JOHN HOLLAND

Waterloo Integrated Station Development

Construction Noise and Vibration Impact Statement

Amendment 3 - Capping Beam Removal

SMCSWSWL-JHG-SWL-EM-REP-0000014

VMS Report Number 10-1808R3R1

Document and Revision History

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Client	Sydney Metro City & Southwest

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Rev #	Date	Description	Prepared by	Reviewed by	Approved by
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Appendix A-C are available on request

APPROVAL
CITY & SOUTHWEST ACOUSTICS ADVISOR

Review of	**Construction Noise and Vibration Statement Waterloo Integrated Station Development (WISD)**	**Document reference:**	**Construction Noise and Vibration Impact Statement – Waterloo Integrated Station Development – Amendment 3 – Capping Beam Removal** **Prepared by VMS Australia Pty Ltd** *Reference: 10-1808R3R1 Revision 1* *Date: 16 May 2022*
Prepared by:	Carl Fokkema Alternate Acoustics Advisor		
Date of issue:	18 May 2022		

As approved Alternate Acoustics Advisor for the Sydney Metro City & Southwest project, I have reviewed and provided comment on the Construction Noise and Vibration Impact Statement (CNVIS) – Amendment 3 – Capping Beam Removal, as required under A27 (d) of the project approval conditions (SSI 15-7400).

I am satisfied that the CNVIS Amendment 3- Capping Beam Removal R3R1 is technically valid and includes appropriate noise and vibration mitigation and management (16 May 2022). On this basis I endorse CNVIS 10-1808R3R1 Revision 1 in respect of Capping Beam Removal.

Carl Fokkema, City & Southwest Alternate Acoustics Advisor

Construction Noise and Vibration Impact Statement

Waterloo Integrated Station Development

Amendment 3 - Capping Beam Removal

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Report Number 10-1808R3R1

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Reference	Status	Date	Prepared	Checked	Authorised
10-1808R3R1	Revision 1	16 May 2022	Yang Liu	Mark Blake	Yang Liu

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

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Glossary

Term/Acronym	Definition
AA	The independent Acoustic Advisor appointed under the Project Planning Approval
Acceleration	Acceleration is defined as the rate of change of Velocity of a particle over a period of time and is typically measured in the units of m/sec^2.
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.
AMMM	Additional Mitigation Measures Matrix
Annoying Activities	As defined by the Interim Construction Noise Guideline to include: • use of 'beeper' style reversing or movement alarms, particularly at night-time • use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work • grinding metal, concrete or masonry • rock drilling • line drilling • vibratory rolling • rail tamping and regulating • bitumen milling or profiling • jackhammering, rock hammering or rock breaking • impact piling
AS 1055	Standards Australia AS1055–1997™ – Description and Measurement of Environmental Noise
AS2187:2006	Australian Standard AS 2187.2-2006: Explosives - Storage and Use - Use of Explosives
AS2436	Standards Australia AS 2436–2010™ – Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites.
AS61672 or AS1259	Standards Australia AS IEC 61672.1–2004™ – Electro Acoustics - Sound Level Meters Specifications Monitoring or Standards Australia AS1259.2-1990™ – Acoustics – Sound Level Meters – Integrating/Averaging as appropriate to the device.
Attenuation	The reduction in the level of sound or vibration.
AVTG	Assessing Vibration – a technical guideline
A-weighting, dBA	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
BS 6472	British Standard (BS 6472–1992) – Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz) dated 1992;
BS 7385	British Standard BS7385: Part 2-1993 - Evaluation and Measurement for Vibration in Buildings — Part 2 – Guide to Damage Levels from Ground-borne Vibration, dated 1993.
CEMF	Construction Environmental Management Framework (Appendix B) of the Submissions and Preferred Infrastructure Report)
CEMP	Construction Environmental Management Plan

Term/Acronym	Definition
CNS	Transport for New South Wales Construction Noise Strategy (Document Number ST-157/4.1, 23 April 2019)
CNVIS	Construction Noise and Vibration Impact Statement
CNVMP	Construction Environmental Management Sub-plan , Waterloo Integrated Station Development, Noise and Vibration Management Sub-Plan (this document)
CNVS	Sydney Metro City & Southwest Construction Noise and Vibration Strategy (Report Number 610.14213 R3, dated 9 August 2017)
CoA	Conditions of Approval for SSI 15_7400
Construction	Includes all physical work required to construct the Project, as defined in the CoA
CSSI	Critical State Significant Infrastructure
DECCW	Department of Environment, Climate Change and Water (now Environment, Energy and Science (EES) Group)
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa. Note that the above formula is only valid for sound propagation in the free-field (see below).
DIN4150:3	German Institute for Standardisation – DIN 4150 (1999-02) Part 3 – Structural Vibration - Effects of Vibration on Structures.
DP&I	NSW Department of Primary Industries, including DPI Agriculture, DPI Biosecurity and Food Safety, DPI Land and Natural Resources, DPI Crown Lands and Water and DPI Fisheries
DPIE	NSW Department of Planning, Industry and Environment
EIS	Sydney Metro City & Southwest Chatswood to Sydenham Environmental Impact Statement, 3 May 2016
ENMM	Environmental Noise Management Manual (RTA 2001)
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence under the POEO Act
ER	The independent Environmental Representative appointed under the Project Planning Approval
Fast/Slow Time Weighting	Averaging times used in sound level meters.
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. engineering considerations and what is practical to build. Reasonable Feasible relates to relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.

Term/Acronym	Definition
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m
Heritage item	A place, building, work, relic, archaeological site, tree, movable object or precinct of heritage significance that is listed under one or more of the following registers: the State Heritage Register under the Heritage Act 1977 (NSW), a heritage item registered under a Local Environmental Plan under the EP&A Act, the World, National or Commonwealth Heritage lists under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), and an Aboriginal object or Aboriginal place as defined in section 5 of the National Parks and Wildlife Act 1974 (NSW).
Hertz, Hz	The unit of Frequency (or Pitch) of a sound or vibration. One hertz equals one cycle per second. 1 kHz = 1000 Hz, 2 kHz = 2000 Hz, etc.
HNML	Highly Noise Affected Management Level
ICNG	Interim Construction Noise Guideline (OEH, 2009)
Infrastructure Approval	CSSI project approval for SSI 15_7400 Sydney Metro granted by the Minister for Planning on 9 January 2017
ISD	Integrated Station Development
JHPL	John Holland Pty Ltd
L90,15minute	A noise level index. The noise level exceeded for 90% of the time over a 15-minute period. L90 can be considered to be the "average minimum" noise level and is often used to describe the background noise.
Leq,15minute	A noise level index called the equivalent continuous noise level over a 15-minutes period. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
Lmax,15minute	A noise level index defined as the maximum noise level during a 15-minute period. Lmax is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
Metro Quarter Development	Metro Quarter Development (MQD) comprises the land bounded by Botany Road, Raglan Street, Cope Street and Wellington Street, but excluding the Congregational Church located at 103 Botany Road. It is situated approximately 3km from the Sydney CBD and is surrounded by established residential and commercial land uses.
Monitoring Program	Construction Noise and Vibration Monitoring Program
NCA	Noise Catchment Area
NML	Noise Management Level as derived from the Interim Construction Noise Guideline
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
NPfI	NSW Noise Policy for Industry (2017)
NSW Vibration Guideline	NSW Department of Environment and Conservation – NSW Environmental Noise Management – Assessing Vibration: a Technical Guideline (the NSW Vibration Guideline), February 2006.

Term/Acronym	Definition
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.
OEH	Office of Environment and Heritage
OOHW	Out of Hours Works
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
PPV	The particles of a medium are displaced from their random motion in the presence of a vibration wave. The greatest instantaneous velocity of a particle during this displacement is called the Peak Particle Velocity (PPV) and is typically measured in the units of mm/s.
Project	Sydney Metro City & Southwest - Waterloo Integrated Station Development
Project Planning Approval	Critical State Significant Infrastructure Sydney Metro & Southwest Chatswood to Sydenham Infrastructure Approval dated 9 January 2017 (Application no. SSI 15_7400)
RBL	The Rating Background Level for each period is the median value of the Assessment Background Level values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
REMM	Revised Environmental Mitigation Measures (Chapter 11 of the Submissions and Preferred Infrastructure Report).
Residential zones	As defined by the relevant Local Environment Plan including Zone R1 General Residential, Zone R2 Low Density Residential, Zone R3 Medium Density Residential, Zone R4 high Density Residential
RMS	NSW Roads and Maritime Services
RNP	NSW Road Noise Policy (DECCW 2011)
Secretary	Secretary of the NSW Department of Planning and Environment or nominee
Sensitive periods	Period of time determined in consultation with affected sensitive receiver
Sensitive receiver	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds). Receivers that may be considered to be sensitive include commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces) and industrial premises, and others as identified by the Secretary
Sound Power	Sound Power is the rate at which sound energy is emitted, reflected, transmitted or received, per unit time. Unlike sound pressure, sound power is neither room-dependent nor distance-dependent.
Sound Power Level (SWL)	The Sound Power Level is the sound power relative to a standard reference pressure of 1pW ($20x10^{-12}$ Watts) on a decibel scale. The SWL of a simple point source may be used to calculate the SPL at a given distance (r) using the following formula: $SPL = SWL - 10 \times Log_{10}(4 \times \pi \times r^2)$ Note that the above formula is only valid for sound propagation in the free-field (see below).

Term/Acronym	Definition
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (SPL)	The sound level is the sound pressure relative to a standard reference pressure of 20µPa ($20x10^{-6}$ Pascals) on a decibel scale.
Spoil	All material generated by excavation into the ground
SSI	State Significant Infrastructure
Submissions and Preferred Infrastructure Report	Sydney Metro City & Southwest Chatswood to Sydenham Submissions and Preferred Infrastructure Report, October 2016
Sub-plans	Sub Plans to the CEMP requiring the approval the Secretary of the Department of Environment and Planning under Conditions C3 and C7 including construction noise and vibration, construction soil, water and groundwater, heritage, flora and fauna and air quality
SWMS	Safe Work Method Statement
Sydney CBD	Sydney Central Business District
Sydney Metro	Sydney Metro City & Southwest Project
TfNSW	Transport for New South Wales
Vibration Dose, VDV	When assessing intermittent vibration it is necessary to use the vibration dose value (VDV), a cumulative measurement of the vibration level received over an 8-hour or 16-hour period. The VDV formulae uses the RMS Acceleration raised to the fourth power and is known as the Root-mean-quad method. This technique ensures the VDV is more sensitive to the peaks in the acceleration levels. VDVs are typically measured in the units of $m/s^{1.75}$.
VMS	VMS Australia Pty Ltd
Works	All physical activities to construct the Project
Waterloo ISD	Waterloo Integrated Station Development Project comprises of construction of the new Waterloo station infrastructure to support customer movement and experience.

1 Project Information

1.1 Introduction

The New South Wales (NSW) Government through Transport for NSW (TfNSW) is implementing *Sydney's Rail Future*, a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of commuters and customers in the future.

Sydney Metro is a new standalone rail network identified in *Sydney's Rail Future*. The Sydney Metro network consists of Sydney Metro Northwest (previously known as the North West Rail Link) and Sydney Metro City & Southwest.

The proposed Sydney Metro City & Southwest (SMC&SW) comprises of two core components:

- The Chatswood to Sydenham project involves the construction and operation of an underground rail line approximately 15.5 kilometres long inclusive of new stations between Chatswood and Sydenham.
- The second core component will involve upgrading the 13.5 kilometre rail line and existing stations from Sydenham to Bankstown.

Waterloo Integrated Station Development (Waterloo ISD, the Project) comprises the construction of the new station infrastructure to support customer movement and experience.

The Waterloo ISD is located within the South Sydney local area in the suburb of Waterloo, as shown in **Figure 1.** The Project Site is situated on one city block bounded by Botany Road, Raglan Street, Cope Street and Wellington Street, but excluding the Congregational Church located at 103 Botany Road. The Project Site is situated approximately 3km from the Sydney CBD and is surrounded by established residential dwellings and businesses.

Figure 1 Project Site Location Plan

2 Objectives

Condition E33 of the Sydney Metro City & Southwest Chatswood to Sydenham Infrastructure Approval (CoA, under Section 115ZB of the Environmental Planning Act 1979, Application No: SSI 15_7400, determined 9 January 2017) requires that a Construction Noise and Vibration Impact Statement (CNVIS) must be prepared for each construction site prior to undertaking works which may cause adverse noise and vibration impacts. The key objectives of the CNVIS are to:

- Identify noise and vibration sensitive receivers.
- Predict the noise and vibration impacts from the proposed construction works.
- Based on the predictions, assess the noise and vibration impacts against the objectives set out in the Construction Noise and Vibration Management Plan (CNVMP).
- Where exceedances of the nominated noise and vibration objectives have been predicted, include site specific mitigation measures identified through consultation with affected receivers to reduce noise and vibration impacts.

The approved CNVIS for the Project was prepared in October 2020 to comply with the Sydney Metro City & Southwest Construction Noise and Vibration Strategy (CNVS), the Interim Construction Noise Guidelines (Department of Environment and Climate Change, 2009) (ICNG) and the conditions in the SSI 15_7400 Infrastructure Approval. In addition, the CNVIS draws guidance from the Construction Noise and Vibration Management Plan (CNVMP, JHPL Document Reference: SMCSWSWL-JHG-SWL-EM-PLN-000005).

VMS was subsequently engaged to prepare an amendment (Amendment 1) to the approved CNVIS based on the current work method and program, and in particular to assist in the management and scheduling of OOHWs. The amended CNVIS (CNVIS Amendment 1, report number: 10-1808R1R2) has been submitted to Sydney Metro and endorsed by the Acoustics Advisor dated 25 November 2021.

This CNVIS (CNVIS Amendment 3) is the third amendment to the approved CNVIS and provides detailed assessment of the proposed additional Capping Beam Removal construction works.

This document will be read in addition to the CNVIS Amendment 1 (report number: 10-1808R1R2) dated 24 November 2021 and CNVIS Amendment 2 (report number: 10-1808R2R1) dated 8 December 2021 for the additional construction activities. This document may be altered during the course of works. Any changes to this document will be submitted to relevant parties for approval prior to implementation.

3 Additional Construction Activities and Tasks

The Project scope of works (Project Works) is detailed in the Construction and Site Management Plan (CSMP). **Table 1** summaries the additional noise and vibration producing construction activities associated with the Projects Works and used for assessment in this CNVIS.

Table 1 Project Scope of Works

Construction Scenario ID	Construction Activity
S15	Capping Beam Removal

4 Construction Program

The construction program for the Project including the estimated commencement date and completion date are presented in **Table 2**.

Table 2 Project Construction Program

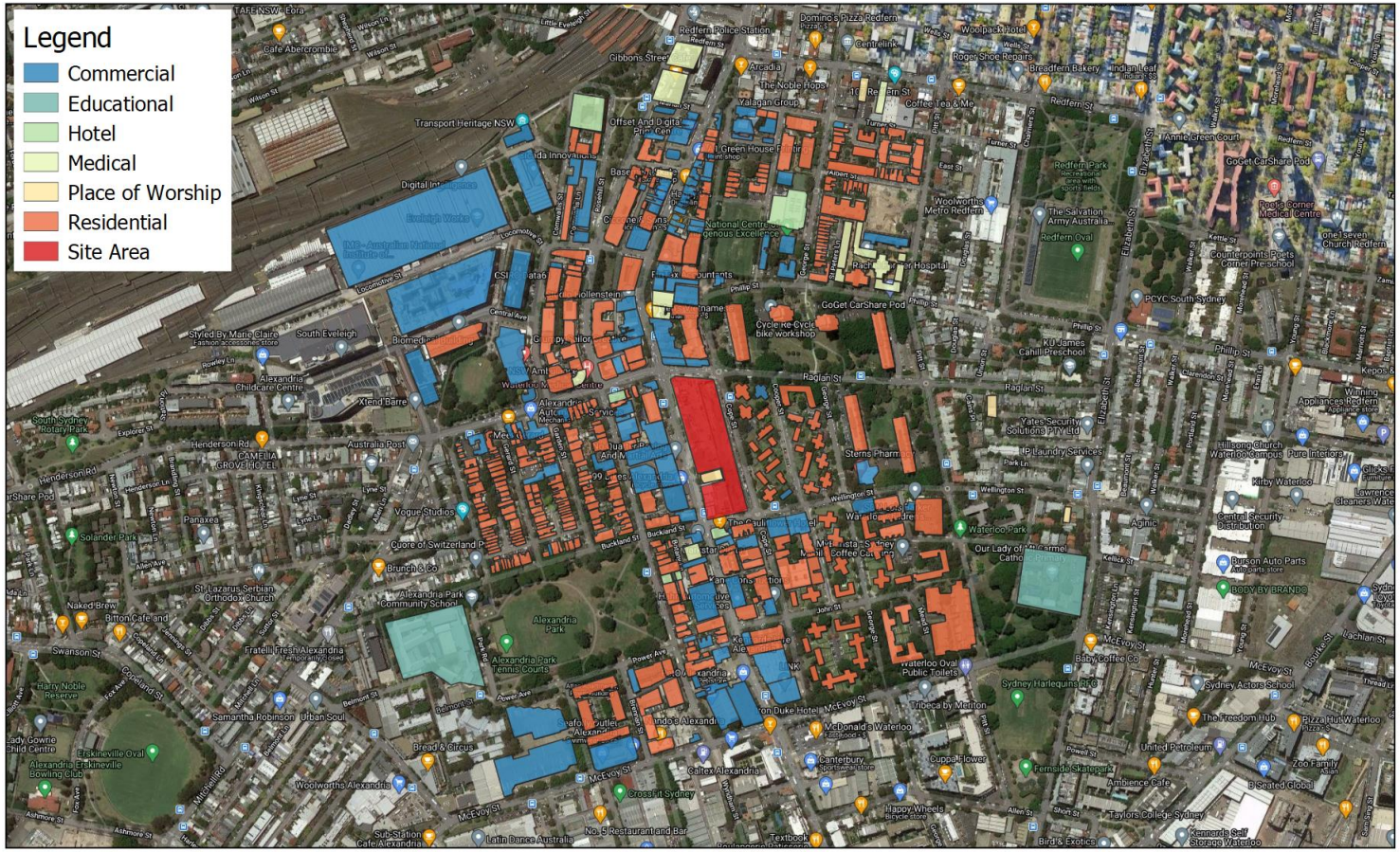
Stage	Phase	Activities	Commencement	Completion
Site Setup	Establishment of site compound	Installation of site sheds, establishment of site access (vehicle & pedestrian), hoarding adjustments etc	Aug-20	Oct-20
	General Site Operations	Deliveries, operation of water treatment plant, crane movements etc	Aug-20	Oct-23
Station Construction	Piling/Foundations	Piling works, waterproofing, base slab construction, commence wall construction	Oct-20	Mar-21
	Structure	FRP walls/Slabs, install precast elements, removal of capping beam	Oct-20	Aug-22
	Fitout	Blockwork, paving, services installation, cladding works, glazing, building finishes etc	Oct-20	Oct-23
Surface Works	Utilities	Service location, utility relocation and diversion works (trenching, install, backfill, cut-over), smart pole installation	Aug-20	Dec-22
	Civil/Pavements	Removal of redundant pavement, re-construction of new pavement, asphalting, kerb construction and re-alignment, traffic signal install and commissioning, line marking, retaining wall/vehicle barrier construction, stormwater drainage	Jan-21	Dec-23
	Precinct	Hard landscaping, soft landscaping, street furniture, public art	Jun-21	Dec-23

5 Sensitive Receivers

The Project has noise and vibration sensitive receivers within adjoining or adjacent buildings to the Project Site. The properties identified to be potentially most affected by the Project Works are detailed in **Appendix A**.

Figure 2 shows usage of the surrounding receivers. **Figure 3** shows the sensitivity to vibration for the surrounding receivers.

Figure 2 Site Plan – Receiver Usage



Project No.:	10-1808
Date:	13/10/2020
Drawn by:	YL
Scale:	1:9034
Sheet Size:	@A4
Projection:	GDA 1994 MGA Zone 56

0 100 200

N

Sydney Metro City & Southwest

Waterloo Integrated Station Development

Receiver Usage

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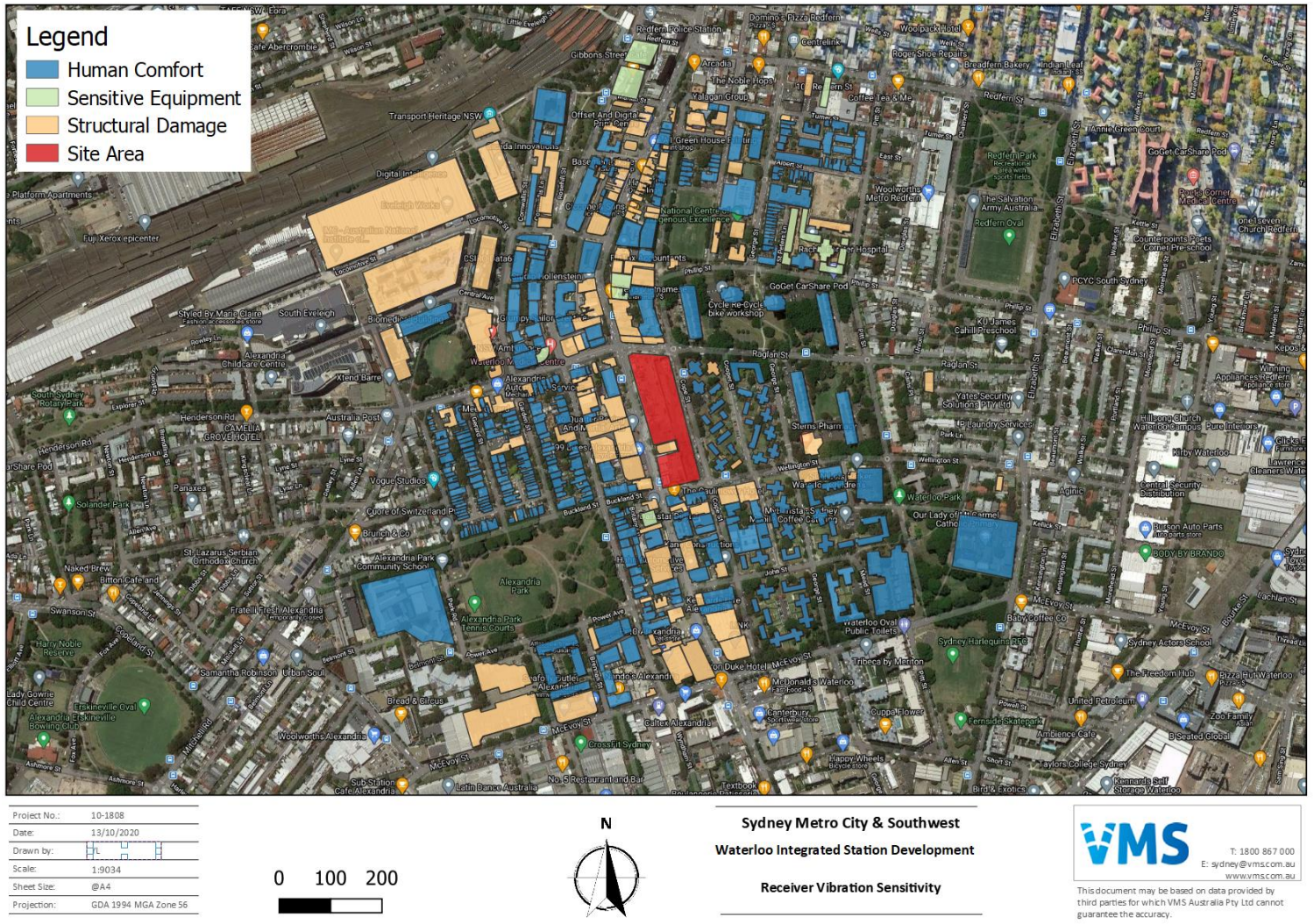
This document may be based on data provided by third parties for which VMS Australia Pty Ltd cannot guarantee the accuracy.

Note 1: The Receiver Type colour coding presented represents the building usage type. Refer to Appendix A for detailed building usage.

Figure 3 Site Plan – Receiver Vibration Sensitivity



Note 1: The Receiver Type colour coding presented represents the receiver vibration sensitivity throughout the entire building. Refer to Appendix A for detailed building usage.

6 Construction Hours

6.1 Approved Construction Hours

The standard construction hours are outlined in the Project contract and as per CoA E36 are as follows:

- 7:00 am to 6:00 pm, Mondays to Fridays, inclusive;
- 8:00 am to 1:00 pm on Saturdays; and
- at no time on Sundays or public holidays.

7 Background Noise Levels

Unattended environmental noise monitoring was conducted by SLR Consulting Pty Ltd between 31 August and 13 September 2015 in order to identify the existing rating background levels (RBLs) at the potentially noise affected receivers in absence of the construction works at Waterloo ISD. Based on the information presented in Section 2.3 of *Chatswood to Sydenham Environmental Impact Statement* prepared by SLR Consulting dated in 2016, the RBL for day, evening and night-time period are summarised in **Table 3**.

Table 3 Rating Background Levels (dBA)[1,2]

	Daytime 7:00 am to 6.00pm	Evening 6:00 pm to 10:00 pm	Night 10:00 pm to 7:00 am
RBL	54	47	39

Note 1: The RBL noise levels have been obtained using the calculation procedures documented in the Industrial Noise Policy (INP).

Note 2: In accordance with the INP, where the RBL is found to be less than 30 dBA, then it is set to 30 dBA

8 Construction Noise and Vibration Management Levels

8.1 Construction Noise Management Levels

The noise (including ground-borne noise) and vibration management levels have been nominated in the CNVMP in accordance with CoA (SSI 15_7400) and ICNG.

8.1.1 Residential Receivers

Site specific residential construction Noise Management Levels (NMLs) for Waterloo ISD have been nominated in the CNVMP and reproduced in **Table 4**.

Table 4 Residential Construction Noise Management Levels

Receiver Types	LAeq(15minute) Construction NMLs (dBA)			
	Daytime[1]	Daytime OOH[2]	Evening[3]	Night-time[4]
Residential	64	59	52	44

Note 1: The Daytime period includes Monday to Friday 7.00 am to 6.00 pm and Saturdays 8.00 am to 1.00 pm, except for Public Holidays.

Note 2: The Daytime Out of Hours period includes Saturdays 7.00 am to 8.00 am and 1.00 pm to 6.00 pm, and Sundays and Public Holidays 7.00 am to 6.00 pm

Note 3: The Evening period includes 6.00 pm to 10.00 pm.

Note 4: The Night-time period includes 10.00 pm to 7.00 am.

8.1.2 Other Land Uses

The Project specific $L_{Aeq(15minute)}$ NMLs for non-residential receivers are summarised in the CNVMP and reproduced in **Table 5**.

Table 5 Summary of Noise Management Levels for Other Land Uses

Land Use	Area	NML $L_{Aeq(15minute)}$ Noise Levels	
		External	Internal
Hotel[1]	Bars and Lounges	70 dBA	50[2,3] (Daytime & Evening)
	Sleeping Areas: - Hotels near major roads	As per **Table 4** for residential[4]	40[4] (Night-time)
Café[1]	Coffee bar	70 dBA[3]	50[2,3] (when in use)
Bar/Restaurant[1]	Bars and Lounges / Restaurant	70 dBA[3]	50[2,3](when in use)
Library[1]	Reading Areas	70 dBA	45[5](when in use)
Recording Studio[1]	Music Recording Studios	70 dBA	25[6](when in use)
Theatre/ Auditorium[1]	Drama Theatres	70 dBA	30[6](when in use)
Childcare Centres	Internal Play Area	65 dBA	55 dBA
	Sleeping Area	50 dBA (when in use)	40 dBA (when in use)
Classrooms at schools and other education institutions		55 dBA	45 dBA[7] (when in use)
Hospital wards and operating theatres		70 dBA	45 dBA
Places of Worship		70 dBA	45 dBA
Active recreation areas[8]		65 dBA	-
Passive recreation areas[9]		60 dBA	-
Community centres		Depends on the intended use of the centre. Refer to the recommended upper internal design sound levels in AS 2107 for specific uses.	
Commercial premises[10]	offices, retail outlets and small commercial premises	70 dBA (when in use)	45 dBA (when in use)
Industrial premises[10]		75 dBA (when in use)	-

Note 1: Design noise levels specified in AS 2107 internal noise levels.

Note 2: Where no external seating has been identified, fixed window glazing and air conditioning is assumed to mitigate high existing ambient noise levels and/or control internal noise break-out. A minimum outside-to-inside attenuation of 20 dB is assumed. The internal ICNG noise goal then corresponds to a façade level of 70 dBA.

Note 3: Where an open frontage or outdoor seating area has been identified, the external noise goal is taken as 60 dBA.

Note 4: Hotels (sleeping areas during the night-time) are assumed to have incorporated acoustic façade design in order to mitigate high existing ambient noise levels (refer to Section 3) to achieve the internal design noise level of 40 dBA specified in AS 2107. Notwithstanding, the more conservative external NML corresponding to residential receivers (refer to **Table 4**) has been applied to the sleeping areas of hotels.

Note 5: These receivers are typically well insulated from external noise break-in.

Note 6: These receivers are typically well insulated from external noise break-in, with significant acoustic mitigation included in the façade design.

Note 7: Assumed based on external noise levels being 10 dB higher than internal noise levels when windows are open.

Note 8: Characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.

Note 9: Characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (eg reading and meditation).

Note 10: Assess at the most affected occupied point on the premises.

8.1.3 Sleep Disturbance

The CNVMP, in accordance with the ICNG, recommends that where construction works are planned to extend over more than two consecutive nights between 10pm and 7am, maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL should be considered.

Based on the information presented in the NSW Road Noise Policy (RNP) and Environmental Noise Management Manual (ENMM), the research on sleep disturbance to date has shown that:

- *Maximum internal noise levels below 50-55 dB(A) are unlikely to awaken people from sleep;*
- *One or two noise events per night, with maximum internal noise levels of 65-70 dB(A), are not likely to affect health and wellbeing significantly.*

Accordingly, to assess the potential of sleep disturbance, an initial screening level will be adopted using the below guidance (CNVS v3.0):

- L_{Amax} ≤ RBL + 15 dBA
- L_{Amax} ≤ 65 dBA (assuming windows open)

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

- The likely number of events that might occur during the night assessment period; and
- Whether events exceed an 'awakening reaction' level of 55 dBA L_{Amax} (internal)

The NSW EPA's Noise Policy for Industry (2017) also state that the maximum noise level event assessment for sleep disturbance should be undertaken where the Project night-time noise levels at a residential location exceed:

- L_{Aeq}, 15min 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

8.1.4 Ground-borne Noise

Ground-borne noise refers to noise produced by vibration of floor slabs and other building elements, which radiates noise into the interior of a building, sometimes referred to as regenerated noise. The ground-borne noise management levels recommended in the CNVMP, in accordance with ICNG and CoA E41 and CoA E42, are presented in **Table 6**.

Table 6 Ground-borne Noise Management Levels

Time	Building Category	Management Level – LAeq(15minute)
Day: 7:00 am – 6:00 pm	Internal residential	45 dB
	Internal commercial	50 dB
Evening: 6:00 pm – 10:00 pm	Internal residential	40 dB
Night: 10:00 pm – 7:00 am	Internal residential	35 dB

8.2 Vibration Management Levels

The CNVIS has been prepared to address the vibration requirements of CoA E28, E29, E30 and E31. The following sections describe the vibration management criteria. Notification to affected receivers will be completed in accordance with the Community Communication Strategy.

8.2.1 Human Comfort Continuous and Impulsive Vibration Criteria

Vibration and its associated effects on people are usually classified as continuous, impulsive or intermittent as follows:

- Continuous vibration: machinery, steady road traffic, continuous construction activity such as underground drilling
- Impulsive vibration: infrequent activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading
- Intermittent vibration: trains, nearby intermittent demolition activity, rock breakers and jack hammers.

The CNVMP nominates preferred and maximum values for continuous, impulsive and intermittent vibration for residential and office buildings as reproduced in **Table 7**, **Table 8** and **Table 9** (respectively). It is noted that the Conditions of Approval define a "perceptible level of vibration" as the "preferred" peak velocity levels presented in **Table 7** and **Table 8**.

Table 7 Criteria for exposure to Continuous Vibration

Space Occupancy	Time of Day	Peak velocity (mm/s)	
		Preferred[1]	Maximum
Residential	Day	0.28	0.56
	Night	0.20	0.4
Offices	Day/Night	0.56	1.1

Note 1: The Preferred Peak Velocity presented represent a "perceptible level of vibration".

Table 8 Criteria for exposure to Impulsive Vibration

Space Occupancy	Time of Day	Peak velocity (mm/s)	
		Preferred[1]	Maximum
Residential	Day	8.6	17.0
	Night	2.8	5.6
Offices	Day/Night	18.0	36.0

Note 1: The Preferred Peak Velocity presented represent a "perceptible level of vibration".

Table 9 Acceptable Vibration Dose Values

Space Occupancy	Time of Day	VDV ($m/s^{1.75}$)	
		Preferred	Maximum
Residential	Day	0.20	0.40
	Night	0.13	0.20
Offices, schools, educational institutions, places of worship	Day/Night	0.40	0.80

8.2.2 Structural Damage Site Vibration Control Criteria

Project site specific structural damage vibration control criteria haven been nominated in the CNVMP in accordance with CoA E28 and are reproduced in **Table 10**.

Table 10 Nominated Structural Damage Site Vibration Control Criteria

Building type	Included Buildings	Site Control Criteria[1]	
		Operator warning level	Operator halt level
Reinforced frame structure	All surrounding commercial	20 mm/s PPV	25 mm/s PPV
Unreinforced or light framed structures	All surrounding Residential	5 mm/s PPV	7.5 mm/s PPV
Heritage (structurally sound)	Waterloo Congregational Church, The Cauliflower Hotel, Redfern Surf Club	5 mm/s PPV	7.5 mm/s PPV
Buried Utilities	All	20 mm/s PPV	25 mm/s PPV
Human Response	All	0.2 $m/s^{1.75}$ VDV	0.4 $m/s^{1.75}$ VDV
Vibration Sensitive Equipment	Medical Centre, Hospital	0.013 mm/s PPV	0.018 mm/s PPV

Note 1: An exceedance of the operator warning level does not require activities to cease, but will alert the Project Manager and Foreman to proceed with caution at a reduced force or load.

8.3 Additional Mitigation Measures Matrix Category

Additional Mitigation Measures Matrix (AMMM) has been developed in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (CNVS). The AMMM includes definition of the level of noise impact compared with the background noise levels (RBLs) during standard construction hours and OOHW periods. According to the CNVS, the following steps need to be carried out to determine the additional mitigation measures to be implemented:

- Determine the duration (time period) when the work is to be undertaken.
- Determine the level of exceedance.
- From the relevant AMMM table, identify the additional mitigation measures to be implemented.

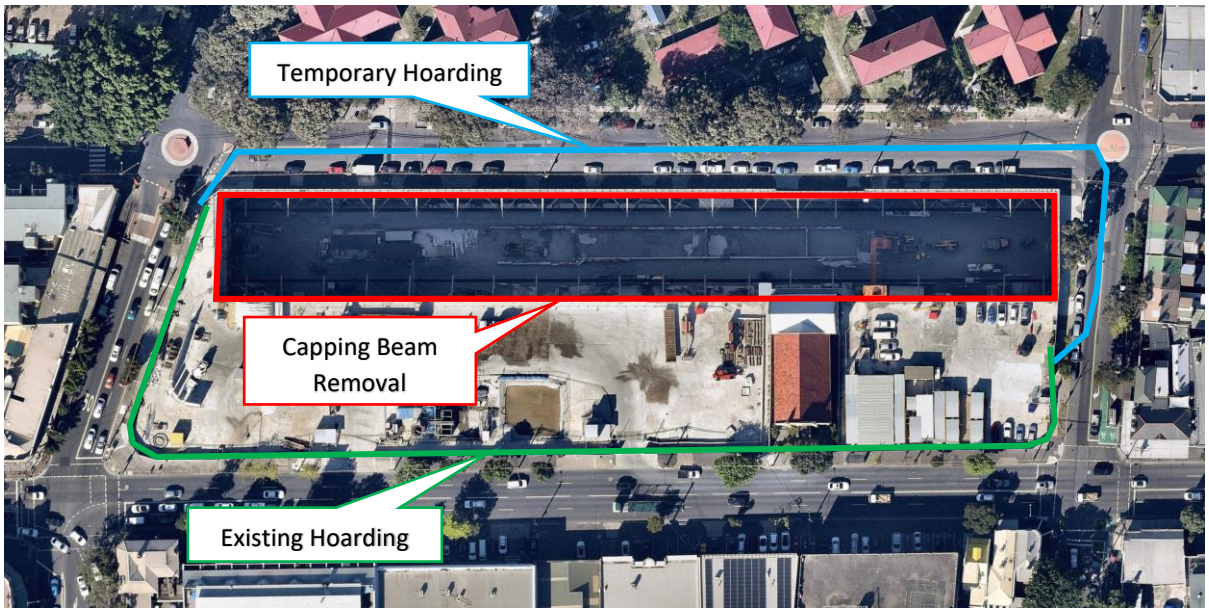
The standard and additional mitigation measures to be implemented based on the predicted construction noise levels will be discussed in **Section 12**.

9 Construction Methodology - Noise and Vibration Sources

9.1 Construction Activities

The proposed construction activities and tasks are outlined in **Table 11**. Temporary hoarding (ie. water filled barriers or concrete barriers fitted with acoustic blankets) with a height of 2070mm will be installed along Cope Street and Wellington Street to manage the noise emission from the proposed construction activities. The location of the proposed construction works are shown in **Figure 4**.

Figure 4 Location of Works



Source: JHG

Noise and vibration will be generated from the construction activities. The major noise and vibration generated equipment for each additional construction activity considered in this CNVIS are presented in **Table 11**.

Table 11 Equipment for each Construction Activity

Construction Scenario ID	Construction Activity	Location	Equipment
S15	Capping Beam Removal	Project Site	40t excavator with hammer; 40t excavator with bucket; Wire saw; Powered hand tools; Core drill; Jackhammer; and 8t excavator.

Capping beam removal will be completed using two alternative methods which have been selected based selecting plant and equipment that is suitable for the work with consideration for minimising impacts as much as possible. The capping beam surrounds the Waterloo station box. The section at the northern and southern ends of the station box can be removed using a wire saw, core drill, crane (already on site); and trucks to remove concrete segments from site. These areas will take approximately two and three weeks to complete once commenced.

The capping beam on the eastern and western sides of the station box will be removed using an excavator with hammer attachment. This will be supported by an excavator (with bucket). This method has been selected over the wire saw method due to site constraints which would inhibit or significantly increase the project duration. The constraints include inground utilities that are located adjacent to the capping beam which would require identification and/or removal to facilitate this activity. These areas will take approximately three months to complete and are expected to commence in late May 2022 and be completed in early September 2022.

9.2 Noise and Vibration Sources

9.2.1 Plant and Equipment at Noise Source Control

Plant and equipment likely to be used during construction are identified in **Table 12** along with maximum allowable sound levels in accordance with the CNVS.

Table 12 Maximum Plant and Equipment Sound Levels[1]

Plant Item	Maximum Allowable Construction Plant Sound Levels – dBA	
	Sound Power Level	Sound Pressure Level at 7m
40t excavator with hammer;	118	93
40t excavator with bucket;	115	90
Wire saw;	95	70
Powered hand tools;	94	69
Core Drill	107	82
Jackhammer;	113	88
8t excavator;	100	75

Note 1: Source - Maximum allowable sound level nominated in CNVS where possible.

9.2.2 Correction Factors

CoA E37 and E38 require that construction activities which have been proven to be "annoying" have a 5 dB penalty applied to them. In accordance with CoA E37 and E38, the following activities have been considered as being particularly annoying and as such, a 5 dB correction has been incorporated into the noise modelling process for them.

- Jackhammers/rock breakers.

10 Construction Noise and Vibration Assessment

10.1 Airborne Noise Assessment

Construction noise levels from the proposed S15 (Capping Beam Removal) construction activity have been predicted at the nearest noise sensitive residential and non-residential receivers and assessed against the NMLs presented in **Section 8.1** for standard construction hours and OOHW periods.

10.1.1 Residential Receivers

The predicted numbers of exceedances of the NMLs at residential receivers due to the proposed S15 (Capping Beam Removal) construction works during daytime standard hours and OOHW periods are summarised in **Table 13** and **Table 14**. The full set of predicted external noise levels for the noise affected residential receivers are shown in **Appendix B1**. The detail numbers of exceedances of the NMLs at residential receivers due to the construction works during daytime standard hours and OOHW periods are presented in **Appendix B3**.

The numbers of receivers presented in **Table 13** and **Table 14** are split into the following categories:

Standard construction hours:

- Less than 10dB above NML - Construction noise clearly audible
- 10-20 dB above NML - Construction noise moderately intrusive
- greater than 20 dB above NML - Construction noise highly intrusive
- greater than 75 dBA - highly noise affected

OOHW periods (i.e. daytime shoulder, evening and night):

- Less than 5 dB above NML - Construction noise clearly noticeable
- 5-15 dB above NML - Construction noise clearly audible
- 15-25 dB above NML - Construction noise clearly moderately intrusive
- greater than 25 dB above NML - highly intrusive

Table 13 Number of residential buildings where noise levels may exceed construction NMLs – Day (Standard Hours)

Construction Scenario ID	Plant/Equipment	Number of residential buildings where $L_{Aeq(15minute)}$ noise levels may exceed construction NMLs			
		0-10 dBA	10-20 dBA	>20 dBA	Highly Affected, >75dBA
S15	40t excavator with hammer	88	17	2	17

Construction Scenario ID	Plant/Equipment	Number of residential buildings where $L_{Aeq(15minute)}$ noise levels may exceed construction NMLs			
		0-10 dBA	10-20 dBA	>20 dBA	Highly Affected, >75dBA
	40t excavator with bucket	18	8	-	6
	Wire saw	5	-	-	-
	Powered hand tools	-	-	-	-
	Jackhammer	24	15	-	11
	Core drill	11	-	-	-
	8t excavator	-	-	-	-
	40t excavator + 8t excavator	20	8	-	6
	40t excavator + Wire Saw	18	8	-	6

Table 14 Number of residential buildings where noise levels may exceed construction NMLs – Day (OOHW Periods)

Construction Scenario ID	Plant/Equipment	Number of residential buildings where $L_{Aeq(15minute)}$ noise levels may exceed construction NMLs				
		0-5 dBA	5-15 dBA	15-25 dBA	>25 dBA	Highly Affected, >75dBA
S15	40t excavator with hammer	134	88	17	2	17
	40t excavator with bucket	30	18	8	-	6
	Wire saw	6	5	-	-	-
	Powered hand tools	-	-	-	-	-
	Core drill	6	11	-	-	-
	Jackhammer	68	24	15	-	11
	8t excavator	8	-	-	-	-
	40t excavator + 8t excavator	30	20	8	-	6
	40t excavator + Wire Saw	30	18	8	-	6

Additional Mitigation Measures Matrix (AMMM) has been developed in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (CNVS). The predicted number of exceedances of the RBLs in accordance with AMMM categories at residential receivers due to the construction works during daytime standard hours and OOHW periods are summarised in **Table 15**. The detailed numbers of exceedances of the RBLs at residential receivers due to the construction works during daytime standard hours and OOHW period sare presented in **Appendix B3**.

In accordance with AMMM, the numbers of receivers presented in **Table 15** are split into the following categories:

- 0-10 dB above RBL - Construction noise noticeable
- 10-20 dB above RBL - Construction noise clearly audible

- 20-30 dB above RBL - Construction noise moderately intrusive
- greater than 30 dB above RBL - Construction noise highly intrusive

Table 15 Number of residential buildings where noise levels may exceed RBLs (AMMM category) – Day

Construction Scenario ID	Plant/Equipment	Number of residential buildings where noise levels may exceed RBLs - Quantitative assessment of noise levels			
		0-10 dBA	10-20 dBA	20-30 dBA	>30 dBA
		-	-	M, LB	M, LB
S15	40t excavator with hammer	236	88	17	2
	40t excavator with bucket	129	18	8	-
	Wire saw	22	5	-	-
	Powered hand tools	6	-	-	-
	Core drill	24	11	-	-
	Jackhammer	202	24	15	-
	8t excavator	16	-	-	-
	40t excavator + 8t excavator	130	20	8	-
	40t excavator + Wire Saw	129	18	8	-

10.1.2 Other Receivers

The numbers of non-residential noise sensitive receivers where noise levels are expected to exceed the NMLs during daytime standard construction hours and OOHW periods of the receiver are summarised in **Table 16** and **Table 17**. The full set of predicted external noise levels and noise exceedances for all the noise affected non-residential receivers are shown in **Appendix B2**. The detailed numbers of exceedances of the NMLs at non-residential receivers due to the construction works during daytime period are presented in **Appendix B3**.

Table 16 Number of non-residential buildings where noise levels may exceed construction NMLs – Day (Standard Hours)

Construction Scenario ID	Plant/Equipment	Number of non-residential buildings where noise levels $L_{Aeq(15minute)}$ may exceed construction NMLs			
		0-10 dBA	10-20 dBA	>20 dBA	Highly Affected, >75dBA
S15	40t excavator with hammer	12	1	-	9
	40t excavator with bucket	4	-	-	1
	Wire saw	1	-	-	-
	Powered hand tools	-	-	-	-
	Core drill	-	-	-	-
	Jackhammer	10	-	-	2
	8t excavator	-	-	-	-
	40t excavator + 8t excavator	4	-	-	1
	40t excavator + Wire Saw	4	-	-	1

Table 17 Number of Non-residential buildings where noise levels may exceed construction NMLs – Day (OOHW Periods)

Construction Scenario ID	Plant/Equipment	Number of residential buildings where $L_{Aeq(15minute)}$ noise levels may exceed construction NMLs				
		0-5 dBA	5-15 dBA	15-25 dBA	>25 dBA	Highly Affected, >75dBA
S15	40t excavator with hammer	3	10	-	-	9
	40t excavator with bucket	3	1	-	-	1
	Wire saw	1	-	-	-	-
	Powered hand tools	-	-	-	-	-
	Core drill	-	-	-	-	-
	Jackhammer	9	1	-	-	2
	8t excavator	-	-	-	-	-
	40t excavator + 8t excavator	3	1	-	-	1
	40t excavator + Wire Saw	3	1	-	-	1

The predicted numbers of exceedances of the RBLs in accordance with AMMM categories at non-residential receivers due to the construction works during both standard construction hours and OOHW periods are summarised in **Table 18**. The detailed numbers of exceedances of the RBLs at non-residential receivers due to the construction works during daytime period are presented in **Appendix B3**.

Table 18 Number of non-residential buildings where noise levels may exceed RBLs (AMMM category) – Day

Construction Scenario ID	Plant/Equipment	Number of non-residential buildings where noise levels may exceed RBLs - Quantitative assessment of noise levels			
		0-10 dBA	10-20 dBA	20-30 dBA	>30 dBA
		-	-	M, LB	M, LB
S15	40t excavator with hammer	16	8	9	-
	40t excavator with bucket	9	9	1	-
	Wire saw	7	3	-	-
	Powered hand tools	1	-	-	-
	Core drill	9	2	-	-
	Jackhammer	13	8	3	-
	8t excavator	8	-	-	-
	40t excavator + 8t excavator	10	9	1	-
	40t excavator + Wire Saw	9	9	1	-

Note that the potential impacts identified in **Table 16** to **Table 18** apply when the properties are in use, i.e. during commercial opening hours or religious services. Some works would be undertaken outside of standard construction hours, sensitive receivers such as commercial and industrial receivers may not be affected significantly by the works.

10.1.3 Cumulative construction noise impacts

While most construction activities are expected to occur at separate times and locations, it is possible that noisy construction activities for the project may occur at the same time in close proximity to each other. In these cases, it is possible that predicted noise levels may increase by up to 3 dBA and there is potential that this would increase the number of receivers where noise levels would be greater than 20 dB above the NMLs.

10.2 Ground-borne Noise

The internal ground-borne noise levels at the most noise sensitive receivers have been predicted from the vibration generating construction activities. The numbers of receivers which resulting ground-borne noise exceedances are split into the following categories:

- 0-10dB above ground-borne NML - Construction noise clearly audible
- 10-20 dB above ground-borne NML - Construction noise moderately intrusive
- greater than 20 dB above ground-borne NML - Construction noise highly noise affected

10.2.1 Residential Receivers

The predicted numbers of exceedances of the internal ground-borne noise management levels (refer to **Table 6**) for residential receivers during day and night-time periods are presented in **Table 19**, together with the AMMM categories (refer to **Table 27**). The full set of predicted ground-borne noise levels and exceedance for the noise affected residential receiver are shown in **Appendix C**.

Table 19 Number of residential buildings where noise levels may exceed ground-borne NMLs

Construction Scenario ID	Plant/Equipment	Number of residential buildings where LAeq(15minute) noise levels may exceed ground-borne NMLs		
		Day		
		0-10 dB	10-20 dB	>20 dB
		LB	LB	M, LB, SN
S15	40t excavator with hammer	-	-	-

The predicted ground-borne noise levels at all residential receivers complied with Project NMLs outlined in **Table 6** during daytime periods.

10.2.2 Other Receivers

The predicted numbers of exceedances of the internal ground-borne noise management levels (**Table 6**) for non-residential receivers during daytime period are presented in **Table 20**. The full set of predicted ground-borne noise levels and exceedance for the noise affected non-residential receiver are shown in **Appendix C**.

Table 20 Number of non-residential buildings where internal noise levels may exceed ground-borne NMLs

Construction Scenario ID	Plant/Equipment	Number of non-residential buildings where noise levels LAeq(15minute) may exceed ground-borne NMLs		
		Day		
		0-10 dB	10-20 dB	>20 dB
		LB	LB	M, LB, SN
S15	40t excavator with hammer	-	-	1

One (1) non-residential receiver (Waterloo Congregational Church) will be potentially affected by the ground-borne noise from the S15 (Capping Beam Removal) construction works when 40t excavator hammer is used during daytime period.

10.3 Vibration Assessment

10.3.1 Minimum working distance

Vibration-intensive construction works may include the use of jack hammers, rock breakers and other vibration intensive plant. The minimum working distances of these vibration intensive plants should always be complied with at all times in order to prevent the building damage. The distances are noted as being indicative and are likely to vary depending on the particular item of plant and local geotechnical conditions. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

The minimum working distances for the vibration intensive equipment from off-site receivers are recommended in Appendix D of TfNSW's Construction Noise Strategy and reproduced in **Table 21**. The distances indicate the minimum separation distances where no adverse impacts from vibration intensive works are likely in terms of cosmetic damage to buildings/structures or human comfort.

Table 21 Recommended minimum working distances for vibration intensive plant[1]

Plant Item	Approx. Size/Weight/Model	Minimum Working Distance	
		Cosmetic Damage (BS7385)	Human Response (OE&H vibration guideline)
Vibratory Roller	1-2 tonne	5 m	15m to 20 m
	2-4 tonne	6 m	20 m
	4-6 tonne	12 m	40 m
	7-13 tonne	15 m	100 m
	13-18 tonne	20 m	100 m

Plant Item	Approx. Size/Weight/Model	Minimum Working Distance	
		Cosmetic Damage (BS7385)	Human Response (OE&H vibration guideline)
	> 18 tonne	25 m	100 m
Small Hydraulic Hammer	(300 kg – 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Pile Driver	Sheet piles	2m to 20 m	20 m
Pilling Rig - Bored	≤ 800 mm	2 m (nominal)	N/A
Pilling Rig – hammer	12 t down force	15 m	50 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: more stringent conditions may apply to heritage or other sensitive structures

Based on the indicative construction activities assessed for the project, some works may occur within the minimum working distances for human comfort and cosmetic damage of residential/commercial buildings and heritage listed items. It is noted that the minimum working distances can vary from site to site depending on ground conditions etc. To account for this the minimum working distances presented in **Table 21** are typically conservative in order to cover most sites and ground conditions. If vibration-intensive works are required within these minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in **Section 12**.

10.3.2 Human Comfort vibration Assessment

The predicted number of exceedances of the maximum human comfort vibration criteria (refer to **Table 9**) for residential and non-residential receivers are presented in **Table 22** and **Table 23**, respectively, for the vibration generating construction activities. The full set of predicted human comfort vibration levels and exceedance at the vibration sensitive residential and non-residential receivers are shown in **Appendix C**.

Table 22 Number of residential buildings where vibration levels may exceed human comfort vibration criteria

Construction Scenario ID	Plant/Equipment	Number of residential buildings where vibration levels may exceed human comfort vibration criteria
		Day
		M, LB, RP
S15	40t excavator with hammer	-

Table 23 Number of non-residential buildings where vibration levels may exceed human comfort vibration criteria

Construction Scenario ID	Plant/Equipment	Number of non-residential buildings where vibration levels may exceed human comfort vibration criteria
		Day
		M, LB, RP
S15	40t excavator with hammer	1

The predicted vibration level generated by the S15 (Capping Beam Removal) activities at all residential receivers complied with human comfort vibration criteria outlined in **Section 8.2.1** during daytime periods. One (1) non-residential receiver (Waterloo Congregational Church) will be potentially affected by the vibration emission generated by the S15 (Capping Beam Removal) activities when 40t excavator hammer is used during daytime period.

10.3.3 Structural Damage Assessment

The predicted number of exceedances of the structural damage criteria (refer to **Table 10**) for residential and non-residential receivers are presented in **Table 24** and **Table 25**, respectively, for the vibration generating construction activities. The full set of predicted vibration levels (PPV) and exceedances at the vibration sensitive residential and non-residential receivers are shown in **Appendix C**.

Table 24 Number of residential buildings where vibration levels may exceed structural damage vibration criteria

Construction Scenario ID	Plant/Equipment	Number of residential buildings where vibration levels may exceed structural damage vibration criteria
		Day
		M, LB, RP
S15	40t excavator with hammer	-

Table 25 Number of non-residential buildings where vibration levels may exceed structural damage vibration criteria

Construction Scenario ID	Plant/Equipment	Number of non-residential buildings where vibration levels may exceed structural damage vibration criteria
		Day
		M, LB, RP
S15	40t excavator with hammer	1

The predicted vibration level generated by the S15 (Capping Beam Removal) activities at all residential receivers complied with structural damage vibration criteria outlined in **Section 8.2.2** during daytime periods. One (1) non-residential receiver (Waterloo Congregational Church) will potentially be structurally affected by the vibration generated by the S15 (Capping Beam Removal) construction works when 40t excavator hammer is used during daytime period.

11 Discussion of Results

The predicted airborne noise levels from the proposed construction S15 (Capping Beam Removal) presented in **Appendix B1** show that the worst case predicted noise levels of up to 85 dBA is likely to occur at the most noise affected residential receivers (104 Raglan Street and 209 Cope Street) when 40t excavator hammer is being used. The Project NMLs of 64 dBA and 59 dBA for daytime standard hours and OOHW periods are exceeded by up to 21 dB and 26 dB, respectively, at the nearest residential receivers. The predicted construction noise levels are above the highly affected noise level of 75 dBA by up to 10 dB during daytime period. The predicted $L_{Aeq(15minute)}$ noise levels exceed the daytime RBLs of 54 dBA by up to 31 dB from the proposed S15 (Capping Beam Removal) activities at the nearest residential receivers

The predicted airborne noise levels presented in **Appendix B2** show that the worst case predicted noise level of up to 80 dBA at the nearest commercial receiver (76-84 Wyndham St), 81 dBA at the nearest industrial receiver (223 Cope Street), 68 dBA at active recreation areas (Cope Street Football Field), 67 dBA at passive recreation areas (Alexandria Park), and 84 dBA at the place of worship (Waterloo Congregational Church) are likely to occur during the "Capping Beam Removal" works when 40t excavator hammer is being used during daytime period.

The Project daytime NMLs are exceeded by up to 14 dB at the nearest non-residential receiver (Waterloo Congregational Church). The impacts for the non-residential receivers are only applied when the properties are in use, i.e. during commercial opening hours or religious services.

The results indicate the use of a 40t excavator hammer during the proposed "Capping Beam Removal" work creates the greatest exceedance during daytime period. The use of the 40t excavator hammer will be required during the initial work, i.e. to break the capping beams prior to excavation, the activities that follow are expected to generate less noise as the work continues through the daytime period. Alternative construction techniques, where possible, would be investigated during detailed planning and the noise mitigation measures presented in **Section 12** are recommended to be implemented to manage noise emissions. The community consultation will outline the work and the expected noise duration.

Attended noise monitoring will be undertaken as outlined in **Section 12**. The monitoring will be used to confirm the effectiveness of the noise management measures and if additional measures are required.

Recommended safe working distances are presented **Table 21** in order to assess the number of the receivers which may experience vibration affecting structural damage and human comfort. Where vibration intensive works need to be undertaken within the recommended minimum working distances, measures including vibration monitoring would be undertaken in line with the Construction Noise and Vibration Management Plan.

12 Mitigation Measures

12.1 Consultation to Identify Mitigation Measures

The Waterloo ISD Community Manager, who previously worked for the Sydney Metro Tunnel and Station Excavation Contractor, completed consultation with the Waterloo community and stakeholders. The following provides details of the consultation completed.

The Project Planning Approval Condition E33 requires the CNVIS to include specific mitigation measures identified through consultation with affected sensitive receivers. The consultation undertaken included the following:

- 5,100 leaflets were distributed (Friday 5 June 2020) to properties within 500 metres catchment area of the site, seeking community comments on the Waterloo Integrated Station Development, including construction impacts;

- eNews to approximately 1100 email subscriber (Friday 12 June 2020) seeking comments on the Waterloo Integrated Station Development, which included construction impacts;
- Community and Stakeholder Manager sent follow up emails to residents and businesses, seeking feedback in relation to previous construction impacts as well as any suggestions to consider in the development of the CNVIS;
- A total of 12 webinar sessions were held in June, where participants living or working in the area were asked to comment about construction impacts or make suggestions for improvements. Approximately 50 individuals attended the webinars to-date;
- Of the residents, business and landowner who attended the webinars, 11 individuals provided comments in relation to construction impact. Their properties were located in Wellington Street, Cope Street, Buckland Street, Regent Street and Botany Road.

12.2 Mitigation Measures

The outcome from the consultation sessions with the sensitive receivers and on the basis of being feasible and reasonable, mitigation measures that will be implemented during the construction works are summarised as follows:

- Adherence to daytime construction hours is recommended for construction works, in particular hydraulic hammering activities;
- Use hydraulic sears or pulverisers instead of hydraulic hammering where possible;
- Use dampened rock hammers;
- Night works, where applicable, should be programmed to minimise the number of consecutive nights work impacting the same receivers;
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers will result in reduced noise emissions;
- Equipment which is used intermittently is to be shut down when not in use;
- Where possible, the offset distance between noisy plant items and nearby noise sensitive receivers should be as great as possible;
- Where possible, equipment with directional noise emissions should be oriented away from sensitive receivers;
- Undertake compliance checks on the noise emissions of plant and machinery used for the Project to indicate whether noise emissions from plant items are higher than noise emissions from well-maintained plant;
- Regular noise monitoring during construction at sensitive receivers during critical periods to identify and assist in managing high risk noise events;
- Where possible heavy vehicle movements should be limited to daytime hours;
- Non-tonal reversing alarms should be fitted to all permanent mobile plant and during out of hours works;
- Reversing of equipment should be minimised so as to prevent nuisance caused by reversing alarms;
- Loading and unloading should be carried out away from sensitive receivers, where practicable;
- Installation of localised noise barriers around noisy areas;
- Installation of sound barrier screening to scaffolding where permitted noise levels are exceeded at neighbouring noise affected properties;
- Provision of respite from noise intensive activities;

- Alternate construction method or other negotiated outcomes with the affected community;
- Modifications or alterations to plant and equipment;
- Limiting times for certain construction activities that are high noise generating;
- Where possible separate structural connections between adjoining buildings using saw-cutting and propping, hand held splitters and pulverisers or hand demolition to reduce structure borne noise impacts.

12.3 Additional Mitigation Measures

Additional Mitigation Measures Matrix (AMMM) has been developed in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (CNVS). The AMMM includes definition of the level of noise impact compare with the background noise levels (RBLs) during standard construction hours and OOH periods. According to the CNVS, the following steps need to be carried out to determine the additional mitigation measures to be implemented:

- Determine the duration (time period) when the work is to be undertaken.
- Determine the level of exceedance.
- From the relevant AMMM table, identify the additional mitigation measures to be implemented.

Where the predicted construction noise and vibration levels exceed the noise and vibration management levels after the standard mitigation measures are applied, the additional noise mitigation measures in accordance with AMMM of the CNVS will be implemented based on the level of noise impact which triggers consideration of each additional mitigation measure (reproduced in **Table 26**, **Table 27** and **Table 28**).

The abbreviations are defined as the following:

AA: Alternative Accommodation; M: Monitoring; IB: Individual Briefing; LB: Letter Box Drops; RO: project specific Respite Offer; PC: Phone Calls and emails; and SN: Specific Notifications.

Table 26 AMMM - Airborne Construction Noise

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

Table 27 AMMM - Ground-borne Construction Noise

Time Period		Mitigation Measures Predicted LAeq(15minute) Noise Level Exceedance		
		0 to 10 dB	10 to 20 dB	>20 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	LB	LB	M, LB, SN
	Sat (8.00 am - 1.00 pm)			
	Sun/Pub Hol (Nil)			
OOHW	Mon-Sun (6.00 pm - 10.00 pm)	LB	M, LB, SN	M, IB, LB, PC, RO, SN
	Sat (1.00 pm - 10.00 pm)			
	Sun/Pub Hol (8.00 am - 6.00 pm)			
OOHW	Mon-Sat (10.00 pm - 7.00 am)	M, LB, SN	AA, M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)			
	Sun/Pub Hol (6.00 pm - 7.00 am)			

Table 28 AMMM - Ground-borne Vibration

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

13 Noise and Vibration Monitoring

Management and control of noise and vibration impacts shall be monitored and assessed as described below. Noise and vibration monitoring is to be undertaken by suitably qualified persons in accordance with the CNVMP.

Operator-attended measurements are to be undertaken within a period of 14 days from the commencement of each stage of construction in order to confirm that the noise and vibration levels in the adjacent community are consistent with the predictions in the CNVIS. Operator-attended noise measurements would be repeated at a minimum interval of every month in order to ensure ongoing compliance.

Figure 5 presents proposed noise monitoring locations for the additional construction scenarios. Real-time continuous noise monitoring would be implemented upon commencement of a high-risk activity or as required to manage a complaint. High-risk activities are defined in the Sydney Metro City & Southwest Out of Hours Work Strategy / Protocol (Version 4.3). The continuous noise monitor would be placed either within the construction site or alternatively at the Church.

Operator-attended noise monitoring is to be conducted at the nearest noise affected receivers upon commencement of the additional construction scenario S15 (Capping Beam Removal) in order to verify the noise modelling assumptions and results presented in the CNVIS. The following key locations are indicative monitoring locations based on the proximity to the works:

- 209 Cope Street
- 104 Reglan Street
- 123 Wellington Street
- 213 Cope Street
- 219 Cope Street
- 122-136 Wellington Street

Operator-attended noise monitoring will occur at the representative location closest to the receiver to review the predicted noise levels with the actual noise levels.

If the measured noise level from the operator-attended survey exceeds the CNVIS predicted noise level and the exceedance is related to construction activities (and not external sources e.g. road traffic), noise management and mitigation measures will be carried out in accordance CNVMP **Section 13.6.3** and **13.7.3**, including identifying and applying additional mitigation and management (ie. Replace the equipment, reduce the number of equipment or use of noise barrier etc.)

Figure 5 Noise and Vibration Monitoring Locations

Table 29 presents the indicative noise and vibration monitoring locations for the monitoring program for the proposed S15 (Capping Beam Removal) activities.

Noise measurements shall be undertaken consistent with the procedures documented in *AS 1055.1-1997 Acoustics - Description and Measurement of Environmental Noise - General Procedures*.

Table 29 Noise Monitoring Program

Type	Location	Timing/Frequency	Purpose
Noise	209 Cope Street	Operator-attended	Monitoring noise emissions from S15 (Capping Beam Removal) works
	104 Reglan Street		
	123 Wellington Street		
	213 Cope Street		
	219 Cope Street		
	122-136 Wellington Street		
Vibration	105 Botany Road (Waterloo Congregational Church)	Continuous	Monitoring vibration emissions from all construction activities that result in vibration

13.1 Plant and Equipment Noise Auditing

Internal compliance auditing of plant and equipment noise emissions would be undertaken via operator-attended measurements of a representative selection of plant and equipment used on-site. The representative items of equipment are to be regularly monitored to confirm that the operating noise levels of all noise intensive plant items comply with the maximum sound power levels in **Table 12**. Monitoring will be completed on a monthly basis.

13.2 Reporting

As per the requirements of the CNVMP, noise and vibration monitoring reports will be submitted to the Project Director and Environment and Sustainability Manager with noise and/or vibration monitoring results and details of affected sensitive receivers within one week of being undertaken or at weekly intervals for continuous monitoring. In the case of noise exceedances, details of the plant or operations causing the exceedances along with corrective action and the status of its implementation are to be supplied.

Details of noise and vibration monitoring will be reported to Sydney Metro on an annual basis. The consolidated noise and vibration monitoring report will be submitted to the Secretary and relevant regulatory agencies for information by Sydney Metro as required by Project Planning Approval C16.

13.3 Inspections

An activity log or site diary will be used by the Site Supervisor on site to keep an accurate record of construction activities on a daily basis. If required, the activity log will be used to correlate on-site activities with measured noise and vibration levels and/or complaints. The acoustic consultant may periodically review the proposed monitoring program with the aim to reduce or increase the monitoring depending on monitoring results and community feedback received.

The Site Supervisor, Environment & Sustainability Manager or nominated representative is to conduct regular site inspections, observing any instances of excessively noisy machinery or key activities that are associated with the works. Noise or vibration records are to be reviewed for potential issues arising from works. Results from the inspection are then to be recorded on an environmental checklist.

Copies of noise and vibration monitoring results will be made available to the Client as required.

14 Discussion of Additional Management Measures Triggered

AMMM have been triggered for airborne noise from the proposed additional construction activities listed in **Table 11**.

In summary, the following AMMM categories have been triggered:

Daytime standard hours:

- Monitoring
- Letter Box Drops

Daytime OOH periods:

- Monitoring
- Letter Box Drops
- Individual Briefing
- Phone Calls and emails
- Project Specific Respite Offer
- Specific Notifications

The residential receivers which trigger AMMM from airborne noise have been identified and listed in **Table 30** for the proposed S15 construction scenario (Capping Beam Removal).

Table 30 Residential Receivers Triggered Project Specific Respite Offer – Daytime OOHW period

Construction Scenario	Plant/Equipment	Receivers Triggered Project Specific Respite Offer (RO)
S15 Capping Beam Removal	40t excavator hammer	104 Raglan Street
		209 Cope Street

15 Conclusion

Noise and vibration impact assessment for the additional construction works associated with the Waterloo ISD have been undertaken. Due to the close proximity of adjacent receivers to the construction works, the noise generated activities from construction scenario S15 (Capping Beam Removal) are predicted up to 85 dBA at 123 Wellington Street and 209 Cope Street when 40t excavator is being used. The predicted noise levels from the proposed construction works exceeded the daytime NMLs by up to 21 dB and 26 dB, respectively, during standard hours and OOH periods. The predicted construction noise levels are above the highly affected noise level of 75 dBA by up to 10 dB when 40t excavator hammer is being used. The predicted construction noise levels exceeded the daytime RBLs by up to 31 dB at the most noise affected residential receivers.

The construction noise levels are predicted as up to 84 dBA at the nearest non-residential receiver when 40t excavator is being used. The predicted noise levels exceeded the daytime NMLs by up to 14 dB from the proposed "Capping Beam Removal" activities. It is also worth noting that the impacts for the non-residential receivers are only applied when the properties are in use, i.e. during commercial opening hours or religious services. Thus, the OOHWs undertaken during daytime periods may not affect significantly the non-residential receivers.

Additional noise mitigation measures in accordance with AMMM are recommended to be implemented for construction works conducted during standard construction hours and OOHW periods in accordance with the CNVMP.

Negotiations may be undertaken with these receivers in order to ensure that appropriate periods of respite are offered during sensitive periods.

Vibration safe working distances have been determined in accordance with the CNVS. Where applicable, periods of respite would be negotiated with receivers as per above and in accordance with AMMM.