

Barangaroo Station

Construction Noise & Vibration Impact Statement (CNVIS) Civil Works

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BR COP
4 November 2022



BARANGAROO STATION

Construction Noise and Vibration Impact Statement - Civil Works

Project overview

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BARANGAROO METRO STATION

Construction Noise and Vibration Impact Statement: Civil works

3 November 2022

BESIX Watpac

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1 Introduction

This Construction Noise and Vibration Impact Statement (CNVIS) has been prepared on behalf of BESIX Watpac in accordance with the Construction Noise and Vibration Management Plan (CNVMP) [TM031-01F01 Barangaroo Metro Station NVMP] [1] for the Sydney Metro Barangaroo Station (the Project).

1.1 Relevant requirements and purpose of this CNVIS

The Minister approved the Stage 2 (Chatswood to Sydenham) Metro application lodged by Transport for NSW (TfNSW) as a Critical State Significant Infrastructure (CSSI) project (under Section 115ZB of the Environmental Planning Act 1979, application no SSI 15_7400) on 9 January 2017. The construction of Barangaroo station forms part of the Sydney City Metro & Southwest (SMCSWCS) project. This project falls under the construction and operation of the section between Chatswood and the Sydenham dive site known as "CSSI_7400".

BESIX Watpac have been contracted by Sydney Metro for the construction of the Sydney Metro Barangaroo station, including station fit-out, building a station entrance next to Nawi Cove and reinstatement of Hickson Road. The two major stages for the Project are:

1. Underground station fit-out works (addressed in a separate CNVIS);
2. Civil works including all utility and road reinstatement works (this CNVIS).

Condition E33 from the Project Planning Approval SSI 15_7400 requires that:

Construction Noise and Vibration Impact Statements must be prepared for each construction site before construction noise and vibration impacts commence and include specific mitigation measures identified through consultation with affected receivers.

This CNVIS applies to the proposed Civil works at Barangaroo worksite during standard construction hours as well as works outside of standard construction hours. The construction hours of work are defined by the Project Planning Approval conditions as outlined in the CNVMP. Barangaroo station fitout works are addressed in a separate CNVIS.

This CNVIS forms part of the CNVMP for the Project.

1.2 Structure of this CNVIS

This CNVIS is structured as follows:

- **Section 2** - Description of construction works and hours
- **Section 3** - Nearest sensitive receivers
- **Section 4** - Construction noise and vibration objectives

- **Section 5** - Construction noise assessment
- **Section 6** - Construction vibration impacts
- **Section 7** - Ground-borne noise assessment
- **Section 8** – Traffic noise assessment
- **Section 9** – Cumulative impacts

1.3 Quality assurance

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Description of construction works and hours

2.1 Summary of works addressed in this CNVIS

2.1.1 Construction activities

This CNVIS provides an assessment of noise and vibration impacts from activities associated with Civil works for the construction of the Sydney Metro Barangaroo station. The works assessed in this CNVIS are identified and documented in the CNVMP. An overview of the project extent is shown in Figure 2.1.

Figure 2.1: Sydney Metro Barangaroo Station – project overview



The works covered by this CNVIS, include:

- Site preparation and establishment works;
- Survey and existing utilities identification works;
- Utilities works;
- Demolition works;
- Road upgrading works;
- Traffic switch works;
- Earthing rod installation works;
- Northern shaft backfill works;
- Northern shaft shed demolition and removal works;
- General landscaping and hardscaping

The detailed description of the work aspect for each construction activity listed above is presented in APPENDIX C. Furthermore, a list of plant and equipment to be used for each construction activity is also presented in APPENDIX C.

The works are anticipated to commence approximately in August 2021 and expected to finish in April 2023. The timing of each construction activity is also included in APPENDIX C.

2.1.2 Construction traffic

The Barangaroo site construction works will generate additional traffic movements in the form of:

- Light vehicle movements generated by construction personnel travelling to and from work,
- Heavy vehicle movements generated by delivery vehicles bringing materials, stabilised sands, plant and equipment to the worksite.

Construction traffic on-site (i.e. within the Project footprint) is included as part of the construction noise assessment of the works activities identified in APPENDIX C. When construction related traffic moves onto the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site's activities. Construction traffic noise is addressed in Section 8.

2.1.3 Cumulative construction impacts

CSSI 7400 Condition of Approval E39 requires BESIX Watpac to consult with proponents of other construction works in the vicinity of the worksite and take reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receivers. Further to this, Condition E40 requires works to be coordinated to provide the required respite periods identified in accordance with the terms of the CSSI 7400 approval.

Potentially concurrent construction activities within the vicinity of the Barangaroo site have also been considered, as discussed in Section 9.

2.2 Construction methodology (PPA Condition E35)

Discussion regarding alternatives to rock hammering and blasting to satisfy PPA Condition E35 has been addressed in Section 6.4 of the NVMP.

2.3 Construction hours

The construction hours for the Project are defined by Project Planning Approval (PPA) Conditions E36, E37, E38, E41, E42 and E44. The standard hours and out-of-hours work (OOHW) periods are depicted in Table 2-1 below. The OOHW periods are further defined as OOHW Period 1 and 2 based on the Transport for NSW Construction Noise Strategy (TfNSW CNS), as noted in the NVMP.

The two-week construction pause in July 2021 and the ongoing restrictions related to COVID, particularly in a number of hot-spot local government areas, has had a significant impact on construction activity and scheduling across all of the City & Southwest construction sites. Even though most sites have now been able to recommence some form of construction, there remains ongoing challenges regarding resourcing and limits placed on the numbers of workers permitted to be on site at any one time. Based on current trends and information from the NSW Government, this situation is not expected to change anytime soon.

Allowing these works to occur as OOHW will:

- Ensure key NSW Government program milestones are met.
- Ensure delivery of community and rail commuter user benefits.
- Allow increased project efficiency.

The Project has been identified as Critical State Significant Infrastructure by the NSW Government and will provide an important commuter link connecting the existing Sydney Metro Northwest with the CBD and South West. There are considerable benefits to the Project, NSW Government and the community from the prompt completion of construction of the Project. For the community particularly, completion of construction works will allow restoration of amenity and, in many respects, an increase in the quality of this amenity.

Any work outside standard construction hours must be undertaken in accordance with the Out of Hours Works Protocol and the CNVMP [1].

2.5 COVID-19 extended construction hours

The Environmental Planning and Assessment (COVID-19 Development – Infrastructure Construction Work Days) Order 2020 commenced on 9 April 2020 and will continue until 31 March 2022. The order permits standard construction hours on this project to be extended as follows:

- Saturday from 7am to 8am and from 1pm to 6pm (no high noise work permitted)
- Sundays from 7am to 6pm (no high noise work permitted)
- Public holidays from 7am to 6pm (no high noise work permitted).

High noise work means activities such as rock breaking, rock hammering, sheet piling, pile driving or similar noisy activities, unless an existing consent or approval already allows these works to occur on any of the extended days.

Appropriate noise management levels for the extended hours period (i.e. Sundays/ Public Holidays 7am to 6pm) are as outlined for the Day (D/ D(O)) period in Section 4.1.1.

3 Nearest sensitive receivers

3.1 Residential receivers

To assess and manage construction noise and vibration impact, the residential areas surrounding the Project worksites have been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to the commencement of construction work. The NCAs are based on those established in the EIS for the Project [2], with some modifications to allow for site specific characteristics.

All relevant residential sensitive receivers near the worksite are identified on aerial photographs located in APPENDIX B.

3.2 Other sensitive receivers (PPA Condition E34)

Additional to residential receivers above, 'other' noise and vibration sensitive receivers such as passive recreation areas and places of worship surrounding the construction area have been identified and are summarised on an aerial photograph located in APPENDIX B.

CSSI-7400 Condition E34 states:

Noise generating works in the vicinity of potentially-affected, religious, educational, community institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) must not be timetabled within sensitive periods, unless other reasonable arrangements to the affected institutions are made at no cost to the affected institution or as otherwise approved by the Secretary.

Sydney Metro and BESIX Watpac have undertaken consultation with identified sensitive receivers to determine sensitive periods. This has been taken into consideration in finalising respite strategies for high noise impacts (Section 5.4.2).

3.3 Commercial and industrial premises

All commercial and industrial premises near the worksite have been considered in this assessment.

3.4 Heritage receivers

Heritage receivers are identified in the Land Use Survey in Annexure B of the CNVMP. Table 3-1 identifies the heritage-listed structures close to work areas:

Table 3-1: Assessment heritage receivers

Site	Item	Address	Significance
Barangaroo	Terrace duplex group including interiors	2–36 High Street	Item 883 City of Sydney LEP ; SHR Item 00920

Site	Item	Address	Significance
	Terrace duplex group including interiors	3, 5, 7, 9 High Street	Item 884 City of Sydney LEP ; SHR Item 00918
	Lance Kindergarten including buildings and their interiors, early remnant fencing and grounds	37 High Street	Item 886 City of Sydney LEP
	Terrace duplex group including interiors	38–72 High Street	Item 888 City of Sydney LEP ; SHR Item 00919
	Terrace duplex group including interiors	74–80 High Street	Item 889 City of Sydney LEP ; SHR Item 00868
	Palisade Hotel including interior and archaeological site	35-37 Bettington Street	Item 874 City of Sydney LEP ; Archaeological site A1191 ; SHR Item 00510
	Bridges over Hickson Road	Argyle Place (and Munn and Windmill Streets)	Item 869 City of Sydney LEP
	Retaining Wall, Palisade Fence and Steps	High Street	Item 881 City of Sydney LEP/Item 882 City of Sydney LEP
	Hickson Steps	16-28 Windmill St	Maritime NSW S170 Register Item 4920007
	Dalgety Terrace	7, 9, 11, 13 Dalgety Terrace	SHR00867
	Terraces	27a, 29a, 31a, 33, 35a Dalgety Terrace	SHR00923
	Terraces	15, 17, 19, 21, 23, 25 Dalgety Terrace	SHR00867
	Dalgety's Bond Stores Group of Buildings	6-20 Munn Street	Maritime NSW S170 Register; SHR Item 00526
	Shops	10, 10a, 12, 12a Argyle Place	SHR00891
	Lord Nelson Hotel	19 Kent Street	SHR00509

4 Construction noise and vibration objectives

4.1 Noise goals

4.1.1 Noise management levels (NMLs)

Construction noise management levels (NMLs) have been determined using the Construction Environmental Management Framework (CEMF) [9], CSSI-7400 Conditions, in accordance with the Sydney Metro City & Southwest Construction Noise and Vibration Strategy (SMCSNVS) [7] and as set out in the NVMP.

For the Barangaroo site, external NMLs are derived from the Interim Construction Noise Guideline (ICNG)[3], as summarised in Table 4-1 below. Internal NMLs are also applicable at residential receiver locations during the 7 am to 8 pm period through CSSI-7400 Conditions E37 and E38; and during the 8 pm to 7 am period per E41 and E42, as summarised in Table 4-1 below.

Table 4-1: Application of NMLs at CS2 SMTF-S (CSSI 7400 Conditions of Approval)

Time Period	Area	Receiver Type	Reference	Noise management level ³
ICNG				
Day ¹	All	All	CNVS ³ Section 5.3	ICNG (see Table B1 in APPENDIX B)
Day ¹ OOHW Period 1	All	All	CNVS ³ Section 5.3	ICNG (see Table B1 in APPENDIX B)
Evening ¹ OOHW Period 1	All	All	CNVS ³ Section 5.3	ICNG (see Table B1 in APPENDIX B)
Night ¹ OOHW Period 2	All	All	CNVS ³ Section 5.3	ICNG (see Table B1 in APPENDIX B)
CSSI-7400				
Day ¹ (D/ D(O))	Identified precincts (including Marrickville)	All	CSSI-7400 E38	Noise levels are required to be less than $L_{Aeq(15minute)}$ 60 dB(A) for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below $L_{Aeq(15minute)}$ 55 dB(A). Noise equal to or above $L_{Aeq(15minute)}$ 60 dB(A) is allowed for the remaining 6.5 hours between 7am and 8pm. ⁴
Evening ¹ 6pm to 8pm (E1)				
Evening ¹ 8pm to 10pm (E2)	Residential zones ²	Residential	CSSI-7400 E42	$L_{Aeq(15minute)}$ 45 dB(A) (internal)
Night ¹ 10pm to 7am (N)				
Night ¹ 10pm to 7am (N)				
All	All	All	SSI-7400 E43	$L_{Aeq(8hour)}$ 85 dB(A) (external) near the CCSI

1. Day refers to 7am to 6pm Monday to Friday and 8am to 6pm Saturday, Sunday and Public Holidays; Evening refers to Monday to Sunday 6:00pm to 10:00pm; Night refers to Monday to Friday 10:00pm to 7:00am and Saturdays, Sundays and public holidays 10:00pm to 8:00am.
2. These are identified by the applicable Local Environmental Plan land zoning of the receiver.
3. Sydney Metro City & South West Construction Noise and Vibration Strategy (Sydney Metro 2016)
4. Criteria as described in SSI 7400 Condition E38
5. A 5 dB penalty shall be applied if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned

4.1.2 Sensitive receiver NMLs and respite for high noise impact works (CSSI-7400 Conditions E37 and E38)

Day-time works need to be assessed against the requirements of CSSI-7400 Conditions E37 and E38. Consultation will be undertaken with receivers predicted to experience internal noise levels greater than $L_{Aeq(15\text{minute})}$ 60 dB(A), between 7am and 8pm, to determine appropriate hours of respite in accordance with CSSI-7400 Conditions E37 and E38. Receivers have been identified using the following process:

- An NML equivalent to an internal noise level of $L_{Aeq(15\text{minute})}$ 60 dB(A) was established for all identified receivers:
 - For residential receivers, the equivalent external NML is based on a 10 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows open)
 - For non-residential receivers with light weight glazing, the equivalent external NML is based on a 20 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows closed)
 - Where additional information is available (e.g. if residential or non-residential properties have been acoustically treated), alternative outdoor to indoor noise difference will be determined to establish the equivalent external noise threshold.
- Receivers where noise is predicted to be above the equivalent external NML are identified as requiring consultation (APPENDIX D.2).

The adopted difference between external and internal noise levels is identified in APPENDIX D.

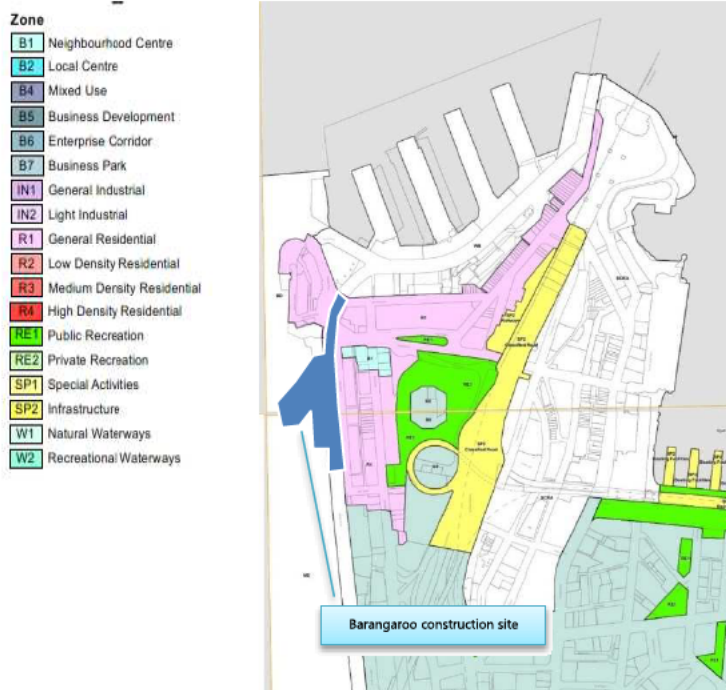
4.1.3 Residential receiver NMLs – 8pm to 7am (CSSI-7400 Conditions E41 and E42)

CSSI-7400 Conditions E41 and E42 require that residential receivers within non-residential zones or residential zones (respectively) are not above the internal noise levels identified in Table 4-1. In accordance with CSSI-7400 Conditions E41 and E42, if construction works are particularly annoying (as described in *ICNG NMLs* above) or include ground-borne noise or a perceptible level of vibration at the affected receiver, a 5 dB(A) penalty should be added to the predicted construction noise level.

Where the above internal noise levels cannot be achieved, additional mitigation in accordance with the *Sydney Metro City and South West Noise and Vibration Strategy* (SMCSNVS) [7] is to be offered.

Addendum A of the SMCSNVS notes that the applicable Local Environmental Plan land zoning of the receiver be used to identify if residential receivers are located within residential or non-residential zones. Figure 4.1 is an extract from Sydney Local Environmental Plan 2012 land zoning maps LZN_013 and LZN_014 (accessed 30/10/17). As shown in Figure 4.1, the nearest residential receivers are in a residential zone (R1 General Residential).

Figure 4.1: Extract from Sydney Local Environmental Plan 2012 Land Zoning Map - compilation of Sheet LZN_013 and Sheet LZN_014



For this assessment, all residential receivers are assumed to be in residential zones (CoA E42), with a corresponding internal noise threshold level of $L_{Aeq(15\text{minute})}$ 45 dB(A) between 8pm and 7am. Based on a minimum (conservative) external to internal noise difference of 10 dB(A) (assuming windows open), an equivalent external noise threshold of $L_{Aeq(15\text{minute})}$ 55 dB(A) is applicable between 8pm and 7am for all receivers, except for few receivers where previous measurements and site inspections confirmed the existing façade loss (APPENDIX D). Where these external equivalent levels are above the external noise threshold, additional mitigation may be required in accordance with the SMCSNVs.

The assessment presented in Section 5 has assessed all receivers against the approach outlined in the SMCSNVs [7] and the CNVMP [1] which achieves the requirements of CSSI-7400 Conditions E41 and E42, and is consistent with the ICNG [3] and the EIS [2].

4.1.4 Sleep disturbance

Consistent with Section 4.5.5 of the NVMP, to assess the likelihood of sleep disturbance, an initial screening level of $L_{Amax} < L_{A90,15\text{min}} + 15$ is used. In situations, where this results in an internal screening levels of less than 45 dB(A) (internal), a minimum internal screening level of 45 dB(A) is set. Note that this is equivalent to an external maximum noise level of 55 dB(A) with windows open or 65 dB(A) with closed windows, based on an outside-to-inside noise reduction of respectively 10 dB(A) and 20 dB(A).

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

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

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

4.1.5 National Standard for exposure to noise

In accordance with PPA Condition E43, BESIX Watpac will be managed to ensure that noise generated by construction will not be above the National Standard for exposure to noise in the occupational environment of an eight-hour equivalent continuous A-weighted sound pressure level ($L_{Aeq,8hr}$) of 85 dB(A) for any employee working at a location near a Barangaroo Sydney Metro worksite.

Representative noise measurements will be undertaken in close proximity to the nearby worksites to determine the L_{Aeq8h} that workers from adjacent worksites may be experienced due to works associated with Sydney Metro Barangaroo site.

4.1.6 Construction related road traffic noise objectives

On the roads immediately adjacent to construction sites, the community may associate heavy vehicle movements with the site. Construction traffic movements on public roads will aim to limit any increase in existing road traffic noise levels to no more than 2 dB(A). All feasible and reasonable noise mitigation and management measures will be implemented.

4.2 Construction vibration goals

As reported in Section 4.8 of the CNVMP [1], construction vibration goals have been determined using:

- Human comfort – disturbance to building occupants: vibration in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Effects on building contents – vibration where the building contents may be affected.
- Effects on building structures – vibration in which the integrity of the building or structure itself may be prejudiced.

4.2.1 Disturbance to buildings occupants

The vibration dose values recommended in the guideline 'Assessing Vibration; a technical guideline' are presented in Table 4-2.

Table 4-2: Vibration Dose Values for intermittent vibration

Place and Time	Preferred Vibration Dose Value (VDV) in $m/s^{1.75}$	Maximum Vibration Dose Value (VDV) in $m/s^{1.75}$
Critical areas ¹ (day or night)	0.1	0.2
Residential buildings 16 hr day	0.2	0.4
Residential buildings 8 hr night	0.13	0.26
Offices, schools, educational institutions and places of worship (day or night)	0.4	0.8
Workshops (day or night)	0.8	1.6

Notes:

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

To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. This screening test is a conservative approach since it is based on the continuous vibration velocity criteria (i.e. vibration that continues uninterrupted for a defined assessment period) whilst construction works are mostly intermittent. The screening test (Table 4-3) will be based on maximum peak values for surface construction works, which are intermittent in nature. This approach has been adopted so that the screening test is not unduly stringent.

If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (i.e. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

Table 4-3: Construction vibration disturbance – initial screening test.

Place and Time	Preferred peak velocity, mm/s (>8Hz)	Maximum peak velocity, mm/s (>8Hz)
Critical areas (day or night)	0.14	0.28
Residential buildings 16 hr day	0.28	0.56
Residential buildings 8 hr night	0.20	0.40
Offices, schools, educational institutions and places of worship (day or night)	0.56	1.10
Workshops (day or night)	1.10	2.20

4.2.2 Structural damage to buildings

Potential structural damage of buildings caused by vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 (1993) as required by Project Planning Approval Condition E28. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-

structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

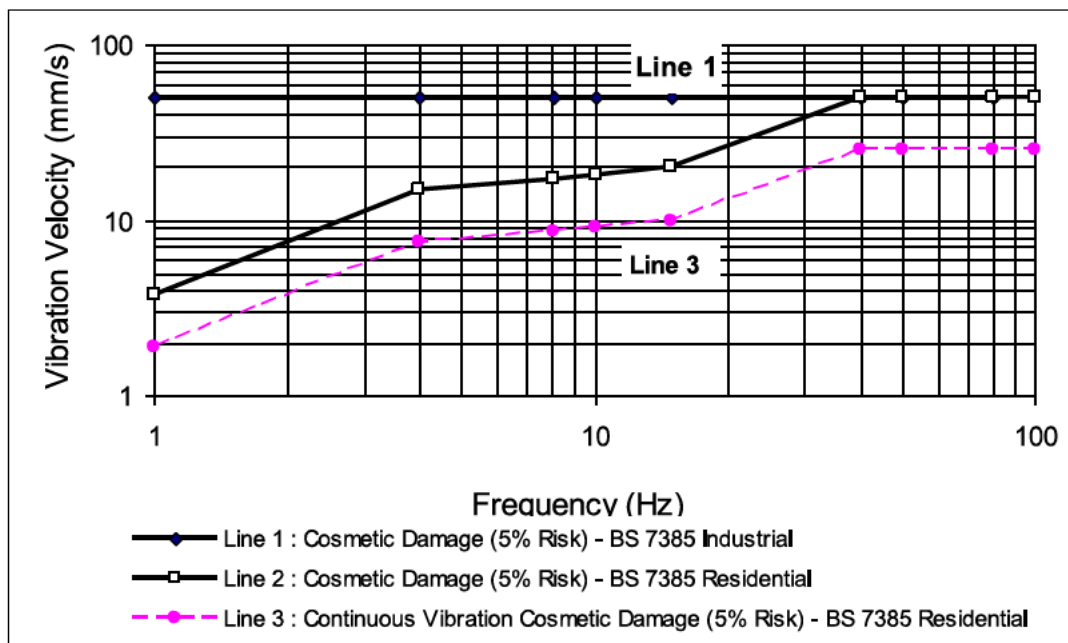
Table 4-4 sets out the recommended limits from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential, commercial and industrial buildings. This is shown graphically in Figure 4.2.

Table 4-4: Transient vibration guide values - minimal risk of cosmetic damage (BS 7385) - peak component particle velocity

Line	Type of structure	Frequency range 4 to 15 Hz	Frequency range 15 to 40 Hz	Frequency range 40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4Hz, increasing to 20 mm/s at 15Hz	20 mm/s at 15Hz, increasing to 50 mm/s at 40Hz	50 mm/s

BS7385 states that the guide values in Table 4-4 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4-4 may need to be reduced by up to 50%, as shown by Line 3 of Figure 4.2 for residential buildings.

Figure 4.2: Graph of Transient Peak Component Particle Velocity Vibration Guide Values for Cosmetic Damage



4.2.3 General vibration screening criterion

The British Standard states that the guide values in Table 4-4 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings. Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4-4 may need to be reduced by up to 50%. This is especially applicable at the lower frequencies where lower guide values apply.

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

- Reinforced or framed structures (Line 1): **25.0 mm/s**
- Unreinforced or light framed structures (Line 2): **7.5 mm/s**

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable vibration level. The analysis would take into consideration the transient vibration guide values for minimal risk of cosmetic damage set out in Figure 4.2.

4.2.4 Heritage structures/buildings

The British Standard BS7385 states that *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

In accordance with Project Planning Approval Condition E31, the advice of a heritage specialist on methods and locations for installing equipment used for vibration, movement and noise monitoring of heritage-listed structures will be sought.

Unless otherwise advised, a conservative vibration damage screening level (peak component particle velocity) for heritage buildings/structures can be set to 2.5mm/s (the more stringent criterion in the German Standard DIN 4150-2016 Structural Vibration Part 3: Effects of Vibration on Structures). This screening level will allow potentially impacted heritage structures to be identified. If a heritage structure is predicted to be exposed to vibration levels above the conservative vibration screening level of 2.5mm/s, further investigation would be undertaken to determine whether the structure is structurally unsound. Where a heritage building is deemed to be sensitive to vibration impacts, the more stringent DIN 4150-2016 Group 3 guideline values can be applied. Otherwise, structural damage vibration limits based on BS 7385 (Section 4.2.3) can be applied.

4.2.5 Sensitive scientific and medical equipment

No sensitive scientific or medical equipment are known to be located near the assessed works. If they are identified, relevant vibration criteria should be established for each item in line with Section 4.8.5 of the NVMP [1], and any corresponding management or mitigation measures determined.

4.2.6 Utilities and other vibration sensitive structures

Where utilities or other vibration sensitive structures are identified, relevant vibration criteria will be established for each item per Section 4.8.6 of the CNVMP [1], and any corresponding management or mitigation measures determined.

5 Construction noise assessment

5.1 Noise prediction methodology

Modelling and assessment of airborne noise impacts from activities associated with the construction works were determined by modelling the noise sources, receiver locations, topographical features, and possible noise mitigation measures using a Cadna-A computer noise model developed for this project. The model calculates the contribution of each noise source at identified sensitive receiver locations and allows for the prediction of the total noise from a site for the various stages of the construction works.

The noise prediction models take into account:

- Location of noise sources and sensitive receiver locations.
- Height of sources and receivers referenced to one metre digital ground contours for the site area and surrounding area.
- Sound Power Levels (L_w) of plant and equipment likely to be used during the various construction activities (see Table C1 in APPENDIX C). Table C1 also identifies the plant and equipment that will operate during each assessment period and the likely timing of each activity/aspect.
- Separation distances between sources and receivers.
- Ground type between sources and receivers.
- Attenuation from barriers (natural and purpose built).

Key details regarding the construction site layout, the likely plant and equipment (including truck movements), and hours of operation were informed by the Design and Construction Teams. This information is presented in APPENDIX C and formed the basis for all modelling assumptions used in this assessment.

5.2 Detailed design outcomes

The key noise mitigation measures that have been included in the noise modelling results presented in this CNVIS are:

- Acoustic shed (in Hickson Road) for materials and stabilised sand deliveries;
- Acoustic treatment of shed louvres to further reduce noise during underground tunnel and station fit-out works;
- Acoustic blankets closing off the shed louvres when delivering stabilised sand;
- Full enclosure of the station box with a concrete roof;

- Partial/total enclosures for pumps and other plant/equipment;
- Acoustic attenuators for ventilation fans required to support underground ventilation.

The above recommendations are all existing measures which have previously been implemented for past construction works. All hoardings and acoustic sheds developed for the TSE works will remain on site and will not be altered from the existing configuration until the end of the project.

5.3 Predicted noise levels

Predicted L_{Aeq} noise levels from the worksite are assessed against the NMLs and summarised in the following sections, with colour coding to denote the highest level of exceedance of the NML. Detailed results for each receiver are given in APPENDIX D.

The noise predictions presented in this CNVIS represent a realistic worst-case scenario when construction occurs at work locations close to residences and other sensitive receivers. At each receiver, noise levels will vary during the construction period based on the position of equipment within the worksite, the distance to the receiver, the construction activities being undertaken and the noise levels of particular plant items and equipment. Actual noise levels will often be less than the predicted levels presented in this CNVIS.

The construction activities included in this CNVIS are summarised in Table 5-1. Each construction activity has been grouped into the following two sub-categories:

- Typical activities (T), which will exclude high impact sources (e.g. rock hammer, concrete saw, jackhammers);
- High impact activities (H), which will include high impact sources (e.g. rock hammer, concrete saw, jackhammers).

Table 5-1: Summary of construction activities

Work Activity (APPENDIX C)	Work area	Typical activities (T)	High impact activities (H)	Scenario reference code (APPENDIX C)
Zone 1	See APPENDIX B	✓	✓	Zone1-T, Zone1-H
Zone 2	See APPENDIX B	✓	✓	Zone2-T, Zone2-H
Zone 3	See APPENDIX B	✓	✓	Zone3-T, Zone3-H
Zone 3.1	See APPENDIX B	✓	✓	Zone3.1-T, Zone3.1-H
Zone 4	See APPENDIX B	✓	✓	Zone4-T, Zone4-H
Zone 4.1	See APPENDIX B	✓	✓	Zone4.1-T, Zone4.1-H
Zone 5	See APPENDIX B	✓	✓	Zone5-T, Zone5-H
Zone 6	See APPENDIX B	✓	✓	Zone6-T, Zone6-H
Zone 8	See APPENDIX B	✓		Zone8-T
Zone 9	See APPENDIX B	✓	✓	Zone9-T, Zone9-H

Work Activity (APPENDIX C)	Work area	Typical activities (T)	High impact activities (H)	Scenario reference code (APPENDIX C)
Zone A	See APPENDIX B	✓	✓	ZoneA-T, ZoneA-H
Zone B	See APPENDIX B	✓	✓	ZoneB-T, ZoneB-H
Zone C	See APPENDIX B	✓	✓	ZoneC-T, ZoneC-H
All zones	See APPENDIX B	✓	✓	AllZones-T, AllZones-H
Northern shaft backfill	See APPENDIX B	✓		NSB

5.3.1 ICNG NMLs

5.3.1.1 ICNG Standard construction hours

Table 5-2 presents the predicted worst case construction noise levels for each of the construction work zones identified in Table 5-1 at the most noise affected receivers. The results are presented in terms of level above the ICNG standard daytime NMLs.

For **Standard Hours** construction noise impacts are presented as follows:

- ◆ Complies with NML
- < 10dB(A) above NML - construction noise clearly audible
- ◆ > 10dB(A) above NML - construction noise moderately intrusive
- > 75dB(A) - highly noise affected (for residential receivers)

Table 5-2: Summary of construction noise impacts – standard construction hours

NCA	Standard construction hours D(S)															
	Construction scenario (see APPENDIX C)															
	Zone1-T	Zone1-H	Zone2-T	Zone2-H	Zone3-T	Zone3-H	Zone3.1-T	Zone3.1-H	Zone4-T	Zone4-H	Zone4.1-T	Zone4.1-H	Zone5-T	Zone5-H		
BN_01	●	○	●	●	●	●	●	●	●	●	○	●	○	●	●	
BN_02	●	◆	●	◆	●	◆	●	●	●	◆	●	●	○	○	□	
BN_03	○	□	○	□	○	□	○	□	○	□	○	□	○	□	○	
BN_04	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
BN_05	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
BN_06	●	●	●	●	●	●	●	●	●	●	-	●	●	●	-	
OSR	○	◆	●	●	○	◆	●	○	○	○	◆	●	○	◆	●	
	Zone6-T	Zone6-H	Zone8-T	Zone9-T	Zone9-H	ZoneA-T	ZoneA-H	ZoneB-T	ZoneB-H	ZoneC-T	ZoneC-H	AllZones-T	AllZones-H	NSB		
BN_01	●	●	●	●	○	●	●	○	○	●	●	●	○	●	●	
BN_02	○	□	●	●	○	●	◆	●	○	○	○	○	○	○	●	
BN_03	○	□	●	○	○	○	□	○	□	●	◆	○	○	□	●	
BN_04	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	
BN_05	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	
BN_06	●	●	●	●	●	●	●	●	●	-	●	●	●	●	-	
OSR	○	◆	●	○	○	○	◆	○	○	○	◆	○	◆	○	●	

Notes: Day D(S): 7am to 6pm Monday to Friday and 8am to 1pm on Saturdays

During the standard construction hours, residential receivers within the proximity of the construction zones in NCAs BN_03 and BN_02 are predicted to be highly noise affected when high impact activities are occurring. During typical activities, residential receivers within the proximity of the construction zones in NCA BN_01, BN_02 and BN_03 are predicted to be less than 10dB(A) above the corresponding NMLs. Other residential receivers in NCA BN_04, BN05, and BN06 are predicted to comply with the corresponding NMLs during typical activities.

Noise levels for nearby other sensitive receivers are predicted to be greater than 10dB(A) above the corresponding NMLs, during high impact activities. During typical activities, nearby other sensitive receivers are predicted to be complying or less than 10dB(A) above the corresponding NMLs.

5.3.1.2 ICNG OOHW

Table 5-3 and Table 5-4 presents the predicted worst-case construction noise levels for each of the construction work zones identified in Table 5-1 at the most noise affected receivers in each NCA. The results are presented in terms of level above the ICNG NMLs for the OOHW period.

- Below NML
- < 5dB(A) above NML - construction noise noticeable
- ◆ 5 to 15dB(A) above NML - construction noise clearly audible
- > 15 to 25dB(A) above NML - construction noise moderately intrusive
- >25dB(A) above NML - construction noise highly intrusive

Table 5-4: Summary of construction noise impacts at nearby receivers – OOHW Period 2

NCA	Construction scenario (see APPENDIX C)																
OOHW Period 2 – Night N																	
	Zone1-T	Zone1-H	Zone2-T	Zone2-H	Zone3-T	Zone3-H	Zone3-1-T	Zone3-1-H	Zone4-T	Zone4-H	Zone4-1-T	Zone4-1-H	Zone5-T	Zone5-H			
BN_01	-1	-1	-1	-1	●	◆	○	■	●	■	○	■	■	-1	-1		
BN_02	-1	-1	-1	-1	◆	□	○	■	◆	□	◆	■	◆	-1	-1		
BN_03	-1	-1	-1	-1	■	□	■	■	■	□	■	■	□	-1	-1		
BN_04	-1	-1	-1	-1	●	●	●	○	●	●	●	●	●	●	-1	-1	
BN_05	-1	-1	-1	-1	●	◆	◆	◆	●	◆	◆	◆	◆	-1	-1		
BN_06	-1	-1	-1	-1	●	◆	●	◆	●	◆	◆	◆	◆	-1	-1		
OSR	-1	-1	-1	-1	○	■	●	◆	●	■	●	●	●	-1	-1		
	Zone6-T	Zone6-H	Zone6-T	Zone6-H	Zone9-T	Zone9-H	ZoneA-T	ZoneA-H	ZoneB-T	ZoneB-H	ZoneC-T	ZoneC-H	AllZones-T	AllZones-H	NSB		
BN_01	●	◆	-1	-1	-1	-1	●	◆	○	■	●	◆	N/A	N/A	●		
BN_02	■	□	-1	-1	-1	-1	◆	□	◆	■	■	■	N/A	N/A	○		
BN_03	■	□	-1	-1	-1	-1	■	□	■	■	□	■	N/A	N/A	○		
BN_04	●	●	-1	-1	-1	-1	●	●	●	●	●	●	N/A	N/A	-		
BN_05	●	◆	-1	-1	-1	-1	●	◆	●	◆	-	◆	N/A	N/A	-		
BN_06	●	◆	-1	-1	-1	-1	●	◆	●	◆	-	◆	N/A	N/A	-		
OSR	◆	□	-1	-1	-1	-1	○	■	●	◆	◆	■	N/A	N/A	●		

Notes: Night N: 10pm to 7am Monday to Friday, 10pm to 6pm on Saturdays and 6pm to 6am on Sunday or Public Holidays

1: No OOHW works have been proposed for this construction zone

During the OOHW daytime, noise levels are predicted to be greater than 25dB(A) above the ICNG NMLs at the most affected residences in NCA BN_03 for high impact activities. During typical activities, exceedances up to 15 dB(A) above the ICNG NMLs have been predicted at the most affected residences in NCA BN_02 and BN_03.

During the OOHW evening period, noise levels are predicted to be greater than 25dB(A) above the ICNG NMLs at the most affected residences in NCA BN_03 for high impact activities. Residences in NCA BN_02 adjacent to work zone 6 and work zone C are predicted to experience noise levels that are greater than 25dB(A) during high impact activities.

During the OOHW night-time period, noise levels are predicted to be greater than 25dB(A) above the ICNG NMLs at the most affected residences in NCA BN_02 and BN_03 for high impact activities.

Few non-residential sensitive receivers (i.e. OSR) have been predicted to be greater than 25dB(A) above the ICNG NMLs during Zone 6 high impact activities. During typical activities, exceedances up to 15 dB(A) above the ICNG NMLs have been predicted at the most affected other sensitive receivers. However, these receivers are not expected to be in operation outside standard construction hours.

During northern shaft backfill works, predicted levels are expected to be slightly above the relevant night-time NMLs.

Mitigation and management measures are discussed in Section 5.4 of this report.

5.3.2 CSSI-7400 Conditions E37/E38

Table 5-5 presents the predicted worst-case construction noise levels for each of the construction stages identified in Table 5-1 at the most affected residential receiver in each NCA and other sensitive receivers (OSR). The results are compared with the internal NMLs in CSSI-7400 Conditions E37 and E38. Where the measured or predicted noise levels are above the equivalent external NML, consultation will be undertaken with affected receivers to determine appropriate hours of respite in accordance with CSSI-7400 Conditions E37 and E38. The impacts presented are as follows:

- ◆ Noise levels predicted to be below internal NMLs in CSSI-7400 Conditions E37 and E38
- Noise levels predicted to be above internal NMLs in CSSI-7400 Conditions E37 and E38

Table 5-5: Summary of construction noise impacts for the Day and E1 period – CSSI-7400 Conditions E37/ E38

NCA	Standard construction hours D(S) and Evening E1 period (7am to 8pm)																												
	Construction scenario (see APPENDIX C)																												
	Zone1-T	Zone1-H	Zone2-T	Zone2-H	Zone3-T	Zone3-H	Zone3.1-T	Zone3.1-H	Zone4-T	Zone4-H	Zone4.1-T	Zone4.1-H	Zone5-T	Zone5-H	Zone6-T	Zone6-H	Zone8-T	Zone9-T	Zone9-H	ZoneA-T	ZoneA-H	ZoneB-T	ZoneB-H	ZoneC-T	ZoneC-H	AllZones-T	AllZones-H	NSB	
BN_01	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BN_02	●	□	●	●	□	●	●	●	□	●	●	●	●	●	●	□	●	●	●	●	●	●	●	●	●	●	●	●	□
BN_03	●	□	●	●	□	●	●	●	□	●	●	●	●	●	●	□	●	●	●	●	●	●	●	●	●	●	●	●	□
BN_04	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BN_05	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BN_06	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
OSR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	□	●	●	●	●	●	●	●	●	●	●	●	●	□

Notes: D(S): 7am to 6pm Monday to Friday and 8am to 6pm Saturday, Sunday and Public Holidays
 E1: Evening period from 6pm to 8pm

Based on the results presented in Table 5-5, noise levels are predicted to comply with CSSI-7400 E37 and E38 during typical activities for nearby residential and other sensitive receivers. Noise levels are predicted to be exceed Conditions E37 and E38 during high impact activities for most affected residential receivers in NCA BN_02 and BN03.

The affected receivers requiring consultation are listed in APPENDIX D.2.

5.3.3 CSSI-7400 Conditions E41/E42

Table 5-6 summarises the predicted noise impacts for each construction stage in each NCA compared with the internal NMLs in CSSI-7400 Conditions E41 and E42. Where predicted levels are above the E41/42 NMLs at residential receivers, additional mitigation measures will be implemented in accordance with the SMCNVS.

The impacts presented are as follow:

- ◆ Noise levels predicted to be below internal NMLs in CSSI-7400 Conditions E41 and E42
- Noise levels predicted to be above internal NMLs in CSSI-7400 Conditions E41 and E42

Table 5-6: Summary of construction noise impacts for the E2 and Night period – CSSI-7400 Conditions E41/42 (residential only)

NCA	Evening E2 period and Night-time period (8pm to 7am)															
	Construction scenario (see APPENDIX C)															
	Zone1-T	Zone1-H	Zone2-T	Zone2-H	Zone3-T	Zone3-H	Zone3.1-T	Zone3.1-H	Zone4-T	Zone4-H	Zone4.1-T	Zone4.1-H	Zone5-T	Zone5-H	NSB	
BN_01	-1	-1	-1	-1	●	□	●	●	□	□	●	●	□	-1	-1	
BN_02	-1	-1	-1	-1	□	□	●	●	□	□	●	●	□	-1	-1	
BN_03	-1	-1	-1	-1	□	□	□	□	□	□	□	□	□	-1	-1	
BN_04	-1	-1	-1	-1	●	□	●	●	□	●	●	●	□	-1	-1	
BN_05	-1	-1	-1	-1	●	□	●	●	●	□	●	●	□	-1	-1	
BN_06	-1	-1	-1	-1	●	□	●	●	●	□	●	●	□	-1	-1	
	Zone6-T	Zone6-H	Zone8-T	Zone9-T	Zone9-H	ZoneA-T	ZoneA-H	ZoneB-T	ZoneB-H	ZoneC-T	ZoneC-H	AllZones-T	AllZones-H	NSB		
BN_01	●	□	-1	-1	-1	●	□	●	□	●	□	N/A	N/A	●		
BN_02	□	□	-1	-1	-1	●	□	●	□	□	□	N/A	N/A	●		
BN_03	□	□	-1	-1	-1	□	□	□	□	□	□	N/A	N/A	●		
BN_04	●	●	-1	-1	-1	●	□	●	●	●	●	N/A	N/A	●		
BN_05	●	●	-1	-1	-1	●	●	●	□	-	●	N/A	N/A	●		
BN_06	●	●	-1	-1	-1	●	●	●	●	-	●	N/A	N/A	●		

Notes: E2: Late evening period from 8pm to 10pm

N: Night-time period from 10pm to 7am Sunday to Thursday and 10pm to 8am Friday, Saturday and Public Holidays

1: No OOHW works have been proposed for this construction zone

From Table 5-6 above, noise levels during the Evening E2 and night-time period are predicted to comply with CSSI-7400 E41 and E42 during Northern shed backfill activity for nearby residential receivers. For all other activities, the noise levels are predicted to be above the E41 and E42 noise goals.

Where the E41 and E42 noise goals are exceeded, additional noise mitigation would be offered as detailed in Section 5.4.

5.3.4 Sleep disturbance

The maximum noise levels associated with on-site heavy vehicle movements may potentially cause sleep disturbance at nearby residential receivers.

The L_{max} noise levels associated these events are expected to generally be below the screening levels except for concrete/delivery trucks accessing and exiting the shed in Hickson Road from the southern doors. In this case, although maximum noise levels may be above the screening levels, they are well below the sleep disturbance 'awakening reaction' internal NML of 55 dB(A) $L_{A,max}$. Nonetheless, these activities will be managed by minimising unnecessary acceleration on site and installing air brake silencers and broadband reversing alarms on heavy vehicles. Other potential truck noise controls such as installing OEM compliant mufflers will be considered. Toolbox talks will be used to advise all personnel of the need to follow quiet work practices during OOHW periods and of the need to respect the residential receivers surrounding the work site. Other management measures are outlined in Section 5.4 to aid in providing additional noise reduction benefits where predicted levels are above the objective.

5.4 Noise mitigation and management

5.4.1 Consultation with affected receivers (CSSI-7400 Condition E33)

CSSI-7400 Condition E33 requires consultation with affected receivers to assist in determining site-specific mitigation measures to be included in this CNVIS.

BESIX Watpac has engaged with the contractor previously working on Sydney Metro City and Southwest Project at Barangaroo worksite (JHCPBG JV) to provide a register of the consultation outcomes. Nevertheless, BESIX Watpac will continue to consult with potentially affected sensitive receivers, both prior to and following commencement of construction to inform the identification of mitigation measures for the Barangaroo site.

These measures may include:

- minimising high noise impact works during night-time hours;
- limiting night-time works in individual locations to no more than two consecutive nights, three nights a week and ten nights a month whenever practicable;
- scheduling high noise impact works around sensitive periods where feasible and reasonable;
- providing respite from high-impact noisy works during the childcare centre's requested respite periods.
- Reorganising the program of works, where possible, to work in with KU Lance Child Care Centre's needs.

5.4.2 Respite periods

BESIX Watpac has engaged with the contractor previously working on Sydney Metro City and Southwest Project at Barangaroo worksite (JHCPBG JV) to provide a register of the consultation undertaken in accordance with CoA E37. This has been taken into consideration in finalising respite strategies for high noise impacts.

Consistently with JHCPBG JV respite strategy, BESIX Watpac will provide the same respite periods during high noise impacts, which are:

- Monday to Friday from 09:30am to 10:30am
- Monday to Friday from 12:30pm to 01:30pm

5.4.3 Site noise control measures

Table 5-7 shows the noise control measures recommended to reduce potential noise impacts.

Table 5-7: Site noise control measures

Control type	Control measure	Typical use
At-source control measures	Noise control kits	<p>Plant that is brought to site for works should meet the sound power limits identified in Table C1. Where plant are above limits then the plant may require installation of 'noise control kits' to comply with the noise limits in Table C1. Such 'noise control kits' comprise:</p> <ul style="list-style-type: none"> • high performance 'residential-grade' exhaust mufflers, • additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and • air intake and discharge silencers / louvres. <p>The need to fit 'noise control kits' onto the identified plant, will be confirmed once each plant item is tested prior to its regular use on site, in accordance with Section 8 of the NVMP.</p>
	Limit equipment in use	Only the equipment necessary during each stage of the works will be used.
	Timing of equipment in use	Where practicable, activities and plant will be limited as outlined in Table C1 (APPENDIX C).
	Limit activity duration	Any equipment not in use for extended periods shall be switched off. For example, heavy vehicles should switch engines off when not in use.
	Use and siting of plant	Avoid/ limit simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver. Direct noise-emitting plant away from sensitive receivers where practicable. Locate fixed location plant items as far from sensitive receivers as practicable.
	Equipment selection	Use quieter and less noise/ vibration emitting construction methods where feasible and reasonable.
	Truck movements	Where practicable, avoid the use of park air brakes at night. Air brake silencers are to be correctly installed and fully operational for any heavy vehicles (as per CNVMP). Minimise unnecessary acceleration on site.
	Non-tonal alarms	Alternative alarms, such as 'quackers' will be installed on all vehicles & mobile plant regularly used on site and on all vehicles & mobile plant required for OOHW.
Path mitigation measures	Temporary noise screens	Where practicable, temporary noise screens (e.g. Flexshield, Echo-barrier, or similar) should be used to provide additional noise reduction during works. Temporary noise screens can provide 5 to 10 dB noise reduction, where they can break line of sight.
Noise management measures	Site inductions & Toolbox Talks	<p>All employees, contractors and subcontractors will receive a Project induction. The environmental component may be covered in toolboxes and should include:</p> <ul style="list-style-type: none"> • location of nearest sensitive receivers • relevant project specific and standard noise and vibration mitigation measures; • permitted hours of work; • OOHW Procedure and Form • construction employee parking areas.
	Community consultation	Inform community of construction activity and potential impacts.
	Respite periods	Noise levels are required to be less than $L_{Aeq(15 \text{ minute})}$ 60 dB(A) for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below $L_{Aeq(15 \text{ minute})}$ 55 dB(A). Noise equal to or above $L_{Aeq(15 \text{ minute})}$ 60dB(A) is allowed for the remaining 6.5 hours between 7am and 8pm.

Control type	Control measure	Typical use
	Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
	Noise monitoring	Noise monitoring is to be carried out as detailed in Section 5.4.5
	Dive services building OOHW	For deliveries during OOHW periods, unloading to occur away from the northern extent of the site where possible. Unloading deliveries adjacent to the dive services building to occur where no alternatives are available.

5.4.4 Additional noise mitigation measures

In circumstances where, after application of all reasonable and feasible mitigation measures, the $L_{Aeq(15\text{minute})}$ airborne construction noise levels are still predicted to exceed the NMLs, additional airborne noise management measures can be applied to further limit the risk of annoyance from construction noise (Figure 5.1). This requirement is supplemental to the basic requirements in the ICNG. These measures are consistent with the approach outlined in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (SMCSNVS) [7].

Figure 5.1: Additional airborne noise mitigation measures

Time Period		Mitigation Measures			
		Predicted $L_{Aeq(15\text{minute})}$ Noise Level Above Background (RBL)			
		0 to 10 dB	10 to 20 dB	20 to 30 dB	> 30 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	-	-	M, LB,	M, LB
	Sat (8.00 am - 1.00 pm)				
	Sun/Pub Hol (Nil)				
OOHW 1	Mon-Fri (6.00 pm - 10.00 pm)	-	LB	M, LB	M, IB, LB, PC, RO, SN
	Sat (1.00 pm - 10.00 pm)				
	Sun/Pub Hol (8.00 am - 6.00 pm)				
OOHW 2	Mon-Fri (10.00 pm - 7.00 am)	-	M, LB,	M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)				
	Sun/Pub Hol (6.00 pm - 7.00 am)				

Notes: LB = Letter box drops

SN = Specific notifications

RO = Project specific respite offer

M = Monitoring

IB = Individual Briefing

AA* = Alternative accommodation

PC = Phone Call and email

Where OOHW occur in the evening/night shoulder period (10:00pm to 12:00am) or the night/morning shoulder period (5:00am to 7:00am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

*AA applies where a construction activity impacts receivers over 2 or more consecutive nights.

APPENDIX D.4 presents a summary of the additional noise mitigation measures applicable for construction activities where, after application of all reasonable and feasible mitigation options, construction noise levels are still above the NMLs.

During Stay-at-Home Health Orders, BESIX Watpac will consider the suitability of the above additional mitigation measures and endeavour to provide, if necessary, more suitable mitigation measures following consultation with the community and Sydney Metro. The respite to be offered will be tailored to circumstances noting that not all respite offers will be appropriate during the COVID 19 pandemic. Current or future COVID 19 restrictions will guide what respite offers can be provided, for example, meal vouchers can be replaced by general-use Eftpos/Mastercard vouchers.

5.4.5 Noise monitoring

Attended noise monitoring will be undertaken to verify that construction activities are consistent with the noise modelling scenarios and that noise levels resulting from construction works are not higher than the levels predicted in this CNVIS or relevant NMLs. Attended monitoring on private property is subject to obtaining the property owner/occupier's consent (where required).

Attended noise monitoring will be undertaken during works at one of the representative receivers identified in the table below in the NCAs most impacted by the works. Nominated attended measurement locations have been selected with the best opportunity to validate the predicted noise levels.

Table 5-8: Nominated verification monitoring locations

NCA	Nominated receiver address	Monitoring location at 1 m from
BN_01	23 Barangaroo Avenue, Barangaroo	Northern facade
BN_02	18-20 Bettington Street, Millers Point	Southern facade
	35-35A Dalgety Road, Millers Point	Eastern facade
BN_03	46-46A High Street, Millers Point	Western facade
	60-60A High Street, Millers Point	Western facade
OSR	37 High Street, Millers Point	Western facade
	35-37 Bettington Street, Millers Point	Eastern facade

Note: Monitoring on private property is subject to owner consent and where relevant, occupier consent

If verification monitoring shows that the external noise levels from the construction works are above the predicted levels, investigation will be undertaken to understand the cause of the exceedance and relevant reasonable and feasible mitigation measures will be implemented.

Periodic assessment of plant noise levels will also be undertaken in accordance with the NVMP to confirm the plant noise levels are within the recommended levels in APPENDIX C Table C1.

Real-time noise monitoring in accordance with PPA Condition C11 is proposed for this site and will commence prior to the start of the demolition works. The real-time noise monitor will be installed at the site office on Hickson Road by trained personnel, familiar with the relevant standards and assessment procedures which are outlined in Appendix E of the NVMP. The real-time monitoring data will be available to the construction team, Sydney Metro, ER, AA, DPIE and EPA via a web-based portal.

5.4.6 Complaints handling

Complaints will be recorded and managed as detailed in the Community Communications Strategy and Business Management Plan.

Sydney Metro operate a 24-hour construction complaints line (1800 171 386). Enquiries/ complaints may also be received through the Sydney Metro project email (sydneymetro@transport.nsw.gov.au).

6 Construction vibration impacts

6.1 Minimum working distances for vibration intensive plant

From the plant and equipment listed in APPENDIX C, high vibration generating plant and equipment are summarised for each construction work zone in Table 6-1 below.

Table 6-1: Vibration generating plant and equipment

Construction Zone	Vibration intensive plant/equipment	Time period		
		Standard hours	OOHW Period 1	OOHW Period 2
Zone 1	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (Padfoot)	✓		
	Vibratory piling rig	✓		
Zone 2	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (20T Padfoot)	✓		
Zone 3	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (Padfoot)	✓		
Zone 3.1	Jackhammer	✓		
Zone 4	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (Padfoot)	✓		
Zone 4.1	Jackhammer	✓		
Zone 5	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Vibratory Roller (Padfoot)	✓		
Zone 6	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (Padfoot)	✓		
Zone 9	Jackhammer	✓		
	Compactor / Wacker packer	✓		
	Excavator with hammer (35T)	✓		
	Vibratory Roller (Padfoot)	✓		
Zone A	Compactor / Wacker packer	✓	✓	✓

Construction Zone	Vibration intensive plant/equipment	Time period		
		Standard hours	OOHW Period 1	OOHW Period 2
Zone B	Compactor / Wacker packer	✓	✓	✓

Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration, and the receiver structure. The recommended minimum working distances for vibration intensive plant in Table 6-2 and Table 6-3 are taken from a database of vibration levels measured at various sites or obtained from other sources (e.g. BS5228-2:2009). They are not specific to these works as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

Site specific minimum working distances for vibration significant plant items must be measured on site where plant and equipment are likely to operate close to or within the recommended minimum working distances for cosmetic damage (Table 6-2).

Table 6-2: Minimum working distances (m) for cosmetic damage (continuous vibration).

Plant item	Minimum working distance (m)			
	Reinforced or framed structures (e.g. commercial buildings) ¹	Unreinforced or light framed structures (e.g. residential buildings) ¹	Sensitive structures (e.g. heritage structures) ²	Site-specific MWD for the Hickson Road wall ⁷
Jackhammer	5 ³	5 ³	5 ³	1 ⁵
Compactor / Wacker packer	5 ³	5 ³	5 ³	1 ⁵
Excavator with rock hammer (25t)	5	10	10	1 ⁴
Vibratory Roller (Padfoot)	5	10	20	5 ⁶
40t Vibratory piling rig (90kN force)	5	5	15	5 ⁶

Note 1: Initial screening test criteria reduced by 50% due to potential dynamic magnification in accordance with BS7385.

Note 2: In accordance with Section 5.8.1 of CNVMP, a site inspection should determine whether a heritage structure is structurally unsound.

Note 3: Minimum working distances are in 5m increments only to account for the intrinsic uncertainty of this screening method. Jackhammers and compactors are likely to have minimum working distances smaller than 5 m.

Note 4: Refer to vibration monitoring report (reference: TM031-05F02 Rockhammering Noise and Vibration Monitoring Report, dated: 19/09/2022, revision 2).

Note 5: The site-specific MWDs has been derived from the rockhammering vibration monitoring assuming this plant is less vibration intensive.

Note 6: Valid until monitoring verification onsite confirms otherwise.

Note 7: Applicable in situations where there is the same structural connection to the Hickson Road wall as during the vibration measurements on 15/07/2022

Table 6-3: Minimum working distances (m) for human annoyance and / or equipment function (continuous vibration).

Plant item	Minimum working distances, m				
	Critical areas ^{1,4}	Residences Day ²	Residences Night ²	Offices ^{3,4}	Workshops ⁴
Jackhammer	25	15	20	10	5

Plant item	Minimum working distances, m				
	Critical areas ^{1,4}	Residences		Offices ^{3,4}	Workshops ⁴
		Day ²	Night ²		
Compactor / Wacker packer	20	10	15	5	5
Excavator with rock hammer (35T)	40	25	30	20	15
Vibratory Roller (Padfoot)	120	70	90	40	25
Vibratory piling rig	185	80	120	35	15

Notes 1: Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.

2: Daytime is 7 am to 10 pm; Night-time is 10 pm to 7am.

3: Examples include offices, schools, educational institutions and place of worship.

4: Applicable when in use.

6.2 Vibration assessment

6.2.1 Structural damage

The numbers of buildings which are close to or within the minimum working distances for cosmetic damage are shown in Table 6-4. More detailed results are presented in APPENDIX E. The figures in APPENDIX E identify the minimum working distances for vibration over aerial photographs that also show the work areas and the land uses.

Table 6-4: Number of buildings within minimum working distances for cosmetic damage

Work Zones	Plant item	Number of buildings ¹	
		Screening criteria for non-heritage structures	Screening criteria for heritage structures
Zone 1	Jackhammer	0	0
	Compactor / Wacker packer	0	0
	Excavator with hammer (35T)	0	0
	Vibratory Roller (Padfoot)	0	0
	Vibratory piling rig	0	0
Zone 2	Jackhammer	0	0
	Compactor / Wacker packer	0	0
	Excavator with hammer (35T)	0	0
	Vibratory Roller (20T Padfoot)	0	0
Zone 3	Compactor / Wacker packer	0	0
	Excavator with hammer (35T)	1	0
	Vibratory Roller (Padfoot)	1	1
Zone 3.1	Jackhammer	0	0
Zone 4	Jackhammer	0	1
	Compactor / Wacker packer	0	1
	Excavator with hammer (35T)	0	1

Work Zones	Plant item	Number of buildings ¹	
		Screening criteria for non-heritage structures	Screening criteria for heritage structures
	Vibratory Roller (Padfoot)	0	1
Zone 4.1	Jackhammer	0	1
Zone 5	Jackhammer	1	0
	Compactor / Wacker packer	1	0
	Vibratory Roller (Padfoot)	1	0
Zone 6	Jackhammer	2	0
	Compactor / Wacker packer	2	0
	Excavator with hammer (35T)	2	1
	Vibratory Roller (Padfoot)	2	1
Zone 9	Jackhammer	0	0
	Compactor / Wacker packer	0	0
	Excavator with hammer (35T)	0	0
	Vibratory Roller (Padfoot)	0	0
Zone A	Compactor / Wacker packer	1	1
Zone B	Compactor / Wacker packer	0	1

Notes: 1: Site inspection should determine structural conditions of all potentially vibration affected buildings.

The table above shows there are 2 non-heritage buildings and 1 heritage structures located within the minimum working distances established for cosmetic damage during the civil works. These buildings/structures are identified in Table 6-7 and in APPENDIX E.

To minimise the risk of vibration impact on structures, condition surveys of all the vibration affected buildings/structures, identified in Table 6-7 below, will be conducted prior to commencement of construction work that generates vibration. The building condition survey reports will be provided to Renzo Tonin where required to assist in the confirmation of appropriate vibration criteria (e.g. reinforced or unreinforced structures, structurally sound or unsound heritage buildings).

Where a vibration intensive plant is required to operate within site specific minimum working distances, vibration monitoring is recommended to verify that vibration levels achieve compliance with the structural damage objectives.

If the monitoring above identifies that vibration is likely to exceed the structural damage objectives, a different construction method with lower source vibration levels should be considered.

6.2.2 Human annoyance

The assessing vibration guideline [4] notes that inside dwellings, adverse comments often arise when occupants can perceive (feel) vibration, particularly when the vibration arises from a source located

outside their home (or outside their control) and assume that the vibration has the potential to damage their building or contents.

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

At properties near the worksite, it is likely that the nearest receivers will be able to feel vibration levels when vibration-generating equipment is being utilised. Properties where vibration levels may be above the vibration disturbance goals in Table 6-3 and there is a probability of adverse comment are shown in Table 6-5.

Table 6-5: Properties within minimum distances for human annoyance

Plant items	Worksite	Critical areas ^{1,4}	Residences ⁵		Offices ^{3,4}	Workshop ⁴
			Day ²	Night ²		
Jackhammer	Zone 1 ⁷	0	26	- ⁶	0	0
Compactor / Wacker packer	Zone 2 ⁸	0	25	- ⁶	0	0
Excavator with rock hammer (35T)	Zone 3 ⁸	0	63	- ⁶	2	0
Vibratory Roller (Padfoot)	Zone 3.1 ⁹	0	0	- ⁶	2	0
Vibratory piling rig	Zone 4 ⁸	0	66	- ⁶	2	0
	Zone 4.1 ⁹	0	1	- ⁶	0	0
	Zone 5 ⁸	0	24	- ⁶	2	0
	Zone 6 ⁸	0	55	- ⁶	7	0
	Zone 9 ⁸	0	31	- ⁶	0	0
	Zone A ¹⁰	0	0	3	1	0
	Zone B ¹⁰	0	0	0	0	0

- Notes:
1. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.
 2. Daytime is 7 am to 10 pm; Night-time is 10 pm to 7am.
 3. Examples include offices, schools, educational institutions and place of worship.
 4. Applicable when in use.
 5. Hotels and childcare centres are included in the residence category.
 6. No vibration intensive activity is proposed during night-time period.
 7. Most vibration intensive plant (Vibratory piling rig) has been used to estimate the maximum number of buildings within MWD for human annoyance.
 8. Most vibration intensive plant (Vibratory Roller (Padfoot)) has been used to estimate the maximum number of buildings within MWD for human annoyance.
 9. Most vibration intensive plant (Jackhammer) has been used to estimate the maximum number of buildings within MWD for human annoyance.
 10. Most vibration intensive plant (Compactor / Wacker packer) has been used to estimate the maximum number of buildings within MWD for human annoyance.

As can be noted from the table above, there are residential properties, and offices that may be exposed to vibration above the screening limit for human annoyance. These receivers are identified in APPENDIX E.

The above assessment is based on vibration-generating equipment being operating at the closest location to nearby receivers. When vibration-generating equipment operates further from the closest point, the predicted vibration levels will reduce along with the probability of adverse comment.

Attended vibration measurements are proposed to be carried out proactively and in response to vibration complaints. If measurement results indicate events above the vibration objectives for human annoyance, vibration control and management measures will be provided to reduce vibration impact (see Section 6.3.1).

6.3 Vibration mitigation measures

6.3.1 Vibration control and management measures

In addition to the vibration control measures presented in the CNVMP, the following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort vibration and structural damage limits identified in Section 4.2.

Table 6-6: Site vibration control measures

Control type	Control measure	Typical use
Construction Planning	Building condition surveys	Undertake building dilapidation surveys on all buildings located within the buffer zones established for cosmetic damage prior to commencement of activities with the potential to cause property damage (see Section 6.1).
	Community consultation	Implement community consultation measures – inform community of construction activity & potential impacts – inform community that the level of vibration at which people perceive it, or at which loose objects may rattle, is far lower than the level at which minor cosmetic damage is expected to occur
	Equipment selection/ construction method	Use less vibration emitting construction methods where feasible & reasonable, for example vibratory rollers can, where practicable, be operated with the vibratory mode switched off to reduce vibration impact.
	Plan work activities to minimise vibration.	Plan traffic flow, parking & loading/unloading areas to maximise distances between truck routes and sensitive receivers.
Complaints Management	Construction Complaints Management System	Complaints will be managed in accordance with the Construction Complaints Management System (see Section 0). Each complaint shall be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences. Management measures may include modification of construction methods such as using smaller equipment and establishment of safe buffer zones as mentioned above.

6.3.2 Additional vibration mitigation measures

In circumstances where, after application of all reasonable and feasible mitigation measures, construction vibration is still found to exceed the maximum Vibration Dose Value outlined in Table 4-2, additional vibration management measures can be applied to further limit the risk of annoyance from construction noise (Figure 6.1).

Figure 6.1: Additional vibration management measures

Time Period		Mitigation Measures Predicted Vibration Levels Exceed Maximum Levels(VDV)***
Standard	Mon-Fri (7.00 am - 6.00 pm)	M, LB, RP
	Sat (8.00 am - 1.00 pm)	
	Sun/Pub Hol (Nil)	
OOHW 1	Mon-Fri (6.00 pm - 10.00 pm)	M, IB, LB, PC, RO, SN
	Sat (1.00 pm - 10.00 pm)	
	Sun/Pub Hol (8.00 am - 6.00 pm)	
OOHW 2	Mon-Fri (10.00 pm - 7.00 am)	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)	
	Sun/Pub Hol (6.00 pm - 7.00 am)	

Notes: LB = Letter box drops

SN = Specific notifications

RO = Project specific respite offer

M = Monitoring

IB = Individual briefing

AA* = Alternative accommodation

PC = Phone call and email

Where OOHW occur in the evening/night shoulder period (10:00pm to 12:00am) or the night/morning shoulder period (5:00am to 7:00am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

*AA applies where construction activity impacts receivers over 2 or more consecutive nights.

***Maximum levels are the maximum vibration dose values (VDV) from Table 4-2

6.3.3 Vibration monitoring

Attended vibration monitoring is to be undertaken to determine and verify site specific minimum working distances for cosmetic damage and human annoyance. As a minimum, it is recommended that attended monitoring is undertaken at the locations in Table 6-7 when vibration significant plant items operate close to or within the minimum working distances. Additional monitoring may also be required in response to vibration complaints.

Real-time vibration monitoring in accordance with PPA Condition C11 is proposed for this site and will commence when works are planned to be close or within minimum working distances for cosmetic damage. The real-time vibration monitors will be installed at the site office along Hickson Road by trained personnel, familiar with the relevant standards and assessment procedures which are outlined in APPENDIX E of the NVMP.

Table 6-7: Attended vibration monitoring - nominated representative locations

Plant	Construction Zone	Address	Vibration objectives to check	
			Cosmetic damage	Human annoyance ¹
Jackhammer Compactor / Wacker packer Excavator with hammer (35T) Vibratory Roller (Padfoot)	Zone 6	25 Hickson Road (site office)	√	√ ²

Plant	Construction Zone	Address	Vibration objectives to check	
			Cosmetic damage	Human annoyance ¹
Jackhammer Compactor / Wacker packer Excavator with hammer (35T) Vibratory Roller (Padfoot)	Zone 6	8 Windmill Street, Millers Point	√	√ ²
Jackhammer Compactor / Wacker packer Excavator with hammer (35T) Vibratory Roller (Padfoot)	Zone 3, Zone 4, Zone 4.1 and Zone 6	High Street Heritage Wall	√	

Notes: 1: In the event of complaint related to vibration.

2: Monitoring on private property is subject to owner consent and where relevant, occupier consent.

Although earthing rod installation is not considered a vibration intensive activity, vibration monitoring will be conducted as requested by the heritage consultant via email on 24/10/2022, consistent with the commitments in the HMP and the requirements of the conditions NAH11.

6.3.4 Complaints handlings

Vibration complaints will be recorded and managed as detailed in the Community Communications Strategy and Business Management Plan.

Sydney Metro operate a 24-hour construction complaints line (1800 171 386). Enquiries/ complaints may also be received through the Sydney Metro project email (sydneymetro@transport.nsw.gov.au).

7 Ground-borne noise assessment

Due to the nature of the proposed civil works, which are surface works, airborne noise is expected to be much higher than ground-borne noise levels at the nearest sensitive receivers.

The risk of annoyance due to ground-borne noise is therefore considered low and has not been addressed further in this CNVIS.

8 Traffic noise assessment

8.1 Traffic sources

A maximum of 6 concrete/delivery trucks per hour may be required during day and night-time periods for utility works, road works and deliveries to the Hickson Road shed (this includes the night-time movements for the underground station fit-out). Details of projected heavy vehicle movements associated with the construction works were provided by BESIX Watpax and described in APPENDIX C Table C1. Light vehicle movements are expected to be up to 300 movements during the day and 72 movements at night.

Traffic counts for Hickson Road over the week of 9 December 2017 to 15 December 2017 were provided by JHCPBG and used to predict the relative increase in road traffic noise levels from the project. Those traffic volumes are detailed in Table 8-1.

Table 8-1: Traffic noise modelling data - existing road network

Site	Road	Road category (RNP)	15-hour day period (7am-10pm)				9-hour night period (10pm-7am)			
			Existing		Project		Existing		Project	
			TOTAL	HV	TOTAL	HV	TOTAL	HV	TOTAL	HV
Barangaroo	Hickson Road	Arterial	9768	634	480	180	1614	157	180	108

8.2 Predicted construction traffic noise

The potential impact of construction road traffic noise to nearby residential receivers has been estimated using the United Kingdom Department of Environment's 'Calculation of Road Traffic Noise' (1988) method. The method uses the average 1-hour traffic volume for the 'assessment period' (i.e. day or night) to predict the $L_{10, 1\text{hour}}$ noise levels. A correction of -3dB(A) is applied to obtain the $L_{\text{eq}, 1\text{hour}}$ noise levels which equate to the L_{Aeq} noise levels for the 'assessment period'.

For this assessment, the model has taken into account:

- traffic volume and heavy vehicle forecasts;
- posted vehicle speed;
- road gradient;
- ground reference levels of the road and receivers;
- separation distances of the road to receivers;
- ground type between the road and receivers; and
- angles of view of the road from the receiver's position.

For assessment purposes, closest residential receivers are along High Street.

Table 8-2 below summarises the predicted construction traffic noise levels during day and night periods.

Table 8-2: Predicted traffic noise levels (with/ without construction)

Site	Road	Predicted noise level, dB(A)					
		Day period (7am to 10pm)			Night period (10pm to 7am)		
		Noise descriptor	No construction	With construction	Noise descriptor	No construction	With construction
Barangaroo	Hickson Road	L _{Aeq(15h)}	52.1	52.8	L _{Aeq(9h)}	47.8	49.6

Note: **Bold text indicates more than 2dB(A) increase in traffic noise levels resulting from construction traffic.**

The predicted road traffic noise levels indicate a **less than 2dB(A) increase in overall day L_{Aeq(15h)} and night L_{Aeq(9h)} noise** and so construction traffic is predicted to have minimal impact on nearby road network used to access/exit the site.

8.3 Traffic noise mitigation and management

No mitigation or management measures are required when construction vehicles are on public roads, provided hourly traffic movements associated with construction are consistent with the assumptions outlined above.

9 Cumulative impacts

The impacts addressed in this assessment have also considered the additional works that are proposed to occur for the underground station fit-out works which are assessed in a separate CNVIS (*Underground Station CNVIS*). The impacts predicted in this CNVIS are considerably higher than those presented in the *Underground Station CNVIS* as they are associated with high noise impact works on surface. As a result, any increase in noise from the underground station fit-out works would not be significant, therefore the cumulative worst-case impacts from all Sydney Metro Barangaroo Station works are assessed in this CNVIS.

BESIX Watpac are aware of other ongoing, potentially concurrent construction activities within the vicinity of the Barangaroo site. These works, summarised in Table 9.1, are mainly undertaken during standard construction hours and they may have the potential to increase cumulative noise impacts on receivers up to 1-2dB(A). These works have been considered but it has been determined that, due to the nature of the other unrelated construction works and the minor increase in cumulative impacts, no additional physical mitigation measures are deemed reasonable. Nevertheless, BESIX Watpac will continue consulting with proponents of other nearby construction works and take all reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receivers.

Table 9.1: Other construction works close to Barangaroo worksite

Construction company	Project	Timing of activities	Hours of works	Works location	Activity types	General plant types
Lendlease	One Sydney Harbour	September 2020 to 2025	Standard construction hours only	100 Barangaroo Ave, Barangaroo	Building construction	Cranes, concrete and delivery trucks, power tools, forklift, EWP
CPB UGL	Sydney Metro Linewide	November 2020 to 2023	Day and night	Hickson Road acoustic shed, cross over cavern and underground station	Delivery and tunnel fitout	Cranes, delivery trucks, power tools
John Holland	Waterloo ISD	September 2021 to September 2022	Day and night	Adjacent to Zone 9	Laydown area	Forklift and franna crane

10 Conclusion

Construction noise and vibration associated with the civil works for the construction of the Sydney Metro Barangaroo Station project have been identified and described in this report. The noise sensitive receivers surrounding the works areas and the relevant construction noise objectives have been identified and discussed to allow the assessment of potential construction noise and vibration impacts.

Construction noise

The expected construction noise levels have been predicted and presented in Section 5.3 and APPENDIX D.

During the standard construction hours, residential receivers within the proximity of the construction zones in NCAs BN_03 and BN_02 are predicted to be highly noise affected when high impact activities are occurring. During typical activities, residential receivers within the proximity of the construction zones in NCA BN_01, BN_02 and BN_03 are predicted to be less than 10dB(A) above the corresponding NMLs. Noise levels are predicted to be exceed CoA E37 during high impact activities for most affected residential receivers in NCAs BN_02 and BN03.

Outside standard construction hours, noise levels are predicted to be greater than 25dB(A) above the ICNG NMLs at the most affected residences in NCA BN_02 and BN_03 for high impact activities.

During northern shaft backfill works, predicted levels are expected to be slightly above the relevant night-time NMLs but below the E41 noise goal.

All relevant mitigation measures are presented in Section 5.4 to reduce potential noise impact. Respite periods for high noise works are presented in Section 5.4.2.

Construction traffic

The predicted road traffic noise levels associated with the proposed civil works indicate a less than 2dB(A) increase in overall day $L_{Aeq(15h)}$ and night $L_{Aeq(9h)}$ noise. As a result, construction traffic is predicted to have minimal impact on nearby road network used to access/exit the site.

Ground-borne noise

Due to the nature of the proposed civil works, which are surface works, airborne noise is expected to be much higher than ground-borne noise levels at the nearest sensitive receivers. The risk of annoyance due to ground-borne noise is therefore considered negligible.

Construction vibration

Vibration impacts have been presented in Section 6.2. Receivers are identified within minimum work distances for cosmetic damage and human annoyance. Vibration management measures have been presented in Section 6.3 to aid in minimising any potential vibration impacts. Vibration minimum working distances have been presented in APPENDIX E.

References

- [1] BARANGAROO METRO STATION – Noise and Vibration Management Plan (TM031-01F01 Barangaroo Metro Station NVMP)
- [2] SLR Consulting Australia Pty Ltd 2016 Sydney Metro Chatswood to Sydenham - Technical Paper 2: Noise and Vibration Report Number 610.14718R1 – 28 April 2016
- [3] Department of Environment and Climate Change 2009 NSW Interim Construction Noise Guideline (ICNG),
- [4] Department of Environment Conservation NSW 2006 Assessing Vibration; a technical guideline
- [5] British Standard 7385 Part 2 1993, Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration
- [6] British Standard BS 6472-2008, Evaluation of human exposure to vibration in buildings (1-80Hz)
- [7] Transport for NSW Sydney Metro City & Southwest Construction Noise Strategy (ref: 610.14213-R3) 08 August 2016
- [8] Transport for NSW Construction Noise Strategy (ref: 7TP-ST-157/2.0) April 2012
- [9] Transport for NSW Sydney Metro Construction Environmental Management Framework August 2016

APPENDIX A Glossary of terminology

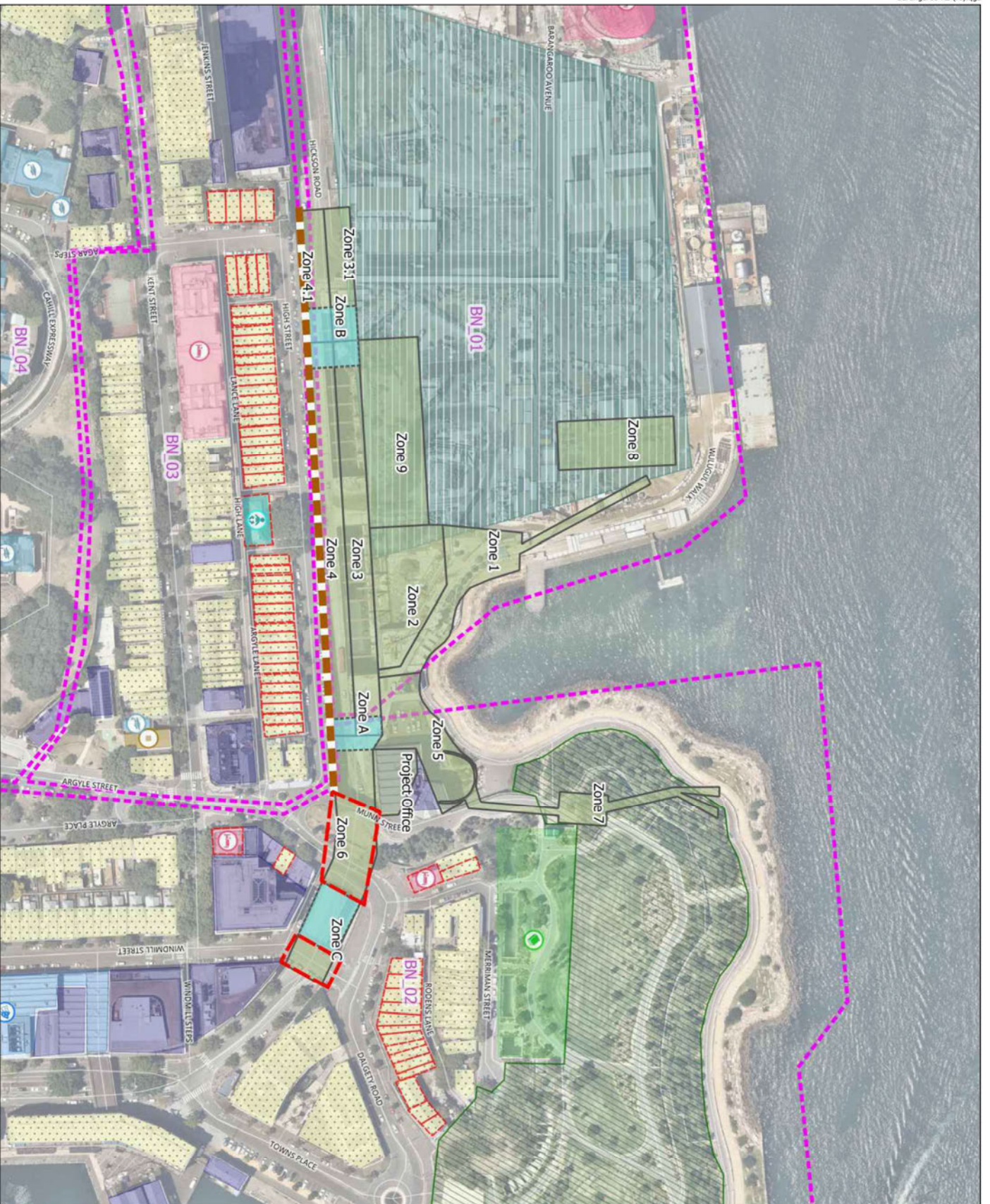
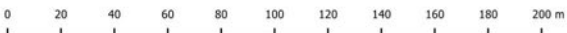
The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The A-weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L _{Max}	The maximum sound pressure level measured over a given period.
L _{Min}	The minimum sound pressure level measured over a given period.

L ₁	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L ₁₀	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L ₉₀	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L _{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L _{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B **Nearest sensitive receivers and noise management levels**

Figure B1 –Construction work areas, NCAs and land use



REV	BY	DATE	DESCRIPTION
01	RZ	31/08/21	Prepare figures
02	NT		Full size as
03	NT		1:2000
04	NT		Scale from this drawing

Co-ordinate System: MGA Zone 56

CLIENT

ACOUSTIC CONSULTANT

PH: (02) 8218 0500 Fax: (02) 8218 0501

LEGEND

	Noise sensitive receivers		Flight simulator
	Residential		Childcare
	Mixed use		Educational
	Commercial		Theatre/Auditorium
	Industrial		Cinema
	Hotel/Hotel/Hostel		Laboratory
	Medical facility		Recreational - Passive
	Place of Worship		Recreational - Active
	Community centre		Other
	Recording studio		Heritage
	Library/Museum		
	NCA		
	Heritage Wall		
	Additional Work Zones		
	Project Work Zones		

Sydney Metro Barangaroo Station
Civil Works
Land Use: NCAs
All Project Work Zones

Table B1: Noise Sensitive Receivers and Construction Noise Management Levels

BARANGAROO CIVIL WORKS

Receptor Type	Reference BML	Existing Noise Levels, dBA										Residential NMTs based on (CNG (to guide notifications and feasible and reasonable mitigation measures))										Residential External Noise Management Levels (NMT) (Leq(15 min))				Comments
		BML Day	BML Evening	BML Night	Leq _{1h} D	Leq _{1h} E	Leq _{1h} N	D(5)	D(10)	E1/E2	N1	N	N _{MS}	D15/10/1	E2/N	Sleep Disturbance	Max ^a									
BN_Q1	Residential tower under construction	EIA R.12	50	45	40	61	64	51	60	55	50	47.5	45	45	50	70-80	55-65	55	65	Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)						
BN_Q2	Residential building south of Argyle St and	EIA R.12	50	45	40	61	64	51	60	55	50	47.5	45	50	70-80	55-65	55	65	Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
BN_Q3	Residential building east of High St and south of	EIA R.12	50	45	40	61	64	51	60	55	50	47.5	45	50	70-80	55-65	55	65	Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
BN_Q4	Mixed residential and commercial west of Harbour	EIS R.13	62	62	62	66	65	63	67	67	67	62	57	62	70-80	55-65	67	65	Source: CNG, assuming a conservative fluoride loss of 20 dB(A)							
BN_Q5	Mixed residential and commercial at Lanes Bay and	EIS R.28	51	46	41	56	52	47	56	56	51	48.5	46	51	70-80	55-65	56	65	Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
BN_Q6	Residential buildings in Salsburgh East	EIS R.29	49	49	41	55	55	49	59	54	54	50	46	50	70-80	55-65	56	65	Source: CNG							
Other sensitive receptors																										
Studio building (music recording studio)									45	45	45	45	45	45					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Studio building (film or television studio)									50	50	50	50	50	50					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Cinema space, theatre, auditorium									55	55	55	55	55	55					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Head (Shopping area): hotels near major roads									60	60	60	60	60	60					Source: CNG, assuming a conservative fluoride loss of 20 dB(A)							
Classrooms at schools and other educational institutions									55	55	55	55	55	55					Source: CNG, assuming a conservative fluoride loss of 20 dB(A)							
Office centre (internal play and sleeping areas)									50	50	50	50	50	50					Source: M&C - builder for Child Care Facility Assessment, assuming a conservative fluoride loss of 10 dB(A)							
Hospital wards and operating theatres									65	65	65	65	65	65					Source: CNG, assuming a conservative fluoride loss of 20 dB(A)							
Places of worship									55	55	55	55	55	55					Source: CNG, assuming a conservative fluoride loss of 20 dB(A)							
Library (reading area)									65	65	65	65	65	65					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Hotel (bars and lounges)									70	70	70	70	70	70					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Community centres - Municipal Buildings									60	60	60	60	60	60					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Restaurant, bar (bars and lounges/Restaurants)									70	70	70	70	70	70					Source: AC2107 'maximum', assuming a conservative fluoride loss of 20 dB(A)							
Party restaurant (bar/club/nightclub)									60	60	60	60	60	60					Source: CNG							
Active recreation areas (e.g. sports fields)									65	65	65	65	65	65					Source: CNG							
Commercial premises (working offices and retail outlets)									70	70	70	70	70	70					Source: CNG							
Industrial premises:									75	75	75	75	75	75					Source: CNG							
Notes:																										
1 - Sample in the external equivalent NMT depends on the specific building layout and is based on 'N1 condition B1' and 'E1/E2'																										
2 - Levels are estimated assuming an open window (i.e. 100% facade loss)																										
D(5): standard construction hours from 7 am to 6 pm Saturday, Friday, from 8 am to 6 pm Saturday, Sunday and Public Holiday																										
D(10): out-of-hours day period from 1 pm to 6 pm Saturday, from 8 am to 6 pm Sunday and Public Holiday - CDMW P1																										
E1: early evening period from 6 pm to 8 pm Monday to Sunday - CDMW P1																										
E2: late evening period from 8 pm to 10 pm Monday to Sunday - CDMW P1																										
N1: night shoulder period from 10pm to 2am Monday to Sunday - CDMW P1																										
N: night time period from 2am to 5am Monday to Friday, from 2am to 8 am Saturday, Sunday and Public Holiday - CDMW P2																										
N _{MS} : morning shoulder period from 1 am to 7 am Monday to Friday, from 6 am to 8 am Saturday, Sunday and Public Holiday - CDMW P1																										

APPENDIX C Construction timetable/ activities/ management

Table C1: Construction Inventory, activities / equipment

Activity	Aspect	Initiative timing Duration	Work area	Sounding ID	Plant / Equipment	Plant Equipment (operational by month)	Number of plant/equipment items (operational by month)				Sound Power Level (dB) (New Model, daily)				High noise plant	Variable duration plant	Notes	
							Day	Evening	Night	Leak	Leak	Leak	Leak	Leak				
Hand levelling work (CONV-work-6)	Hand levelling work (CONV-work-6)	Apr 2022-Mar 2023 / 13 months	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Concrete in bucket (250)	Concrete in bucket (250)	1	1	1	1	103	103	103	103				
						Concrete in bucket (500)	1	1	1	1	103	103	103	103				
						Concrete in bucket (1000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (2000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (3000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (4000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (5000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (6000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (7000)	1	1	1	1	103	103	103	103				
						Concrete in bucket (8000)	1	1	1	1	103	103	103	103				
Hand levelling work (CONV-work-6)	Hand levelling work (CONV-work-6)	Apr 2022-Mar 2023 / 13 months	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Concrete in bucket (250)	1	1	1	1	103	103	103	103					
					Concrete in bucket (500)	1	1	1	1	103	103	103	103					
					Concrete in bucket (1000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (2000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (3000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (4000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (5000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (6000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (7000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (8000)	1	1	1	1	103	103	103	103					
Hand levelling work (CONV-work-6)	Hand levelling work (CONV-work-6)	Apr 2022-Mar 2023 / 13 months	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Concrete in bucket (250)	1	1	1	1	103	103	103	103					
					Concrete in bucket (500)	1	1	1	1	103	103	103	103					
					Concrete in bucket (1000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (2000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (3000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (4000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (5000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (6000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (7000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (8000)	1	1	1	1	103	103	103	103					
Hand levelling work (CONV-work-6)	Hand levelling work (CONV-work-6)	Apr 2022-Mar 2023 / 13 months	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Concrete in bucket (250)	1	1	1	1	103	103	103	103					
					Concrete in bucket (500)	1	1	1	1	103	103	103	103					
					Concrete in bucket (1000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (2000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (3000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (4000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (5000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (6000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (7000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (8000)	1	1	1	1	103	103	103	103					
Hand levelling work (CONV-work-6)	Hand levelling work (CONV-work-6)	Apr 2022-Mar 2023 / 13 months	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6, Zone 7, Zone 8, Zone 9	Concrete in bucket (250)	1	1	1	1	103	103	103	103					
					Concrete in bucket (500)	1	1	1	1	103	103	103	103					
					Concrete in bucket (1000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (2000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (3000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (4000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (5000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (6000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (7000)	1	1	1	1	103	103	103	103					
					Concrete in bucket (8000)	1	1	1	1	103	103	103	103					

APPENDIX D Detailed predicted noise levels

D.1 Predicted noise levels

The detailed predicted levels have been provided to BESIX Watpac in a spreadsheet table in order to more adequately mitigate and manage potential noise impacts.

D.2 Consultation required under conditions E37/E38

Address	Required consultation E37
24 MUNN STREET BARANGAROO	√
68 BETTINGTON STREET MILLERS POINT	√
35-35A DALGETY ROAD MILLERS POINT	√
33-33A DALGETY ROAD MILLERS POINT	√
31-31A DALGETY ROAD MILLERS POINT	√
29-29A DALGETY ROAD MILLERS POINT	√
27-27A DALGETY ROAD MILLERS POINT	√
18-20 MUNN STREET MILLERS POINT	√
21-21A HICKSON ROAD MILLERS POINT	√
8 Argyle Place, Millers Point	√
127-153 KENT STREET MILLERS POINT	√
7-7A HIGH STREET MILLERS POINT	√
80-80A HIGH STREET MILLERS POINT	√
2-2A HIGH STREET MILLERS POINT	√
2 HIGH STREET MILLERS POINT	√
85-87 KENT STREET MILLERS POINT	√
81 KENT STREET MILLERS POINT	√
79 KENT STREET MILLERS POINT	√
77 KENT STREET MILLERS POINT	√
75 KENT STREET MILLERS POINT	√
73 KENT STREET MILLERS POINT	√
71 KENT STREET MILLERS POINT	√
59 KENT STREET MILLERS POINT	√
61 KENT STREET MILLERS POINT	√
63 KENT STREET MILLERS POINT	√
53 KENT STREET MILLERS POINT	√
55 KENT STREET MILLERS POINT	√
38-38A HIGH STREET MILLERS POINT	√
40-40A HIGH STREET MILLERS POINT	√
42-42A HIGH STREET MILLERS POINT	√
44-44A HIGH STREET MILLERS POINT	√
46-46A HIGH STREET MILLERS POINT	√
48-48A HIGH STREET MILLERS POINT	√
50-50A HIGH STREET MILLERS POINT	√

Address	Required consultation E37
52-52A HIGH STREET MILLERS POINT	√
54-54A HIGH STREET MILLERS POINT	√
56-56A HIGH STREET MILLERS POINT	√
58-58A HIGH STREET MILLERS POINT	√
60-60A HIGH STREET MILLERS POINT	√
62-62A HIGH STREET MILLERS POINT	√
64-64A HIGH STREET MILLERS POINT	√
66-66A HIGH STREET MILLERS POINT	√
68-68A HIGH STREET MILLERS POINT	√
70-70A HIGH STREET MILLERS POINT	√
72-72A HIGH STREET MILLERS POINT	√
78-78A HIGH STREET MILLERS POINT	√
76-76A HIGH STREET MILLERS POINT	√
4-4A HIGH STREET MILLERS POINT	√
6-6A HIGH STREET MILLERS POINT	√
8-8A HIGH STREET MILLERS POINT	√
10-10A HIGH STREET MILLERS POINT	√
12-12A HIGH STREET MILLERS POINT	√
14-14A HIGH STREET MILLERS POINT	√
16-16A HIGH STREET MILLERS POINT	√
18-18A HIGH STREET MILLERS POINT	√
20-20A HIGH STREET MILLERS POINT	√
22-22A HIGH STREET MILLERS POINT	√
24-24A HIGH STREET MILLERS POINT	√
26-26A HIGH STREET MILLERS POINT	√
28-28A HIGH STREET MILLERS POINT	√
30-30A HIGH STREET MILLERS POINT	√
32-32A HIGH STREET MILLERS POINT	√
34-34A HIGH STREET MILLERS POINT	√
36-36A HIGH STREET MILLERS POINT	√
83 KENT STREET MILLERS POINT	√
3-3A HIGH STREET MILLERS POINT	√
5-5A HIGH STREET MILLERS POINT	√
CUTAWAY MUSEUM	√
30-34 HICKSON ROAD MILLERS POINT	√
8 WINDMILL STREET MILLERS POINT	√

Address	Required consultation E37
6 ARGYLE PLACE, MILLERS POINT	√
1 KENT STRET / 14 ARGYLE PLACE MILLERS	√

D.3 Number of receivers above NMLs

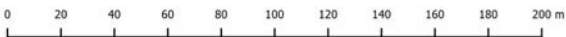
The number of exceedances has been provided to BESIX Watpac in a spreadsheet table.

D.4 Additional mitigation measures

The additional mitigation measures have been provided to BESIX Watpac in a spreadsheet table in order to more adequately mitigate and manage potential noise impacts.

APPENDIX E Vibration impact

E.1 Minimum working distances – Vibration



REV#	BY	DATE	DESCRIPTION	APPROVER
0	RZ	31/08/21	Prepare figures	NT
1	AS		Final size as	

Co-ordinate System: MGA Zone 56

SCALE: 1:2000

NOTE: Do not scale from this drawing.

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Sydney Metro Barangaroo Station
Civil Works

MWD for cosmetic damage and human annoyance
Zone 1

LEGEND

Noise sensitive receivers

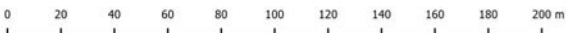
- Residential
- Mixed use
- Commercial
- Industrial
- Hotel/Motel/Hostel
- Medical facility
- Place of Worship
- Community centre
- Recording studio
- Library/Museum
- Flight simulator
- Childcare
- Educational
- Theatre/Auditorium
- Cinema
- Laboratory

WMD for cosmetic damage and human annoyance

- Receivers within MWD for cosmetic damage
- WMD for cosmetic damage and human annoyance for Vibratory piling
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)

Other

- Heritage Wall
- Zone 1
- Heritage
- Recreational - Active
- Recreational - Passive
- Other



REV#	BY	DATE	DESCRIPTION
R2		31/08/21	Prepare figures
AS	Original		

Co-ordinate System: MGA Zone 56

APPROVER: NT

FULL SIZE AS

1:2000

NOTE: Do not scale from this drawing.

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LEGEND

Noise sensitive receivers

- Residential
- Mixed use
- Commercial
- Industrial
- Hotel/Motel/Hostel
- Medical facility
- Place of Worship
- Community centre
- Recording studio
- Library/Museum
- Flight simulator
- Childcare
- Educational
- Theatre/Auditorium
- Cinema
- Laboratory
- Recreational - Passive
- Recreational - Active
- Other
- Heritage

Receivers within MWD for cosmetic damage

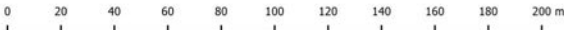
- MWD for cosmetic damage and human annoyance for Vibratory roller (Padfoot) - High Vibration
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)

Other symbols:

- Heritage Wall
- Zone 2

Sydney Metro Barangaroo Station
Civil Works
MWD for cosmetic damage and human annoyance
Zone 2

Sheet 2 of 11



REV	BY	DATE	DESCRIPTION	APPROVER
01				
02	RZ	31/08/21	Prepare figures	NT
03	AS		Finalize drawing	
04	Original			

Co-ordinate System: MGA Zone 56

Scale: 1:2000

Scale bar: 0, 40, 80, 120 m

North arrow

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LEGEND

	Noise sensitive receivers		Flight simulator
	Residential		Childcare
	Mixed use		Educational
	Commercial		Theatre/Auditorium
	Industrial		Cinema
	Medical facility		Laboratory
	Hotel/Hotel/Hostel		Recreational - Passive
	Community centre		Recreational - Active
	Recording studio		Other
	Library/Museum		Heritage

Heritage Wall

Zone 3

Receivers within MWD for cosmetic damage

MWD for cosmetic damage and human annoyance for Vibratory roller (Padfoot) - High Vibration

Unreinforced structures (7.5mm/s ppv)

Heritage structures (2.5mm/s ppv)

Human annoyance - Residential (day)





REV	BY	DATE	DESCRIPTION
1	RZ	31/08/21	Prepare figures
2	NT		APPROVER
3	NT		FULL SIZE AS
4	NT		1:2000

NOTE: Do not scale from this drawing.

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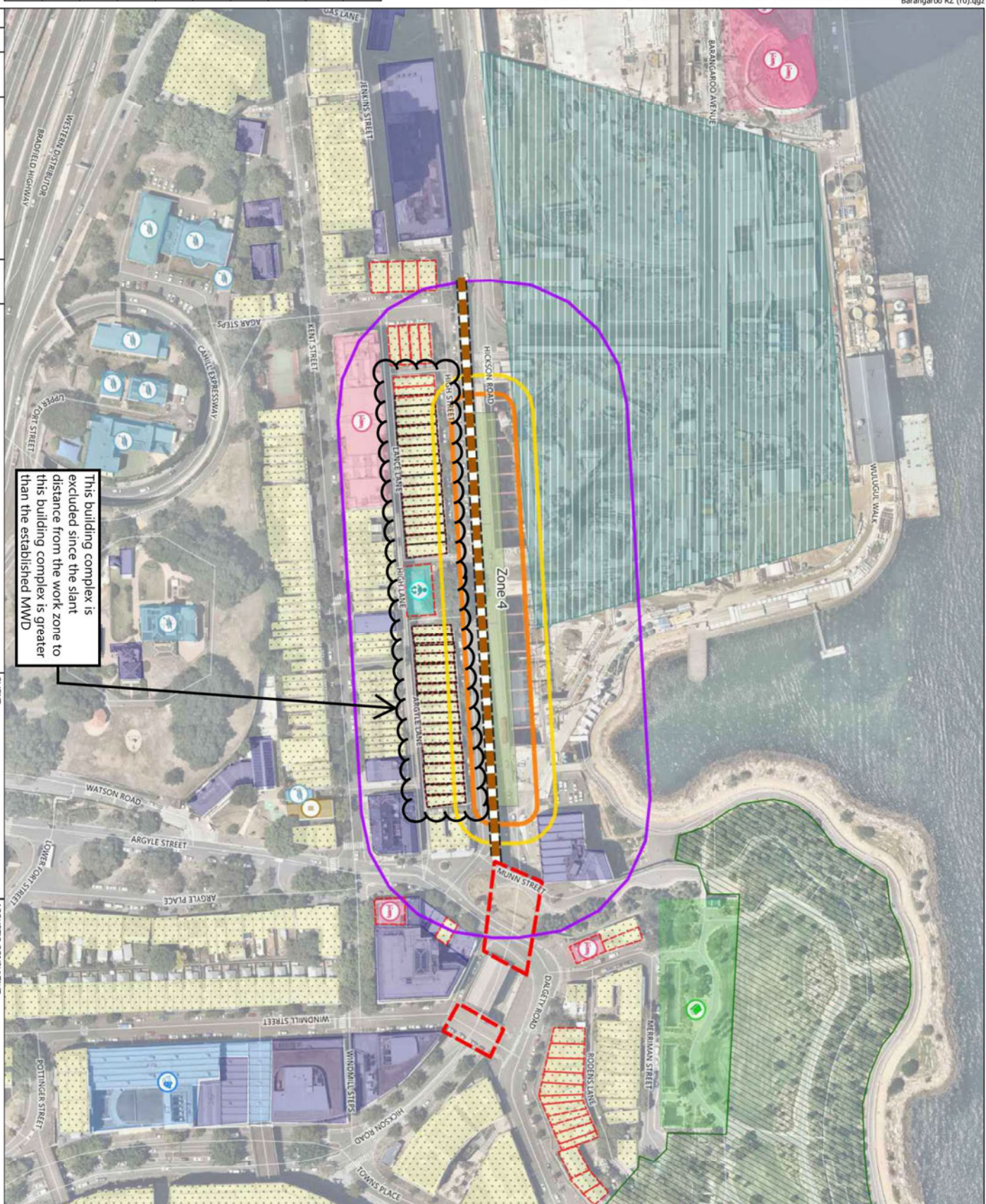
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Sydney Metro Barangaroo Station
Civil Works

MWD for cosmetic damage and human annoyance
Zone 3.1

LEGEND

Noise sensitive receivers	Flight simulator
Residential	Childcare
Mixed use	Educational
Commercial	Theatre/Auditorium
Industrial	Cinema
Hotel/Motel/Hostel	Laboratory
Medical facility	Recreational - Passive
Place of Worship	Recreational - Active
Community centre	Other
Recording studio	Heritage
Library/Museum	
Heritage Wall	
Zone 3.1	
Receivers within MWD for cosmetic damage for Jackhammer	
Unreinforced structures (7.5mm/s ppv)	
Heritage structures (2.5mm/s ppv)	
Human annoyance - Residential (day)	



This building complex is excluded since the start distance from the work zone to this building complex is greater than the established MWD

REV	BY	DATE	DESCRIPTION	APPROVER	FULL SIZE AS
R2	31/08/21		Prepare figures	NT	1:2000
A3	Original		Co-ordinate System: MGA Zone 56		NOTE: Do not scale from this drawing.



LEGEND

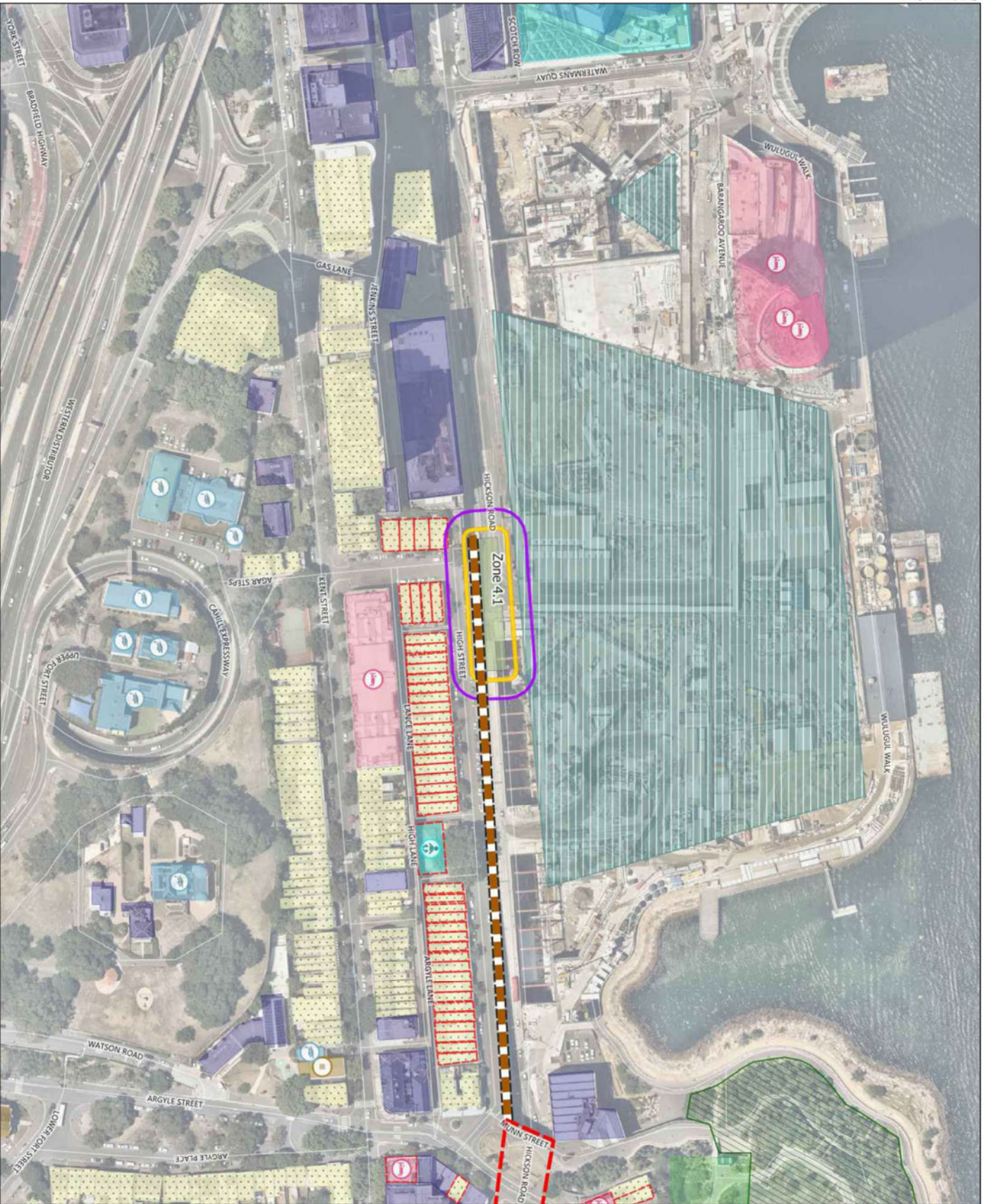
Noise sensitive receivers

- Residential
- Mixed use
- Commercial
- Industrial
- Hotel/Hotel/Hostel
- Medical facility
- Place of Worship
- Community centre
- Recording studio
- Library/Museum
- Flight simulator
- Childcare
- Educational
- Theatre/Auditorium
- Cinema
- Laboratory
- Recreational - Passive
- Recreational - Active
- Other
- Heritage

MWD for cosmetic damage and human annoyance

- Receivers within MWD for cosmetic damage
- MWD for cosmetic damage (Padfoot) - High Vibration
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)
- Heritage Wall
- Zone 4

Sydney Metro Barangaroo Station
Civil Works
MWD for cosmetic damage and human annoyance
Zone 4



REV	BY	DATE	DESCRIPTION
RZ		31/08/21	Prepare figures
AS			Original

Co-ordinate System: MGA Zone 56

APPROVER: NT

DATE: 31/08/21

DESCRIPTION: Prepare figures

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Sydney Metro Barangaroo Station
Civil Works

MWD for cosmetic damage and human annoyance
Zone 4.1

LEGEND

Noise sensitive receivers	Flight simulator
Residential	Childcare
Mixed use	Educational
Commercial	Theatre/Auditorium
Industrial	Cinema
Hotel/Motel/Hostel	Laboratory
Medical facility	Recreational - Passive
Community centre	Recreational - Active
Place of Worship	Other
Recording studio	Heritage
Library/Museum	

Heritage Wall

Zone 4.1

Receivers within MWD for cosmetic damage

MWD for cosmetic damage and human annoyance for Jackhammer

Unreinforced structures (7.5mm/s ppv)

Heritage structures (2.5mm/s ppv)

Human annoyance - Residential (day)



REV	BY	DATE	DESCRIPTION
0	RZ	31/08/21	Prepare figures
1	MT		

Co-ordinate System: MGA Zone 56

APPROVER: MT

FULL SIZE AS SHOWN

1:2000

0 40 80 120 m

NOTE: Do not scale from this drawing.



LEGEND

Noise sensitive receivers

- Flight simulator
- Childcare
- Educational
- Theatre/Auditorium
- Cinema
- Laboratory
- Recreational - Passive
- Recreational - Active
- Other
- Heritage

Heritage Wall

Zone 5

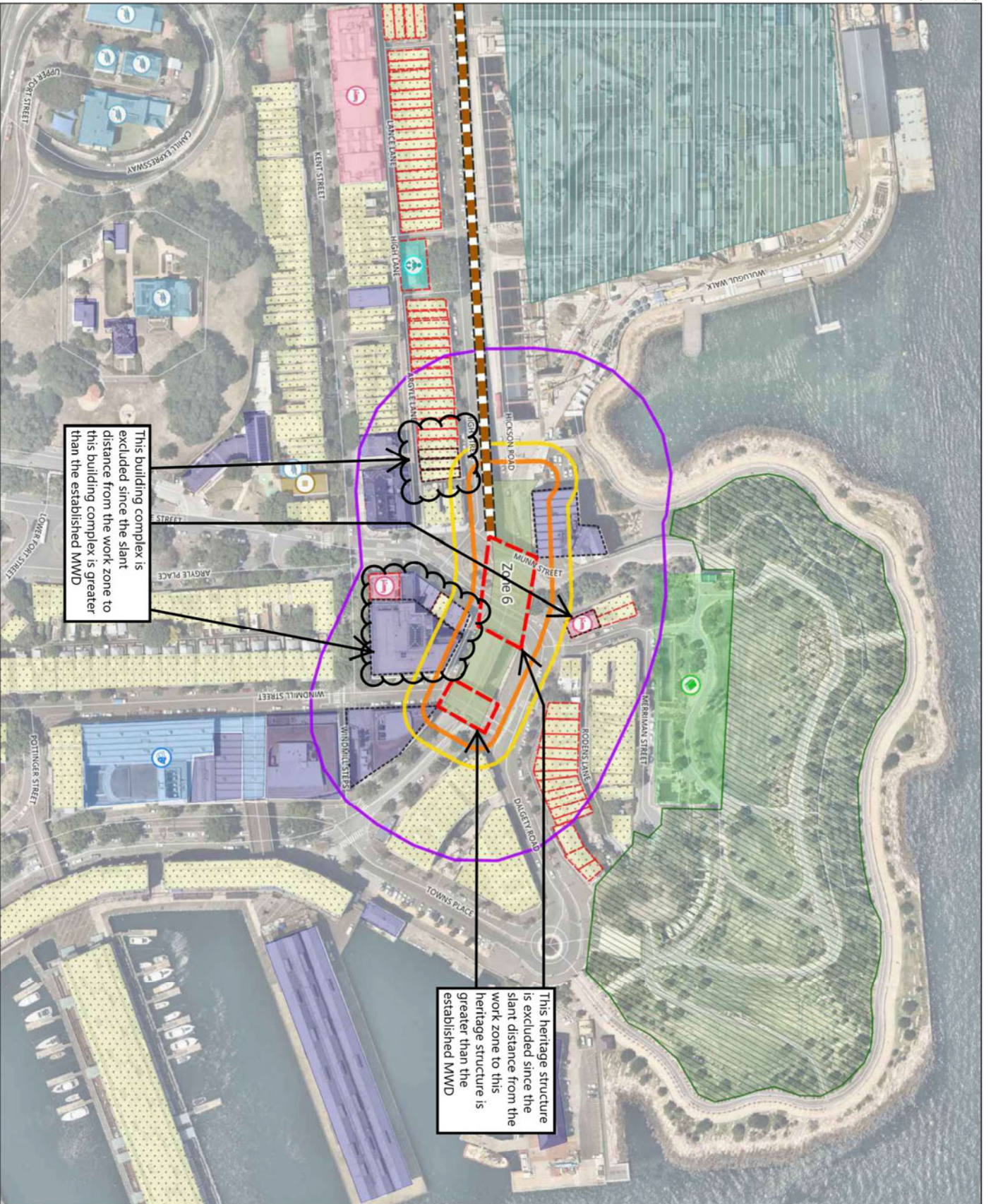
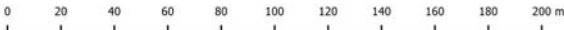
Receivers within MWD for cosmetic damage

MWD for cosmetic damage and human annoyance

- for Vibratory roller (Padfoot) - High Vibration
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)

Other symbols: Library/Museum, Recording studio, Community centre, Place of Worship, Medical facility, Hotel/Motel/Hostel, Industrial, Commercial, Mixed use, Residential.





This building complex is excluded since the slant distance from the work zone to this building complex is greater than the established MWD

This heritage structure is excluded since the slant distance from the work zone to this heritage structure is greater than the established MWD

REV	BY	DATE	DESCRIPTION
R2		31/08/21	Prepare figures
AS	Original		

Co-ordinate System: MGA Zone 56

APPROVER: NT

FULL SIZE AS

1:2000

0 40 80 120 m

NOTE: Do not scale from this drawing.

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Inspired to achieve

LEGEND

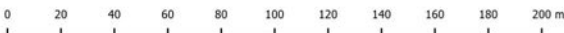
	Flight simulator		Library/Museum
	Childcare		Recording studio
	Educational		Community centre
	Theatre/Auditorium		Place of Worship
	Cinema		Medical facility
	Laboratory		Hotel/Motel/Hostel
	Recreational - Passive		Industrial
	Recreational - Active		Commercial
	Other		Mixed use
	Heritage		Residential

	Receivers within MWD for cosmetic damage
	MWD for cosmetic damage and human annoyance for Vibratory roller (Padfoot) - High Vibration
	Unreinforced structures (7.5mm/s ppv)
	Heritage structures (2.5mm/s ppv)
	Human annoyance - Residential (day)

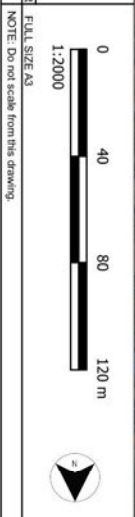
Sydney Metro Barangaroo Station Civil Works

MWD for cosmetic damage and human annoyance Zone 6

Sheet 8 of 11



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BESIX Watpac

ACOUSTIC CONSULTANT
RENZO TONIN & ASSOCIATES
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Sydney Metro Barangaroo Station
Civil Works
MWD for cosmetic damage and human annoyance
Zone 9



	Flight simulator
	Childcare
	Educational
	Theatre/Auditorium
	Cinema
	Laboratory
	Recreational - Passive
	Recreational - Active
	Other
	Heritage
	Heritage
	Heritage Wall
	Zone 9
	Receivers within MWD for cosmetic damage
	MWD for cosmetic damage and human annoyance for Vibratory roller (Padfoot) - High Vibration
	Unreinforced structures (7.5mm/s ppv)
	Heritage structures (2.5mm/s ppv)
	Human annoyance - Residential (day)

LEGEND

Noise sensitive receivers

- Residential
- Mixed use
- Commercial
- Industrial
- Hotel/Motel/Hostel
- Medical facility
- Place of Worship
- Community centre
- Recording studio
- Library/Museum
- Flight simulator
- Childcare
- Educational
- Theatre/Auditorium
- Cinema
- Laboratory
- Recreational - Passive
- Recreational - Active
- Other
- Heritage

- Receivers within MWD for cosmetic damage
- MWD for cosmetic damage and human annoyance for Vibratory roller (Padfoot) - High Vibration
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)



REV	BY	DATE	DESCRIPTION
RZ	31/08/21		Prepare figures
AS	Original		

Co-ordinate System: MGA Zone 56

APPROVER: NT

FULL SIZE AS

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0 40 80 120 m

NOTE: Do not scale from this drawing.



CLIENT: Sydney Metro Barangaroo Station Civil Works

ACoustic CONSULTANT: RENZO TONIN & ASSOCIATES

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MWD for cosmetic damage and human annoyance Zone A

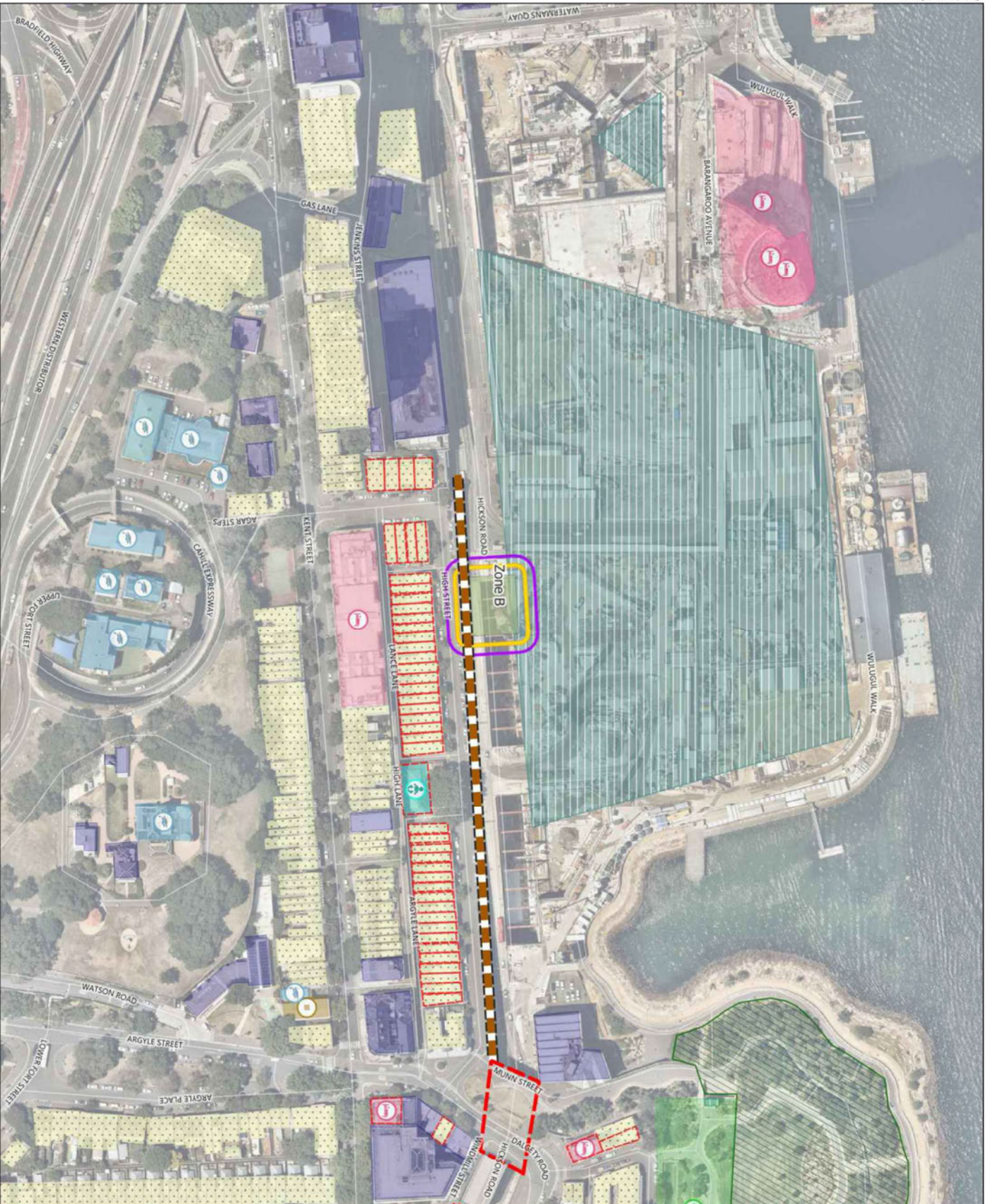
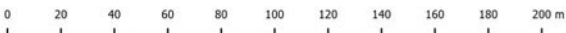
Sheet 10 of 11

LEGEND

- Noise sensitive receivers**
- Residential
 - Mixed use
 - Commercial
 - Industrial
 - Hotel/Motel/Hostel
 - Medical facility
 - Place of Worship
 - Community centre
 - Recording studio
 - Library/Museum
 - Flight simulator
 - Childcare
 - Educational
 - Theatre/Auditorium
 - Cinema
 - Laboratory
 - Recreational - Passive
 - Recreational - Active
 - Other
 - Heritage

- Heritage Wall
- Zone A
- Receivers within MWD for cosmetic damage
- MWD for cosmetic damage and human annoyance for Compactor / Wacker packer
- Unreinforced structures (7.5mm/s ppv)
- Heritage structures (2.5mm/s ppv)
- Human annoyance - Residential (day)





REV	BY	DATE	DESCRIPTION
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Sydney Metro Barangaroo Station
Civil Works

MWD for cosmetic damage and human annoyance
Zone B

LEGEND

Noise sensitive receivers	Flight simulator
Residential	Childcare
Mixed use	Educational
Commercial	Theatre/Auditorium
Industrial	Cinema
Hotel/Motel/Hostel	Laboratory
Medical facility	Recreational - Passive
Place of Worship	Recreational - Active
Community centre	Other
Recording studio	Heritage
Library/Museum	Heritage
Receivers within MWD for cosmetic damage	
MWD for cosmetic damage and human annoyance for Compactor / Wacker packer	
Unreinforced structures (7.5mm/s ppv)	
Heritage structures (2.5mm/s ppv)	
Human annoyance - Residential (day)	
Zone B	
Heritage Wall	

APPROVAL
CITY & SOUTHWEST ACOUSTICS ADVISOR

Review of:	Barangaroo Metro Station Construction Noise and Vibration Impact Statement: Civil works	Document reference:	TM031-02F01 CIVIL CNVIS (r6)
Prepared by:	[REDACTED] Acoustics Advisor		Prepared by Renzo Tonin & Associates Pty Ltd
Date of issue:	10 November 2022		3 November 2022

As approved Acoustics Advisor for the Sydney Metro City & Southwest project, and as required under A27 (d) of the project approval conditions (SSI 15-7400), I have reviewed and provided comment on the Construction Noise and Vibration Impact Statement (CNVIS) for Barangaroo Metro Station, Civil works (revision 6). This revision includes updates to Saturday construction hours to reflect the extended hours in Modification 9 and an assessment of potential noise and vibration impacts from earthing rod installation works.

I am satisfied that the CNVIS is technically valid and includes appropriate noise and vibration mitigation and management. On this basis, I endorse the CNVIS referenced herein.

[REDACTED]

Daniel Weston, City & Southwest Acoustics Advisor