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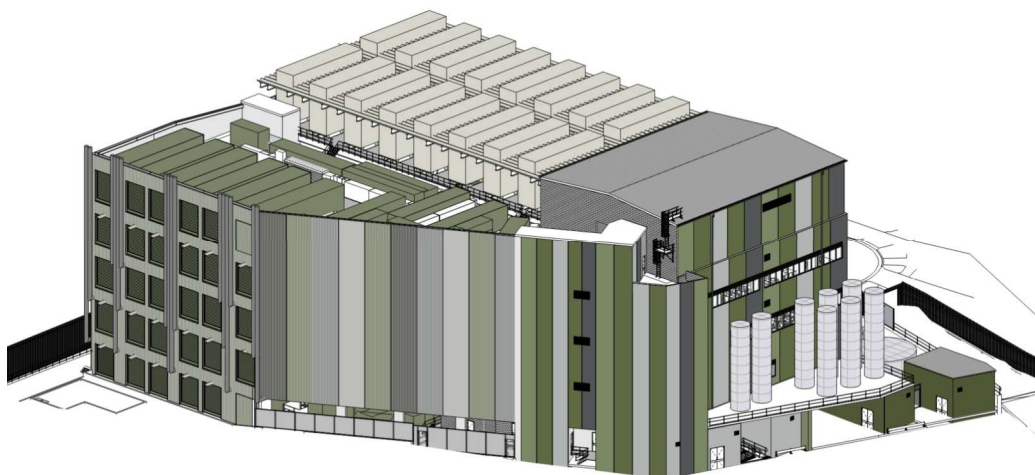
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CLIENT



PROJECT

SYD2 Shell E

TITLE

CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

ORIGINATOR



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Construction Noise and Vibration Management Plan

25 March 2026

A.W. Edwards Pty Limited

TN610-07F02 SYD02 Shell E CNVMP(r1)

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1 Introduction

1.1 Overview

Renzo Tonin & Associates (RTA) has been engaged by A.W. Edwards Pty Limited (AWE), to prepare a construction noise and vibration management plan (CNVMP) for the proposed data centre development known as SYD02 Shell E (formerly known as the Apollo Place Data Centre) (the Project).

The Project site is located at the land identified at 1 Apollo Place, Lane Cove West (SP 80721) and 1 Sirius Road, Lane Cove West (Lot 1 DP 1271404) as shown in Figure 2-1. The Project forms part of the State Significant Development (SSD) 67407231.

As part of the State Significant Development Application (SSDA) a noise and vibration impact assessment report (SSDA NVIA) was prepared for the Project by RTA (report ref: TN610-03F01 Apollo Place Data Centre SSDA NVIA (r6) dated 9 September 2024).

The scope of this CNVMP is to describe how noise and vibration impacts during construction of the Project will be managed. This CNVMP will:

- Identify the site, proposed construction works and nearby noise sensitive development.
- Present information about ambient noise levels in the vicinity of the Project.
- Identify relevant noise and vibration objectives with respect to construction noise and vibration.
- Assess likely noise and vibration impacts from the construction works.
- Identify noise and vibration mitigation and management measures for the works to avoid or minimise noise and vibration impacts (including high noise generating works) and how these would be implemented where feasible and reasonable. This will include the items identified in the SSDA NVIA.

The noise and vibration impacts from the construction of the Project are addressed in this CNVMP in accordance with relevant NSW Environment Protection Authority (EPA) requirements and guidelines.

1.2 Consent conditions

This CNVMP has been prepared with reference to the requirements of the SSD 67407231 Development Consent, and has been prepared to satisfy condition of consent (CoC) B7. This specific requirement, and the conditions of consent (CoC) relevant to this CNVMP are listed Table 1-1 below.

A cross reference is also included to indicate where the condition is addressed in this CNVMP or other project management documents.

Construction of the Project will not commence until the CNVMP required by condition B7 is approved by the Planning Secretary.

Table 1-1: SSD 67407231 consent condition requirements (construction noise and vibration)

Requirement	Where addressed in this CNVMP						
Hours of Work B1. The Applicant must comply with the hours detailed in Table 2 below. <i>Table 2 Hours of Work</i> <table><tr><th>Activity</th><th>Day</th><th>Time</th></tr><tr><td>Construction</td><td>Monday – Friday Saturday</td><td>7 am to 6 pm 8 am to 1 pm</td></tr></table>	Activity	Day	Time	Construction	Monday – Friday Saturday	7 am to 6 pm 8 am to 1 pm	Section 4.1, more specifically Section 4.1.1
Activity	Day	Time					
Construction	Monday – Friday Saturday	7 am to 6 pm 8 am to 1 pm					
B2. Works outside of the hours identified in condition B1 may be undertaken in the following circumstances: (a) works that are inaudible at the nearest sensitive receivers; (b) works agreed to in writing by the Planning Secretary; (c) for the delivery of materials required outside these hours by the NSW Police Force or other authorities for safety reasons; or (d) where it is required in an emergency to avoid the loss of lives, property or to prevent environmental harm.	Section 4.1.2						
Construction Noise Limits B3. The development must be constructed to achieve, as far as feasible and reasonable, the construction noise management levels detailed in the ICNG. All feasible and reasonable noise mitigation measures must be implemented and any activities that could exceed the construction noise management levels must be identified and managed in accordance with the management and mitigation measures in Appendix 2 of this consent and the development’s CNVMP (see condition B7)	Section 4.2						
Vibration Criteria B4. Vibration caused by construction at any structure outside the site must be limited to: (a) for structural damage, the latest version of DIN 4150-3 (2016-12) Vibration in Buildings – Part 3: Effects on Structures (German Institute for Standardisation, 2016) and BS 7385-2 Evaluation and measurement for vibration in buildings Guide to damage levels from groundborne vibration (British Standards Institution, 1993); and (b) for human exposure, the acceptable vibration values set out in the Environmental Noise Management Assessing Vibration: a technical guideline (DEC, 2006) (as may be updated or replaced from time to time).	Section 4.3						
B5. Vibratory compactor, rock hammer or piling equipment must not be used closer than 30 metres from any structure at 5 Sirius Road (Lot 5 DP 241786), 7 Sirius Road (Lot 42 DP 571838), 9 Sirius Road (Lot 3 DP 241786) and 3 Apollo Place (Lot 8 DP 241877), unless vibration monitoring confirms compliance with the vibration criteria specified in condition B4.	Section 6.1 and more specifically, Section 6.2.4						
B6. The limits in conditions B4 and B5 apply unless otherwise outlined in the development’s CNVMP, approved as part of the CEMP required by condition C2 of this consent	Section 4.3						

Requirement	Where addressed in this CNVMP
Construction Noise and Vibration Management Plan B7. The Applicant must prepare a Construction Noise and Vibration Management Plan (CNVMP) for the development to the satisfaction of the Planning Secretary. The CNVMP must form part of the development's CEMP in accordance with condition C2 and must: (a) be prepared by a suitably qualified and experienced noise expert; (b) include evidence of consultation with TfNSW and Transurban; (c) describe the procedures to: (i) refine the construction methodology and work schedule to minimise construction noise and vibration impacts; (ii) achieve the noise management levels in ICNG (as may be updated or replaced from time to time); (iii) achieve the vibration criteria specified in condition B4; and (iv) carry out noise and vibration monitoring, including details of the associated frequency/duration; (d) include: (i) a vibration trigger action response plan developed in consultation with TfNSW and Transurban; (ii) management and mitigation measures, including any described in Appendix 2 of this consent; (iii) a description of measures to be implemented to manage high noise or vibration generating works such as piling, rock breaking and vibratory compaction, in close proximity to sensitive receivers; (iv) strategies that have been developed in consultation with the directly adjoining properties for managing noise and vibration impacts, such as any alternative construction methods with lower source intensity levels and provision for respite periods; (v) a description of the community consultation undertaken to develop the strategies in (d)(iii) and (d)(iv) above; and (vi) a complaints management system to be implemented for the duration of construction.	This Plan · · · Section 1.3 APPENDIX B Section 6 · Section 6.2.4
B8. The Applicant must: (a) not commence construction of the development until the CNVMP required by condition B7 is approved by the Planning Secretary; and (b) implement the most recent version of the CNVMP approved by the Planning Secretary for the duration of construction.	Section 1.2
Lane Cove Tunnel Exhaust Structure B9. Prior to the commencement of construction, the Applicant must, to the satisfaction of the Planning Secretary: (a) provide engineering certification that demonstrates the stability of the rock (ie. 'island or plinth') to be left between the existing structures and new below-ground structures is maintained; (b) finalise the detailed design of the foundation; (c) enter into an interface agreement, with LCT-MRE Pty Ltd, if deemed necessary by TfNSW or Transurban; (d) undertake a pre-construction dilapidation report of the adjacent Lane Cove Tunnel exhaust structure; and (e) install vibration monitoring equipment at the adjacent Lane Cove Tunnel exhaust structure. Note: The Applicant must consult with TfNSW and Transurban in relation to the matters listed in (a) to (e) above to ensure that the structural integrity and operation of the Lane Cove Tunnel infrastructure is maintained.	Section 6.2.2

Requirement	Where addressed in this CNVMP
B10. Prior to the commencement of operation, or as otherwise agreed to by the Planning Secretary, the Applicant must: (a) undertake a post-construction dilapidation report of the adjacent Lane Cove Tunnel exhaust structure and submit to TfNSW and Transurban; and (b) obtain written confirmation from TfNSW and Transurban that any required remedial works identified in the post-construction dilapidation report have been completed by the Applicant at no cost to TfNSW and/or Transurban.	Not applicable to construction.
Dilapidation Report – Private Land B11. During the following phases of development: (a) prior to the commencement of construction; and (b) within one month of the conclusion of the construction works, the Applicant must offer and prepare (if the offer is accepted) a pre-construction and post-construction dilapidation survey at the properties located at 7 Sirius Road (Lot 42 DP 571838), 9 Sirius Road (Lot 3 DP 241786) and 3 Apollo Place (Lot 8 DP 241877). The surveys must be submitted to the Planning Secretary, Council and the property owner within seven days of being prepared.	Section 6.2.4, more specifically Section 6.2.4.1
B12. Should the survey at condition B11(b) identify any damage, the Applicant must discuss the repairs to be undertaken with the relevant property owners, and repair or pay the full costs associated with repairing any part of the building that is determined to be damaged by the carrying out of construction works associated with the development.	Section 6.2.4.1

1.3 Acoustic terms & quality

This report is technical in nature and uses acoustic terminology throughout. A summary and explanation of the common acoustic terms that have been used in this report is presented in APPENDIX A.

This CNVMP was prepared by suitably qualified and experienced acoustic consultants. The authors of this documents are acoustic engineers who are of Member grade of the Australian Acoustical Society (AAS) with suitable experience in construction noise and vibration in NSW or were instructed by an experienced acoustic engineer of Member grade. Additionally, all engineers involved in the preparation of this document are employed by Renzo Tonin & Associates, which is a member firm of the Association of Australasian Acoustic Consultants (AAAC).

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.

2 Project description

2.1 The Project

This CNVMP has been prepared for the construction of a data centre and associated infrastructure and amenities at 1 Apollo Place (SP 80721) and 1 Sirius Road (Lot 1 DP 1271404, which includes 2 Apollo Place), Lane Cove West within Lane Cove Council Local Government Area (LGA). The Project site is approximately 5,282 m² in area and is irregular in shape.

The site currently comprises a four (4) storey office building (2 Apollo Road), and a vacant lot (1 Apollo Place). The Site has four existing vehicle driveway crossovers to Apollo Place. The neighbouring lot to the south is currently an office building. The neighbouring lots to the east are a plastic tool manufacturer and orthopaedics manufacturer.

The Site is located approximately 9.1 km northwest of the Sydney CBD and 12.4 km east of Parramatta. The Site is approximately 500m north of the Lane Cove Business Park and approximately 2.5km from the Lane Cove town centre. The Lane Cove River and Stringybark Creek are located approximately 200 - 250m north and west of the Site.

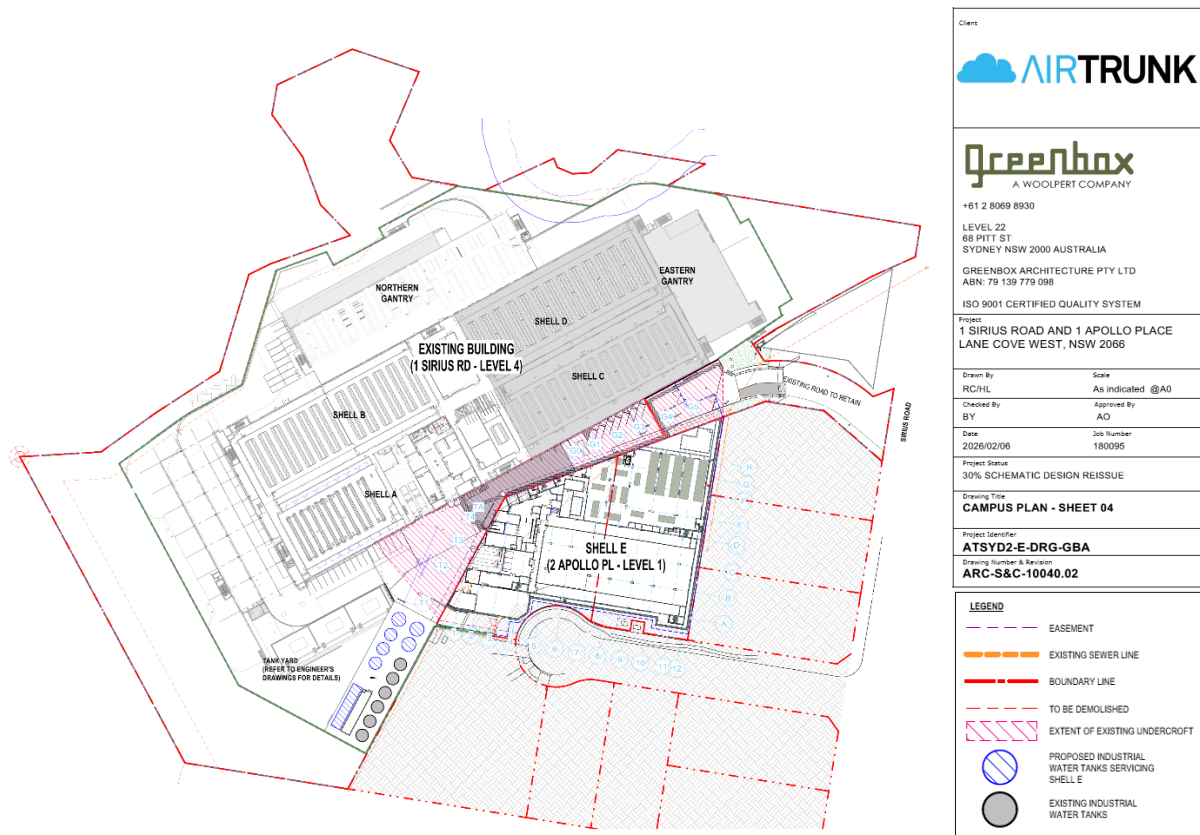
The Lane Cove Tunnel which forms part of the Hills Motorway (M2) is located 500 metres north of the Site. A motorway stack known as the Western Stack is located within the north-western lot adjacent to the Site (3 Sirius Road). The Site is strategically positioned within the Lane Cove West Business Park, which is designated for such industrial-related uses, the proposed development represents a logical outcome that would provide employment-generating opportunities close to where people live and nearby to available transport infrastructure routes.

The location of the Project site is indicated in Figure 2-1. The Project site layout is shown in Figure 2-2.

Figure 2-1: Project location and site context



Figure 2-2: Campus Plan Level 1 site layout (including existing building and SHELL E, 6 February 2026)



2.2 Summary of construction works

This CNVMP has been prepared to address the following aspects for the Project covered by SYD02 Shell E (the Project):

- PHASE 1: Site establishment, including site amenity installation, sediment / erosion control installation and stormwater works
- PHASE 1: Civil and piling start, including surface preparation, piling pad construction and commencement of continuous flight auger (CFA) piling
- PHASE 2: Civil and in-ground works, including continuation of CFA piling, commencement of bulk excavation, infrastructure and services augmentation works and rock anchoring
- PHASE 2: Bulk civil excavation, including bulk earthworks, stormwater works and cut/fill and excavation works
- PHASE 3: Building construction works, including construction of the main buildings structure and other buildings/structures/services
- PHASE 3: Building fit-out
- PHASE 3: Testing and commissioning.

Construction activities associated with the Project will result in increased noise levels during the works. The works undertaken can consist of a mixture of both high and low noise activities. This assessment

identifies potentially noisy activities, their impacts on surrounding receivers and outlines management strategies to control the impacts of noise and vibration during the construction phases.

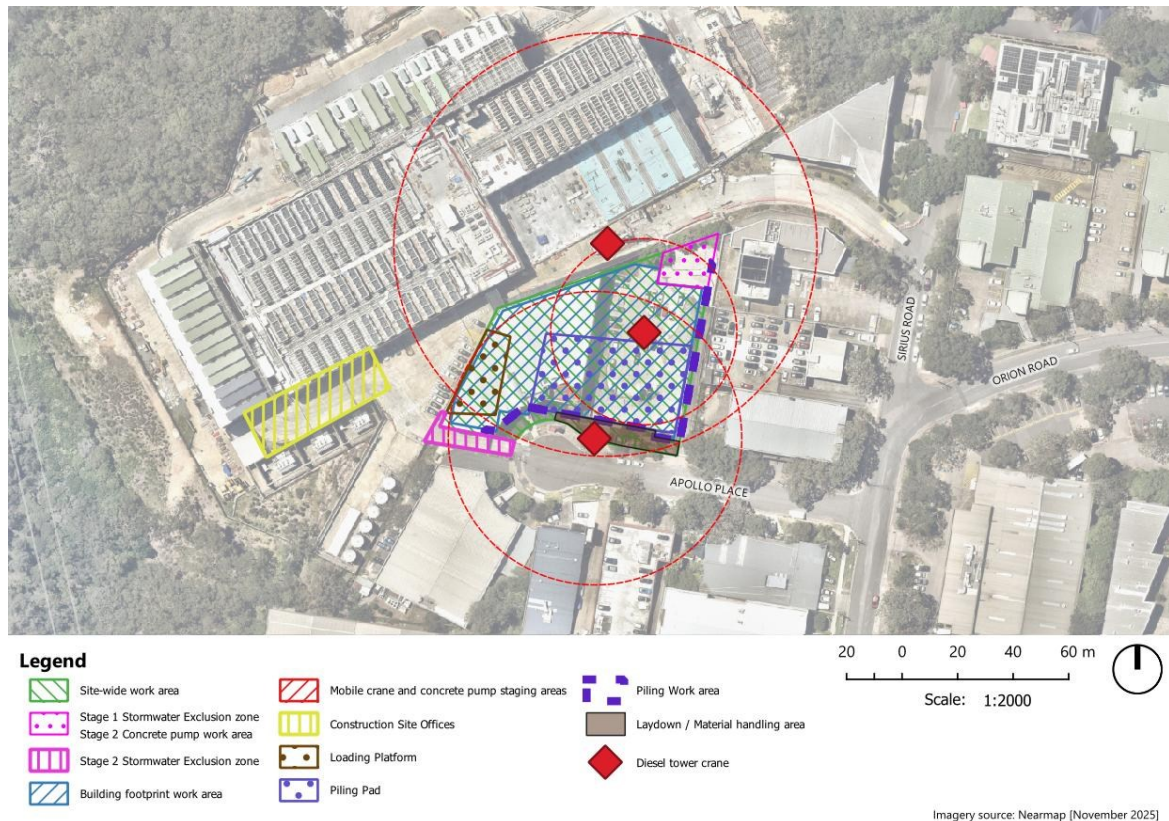
The construction of the Project is programmed to take place over approximately 1.5 to 2 years. The proposed construction works schedule and durations are outlined in Table 2-1.

Table 2-1: Proposed construction works schedule and durations – The Project

Project phase	Construction phase/ (work area, see The construction works listed in the Table 5-1 may overlap during the construction program.)	Description of construction works	Estimated duration ^{1, 2}
Phase 1	Site establishment (site wide)	Stormwater works Installation of environment controls Establishment of construction facilities	12 – 16 week
	Civil and piling start works (building footprint / piling areas)	Surface preparation works/ excavation works Piling pad construction Continuous flight auger (CFA) piling (start)	
Phase 2	Civil and in-ground works (site wide)	Continuous flight auger (CFA) piling (complete) Bulk Excavation works Infrastructure and services augmentation works Rock anchoring Stormwater works and detailed excavation	60 – 80 weeks
	Bulk civil excavation	Bulk earthworks Stormwater works Cut/fill and excavation works	
Phase 3	Building construction works (building footprint / staging areas)	Construction of the main building structure Construction of other buildings/structures/services	
	Building fit-out (building footprint / staging areas)	Internal fit-out within the building Deliveries	
	Testing and commissioning (building footprint / staging areas)	Services fit-off Installation, energisation and testing of assets	

Notes: 1. In some cases, multiple works will occur during the one possession period. As such there are overlaps between the various works and the approximate duration of possession periods.

2. Timeframes are indicative and may change.

Figure 2-3: Key construction work areas

2.3 Construction traffic

The 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:
 - Trucks removing construction refuse from the site
 - Delivery vehicles bringing raw materials, plant, and equipment to the site.

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 5.1. 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 on public roads rather than as part of the construction site's activities.

3 Existing noise environment and noise and vibration sensitive receivers

Criteria for the assessment and management of construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development. As the noise environment of an area almost always varies over time, background and ambient noise levels need to be determined for the operational times of the proposed development. Background noise varies over the course of any 24-hour period, typically from a minimum at 3:00am in the morning to a maximum during morning and after-noon traffic peak hours. Therefore, the NSW Environment Protection Authority (EPA) Noise Policy for Industry (NPfI) (EPA 2017) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. As per Section 4.1.1 of the NSW Interim Construction Noise Guideline (DECC, 2009) (ICNG), the NPfI [which superseded the NSW Industrial Noise Policy (EPA, 2000)] details the procedure for determining the rating background noise level (RBL). Fact Sheet B of the NPfI outlines the methods for determining the background noise level of an area. The typical time periods in accordance with the NPfI are as follows:

- Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

3.1 Environmental noise monitoring

The SSD NVIA relied noise measurement data presented in noise impact assessments obtained for the SSD 9741 project for the residential receivers in proximity to the Project, to establish background noise levels in accordance with the NPfI.

- Pulse White Noise Acoustics, AirTrunk SYD2 – Updated Acoustic Treatment Summary, report reference 220364-13 – AT SYD2 - Treatment Summary – R4.4, 9 April 2024, version R4.4 (PWNA, dated 9 April 2024) (PWNA UPDATED MOD3 NVIA).
- ARUP, Lane Cove West Data Centre, Acoustic Assessment - SSD 9741, Job number 259234, File reference AC01 (ARUP, Issue 4, dated 15 March 2019) (ARUP NVIA).

The measured background noise levels presented as in the SSD NVIA are shown in Table 3-1 below.

Table 3-1: Measured rating background noise levels (RBL), dB(A)

Ref.	Location description	Rating background noise levels (RBL), LA90, 15 minute		
		Day ¹	Evening ²	Night ³
L1	150 Epping Road, Lane Cove	46	46	41
L2	14 Jeanette Street, East Ryde ⁵	42	42	31

Notes: 1. Day: 7:00am to 6:00pm Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays
 2. Evening: 6:00pm to 10:00pm Monday to Sunday & Public Holidays
 3. Night: 10:00pm to 7:00am Monday to Sunday & Public Holidays
 4. RBL values based upon Table 3 of the PWNA UPDATED MOD3 NVIA.
 5. From PWNA UPDATED MOD3 NVIA which adopted data from the ARUP NVIA.

3.2 Sensitive receivers

3.2.1 Nearby noise and vibration sensitive receivers

The Project site is located within the Lane Cove West Business Park, with the land immediately surrounding the site being commercial and industrial developments in nature, including the newly constructed data centre (SSD 9741) (the existing data centre), which is connected to the Project. The site is surrounded by various receiver types, including:

North: North of the Proposal are the closest residential receivers, in the residential towers located at 150 Epping Road (R1A to R1E). This includes five residential apartment towers which range from 4 storeys to 24 storeys with multiple receivers, on the southern side of Epping Road. A childcare centre (CC1) and commercial tenancies are also collocated at this address. More distant from the Proposal, on the northern side of Epping Road are commercial and childcare receivers, and north and north-west are the residential areas of Lane Cove North.

East and South: Directly east and south of the Proposal are commercial and industrial receivers within the Lane Cove West Business Park, additionally there are two childcare centres that are located within the business park. Further to the east is the residential areas of Lane Cove West, which are substantially shielded from the Proposal by the Lane Cove West Business Park built structures.

West and south-west: West and south-west from the Proposal, across the valley over the Lane Cove River, are the residential areas of East Ryde, with receivers along the key streets of Jeanette Street, Pittwater Road and Melba Drive. These residential areas are located on elevated terrain compared to the Pittwater Road and the Lane Cove River Valley in between.

North-west: North-west from the Proposal are the residences along Magdala Road, North Ryde, between 500m and 600m from the Proposal. Additionally, there are a number of active recreation receivers (sport fields) on the west side of the Lane Cove River, with recreation areas in the Lane Cove National Park, considered a passive recreation receiver.

3.2.2 Noise catchment areas

As the existing acoustic environment varies at the nearby residential receivers, these residential receivers have been grouped into Noise Catchment Areas (NCAs) based upon areas with similar acoustic environments. This has been done to logically group the receivers to assist with the assessment and allocate the appropriate project noise trigger levels or management levels to each receiver. These have also been done in a manner to be consistent with the existing data centre (SSD 9741), consistent with the SSD CNVIA. The locations of these noise catchment area boundaries are also shown in Figure 3-1.

3.2.3 Representative receivers

Noise levels have been modelled to all nearby and potentially impacted noise sensitive receiver locations, however for the purposes of simplifying the reporting of results, only the results from critical representative receiver locations are included, which includes critical floor locations as a number of receivers are multi-storey buildings.

As such, there has been 33 representative assessment receivers included in the assessment. The following representative receivers have been identified:

- **NCA1** is north-east from the Project site, and contains residences within the 5 residential towers located at 150 Epping Road. This includes residential apartment towers from 4 storey to 24 storeys with multiple receivers.
- **NCA2** is north-west from the Project site and contains residences along Magdala Road, north west from the Proposal. These are typically single and two storey residential dwellings.
- **NCA3** is west and south-west from the Project site, and contains residences in East Ryde, with key receivers along Jeannette Street, Pittwater Road and Melba Drive.
- **Childcare** – There are three childcare centres located nearby, two within the Lane Cove West Business Park, and one located within the NCA1, directly adjacent to Epping Road. The location is shielded by the residential towers from the Project site. This childcare includes an outdoor play area on the southern sides of the facility.
- **Commercial and industrial receivers** – As the site is located within the Lane Cove West Business Park, there are a number of commercial and industrial premises are located around the site on Apollo Place and Sirius Road, including the existing AirTrunk Building (Shell A, B, C and D). The Lane Cove Tunnel Exhaust Structure is located at 3 Sirius Road, immediately adjacent to the north east boundary of the site.

The locations of the representative receiver points are presented in Table 3-2 below and a map of these locations presented in Figure 3-1.

Table 3-2: Construction noise assessment representative receivers

Residential noise catchment area (NCA)	Receiver number ²	Address / location	Receiver type	Number of floors	Approximate distance to the Project site, metres
NCA1	R1A	150 Epping Road, Lane Cove West	Residential	24	340
NCA1	R1B	150 Epping Road, Lane Cove West	Residential	6	310
NCA1	R1C	150 Epping Road, Lane Cove West	Residential	5	280
NCA1	R1D	150 Epping Road, Lane Cove West	Residential	4	270
NCA1	R1E	150 Epping Road, Lane Cove West	Residential	10	300
NCA2	R2A	65 Magdala Road, North Ryde	Residential	1	520
NCA2	R2B	63 Magdala Road, North Ryde	Residential	2	540
NCA2	R2C	57 Magdala Road, North Ryde	Residential	2	560
NCA2	R2D	47A Magdala Road, North Ryde	Residential	2	600
NCA3	R3	14 Jeanette Street, East Ryde	Residential	2	700
NCA3	R4	20 Jeanette Street, East Ryde	Residential	2	700
NCA3	R5	12 Wolfe Road, East Ryde	Residential	1	870
NCA3	R6	3 Jeanette Street, East Ryde	Residential	1	670
NCA3	R7	25 Jeanette Street, East Ryde	Residential	2	670
NCA3	R8	314 Pittwater Road, East Ryde	Residential	3	570
NCA3	R9	304 Pittwater Road, East Ryde	Residential	3	550
NCA3	R10	286 Pittwater Road, East Ryde	Residential	3	590
NCA3	R11	121 Melba Drive, East Ryde	Residential	2	660
NCA3	R12	111 Melba Drive, East Ryde	Residential	2	640
NCA3	R13	99 Melba Drive, East Ryde	Residential	2	680
-	CC1	150 Epping Road, Lane Cove West	Childcare	1	350
-	CC2	18-20 Orion Road, Lane Cove West	Childcare	1	230
-	CC3	3 Chaplin Drive, Lane Cove West	Childcare	1	190
-	C3 ³	3 Sirius Road, Lane Cove West ¹	Commercial	5	Adjacent
-	C4	1a Sirius Road, Lane Cove West	Commercial	8	30
-	C5	4 Apollo Place, Lane Cove West	Commercial	12	30
-	C6	5 Apollo Place, Lane Cove West	Commercial	5	20
-	C7	11 Sirius Road, Lane Cove West	Commercial	3	20
-	C8	9 Sirius Road, Lane Cove West	Commercial	7	10
-	C9	7 Sirius Road, Lane Cove West	Commercial	7	Adjacent
-	P1	Lane Cove National Park	Recreational - Passive	-	180
-	A1	-	Recreational - Active	-	320
-	A2	-	Recreational - Active	-	550

Notes: 1. Also known as 5 Sirius Road, Lane Cove West.

2. Receiver identification has been done for consistency with SSD 9741 MOD3 NVIA (Pulse White Noise Acoustics, AirTrunk SYD2 – Updated Acoustic Treatment Summary, reference 220364-13 – AT SYD2 – Treatment Summary – R4.4, version R4.4).

3. For C1 and C2 identified in SSD 9741 MOD3 NVIA, C1 is an industrial premises and is understood to be used as part of the construction for the Proposal, C2 is demolished to make way for the Proposal.

Figure 3-1: Site location, nearby noise sensitive receivers, land uses and NCAs



Legend

- Proposal boundary
- Existing data centre (SSD-9741)
- Residential noise catchment area (NCA) boundary
- Representative receiver location

Receiver type

Residential	Industrial
Educational	Recreational - Active
Childcare	Recreational - Passive
Commercial	

Landuse classification based upon a desktop review only, subject to further review and detailed design.
Imagery source: Nearmap (December 2023)

4 Construction noise and vibration objectives

4.1 Construction hours

4.1.1 Standard construction hours

The ICNG establishes standard construction hours, which are:

- 7:00am to 6:00pm Monday to Friday
- 8:00am to 1:00pm on Saturday
- No work performed on Sunday and Public Holidays.

The construction works for the Project are proposed to take place during these hours. This is consistent with condition CoC B1.

4.1.2 Works outside standard construction hours

There are no OOH construction works (OOHW) currently proposed for Project. During further construction planning, where OOHW are identified as being required (for emergency works, oversized equipment delivery, etc) these works would be subject to a separate approval process.

As per CoC B2, construction works may be undertaken outside the recommended standard hours (OOH) in the following circumstances, which are to be confirmed following approval:

1. works that are inaudible at the nearest sensitive receivers
2. works agreed to in writing by the Planning Secretary
3. for the delivery of materials required outside these hours by the NSW Police Force or other authorities for safety reasons; or
4. where it is required in an emergency to avoid the loss of lives, property or to prevent environmental harm.

Where OOHW are proposed to take place, the proposed construction works may require an assessment of potential noise and/or vibration impacts, and the identification of feasible and reasonable mitigation and management measures that would be implemented as part of the construction works to manage potential noise and vibration impacts on nearby sensitive receivers.

For the purposes of Item 1, inaudibility is not meant to be a measurable criterion. Guidance for informing the risk of inaudibility could be set at a reference level of background level + 0 dB. This reference level would apply for both the average noise level (including considering the character of the noise) and instantaneous noise events. This approach is not for compliance purposes, but to inform a risk assessment regarding the likelihood that the works can be undertaken and be inaudible.

4.2 Noise management levels (NMLs)

4.2.1 NSW Interim Construction Noise Guideline (ICNG)

The NSW Interim Construction Noise Guideline (DECC, 2009) (ICNG) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Identify and minimise noise from construction works
- Encourage construction during normal working hours only, unless approval is given for works that cannot be undertaken during these hours
- Use of 15 minute average ($L_{Aeq(15min)}$) as the descriptor for measuring and assessing construction noise.
- The establishing of "Noise Management Levels". These are noise levels which if exceeded, trigger the need to consider the application of feasible and reasonable noise mitigation. They are not intended to act as a prohibition on an activity if the trigger level is expected to be exceeded.
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

Table 4-1 reproduced from the ICNG, sets out the airborne noise management levels and how they are to be applied for residential receivers. CoC B3 requires the Project to be constructed to achieve, as far as feasible and reasonable, the construction noise management levels detailed in the ICNG.

Table 4-1: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq(15 min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15 min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of day	Management level <i>L_{Aeq}</i> (15 min) *	How to apply
No work on Sundays or public holidays	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. - Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: - times identified by the community when they are less sensitive to noise (such as before/ after school for works near schools, or mid-morning or mid-afternoon for works near residences) - if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	- A strong justification would typically be required for works outside the recommended standard hours. - The proponent should apply all feasible and reasonable work practices to meet the noise affected level. - Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. - For guidance on negotiating agreements see <i>ICNG</i> section 7.2.2.

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

Table 4-2 sets out the ICNG noise management levels for other noise sensitive receiver locations.

Table 4-2: Noise management levels at other noise sensitive land uses

Land use	Time of day	Where objective applies	Management level <i>L_{Aeq}</i> (15 min)
Classrooms at schools and other educational institutions	When in use	Indoor noise level Outdoor noise level ¹	45 dB(A) 55 dB(A)
Hospital wards and operating theatres	When in use	Indoor noise level Outdoor noise level ¹	45 dB(A) 55 dB(A)
Places of worship	When in use	Indoor noise level Outdoor noise level ¹	45 dB(A) 55 dB(A)
Active recreation areas	When in use	Outdoor noise level	65 dB(A)
Passive recreation areas	When in use	Outdoor noise level	60 dB(A)
Commercial premises	When in use	Outdoor noise level	70 dB(A)
Industrial premises	When in use	Outdoor noise level	75 dB(A)

Notes: 1. Outdoor noise level based on internal noise level in ICNG and assumes 10 dB loss through an open window
2. Noise management levels apply when receiver areas are in use only.

4.2.2 Summary of construction noise management levels

Table 4-3 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 3.1. The assessment locations and nearby sensitive receivers for the construction assessment are identified in Figure 3-1.

Table 4-3: Construction noise management levels

NCA / Rec. Id (see Section 3.2 for construction assessment receiver locations)	Location description	Noise management level $L_{Aeq(15min)}$ ¹
		Monday to Fridays (7am to 6pm) Saturdays (8am to 1pm)
NCA1	Residential	56
NCA2	Residential	52
NCA3	Residential	52
CC1 to CC3	Childcare centre	55 ²
C3 to C9	Commercial premises	70 ²
P1	Passive recreation	60
A1 to A2	Active recreation	65

- Notes: 1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
2. Noise management levels apply when receiver areas are in use only.
3. External noise management level. A conversion from internal to external assumes 10 dB(A) loss from outside to inside through open window.

4.2.3 Construction-related road traffic noise

When trucks and other vehicles are operating within the boundary of a construction site, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. 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.

The community may associate heavy vehicle movements with the Project works, when vehicles are travelling on roads located immediately adjacent to construction sites. However, once the heavy vehicles move further from construction sites onto major collector or arterial roads, the noise may be perceived as being part of the general road traffic.

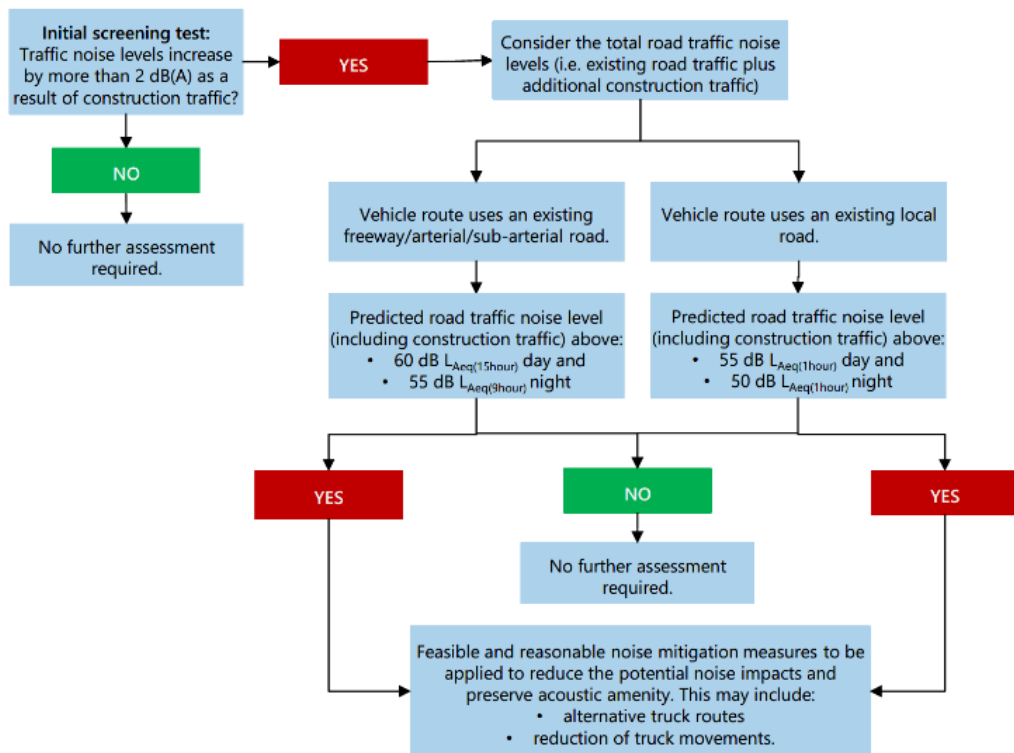
The ICNG refers to the NSW Road Noise Policy (RNP) for the assessment of noise from construction traffic on public roads. The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB(A) represents a minor impact. As such, in line with the RNP, where increases are 2 dB or less than the corresponding 'without construction traffic' scenario, no further assessment is required.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration should be given to the actual noise levels associated with construction traffic and whether these levels comply with the road traffic noise criteria in the RNP presented in Table 4-4.

Table 4-4: Construction-related road traffic noise assessment criteria

Road type	Day criteria (7:00am – 10:00pm)	Night criteria (10:00pm – 7:00am)
Freeway/ arterial/ sub-arterial roads	60 L_{Aeq} 15 hour	55 L_{Aeq} 9 hour
Local roads	55 L_{Aeq} 1 hour	50 L_{Aeq} 1 hour

The process that should be used to assess and manage potential noise impacts from construction traffic is presented in Figure 4-1.

Figure 4-1: Construction traffic noise assessment process

4.3 Construction vibration objectives

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings, and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The International System of Units (SI unit) for distance is the metre (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x , y , and z) then the resultant PPV is the vector sum (ie. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared (m/s²). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

4.3.1 Disturbance to buildings occupants

CoC B4(b) requires that vibration caused by construction at any structure outside the site must be limited to the acceptable vibration values for human annoyance set out in the NSW 'Environmental Noise Management Assessing Vibration: A Technical Guideline' (AVTG).

The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 4-5 provides definitions and examples of each type of vibration.

Table 4-5: Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

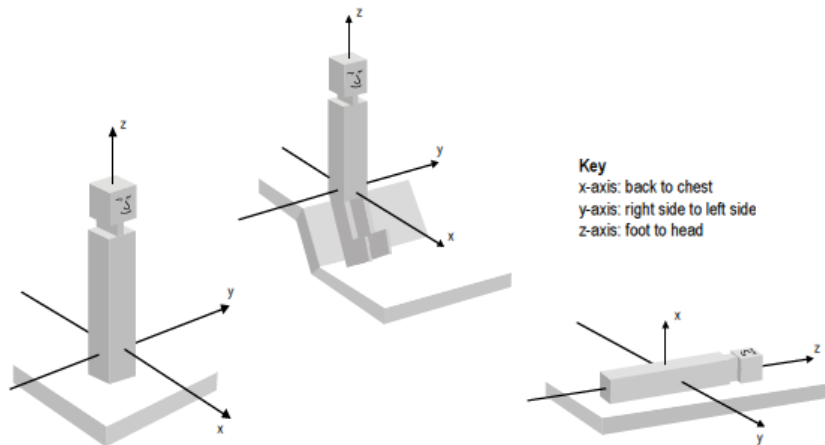
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

‘Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).’

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, ie. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 4-2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 4-2: Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the locations applicable to receivers surrounding the site are reproduced Table 4-6.

Table 4-6: Preferred and maximum levels for human comfort

Location	Assessment period ^[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s ² , 1-80Hz)					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s ² , 1-80Hz)					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072

Location	Assessment period ^[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2. 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. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

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. The screening test is based on the continuous vibration velocity (ie. vibration that continues uninterrupted for a defined period). If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (ie. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

The initial screening test values and VDV's recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected, are presented in Table 4-7. The 'Low probability of adverse comment eVDV' represent the preferred and maximum value presented in the AVTG.

Table 4-7: Vibration management levels for disturbance to building occupants

Place and Time	Initial screening test Velocity, PEAK, mm/s (>8Hz)	Low probability of adverse comment eVDV m/s ^{1.75}	Adverse comment possible eVDV m/s ^{1.75}	Adverse comment probable eVDV m/s ^{1.75}
Critical areas (day or night) ¹	0.28	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Residential buildings 16 hr day ²	0.56	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night ²	0.40	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices, schools, educational institutions and places of worship (day or night)	1.10	0.4 to 0.8	0.8 to 1.6	1.6 to 2.4
Workshops (day or night)	2.20	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

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

2. Daytime is 7am to 10pm and night-time is 10pm to 7am

4.3.2 Cosmetic damage to building structures

Vibration caused by construction at any structure outside the site must be limited to German Standard DIN4150-3 2016-12 Vibration in Buildings – Part 3: Effects on Structures (German Institute for Standardisation, 2016) and BS 7385-2 Evaluation and measurement for vibration in buildings Guide to damage levels from groundborne vibration (British Standards Institution, 1993). Currently there is no existing Australian Standard for assessment of damage to building structures caused by vibration energy.

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.

The British Standard BS7385-2:1993 (Table 1) establishes transient vibration guide values below which there is minimal risk of vibration induced cosmetic damage based on the type of building. The vibration guide values are reproduced in Table 4-8 below. The guide values take into consideration the magnitude, frequency and duration of the vibration and relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings, consistent with the SSD NVIA.

Table 4-8: BS 7385 Transient vibration guide values for minimal risk of cosmetic damage

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

Notes: 1. Value applies at the base of the building on the side of the building facing the source of vibration
 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, then the guide values in Table 4-7 may need to be reduced by up to 50 percent. This is especially applicable at the lower frequencies where lower guide values apply.

On this basis, consistent a **conservative vibration screening level** 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 safe vibration level. The analysis would take into consideration the transient vibration guide values for minimal risk of cosmetic damage set out in Table 4-8.

4.3.3 Heritage items

The German Standard DIN 4150 provides a conservative guideline values for vibration velocity for evaluating the effects of short-term vibration on structures. The guideline values (in peak particle velocity (PPV) (mm/s)) apply at the foundation of the building, or the top most floor, and are

summarised in Table 4-9. Under this CNVMP DIN 4150 applies to building types not identified in Table 4-8 (ie. Line 3 "heritage listed buildings").

Table 4-9: DIN 4150-3 guideline values for short-term vibration on structures

Line	Type of structure	Guideline values vibration velocity (mm/s)				
		Foundations, all directions at a frequency of:			Topmost floor, horizontal	Floor slabs, vertical
		1 to 10Hz	10 to 50Hz	50 to 100Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 30	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, cannot be classified into Group 1 or 2 and are of great intrinsic value e.g. heritage listed buildings	3	3 to 8	3 to 8	8	20

As noted in BS 7385, heritage buildings and structures should not be assumed to be more sensitive to vibration, unless structurally unsound. A conservative vibration damage screening level for heritage buildings/structures can be set to 3 mm/s (peak component particle velocity), the more stringent criterion in the German Standard DIN 4150. This screening level will allow potentially vibration 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 3mm/s, further investigation would be undertaken to determine whether the structure is structurally unsound.

Where a heritage building is deemed to be unsound and sensitive to vibration impacts, the more stringent DIN 4150 Line 3 "heritage listed buildings" guideline values can be applied. Otherwise, structural damage vibration limits based on BS 7385-2:1993 (Table 4-8) can be applied.

4.3.4 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for such equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment specific data provided by manufacturers, there are generic vibration criteria that can be used to assess the impact of vibration generating activities on buildings housing vibration sensitive equipment. For example, the Vibration Criteria (VC) curves are often referred to as they are generic and apply to all tools/ equipment types within each category. The VC curves are defined over the frequency range 8 to 100 Hz.

Table 4-10 below summarises a range of suitable and conservatively stringent vibration limits that are applicable to buildings housing vibration sensitive equipment which may potentially be affected by construction vibration.

Table 4-10: Acceptable vibration limits for vibration measured on building structure housing sensitive equipment

Equipment Requirements	Vibration Limit ¹ mm/s,		Description of Use ³
	RMS ⁴	Peak ⁵	
Computer Areas ²	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.
Medical ^{2,3}	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A ³	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc

- Notes: 1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment.
2. Based on AS 2834 Computer Accommodation
3. Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment
4. Root Mean Square value representing the average value of a signal
5. In the absence of Peak limits, RMS limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414

4.3.5 Damage to buried services/ utilities

Section 5.3 of DIN 4150-3:2016 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 4-11 below.

Table 4-11: Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Buried services/Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For long-term vibration the guideline levels presented in Table 4-11 should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out. This may include a specific vibration impact statement addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

For buried cables in Sydney, Ausgrid Network Standard NS193 [11] sets out ground vibration limits for buried cables.

Table 4-12: Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried cables

Buried services/Pipe Material	Guideline values for vibration velocity measured on the cable, mm/s
All cables (excluding the assets listed below)	80-100
Cables in conduits encased in TSB or concrete	50-60
Cable joints (excluding oil-filled and gas-filled transmission cables)	40-50
Oil-filled and gas-filled transmission cable joints	20-25

As the type of cables buried in Apollo Place are unknown, a conservative limit of 20 mm/s is applied based on the strictest criteria established in Table 4-12

5 Construction noise and vibration assessment

5.1 Construction noise and vibration activities and assumptions

The Amended SSDA NVIA undertook an assessment of construction noise and vibration impacts. As part of design development the works and extent of the assessed activities has been updated. An assessment of the potential construction noise and vibration impacts has been carried out to determine whether mitigation would be required, and to determine appropriate management controls. A summary of the indicative construction works schedule currently developed by AWE (SYD02 Shell E contractor), as part of project planning is provided in Section 2.2.

Construction noise levels were assessed by modelling the noise sources from six construction scenarios, which then represent the different construction works stages and locations.

The construction works scenarios and locations (Table 5-1 and Figure 5-1) and assumed construction plant and equipment requirements (Table 5-2) have been reviewed and updated by AWE from those presented in the NVIA. These may be updated as part of future Project planning.

Table 5-1: Construction works scenarios and locations

Scenario	Description of construction works (plant items, see Table 5-2)	Construction works area (Figure 5-1)
P1SE	PHASE 1: Site establishment - Stormwater works - Installation of environment controls - Establishment of construction facilities	Stage 1 Stormwater Exclusion Zone Site wide Construction site offices
P1CP	PHASE 1: Civil and piling start - Surface preparation works/ excavation works - Piling pad construction - Continuous flight auger (CFA) piling (start)	Building footprint Piling Pad work area Piling work area
P2CG	PHASE 2: Civil and in-ground works - Continuous flight auger (CFA) piling (complete) - Bulk Excavation works - Infrastructure and services augmentation works - Rock anchoring - Stormwater works and detailed excavation	Piling work area Building footprint Site wide Piling work area Site wide
P2BE	PHASE 2: Bulk civil excavation - Bulk earthworks - Stormwater works - Cut/fill and excavation works	Building footprint Stage 2 Stormwater Exclusion Zone Building footprint
P3BC	PHASE 3: Building construction works - Construction of the main building structure - Construction of other buildings/structures/services - Concrete placement	Building footprint Site wide Stage 1 Stormwater Exclusion Zone

Scenario	Description of construction works (plant items, see Table 5-2)	Construction works area (Figure 5-1)
P3BF	PHASE 3: Building fit-out - Internal fit-out within the building - Deliveries	Building footprint / Laydown areas/ Loading zone
P3TC	PHASE 3: Testing and commissioning - Services fit-off - Installation, energisation and testing of assets	Building footprint / Laydown areas

The construction works listed in the Table 5-1 may overlap during the construction program.

Table 5-2: Typical construction equipment & sound power levels

Individual plant item	Plant sound power level (L _w re. 1pW), L _{Aeq,15min} , dB(A)	Vibration significant source?	Estimated number of plant per construction scenario						
			P1SE	P1CP	P2CG	P2BE	P3BC	P3BF	P3TC
Bobcat	107	-	-	-	-	-	-	-	1
Bulldozer (D8R)	116	-	-	1	-	1	-	-	-
Compressor	100	-	-	-	-	-	1	-	-
Concrete agitator	108	-	-	1	1	-	1	1	-
Concrete pump	103	-	-	1	1	-	1	2	-
Concrete vibrators	99	-	-	-	-	-	4	8	-
Concrete/Road saw	119 ²	-	-	-	1	1	-	-	-
Delivery truck	106	-	-	-	-	-	2 ph	2 ph	2 ph
Drill rig/ rock anchors	111 ²	Y	-	-	1	-	-	-	-
Elevated work platform (EWP)	95	-	1	-	-	-	1	1	1
Excavator (30t) with bucket	105	-	1	1	1	1	-	-	-
Excavator (50t) with bucket	107	-	-	-	1	1	-	-	-
Excavator (50t) with large rockhammer	126 ²	Y	-	-	-	1	-	-	-
Fibre cable winch	86	-	-	-	1	-	-	-	-
Franna crane	99	-	1	-	-	-	1	-	-
Generator	94	-	-	1	1	-	-	-	-
Hand tools (powered)	107	-	V ³	V ³	V ³	V ³	V ³	V ³	V ³
Hand tools (non-powered)	98	-	V ³	V ³	V ³	V ³	V ³	V ³	V ³
Handtool - grout / hand mixer	107	-	-	-	-	V ³	-	-	-
Jackhammer	118 ²	Y	-	1	1	1	-	-	-
Mobile crane (300t)	105	-	-	-	-	-	1	1	1
Piling rig - bored	112	Y	-	1	1	-	-	-	-
Pump	104	-	-	-	-	-	1	-	-
Shotcrete pump/ compressor	104	-	-	-	-	-	1	-	-
Small truck	104	-	4 ph	-	-	-	4 ph	4 ph	-
Smooth drum roller (13t) - low vibration mode	114 ²	Y	-	1	1	-	-	-	-
Telehandler	98	-	1	1	1	-	1	1	1

Individual plant item	Plant sound power level (Lw re. 1pW), LAeq,15min, dB(A)	Vibration significant source?	Estimated number of plant per construction scenario						
			P1SE	P1CP	P2CG	P2BE	P3BC	P3BF	P3TC
Tipper truck	104	-	-	2	2	2	-	-	-
Tower crane - diesel	114	-	-	-	2	2	1	1	-
Trowelling machine	94	-	-	-	1	-	1	1	-
Truck and Dog	106	-	-	4 ph	-	4 ph	4 ph	-	-
Truck with Hiab	96	-	1	-	-	-	-	-	-
Water cart	107	-	-	1	1	1	-	-	-

Notes: 1. The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the ICNG, information from past projects and/or information held in the Renzo Tonin & Associates library files.

2. In accordance with the ICNG, a 5 dBA 'penalty' is applied for activities identified as particularly annoying, such as rock hammers.

3. V = Various

Final required plant and/or equipment may vary from this. Any revised plant/ equipment should be reviewed prior to construction to ensure that noise emissions are likely to remain consistent with this assessment, and the appropriate mitigation and management measures, as detailed in Section 6 are implemented where feasible and reasonable. If there are substantial changes to the construction scenarios, plant and equipment presented in Table 5-1 and Table 5-2, and the location of works (Figure 5-1), then the changes to noise and vibration impacts are to be reviewed, and the mitigation and management measures that will be implemented updated so that impacts are managed consistent with this CNVMP.

This CNVMP and the Construction Environmental Management Plan (CEMP) may be updated from time to time, as detailed in Section 8. This may trigger amendment of the mitigation and management measures required to ensure the construction works are managed consistently with this CNVMP.

A.W. EDWARDS PTY LIMITED
TN610-07F02 SYD02 SHELL E CNVMP(R1)



5.2 Construction airborne noise assessment

5.2.1 Noise prediction methodology

A noise model was developed for the Project using the CadnaA computer modelling program and noise levels were predicted using the noise propagation algorithm ISO 9613-2 (1996), which incorporates moderately adverse meteorological conditions, implemented in accordance with ISO/TR 17534-3 (2015).

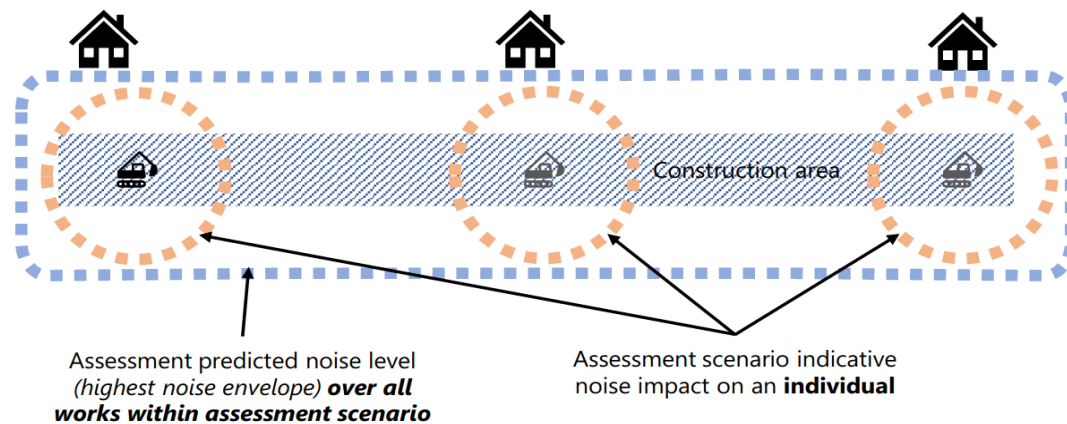
- The noise prediction model considers:
- Location of noise sources and sensitive receiver building locations
- Height of sources and receivers referenced to digital ground contours for the site and surrounding area
- Sound Power Levels (L_w) of plant and equipment likely to be used during the various construction activities
- Noise-sensitive buildings in the project have been assessed separately
- Separation distances between sources and receivers
- Acoustic shielding, potential reflections and attenuation from intervening structures, barriers and topography (natural and purpose built)
- Ground absorption between the source and receiver.
- The predicted levels are conservative and represent the equipment/plant operating simultaneously in any 15 minute period. Where plant items are not operating simultaneously, or for reduced times in a 15 minute period, noise impacts could be lower than predicted.

Construction noise levels were predicted to the sensitive receiver buildings identified in Section 3.2 based on the assumptions regarding construction scenarios, work area locations and noise sources detailed in Section 5.1. Construction noise varies throughout the construction program due to the transient nature of the works, the location of the receiver with respect to the construction work area, shielding from intervening topography and structures, and the type and duration of plant and equipment in use.

The upper range of predicted noise levels in Section 5.2.2 assumes that construction activities occur at the point closest to each receiver. In reality, construction activities will take place at various locations across the work area, so actual noise levels at each receiver will vary. Consequently, the highest predicted levels are only likely when works are positioned at the nearest point to a receiver. As construction progresses and activities move around the site, noise impacts will generally be lower than upper range of predicted noise levels. This concept is illustrated in Figure 5-2 and should be considered when interpreting the predicted noise levels in this assessment.

A 5 dB(A) penalty in accordance with the ICNG has been factored into the noise modelling levels where applicable to allow for particularly annoying activities, such as rock hammering, saw cutting and jack hammering.

Figure 5-2: Predicted level are based works at the closest point of the construction works area



5.2.2 Predicted construction noise levels

Table 5-3 shows expected ranges in construction noise levels based on plant and equipment operating at the closest and furthest points from a receiver, accounting for distance attenuation and shielding. Receivers with direct line-of-sight typically experience the highest levels, while those without line-of-sight are generally 5–10 dB(A) lower.

Table 5-3: Predicted L_{Aeq(15min)} noise levels for construction plant and activities, dB(A)

Receiver ID	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	CC1	CC2	CC3	C03	C04	C05	C06	C07	C08	C09	P01	A01	A02
Receiver type ²	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	CHC	CHC	CHC	COM	COM	COM	COM	COM	COM	COM	REC_P	REC_A	REC_A
NML(external) Standard hours ¹	56	56	56	56	56	52	52	52	52	52	52	52	52	52	52	52	52	52	52	55 ³	55 ³	55 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	60 ³	65 ³	65 ³
P1SE - PHASE 1: Site establishment																																
EWP	<20-33	<20-34	<20-35	<20-35	<20-35	<20	<20	<20	<20	<20	<20	<20	<20	<20-26	<20-27	<20	<20-26	<20-23	<20-26	<20	<20	<20-21	<20-62	<20-55	<20-56	<20-57	<20-56	<20-64	<20-70	<20	<20	<20
Excavator (30t) with bucket	<20-40	<20-41	<20-42	<20-42	<20-41	<20-22	<20-23	<20-23	<20-24	<20-25	<20	<20	<20-25	<20-33	<20-34	<20-27	<20-33	<20-29	<20-33	<20-23	<20-24	<20-28	25-69	22-62	24-63	24-64	22-63	24- 71	26- 77	<20-24	<20-25	<20-22
Franna crane	<20-37	<20-38	<20-39	<20-39	<20-39	<20	<20-20	<20	<20-21	<20-22	<20	<20	<20-22	<20-30	<20-31	<20-24	<20-30	<20-27	<20-30	<20	<20-21	<20-25	22-66	<20-59	21-60	21-61	<20-60	21-68	23- 74	<20-21	<20-22	<20
Hand tools (powered)	<20-45	<20-46	<20-47	<20-47	<20-47	<20-27	<20-28	<20-28	<20-29	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	21-33	30- 74	27-67	29-68	29-69	27-68	29- 76	31- 82	<20-29	<20-30	<20-28
Small truck	<20-42	<20-43	<20-44	<20-44	<20-44	<20-24	<20-25	<20-25	<20-26	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	27- 71	24-64	26-65	26-66	24-65	26- 73	28- 79	<20-26	<20-27	<20-25
Telehandler	<20-36	<20-37	<20-38	<20-38	<20-38	<20	<20-19	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20	<20-24	22-65	<20-58	21-59	<20-61	<20-59	20-67	22- 73	<20	<20-21	<20
Truck with Hiab	<20-34	<20-35	<20-36	<20-36	<20-36	<20	<20	<20	<20	<20	<20	<20	<20	<20-27	<20-28	<20-21	<20-27	<20-24	<20-27	<20	<20	<20-22	<20-63	<20-56	<20-57	<20-58	<20-57	<20-65	<20- 71	<20	<20	<20
Combined top 3 ⁸	<20-47	<20-49	<20-50	<20-50	<20-49	<20-29	<20-31	<20-30	<20-31	<20-33	<20-24	<20-27	<20-33	<20-41	<20-42	<20-34	<20-40	<20-37	<20-40	<20-30	<20-32	23-35	33- 77	30-69	32-70	31- 72	30- 71	32- 78	33- 85	21-31	<20-32	<20-30
P1CP - PHASE 1: Civil and piling start																																
Bulldozer (D8R)	22-52	23-54	23-54	24-55	23-54	<20-34	<20-35	<20-34	<20-33	<20-38	<20-29	<20-32	<20-38	<20-45	<20-46	<20-39	<20-45	<20-42	<20-46	20-35	24-36	28-40	39- 81	34- 73	36- 74	36- 75	35- 74	37- 82	38- 88	25-36	21-37	<20-34
Concrete agitator	<20-45	<20-47	<20-48	<20-49	<20-47	<20-28	<20-28	<20-28	<20-27	<20-31	<20-23	<20-26	<20-31	<20-39	<20-40	<20-33	<20-39	<20-36	<20-39	<20-29	<20-30	21-34	32- 75	28-67	30-67	30-69	28-68	31- 76	32- 81	<20-29	<20-31	<20-28
Concrete pump	<20-40	<20-42	<20-43	<20-44	<20-42	<20-23	<20-23	<20-23	<20-22	<20-26	<20	<20-21	<20-26	<20-34	<20-35	<20-28	<20-34	<20-31	<20-34	<20-24	<20-25	<20-29	27-70	23-62	25-62	25-64	23-63	26- 71	27- 76	<20-24	<20-26	<20-23
Excavator with bucket (30t)	<20-39	<20-41	<20-42	<20-43	<20-41	<20-22	<20-22	<20-22	<20-21	<20-25	<20	<20	<20-25	<20-33	<20-34	<20-27	<20-33	<20-29	<20-33	<20-23	<20-24	<20-28	26-68	22-61	24-61	24-63	22-62	25-69	26- 75	<20-23	<20-24	<20-22
Generator	<20-31	<20-33	<20-34	<20-35	<20-33	<20	<20	<20	<20	<20	<20	<20	<20	<20-25	<20-26	<20	<20-25	<20-22	<20-25	<20	<20	<20	<20-61	<20-53	<20-53	<20-55	<20-54	<20-62	<20-67	<20	<20	<20
Hand tools (powered)	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Hand tools (non-powered)	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Jackhammer	24-54	25-56	25-56	26- 57	25-56	<20-36	<20-37	<20-36	<20-35	<20-40	<20-31	<20-34	<20-40	<20-47	<20-48	<20-41	<20-47	<20-44	<20-48	22-37	26-38	30-42	41- 83	36- 75	38- 76	38- 77	37- 76	39- 84	40- 90	27-38	23-39	<20-36
Piling rig - bored	<20-49	21-51	21-52	21-53	21-51	<20-32	<20-32	<20-32	<20-31	<20-35	<20-27	<20-30	<20-35	<20-43	<20-44	<20-37	<20-43	<20-40	<20-43	<20-33	22-34	25-38	36- 79	32- 71	34- 71	34- 73	32- 72	35- 80	36- 85	23-33	<20-35	<20-32
Smooth drum roller (13t) - low vibration mode	21-51	23-53	23-54	23-55	23-53	<20-34	<20-34	<20-34	<20-33	<20-37	<20-29	<20-32	<20-37	<20-45	<20-46	<20-39	<20-45	<20-42	<20-45	20-35	24-36	27-40	38- 81	34- 73	36- 73	36- 75	34- 74	37- 82	38- 87	25-35	20-37	<20-34
Telehandler	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Tipper truck	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	28- 71	24-63	26-63	26-65	24-64	27- 72	28- 77	<20-25	<20-27	<20-24
Truck and dog	<20-43	<20-45	<20-46	<20-47	<20-45	<20-26	<20-26	<20-26	<20-25	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	30- 73	26-65	28-65	28-67	26-66	29- 74	30- 79	<20-27	<20-29	<20-26
Water cart	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-31	<20-35	<20-25	<20-26	<20-30	28-70	24-63	26-63	26-65	24-64	27- 71	28- 77	<20-25	<20-26	<20-24
Combined top 3 ⁸	27- 57	29- 59	29- 60	29- 61	29- 59	<20-40	<20-40	<20-40	<20-39	<20-43	<20-35	<20-38	<20-43	<20-51	<20-52	<20-45	<20-51	<20-48	<20-51	26-41	30-42	33-46	44- 87	40- 79	42- 79	42- 81	40- 80	43- 88	44- 93	31-41	26-43	<20-40
P2CG - PHASE 2: Civil and in-ground works																																
Concrete agitator	<20-45	<20-47	<20-48	<20-49	<20-47	<20-28	<20-28	<20-28	<20-27	<20-31	<20-23	<20-26	<20-31	<20-39	<20-40	<20-33	<20-39	<20-36	<20-39	<20-29	<20-30	21-34	32- 75	28-67	30-67	30-69	28-68	31- 76	32- 81	<20-29	<20-31	<20-28
Concrete pump	<20-40	<20-42	<20-43	<20-44	<20-42	<20-23	<20-23	<20-23	<20-22	<20-26	<20	<20-21	<20-26	<20-34	<20-35	<20-28	<20-34	<20-31	<20-34	<20-24	<20-25	<20-29	27-70	23-62	25-62	25-64	23-63	26- 71	27- 76	<20-24	<20-26	<20-23
Concrete saw	31- 61	33- 63	33- 64	33- 65	33- 63	27-44	27-44	26-44	24-43	23-47	21-39	24-42	24-47	25- 55	26- 56	26-49	24- 55	24-52	23- 55	30-45	34-46	37-50	48- 91	44- 83	46- 83	46- 85	44- 84	47- 92	48- 97	35-45	30-47	25-44
Drill rig	<20-48	<20-50	20-51	20-52	<20-50	<20-31	<20-31	<20-31	<20-30	<20-34	<20-26	<20-29	<20-34	<20-42	<20-43	<20-36	<20-42	<20-39	<20-42	<20-32	21-33	24-37	35- 78	31-70	33-70	33- 72	31- 71	34- 79	35- 84	22-32	<20-34	<20-31

Receiver ID	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	CC1	CC2	CC3	C03	C04	C05	C06	C07	C08	C09	P01	A01	A02
Receiver type ²	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	CHC	CHC	CHC	COM	COM	COM	COM	COM	COM	COM	REC_P	REC_A	REC_A
NML(external) Standard hours ¹	56	56	56	56	56	52	52	52	52	52	52	52	52	52	52	52	52	52	52	55 ³	55 ³	55 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	60 ³	65 ³	65 ³
Excavator with bucket (30t)	<20-39	<20-41	<20-42	<20-43	<20-41	<20-22	<20-22	<20-22	<20-21	<20-25	<20	<20	<20-25	<20-33	<20-34	<20-27	<20-33	<20-29	<20-33	<20-23	<20-24	<20-28	26-68	22-61	24-61	24-63	22-62	25-69	26- 75	<20-23	<20-24	<20-22
Excavator with bucket (50t)	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-31	<20-35	<20-25	<20-26	<20-30	28-70	24-63	26-63	26-65	24-64	27- 71	28- 77	<20-25	<20-26	<20-24
Fibre cable winch	<20-23	<20-25	<20-26	<20-27	<20-25	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20-53	<20-45	<20-45	<20-47	<20-46	<20-54	<20-59	<20	<20	<20
Generator	<20-31	<20-33	<20-34	<20-35	<20-33	<20	<20	<20	<20	<20	<20	<20	<20	<20-25	<20-26	<20	<20-25	<20-22	<20-25	<20	<20	<20	<20-61	<20-53	<20-53	<20-55	<20-54	<20-62	<20-67	<20	<20	<20
Hand tools (powered)	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-31	<20-35	<20-25	<20-26	<20-30	28-70	24-63	26-63	26-65	24-64	27- 71	28- 77	<20-25	<20-26	<20-24
Hand tools (non-powered)	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Jackhammer	24-54	25-56	25-56	26-57	25-56	<20-36	<20-37	<20-36	<20-35	<20-40	<20-31	<20-34	<20-40	<20-47	<20-48	<20-41	<20-47	<20-44	<20-48	22-37	26-38	30-42	41- 83	36- 75	38- 76	38- 77	37- 76	39- 84	40- 90	27-38	23-39	<20-36
Piling rig - bored	<20-49	21-51	21-52	21-53	21-51	<20-32	<20-32	<20-32	<20-31	<20-35	<20-27	<20-30	<20-35	<20-43	<20-44	<20-37	<20-43	<20-40	<20-43	<20-33	22-34	25-38	36- 79	32- 71	34- 71	34- 73	32- 72	35- 80	36- 85	23-33	<20-35	<20-32
Smooth drum roller (13t) - low vibration mode	21-51	23-53	23-54	23-55	23-53	<20-34	<20-34	<20-34	<20-33	<20-37	<20-29	<20-32	<20-37	<20-45	<20-46	<20-39	<20-45	<20-42	<20-45	20-35	24-36	27-40	38- 81	34- 73	36- 73	36- 75	34- 74	37- 82	38- 87	25-35	20-37	<20-34
Telehandler	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Tipper truck	<20-38	<20-40	<20-41	<20-42	<20-40	<20-21	<20-21	<20-21	<20-20	<20-24	<20	<20	<20-24	<20-32	<20-33	<20-26	<20-32	<20-28	<20-32	<20-22	<20-23	<20-27	25-67	21-60	23-60	23-62	21-61	24-68	25- 74	<20-22	<20-23	<20-21
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Trowelling machine	<20-31	<20-33	<20-34	<20-35	<20-33	<20	<20	<20	<20	<20	<20	<20	<20	<20-25	<20-26	<20	<20-25	<20-22	<20-25	<20	<20	<20	<20-61	<20-53	<20-53	<20-55	<20-54	<20-62	<20-67	<20	<20	<20
Water cart	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Combined top 3 ⁸	32- 62	34- 64	34- 65	34- 66	34- 64	<20-45	<20-45	<20-45	<20-44	<20-48	<20-40	<20-43	<20-48	<20- 56	<20- 57	<20-50	<20- 56	<20- 53	<20- 56	31-46	35-47	38-51	49- 92	45- 84	47- 84	47- 86	45- 85	48- 93	49- 98	36-46	31-48	<20-45
P2BE - PHASE 2: Bulk civil excavation																																
Bulldozer (D8R)	22-52	23-54	23-54	24-55	23-54	<20-34	<20-35	<20-34	<20-33	<20-38	<20-29	<20-32	<20-38	<20-45	<20-46	<20-39	<20-45	<20-42	<20-46	20-35	24-36	28-40	39- 81	34- 73	36- 74	36- 75	35- 74	37- 82	38- 88	25-36	21-37	<20-34
Concrete saw	31- 61	33- 63	33- 64	33- 65	33- 63	27-44	27-44	26-44	24-43	23-47	21-39	24-42	24-47	25- 55	26- 56	26-49	24- 55	24-52	23- 55	30-45	34-46	37-50	48- 91	44- 83	46- 83	46- 85	44- 84	47- 92	48- 97	35-45	30-47	25-44
Excavator with bucket (30t)	<20-39	<20-41	<20-42	<20-43	<20-41	<20-22	<20-22	<20-22	<20-21	<20-25	<20	<20	<20-25	<20-33	<20-34	<20-27	<20-33	<20-29	<20-33	<20-23	<20-24	<20-28	26-68	22-61	24-61	24-63	22-62	25-69	26- 75	<20-23	<20-24	<20-22
Excavator (50t) with large rockhammer	30- 60	32- 62	32- 63	32- 64	32- 62	26-43	26-43	25-43	22-42	22-46	<20-37	23-41	23-46	24- 54	25- 55	25-48	23- 54	23-50	22- 54	29-44	33-45	36-49	47- 89	43- 82	45- 82	45- 84	43- 83	46- 90	47- 96	34-44	29-45	24-43
Hand tools (powered)	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-31	<20-35	<20-25	<20-26	<20-30	28-70	24-63	26-63	26-65	24-64	27- 71	28- 77	<20-25	<20-26	<20-24
Hand tools (non-powered)	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Jackhammer	24-54	25-56	25-56	26-57	25-56	<20-36	<20-37	<20-36	<20-35	<20-40	<20-31	<20-34	<20-40	<20-47	<20-48	<20-41	<20-47	<20-44	<20-48	22-37	26-38	30-42	41- 83	36- 75	38- 76	38- 77	37- 76	39- 84	40- 90	27-38	23-39	<20-36
Telehandler	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Tipper truck	<20-38	<20-40	<20-41	<20-42	<20-40	<20-21	<20-21	<20-21	<20-20	<20-24	<20	<20	<20-24	<20-32	<20-33	<20-26	<20-32	<20-28	<20-32	<20-22	<20-23	<20-27	25-67	21-60	23-60	23-62	21-61	24-68	25- 74	<20-22	<20-23	<20-21
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Truck and dog	<20-43	<20-45	<20-46	<20-47	<20-45	<20-26	<20-26	<20-26	<20-25	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	30- 73	26-65	28-65	28-67	26-66	29- 74	30- 79	<20-27	<20-29	<20-26
Water cart	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Combined top 3 ⁸	34- 64	36- 66	36- 67	36- 68	36- 66	30-47	30-47	29-47	26-46	26-50	24-41	27-45	27-50	28- 58	29- 59	29- 52	27- 58	27- 54	26- 58	33-48	37-49	40-53	51- 93	47- 86	49- 86	49- 88	47- 87	50- 94	50- 94	38-48	33-49	28-47

Receiver ID	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	CC1	CC2	CC3	C03	C04	C05	C06	C07	C08	C09	P01	A01	A02
Receiver type ²	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	CHC	CHC	CHC	COM	COM	COM	COM	COM	COM	COM	REC_P	REC_A	REC_A
NML(external) Standard hours ¹	56	56	56	56	56	52	52	52	52	52	52	52	52	52	52	52	52	52	52	55 ³	55 ³	55 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	60 ³	65 ³	65 ³
P3BC(G) - PHASE 3: Building construction works (ground level)																																
Compressor	<20-27	<20-21	<20-22	<20-21	<20-23	<20	<20	<20	<20	<20	<20	<20	<20-23	22-30	23-31	<20-26	23-30	23-24	22-29	<20	<20	22-23	51-57	47-54	49-56	49-52	46-52	47-55	51-57	<20	<20	<20
Concrete agitator	21-35	23-29	24-30	24-29	24-31	<20-21	<20-21	<20-22	<20-22	<20-22	<20	<20-22	<20-31	30-38	31-39	<20-34	31-38	31-32	30-37	20-25	26-28	30-31	59-65	55-62	57-64	57-60	54-60	55-63	59-65	23-27	<20-26	<20-20
Concrete pump	<20-30	<20-24	<20-25	<20-24	<20-26	<20	<20	<20	<20	<20	<20	<20	<20-26	25-33	26-34	<20-29	26-33	26-27	25-32	<20-20	21-23	25-26	54-60	50-57	52-59	52-55	49-55	50-58	54-60	<20-22	<20-21	<20
Concrete vibrator	<20-34	<20-36	<20-37	<20-38	<20-36	<20	<20	<20	<20	<20-20	<20	<20	<20-20	<20-28	<20-29	<20-22	<20-28	<20-25	<20-28	<20	<20	<20-23	21-64	<20-56	<20-56	<20-58	<20-57	<20-65	21-70	<20	<20	<20
Delivery truck	<20-43	<20-45	<20-46	<20-47	<20-45	<20-26	<20-26	<20-26	<20-25	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	30- 73	26-65	28-65	28-67	26-66	29- 74	30- 79	<20-27	<20-29	<20-26
EWP	<20-32	<20-34	<20-35	<20-36	<20-34	<20	<20	<20	<20	<20	<20	<20	<20	<20-26	<20-27	<20	<20-26	<20-23	<20-26	<20	<20	<20-21	<20-62	<20-54	<20-54	<20-56	<20-55	<20-63	<20-68	<20	<20	<20
Franna crane	<20-36	<20-38	<20-39	<20-40	<20-38	<20	<20	<20	<20	<20-22	<20	<20	<20-22	<20-30	<20-31	<20-24	<20-30	<20-27	<20-30	<20-20	<20-21	<20-25	23-66	<20-58	21-58	21-60	<20-59	22-67	23- 72	<20-20	<20-22	<20
Hand tools (powered)	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Hand tools (non-powered)	<20-27	<20-29	<20-30	<20-31	<20-29	<20	<20	<20	<20	<20	<20	<20	<20	<20-21	<20-22	<20	<20-21	<20	<20-21	<20	<20	<20	<20-57	<20-49	<20-49	<20-51	<20-50	<20-58	<20-63	<20	<20	<20
Mobile crane (300t)	<20-32	<20-26	21-27	21-26	21-28	<20	<20	<20	<20	<20	<20	<20	<20-28	27-35	28-36	<20-31	28-35	28-29	27-34	<20-22	23-25	27-28	56-62	52-59	54-61	54-57	51-57	52-60	56-62	<20-24	<20-23	<20
Pump	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20
Shotcrete pump/ compressor	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20
Small truck	<20-41	<20-43	<20-44	<20-45	<20-43	<20-24	<20-24	<20-24	<20-23	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20-29	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	30- 71	26-63	28-63	28-65	26-64	29- 72	30- 77	<20-25	<20-27	<20-24
Telehandler	<20-35	<20-37	<20-38	<20-39	<20-37	<20	<20	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20-20	<20-24	22-65	<20-57	<20-57	20-59	<20-58	21-66	22- 71	<20	<20-21	<20
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Trowelling machine	<20-31	<20-33	<20-34	<20-35	<20-33	<20	<20	<20	<20	<20	<20	<20	<20	<20-25	<20-26	<20	<20-25	<20-22	<20-25	<20	<20	<20	<20-61	<20-53	<20-53	<20-55	<20-54	<20-62	<20-67	<20	<20	<20
Truck and dog	<20-43	<20-45	<20-46	<20-47	<20-45	<20-26	<20-26	<20-26	<20-25	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	30- 73	26-65	28-65	28-67	26-66	29- 74	30- 79	<20-27	<20-29	<20-26
Combined top 3 ⁸ (excluding tower crane)	<20-47	<20-49	<20-50	<20-51	<20-49	<20-31	<20-31	<20-31	<20-30	<20-33	<20-25	<20-29	<20-35	<20-43	<20-44	<20-38	<20-43	<20-39	<20-42	<20-32	<20-33	31-37	59-77	55-70	57-70	57- 71	54-70	55- 78	59- 83	<20-32	<20-34	<20-30
P3BC(38) - PHASE 3: Building structure (RL37.8)																																
Compressor	<20-35	<20-38	<20-37	<20-37	<20-36	<20	<20	<20	<20	<20	<20	<20	<20	<20-29	<20-29	<20-26	<20-27	<20-23	<20-27	<20	<20	<20	<20-62	<20-51	<20-51	<20-53	<20-52	<20-60	<20-64	<20	<20	<20
Concrete pump ⁷	<20-30	<20-24	<20-25	<20-24	<20-26	<20	<20	<20	<20	<20	<20	<20	<20-26	25-33	26-34	<20-29	26-33	26-27	25-32	<20-20	21-23	25-26	54-60	50-57	52-59	52-55	49-55	50-58	54-60	<20-22	<20-21	<20
Concrete agitator ⁷	21-35	23-29	24-30	24-29	24-31	<20-21	<20-21	<20-22	<20-22	<20-22	<20	<20-22	<20-31	30-38	31-39	<20-34	31-38	31-32	30-37	20-25	26-28	30-31	59-65	55-62	57-64	57-60	54-60	55-63	59-65	23-27	<20-26	<20-20
Concrete vibrator	<20-40	<20-43	<20-42	<20-42	<20-41	<20-25	<20-27	<20-26	<20-22	<20-24	<20	<20-23	<20-25	<20-34	<20-34	<20-31	<20-32	<20-28	<20-32	<20-23	<20-23	<20-23	22-67	<20-56	<20-56	20-58	<20-57	21-65	22- 71	<20-25	<20-27	<20-23
Delivery truck ⁷	<20-44	<20-45	<20-46	<20-46	<20-46	<20-26	<20-27	<20-27	<20-28	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	29- 73	26-66	28-67	28-68	26-67	28- 75	30- 81	<20-28	<20-29	<20-27
EWP	<20-38	<20-41	<20-40	<20-40	<20-39	<20-23	<20-25	<20-24	<20	<20-22	<20	<20	<20-23	<20-32	<20-32	<20-29	<20-30	<20-26	<20-30	<20-21	<20-21	<20-21	<20-65	<20-54	<20-54	<20-56	<20-55	<20-63	<20-69	<20-23	<20-25	<20
Franna crane	<20-34	<20-37	<20-36	<20-36	<20-35	<20	<20	<20	<20	<20	<20	<20	<20	<20-28	<20-28	<20-25	<20-26	<20-22	<20-26	<20	<20	<20	<20-61	<20-50	<20-50	<20-52	<20-51	<20-59	<20-65	<20	<20	<20
Hand tools (powered)	<20-50	21- 53	<20-52	20-52	<20-51	<20-35	<20-37	<20-36	<20-32	<20-34	<20-25	<20-33	<20-35	<20-44	<20-44	<20-41	<20-42	<20-38	<20-42	<20-33	20-33	21-33	32- 77	28-66	30-66	30-68	28-67	31- 75	32- 81	21-35	<20-37	<20-33
Hand tools (non-powered)	<20-33	<20-36	<20-35	<20-35	<20-34	<20	<20	<20	<20	<20	<20	<20	<20	<20-27	<20-27	<20-24	<20-25	<20-21	<20-25	<20	<20	<20	<20-60	<20-49	<20-49	<20-51	<20-50	<20-58	<20-64	<20	<20	<20
Hand tools (grout/ hand mixer)	<20-50	21- 53	<20-52	20-52	<20-51	<20-35	<20-37	<20-36	<20-32	<20-34	<20-25	<20-33	<20-35	<20-44	<20-44	<20-41	<20-42	<20-38	<20-42	<20-33	20-33	21-33	32- 77	28-66	30-66	30-68	28-67	31- 75	32- 81	21-35	<20-37	<20-33
Mobile crane(300t) ⁸	<20-32	<20-26	21-27	21-26	21-28	<20	<20	<20	<20	<20	<20	<20	<20-28	27-35	28-36	<20-31	28-35	28-29	27-34	<20-22	23-25	27-28	56-62	52-59	54-61	54-57	51-57	52-60	56-62	<20-24	<20-23	<20
Pump ⁸	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20

Receiver ID	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	CC1	CC2	CC3	C03	C04	C05	C06	C07	C08	C09	P01	A01	A02
Receiver type ²	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	CHC	CHC	CHC	COM	COM	COM	COM	COM	COM	COM	REC_P	REC_A	REC_A
NML(external) Standard hours ¹	56	56	56	56	56	52	52	52	52	52	52	52	52	52	52	52	52	52	52	55 ³	55 ³	55 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	60 ³	65 ³	65 ³
Shotcrete pump/ compressor ⁷	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20
Small truck ⁷	<20-42	<20-43	<20-44	<20-44	<20-44	<20-24	<20-25	<20-25	<20-26	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	29- 71	26-64	28-65	28-66	26-65	28- 73	30- 79	<20-26	<20-27	<20-25
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Trowelling machine	<20-37	<20-40	<20-39	<20-39	<20-38	<20-22	<20-24	<20-23	<20	<20-21	<20	<20	<20-22	<20-31	<20-31	<20-28	<20-29	<20-25	<20-29	<20-20	<20-20	<20-20	<20-64	<20-53	<20-53	<20-55	<20-54	<20-62	<20-68	<20-22	<20-24	<20
Truck and dog ⁷	<20-44	<20-45	<20-46	<20-46	<20-46	<20-26	<20-27	<20-27	<20-28	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	29- 73	26-66	28-67	28-68	26-67	28- 75	30- 81	<20-28	<20-29	<20-27
Combined top 3 ⁸ (excluding tower crane)	21-53	27-56	24-55	27-55	24-54	<20-38	<20-40	<20-39	<20-35	<20-37	<20-28	<20-36	<20-39	30-48	31-48	<20-44	31-46	31-42	30-46	20-36	28-37	31-37	59- 80	55-70	57-70	57- 71	54-70	55- 78	59- 84	<20-38	<20-40	<20-36
P3BC(50) - PHASE 3: Building structure (RL49.8)																																
Compressor	<20-36	<20-38	<20-37	<20-37	<20-37	<20-31	<20-31	<20-30	<20	<20-22	<20	<20-22	<20-27	<20-30	<20-31	<20-28	<20-28	<20-24	<20-28	<20	<20	<20	21-64	<20-50	<20-50	<20-53	<20-52	<20-58	<20-60	<20-25	<20-34	<20-28
Concrete agitator ⁷	21-35	23-29	24-30	24-29	24-31	<20-21	<20-21	<20-22	<20-22	<20-22	<20	<20-22	<20-31	30-38	31-39	<20-34	31-38	31-32	30-37	20-25	26-28	30-31	59-65	55-62	57-64	57-60	54-60	55-63	59-65	23-27	<20-26	<20-20
Concrete pump ⁷	<20-30	<20-24	<20-25	<20-24	<20-26	<20	<20	<20	<20	<20	<20	<20	<20-26	25-33	26-34	<20-29	26-33	26-27	25-32	<20-20	21-23	25-26	54-60	50-57	52-59	52-55	49-55	50-58	54-60	<20-22	<20-21	<20
Concrete vibrator	<20-41	<20-43	<20-42	<20-42	<20-42	<20-36	<20-36	<20-35	<20-26	<20-27	<20	<20-27	<20-32	<20-35	<20-36	<20-33	<20-34	<20-29	<20-33	<20-27	<20-24	<20-25	28-69	24-55	26-56	26-58	24-57	26-63	27-65	<20-30	<20-39	<20-33
Delivery truck ⁷	<20-44	<20-45	<20-46	<20-46	<20-46	<20-26	<20-27	<20-27	<20-28	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	29- 73	26-66	28-67	28-68	26-67	28- 75	30- 81	<20-28	<20-29	<20-27
EWP	<20-31	<20-33	<20-32	<20-32	<20-32	<20-26	<20-26	<20-25	<20	<20-20	<20	<20-20	<20-22	<20-25	<20-26	<20-23	<20-24	<20	<20-23	<20	<20	<20	21-59	<20-45	<20-46	<20-48	<20-47	<20-53	<20-55	<20-20	<20-29	<20-23
Franna crane	<20-35	<20-37	<20-36	<20-36	<20-36	<20-30	<20-30	<20-29	<20	<20-21	<20	<20-21	<20-26	<20-29	<20-30	<20-27	<20-28	<20-23	<20-27	<20	<20	<20	21-63	<20-49	<20-50	<20-52	<20-51	<20-57	<20-59	<20-24	<20-33	<20-27
Hand tools (powered)	25-51	27-53	26-52	26-52	25-52	20-46	20-46	<20-45	<20-36	<20-37	<20-29	<20-37	<20-42	<20-45	<20-46	<20-43	<20-44	<20-39	<20-43	22-37	26-34	27-35	38- 79	34-65	36-66	36-68	34-67	36- 73	37- 75	26-40	23-49	<20-43
Hand tools (non- powered)	<20-34	<20-36	<20-35	<20-35	<20-35	<20-29	<20-29	<20-28	<20	<20-20	<20	<20-20	<20-25	<20-28	<20-29	<20-26	<20-27	<20-22	<20-26	<20	<20	<20	21-62	<20-48	<20-49	<20-51	<20-50	<20-56	<20-58	<20-23	<20-32	<20-26
Hand tools (grout/ hand mixer)	25-51	27-53	26-52	26-52	25-52	20-46	20-46	<20-45	<20-36	<20-37	<20-29	<20-37	<20-42	<20-45	<20-46	<20-43	<20-44	<20-39	<20-43	22-37	26-34	27-35	38- 79	34-65	36-66	36-68	34-67	36- 73	37- 75	26-40	23-49	<20-43
Mobile crane(300t) ⁸	<20-32	<20-26	21-27	21-26	21-28	<20	<20	<20	<20	<20	<20	<20	<20-28	27-35	28-36	<20-31	28-35	28-29	27-34	<20-22	23-25	27-28	56-62	52-59	54-61	54-57	51-57	52-60	56-62	<20-24	<20-23	<20
Pump ⁷	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20
Shotcrete pump/ compressor ⁷	<20-31	<20-25	<20-26	<20-25	<20-27	<20	<20	<20	<20	<20	<20	<20	<20-27	25-34	26-35	<20-30	26-34	26-27	25-31	<20	<20-22	24-25	53-59	47-54	49-56	49-52	49-52	47-55	51-57	<20	<20	<20
Small truck ⁷	<20-42	<20-43	<20-44	<20-44	<20-44	<20-24	<20-25	<20-25	<20-26	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	29- 71	26-64	28-65	28-66	26-65	28- 73	30- 79	<20-26	<20-27	<20-25
Telehandler	<20-34	<20-36	<20-35	<20-35	<20-35	<20-29	<20-29	<20-28	<20	<20-20	<20	<20-20	<20-25	<20-28	<20-29	<20-26	<20-27	<20-22	<20-26	<20	<20	<20	21-62	<20-48	<20-49	<20-51	<20-50	<20-56	<20-58	<20-23	<20-32	<20-26
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Trowelling machine	<20-38	<20-40	<20-39	<20-39	<20-39	<20-33	<20-33	<20-32	<20-23	<20-24	<20	<20-24	<20-29	<20-32	<20-33	<20-30	<20-31	<20-26	<20-30	<20-24	<20-21	<20-22	25-66	21-52	23-53	23-55	21-54	23-60	24-62	<20-27	<20-36	<20-30
Truck and dog ⁷	<20-44	<20-45	<20-46	<20-46	<20-46	<20-26	<20-27	<20-27	<20-28	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	29-73	26-66	28-67	28-68	26-67	28- 75	30- 81	<20-28	<20-29	<20-27
Combined top 3 ⁸ (excluding tower crane)	29-54	31-56	30-55	30-55	29-55	<20-49	<20-49	<20-48	<20-39	<20-40	<20-32	<20-40	<20-45	30-48	31-49	<20-46	31-48	31-42	30-47	26-40	31-38	33-39	59- 82	55-69	57-70	57- 71	54-70	55- 76	59- 78	30-43	26-52	<20-46

Receiver ID	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	CC1	CC2	CC3	C03	C04	C05	C06	C07	C08	C09	P01	A01	A02
Receiver type ²	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	RES	CHC	CHC	CHC	COM	COM	COM	COM	COM	COM	COM	REC_P	REC_A	REC_A
NML(external) Standard hours ¹	56	56	56	56	56	52	52	52	52	52	52	52	52	52	52	52	52	52	52	55 ³	55 ³	55 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	70 ³	60 ³	65 ³	65 ³
P3BF - PHASE 3: Building fitout																																
Concrete agitator	<20-45	<20-47	<20-48	<20-49	<20-47	<20-28	<20-28	<20-28	<20-27	<20-31	<20-23	<20-26	<20-31	<20-39	<20-40	<20-33	<20-39	<20-36	<20-39	<20-29	<20-30	21-34	32- 75	28-67	30-67	30-69	28-68	31- 76	32- 81	<20-29	<20-31	<20-28
Concrete pump	<20-40	<20-42	<20-43	<20-44	<20-42	<20-23	<20-23	<20-23	<20-22	<20-26	<20	<20-21	<20-26	<20-34	<20-35	<20-28	<20-34	<20-31	<20-34	<20-24	<20-25	<20-29	27-70	23-62	25-62	25-64	23-63	26- 71	27- 76	<20-24	<20-26	<20-23
Concrete vibrators	<20-36	<20-38	<20-39	<20-40	<20-38	<20	<20	<20	<20	<20-22	<20	<20	<20-22	<20-30	<20-31	<20-24	<20-30	<20-27	<20-30	<20-20	<20-21	<20-25	23-66	<20-58	21-58	21-60	<20-59	22-67	23- 72	<20-20	<20-22	<20
Delivery truck ⁷	<20-44	<20-45	<20-46	<20-46	<20-46	<20-26	<20-27	<20-27	<20-28	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	29- 73	26-66	28-67	28-68	26-67	28- 75	30- 81	<20-28	<20-29	<20-27
EWP	<20-32	<20-34	<20-35	<20-36	<20-34	<20	<20	<20	<20	<20	<20	<20	<20	<20-26	<20-27	<20-20	<20-26	<20-23	<20-26	<20	<20	<20-21	22-62	<20-54	<20-54	20-56	<20-55	21-63	22- 68	<20	<20	<20
Hand tools (powered)	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Hand tools (non-powered)	<20-35	<20-37	<20-38	<20-39	<20-37	<20	<20	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20-20	<20-24	22-65	<20-57	<20-57	20-59	<20-58	21-66	22- 71	<20	<20-21	<20
Mobile crane (300t)	<20-42	<20-44	<20-45	<20-46	<20-44	<20-25	<20-25	<20-25	<20-24	<20-28	<20	<20-23	<20-28	<20-36	<20-37	<20-30	<20-36	<20-33	<20-36	<20-26	<20-27	<20-31	29- 72	25-64	27-64	27-66	25-65	28- 73	29- 78	<20-26	<20-28	<20-25
Small truck ⁷	<20-42	<20-43	<20-44	<20-44	<20-44	<20-24	<20-25	<20-25	<20-26	<20-27	<20	<20-22	<20-27	<20-35	<20-36	<20	<20-35	<20-32	<20-35	<20-25	<20-26	<20-30	29- 71	26-64	28-65	28-66	26-65	28- 73	30- 79	<20-26	<20-27	<20-25
Telehandler	<20-35	<20-37	<20-38	<20-39	<20-37	<20	<20	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20-20	<20-24	22-65	<20-57	<20-57	20-59	<20-58	21-66	22- 71	<20	<20-21	<20
Tower crane (diesel ⁶)	57	58	58	58	59	53	54	53	44	45	37	46	50	51	52	46	50	46	49	45	41	41	73	69	66	66	66	68	71	41	51	52
Trowelling machine	<20-31	<20-33	<20-34	<20-35	<20-33	<20	<20	<20	<20	<20	<20	<20	<20	<20-25	<20-26	<20	<20-25	<20-22	<20-25	<20	<20	<20	<20-61	<20-53	<20-53	<20-55	<20-54	<20-62	<20-67	<20	<20	<20
Combined top 3 ⁸ (excluding tower crane)	<20-49	21-51	21-52	21-53	21-51	<20-32	<20-32	<20-32	<20-31	<20-35	<20-27	<20-30	<20-35	<20-43	<20-44	<20-37	<20-43	<20-40	<20-43	<20-33	22-34	25-38	36- 79	32- 71	34- 71	34- 73	32- 72	35- 80	36- 85	23-33	<20-35	<20-32
P3TC – PHASE 3: Testing and Commissioning																																
Bobcat	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Delivery truck	<20-43	<20-45	<20-46	<20-47	<20-45	<20-26	<20-26	<20-26	<20-25	<20-29	<20-21	<20-24	<20-29	<20-37	<20-38	<20-31	<20-37	<20-34	<20-37	<20-27	<20-28	<20-32	30- 73	26-65	28-65	28-67	26-66	29- 74	30- 79	<20-27	<20-29	<20-26
EWP	<20-32	<20-34	<20-35	<20-36	<20-34	<20	<20	<20	<20	<20	<20	<20	<20	<20-26	<20-27	<20	<20-26	<20-23	<20-26	<20	<20	<20-21	<20-62	<20-54	<20-54	<20-56	<20-55	<20-63	<20-68	<20	<20	<20
Hand tools (powered)	<20-44	<20-46	<20-47	<20-48	<20-46	<20-27	<20-27	<20-27	<20-26	<20-30	<20-22	<20-25	<20-30	<20-38	<20-39	<20-32	<20-38	<20-35	<20-38	<20-28	<20-29	20-33	31- 74	27-66	29-66	29-68	27-67	30- 75	31- 80	<20-28	<20-30	<20-27
Hand tools (non-powered)	<20-35	<20-37	<20-38	<20-39	<20-37	<20	<20	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20-20	<20-24	22-65	<20-57	<20-57	20-59	<20-58	21-66	22- 71	<20	<20-21	<20
Mobile crane (300t)	<20-42	<20-44	<20-45	<20-46	<20-44	<20-25	<20-25	<20-25	<20-24	<20-28	<20	<20-23	<20-28	<20-36	<20-37	<20-30	<20-36	<20-33	<20-36	<20-26	<20-27	<20-31	29- 72	25-64	27-64	27-66	25-65	28- 73	29- 78	<20-26	<20-28	<20-25
Telehandler	<20-35	<20-37	<20-38	<20-39	<20-37	<20	<20	<20	<20	<20-21	<20	<20	<20-21	<20-29	<20-30	<20-23	<20-29	<20-26	<20-29	<20	<20-20	<20-24	22-65	<20-57	<20-57	20-59	<20-58	21-66	22- 71	<20	<20-21	<20
Combined top 3 ⁸	<20-49	20-51	21-52	21-52	20-51	<20-31	<20-32	<20-31	<20-31	<20-35	<20-26	<20-29	<20-35	<20-43	<20-43	<20-36	<20-42	<20-39	<20-43	<20-32	21-33	25-37	36- 78	31-70	33- 71	34- 72	32- 71	34- 79	36- 85	22-33	<20-34	<20-31

- Notes:
1. Standard construction hours – Mon-Fri – 7:00am to 6:00pm, Sat – 8:00am to 1:00pm, Day (OOH) = Sat – 1:00pm to 6:00pm, Sun – 8pm to 6pm

2. RES = Residential, CHC = Childcare, CHC = Childcare. COM = Commercial, REC_P = Passive Recreation, REC_A = Active Recreation

3. Only applies when in use

4. **Bold black** text is where the highest (ie. closest) predicted noise level could reach above the **Day (standard) NML**.

5. **Bold blue** text indicates where the highest (ie. closest) predicted noise level could reach above the Highly Noise Affected level (ie. >75 dB(A)) for residences.

6. Modelled at RL 60m

7. Modelled at ground level

8. Combined level from up to 3 (noisiest) plant operating concurrently

5.2.3 Discussion of construction noise results

The predicted noise levels presented above indicate that some commercial receivers, in particular C03, C08 and C09, are likely to be construction noise affected (ie. experience noise levels above the NML) during all construction stages, due to the close proximity of the works area to the commercial receivers. For construction activities with high noise generating plant and equipment such as excavators with rockhammers, or when works are closer to the commercial properties, the receivers may be highly noise affected (ie. experience noise levels above 75 dB(A)).

Residential receivers are further away from the site, as can be seen from Figure 3-1. Most construction activities are below or within 10 dB of the NML during standard construction hours. For works where high noise generating equipment is not operating, and where the works are occurring within the site further away from the residential receivers, the predicted noise levels are generally below the NMLs. Predicted noise levels indicate there will be no 'highly noise affected' [>75 dB(A)] residential receivers during the construction works.

Noise emissions are predicted to be highest when high noise generating equipment such as excavators with rockhammers and during the tower crane operation.

The highest predicted noise levels are during the Phase 2 Civil and in-ground works and Phase 2 Bulk civil excavation, when these are being undertaken on the eastern and southern side of the site, and are occurring near the adjacent commercial receivers (C03, C08 and C09).

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce construction noise levels towards achieving the NMLs. Further details on construction noise mitigation and management measures are provided in Section 6.1 below.

5.2.4 Cumulative noise impacts

5.2.4.1 SSD 9741 Lane Cove West Data Centre – Shell C Project and fit-out

The existing data centre (SSD 9741) – 1 Sirius Road, Lane Cove West was noted in the NVIA to be undergoing construction works in 2024 and 2025. These works may extend into 2026, concurrent with the Project works.

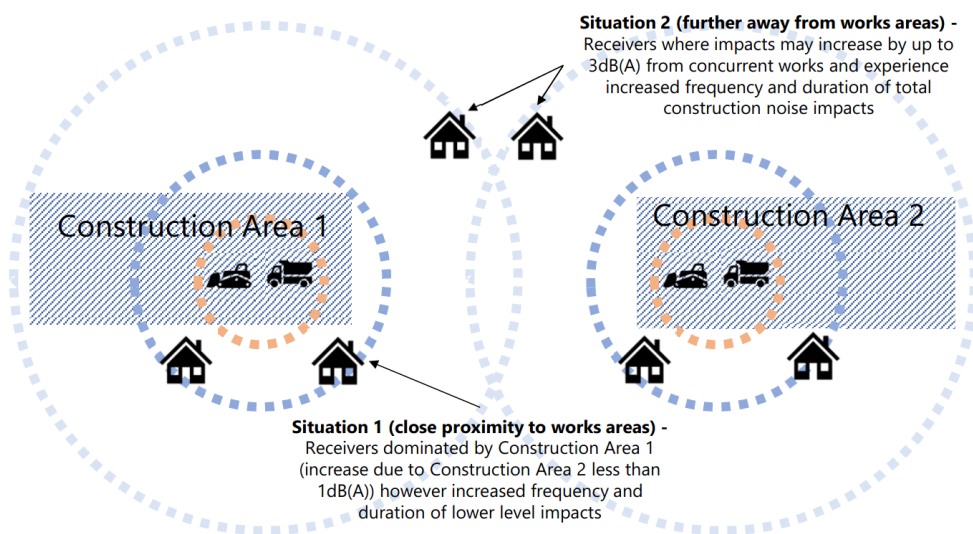
As of 27 February 2026, no further concrete work is required. Steel gantry is being installed until May 2026, along with installation of additional pre-cast concrete panels. The gantry install involves lifting of steel members and fixing them into place. There may be some additional rock anchors being installed.

The remainder of the works are generally internal fitout works extending to Sept 2026.

5.2.4.2 Review of likely cumulative impacts

Typically, while impacts from one project or one construction site may be relatively short-term or noise intensive periods intermittent, when multiple construction projects are occurring at the same time near a receiver cumulative construction noise impacts can occur. This can mean that construction noise impacting a sensitive receiver may be louder than from an individual set up works [by up to 3 dB(A)], the overall duration of construction impacts may be overall longer or impacts more frequent. Typically, concurrent projects can impact nearby receiver locations in one of two ways, as also shown in Figure 5-3.

Figure 5-3: Cumulative construction



There is potential for cumulative noise impacts from the Project combined with other concurrent construction projects, and so it is recommended that mitigation and management measures are implemented to minimise cumulative impacts, as detailed in Section 6.1. In addition, the following measures are to be used to mitigate and manage cumulative noise impacts and reduce the likelihood of construction fatigue:

- Coordination between construction sites is essential to minimise cumulative noise impacts wherever feasible and reasonable. For example, when multiple sites are undertaking high-noise activities, such as rock hammering or other noise-intensive works within proximity to the same noise-sensitive receivers, these activities should be managed collaboratively. However, based on the remaining works described in Section 5.2.4.1, this is unlikely. Nonetheless, works would be managed to ensure that such works do not occur concurrently during designated respite periods and that scheduling considers the combined impact of both projects.
- Community consultation would be undertaken through continued letter box drops which details project contact details to communicate construction noise issues, to gauge key noise impacts and issues and identify any unknown impacts from concurrent or consecutive sets of constructions works.

- Consideration of cumulative construction noise impacts during the development of noise mitigation and management measures for the worksites, including coordination between construction projects, where reasonable and feasible (ie. consideration of respite periods provided by other projects for high noise impact works, so that timetables between projects don't result in conflicting periods of respite).

The incorporation of the above measures into the works program would be further reviewed during construction planning, and updated where required throughout the project, considering the construction progress of the Project and the nearby other construction works.

5.2.5 Construction-related road traffic

The worksite 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:
 - Trucks removing construction waste from the site
 - Delivery vehicles bringing raw materials, plant, and equipment to the site

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 5.1. When construction-related traffic moves on the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as additional road traffic on public roads rather than as part of the construction site's activities.

Based upon input from the project team, it is expected that the peak traffic activity generated during the Phase 2 construction works. The number of concrete trucks generated during a concrete pour will typically range from 30 to 40 concrete trucks per day for large pours and some 15 to 20 concrete trucks per day for moderate sized pours. During other construction stages, the estimated daily number of heavy vehicles accessing the site will be up to 15 to 20 trucks per day during peak periods or an average of 2 to 3 per hour, over a standard 10-hour work day.

Construction traffic would access the site from Orion Road via Epping Road, which are sub-arterial and arterial roads (respectively). Considering the existing high traffic volumes of the construction traffic route to/from the site presented, and the expected volumes construction vehicles associated with the project, construction related road traffic noise level is not predicted to increase traffic noise levels by more than 2 dB on the surrounding roads.

Construction related road traffic noise is therefore expected to comply with the requirements of the RNP and is not expected to cause any adverse impacts and is not further addressed in this report.

5.3 Construction vibration assessment

5.3.1 Vibration sources

The pattern of vibration radiation is very different to the pattern of airborne noise radiation. Unlike noise, vibration cannot be readily predicted. There are many variables from site to site, such as the intervening geology between the activity and the receiver, building types and foundations. Vibration is also dependent on the actual plant used, its operation and the dominant frequencies of vibration generated, and the plant location on site relative to receivers.

The recommended minimum working distances for vibration intensive plant are presented in Table 5-4 and Table 5-5. The data relied upon for this assessment is taken from a database of vibration levels measured at various sites or obtained from other sources (such as BS5228-2:2009). They are not specific to this Project.

Site specific minimum working distances for vibration intensive plant items must be measured on site where plant and equipment are likely to operate close to or within the minimum working distances for cosmetic damage, as detailed in Table 5-4.

Table 5-4: Minimum working distances (m) for cosmetic damage (continuous vibration)

Plant item	Minimum working distance (m) ⁶		
	Reinforced or framed structures (e.g. commercial buildings) ^{1,3}	Unreinforced or light framed structures (e.g. residential buildings) ^{1,3}	Sensitive structures (e.g. heritage structures) ^{2,4,5}
Drill rig / rock anchors	5	5	5
Excavator with large rockhammer (50t)	5	10	20
Jackhammer	5	5	5
Piling rig (bored)	5	5	10
Smooth drum roller (13t) - High vibration	5	5	15
Smooth drum roller (13t) - Low vibration	5	5	10

- Notes: 1. Criteria referenced from British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings'.
 2. Criteria referenced from DIN 4150 Part 3, Structural Damage - Safe Limits for Short-term Building Vibration.
 3. Initial screening test criteria reduced by 50% due to potential dynamic magnification in accordance with BS7385.
 4. A building condition inspection should determine whether a heritage item is structurally unsound.
 5. Heritage specialist will be consulted to determine appropriate vibration criteria and associated MWDs, vibration monitoring locations and monitor setup.
 6. Minimum working distances are in 5m increments only to account for the intrinsic uncertainty of this screening method.

Table 5-5: Minimum working distances (m) for human annoyance (continuous vibration)

Plant item	Minimum working distances (m)				
	Critical areas ^{2,3} 0.28 mm/s	Residences		Offices ² 1.1 mm/s	Workshops ² 2.2 mm/s
		Day ¹ 0.56mm/s	Night ¹ 0.40 mm/s		
Drill rig / rock anchors	15	10	15	5	5
Excavator with large rockhammer (50t)	65	45	55	30	20
Jackhammer	25	15	20	10	5
Piling rig (bored)	20	15	15	10	10
Smooth drum roller (13t) - High vibration	105	55	75	30	15
Smooth drum roller (13t) - Low vibration	75	40	55	20	10

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2. Applicable when in use

3. 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. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The surrounding commercial/ industrial area includes some high technology buildings housing sensitive computer or telecommunications equipment (including the existing AirTrunk datacentre). Minimum working distances based on the vibration criteria for buried services are presented in Table 5-7 following.

Table 5-6: Minimum working distances (m) for building structure housing sensitive equipment

Plant item	Minimum working distance (m) ⁶		
	Computer Areas ²	Medical ^{2,3}	VC-A ³
Drill rig / rock anchors	10	30	55
Excavator with large rockhammer (50t)	30	105	160
Jackhammer	5	10	20
Piling rig (bored)	10	25	35
Smooth drum roller (13t) - High vibration	130	585	990
Smooth drum roller (13t) - Low vibration	95	415	705

Notes: 1. Criteria referenced from DIN 4150 Part 3, Structural Damage - Safe Limits for Short-term Building Vibration.

2. Lower value of recommended goals in Section 4.3.5 referenced from guidelines/ standards for various utility asset owners.

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

Where works are occurring near buried utility assets, consultation should be undertaken with the asset owner to confirm acceptable vibration limits to minimise the likelihood of vibration induced damage to the asset. Minimum working distances based on the vibration criteria for buried services are presented in Table 5-7 following.

Table 5-7: Minimum working distances (m) for buried pipework/ cables (continuous vibration)

Plant item	Minimum working distance (m) ⁶			
	Steel (including welded pipes) ^{1,3}	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal ^{1,3}	Electrical cables and tele-communication services ^{2,3}	Masonry, plastics ^{1,3}
Drill rig / rock anchors	5	5	5	5
Excavator with large rockhammer (50t)	5	5	5	5
Jackhammer	5	5	5	5
Piling rig (bored)	5	5	5	5
Smooth drum roller (13t) - High vibration	5	5	5	5
Smooth drum roller (13t) - Low vibration	5	5	5	5

Notes: 1. Criteria referenced from DIN 4150 Part 3, Structural Damage - Safe Limits for Short-term Building Vibration.

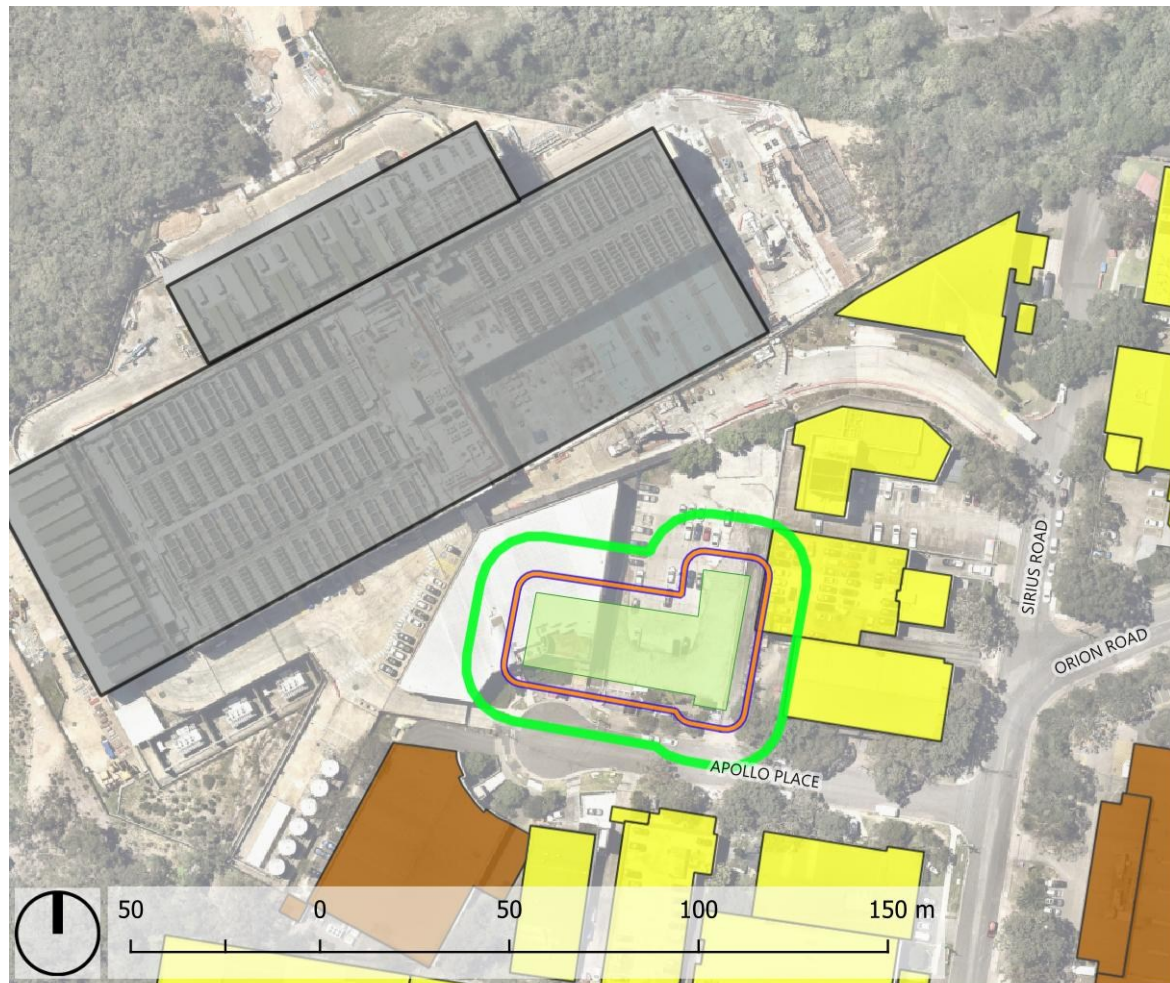
2. Lower value of recommended goals in Section 4.3.5 referenced from guidelines/ standards for various utility asset owners.

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

Potential vibration impacts are to be further reviewed during the construction design, planning stages to determine if the final selected plant and equipment could be located within the minimum working distances and/or result in vibration about the applicable vibration limits. Where then identified, and feasible and reasonable mitigation and management would be implemented to achieve the applicable vibration limits.

As a screening assessment, the largest minimum working distances from the various proposed vibration intensive activities has been mapped from the project construction boundary and presented in Figure 5-4, Figure 5-5 and Figure 5-6. No heritage items were identified in the study area.

Figure 5-4: Minimum working distances for cosmetic damage from PHASE 1: Civil and piling start and PHASE 2: Civil and in-ground works (Smooth drum roller (13t) – high vibration mode)



Nearby building structures and usage type

- Industrial
- Commercial
- Existing data centre (SSD 9741)

Vibration intensive works area

- Piling Pad

Identified heritage item

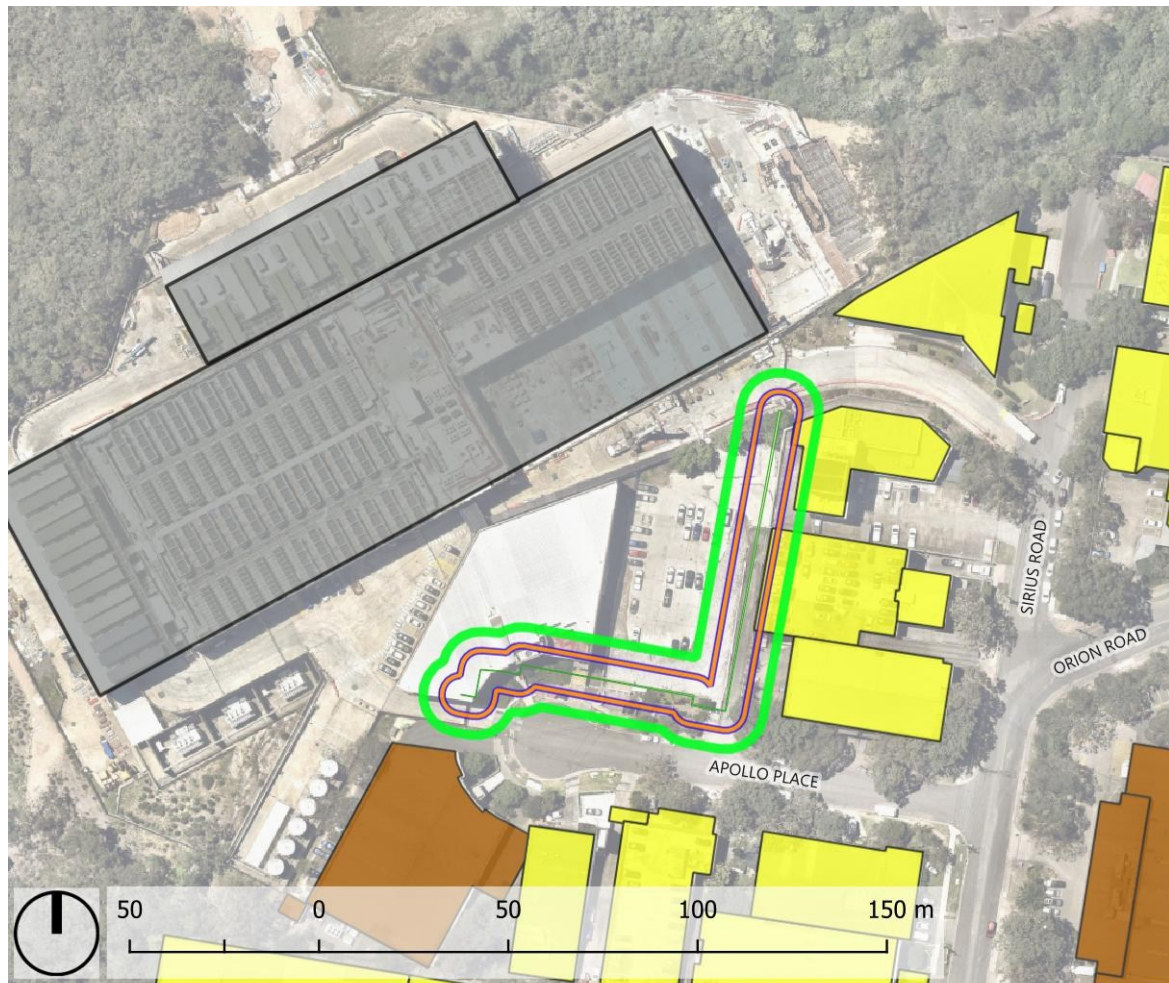
- Listed heritage item

Minimum working distance

Works with Smooth drum roller (13t) - high vibration mode

- Cosmetic damage MWD for reinforced structures (ie. commercial)
- Cosmetic damage MWD for unreinforced structures (ie. residential)
- Cosmetic damage MWD for structurally unsound structures

Figure 5-5: Minimum working distances for cosmetic damage from PHASE 1: Civil and piling start and PHASE 2: Civil and in-ground works (Piling Rig - bored and Drill Rig)



Nearby building structures and usage type

- Industrial
- Commercial
- Existing data centre (SSD 9741)

Vibration intensive works area

- Piling Location

Identified heritage item

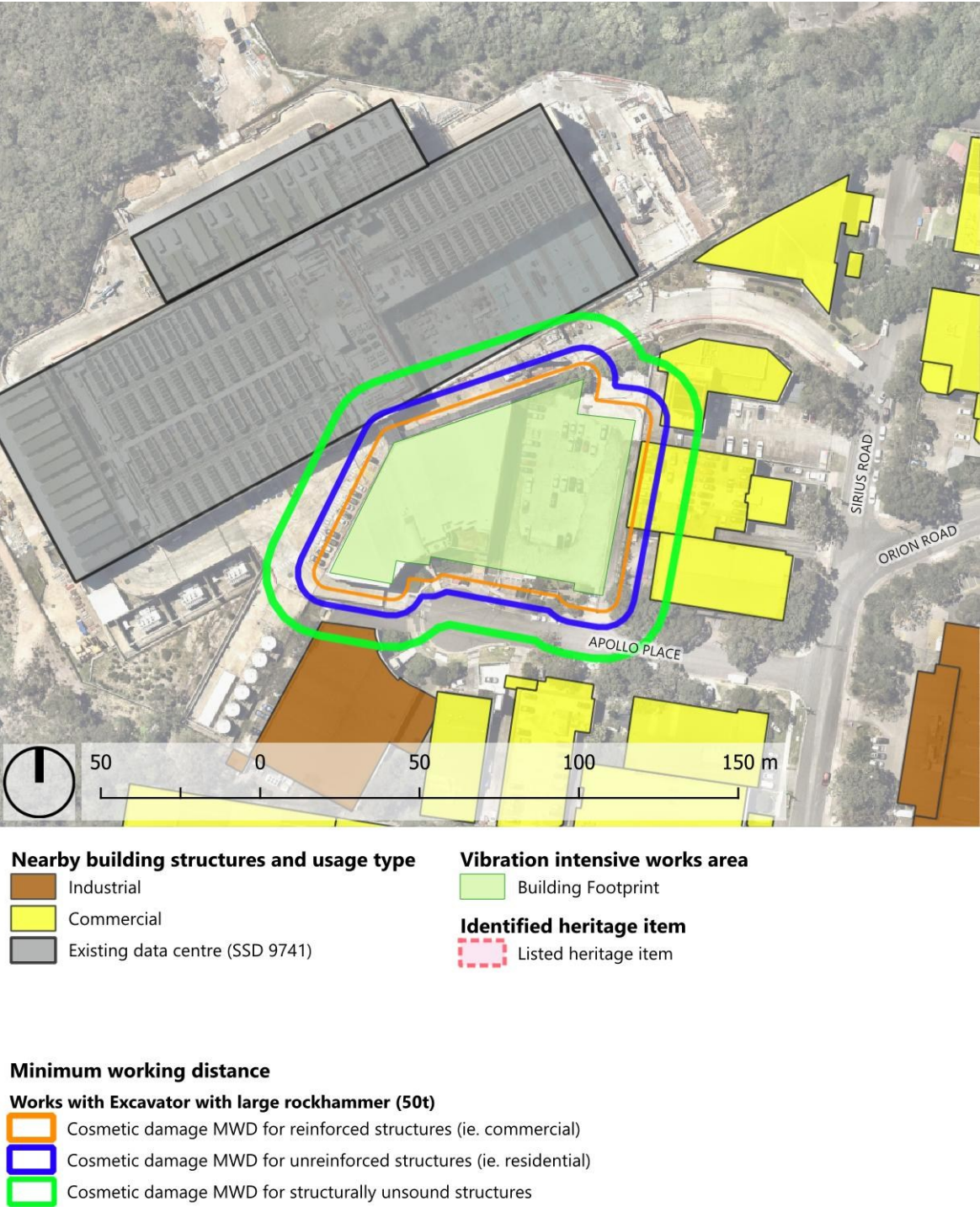
- Listed heritage item

Minimum working distance

Works with Piling Rig - Bored

- Cosmetic damage MWD for reinforced structures (ie. commercial)
- Cosmetic damage MWD for unreinforced structures (ie. residential)
- Cosmetic damage MWD for structurally unsound structures

Figure 5-6: Minimum working distances for cosmetic damage from PHASE 2: Bulk civil excavation (Excavator with large rockhammer (50t) and jackhammer)



The recommended minimum working distances for vibration intensive plant for human annoyance are presented Table 5-5.

5.3.2 Vibration assessment

5.3.2.1 Cosmetic damage

Figure 5-4, Figure 5-5 and Figure 5-6 show the adjacent receivers to the work areas are commercial or industrial tenants. Two commercial structures are within the relevant minimum working distance for cosmetic damage for reinforced or framed structures identified in Table 5-4. Table 5-8 below summarises the vibration intensive plant that is likely to operate within the minimum working distance (cosmetic damage) of sensitive receiver buildings.

Table 5-8: Sensitive receivers within the minimum working distance for cosmetic damage

Sensitive receiver	Construction phase and plant/ equipment		
	P1CP PHASE 1: Civil and piling start	P2CG PHASE 2: Civil and in-ground works	P2BE PHASE 2: Bulk civil excavation
7 Sirius Road, Lane Cove West (C9)	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
3 Sirius Road, Lane Cove West (C3) - Carpark structure	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment

No heritage items are potentially vibration impacted.

5.3.2.2 Human annoyance

Figure 5-4, Figure 5-5 and Figure 5-6 show that sensitive receivers adjacent to the work areas may be annoyed by vibration from construction activity when works are within the minimum working distance from the building. Table 5-9 below summarises the vibration intensive plant that is likely to operate within the minimum working distance (human annoyance) of sensitive receiver buildings. The sensitive receivers identified may experience vibration from the identified works/ activities.

Table 5-9: Sensitive receivers within the minimum working distance for human annoyance

Sensitive receiver	Construction phase and plant/ equipment		
	P1CP PHASE 1: Civil and piling start	P2CG PHASE 2: Civil and in-ground works	P2BE PHASE 2: Bulk civil excavation
3 Sirius Road, Lane Cove West (C3) - Carpark structure	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
5 Sirius Road, Lane Cove West (C3) – Ventilation shaft building	Piling rig – bored Smooth drum roller (13t)	Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
7 Sirius Road, Lane Cove West (C9) – commercial building	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
9 Sirius Road, Lane Cove West (C8) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment

Sensitive receiver	Construction phase and plant/ equipment		
	P1CP PHASE 1: Civil and piling start	P2CG PHASE 2: Civil and in-ground works	P2BE PHASE 2: Bulk civil excavation
4 Apollo Place, Lane Cove West (C5) – commercial building	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
5 Apollo Place, Lane Cove West (C6) – commercial building	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
3 Apollo Place, Lane Cove West – industrial building	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
2 Apollo Place, Lane Cove West (existing AirTrunk datacentre)	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
1A Sirius Road, Lane Cove West (C4) – commercial building	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
11 Sirius Road, Lane Cove West (C7) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment

Potential human annoyance impacts should be further reviewed when vibration intensive works are proposed to take place within the minimum working distances, and feasible and reasonable mitigation and management measures adopted as detailed in Section 6.2.4. Attended vibration measurements for human annoyance are proposed to be carried in response to vibration complaints (Section 6.2.4).

5.3.2.3 Vibration sensitive equipment

The commercial or industrial tenants surrounding the site, including the existing data centre (SSD 9741) are likely to house computing equipment which may be sensitive to vibration. The vibration objectives for sensitive equipment outlined in Section 4.3.4 establish a screening vibration limit of 1.0 mm/s (Peak) for computer areas. This is consistent with the initial screening limit for disturbance to occupants of office spaces, established in Table 4-7 and the minimum working distances identified in Table 5-5.

Based on the minimum working distance of up to 30 metres for larger and vibration intensive plant (ie. vibratory rollers and/or excavators with rockhammer) vibration levels are expected to exceed the vibration screening limit for computer areas at the adjacent and nearby commercial or industrial receivers, including the existing data centre. The potentially affected receivers are identified in Table 5-10.

Table 5-10: Sensitive receivers within the minimum working distance for computer areas

Sensitive receiver	Construction phase and plant/ equipment		
	P1CP PHASE 1: Civil and piling start	P2CG PHASE 2: Civil and in-ground works	P2BE PHASE 2: Bulk civil excavation
3 Sirius Road, Lane Cove West (C3) - Carpark structure	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
5 Sirius Road, Lane Cove West (C3) – Ventilation shaft building	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment

Sensitive receiver	Construction phase and plant/ equipment		
	P1CP PHASE 1: Civil and piling start	P2CG PHASE 2: Civil and in-ground works	P2BE PHASE 2: Bulk civil excavation
7 Sirius Road, Lane Cove West (C9) – commercial building	Drill rig Piling rig – bored Smooth drum roller (13t)	Drill rig Piling rig – bored Smooth drum roller (13t)	50t excavator with rockhammer attachment
9 Sirius Road, Lane Cove West (C8) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment
4 Apollo Place, Lane Cove West (C5) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment
5 Apollo Place, Lane Cove West (C6) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment
3 Apollo Place, Lane Cove West – industrial building	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
2 Apollo Place, Lane Cove West (existing AirTrunk datacentre)	Smooth drum roller (13t) – high vibration mode	Smooth drum roller (13t) – high vibration mode	50t excavator with rockhammer attachment
1A Sirius Road, Lane Cove West (C4) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	50t excavator with rockhammer attachment
11 Sirius Road, Lane Cove West (C7) – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
13 Sirius Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
15 Sirius Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
17 Sirius Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
19 Sirius Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
4 Sirius Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
2-6 Orion Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	-
79-85 Mars Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	
87 Mars Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	
89 Mars Road, Lane Cove West – commercial building	Smooth drum roller (13t)	Smooth drum roller (13t)	

As such, impacts on sensitive equipment should be further reviewed when vibration intensive works are proposed to take place within the minimum working distances, and feasible and reasonable mitigation and management measures adopted as detailed in Section 6.2.4. This may include attended vibration measurements (Section 6.2.4). Consultation should confirm whether any additional vibration sensitive equipment is located within the nearby commercial or industrial receiver buildings.

5.3.3 Damage to buried services and utilities

Buried utility asset owners should be consulted where vibration intensive works occur close to buried assets to confirm vibration limits for each asset. Monitoring on site would be undertaken to confirm site specific minimum working distance.

There is an Ausgrid Kiosk located within 5 metres of the nearest construction work area.

Known buried services in Apollo Place are more than 5 metres from the nearest work area. No buried services have been identified as at risk of vibration impact to date.

6 Construction mitigation and management measures

6.1 Standard noise and vibration mitigation and management measures

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers.

These should be considered and implemented where feasible and reasonable where there is potential for the noise management levels presented in Section 4.2 to be exceeded by the construction works either individually or cumulatively, which includes both external construction projects and other stages of SSD 67407231.

In accordance with the ICNG, feasible noise mitigation measures are those work practices or measures to reduce noise that are capable of being put into practice or of being engineered and are practical to build given project constraints such as safety and maintenance requirements. Reasonable noise mitigation measures are those feasible noise mitigation measures that are considered reasonable in the circumstances, based on a judgement that the overall noise benefits outweigh the overall adverse social economic and environmental effects, including the cost of implementing the measure. To make such a judgement, consideration is to be given to noise level impacts, duration of impacts, noise mitigation benefits, cost effectiveness of noise mitigation and community views.

Taking into account the predicted noise levels set out in Section 5.2.2 the following noise management are to be considered by a contractor during construction planning and implemented where feasible and reasonable. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table 6-1 outlines the noise control measures that will be implemented manage the potential for noise to impact on sensitive receivers near to the Project construction works, which are to be applied where reasonable and feasible. Some measures will assist with minimising vibration impacts too, and are indicated where this is applicable, refer to Section 6.2.4 for vibration management measures.

Additionally, implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', are expected to reduce predicted construction noise levels. Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 6-1: Noise and vibration mitigation and management measures

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
At-source mitigation measures									
Equipment selection	Airborne noise Vibration	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable, for example where practicable, vibratory rollers would be operated in low vibration mode or with the vibratory mode switched off to reduce vibration impacts.) Where loud plant and/or equipment are being used in construction works, where feasible and reasonable the selection of alternative quieter plant and/or equipment should be considered for tasks. Consider replacement of the diesel tower crane with an electric or battery-hybrid tower crane to reduce noise emission during craneage.	Variable. Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented. To be determined on a case-by-case basis.	Yes	Sufficient noise or vibration reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Project team shall review plant and equipment on a case-by-case basis and find opportunities to use items with lower noise/vibration impacts.
Equipment noise and vibration levels	Airborne noise Vibration	Plant and equipment must be properly maintained. Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended, confirmed through regular inspection. When selecting equipment, the proponent should contact manufacturers or suppliers and ask for the noise level data of a range of suitable equipment. The proponent may also wish to compare the noise level data of similar equipment from different manufacturers or suppliers.	Variable. Typically potential benefits of 5-10 dB(A). Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented.	Yes	Routine measure for project team. Sufficient noise reduction could be achieved at enough receivers. Cost effective.	Yes	Yes	Unnecessarily loud equipment (or use of equipment) will be avoided where it is reasonable. Where atypically high noise levels and/or annoying characteristics occur because of inappropriate use, or due to faults or poor maintenance, the equipment should not be operated until repaired or replaced. This measure should be implemented through regular inspection by the appropriate project personnel. When selecting plant and equipment, a preference should be made for quieter plant/equipment items where an alternative is feasible and reasonable.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Alternative construction methods to reduce vibration	Vibration	Alternative, less vibration generating construction methods will be reviewed where vibration significant works found to be within the site-specific minimum working distance of a structure, as determined by site vibration monitoring. For example, the use of rocksaw cutting instead of rockbreaking to excavate.	Variable. Minimise vibration impacts and reduce risk of structural damage and/or annoyance.	This measure could be feasibly implemented. To be determined on a case-by-case basis.	Yes	Sufficient vibration reduction could be achieved at identified structure to reduce the risk of structural damage from vibration significant works.	Yes	Yes	The use of alternative methods to reduce vibration transmission will be considered where site specific vibration assessments indicate that minimum working distances for cosmetic damage cannot be met.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions, with quieter and less noise/vibration emitting construction methods where feasible and reasonable.	Variable. Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented. To be determined on a case-by-case basis.	Yes	Sufficient noise or vibration reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Project team shall review plant and equipment on a case-by-case basis and find opportunities to use items with lower noise/vibration impacts. When selecting plant and equipment, a preference should be made for quieter plant/equipment items where an alternative is feasible and reasonable.
Worksite planning and layout	Airborne noise Vibration	Locate noise-generating activities away from sensitive receivers, where practicable. Plan traffic flow, parking, loading/unloading, and other vehicle movements to keep vehicles away from sensitive receivers where possible and to minimise reversing movements. Considerations should be given to minimising cumulative/concurrent impacts from other SSD 67407231 stages during layout planning (ie. access locations or parking locations).	Variable. Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented, subject to site constraints.	Yes	Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Fixed noise sources are located away from sensitive receivers. Where feasible with space restrictions loading/unloading to be conducted away from sensitive receivers and truck reversing movements to be minimised.
Use and siting of plant	Airborne noise Vibration	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers. Any equipment not in use for extended periods during construction work must be switched off.	Up to 20 dB reduction + reduce vibration	This measure could be feasibly implemented, subject to site constraints.	Yes	Routine measure for project team. Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Equipment that is not directly needed for works at a given time will be switched off. Excess equipment will be avoided where it is not needed for the works and where it is reasonable to do without it.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Alternative reverse or other audible alarms, such as 'quackers' instead of the tonal 'beeping" type will be installed on all vehicles, mobile plant and fixed plant regularly used on site and on all vehicles & plant required for OOHV. For example, avoid tonal alarms on plant items such as gantry cranes, EWP's etc. Consider limiting the volume of other audible alarms on plant/ equipment, while maintaining safe working. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.	5-10 dB reduction	This measure could be feasibly implemented.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Project team will mandate use of non-tonal reversing alarms on regularly used on site equipment.
Minimise disturbance arising from delivery of goods	Airborne noise	Loading and unloading of materials/ deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers if possible. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Minimise unnecessary acceleration on site and avoid vigorous slamming of truck doors, or noise events from tailgates.	Variable. Reduce noise/ vibration impact + risk of annoyance.	This measure could be feasibly implemented, subject to trial of long-life shotcrete mix on site.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Drivers will be reminded to drive responsibly on-site as part of toolbox talks and/or inductions, especially when accessing and departing the site. See also Heavy vehicle code of conduct and truck routes below.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Silencers on mobile plant, tower crane	Airborne noise	Where possible reduce noise from mobile plant and the tower crane through additional fittings, or the selection of items with preinstalled noise mitigation measures, including: - Residential grade mufflers - Air Parking brake engagement is silenced - sound-dampening enclosures or soundproof covers around the diesel engine (and hydraulic power unit). Ensure plant including the silencer is well maintained. Ensure all machinery covers and access panels are properly fitted and kept closed during operation.	0-20 dB reduction Reduce annoyance + sleep disturbance.	This measure could be feasibly implemented. Subject to availability for each equipment item.	Yes	Potential benefit of 0-20 dB(A). Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Prior to regular use onsite each plant item should be inspected by the appropriate project personnel while it is in operation to confirm if it exhibits atypically high noise levels and/or annoying characteristics. Where this is observed, the need to fit silencers or alternate mitigation/management (ie. use limitations) measures for the identified plant should be considered. When selecting mobile plant and equipment, a preference should be made for items that already have residential grade mufflers and/or air-brake silencers installed.
Prefabrication of materials off-site	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.	5-20 dB reduction Reduce noise/vibration impact + risk of annoyance	This measure could be feasibly implemented for various components.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Where practicable, components will be pre-fabricated and/or prepare materials off-site, and delivered to site for installation.
Engine compression brakes	Airborne noise	Limit the use of engine compression brakes in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.	5-20 dB reduction	This measure could be feasibly implemented. Subject to availability for each equipment item.	Yes	Potential benefit of 5-10 dB(A). Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Drivers will be reminded through toolbox talks or inductions to drive responsibly to and from the site, especially when in residential areas. Good heavy vehicle operating behaviour will be implemented through toolbox talks and as part of the truck management system.
Path mitigation measures									
Site sheds	Airborne noise	Site sheds to be strategically located to provide shielding to nearby residences.	Receiver with line of site of the works area: 5-10 dB reduction	This measure is generally feasible, provided there is sufficient space to locate the sheds.	Yes, where there is sufficient space	Potential benefit of 5-10 dB(A). Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective.	Yes	Yes	Strategically locating site sheds to act as noise barriers will be considered as part of site planning, and adopted where there is sufficient space is available and where significant noise reduction can be achieved.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Laydown and stockpiling	Airborne noise	Locate laydown and stock piling as far from residences within the construction works areas. Alternatively, where this is not possible, they should be considered for use as noise mounds.	Variable. Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented, subject to site constraints.	Yes	Potential benefit of 5-10 dB(A). Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Where feasible, considering space restrictions, loading/unloading at laydown and stock piling areas to be conducted away from sensitive receivers and truck reversing movements to be minimised.
Hoardings	Airborne noise	Erection of hoarding around the perimeter of the site or around noise generating sources. Hoarding would have sufficient height to shield sensitive receivers from noisy activities.	Receiver with line of site of the works area: 5-10 dB reduction	This measure is generally feasible, provided there is sufficient space to complete the works.	Yes, where there is sufficient space	- Potential benefit of 5 dB(A). - Insufficient noise reduction could be achieved at enough receivers. - Not cost effective. - Minor to moderate visual and amenity impacts - Does not outweigh the identified social, economic, and environmental effects.	No	No	Typical height site hoardings would not provide sufficient noise reduction to enough receivers to justify the additional noise impacts and costs of installation. Erecting taller hoardings will require footings for reinforcement and will take longer than the duration of the works. Therefore, it will not be adopted to reduce noise impacts. Hoardings may be implemented for other reasons apart from noise mitigation.
Use temporary noise barriers around high noise work area	Airborne noise	Where high noise works are to be completed in a fixed location, relocatable noise barriers e.g. acoustic blankets hung from temporary construction fencing would be used, where safe and practicable. This can include use of temporary barriers around noise generating works at elevated construction locations.	Receiver with line of site of the works area: 5-10 dB reduction	This measure is generally feasible, provided there is sufficient space and on-site safety is maintained.	Yes, where there is sufficient space and deemed safe	Potential benefit of 5-10 dB(A). Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective, subject to safety assessment.	Yes	Yes	Using temporary noise barriers to shield noisy works where they are in a fixed location will be considered as part of site planning, and adopted where there is sufficient space is available, safety is maintained and where significant noise reduction can be achieved.
Maximise distance between vibration intensive activity and neighbouring structures	Vibration	Vibratory compactor, rock hammer or piling equipment would not be used closer than 30 metres from any structure at 5 Sirius Road (Lot 5 DP 241786), 7 Sirius Road (Lot 42 DP 571838), 9 Sirius Road (Lot 3 DP 241786) and 3 Apollo Place (Lot 8 DP 241877), unless vibration monitoring confirms compliance with the vibration criteria specified in condition B4.	Variable. Minimise vibration impact and reduce risk of annoyance.	This measure could be feasibly implemented. Required to satisfy Condition B5.	Yes	Sufficient vibration reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic, and environmental effects.	Yes	Yes	Vibration monitoring would be undertaken where plant is required to operate within 30 metres of structures, to determine site specific minimum working distances to meet Condition B4. See Section 6.2.4 for monitoring details.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Management measures									
Implement stakeholder consultation measures	Airborne noise	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. This should include details considering cumulative impacts across other stages of SSD 67407231 where applicable. In addition to Periodic Notification, the following strategies may be adopted to notify the community of upcoming works: • Project Specific Website • Project Infoline • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings.	Keeps stakeholders informed of the likely impact. Community may identify solution to assist in managing impacts.	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Updates will be distributed regularly for the duration of the project.
Register of noise and vibration sensitive receivers	Airborne noise Vibration	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number. The register may be included as part of the Project's Stakeholder Management Plan or similar	Assists with keeping stakeholders informed of the likely impact. Assists with planning and reducing potential noise/vibration impact + risk of annoyance	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Register will be maintained for the duration of the project.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Site inductions	Airborne noise Vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Keeps construction workforce informed of actions required to minimise noise and vibration impact.	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Inductions and toolbox talks will continue to be conducted for the project.
Construction hours and scheduling	Airborne noise Vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise levels and vibration intensive plant identified within minimum working distances for human response should be scheduled during less sensitive time periods, such as after 9 am and before 5 pm. See Section 6.2.1 for additional information.	Minimise noise and vibration impact and reduce risk of annoyance.	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Construction planning and scheduling will ensure works are undertaken within the approved hours.
Respite coordination	Airborne noise	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 (e.g. aligning respite evenings).	Minimises noise impacts	This measure could be feasibly implemented, if required.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Respite coordination shall be conducted with neighbouring projects. Respite periods would be coordinate through the Monthly coordination meeting between SSD 67407231 contractors.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
High noise generating works and highly noise affected receivers	Airborne noise	Consistent with B50(d), where high noise generating works are proposed nearby to sensitive receivers, and noise levels at receivers could be above 75 dB(A) and so the receivers considered highly noise affected, respite periods should be considered where feasible and reasonable. See Section 6.2.1 for additional information. Periods of respite should be arranged with consideration of potential concurrent construction noise from other Project stages and other external projects (ie. coordinate respite periods so that other projects don't impact receivers during designated periods of respite).	Minimises noise impacts	This measure could be feasibly implemented, if required.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Respite would be implemented where receivers could experience construction noise levels above 75 dB(A). Where respite is required, it would be coordinated with other construction stages.
Behavioural practices	Airborne noise	No unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.	0-20 dB reduction Reduce annoyance + sleep disturbance.	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Inductions and toolbox talks will be used in the project to communicate required practices to reduced noise impacts. Project team shall monitor site behaviour and advise supervisors if issues arise, or additional behavioural practices are needed.
Heavy vehicle routes	Airborne noise	Construction heavy vehicles and delivery vehicles should be scheduled during standard construction hours.	Minimises noise impacts	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Good heavy vehicle operating behaviour will be implemented through toolbox talks and as part of the truck management system.
Heavy vehicle code of conduct	Airborne noise	In accordance with CoC B60, develop a Heavy Vehicle Code of Conduct (HVCC) for all drivers to adhere to. The HVCC would require appropriate training of project contractors. It would include noise management methods such as limiting idling and compression braking, and traffic management practises to minimise noise emissions from vehicles entering and leaving the site.	Minimises noise impacts	This measure could be feasibly implemented.	Yes	Routine task for project team.	Yes	Yes	Good heavy vehicle operating behaviour will be implemented through toolbox talks and as part of the truck management system.
Verification monitoring	Airborne noise	In response to noise complaints, a noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan (CNVMP) or CEMP and any approval conditions.	Minimises noise impacts	This measure could be feasibly implemented.	Yes	Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Noise monitoring shall be carried out in response to verified noise complaints.

Control measure	Applies to	Details of the control measure	Estimated benefit	Feasible mitigation test	Deemed feasible?	Reasonable mitigation test	Deemed reasonable?	Adopted?	Justification and commentary
Plant noise audit		All plant and equipment likely to significantly noise affect sensitive receivers for an extended duration must be tested to check if noise emissions are compliant with noise limits reasonable for that item.	Minimises noise impacts	This measure could be feasibly implemented.	Yes	Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Plant noise audits will be carried out for all critical plant and equipment prior to regular use.
Complaints management	Airborne noise Vibration	See Section 7.3 for further details. In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.	Minimise noise impact and reduce risk of annoyance.	This measure could be feasibly implemented.	Yes	Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Complaints will be investigated and where the investigation identifies noise impacts of issue, appropriate noise amelioration measures put in place to mitigate future occurrences. Noise monitoring shall be carried out in response to verified noise complaints.
Cumulative noise management (external projects)	Airborne noise	Identify any cumulative construction noise issue for developments under construction, considering community feedback. Implement management measures to minimise cumulative impacts, where feasible and reasonable.	Minimises cumulative noise impacts	This measure could be feasibly implemented, if required.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Outcomes from the coordination with other construction projects would be considered in construction planning (ie. any required OOHW and noise intensive works).
Cumulative noise management (Other SSD 67407231 stages)	Airborne noise	Coordinate work between other construction stages to minimise cumulative noise impacts, where feasible and reasonable. Coordination would be through monthly coordination meetings between SSD 67407231 contractors, during which potential cumulative impacts will be discussed along with a review of any likely required respite periods. Ensure that noise management measures consider cumulative impacts when construction works from two stages are occurring nearby to each other or are impacting the same receiver location. Ensure periods of respite are coordinated so that other construction works are not impacting receiver that are being provided respite by another stage.	Minimises cumulative noise impacts	This measure could be feasibly implemented, if required.	Yes	Sufficient noise reduction could be achieved at enough receivers. Deemed to be cost effective. Outweighs the identified social, economic and environmental effects.	Yes	Yes	Identification of noise intensive works and coordination between other construction stages would be undertaken where required, to manage the potential for cumulative impacts from noise generating activities. Monthly coordination meeting between SSD 67407231 contractors would take place, during which potential cumulative impacts will be discussed along with a review of any likely required respite periods so that the project planning for the different SSD 67407231 contractors can take place appropriately so that so that other projects don't impact receivers during designated periods of respite.

6.2 Specific noise and vibration management measures

6.2.1 Highly noise affected receivers

Receivers nearest to the construction work areas may be 'highly noise affected' [ie. exposed to noise levels that exceed 75 dB(A)] as a result of high noise generating works in close proximity.

As such, where construction noise is likely to be above the 'highly noise affected' level, respite periods should be considered where feasible and reasonable. The following potential respite periods would be considered:

- High noise impact activities carried out in continuous blocks of up to three hours. Respite provided between each block of high noise impact activities for at least one hour. No high noise impact activities carried out during this one hour respite period.
- Where an alternative approach to the above is preferable, a respite period can be agreed upon with the potentially impacted receivers if the premises are occupied during the construction period. Potential respite periods would limit the use of high impact activities, such as hammering, to say 9:00am to 5:00pm with a one hour break during this period.

Periods of respite should be arranged with consideration of potential concurrent construction noise from other Project stages and other external projects (ie. coordinate respite periods so that other projects don't impact receivers during designated periods of respite).

Sensitive receivers identified as likely to exceed the 'highly noise affected' level have been identified in the spreadsheet table provided as part of Appendix B.1.

The coordination of respite between other SSD 67407231 contractors would take place through regular coordination meetings between SSD 67407231 contractors as detailed in Table 6-1. During which likely required periods of respite from noise intensive works should be identified, so that the project planning for the different SSD 67407231 contractors can take place appropriately so that so that other projects don't impact receivers during designated periods of respite.

6.2.2 Lane Cove Tunnel Exhaust Structure

Prior to the commencement of construction, AW Edwards will (to the satisfaction of the Planning Secretary):

- (a) prepare an engineering report will be completed certifying the stability of the rock (ie. 'island or plinth') to be left between the existing structures and new below-ground structures is maintained;
- (b) finalise the detailed design of the foundation;
- (c) enter into an interface agreement, with LCT-MRE Pty Ltd, if deemed necessary by TfNSW or Transurban;

- (d) undertake a pre-construction dilapidation report of the adjacent Lane Cove Tunnel exhaust structure; and
- (e) install vibration monitoring equipment at the adjacent Lane Cove Tunnel exhaust structure.

Note: The Applicant must consult with TfNSW and Transurban in relation to the matters listed in (a) to (e) above to ensure that the structural integrity and operation of the Lane Cove Tunnel infrastructure is maintained.

6.2.3 Noise monitoring

The following approach could be adopted regarding noise monitoring procedures during the construction works in response to noise complaints or any unexpected levels of construction noise [to address CoC C7 (d)]. Details of the procedures for noise monitoring are presented in APPENDIX C.

- In the event of a confirmed construction noise complaint, noise monitoring may be carried out to examine construction noise impacts.
- Reasonable and feasible noise reduction measures must be investigated, where necessary.
- Typically short term (attended) noise monitoring would be undertaken to investigate a complaint as opposed to ongoing noise logging as this will enable a faster response time.
- Where short term attended noise measurements cannot produce a suitable outcome, long term noise monitoring will be considered. Typically, long term monitoring is useful primarily to check if start/finish times or respite periods have been adhered to. Given this limitation, that are not typically proposed in first instance.

6.2.4 Vibration management measures and monitoring

In accordance with CoC B5, vibratory compactor, rock hammer or piling equipment must not be used closer than 30 metres from any structure at 5 Sirius Road (Lot 5 DP 241786), 7 Sirius Road (Lot 42 DP 571838), 9 Sirius Road (Lot 3 DP 241786) and 3 Apollo Place (Lot 8 DP 241877), unless vibration monitoring confirms compliance with the vibration criteria specified in condition B4.

Attended vibration monitoring is to be undertaken to determine and verify site vibration levels from construction activity are consistent with the predictions in this report and to confirm specific minimum working distances for cosmetic damage and human annoyance. Attended vibration monitoring will be undertaken during works at the locations identified in Table 6-2 whenever vibration significant plant items are operating within the recommended minimum working distances in Table 5-4, Table 5-5, Table 5-6 and Table 5-7.

Table 6-2: Attended (or unattended) vibration monitoring - nominated representative locations

NCA	Receiver number	Address/ location	Receiver type	Vibration monitoring for:			
				Cosmetic damage	Human annoyance	Computer areas	Services/ utilities
-	C3	3 Sirius Road, Lane Cove West	Commercial	Yes	Yes	Yes	-

NCA	Receiver number	Address/ location	Receiver type	Vibration monitoring for:			
				Cosmetic damage	Human annoyance	Computer areas	Services/ utilities
-	C3	3 Sirius Road, Lane Cove West (Lane Cove Tunnel Ventilation Shaft)	Commercial	-	Yes	Yes	-
-	C4	1a Sirius Road, Lane Cove West	Commercial	-	Yes	Yes	-
-	C5	4 Apollo Place, Lane Cove West	Commercial	-	Yes	Yes	-
-	C6	5 Apollo Place, Lane Cove West	Commercial	-	Yes	Yes	-
-	C7	11 Sirius Road, Lane Cove West	Commercial	-	Yes	Yes	-
-	C8	9 Sirius Road, Lane Cove West	Commercial	-	Yes	Yes	-
-	C9	7 Sirius Road, Lane Cove West	Commercial	Yes	Yes	Yes	-
-	-	2 Apollo Place, Lane Cove West	Commercial	Yes	Yes	Yes	-
-	-	3 Apollo Place, Lane Cove West	Commercial	Yes	Yes	Yes	-
-	-	13 Sirius Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	87 Mars Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	91 Mars Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	15 Sirius Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	2-6 Orion Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	79-85 Mars Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	4 Sirius Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	17 Sirius Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	19 Sirius Road, Lane Cove West	Commercial	-	-	Yes	-
-	-	Ausgrid Kiosk DP558654	Electrical services	-	-	-	Yes

Section 6.2.4.1 and 6.2.4.2 below outline the monitoring and management measures to be implemented by the Project to minimise the risk of vibration from construction activities potentially impacting receivers.

6.2.4.1 Cosmetic damage

- Where vibratory compactor, rock hammer or piling equipment are required to operate closer than 30 metres to sensitive receivers/structures, vibration testing of actual equipment on site should be carried out prior to their use within 30 metres of 5, 7 or 9 Sirius Road or 3 Apollo Place. The monitoring will determine site specific acceptable minimum working distances to confirm compliance with the vibration criteria specified in condition B4.

Re-assess potential impacts (if required). This may include further detailed analysis based on the frequency content of the vibration levels.

- If vibration intensive work is proposed to occur within the site specific acceptable minimum working distance, then the following would be carried out:

- a) Evaluate whether alternative construction methods, plant or equipment can be utilised for the works and re-assess potential impacts (if required).
- b) If there is any risk of exceeding the vibration objectives identified in Section 4.3.2 and after all of the above options have been considered, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the structure cosmetic damage limits. It is recommended that for the operator alerts, that multiple alert levels are set. Typically, this would be an alert trigger level at 75% of the vibration criteria (ie. amber alert), and an alert trigger level at 100% of the vibration criteria (ie. red alert).
Detailed vibration monitoring procedures are outlined in APPENDIX D.
- c) A management procedure would be developed prior to the works taking place to determine the response to each trigger level. It is recommended that this includes a pause and management measures for an alert trigger level at 75% of the vibration criteria, and stop work at an alert trigger level at 100% of the vibration criteria. Where stop work is triggered, it is recommended that the following are undertaken:

STOP WORKS PROCEDURE

- i. Investigate cause of exceedance
- ii. Visual inspection of the vibration sensitive building/structure/item including photos
- iii. If no cosmetic damage is found, works and vibration monitoring can be resumed
- iv. If cosmetic damage has been identified, repair damage or undertake any specific required action (ie. data centre notification) and a different construction method with lower source vibration levels is to be used.
- d) If works are proposed within the cosmetic damage minimum working distance, prior to starting work a building/structure condition survey would be carried out on vibration sensitive items/structures within the minimum working distances and vibration limits determined to manage cosmetic damage.

3. Dilapidation surveys must be conducted for the following;

- a) all receivers within close proximity of the construction site.
- b) In accordance with CoC B11, for properties located at 7 Sirius Road (Lot 42 DP 571838), 9 Sirius Road (Lot 3 DP 241786) and 3 Apollo Place (Lot 8 DP 241877)
 - **prior to commencement of construction,**
 - **within one month of the conclusion of construction works.**

The reports must be submitted to the Planning Secretary and the relevant property owner(s) within seven days of being prepared.

- c) In accordance of CoC B12, if requested by the property owner, the Applicant must repair, or pay the full costs associated with repairing, any damage to adjoining properties caused by carrying out the development in accordance with the preconstruction dilapidation reports required by CoC B11, unless otherwise agreed by the Planning Secretary.

6.2.4.2 Human annoyance

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 construction works, nearby receivers may be able to feel vibration when vibration-generating equipment is being utilised. For this reason, it is appropriate identify properties where there is a probability of adverse comment so that impacts can be managed.

1. Complaints in relation to vibration should be handled consistent with the Stakeholder Management Plan. Following receipt of a complaint which related to construction vibration, acknowledgement of the complaint to the stakeholder or community contact should be made. A proposed response should then be developed by the Project team, which may require input from a noise and vibration consultant.
2. Each complaint should be investigated, and where there is potential that vibration levels could exceed the established limits, vibration monitoring should be undertaken as detailed in in APPENDIX D.
3. Where vibration levels are found to exceed the established limits, appropriate amelioration measures should be put in place to mitigate future occurrences.
4. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.
5. Attended vibration measurements for human annoyance should be carried out as required to appropriately manage the works. The proximity of neighbouring residences will be communicated to subcontractors highlighting the relevant vibration restrictions and criteria for the area. This information will also be communicated during pre-tender meetings, start-up meetings and site inductions of personnel.
6. Notification by letterbox drop would be carried out for all buildings in the vicinity of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property. Notification is to be provided to all occupants prior to any works that may cause vibration.
7. In relation to CoC B6, following the implementation of feasible and reasonable mitigation and management measures, where construction vibration levels remain above the human annoyance limits when a premises is occupied, vibration intensive works, including the use of vibratory compactors, may continue where there is an agreement in place with the potentially impacted receiver.

Detailed vibration monitoring procedures are outlined in APPENDIX D.

7 Compliance management

7.1 Roles and responsibilities

The Construction Environmental Management Plan (CEMP) details roles and responsibilities for environmental management for the Project, this includes noise and vibration aspects covered by this CNVMP. The items that will specifically be covered include:

- Ongoing management of construction works, and implementing the noise and vibration mitigation and management as per this CNVMP.
- Noise and vibration monitoring
- Responses to noise and vibration complaints

7.2 Training

All employees, contractors, sub-contractors and utility staff working on site will undergo site induction training that includes construction noise and vibration management issues. The induction training will address elements related to noise and vibration management including:

- Existence and requirements of this sub-plan
- Relevant legislation
- Approved construction hours
- Location of noise sensitive areas
- Complaints reporting
- General noise and vibration management measures
- Specific responsibilities to minimise impacts on the community and built environment from noise and vibration associated with the works.

7.3 Community consultation and complaints management

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project. This is of paramount importance. Keeping people informed of progress, taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community must be adequately trained and experienced in such matters.

A Stakeholder Management Plan has been established by AW Edwards for the Project for implementation throughout the construction works. This procedure outlines the most effective communication methods to enable effective communication with the community and assist the Project team to deliver the Project with minimal disruption.

Additionally, as per CoC B7 (b) and (d), updates to this CNVMP should be undertaken considering feedback from TfNSW and Transurban and owners of directly adjoining commercial properties. Consultation with these nearby potentially impacted receivers has commenced and will continue as works progress. The details of notification triggers are presented in Appendix B.1. Consultation to date is presented in Stakeholder Management Plan Construction noise and vibration was specifically discussed at these meetings, and property owners/residents were provided with further information in regard to construction noise and vibration, and how construction impacts are proposed to be managed. **Consultation to date has not identified any specific additional updates to this CNVMP.**

Consultation outcomes with potentially impacted receivers should be considered as part of further construction planning in accordance of CoC B7(d). Examples of this would be for receiver respite as per Section 6.2.1.

Owners and occupants of nearby affected properties are to be informed by direct mail of a direct telephone line and contact person to either make a noise and/or vibration complaint or request information.

Nearby development should be notified of the proposed works.

The notification should outline:

- Detail of a site point of contact.
- The anticipated duration of the project as a work
- Identify the duration of the construction stages.
- Identify what stages will have greatest potential impact on each resident. This will provide much clearer information for each party about how the site work will impact them specifically (the duration over which the greatest noise impact will occur).

In accordance with CoC B50 (d), all noise and/or vibration complaints associated with the construction works shall be investigated in accordance with the Noise / Vibration Complaint Management Procedure identified in APPENDIX E.

Where unforeseen construction works are required, they are to be managed consistent with this CNVMP following a review of potential noise and vibration impacts, with management measures as detailed in Section 6 to be implemented where feasible and reasonable, including monitoring as per Section 6.2.3 for noise and Section 6.2.4 for vibration levels where required.

A complaints register will be maintained for the Project, and where the outcomes of investigations can identify improvements in noise and/or vibration management, these will be considered as part of construction planning in accordance with CoC B7(d), and adopted where feasible and reasonable.

8 Review and improvement

8.1 Continuous improvement

Continuous improvement of this CNVMP will be achieved by the ongoing evaluation of environmental management performance against environmental policies, guidelines and objectives for the purpose of identifying opportunities for improvement. The continuous improvement process will be designed to:

- Identify areas for improved environmental management and performance;
- Determine the cause or causes of non-conformances and deficiencies;
- Verify the effectiveness of the corrective and preventative actions;
- Document any changes in procedures resulting from process improvement.

8.2 Update and amendment

The above process may result in the need to update or revise this CNVMP. Where this occurs, a copy of the updated CNVMP and changes will be distributed to all relevant stakeholders.

As part of the future development applications within the Project boundary, this CNVMP should be updated as follows:

- identify the likely noise and vibration impacts during construction, and
- review and update the construction mitigation and management measures in Section 6 so that potential noise and vibration impacts from the works can be appropriately managed in a feasible and reasonable manner. These controls are to be updated if required for the proposed works.

Additionally, inline with the CEMP, the Project will undertake a bi-annually review of the adequacy of the environmental mitigation measures in the CEMP and Sub-Plans, including this CNVMP, as well as the effectiveness of their implementation to determine whether they are still applicable to the activities being carried out onsite. As part of the management plan review, complaints, incidents, stakeholder issues, critical issues, resourcing, recommendations of environmental audits and ER inspections would be reviewed to be included in the latest revision of the plan.

References

1. NSW Department of Climate Change and Water (2011), Road Noise Policy (RNP)
2. NSW Department of Environment and Climate Change (2009), Interim Construction Noise Guideline (ICNG)
3. NSW Environment Protection Authority (2017), Noise Policy for Industry (NPfI)
4. NSW Department of Environment and Conservation, Assessing Vibration – a technical guideline (AVTG), 2006
5. British Standard BS 6472-2008, Evaluation of human exposure to vibration in buildings (1-80Hz)
6. British Standard 7385: Part 2-1993 Evaluation and measurement of vibration in buildings
7. German Standard DIN4150-2016 Structural vibration Part 3: Effects of vibration on Structures
8. Standards Australia (2016), Guide to Noise Control on Construction, Demolition and Maintenance Sites, AS 2436:2010 (R2016)
9. Standards Australia (2018), Acoustics—Description and measurement of environmental noise, AS1055:2018
10. AS IEC 61672.1-2004 Electroacoustic - Sound Level Meters – Specifications
11. Ausgrid (2022) Network Standard Document No. NS193 Ground movement, vibration and pressure limits near buried cables

APPENDIX A Glossary of terminology

A.1 Glossary of terminology - Noise

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

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
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.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
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. 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 LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our environment:

	threshold of hearing	0 dB	The faintest sound we can hear, defined as 20 micro Pascal
		10 dB	Human breathing
	almost silent	20 dB	
		30 dB	Quiet bedroom or in a quiet national park location
	generally quiet	40 dB	Library
		50 dB	Typical office space or ambience in the city at night
	moderately loud	60 dB	CBD mall at lunch time
		70 dB	The sound of a car passing on the street
	loud	80 dB	Loud music played at home
		90 dB	The sound of a truck passing on the street
	very loud	100 dB	Indoor rock band concert
		110 dB	Operating a chainsaw or jackhammer
	extremely loud	120 dB	Jet plane take-off at 100m away
	threshold of pain	130 dB	
		140 dB	Military jet take-off at 25m away
dB(A)	A-weighted decibel. 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 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. The dB(C) level is not widely used but has some applications.		
Deemed-to-Satisfy Provisions	The Deemed-to-Satisfy Provisions are an optional means of achieving compliance with the mandatory Performance Requirements of the National Construction Code. (also see Alternate Solution)		
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.		
DIN	German Standard		
Discontinuous Construction	A wall system having a minimum 20mm cavity between two separate leaves, where, for other than masonry there is no mechanical linkage between leaves except at the periphery.		
DnT,w	Weighted Standardised Field Level Difference A measure of sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in-situ. It is a field measurement that relates to the Rw laboratory measured value but is not equal to it because an in-situ space is not of the same quality as a laboratory space. The value is indicative of the level of speech privacy between spaces. The higher its value the better the insulation performance.		
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999		
ENMM	Environmental Noise Management Manual, Roads and Maritime Services (Transport for NSW)		
EPA	Environment Protection Authority		
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.		

FIIC	Field Impact Isolation Class. A measure of the noise impact performance of a floor. The value indicates the resistance of the floor to the transmission of impact sound and is measured using a standard tapping machine. It is measured in-situ and is therefore subject to the inherent accuracies involved in such a measurement. The term is defined in ASTM E492 and E1007. It is a field measure of the level of impact sound transmitted to a space via a floor. The equivalent measurement in a laboratory is termed the IIC. The higher the value the better the performance.
Flanking	Flanking is the transfer of sound through paths around a building element rather than through the building element material directly. For example, sound travelling through a gap underneath a door or a gap at the top of a wall.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
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.
FSTC	Field Sound Transmission Class A measure of the sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in the field and is therefore subject to the inherent inaccuracies involved in such a measurement. The term was referred to in older superseded versions of the Building Code of Australia and has now been replaced with the term DnT,w.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007
IIC	Impact Isolation Class A measure of the noise impact performance of a floor. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from the operation a standard tapping machine placed on the floor. The term is defined in ASTM E492 and E1007. The higher the number the better the performance.
Impact Noise	The noise in a room, caused by impact or collision of an object onto the walls or the floor. Typical sources of impact noise are footsteps on the floor above a tenancy and the slamming of doors on cupboards mounted on the common wall between tenancies.
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.
INP	NSW Industrial Noise Policy, EPA 1999
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation.
Intertenancy wall	Walls that separate buildings or units within a building. They may provide sound resistance or serve as a fire wall. Synonymous with 'party wall'.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).

ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	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).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amax} .
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amin} .
Ln,w	Weighted Normalised Impact Sound Pressure Level A measure of the sound level transmitted from impacts on a floor to a tenancy below. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from a standard tapping machine. A lower value indicates a better performing floor.
LnT,w	Weighted Standardised Field Impact Sound Pressure Level As for Ln,w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The equivalent measurement in a laboratory is the Ln,w. A lower value indicates a better performing floor.
Laboratory Test	The performance of a building element when measured in a laboratory. The sound insulation performance of a building element installed in a building however can differ from its laboratory performance for many reasons including the quality of workmanship, the size and shape of the space in which the measurement is conducted, flanking paths and the specific characteristics of the material used which may vary from batch to batch.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially similar.
NCG	Noise Criteria Guideline, Roads and Maritime Services (Transport for NSW)

NMG	Noise Mitigation Guideline, Roads and Maritime Services (Transport for NSW)
Noise	Unwanted sound
Normalised	A method of adjusting the measured noise indices in a laboratory so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the $L_{n,w}$ impact sound pressure level measured in a laboratory is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the sound absorption in the receiving room is set at 10m². This enables all laboratories to report the same value when measured under slightly different conditions. See also 'Standardised'.
NRC	Noise Reduction Coefficient. A measure of the ability of a material to absorb sound. The NRC is generally a number between 0 and 1 but in some circumstances can be slightly greater than 1 because of absorption at the edges of the material. A material with an NRC rating of 1 absorbs 100% of incoming sound, that is, no sound is reflected back from the material. The NRS is the average of the absorption coefficient measured in the octave bands 250Hz, 500Hz, 1kHz & 2kHz which correspond to the predominant frequencies associated with the human voice.
Partition wall	A wall dividing two rooms.
Party wall	A wall dividing two tenancies. Synonymous with 'Intertenancy Wall'.
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
RBL	Rating Background Level is the representative LA90 background noise level for a period, as defined in the NSW EPA's noise policies.
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, NSW, May 2013
RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australia. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the $D_{nT,w}$. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (α) and the surface area of the material (m²). For example, a material with $\alpha = 0.65$ and a surface area of 8.2m² would have $0.65 \times 8.2 = 5.33$ Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
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 Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sole-occupancy Unit	An area within a building for the exclusive use of the owner or occupier.
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 by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the R_w and the sound insulation between two rooms can be described by the $D_{nT,w}$.
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 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 of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 micro Pascal.
Spoil	Soil or materials arising from excavation activities.
Standardised	A method of adjusting the measured noise indices in-situ so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the $L'_{n,w}$ impact sound pressure level measured in a room is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the reverberation time in the receiving room is set at 0.5 seconds. This enables the same value to be reported independent of whether the room contains carpet and furnishings and the like. See also 'Normalised'.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by R_w .
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the R_w or R'_{w} or $D_{nT,w}$.

A.2 Glossary of terminology - Vibration

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

Acceleration	The rate of change of velocity, often measured in m/s^2 or g 's. $1\ g = 9.81\ m/s^2$. Commonly used to assess human response to vibration and for machine condition monitoring.
Accelerometer	A vibration transducer sensor that is used to measure acceleration.
ANC	The Association of Noise Consultants, UK.
Ambient vibration	The all-encompassing vibration occurring at a given location, at a given time, composed of all vibration sources near and far.

Amplification	Vibration amplification refers to an increase in vibration. Amplification may occur due to resonance, when an object or structure is excited at its natural frequency.
Attenuation	Attenuation refers to a reduction in vibration. This may occur due to damping of a vibration system, the inclusion of attenuating devices or, in the case of ground vibration, during propagation through the ground. Ground attenuation is determined by the dynamic properties of the site's soil and rock.
AVTG	Assessing Vibration: A Technical Guideline. NSW Department of Environment and Conservation's (DEC) 2006 guideline for assessing human responses to vibration. Based on BS 6472-1992.
Axis	A fixed reference line for the measurement for the measurement of vibration in a particular direction. Vibration is commonly measured in transverse (T), longitudinal (L) and vertical (V) axes (or X, Y and Z).
Background vibration	The underlying level of vibration present in the ambient environment, measured in the absence of the vibration sources of interest.
Blasting	Excavation or demolition using explosives.
Borehole transducer	A geophone transducer rigidly mounted at the bottom of a borehole (either permanently or temporarily) to measure underground vibration.
Broadband vibration	The overall vibration level which encompasses a wide range of frequencies. As opposed to vibration levels for specific frequency bands (see Octave) or narrowband vibration levels as produced by FFT.
BS	British Standard.
Continuous vibration	Vibration that continues uninterrupted over a defined period.
Cosmetic damage	Damage to a structure due to vibration that only affects the appearance of the structure and can be easily repaired, e.g. hairline cracks in mortar joints of brick or concrete constructions, or cracks in plasterwork.
Coupling loss	The change in vibration level when vibration is transmitted from the ground to a building's foundations.
Crest factor	The ratio of the peak value of a vibration event to the RMS value of a vibration event.
Damping	Reduction of vibrational energy due to friction or other forces.
DEC	NSW Department of Environment and Conservation, now the Department of Planning, Industry and Environment.
Decibel [dB]	The logarithmic unit used to represent sound and vibration levels. A vibration level in dB equals 20 times the logarithm to the base 10 of the ratio of the vibration level relative to the reference level. For vibration velocity, the reference level is commonly 1 nm/s. For vibration acceleration, the reference level is commonly 1 $\mu\text{m/s}^2$. Other reference values are commonly used. The reference value should always be stated.
DIN	German Standard.
Displacement	Change in position of a body from a reference point. Usually measured in m or mm.
EPA	Environment Protection Authority.
eVDV	Estimated Vibration Dose Value. See also VDV.
Filter	An electrical circuit that allows signals of certain frequency ranges to pass through, and blocks all other frequencies. Types of filters include low pass filters, high pass filters, and band pass filters.
FFT	Fast Fourier Transform. An algorithm that converts a signal from the time domain to the frequency domain.
Frequency	In the case of vibration, frequency is the number of oscillations that occurs per second. Frequency is measured in units of Hertz (Hz).
Geophone	A vibration transducer sensor that is used to measure velocity.

Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Ground spike	A metal stake with a flat top that is driven into the ground and used to mount a vibration transducer to measure vibration levels.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Intermittent vibration	Either interrupted periods of continuous vibration or repeated periods of impulsive vibration.
Impulsive vibration	Vibration that rapidly builds up to a peak followed by a damped decay. May consist of multiple impulsive events, typically less than 2 seconds in duration.
Isolation	The process of reducing the vibrational energy transmitted to an object, such as a piece of equipment or building, from the source of vibrations.
Minor damage	Damage to a structure due to vibration that affects the serviceability of residential style buildings or other sensitive structures but does not affect the structural elements. E.g. cracks in plastered or rendered surfaces, existing cracks enlarged or partitions detached.
Mode	A mode of vibration is a characteristic pattern or shape in which a mechanical system will vibrate. The actual vibration of a structure is a combination of all the vibration modes, but to varying degrees, depending on the vibration source.
Natural frequency	The frequency at which a system tends to oscillate in the absence of any driving or damping force.
Noise floor	The residual level of unwanted signal measured by an instrumentation system. The signal of interest must be above the noise floor to be measured accurately. See also Signal to noise ratio.
Octave	An octave represents a doubling or halving in frequency. Noise or vibration levels across a frequency spectrum are commonly given in octave or one-third octave frequency bands.
Peak-to-peak	The difference between the highest positive peak level and the lowest negative peak of a vibration event.
Peak vibration velocity	The absolute maximum value of the vibration velocity signal measured in the X, Y or Z axis during a given time interval. Also referred to as the peak component particle velocity.
PPV	Peak Particle Velocity. The absolute maximum value of the vibration velocity signal measured in any axis during a given time interval.
PVS	Peak Vector Sum. The vector sum of the peak vibration velocities measured in the three orthogonal axes.
Resonance	The phenomenon of increased amplitude that occurs when the frequency of an applied force is equal or close to the natural frequency of the system.
RMS	Root Mean Square value representing the average value of a signal.
Sampling rate	The number of samples per second taken from a continuous signal to make a discrete or digital signal. Measured in Hertz. To accurately record the signal and determine the spectrum, the sampling rate must be two or more times the maximum frequency of interest.
Settlement	The movement of soil due to vibration or other forces, often in relation to a building's foundations. The indirect effect of settlement and ground movement may cause building damage, separately from the direct effect of building vibration.
Signal to noise ratio	A ratio of the level of a desired signal to the level of the background, often expressed in decibels.
Source vibration	A source that generates vibration. Can be quantified by the amplitude, frequency content and duration of the vibration. Common sources of vibration include rail and road traffic, construction and demolition activities and blasting.
Spectrum	The result of transforming a signal from the time domain to the frequency domain.

Structural damage	Damage to a structure due to vibration that may affect its serviceability due to damage to structural elements. May result in the reduced stability of the building and/or reduction in load-bearing capacities.
Structural fatigue	The weakening of a material caused by cyclic loading that results in progressive and localised structural damage and the growth of cracks.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft.
Tactile vibration	Vibration of a level that can be felt by humans, dependant on the amplitude and frequency of the source. Note that vibration may also be perceived through indirect effects such as ground-borne noise or the shaking of building elements.
Transducer	A device that converts energy from one form to another. Vibration transducers convert either acceleration, velocity or displacement to an electrical signal that is processed by the monitoring system.
Triaxial	Three axes. Measurement systems often consist of three vibration transducers arranged triaxially – oriented at 90° from each other.
VDV	Vibration Dose Value. A measure of tactile vibration levels used to assess intermittent vibration.
Velocity	The rate of change of vibration displacement, usually measured in mm/s.
Vibration	A mechanical phenomenon whereby oscillations occur about an equilibrium point; a periodic back-and-forth motion of an elastic body or medium, commonly resulting when almost any physical system is displaced from its equilibrium condition.
Vrms	Root mean square (RMS) vibration level for the train passby, typically expressed in mm/s
Waveform	A graphical representation of a vibration event in the time domain, showing the measured vibration levels for each sample.

APPENDIX B Community consultation

B.1 Notification of sensitive receivers

The sensitive receiver notifications have been provided to AWE in a spreadsheet table to more adequately manage the community engagement and notification process.

B.2 Community consultation record

Table B-1: Stakeholder consultation record

Date	Person contacted	Comment

APPENDIX C Specification for Construction Noise Monitoring

C.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project. This is for measurement of receivers construction noise levels, for either at-receiver measurement or intermediate locations.

C.2 Referenced standards and guidelines

- Standards Australia (2019), Electroacoustics - Sound Level Meters - Specifications, AS IEC 61672.1:2019 or Standards Australia (2013), Electroacoustics - Sound Level Meters - Specifications, IEC 61672.1:2013
- Standards Australia (2018), Acoustics—Description and measurement of environmental noise, AS 1055:2018
- NSW Department of Environment and Climate Change (2009), Interim Construction Noise Guideline (ICNG)
- NSW Environment Protection Authority (2017), Noise Policy for Industry (NPfI)

C.3 Monitoring procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Class 2 instruments as described in IEC 61672.1:2013 and calibrated to standards that are traceable to NATA General Accreditation Guidance: General Equipment Table (July 2019), and consistent with the requirements of AS 1055:2018. The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters housed in weather resistant enclosures. The operator may retrieve the data at the conclusion of each monitoring period in person or remotely if the logger is fitted with mobile communications.

All environmental noise measurements shall be taken with the following meter settings:

- Time constant: FAST (ie. 125 milliseconds)
- Frequency weightings: A-weighting
- Sample period: 15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and/or the wind speed is greater than 5m/s (18km/h).

C.4 Long-term (unattended) noise monitoring

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, while acoustically shielded as much as possible from non-construction site noise (eg. road traffic, rail noise and other surrounding noise).

Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: Lmin, L90, Leq, L10, L1 and Lmax.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Meteorological conditions including wind velocity, wind direction and rainfall shall be monitored over the entire noise monitoring period, either on site or recorded from the nearest weather station to the project site.

C.5 Short-term (attended) monitoring

Where noise complaints or requests from relevant authorities are received or as required by project approvals or this management plan, attended short-term noise monitoring shall also be conducted at the requested location and at any other relevant noise receiver location with closest proximity to the construction activities.

The noise verification monitoring locations will take into consideration the nature of construction activities being undertaken by the Project. The identification of monitoring locations will consider the following:

- Most affected noise sensitive receiver location in proximity to the assessed activities,
- Location of previous monitoring sites,
- Proximity of the receiver to a Project worksite,
- Sensitivity of the receiver to noise,
- Background noise levels, and
- Safety of personnel undertaking the measurements,
- Expected duration of the impact.

Noise monitoring should, where practicable, be in positions with unobstructed views of general site activities, whilst shielded as much as possible from non-construction site noise (e.g. road traffic, rail noise and other surrounding noise).

In accordance with Australian Standard AS1055, outdoor noise monitoring is to be undertaken at least 3.5m from any reflecting structure other than the ground. Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 to 1.5m from the ground, unless noise measurements are taken from a balcony or veranda, in which case the same microphone height shall apply off the floor. Noise measurements inside buildings should be at least 1 m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and 1.5m from windows. Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5 dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Short-term noise monitoring shall be used to supplement long-term noise monitoring undertaken at nearby locations, and to establish whether noise levels measured by the long-term noise monitors are determined by construction activities carried out on site.

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported is the following A-weighted noise levels: Lmin, L90, Leq, L10, L1 and Lmax.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements;
- Name of person(s) undertaking the measurements;
- Qualifications and/or competency/suitability of the person carrying out the monitoring;
- Type and model number of instrumentation;
- Results of field calibration checks before and after measurements;
- Description of the time aspects of each measurement (ie. sample times, measurement time intervals and time of day);
- Measurement location details, measurement microphone height, and number of measurements at each location;
- Sketch map of area with critical measurement elements [ie. monitoring location, distance to operating plant/equipment, the location of noise/vibration generating items (construction activities and other environmental noise sources), the location and type of mitigation measures, the location of other acoustically relevant items (e.g. walls/barriers) along with relevant distances to the monitoring location];
- Photographs clearly identifying the monitoring location, setup, and critical measurement elements;

- Weather conditions during measurements, including wind velocity, wind direction, temperature, relative humidity and cloud cover;
- Description of operation and load conditions of the noise sources under investigation;
- Any adjustment made for presence or absence of nearby reflecting surfaces;
- Measured noise levels including the minimum descriptors required;
- Estimated noise level from construction activities only;
- Estimated noise levels from environmental noise sources other than construction; and
- Details of any extraneous noise due to other sources that influenced the measurement (eg traffic, aircraft, trains, dogs barking, insects, other construction equipment etc).

APPENDIX D Specification for Construction Vibration Monitoring

D.1 Scope

This document specifies methods for undertaking vibration monitoring during the construction phase of the project. Vibration monitoring during construction activities may be carried out for the following reasons:

- To confirm acceptability of construction techniques, or confirm compliance with limits for structural or cosmetic damage of buildings; or
- To assess compliance with vibration limits for human exposure to vibration.

Monitoring may be carried out in response to specific conditions of approval or complaint. However, the recommended work practice is to conduct proactive monitoring and establish procedures that provide greater assurance of compliance with relevant policy guidelines and Standards throughout all phases of the project works. It is noted that this specification does not address monitoring of blasting activities.

D.1.1 Requirements for vibration monitoring

Vibration monitoring is to be carried out at the following times in accordance with this Management Plan:

- At the commencement of operation of each piece of plant equipment or site activity which has the potential to generate significant vibration levels. The objective of this monitoring is to refine the indicative working distances for vibration generating equipment and provide site-specific minimum working distances. Refer to procedure below for establishment Vibration Minimum Working Distances.
- At any locations identified within the projects Conditions of Approval / Consent Condition.
- Where vibration complaints or requests from relevant authorities, at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities. This may be carried out with short-term or long-term monitoring methods.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards (including the TfNSW vibration limits) include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards (including the TfNSW vibration limits) include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (ie. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.

- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s^2).

D.2 Referenced standards and guidelines

- AS 2775-2004 *Mechanical vibration and shock – Mechanical mounting of accelerometers*
- AS 2670.2-1990 *Evaluation of human exposure to whole body vibration*
- BS 6472-1992 *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*
- BS 6841-1987 *Guide to measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*
- BS 7482-1991 Parts 1 and 3: *Instrumentation for the measurement of vibration exposure of human beings*
- BS 7385:1 *Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings*
- BS 7385:2 *Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground borne Vibration*
- DIN 4150-2016 Part 3 *Structural vibration – Effects of vibration on structures*
- ISO 4866 *Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings*
- NSW DEC (EPA) 2006 *Assessing Vibration: A technical guide*

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and guidelines listed above; however, the following notes of importance are included herein.

D.3 Vibration minimum working distances

Minimum working distances are to be established for each vibration generating item of equipment, as identified in this Plan, to provide a site-specific minimum working distances.

The testing regime should commence at a suitable time to allow sufficient time to amend construction techniques as necessary, without affecting the overall construction program.

Minimum working distances are to be established using identical equipment or simulated practices at a location removed from the sensitive structure or receiver.

Sufficient measurements are to be carried out in accordance with the relevant Standards to confirm the minimum working distances and confirm the acceptable work practices that are likely to be compliant given the proximity of actual works to sensitive receivers and structures.

Consultation between consultants, engineers and the construction team may be required where revision to work practices is required.

D.3.1 Personnel and equipment

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be checked for accuracy (to manufacturer's specification) at least every two years against a reference vibration transducer that is calibrated at least every three years [ref: NATA General Accreditation Guidance: General Equipment Table (July 2019)].

Vibration monitors consist of a computer unit connected by cable to a tri-axial vibration transducer which senses vertical, axial and horizontal vibration, or three separate uni-axial vibration transducers positioned in the vertical, axial and horizontal axes. The parameters to be measured differ dependent upon the relevant Standards but may include:

Assessment type	Type of vibration	Relevant standard/guideline	Measurement parameters
Human comfort	Continuous and impulsive	DECC guideline BS 6472-1992	RMS acceleration, 1-80Hz. 1/3 octave weighted as defined in BS6841-1987
	Intermittent vibration	DECC guideline BS 6472-1992	RMS acceleration, 1-80Hz Vibration Dose Values (VDVs) in accordance with BS6472-1992
Structural damage	Non-blasting	DIN 4150-2016 Part 3	Peak-particle velocity (PPV), 1-100Hz
	Non-blasting	BS 7385 Part 2	Peak-particle velocity (PPV), 4-250Hz
Structural damage – sensitive structures	Non-blasting	DIN 4150-2016 Part 3	Peak-particle velocity (PPV), 1-100Hz

Short-term vibration monitors should allow real-time analysis of vibration levels to assist assessment and feedback on the subject operations and procedures.

D.3.2 Monitoring procedure

Vibration monitoring equipment should be installed in accordance with the following guidance:

- At a location equivalent to the site and ground conditions at the sensitive receiver location. The working distances should not be established via immediate measurement and activities near the sensitive structure.
- The surface should be solid and rigid in order to best represent the vibration levels entering the building/structure under investigation.
- The vibration sensor or transducer should not be mounted on loose gravel or other unstable surfaces.

- The vibration geophone or transducer(s) should be directly mounted to the vibrating surface using bees wax, double sided adhesive tape, or magnetically fixed to a mounting plate fastened to the vibrating surface.
- Where a suitable mounting surface is unavailable, a metal stake (at least 300mm in length) with a mounting plate should be driven into solid ground adjacent to the building of interest. The vibration sensor or transducer shall be fixed on top of the mounting plate.

The following information shall be recorded:

- Date and time of measurements;
- Name of person(s) undertaking the measurements;
- Qualifications and/or competency/suitability of the person carrying out the monitoring;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (ie. sample times, measurement time intervals and time of day);
- Sketch map of area with critical measurement elements [ie. monitoring location, distance to operating plant/equipment, the location of noise/vibration generating items (construction activities and other environmental noise sources), the location and type of mitigation measures, the location of other acoustically relevant items (e.g. walls/barriers) along with relevant distances to the monitoring location];
- Photographs clearly identifying the monitoring location, and critical measurement elements;
- Measurement location details (including distance from vibrating source) and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation and distance from the measurement location; and
- Possible vibration influences from other sources (e.g. other mechanical plant, traffic, railway).

D.4 Long-term (unattended) monitoring

Long-term unattended vibration monitoring shall be undertaken continuously whilst the vibrating plant is operational within the pre-determined 'minimum working distances' from potentially affected buildings or sensitive structures. Long-term unattended vibration monitoring is generally carried out for the assessment of structural or cosmetic damage rather than human exposure.

D.4.1 Personnel and equipment

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be checked for accuracy (to manufacturer's specification) at least every two years against a reference vibration transducer that is calibrated at least every three years [ref: NATA General Accreditation Guidance - General Equipment - Calibration and Checks, General Equipment Table (January 2018)].

Vibration monitors consist of a computer unit connected by cable to a tri-axial vibration transducer which senses vertical, axial and horizontal vibration, or three separate uni-axial vibration transducers positioned in the vertical, axial and horizontal axes.

Long-term monitoring for the management of structural and cosmetic damage should include the following:

- Vibration levels are to be monitored continuously with the following parameters being stored at a maximum interval period of 5 minutes:
 - Peak-particle velocity (PPV) between 1 Hz and 100 Hz for each direction of the tri-axial geophone (or transducers) and vector-sum peak-particle velocity [DIN4150.3];
 - Peak-particle velocity (PPV) between 4 Hz and 250 Hz for each direction of the tri-axial geophone (or transducers) and vector-sum peak-particle velocity [BS 7385.2].
- Vibration levels are to be stored at the pre-defined intervals in the logger memory for record, data analysis or post-processing. Data may be retrieved at the conclusion of each monitoring period either by operator download or remotely via a telephone modem if the logger is fitted with a remote communications option.
- Monitors should be fitted with an audible, visual, SMS or email alert system, triggered to provide warning when the measured level of vibration approaches or exceeds the limits defined by the relevant Standard.
- Where the trigger limits are exceeded, a detailed waveform recording should be stored including a detailed frequency spectrum for assessment against the frequency limit curve.

D.4.2 Monitoring location and mounting

Vibration monitoring equipment should be installed in accordance with the following guidance:

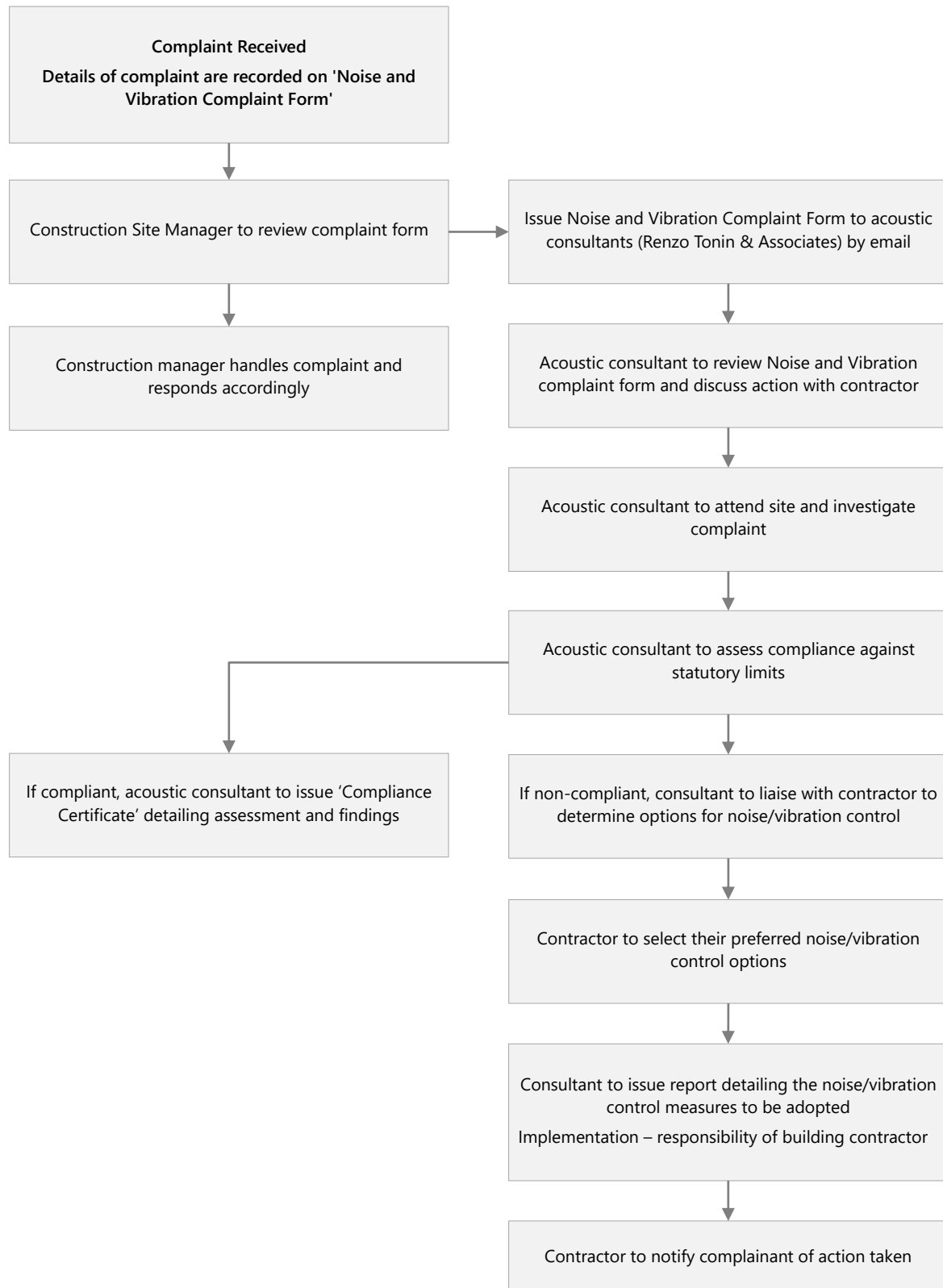
- Equipment should be positioned at the footings or foundations of the building of interest, closest to the vibrating plant.
- The mounting surface should be solid and rigid in order to best represent the vibration levels entering the structure of the building under investigation.
- The vibration geophone or transducer(s) should not be mounted on loose tiles, loose gravel or other unstable surfaces.
- The vibration geophone or transducer(s) should be directly mounted to the vibrating surface using bees wax, double sided adhesive tape, or magnetically fixed to a mounting plate fastened to the vibrating surface.
- Where a suitable mounting surface is unavailable, a metal stake (at least 300mm in length) with a mounting plate should be driven into solid ground adjacent to the building of interest. The vibration sensor or transducer shall be fixed to the mounting plate.

D.5 Vibration measurements in response to complaints

Proactive vibration monitoring and establishment of procedures that comply with the policy guidelines and Standards is the recommended work practice to reduce the risk of complaint regarding vibration from the site.

There may however be cases where specific monitoring is required to investigate a complaint or issue identified during the project works. Vibration monitoring may be carried out using either short-term or long-term methodologies depending on the nature of the complaint. Short-term attended manned procedures would generally be carried out when measurements are required inside a property or where immediate action and detailed observations are required to be made at the time of measurements. Short-term monitoring would generally follow the procedures outlined for the establishment of Minimum Working Distances. Long-term monitoring would be carried out as described in section C.4 above.

APPENDIX E Noise / vibration complaint management procedure



NOISE/ VIBRATION COMPLAINT FORM

Project title:	_____	Date:	_____
Site contractor:	_____	Phone:	_____
Site contact:	_____	Email:	_____

Complaint details

Received by (circle): Phone / Email / In person / Other: _____

Name:	_____	H Ph:	_____
Address:	_____	W Ph	_____
Email:	_____	M Ph	_____

Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise/vibration:

Investigation

Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:

Following approval from the Project Manager, email this form to Renzo Tonin & Associates