Compliance Management Summary

ID	Description	Monitoring Program Reference
Conditions of Approval		
C9	The Proponent must engage a suitably qualified and experienced person to prepare a Construction Noise and Vibration Monitoring Program (CNVMP). The program must be prepared in consultation with the City of Sydney Council and include, but not be limited to: a) noise and vibration monitoring at representative locations adjacent to construction activities (including at the most / worst affected residences) to confirm construction noise and vibration levels; b) noise monitoring during the day, evening and night-time periods throughout the construction period, covering the range of activities (including worst-case construction noise levels) being undertaken; c) method and frequency for reporting of monitoring result; d) procedures to identify and implement additional mitigation measures where results of monitoring indicate noise levels in excess of predicted noise levels and / or vibration levels in excess of vibration criteria; and e) any consultation to be undertaken in relation to the monitoring program.	This document.
C10	The CNVMP must be submitted to the ER for approval and be approved before the commencement of construction.	To be satisfied.
C11	The approved CNVMP must be made publicly available before the commencement of construction and must be implemented for the duration of construction.	To be satisfied.
C12	The results of the construction noise and vibration monitoring must be submitted to the Planning Secretary, and relevant regulatory agencies, for information in the form of a Construction Noise and Vibration Monitoring Report at the frequency identified in the relevant CNVMP.	To be satisfied.
D24	Work Hours Work must be undertaken during the following hours: (a) 7:00am to 6:00pm Mondays to Fridays, inclusive; (b) 8:00am to 6:00pm Saturdays; and (c) at no time on Sundays or public holidays.	**Section 2.2**
D25	Highly Noise Intensive Work Except as permitted by an EPL, highly noise intensive works that result in an exceedance of the applicable NML at the same receiver must only be undertaken: (a) between the hours of 8:00 am to 6:00 pm Monday to Friday; (b) between the hours of 8:00 am to 6:00 pm Saturday; and (c) if continuously, then not exceeding three (3) hours, with a minimum cessation of work of not less than one hour. For the purposes of this condition, 'continuously' includes any period during which there is less than one hour between ceasing and recommencing any of the work.	N/A to the Monitoring Program.
D26	Construction Noise and Vibration Mitigation and Management	N/A to the Monitoring Program.

ID	Description	Monitoring Program Reference
Conditions of Approval		
	Industry best practice construction methods must be implemented, where reasonably practicable, to ensure that noise levels are minimised. Practices must include, but are not limited to: (a) use of regularly serviced low sound power equipment; (b) early occupation and later release of construction sites; (c) scheduling of noisiest work during construction hours specified in Condition D25; (d) temporary noise barriers (including the arrangement of plant and equipment) around noisy equipment and activities such as rockhammering and concrete cutting; and (e) use of alternative construction and demolition techniques that achieve lower noise and vibration levels.	
D27	Variation to Work Hours Notwithstanding Conditions D24 and D25 work may be undertaken outside the hours specified in the following circumstances (a, b, c or d): (a) Safety and Emergencies, including: (i) for the delivery of materials required by the NSW Police Force or other authority for safety reasons; or (ii) where it is required in an emergency to avoid injury or the loss of life, to avoid damage or loss of property or to prevent environmental harm. On becoming aware of the need for emergency work in accordance with Condition D27(a), the ER and the Planning Secretary must be notified of the reasons for such work. Best endeavours must be used to notify all noise and/or vibration affected residents and owners/occupiers of properties identified sensitive land use(s) of the likely impact and duration of those work. (b) Work that meets all of the following criteria: (i) Work that causes LAeq(15 minute) noise levels: • no more than 5 dB(A) above the rating background level at any residence in accordance with the ICNG, and • no more than the 'Noise affected' NMLs specified in Table 3 of the ICNG at other sensitive land use(s); and (ii) Work that causes LAmax noise levels no more than 15 dBA above the RBL at any residence during the night-time; and (iii) Work that causes: • continuous or impulsive vibration values, measured at the most affected residence no more than the preferred values for human exposure to vibration, specified in Table 2.2 of Assessing Vibration: a technical guideline (DEC, 2006), or • intermittent vibration values measured at the most affected residence that are no more than the preferred values for human exposure to vibration, specified in Table 2.4 of Assessing Vibration: a technical guideline (DEC, 2006). (c) By Approval, including:	N/A to the Monitoring Program

ID	Description	Monitoring Program Reference
Conditions of Approval		
	(i) where different construction hours are permitted or required under an EPL in force in respect of the SSI; or (ii) work which is not subject to an EPL that is approved under an Out-of-Hours Work Protocol as required by Condition D28; or (iii) negotiated agreements with directly affected residents and sensitive land use(s). (d) By Activity, including: (i) Deliveries and load out; (ii) Installation of services (Internal only); (iii) Roof construction – Grand Concourse; (iv) Roof construction – Light Rail skylight; (v) Demolition (Internal only – Eddy Avenue Plaza and Central Electric Building); and (vi) Western forecourt strengthening. The activities identified in Condition D27(d) are defined in Table 22, Appendix K in the documents listed in Condition A1. Note: Although the activities identified in Condition D27(d) permit works to occur outside the Work hours identified in Condition D24, these activities still need to be managed within the CEMP and CNVIS frameworks and any other relevant conditions.	
D28	Out-Of-Hours Work Protocol – Works Not Subject to an EPL An Out-of-Hours Work Protocol must be prepared to identify a process for the consideration, management and approval of Work which is outside the hours defined in Conditions D24, and that is not subject to an EPL. The Protocol must be approved by the Planning Secretary before commencement of Out-of-Hours Work and implemented for the duration of the Out-of-Hours Work. The Protocol must be prepared in consultation with the ER and must include: (a) justification as to why these Works need to be undertaken as Out-of-Hours Work; (b) identification of low, medium and high-risk activities and an approval process that considers the risk of activities, proposed mitigation, management, and coordination, including where: (i) the ER must review all proposed out-of-hours activities and confirm their risk levels, (ii) low and medium risk activities can be approved by the ER, and (iii) high risk activities that are approved by the Planning Secretary; (c) a process for the consideration of out-of-hours work against the relevant NML and vibration criteria;	N/A

ID	Description	Monitoring Program Reference
Conditions of Approval		
	(d) a process for selecting, justifying and implementing mitigation measures for residual impacts in consultation with the community at each affected location, including respite periods. The measures must take into account the predicted noise levels (based off worst case scenarios and scenarios where mitigation measures will be implemented) and the likely frequency and duration of the out-of-hours works that sensitive land use(s) would be exposed to, including the number of noise awakening events; (e) procedures to facilitate the coordination of out-of-hours work including those approved by an EPL or undertaken by a third party, to ensure appropriate respite is provided; and (f) notification arrangements for affected receivers for approved out-of-hours work and notification to the Planning Secretary of approved low risk out-of-hours works. The Protocol must be submitted to and approved by the Planning Secretary before the commencement of out-of-hours work. The approved Protocol must be implemented for the duration of Work. This condition does not apply if the requirements of Condition D27 (a),(b), (c)(ii) or (d) are met, or if the Work is subject to an EPL or if a negotiated agreement is made with the impacted residents and sensitive land use(s). Notes: 1. If a certain activity or Work is regulated by the EPA via an EPL, the management of the activity or Work should not be co-regulated under the Protocol. The Protocol process should only be used if a certain activity or Work is not covered by an EPL. 2. The risk assessment(s) must be based on a risk assessment carried out in accordance with AS/NZS ISO 31000:2018 "Risk Management".	
D29	Construction Noise Management Levels and Vibration Criteria Mitigation measures must be implemented with the aim of achieving the following noise management levels and vibration objectives: (a) construction 'Noise affected' NMLs established using the Interim Construction Noise Guideline (DECC, 2009); (b) vibration criteria established using the Assessing vibration: a technical guideline (DEC, 2006) (for human exposure); (c) Australian Standard AS 2187.2 - 2006 "Explosives - Storage and Use - Use of Explosives"DEl; (d) BS 7385 Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2" as they are "applicable to Australian conditions"; and (e) the vibration limits set out in the German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures (for structural damage). Work that exceeds the noise management levels and/or vibration criteria must be managed in accordance with the Noise and Vibration CEMP Sub-plan. Note: The ICNG identifies 'particularly annoying' activities that require the addition of 5 dB(A) to the predicted level before comparing to the construction NML.	**Section 4** and **Section 5**

ID	Description	Monitoring Program Reference
Conditions of Approval		
D30	Mitigation measures must be applied when the following residential ground-borne noise levels are exceeded: (a) evening (6:00 pm to 10:00 pm) — internal LAeq(15 minute): 40 dB(A); and (b) night (10:00 pm to 7:00 am) — internal LAeq(15 minute): 35 dB(A). The mitigation measures must be outlined in the Noise and Vibration CEMP Sub-plan, including in any Out-of-Hours Work Protocol, required by Condition D28.	N/A to the Monitoring Program.
D31	Noise generating work in the vicinity of community, religious, educational institutions, noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) resulting in noise levels above the NMLs must not be timetabled during sensitive periods, unless other reasonable arrangements with the affected institutions are made at no cost to the affected institution. Note: Sensitive periods are to be determined in consultation with the affected community, religious, educational institutions, noise and vibration-sensitive businesses, noting that these may change throughout construction.	N/A to the Monitoring Program.
D32	At no time can noise generated by construction result in any employee not associated with the SSI working at a location near the SSI exceed the National Standard for exposure to noise in the occupational environment of an eight-hour (8hr) equivalent continuous A-weighted sound pressure level of LAeq,8h of 85 dB(A)	N/A to the Monitoring Program.
D33	Construction Noise and Vibration Impact Statements (CNVIS) must be prepared for work that may exceed the noise management levels, vibration criteria and/or ground-borne noise levels specified in Condition D29 and Condition D30 at any residence outside construction hours identified in Condition D24, or where receivers will be highly noise affected. The CNVIS must include specific mitigation measures identified for the affected sensitive land use(s) through consultation and the mitigation measures must be implemented for the duration of the work. A copy of the CNVIS must be provided to the ER prior to the commencement of the associated work. A copy/ies of CNVIS must be made available to the Planning Secretary upon request.	N/A to the Monitoring Program.
D34	Construction Vibration Mitigation - Heritage Vibration testing must be undertaken before and during vibration generating activities that could result in damage to heritage items, to identify minimum working distances to prevent cosmetic damage. ln the event that the vibration testing and attended monitoring shows that the preferred values for vibration are likely to be exceeded, the construction methodology must be reviewed and, if necessary, additional mitigation measures implemented.	**Section 6.2**
D35	Advice from the Heritage Consultant nominated under Condition D10 must be sought on methods and locations for installing equipment used for vibration, movement and noise monitoring at heritage-listed structures.	**Section 6.2**

ID	Description	Monitoring Program Reference
Conditions of Approval		
D36	Before installing at-property treatment at any heritage item identified in the documents listed in Condition A1 or identified as a result of Condition D34, the advice of the Heritage Consultant nominated under Condition D10 must be obtained and implemented to ensure any such work does not have an adverse impact on the heritage significance of the item.	No at-property treatment currently proposed.
Submissions Report		
NV02	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared and implemented as part of the CEMP. The plan will: • Identify nearby sensitive receivers • Describe the activities, construction equipment and work hours that will be completed and quantify resulting impacts at sensitive receivers • Include noise and vibration management criteria and relevant licence and approval conditions • Include measures to manage noise and vibration and minimise the potential for impacts during construction, aligned with the results of community consultation, and consistent with the management approach and mitigation measures in the Construction Noise and Vibration Strategy (CNVS) (Transport for NSW, 2019), where reasonable and feasible • Set out the requirements for noise and vibration monitoring • Set out the procedures for handling complaints • Provide details on how respite will be applied where ongoing high impacts are seen at certain receivers in accordance with the CNVS • Include any requirements contained within the Central SSP study and supporting technical documents where applicable. The CNVMP will consider cumulative construction impacts and the likelihood for 'construction fatigue' from consecutive projects in the areas that have substantial night-time work.	N/A to the Monitoring Program.
NV03	Where noise impacts are predicted, the work will be scheduled within standard construction hours, where possible. If it is not possible then the activities will be completed as early as possible in each work shift. ~~Appropriate respite will be introduced in accordance with the CNVS~~.	N/A to the Monitoring Program.
NV04	Specific consultation will be carried out with nearby sensitive health facilities, educational and place of worship receivers. Noise intensive work that is predicted to impact such receivers will be scheduled outside of particularly sensitive periods, such as exams or religious services, where possible. Hotels and temporary accommodation will be included in the consultation where predicted (night-time) noise impacts may affect the amenity of guests.	N/A to the Monitoring Program.
NV05	Monitoring will be carried out at the start of new noise and vibration intensive activities to confirm that actual levels are consistent with the predictions and that appropriate mitigation measures from the CNVS have been implemented.	**Section 7**

ID	Description	Monitoring Program Reference
Conditions of Approval		
NV06	The following measures will be implemented for significant heritage fabric within the Sydney Terminal Building and Central Railway Stations Group heritage area, including the existing rail tunnels and infrastructure, where vibration-generating activities cannot take place without maintaining the safe working distances set out in the CNVS: • Dilapidation/condition surveys will be carried out before and after work. The survey will include details of any structurally elements that are found to be structurally unsounds and/or considered to be particularly sensitive to vibration • Where any structures are considered structurally unsound or particularly sensitive to vibration, the more stringent DIN 4150 (Deutsches Institute fur Normung, 1999) Group 3 guideline values will be applied • Attended vibration monitoring will be carried out at the start of any new vibration intensive work activity that cannot take place at a safe working distance to confirm the vibration levels produced by the equipment are appropriate • Further attended and/or unattended monitoring will be carried out where vibration intensive equipment is being used near structurally unsound infrastructure and/or locations particularly sensitive to vibration • The potential for vibration impacts on heritage structures will be reviewed during detailed design when construction planning is available to verify the assessment.	**Section 6.2**
NV07	The following measures will be implemented to manage noise impacts within the project area: • Schedule noise intensive work for off-peak commuter times when the area is less busy • Use the minimum practical size of equipment, including silenced compressors, generators, and dust extractors, where noisy work is required while the station is open • Use path controls, such as mobile hoarding, to isolate noise intensive activities from publicly accessible locations. This includes work within the Sydney Terminal Building and Eddy Avenue Plaza.	N/A to the Monitoring Program.
NV08	Location and activity-specific noise and vibration impact assessments will be carried out where: • There is the potential to result in noise levels above 75dBA at any sensitive receiver • Work is scheduled outside of standard construction hours and likely to result in noise levels greater than the relevant NML • Activities that have the potential to exceed relevant criteria for vibration. The assessments will confirm the predicted impacts at the relevant receivers to help with the selection of appropriate management measures, consistent with the requirements of the CNVS.	N/A to the Monitoring Program.

1.1 Consultation

This Monitoring Program was provided to and endorsed by the City of Sydney Council in accordance with CoA C9.

1.2 Information Relied On

- *Assessing Vibration: a technical guideline* issued by the Department of Environment and Conservation, dated February 2006 (Vibration Guideline)
- Australian Standard 1055:2018 *Acoustics - Description and Measurement of Environmental Noise* (AS1055)
- British Standard 6472-1992 *Guide to Evaluation of Human Exposure to Vibration in buildings* (BS6472)
- British Standard 7385.2-1993 *Evaluation and measurement for vibration in buildings* (BS7385)
- *Construction and Maintenance Noise Estimator (Roads)* (EMF-NV-TT-0067)
- *Construction Noise and Vibration Guideline* issued by Transport, dated September 2023 (CNVG)
- German Standard 4150-3 *Structural vibration - Effects of vibration on structures* (DIN4150)
- *Sydney Terminal Building Revitalisation Environmental Impact Statement*, dated February 2023, Application No.: SSI-45421960
- *Sydney Terminal Building Revitalisation Conditions of Approval*, dated August 2023, Application No.: SSI-45421960 (CoA)
- *Sydney Terminal Building Revitalisation Noise and Vibration Impact Assessment* issued by Transport, dated February 2023 (NVIA)
- *Sydney Terminal Building Revitalisation Submission Report* issued by Transport, dated August 2023 (Submissions Report)
- *Construction Noise and Vibration Management Plan* prepared by VMS (Ref: 24265.1.2.R1R5), dated 29 July 2025 (CNVMP).
- *Approved methods for the measurement and analysis of environmental noise in NSW*, issued by the NSW EPA, dated January 2022 (Approved Methods).
- *Construction Environmental Management Plan* (Rev E) prepared by Gartner Rose, dated 2 July 2025 (CEMP).

2 Project Overview

2.1 Description of Works

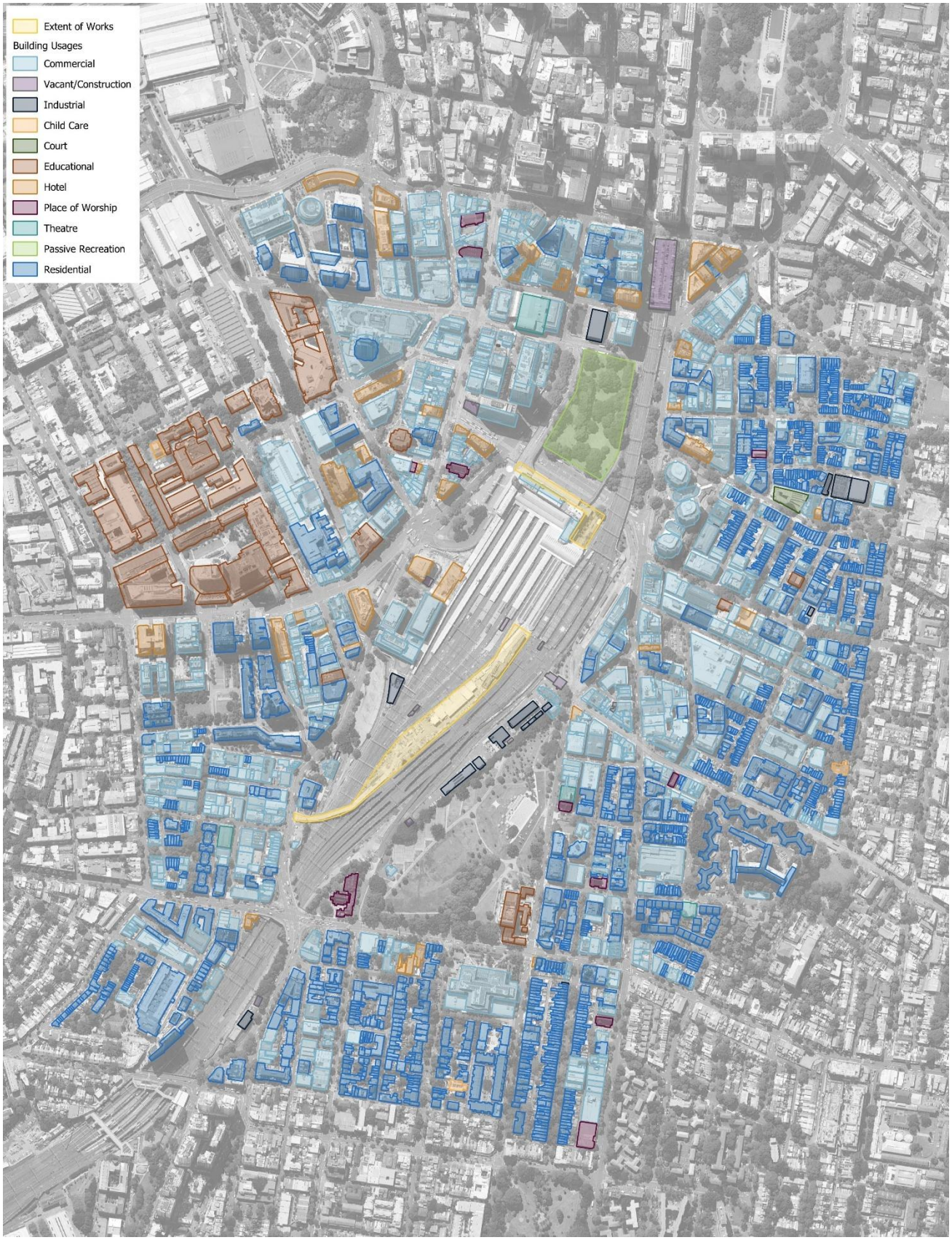
The STBRP incorporates the restoration and revitalisation of the Sydney Terminal Building at Central Station, located in the suburbs of Haymarket and Chippendale, in the City of Sydney local government area.

The Project will be delivered over three phases, summarised below and detailed in **Table 2**:

- Eddy Avenue Plaza:
  - Demolition of existing buildings and ramp.
  - Relocation of hydrant boosters.
  - Major excavation, installation of in-ground services.
  - Construction of new retail buildings, public plaza, lighting, and landscaping.
- Eastern Terrace:
  - Removal and installation of canopies (heritage-sensitive).
  - Installation of glass, steel, and balustrades.
  - Waterproofing, paving, and installation of lighting and CCTV.
- Eastern Avenue Colonnade:
  - Upgrades to paving, services, shopfronts, and ceilings.
  - Works staged in four parts to minimise public disruption.
  - Installation of hard pavement, lighting, and street furniture.

A site plan outlining the extent of works and the locality of the Project with respect to the surrounding environment is presented in **Figure 1**.

Figure 1 Project Site Plan

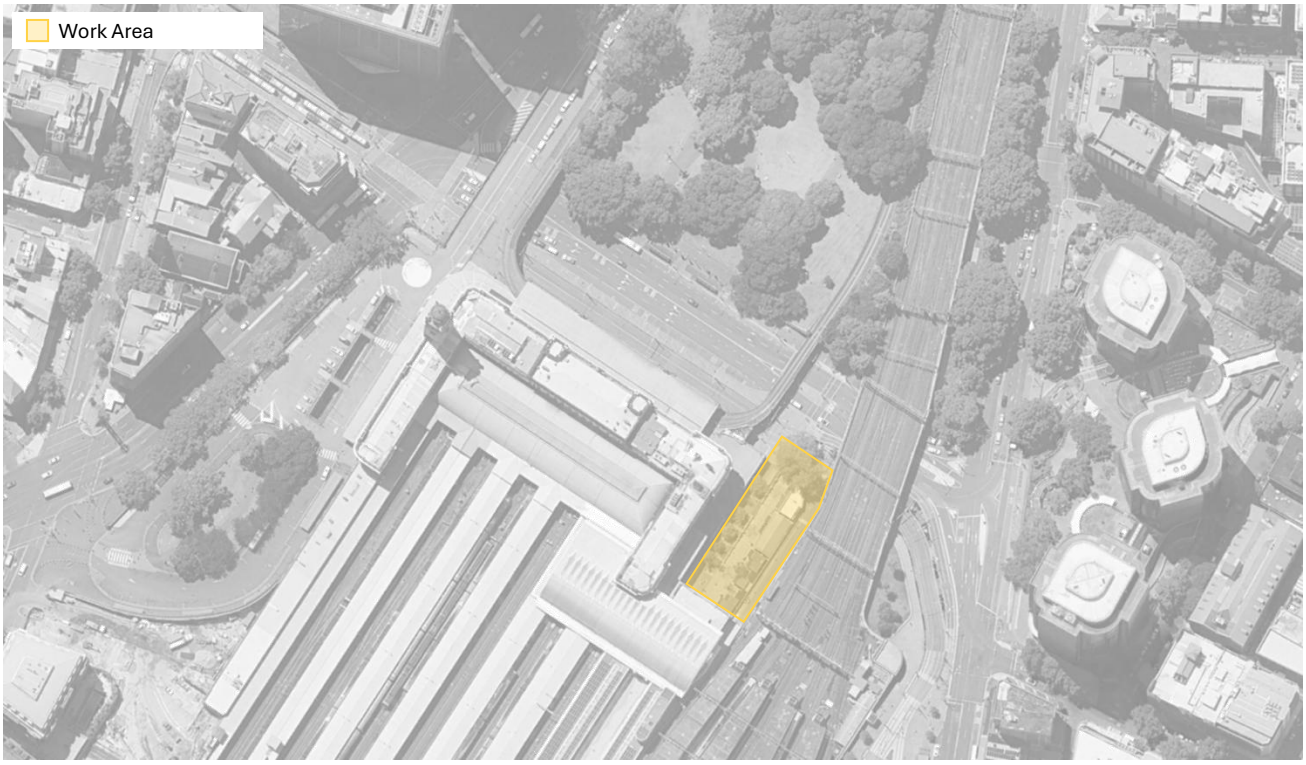


Source: Google Earth (Mark-up by VMS).

Table 2 Works Summary

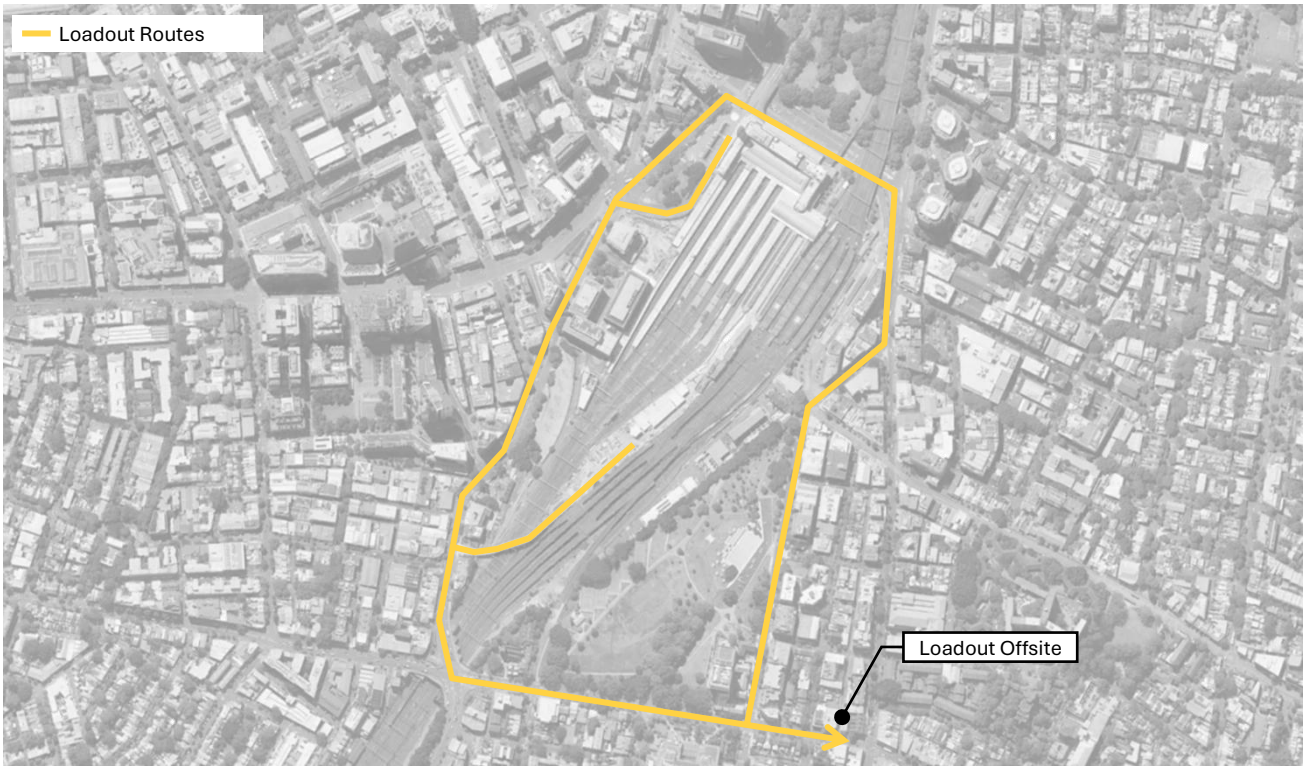
Phase	Date of Works	Works	Work Hours	Location	Work Description
Phase 1 Eddy Avenue Plaza	June 2025 to January 2026	Demolition and Trenching	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Demolition of existing retail buildings, slabs, and plaza concrete pavement in plaza. Utility trenching/install in plaza (Fire Booster relocation). Progressive demolition of existing vehicle access ramp in plaza. Tree removal.
		Spoil Load Out to Sydney Yard	1.00 am to 5.00 am	Between Eddy Plaza and Sydney Yard **Figure 2** **Figure 3** **Figure 4**	Short-haul to Sydney Yard only.
		Spoil Load Out Offsite	4.00 am to 6.00 pm	Sydney Yard **Figure 3** **Figure 4**	From Sydney Yard to off-site tipping facility.
		Rock Anchors	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Underpinning of retaining wall behind ramp.
		Form Reo Pour (FRP)	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Retail building - foundations, base slab, services slab. Plaza - pavement.
				Sydney Yard **Figure 4**	Concrete pumped from Sydney Yard.
		Foundation and Civil Works	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Place and compact material (foundation, subgrade, topsoil). Civil works including stormwater pit and pipe installation, electrical pit and conduit installation, and associated utility works.
		Retail Building Construction	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Craneage and lifting of steel frame components. Steel frame assembly. Trades - plumbing, HVAC, electrical. Fit-out - carpentry, drywall, painting, glazing
Phase 2 Eastern Terrace	September 2025 to February 2026	Eastern Terrace Works	7.00 am to 6.00 pm	Eddy Plaza **Figure 2**	Set up crane with counter-weight trucks.
				Eastern Terrace **Figure 5**	Installation of Class-B Hoarding/Catch-Deck. Break-back of existing footings/connections for awning roof. Removal of existing awning roof. Construction of new footings/connections for awning roof. Installation of new awning roof structure. Installation of new roof sheets. Removal of existing and installation of new pavers/tiling.
Phase 3 Colonnade (Eddy Plaza to Pitt St)	January 2026 to April 2026	Colonnade Works	7.00 am to 6.00 pm	Colonnade **Figure 6**	Install Class-A Hoarding. Pavement: Remove existing asphalt/concrete pavement. Place and compact new material - foundation/subgrade. FRP of new concrete pavement, kerb and driveway. Place new pavers. Shopfronts and ceiling: Refurbishment of existing shopfront facade. Refurbishment of existing colonnade ceiling. Installation of new pendant lighting and associated electrical works.

Figure 2 Eddy Plaza Work Area



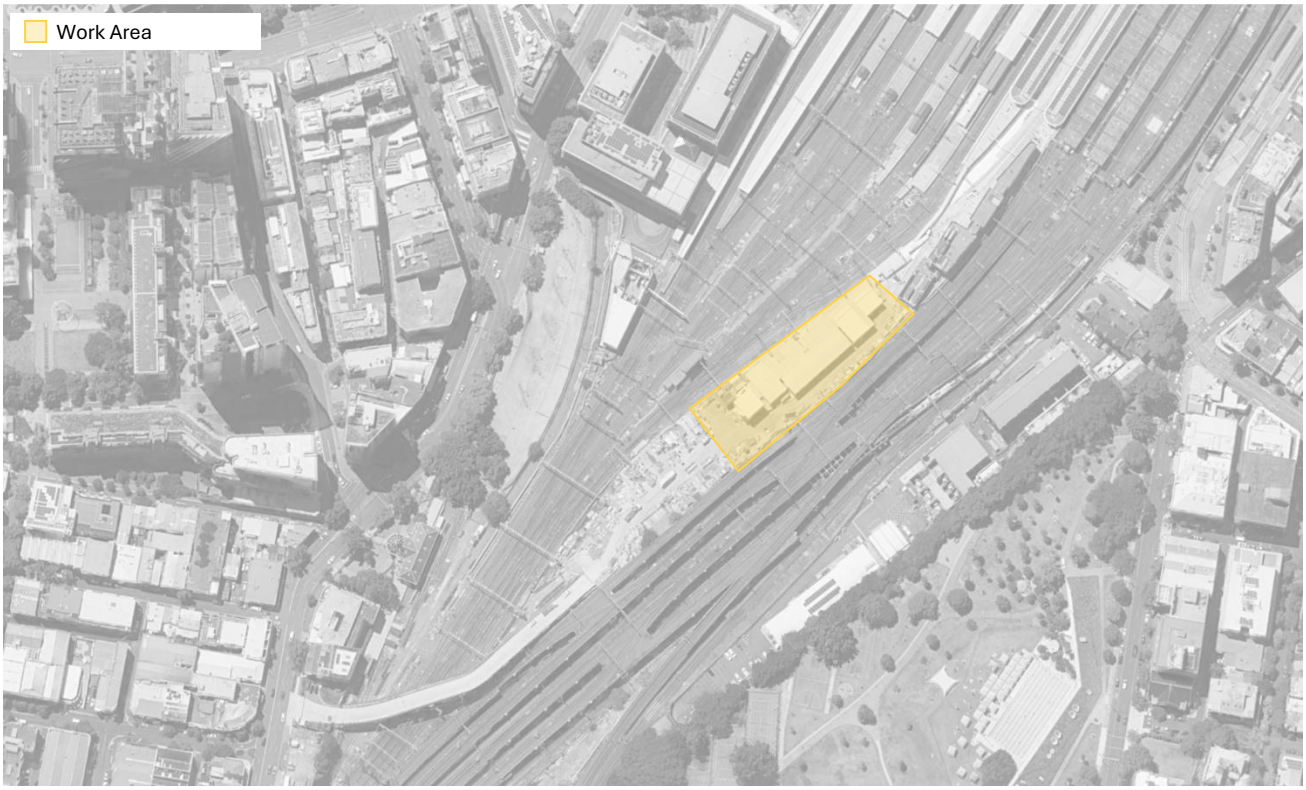
Source: Google Earth (Mark-up by VMS).

Figure 3 Loadout Routes



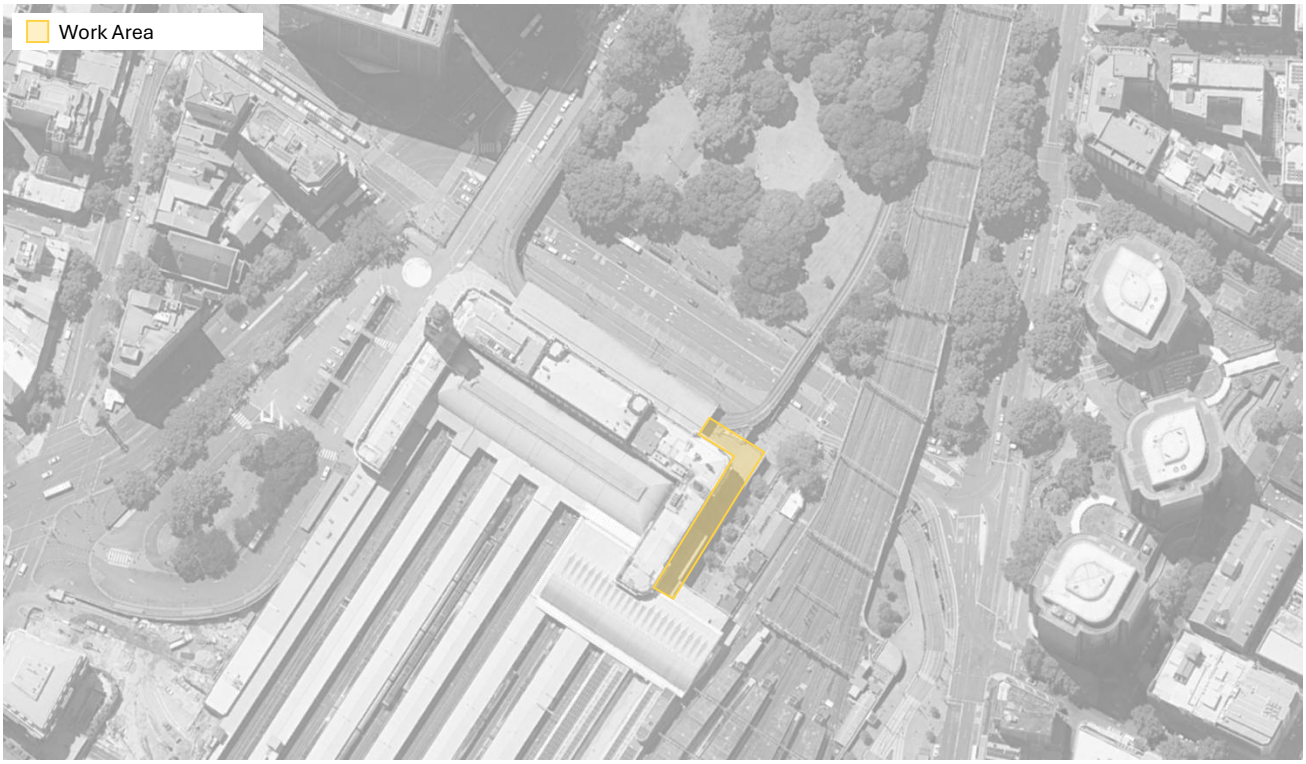
Source: Google Earth (Mark-up by VMS).

Figure 4 Sydney Yard Work Area



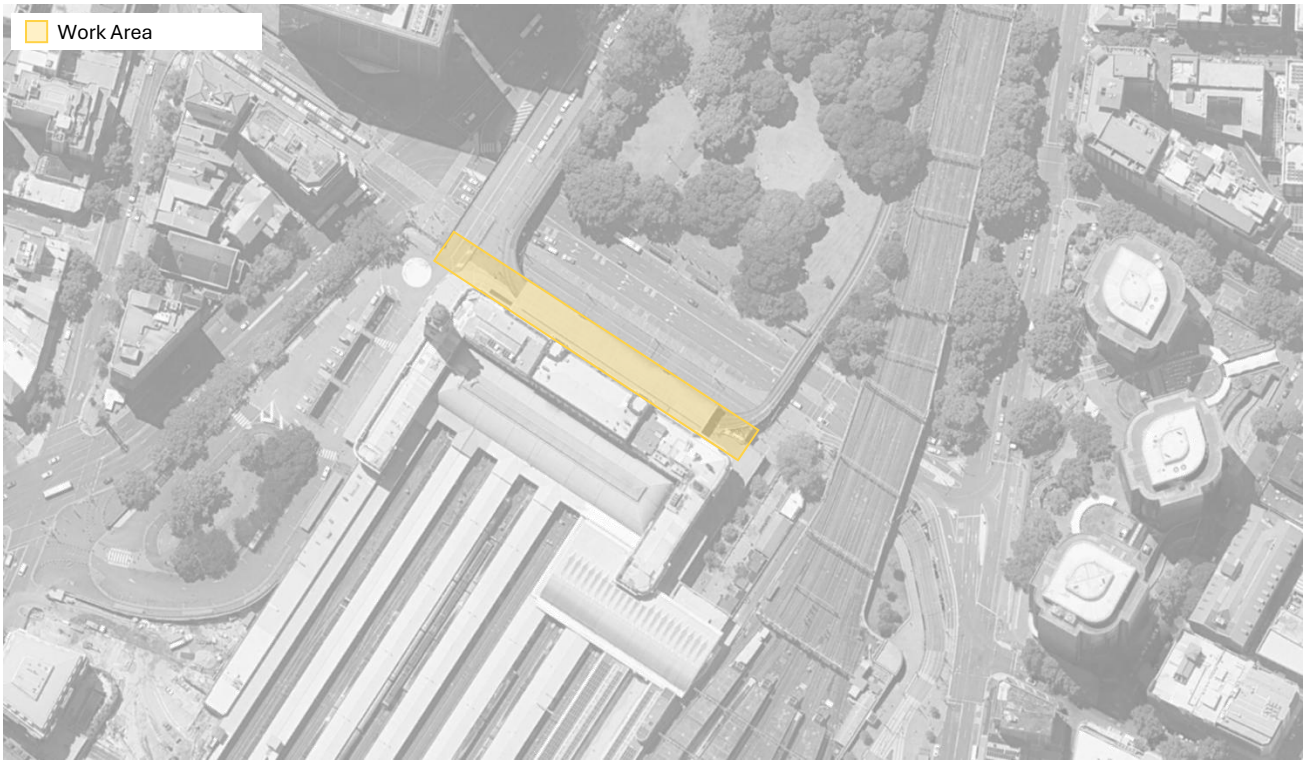
Source: Google Earth (Mark-up by VMS).

Figure 5 Eastern Terrace Work Area



Source: Google Earth (Mark-up by VMS).

Figure 6 Colonnade Work Area



Source: Google Earth (Mark-up by VMS).

2.2 Construction Hours

Standard construction hours are established in CoA D24 as reproduced below.

> *"Work Hours*
>
> *D24 Work must be undertaken during the following hours:*
>
> *(a) 7:00am to 6:00pm Mondays to Fridays, inclusive;*
>
> *(b) 8:00am to 6:00pm Saturdays; and*
>
> *(c) at no time on Sundays or public holidays."*

In accordance with the standard construction hours outlined in CoA D24 and the ICNG, project construction hours are outlined in **Table 3**.

Table 3 Project Construction Hours

Hour Commencing	12.00 am	1.00 am	2.00 am	3.00 am	4.00 am	5.00 am	6.00 am	7.00 am	8.00 am	9.00 am	10.00 am	11.00 am	12.00 pm	1.00 pm	2.00 pm	3.00 pm	4.00 pm	5.00 pm	6.00 pm	7.00 pm	8.00 pm	9.00 pm	10.00 pm	11.00 pm
Monday																								
Tuesday																								
Wednesday				OOHW								Standard								OOHW				
Thursday				Period 2								Hours								Period 1				
Friday																				Evening				
Saturday																								
Sunday									OOHW Period 1											OOHW				
Public Holiday									Day											Period 2				

As noted in **Table 2**, works are proposed to take place predominantly during standard construction hours except for spoil loadout activities which may take place during OOHW Period 2 as permitted via CoA D27.

3 Existing Noise Environment and Receivers

3.1 Noise Catchment Areas

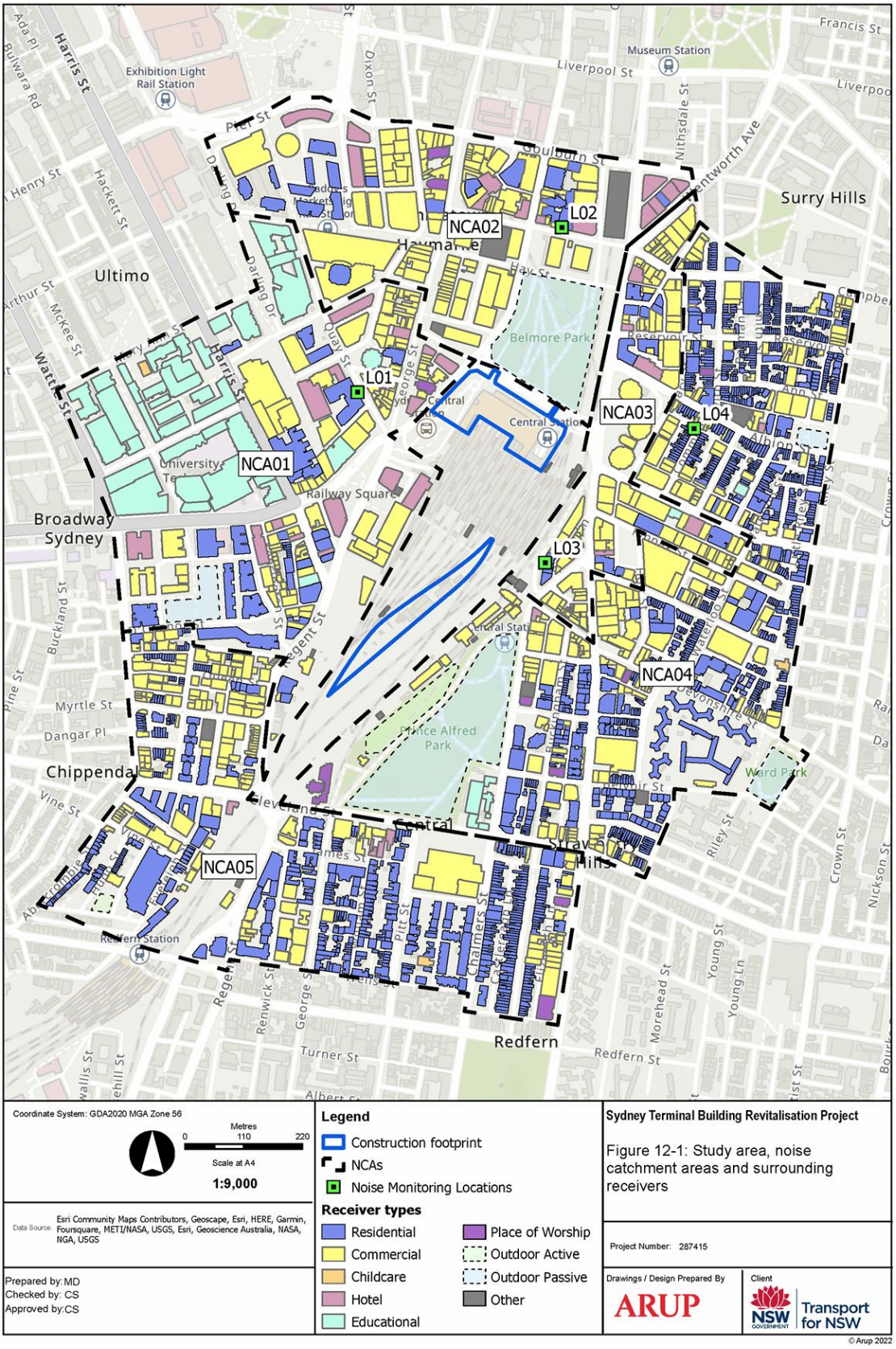
Five Noise Catchment Areas (NCAs) are established in the NVIA and are described in **Table 4** and presented in **Figure 7**.

Table 4 Noise Catchment Areas

NCA	Description
NCA01	The closest receivers are generally commercial, but the NCA also includes several hotels and places of worship. Key receivers in the NCA are TAFE NSW Ultimo and University of Sydney, which occupy a large part of the NCA further to the west. The closest residences are in apartments around 150 metres away on Geroge Street. As they live close to Central Station it is often noisy due to the activity in the area.
NCA02	The closest receivers are generally commercial, but the NCA also includes Belmore Park directly to the north and the Capitol Theatre around 200 metres away. The closest residences are in apartments around 300 metres away on Campbell Street. Again, because these residents live close to Central Station and on a main road, it is often noisy due to the activity in the area.
NCA03	The closest receivers are generally commercial. The closest residences are in apartments around 150 metres northeast on Elizabeth Street and southeast on Chalmers Street. Their proximity to Central Station means they live in a noisy area.
NCA04	The feature of this NCA is the low-density residential housing setback from Central Station and shielded by high-rise buildings in NCA03. The closest residences are around 250 metres away and live in a quieter neighbourhood setting away from Central Station.
NCA05	This NCA is away from Central Station and closer to the Sydney Trains Yard construction compound. The closest residences are around 150 metres away from the Sydney Trains Yard and 600 metres from the main project area and are located in a quieter area because they are further away from the activity around the CBD and Central Station.

Source: NVIA.

Figure 7 Noise Catchment Areas



Source: NVIA.

3.2 Unattended Noise Monitoring

Unattended noise monitoring was conducted by ARUP between October and November 2022 with background levels presented in the NVIA.

A total of four locations were monitored, as identified in **Table 5** and **Figure 7**, with background levels summarised in **Table 5**.

Background levels are referenced to establish airborne NMLs for residential receivers within each NCA in **Section 5**.

Table 5 Unattended Noise Monitoring Results

NCA	Address and Monitoring ID	Measured Noise Levels, dBA					
		Background Noise (RBL)			Average Noise (L_{eq})		
		Day	Evening	Night	Day	Evening	Night
NCA01	107-121 Quay Street, Haymarket (L01)	57	57	50	64	63	60
NCA02	303-321 Castlereagh Street, Haymarket (L02)	59	58	53	62	61	59
NCA03	38 Chalmers Street, Surry Hills (L03)	53	53	48	61	61	59
NCA04	201 Commonwealth Street, Surry Hills (L04)	50	49	44	59	57	55

Source: NVIA.

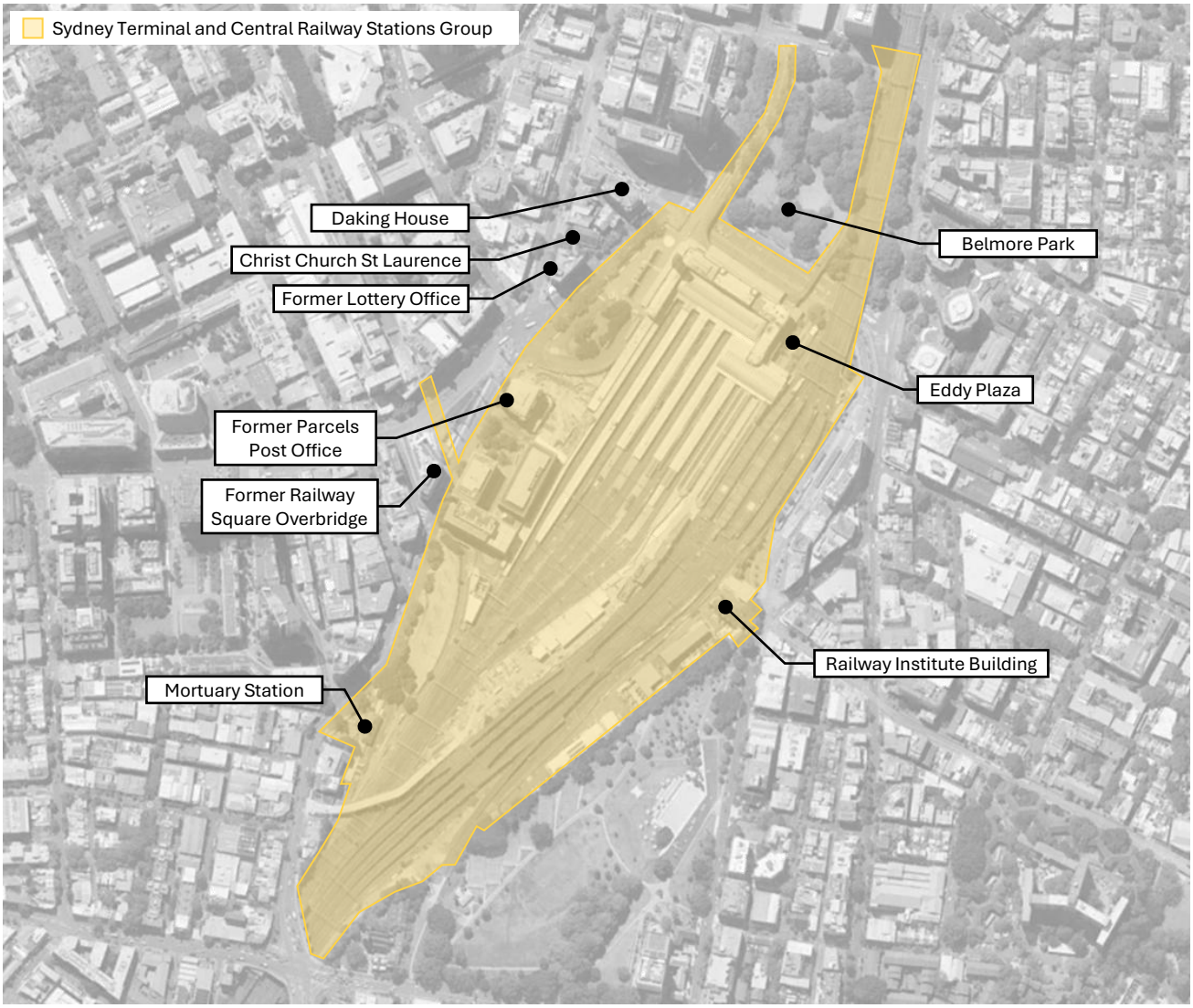
3.3 Sensitive Receivers

Potential noise and vibration impacts are assessed to the sensitive receivers surrounding the proposed works as illustrated in **Figure 1**.

3.3.1 Vibration Sensitive Heritage Receivers

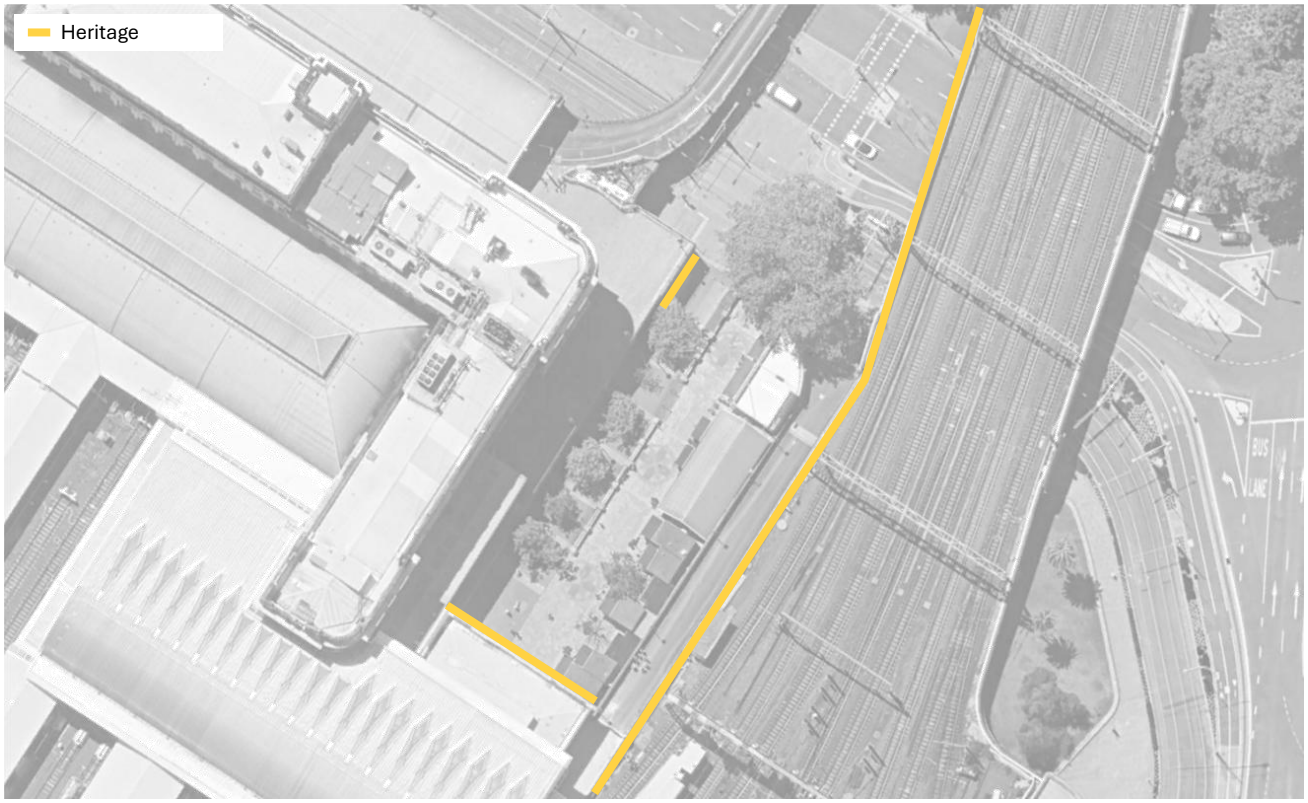
Heritage structures in proximity to works are illustrated in **Figure 8** and **Figure 9**.

Figure 8 Heritage Structures



Source: Contractor (Mark-up by VMS).

Figure 9 Heritage Structures - Eddy Plaza



Source: Google Earth (Mark-up by VMS).

4 Construction Noise and Vibration Criteria

4.1 Construction Noise Criteria

Noise impacts are assessed in accordance with the CNVG, which does not outline specific numerical objectives and rather focuses on the application of mitigation measures to minimise noise impacts based on an exceedance of the Rating Background Level (RBL) or Noise Management Level (NML).

Therefore, no quantitative construction noise criteria are applicable to the Project. NMLs are established in **Section 5**.

4.2 Construction Vibration Criteria

The two main aspects considered relevant by VMS regarding construction vibration with reference to the NIVA are:

- Human Comfort: Potential annoyance to the occupants of buildings due to vibration impinging on the structure.
- Cosmetic Damage: Potential damage to buildings and structures directly from vibration impinging on the structure.

For the management of human comfort, the NVIA refers to the EPA's Vibration Guideline with criteria provided for intermittent vibration based on a Vibration Dose Value (VDV) as reproduced in **Table 6**. To allow for the same vibration parameter to be used across human comfort and building damage, equivalent velocity levels (PPV, mm/s) are presented in **Table 6** with reference to the EPA's Vibration Guideline. Criteria for continuous and impulsive vibration, as outlined in the NVIA, are provided in **Table 7**. A range between preferred and maximum is provided where all reasonable and feasible mitigation measures should be implemented with the aim of meeting preferred values. In the event that maximum Vibration Management Levels are exceeded, Additional Mitigation Measures (AMM) are to be implemented in accordance with the CNVG.

Table 6 Human Comfort Vibration Management Levels - Intermittent

Place and Time	Preferred Value		Maximum Value	
	VDV[1]	PPV[2]	VDV[1]	PPV[2]
Residential buildings (day)	0.2 $m/s^{1.75}$	0.28 mm/s	0.4 $m/s^{1.75}$	0.56 mm/s
Residential buildings (night)	0.13 $m/s^{1.75}$	0.2 mm/s	0.26 $m/s^{1.75}$	0.4 mm/s
Offices, schools, educational institutions, places of worship (anytime)[3]	0.4 $m/s^{1.75}$	0.56 mm/s	0.8 $m/s^{1.75}$	1.1 mm/s
Workshops (anytime)[4]	0.8 $m/s^{1.75}$	1.1 mm/s	1.6 $m/s^{1.75}$	2.2 mm/s

Note 1: VDV management level.

Note 2: Continuous vibration management level.

Note 3: In the absence of specific levels, assumed by VMS to be used for commercial spaces.

Note 4: In the absence of specific levels, assumed by VMS to be used for industrial spaces.

Table 7 Human Comfort Vibration Management Levels - Continuous and Impulsive

Location	Assessment Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration					
Critical Working Areas	Day or night-time	0.0050 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residential	Daytime	0.010 m/s^2	0.0072 m/s^2	0.020 m/s^2	0.014 m/s^2
	Night-time	0.007 m/s^2	0.005 m/s^2	0.014 m/s^2	0.010 m/s^2
Offices, schools, educational institutions and places of worship	Day or night-time	0.020 m/s^2	0.014 m/s^2	0.040 m/s^2	0.028 m/s^2
Workshops	Day or night-time	0.04 m/s^2	0.029 m/s^2	0.080 m/s^2	0.058 m/s^2
Impulsive Vibration					
Critical working areas[1]	Day or night-time	0.0050 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residential	Daytime	0.30 m/s^2	0.21 m/s^2	0.60 m/s^2	0.42 m/s^2
	Night-time	0.10 m/s^2	0.071 m/s^2	0.20 m/s^2	0.14 m/s^2

Offices, schools, educational institutions and places of worship	Day or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Workshops	Day or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2

Source: NVIA.

Note 1: Such as operating theatres or precision laboratories where sensitive operations are occurring.

For the assessment of potential damage to buildings and structures, the NVIA considers German Standard DIN 4150-3:2016, *Structural vibration - Effects of vibration on structures* (**Table 8**), and British Standard BS 7385.2-1993 *Evaluation and measurement for vibration in buildings* (**Table 9**). DIN4150-3 provides more conservative maximum vibration values for short-term vibration and therefore will be adopted in the first instance.

Table 8 Vibration Screening Criteria for Cosmetic Damage - DIN 4150

Line	Type of Structure	Guideline Values Vibration Velocity (mm/s)				
		Foundation, All Directions at a Frequency of			Topmost Floor, Horizontal	Floor Slabs, Vertical
		1 - 10 Hz	10 - 50 Hz	50 - 100 Hz[1]	All Frequencies	All Frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 - 40	40 - 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy.	5	5 - 15	15 - 20	15	20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under the lines above and are of great intrinsic value (e.g. listed buildings)	3	3 - 8	8 - 10	8	20[2]

Note 1: At frequencies above 100 Hz, the guideline values for 100 Hz can be applied as minimum values.

Note 2: In the case of building types as in Line 3, it may be necessary to lower the relevant guideline value to prevent minor damage.

Table 9 Vibration Screening Criteria for Cosmetic Damage - BS 7385.2

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

Note: Values referred to are at the base of the building.

It is noted that in accordance with both BS 7385.2 and the NVIA, heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound following a building condition inspection. As per the NVIA, if heritage structures are found to be unsound, DIN 4150-3 Line 3 values presented in **Table 8** may be applied.

5 Management Levels

5.1 Construction Noise Management Levels

NMLs for receivers potentially impacted by works are nominated in the NVIA and established based on the existing noise environment, summarised **Table 5**, and the construction hours outlined in **Table 3**. NMLs are reproduced in **Table 10**.

The Highly Noise Affected (HNA) level of 75 dBA, defined in the CNVG as the level above which there may be strong community reaction to noise, is also considered.

Table 10 Construction Noise Management Levels - Airborne Noise from On-Site Works

Receiver Type	Noise Management Level[1] - $L_{eq(15\ minute)}$ dBA				Sleep Disturbance - L_{max} dBA		HNA[2] - $L_{eq(15\ minute)}$ dBA
Residential Receivers	Standard Hours (RBL + 10 dBA)	OOH (RBL + 5 dBA)			Screening Level[6]	Awakening Reaction[7]	
		Day[3]	Evening[4]	Night[5]			
NCA01	67	62	62	55	65	75	75
NCA02	69	64	63	58	68	75	75
NCA03	63	58	58	53	63	75	75
NCA04	60	55	54	49	59	65	75
NCA05	60	55	54	49	59	65	75
Other Sensitive Receivers							
Hotel - Day and Evening	70						
Hotel - Night	60						
Commercial	70						
Industrial	75						
Educational	55						
Places of Worship	55						
Active Recreation	65						
Passive Recreation	60						

Note 1: Applied externally for residential receivers and external and when in use for other sensitive receivers.

Note 2: Applies during Standard Hours only.

Note 3: Daytime out of hours is defined as 7.00 am to 8.00 am Saturday, and 8.00 am to 6.00 pm on Sunday and public holidays.

Note 4: Evening hours are defined as 6.00 pm to 10.00 pm.

Note 5: Night hours are defined as 10.00 pm to 7.00 am Monday to Saturday and 10.00 pm to 8.00 am on Sunday.

Note 6: Represents sleep disturbance screening level based on 52 dBA or RBL + 15 dB, whichever is greater.

Note 7: In accordance with the NVIA, the awakening reaction level is based on 55 dBA internal level with a 20 dB facade loss applied for buildings in NCA01, NCA02 and NCA03 (apartment buildings in a relatively high existing noise environment) and a 10 dB facade loss for open windows for receivers in NCA04 and NCA05 (includes low density residential receivers).

Construction noise level predictions and subsequent mitigation measurements have been implemented with consideration of construction methodologies and NMLs presented in **Table 10**. Predicted noise levels are outlined in the CNVMP. Where monitoring is required, construction noise levels are to me monitored to ensure predicted levels are not exceeded.

Noise Management Notification Levels are also outlined in **Table 11**.

Table 11 Noise Management Notification Levels

Structure Type	Noise Notification[1] (dBA)	
	Level 1	Level 2
All	Predicted Level[2] - 5	Predicted Level[2]

Note 1: Noise Notification Levels correspond to the noise level at which local flashing lights/sirens are activated and/or nominated personnel are notified via SMS and/or email.

Note 2: Where predicted levels are below NML, NML - 5 and NML are to be applied for notification level 1 and level 2, respectively.

A trigger of Notification Level 1 ("Warning Level") would require the site activity to proceed with caution considering the number of plant and work intensity.

A trigger of Notification Level 2 ("Exceedance Level") would require the implementation of all reasonable and feasible measures to reduce Project noise emissions and application of AMMs as detailed in **Section 7** if relevant.

5.2 Vibration Management Levels

To indicate compliance with the vibration criteria, minimum working distances as outlined in Transport's *Construction and Maintenance Noise Estimator (Roads)* (EMF-NV-TT-0067) are to be applied (reproduced in **Table 12** below).

Table 12 Recommended Minimum Working Distances

Plant Item	Rating/Description	Minimum Working Distance		
		Cosmetic Damage		Human Comfort
		Light-framed structure (BS 7385)	Heritage and other sensitive structures (DIN 4150)	EPA's Vibration Guideline
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	14 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	16 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	33 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	41 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	54 m	100 m
	> 300 kN (> 18 tonnes)	25 m	68 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	5 m	7 m
Medium Hydraulic Hammer	(900 kg - 12 to 18t excavator)	7 m	19 m	23 m

Large Hydraulic Hammer	(1600 kg - 18 to 34t excavator)	22 m	60 m	73 m
Vibratory Pile Driver	Sheet piles	20 m	50 m	100 m
Pile Boring	≤ 800 mm	2 m (nominal)	5 m	7 m
Jackhammer	Handheld	1 m (nominal)	2 m	3 m
Profiler	Wirtgen W210	4 m	-	-
Asphalt Paver	Vogele Super 1800-3	1 m	-	-
Steel Drum Roller	Hamm HD70 (Oscillating Mode)	2 m	-	-
Steel Drum Roller	Hamm HD70 (Static Mode)	1 m	-	-

5.2.1 Human Comfort

Where required, human comfort is to be initially assessed via a screening assessment involving attended vibration monitoring at the impacted receiver. The screening assessment is to assess vibration against the maximum PPV values outlined in **Table 6**.

Where measured levels are below maximum PPV values, no further action is required. Where measured levels are above maximum PPV values, unattended monitoring in accordance with the following will be required.

Vibration levels are to be assessed against the project-specific Human Comfort Control Levels (HCCL) presented in **Table 13** based on the VDV levels outlined in **Table 6**. Vibration Management Notification Levels are also outlined in **Table 13**.

Table 13 Vibration Management Notification and Human Comfort Control Levels

Structure Type	Vibration Notification[1]		Assessment Requirements
	Level 1	Level 2	HCCL (VDV)
Residential buildings (day)	0.2 $m/s^{1.75}$	0.4 $m/s^{1.75}$	0.4 $m/s^{1.75}$
Residential buildings (night)	0.13 $m/s^{1.75}$	0.26 $m/s^{1.75}$	0.26 $m/s^{1.75}$
Offices, schools, educational institutions, places of worship (anytime)[2]	0.4 $m/s^{1.75}$	0.8 $m/s^{1.75}$	0.8 $m/s^{1.75}$

Note 1: Vibration Notification Levels correspond to the vibration level at which local flashing lights/sirens are activated and/or nominated personnel are notified via SMS and/or email.

Note 2: In the absence of specific levels, assumed by VMS to be used for commercial spaces.

A trigger of Notification Level 1 ("Warning Level") indicates that 50% of the HCCL has been reached. Note, the VDV value will accumulate throughout the day. Therefore, if more than 50% of vibration-intensive works have been completed at the time of the Level 1 Notification, no further action is required. If less than 50% of vibration-intensive works have been completed, works should proceed with caution, or alternative methods should be applied where feasible and reasonable.

A trigger of Notification Level 2 ("Exceedance Level") indicates that the HCCL has been exceeded. Works are to apply all feasible and reasonable measures to reduce vibration impacts. Apply AMMs as detailed in **Section 7** if relevant.

5.2.2 Cosmetic Damage

Where works are to take place within the cosmetic damage minimum working distances outlined in **Table 12**, unattended vibration monitoring is to take place at the impacted receivers. Project-specific Vibration Damage Control Levels (VDCL) and Vibration Management Notification Levels have been nominated and are presented in **Table 14** with reference to the vibration criteria established in **Section 4.2**.

Table 14 Vibration Management Notification and Damage Control Levels

Structure Type	Vibration Notification[1]		Assessment Requirements
	Level 1	Level 2	VDCL
Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	15 mm/s	20 mm/s	**DIN4150.3-2016 - Line 1** 20 mm/s (1 Hz to 10 Hz) 20 mm/s to 40 mm/s (10 Hz to 50 Hz) 40 mm/s to 50 mm/s (50 Hz to 100 Hz and above)
Residential buildings and buildings of similar design and/or occupancy.	4 mm/s	5 mm/s	**DIN4150.3-2016 - Line 2** 5 mm/s (1 Hz to 10 Hz) 5 mm/s to 15 mm/s (10 Hz to 50 Hz) 15 mm/s to 20 mm/s (50 Hz to 100 Hz and above)
Structures that, because of their particular sensitivity to vibration, cannot be classified under the lines above and are of great intrinsic value (e.g. listed buildings) (Heritage)	2 mm/s	3 mm/s	**DIN4150.3-2016 - Line 3** 3 mm/s (1 Hz to 10 Hz) 3 mm/s to 8 mm/s (10 Hz to 50 Hz) 8 mm/s to 10 mm/s (50 Hz to 100 Hz and above)

Note 1: Vibration Notification Levels correspond to the vibration level at which local flashing lights/sirens are activated and/or nominated personnel are notified via SMS and/or email.

A trigger of Notification Level 1 ("Warning Level") would require the site activity to proceed with caution at reduced force or load.

A trigger of Notification Level 2 ("Halt Level") would require the implementation of alternative techniques pending further analysis of the vibration frequency content in order to determine any potential exceedance of the Vibration Damage Control Levels. Apply AMMs as detailed in **Section 7** if relevant.

6 Noise and Vibration Monitoring Procedure

6.1 Noise Monitoring

Noise monitoring is to be undertaken:

- Attended monitoring during the commencement of new noise intensive activities, i.e. the start of any works exceeding NML represented as a new scenario as per the CNVMP in accordance with NV05 and CoA C9.
- Attended monitoring to satisfy the Verification Monitoring requirements outlined in the CNVMP.
- Attended or unattended monitoring throughout the construction period in accordance with Mitigation Measure NV05 and CoA C9.

Unless otherwise specified above, noise monitoring for only the worst affected residences in accordance with CoA C9 is considered necessary. Nevertheless, noise monitoring for the nearest commercial receivers is recommended wherever reasonable.

Provided the very high background noise level in the area, it may be appropriate for monitoring to take place adjacent to the construction site. Where construction noise is below predicted noise levels at the noise monitoring location, compliance with predicted levels may be inferred at other sensitive receiver locations.

Noise monitoring requirements may be met with attended monitoring and/or unattended monitoring as detailed in the following sections.

6.1.1 Attended Noise Monitoring

Attended noise monitoring shall be undertaken by suitably qualified persons in accordance with Transport (and EPA) requirements.

Mitigation Measure NV05, CoA C9, and Verification Monitoring requirements in the CNVMP may be satisfied by conducting attended monitoring in accordance with the following:

- Attended monitoring is to take place at the commencement of new noise and intensive activities, i.e. the start of any works exceeding NML represented as a new scenario in accordance with the CNVMP in accordance with Mitigation Measure NV05. Confirmation is to be made that appropriate mitigation measures from the CNVG have been implemented.
- Attended monitoring is to take place during the commencement of worst-case Colonnade works during standard hours in accordance with the AMM trigger of Verification Monitoring as outlined in the CNVMP. Worst-case works are identified to involve the use of either or both demo saws and hydraulic hammers. Verification Monitoring is triggered at the below receivers:
    - Colonnade Commercial Receivers
    - Belmore Park

- Attended monitoring may take place during the day, evening and night-time periods (if works are being conducted during these periods) at least once a month for 15 minutes continuously at each allocated monitoring location in accordance with CoA C9.
    - For new noise intensive OOHWs, considering the higher sensitivity of receivers and lower NMLs during these periods, periodic attended monitoring conducted to address CoA C9 is to take place at least once a week, with monitoring to take place for 30 minutes continuously (2 x consecutive 15 minute periods) at each allocated monitoring location. Weekly attended monitoring is to take place for one month. Following the initial one month period, provided measured construction noise is below predicted levels, attended monitoring may be reverted to the initial requirements of monthly 15 minute monitoring.
    - Where attended monitoring indicates construction noise is consistently (minimum 4 months) 10 dB or more below predicted levels, attended monitoring frequency may be reduced to quarterly to satisfy CoA C9.

During attended monitoring, typical maximum noise levels associated with particular operations and/or plant items will be noted. Where possible, extraneous noise events will be excluded from the results or highlighted in accompanying notes.

Equipment and methods are to comply with EPAs Approved Methods. The parameters to be measured will be, at minimum, the L_{A90}, L_{A10}, L_{Amax} and L_{Aeq} evaluated over a 15-minute period.

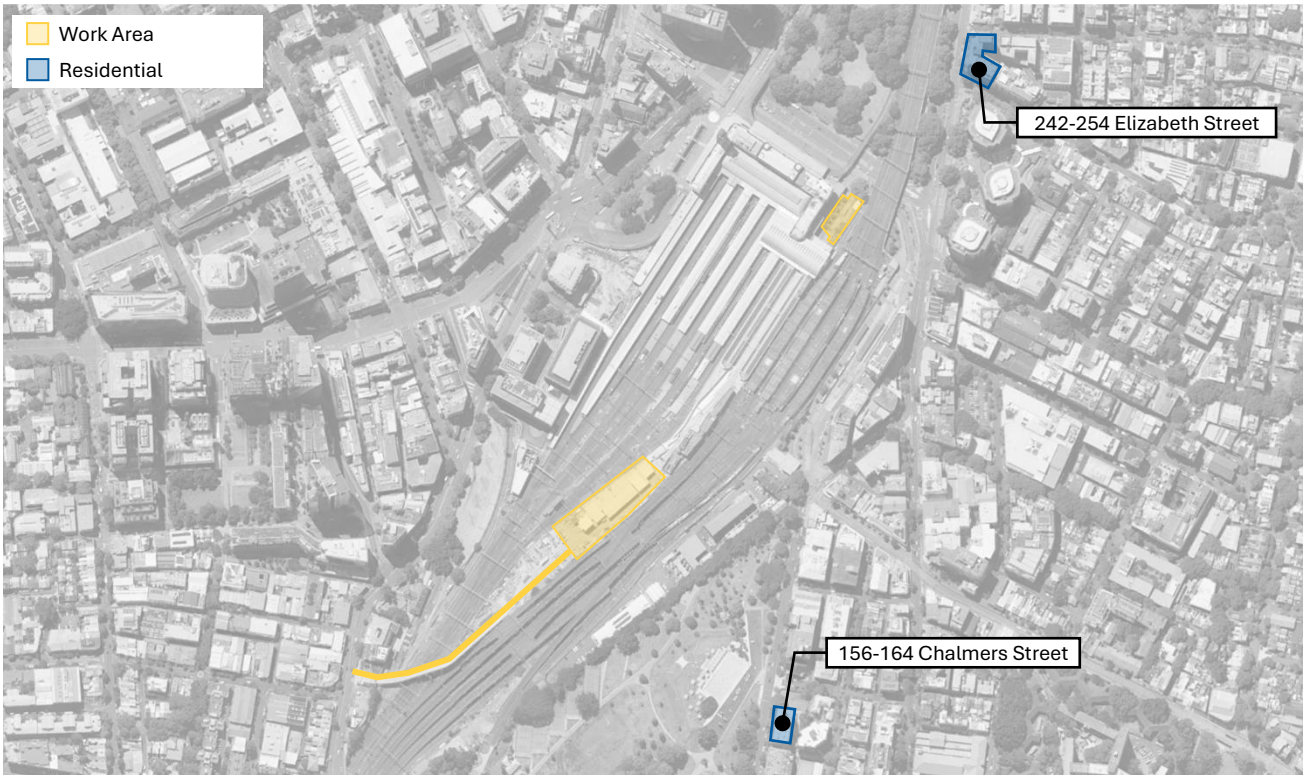
6.1.2 Attended Noise Monitoring Locations

In accordance with CoA C9, monitoring is to take place at the worst affected residences. Worst affected residences are outlined in **Figure 11** and **Figure 10**. These locations are also consider applicable for attended monitoring conducted in accordance with Mitigation Measure NV05. Where on-site observations indicate worst-case impacts are experienced at a receiver not outlined in **Figure 11** and **Figure 10**, monitoring is to be conducted for this receiver instead.

For Verification Monitoring triggered during Colonnade works in accordance with the CNVMP, monitoring is to take place at the non-residential receivers outlined in **Figure 12**.

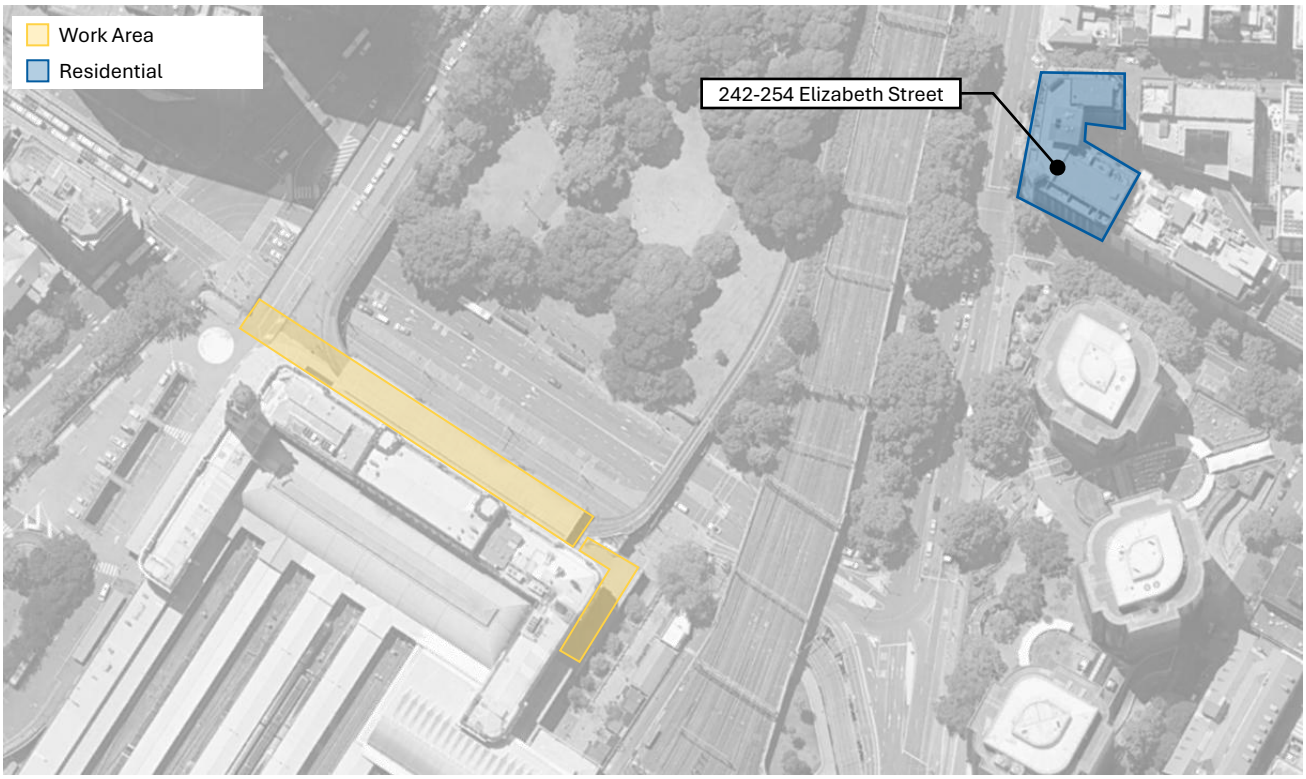
Where project related noise is indistinguishable due to high background noise levels, monitoring may be undertaken at an alternative location where measured levels are used to calculate impacts to receivers of interest. This may be determined on a case-by-case basis.

Figure 10 Worst Affected Residents - Phase 1



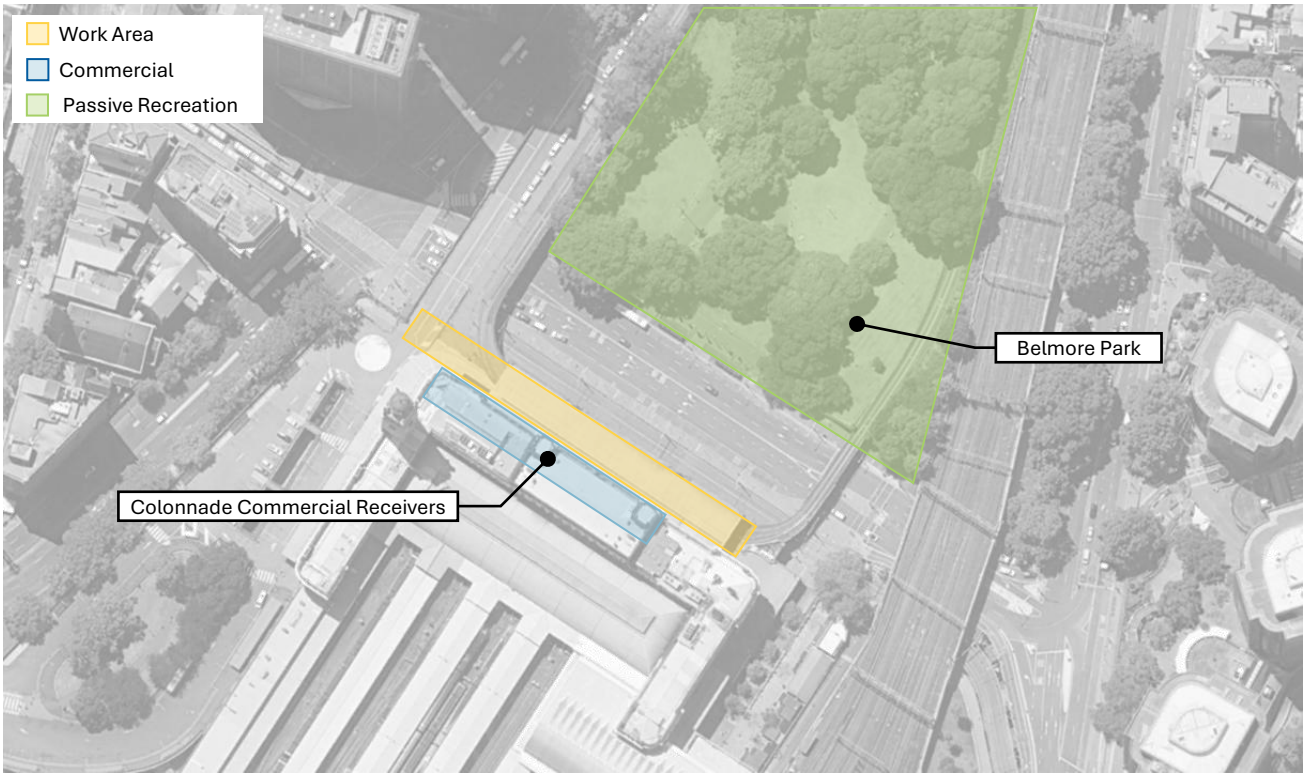
Source: Google Earth (Mark-up by VMS).

Figure 11 Worst Affected Residents - Phase 2 and 3



Source: Google Earth (Mark-up by VMS).

Figure 12 Receivers Triggering Verification Monitoring



Source: Google Earth (Mark-up by VMS).

6.1.3 Unattended Noise Monitoring

The requirement for noise monitoring throughout the construction period in accordance with CoA C9 may be satisfied with continuous unattended monitoring.

Noise monitoring for the construction works would be undertaken using statistical noise loggers. This monitoring would be supplemented by attended monitoring (where necessary) in order to differentiate between construction noise sources and other sources (such as road traffic and pedestrian noise) and also in order to observe and identify any abnormally noisy excavation equipment or operations.

Following an initial monitoring period, recommendations on subsequent unattended monitoring locations may be made, dependent upon the degree of impact on surrounding sensitive receiver locations.

Equipment and methods are to comply with EPAs Approved Methods. The parameters to be measured will be, at minimum, the L_{A90}, L_{A10}, L_{Amax} and L_{Aeq} evaluated over consecutive 15-minute periods.

Noise monitoring equipment is to be set so that an SMS/email notification is sent to relevant parties when noise from noise generating works, or any other activity, exceeds the levels shown in **Table 11**.

6.1.4 Unattended Noise Monitoring Locations

Due to the likely high contribution of ambient noise at residential receivers, alternative monitoring locations in close proximity to works are recommended. Noise monitors are proposed to be located within site below hoarding for ease of deployment, equipment safety, and to further reduce ambient noise contributions. Noise monitoring locations may be revised during deployment provided there is sufficient justification. Noise monitors should be located as far as possible from construction activities (while ensuing minimal ambient noise contribution) as to avoid heightened levels due to nearfield activities, and as a result monitors may be located near or on reflecting surfaces such as hoarding. Where a noise monitor is located with 2 m from a reflecting surface, a 2 dB addition to the Noise Management Notification Level is to be applied to adjust for the presence of the reflecting surface.

Where deploying noise monitors at alternative locations, a transfer function is to be established and applied to the Noise Management Notification Levels of the noise monitor such that updated notification levels at the monitoring location represent an assessment of noise levels against notification levels outlined in **Table 11** at the receiver. Transfer functions may be validated during attended monitoring.

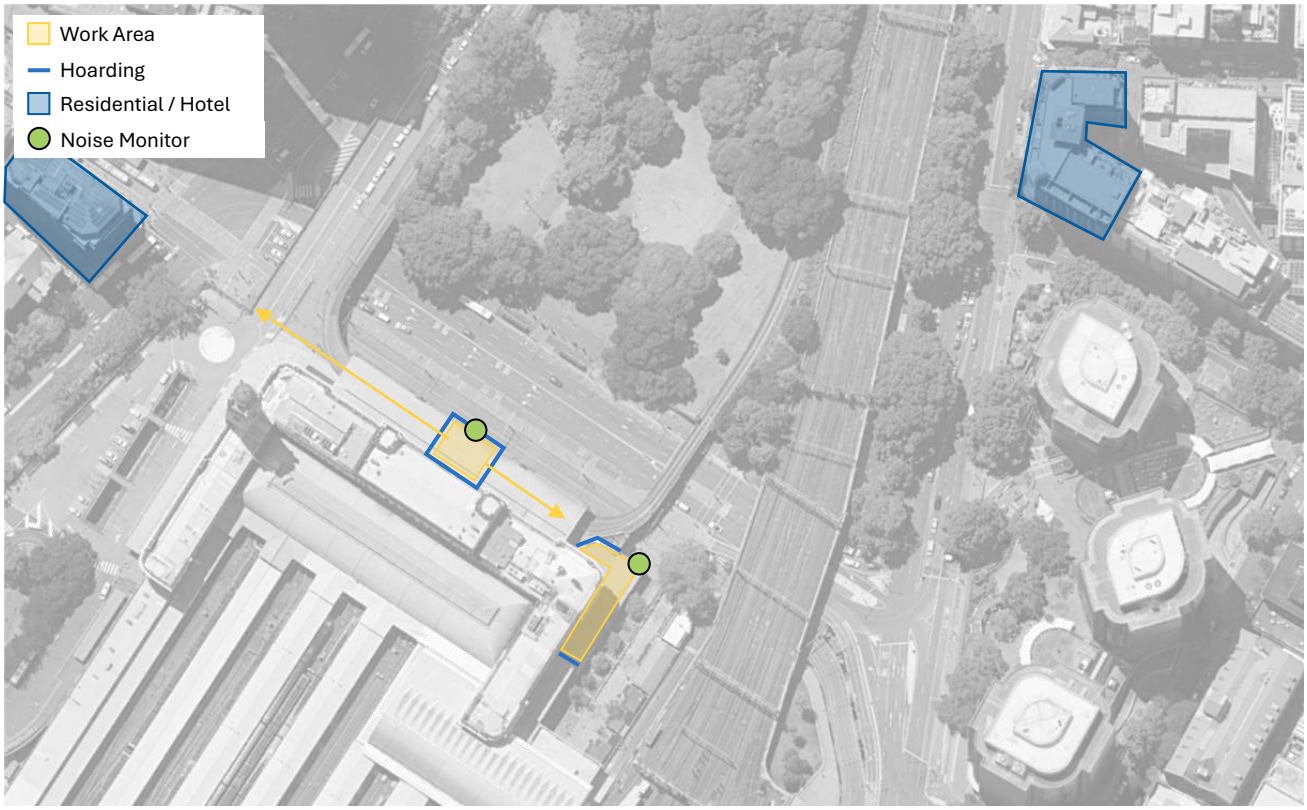
The proposed unattended noise monitoring locations are shown on the site plan presented in **Figure 13** and **Figure 14**.

Additional noise monitors may be deployed for other noise sensitive receivers in response to noise complaints or to provide additional feedback to Project personnel to assist with the management of noise emissions from the Project Site.

Figure 13 Proposed Unattended Noise Monitoring Locations - Phase 1 and 2

Source: Google Earth (Mark-up by VMS).

Figure 14 Proposed Noise Monitoring Locations - Phase 2 and 3



Source: Google Earth (Mark-up by VMS).

6.2 Vibration Monitoring

Vibration monitoring is to be undertaken:

- Attended monitoring the commencement of new noise intensive activities, i.e. the start of any works exceeding NML represented as a new scenario as per the CNVMP in accordance with NV05 and CoA C9.
    - Attended vibration monitoring may not be required provided attended noise monitoring confirms that appropriate mitigation measures from the CNVG have been implemented.
- Throughout the construction period in accordance with Mitigation Measure NV05 and CoA C9.

For Heritage:

- Attended vibration monitoring before vibration generating activities to identify minimum working distances to prevent cosmetic damage in accordance with CoA D34 and Mitigation Measure NV06.
- Vibration monitoring during vibration generating activities accordance with CoA D34 and Mitigation Measure NV06.

Vibration monitoring requirements may be met with a combination of attended monitoring and unattended monitoring as detailed in the following sections.

6.2.1 Attended Vibration Monitoring

Attended vibration monitoring shall be undertaken by suitably qualified persons in accordance with Transport (and EPA) requirements.

In accordance with Mitigation Measure NV05 and CoA C9 attended vibration monitoring is to be conducted at the commencement of any vibration intensive works, unless such works do not take place within minimum working distances and the implementation of mitigation measures on site has been confirmed during attended noise monitoring. Attended vibration monitoring will be used to ensure vibration levels do not exceed vibration criteria. Where works take place within the cosmetic damage minimum working distances outlined in **Table 12** for heritage structures, site specific minimum working distances are to be established during attended measurements in accordance with CoA D34.

Where new vibration intensive works are proposed to take place within the human comfort minimum working distances outlined in **Table 12**, or in response to a complaint, a screening assessment involving attended vibration monitoring at the impacted receiver is to take place. The screening assessment is to assess vibration against maximum PPV values outlined in **Table 6**. Where measured levels are below maximum PPV values, no further action is required. Where measured levels are above maximum PPV values, unattended monitoring is to take place at the impacted receiver.

Attended monitoring is to take place at the closest, potentially most affected receiver, and the closest heritage structure if within the minimum working distance for the heritage structure. It is to be confirmed during attended monitoring that all appropriate mitigation measures have been applied.

Attended vibration monitoring (structural damage and/or human comfort) will also be carried out in response to complaints or exceedance of the VDCL (refer **Table 14**). This monitoring will provide direct feedback to allow appropriate modification of construction techniques.

6.2.2 Unattended Vibration Monitoring

Where works take place within the cosmetic damage minimum working distances outlined in **Table 12** for heritage structures, unattended monitoring will be required for the duration of the works in accordance with CoA D34. If these works are short term, attended monitoring for the duration of works may be alternatively conducted.

For other structure types, where there is a risk works may exceed VDCLs or HCCLs following attended monitoring, or where works are to take place within minimum working distances for structural damage, unattended monitoring is recommended.

Where required, unattended vibration monitoring will be carried out continuously at the potentially most affected receivers/structures during the construction period.

Cosmetic Damage

A sensor mounting plate would be installed on the monitoring locations. The monitoring locations would be on a stiff part of the structures (at the foundations) on the side of the structures adjacent to the subject construction works, in accordance with BS7385.

Vibration monitoring equipment will be set so that an SMS/email notification is sent to relevant parties when vibration from vibration generating works, or any other activity, exceeds the levels shown in **Table 14**, specifically Line 2 unless a building condition inspection finds a heritage structure as structurally unsound, in which case Line 3 values are to be applied.

Human Comfort

In accordance with the Vibration Guideline, monitoring for human comfort is to take place at the place at which vibration affects people, i.e. the centre of the affected room.

Monitoring at this location is preferred in the first instance but is likely not practical. Therefore, the sensor may be located on the side of the structure adjacent to the subject construction works similar with the procedure for cosmetic damage, in accordance with BS7385.

In this case, a transfer function will need to be established during attended measurements such that vibration levels measured on the side of the structure can be translated to a level representative of what would be experienced by a person in the affected space.

If a transfer function cannot be established, conservative assumptions should be applied, or a study conducted, to establish an effective transfer function where appropriate.

Vibration monitoring equipment is to be set so that an SMS/email notification is sent to relevant parties when vibration from vibration generating works, or any other activity, exceeds the levels shown in **Table 13**.

6.2.3 Vibration Monitoring Locations

Vibration intensive works are identified to take place within Eddy Plaza and along the Colonnade. Vibration monitoring, where required, is to take place on the closest, potentially most affected structures. The preferred location of vibration monitoring is to be determined following a detailed review of construction methodology prior to the commencement of vibration intensive works. Multiple monitoring locations may be required where vibration intensive works are proposed to take place over a large extent.

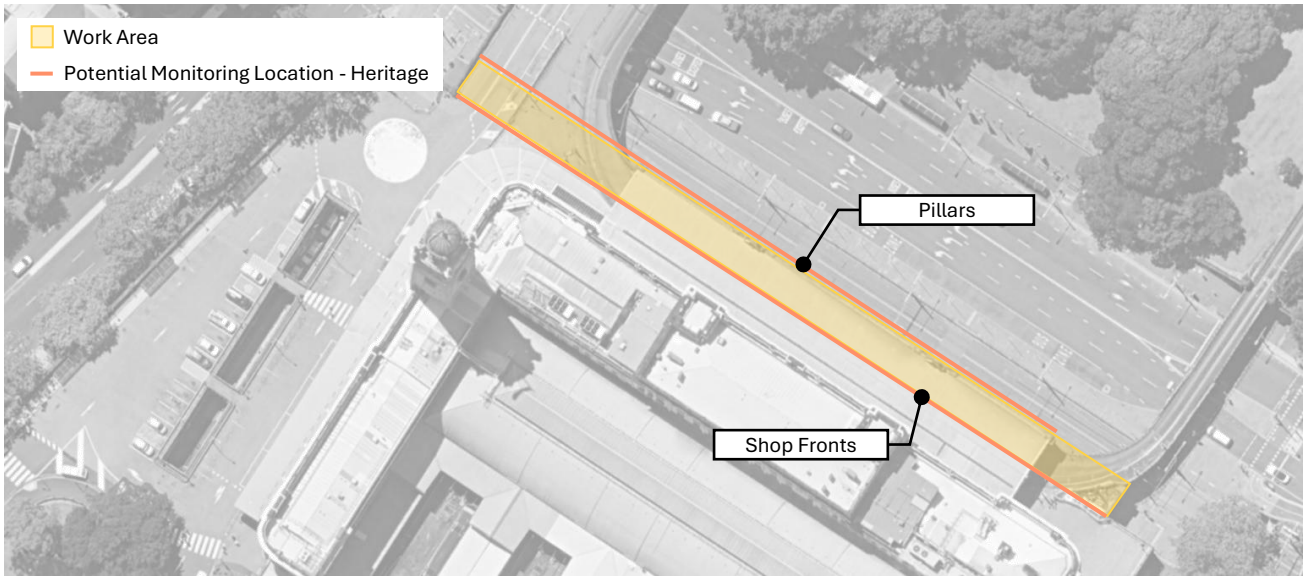
One particular high-risk location to note is the retaining wall east of the access ramp within Eddy Plaza which will require vibration monitoring if vibration intensive works including hammering are to take place within the minimum working distance to this structure.

Vibration monitoring, where required, is to take place on the nearest potentially effected structures which include heritage and non-heritage facades for cosmetic damage monitoring and the nearest occupied receiver for human conform monitoring as illustrated in the site plan presented in Error! Reference source not found. and **Figure 16**.

Figure 15 Proposed Vibration Monitoring Locations - Eddy Plaza

Source: Google Earth (Mark-up by VMS).

Figure 16 Proposed Vibration Monitoring Locations - Colonnade



Source: Google Earth (Mark-up by VMS).

6.3 Supplementary Noise and Vibration Monitoring

Supplementary noise and structural damage and/or human comfort vibration monitoring will, if required, be carried out in response to complaints, exceedances or for the purpose of refining construction techniques in order to minimise noise and vibration emissions. Monitoring would be attended under these circumstances, in order to provide immediate feedback to the operators.

7 Additional Mitigation Measures

Mitigation measures including AMMs are to be applied in accordance with the CNVMP.

Where monitoring is conducted and noise and vibration impacts indicate an exceedance of RBLs, VDCLs, or HCCLs, above those predicted in the CNVMP, AMMs as outlined in **Table 16** and **Table 17** are to be applied.

The description of each AMM in accordance with the CNVG is reproduced in **Table 15**.

Table 15 Additional Mitigation Measures

Measure	Description
Periodic Notification (PN)	For each Transport project, a notification is produced and distributed to stakeholders via letterbox drop or distributed to the project postal and/or email mailing lists. The same information will be published on the Transport corporate website (Transport Projects) or equivalent. Periodic notifications provide an overview of current and upcoming work across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g., traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where work may impact them. Content and length are determined on a project-by-project basis and must be approved by Transport prior to distribution. Most projects distribute notifications monthly. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the Transport Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking, etc.). In these circumstances the Transport Community Engagement Team will determine the community engagement strategy on a case-by-case basis.
Verification Monitoring (V)	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e., for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e., for specific periods of construction noise). Verification must be undertaken by suitably qualified, trained and experienced personnel using appropriate equipment and methodology, with reference to AS1055. Refer to EPA's guideline 'Approved methods for the measurement and analysis of environmental noise in NSW' for additional guidance on personnel, methodology and equipment requirements. The purpose of monitoring is to confirm that: • Construction noise and vibration from the project are consistent with the predictions in the noise assessment. • Mitigation and management of construction noise and vibration is appropriate for receivers affected by the work. Where noise monitoring finds the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended. See Section 7.4 for more details.

Measure	Description
Specific Notification (SN)	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. In addition to Specific Notifications and letters communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped, hand distributed or emailed. • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs. • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. • Specific notifications are used to support periodic notifications, or to advertise unscheduled or high impact work and must be approved by Transport prior to implementation/distribution. Where impacts have already been captured in a Periodic Notification, a Specific Notification may not be required.
Respite Offer (RO)	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased movie tickets, bowling activities, meal vouchers or similar offers designed to provide residents with a short break from impact of construction activity outside of their home. This measure is determined on a case-by-case basis and may not be applicable to all Transport projects.
Alternative Accommodation (AA)	Alternative accommodation options may be provided for residents living near construction activities likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.
Alternative Construction Methodology (AC)	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the work, the proponent needs to consider alternative construction options to achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.
Respite Period (RP)	OOHW during evening and night periods will be restricted so receivers are impacted for no more than three consecutive evenings and no more than two consecutive nights in the same NCA in any one week, except where there is Duration Reduction. A minimum respite period of four evenings/five nights shall be implemented between periods of consecutive evening and/or night work. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by Transport through the OOHW Approval Protocol (Section 5). Note: this management measure does not apply to OOHW Period 1 – Days (See Table 1).

Measure	Description
Duration Reduction (DR)	Where Respite Periods (see management measure above) are counterproductive to reducing noise and vibration impacts to the community, it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by project basis and may not be applicable to all Transport projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with Transport Community and Stakeholder Engagement Representatives.

Table 16 AMM Matrix - Airborne Construction Noise

Construction Hours	Additional Mitigation Measures				
	Exceedance - dBA				HNA - dBA
	RBL: 5-10 NML: n/a NML OOH: 0-5	RBL: 11 to 20 NML: 0-10 NML OOH: 6-15	RBL: 21 to 30 NML: 11-20 NML OOH: 16-25	RBL: >30 NML: >20 NML OOH: >25	Impact >75
Standard Hours Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 6.00 pm	-	-	PN, V	PN, V	PN, V, SN
OOHW Period 1 Monday to Friday 6.00 pm to 10.00 pm Saturday 7.00 am to 8.00 am 6.00 pm to 10.00 pm Sunday/Public Holiday 8.00 am to 6.00 pm	-	PN, RP[1], DR[1]	PN, V, SN, RO, RP[1], DR[1]	PN, V, SN, RO, RP[1], DR[1]	-
OOHW Period 2 Monday to Saturday 12.00 am to 7.00 am 10.00 pm to 12.00 am Sunday/Public Holiday 12.00 am to 8.00 am 6.00 pm to 12.00 am	PN	PN, V, SN, RO[2], RP, DR	PN, V, SN, RO[2], RP, DR	PN, V, SN, RO[2], RP, DR, AA	-

Note 1: Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 7.00 am-8.00 am, Sundays/Public Holidays 8.00 am-6.00 pm)

Note 2: Respite offers during OOHW Period 2 are only applicable for evening periods on Sundays and Public Holidays 6.00 pm-10.00 pm, and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1

Table 17 AMM Matrix - Ground-Borne Vibration

Construction hours	Receiver perception	Trigger	Additional management measures
Standard Hours Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 6.00 pm	Human disturbance (Human Response)	Within relevant minimum working distance	PN, V, RO
	Building Damage (Cosmetic Damage)	Within relevant minimum working distance	V, AC

8 Calibration and Competency

All monitoring will be undertaken by competent personnel, suitability trained and experienced in undertaking noise and/or vibration measurements.

All monitoring equipment is to hold current NATA or manufacturer certification.

Noise monitors are to meet the requirements of EPAs Approved Methods which include but are not limited to:

- Field calibration before and after measurements are made.
- The sound calibrator must comply with the requirements set out in IEC 60942:2017 *Electroacoustics: sound calibrators*.
- The sound calibrator must be of the same class as the sound level meter

Provided noise monitoring is for management purposes, Class 2 or equivalent sound level meters are considered appropriate.

All noise and vibration equipment is to be calibrated in accordance with manufacturer requirements.

9 Reporting

9.1 Attended Monitoring

An attended monitoring report is to be issued to the Contractor within five business days following the completion of attended monitoring.

Attended monitoring reports will be issued to TfNSW and the ER by the Contractor within two business days of the receipt of the reports.

For attended noise monitoring, the monitoring report is to meet the requirements of the EPAs Approved Methods.

For attended vibration monitoring, the monitoring report should follow the requirements of DIN 4150 and/or the Vibration Guideline, as relevant. In summary, the vibration reporting requirements may be met with the following:

- Project description including:
  - Testing agency.
  - Client.
  - Person carrying out measurement.
  - Date and period of measurement.
  - Reason for measurement.
- Relevant guideline or policy that has been applied.
- Details of any background measurements that have been undertaken.
- Details of instruments and methodology (location, orientation, mounting) used for measurements (including reasons for settings and descriptors used and calibration details).
- A site map showing location of vibration sources, measurement locations and receivers (where appropriate), including description of receiver.
- Environmental conditions.
- Vibration criteria applied to the project.
- Vibration source and operating conditions.
- Results including measured vibration levels in accordance with relevant criteria.
- Any observations during measurement.
- If relevant, vibration predictions for the proposed activity.
- If relevant, a comparison of predictions against vibration criteria.
- If relevant, a discussion of proposed mitigation measures, the vibration reduction likely and the feasibility and reasonableness of these measures.
- If relevant, how compliance can be practically determined.
- If relevant, exceedances and details of corrective action applied and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending and the status of its implementation shall be carried forward to following reports.

9.2 Unattended Monitoring

Unattended monitoring results are to be reported on a weekly basis.

Unattended monitoring reports will be issued to TfNSW and the ER by the Contractor within two business days of the receipt of the reports.

These reports will cover the preceding weeks' activities and will include the following:

- Location of unattended monitoring instruments.
- Unattended monitoring results (noise and/or vibration data graphed with two days per page).
- Noise and vibration monitoring results summary together with notes describing any noise and vibration intensive activities (if applicable).
- Summary of measurements exceeding the criteria levels and descriptions of the plant or operations causing these exceedances (if available).
- If relevant, exceedances and details of corrective action applied and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending and the status of its implementation shall be carried forward to following reports.

9.3 Construction Noise and Vibration Monitoring Report

Prepare a Construction Noise and Vibration Monitoring Report in accordance with the following:

- Submitted to the Planning Secretary, and relevant regulatory agencies quarterly.
- Contains a summary of monitoring data and any exceedances and subsequent corrective action as presented in attended and unattended monitoring reports as detailed in **Section 9.1** and **Section 9.2** including:
  - Measured levels.
  - Location.
  - Time of measurement.
  - Assessment against management level.
- All relevant monitoring reports appended.

10 Exceedances and Corrective Action

Where noise and/or vibration monitoring identifies an exceedance of predicted noise levels or vibration criteria associated with the Project works, the contractor is to investigate corrective action. Actions following exceedances are summarised in **Table 18**.

Table 18 Actions Following Exceedances

Category	Attended Monitoring	Unattended Monitoring (Notification Level)	
		Level 1	Level 2
Noise	Where Project noise levels above predicted noise levels are measured, all reasonable and feasible measures to reduce Project noise emissions are to be implemented. Apply AMMs as detailed in **Section 7** if relevant. Notify Transport and the ER of the exceedance and details of corrective action applied.	Site activity to proceed with caution considering number of plant and work intensity.	Implement all reasonable and feasible measures to reduce Project noise emissions. Apply AMMs as detailed in **Section 7** if relevant. Notify Transport and the ER of the exceedance and details of corrective action applied.
Vibration - Human Comfort	Attended monitoring for Human Comfort is to involve a screening assessment as outlined in **Section 5.2.1**. Where levels are exceeded, unattended monitoring is to be undertaken.	If more than 50% of vibration intensive works have been completed at the time of the Level 1 Notification, no further action is required. If less than 50% of vibration-intensive works have been completed, works should proceed with caution, or alternative methods should be applied where feasible and reasonable.	Works are to apply all feasible and reasonable measures to reduce vibration impacts. Apply AMMs as detailed in **Section 7** if relevant. Notify Transport and the ER of the exceedance and details of corrective action applied.
Vibration - Cosmetic Damage	Where vibration criteria are exceeded, implement alternative techniques and continue monitoring to ensure vibration levels are below vibration criteria. Apply AMMs as detailed in **Section 7** if relevant. Notify Transport and the ER of the exceedance and details of corrective action applied.	Proceed with caution at reduced force or load.	Implement alternative techniques pending further analysis of the vibration frequency content in order to determine any potential exceedance of the Vibration Damage Control Levels. Apply AMMs as detailed in **Section 7** if relevant. Notify Transport and the ER of the exceedance and details of corrective action applied.

If on site observations determine an exceedance is attributed to non-project related activities, the above actions can be disregarded. All such observations are to be logged by the Contractor. This may be achieved through responding to emails in the case of email exceedance notifications.

For unattended monitoring exceedances, on site observations are to identify the source of the exceedance.

Where Project related exceedances are frequently reported, noise predictions and/or construction methodologies are to be reviewed.

Appendix A

Acoustic Terminology

Glossary of Noise and Vibration Terminology

Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Power	Sound power is the rate at which sound energy is emitted, reflected, transmitted, or received, per unit time. Unlike sound pressure, sound power is neither room-dependent nor distance-dependent.
Sound Pressure Level (SPL)	The sound level is the sound pressure relative to a standard reference pressure of 20μPa ($20x10^{-6}$ Pascals) on a decibel scale.
Sound Power Level (SWL)	The Sound Power Level is the sound power relative to a standard reference pressure of 1pW ($20x10^{-12}$ Watts) on a decibel scale. The SWL of a simple point source may be used to calculate the SPL at a given distance (r) using the following formula: $SPL = SWL - 10\ Log_{10}(4 \times \pi \times r^2)$. Note that the above formula is only valid for sound propagation in the free-field (see below).
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by $20\ log_{10}$ (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa.
A-weighting (dBA)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{max,T}$	A noise level index defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
$L_{90,T}$	A noise level index. The noise level exceeded for 90% of the time over the period T. L_{90} can be considered to be the "average minimum" noise level and is often used to describe the background noise.
$L_{10,T}$	A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m.
Fast/Slow Time Weighting	Averaging times used in sound level meters.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.
$D_{nT,w}$	The single number quantity that characterises airborne sound insulation between rooms over a range of frequencies.
R_w	Single number quantity that characterises the airborne sound insulating properties of a material or building element over a range of frequencies.
Reverberation	The persistence of sound in a space after a sound source has been stopped.
Peak Particle Velocity (PPV)	The particles of a medium are displaced from their random motion in the presence of a vibration wave. The greatest instantaneous velocity of a particle during this displacement is called the Peak Particle Velocity (PPV) and is typically measured in the units of mm/s.
Hertz (Hz)	The unit of Frequency (or Pitch) of a sound or vibration. One hertz equals one cycle per second. 1 kHz = 1000 Hz, 2 kHz = 2000 Hz, etc.
Acceleration	Acceleration is defined as the rate of change of Velocity of a particle over a period of time and is typically measured in the units of m/sec^2.
Vibration Dose Value (VDV)	When assessing intermittent vibration, it is necessary to use the vibration dose value (VDV), a cumulative measurement of the vibration level received over an 8-hour or 16-hour period. The VDV formulae uses the RMS Acceleration raised to the fourth power and is known as the Root-mean-quad method. This technique ensures the VDV is more sensitive to the peaks in the acceleration levels. VDVs are typically measured in the units of $m/s^{1.75}$.