

PITT STREET METRO STATION – OVER STATION DEVELOPMENT SOUTH

Assessment of Proposed Works Outside of Standard Hours

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The information contained herein is for the purpose of acoustics only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of acoustics engineering including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing and the like.

Supplementary professional advice should be sought in respect of these issues.

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1 Introduction

This report presents an assessment of proposed Outside of Standard Hours Works at the Pitt Street Metro Over Station Development South site.

Renzo Tonin has previously prepared a Construction Noise and Vibration Management Plan for this site in order to address condition of consent B512(b) (*Construction Noise and Vibration Management Plan* Rev 0 dated 26/5/2021 – the “Original CNVMP”).

This report only addresses works that were not already addressed (approved) in the Original CNVMP.

While the Original CNVMP report would generally remain applicable, this report will:

- Address specifically the works proposed that are outside of standard hours.
- Identify current conditions of approval that are proposed to be modified in order to permit the change.

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

2 Consent conditions

The Original CNVMP was prepared in order to address the requirements of SSD 10376D/2018/1128 Condition B51(b) as detailed below:

CONSTRUCTION NOISE AND VIBRATION MANAGEMENT SUB-PLAN

B51. Prior to the issue of the relevant Construction Certificate, the Applicant shall:

- (a) amend, or prepare an addendum to, the Construction Noise and Vibration Management Sub-Plan (CNVMP) applicable to the CSSI approval (CSSI 7400) to apply to the development. The amended CNVMP must be submitted to the Planning Secretary and Certifying Authority, or
- (b) prepare and implement a Construction Noise and Vibration Management Sub-Plan (CNVMP) for the development, independent of the CNVMP approved with the CSSI station works. A copy of the CNVMP must be submitted to the Planning Secretary and Certifying Authority. The Sub-Plan must include:
 - (i) identification of the specific activities that will be carried out and associated noise sources at the premises;
 - (ii) identification of all potentially affected sensitive residential receiver locations;
 - (iii) quantification of the rating background noise level (RBL) for sensitive receivers, as part of the Sub-Plan, or as undertaken in the EIS;
 - (iv) the construction noise, ground-borne noise and vibration objectives derived from an application of the EPA Interim Construction Noise Guideline (ICNG), as reflected in conditions of approval;
 - (v) prediction and assessment of potential noise, ground-borne noise (as relevant) and vibration levels from the proposed construction methods expected at sensitive receiver premises against the objectives identified in the ICNG and conditions of approval;
 - (vi) where objectives are predicted to be exceeded, an analysis of feasible and reasonable noise mitigation measures that can be implemented to reduce construction noise and vibration impacts;
 - (vii) description of management methods and procedures, and specific noise mitigation treatments/measures that can be implemented to control noise and vibration during construction;
 - (viii) where objectives cannot be met, additional measures including, but not necessarily limited to, the following should be considered and implemented where practicable; reduce hours of construction, the provision of respite from noise/vibration intensive activities, acoustic barriers/enclosures, alternative excavation methods or other negotiated outcomes with the affected community;
 - (ix) where night-time noise management levels cannot be satisfied, a report shall be submitted to the Planning Secretary outlining the mitigation measures applied, the noise levels achieved and justification that the outcome is consistent with best practice;
 - (x) measures to identify non-conformances with the requirements of the Sub-Plan, and procedures to implement corrective and preventative action;
 - (xi) suitable contractual arrangements to ensure that all site personnel, including sub-contractors, are required to adhere to the noise management provisions in the Sub-Plan;
 - (xii) procedures for notifying residents of construction activities that are likely to affect their noise and vibration amenity;
 - (xiii) measures to monitor noise performance and respond to complaints;
 - (xiv) measures to reduce noise related impacts associated with offsite vehicle movements on nearby access and egress routes from the site;
 - (xv) procedures to allow for regular professional acoustic input to construction activities and planning; and
 - (xvi) effective site induction, and ongoing training and awareness measures for personnel (e.g. toolbox talks, meetings etc).

As part of this application for extended work hours, a modification of condition B51(b)(iv) and (v) is suggested. It is suggested that clause (iv) and (v) be amended to include reference to City of Sydney Council *Code of Practice: Construction Noise and Vibration in the City Centre* in addition to EPA Interim Construction Noise Guideline when setting construction noise goals.

The purpose of this is:

- It enables the City of Sydney Code of Practice to be adopted when setting what constitutes standard construction hours. This is reasonable given the site location is in the city centre.

- EPA guidelines remain useful for guidance, particularly with reference to its commentary on reasonable and feasible noise mitigation methods in the event that strict compliance with a numerical noise emission target is not feasible.

3 Site Description / Summary of Works

3.1 Site Description

The Pitt Street Metro Station development consists of two station boxes (a north and south site) with an Over Station Development to be constructed over each of the station boxes:

- The north site (on the corner of Park, Pitt and Castlereagh Streets) and
- The south site (on the corner of Bathurst and Pitt Street).

The proposed Over Station Development (South) works involve the construction of residential tower (Levels 6 to 35), constructed on top of the podium building (being the Station Box South building). The upper levels of the Station Box Building (below the Over Station Development) are predominantly plant rooms.

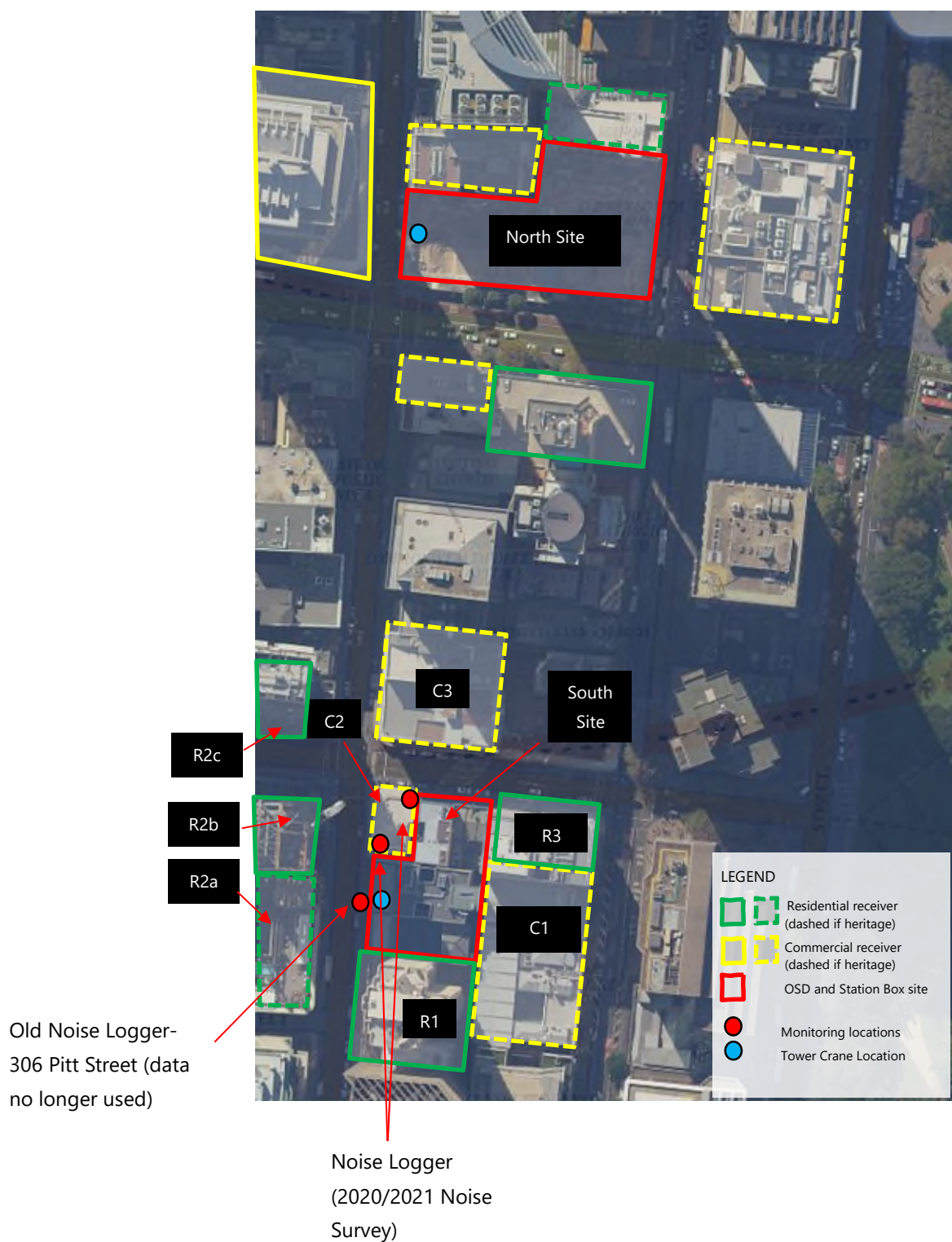
Noise sensitive development in the vicinity of the site is summarised below.

Table 1: Summary of nearest sensitive receivers

Receiver ID	Receiver type	Heritage Item?	Address
South site			
Receiver R1	Residential	No	304-308 Pitt Street (Princeton Apartments)
Receiver R2a	Hotel	No	339 Pitt Street (Primus Hotel)
Receiver R2b	Residential		115 Bathurst Street (Greenland Tower)
Receiver R2c	Hotel		329 Pitt Street (Meriton Suites)
Receiver R3	Residential	No	133-139 Bathurst Street
Receiver C1	Commercial	Yes	211 & 217 Castlereagh Street (Fire and Rescue Building)
Receiver C2	Commercial	Yes	294 Pitt Street (Edinburgh Castle Hotel)
Receiver C3	Commercial	Yes	102-104 Bathurst Street
Receiver C4	Commercial/Special Use	No	South Site Station Box.

The site and adjacent noise receivers are indicated in the aerial photo below. Items of heritage significance are indicated with dashed lines.

Figure 1: Site Aerial Photo and Surrounding Noise Receivers



3.2 Existing and Proposed Construction Hours

3.2.1 Standard Hours of Work

Construction hours are regulated by conditions of consent D3-7, as detailed below.

HOURS OF CONSTRUCTION

- D3. Construction, including the delivery of materials to and from the site, may only be carried out between the following hours:
 - (a) between 7am and 6pm, Mondays to Fridays inclusive; and
 - (b) between 8am and 1pm, Saturdays.
- D4. No work may be carried out on Sundays or public holidays.
- D5. Activities may be undertaken outside of these hours if required:
 - (a) by the Police or a public authority for the delivery of vehicles, plant or materials; or
 - (b) in an emergency to avoid the loss of life, damage to property or to prevent environmental harm.
- D6. Notification of such activities must be given to affected residents before undertaking the activities or as soon as is practical afterwards.
- D7. Rock breaking, rock hammering, sheet piling, pile driving and similar activities may only be carried out between the following hours:
 - (a) 9am to 12pm, Monday to Friday;
 - (b) 2pm to 5pm Monday to Friday; and
 - (c) 9am to 12pm, Saturday.

3.2.2 Proposed Extended Work Hours

The additional hours sought are as follows:

- Weekdays - 6pm to 10pm.
- Saturdays - 7am to 8am.
- Saturdays – 1pm-5pm.

Only specific construction works are proposed during the proposed additional work hours. These are set out below.

3.3 Summary of Proposed Works in Extended Hours

The works proposed during the extended hours is as follows:

Table 2: Works Summary (Outside of Standard Hours)

Stage	Description	Equipment Items
Weekday evenings (10pm finish)	Internal Fit Out Works once building façade is complete.	Hand tools (internal areas), Crane.
Saturday Morning (7am-8am)	Site Set up Internal Fit Out Works once building façade is complete.	Hand tools (internal areas), Electric Tower Crane.
Saturday Afternoon (1pm-5pm)	General Construction: Scaffolding, Formwork, Concrete Pouring, Vibrating and Finishing. Façade Works, Landscaping. Internal Works	Hand Tools (internal and external areas), Concrete Truck, Vibrator and Helicopter Float, Electric tower crane, electric mini crawler crane, hand tools.

Workzones (concrete trucks/deliveries) and crane locations are located on Pitt and Bathurst Street (refer to Appendix E).

4 Background Noise Levels

Background noise levels are used in setting construction noise management levels for the site.

As part of the Original Construction Noise and Vibration Management Plan, a detailed review of historical noise logging at the site was undertaken (noise logging from the EIS Stage, and the Tunnelling Station Excavation Stage/TSE Stage. These background noise surveys were supplemented by additional, more recent background noise surveys when determining background noise levels and construction noise emission goals.

These are summarised below:

Table 3: Ambient Noise Survey Results – South Site

Logger Location	Use for	Measured Noise Level		
		Day ¹	Evening ²	Night ³
302 - 306 Pitt Street (Historical Data)	TSE Noise survey (2018 survey)	63dB(A) _{Leq(15min)}	60dB(A) _{Leq(15min)}	57dB(A) _{Leq(15min)}
		59dB(A) _{L90}	57dB(A) _{L90}	53dB(A) _{L90}
Pitt Street Metro – South Site (Bathurst Street frontage)	2020 Ambient Noise Survey (10 to 17 December 2020)	71dB(A) _{Leq(15min)}	68dB(A) _{Leq(15min)}	67dB(A) _{Leq(15min)}
		65dB(A) _{L90}	63dB(A) _{L90}	59dB(A) _{L90}
Pitt Street Metro – South Site (Pitt Street frontage)	2020 Ambient Noise Survey (23/11 to 29/11 2020)	72dB(A) _{Leq(15min)}	67dB(A) _{Leq(15min)}	65dB(A) _{Leq(15min)}
		64dB(A) _{L90}	61dB(A) _{L90}	58dB(A) _{L90}

- Notes:
1. Day represents the period from 7am to 6pm, Monday to Saturday and 8am to 6pm, Sunday & Public Holidays.
 2. Evening represents the period from 6pm to 10pm, Monday to Sunday & Public Holidays
 3. Night represents the period from 10pm to 7am, Monday to Saturday and 10pm to 8am, Sundays & Public Holidays

5 Noise and Vibration Criteria

5.1 Hierarchy of Noise Controls

Condition B51(v) identifies the NSW *Interim Construction Noise Guideline* (ICNG, 2009) when setting construction noise goals.

Given the site is located within the City of Sydney CBD, it is proposed to modify condition B51(v) to allow typical City of Sydney construction noise requirements to be adopted for the proposed Saturday afternoon periods.

Being a guideline developed specifically for construction work in the Sydney CBD, the City of Sydney Construction Noise Guideline is more appropriate when setting noise emission goals for this project. This is of particular relevance to Saturday afternoon works, which is considered as being within standard construction hours in the Sydney CBD guideline.

5.2 Outside of Standard Hours Noise Criteria – City of Sydney Construction Noise Code

The City of Sydney also has a Construction Noise Code which sets out noise goals specific to the Central Business District. It is noted that the standard time periods, noise targets and noise descriptors differ from the ICNG. A summary of the noise criteria is set out below (time periods relevant to this assessment in **bold**).

Table 5: Summary of City of Sydney Noise Criteria

Category	Time Period	Permissible Noise Level [dB(A)] L _A (Av Max)
Mondays To Fridays		
4	00:00 to 07:00	Background + 0
1	07:00 to 08:00	Background + 5
1	08:00 to 19:00	Background + 5 + 5 to be determined on a site basis
2	19:00 to 23:00	Background + 3
4	23:00 to 24:00	Background + 0
Saturdays		
4	00:00 to 07:00	Background + 0
1	07:00 to 08:00	Background + 5
1	08:00 to 17:00	Background + 5 + 5 to be determined on a site basis
2	17:00 to 23:00	Background + 3
4	23:00 to 24:00	Background + 0
Sundays & Public Holidays		
4	00:00 to 07:00	Background + 0
3	07:00 to 17:00	Background + 3
4	17:00 to 24:00	Background + 0

5.3 Outside of Standard Hours Noise Criteria – EPA Guidelines

Condition B51(b) identifies the NSW *Interim Construction Noise Guideline* (ICNG, 2009) when setting construction noise goals.

While in our view the City of Sydney code is proposed when setting noise emission goals for the proposed construction work, the EPA guidelines remain useful for guidance, particularly with reference to its commentary on reasonable and feasible noise mitigation methods in the event that strict compliance with a numerical noise emission target is not feasible.

The table below reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 4: Noise management levels at residential receivers

Time of day	Management level L_{Aeq} (15 min) *	How to apply
Outside recommended standard hours	Noise affected RBL + 5dB	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 section 7.2.2 <i>[of the ICNG]</i>.

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

The table below sets out the ICNG noise management levels for other noise relevant receiver locations.

Table 5: Noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level L_{Aeq} (15 min)
Commercial premises	External noise level	70 dB(A)

Notes: Noise management levels apply when receiver areas are in use only.

5.4 Summary of Construction Noise Emission Goals

The table below presents the construction noise management levels established for the nearest noise sensitive receivers based upon the long-term monitoring outlined in Section 4.

The noise goals during the proposed extended hours periods are shown in **bold**.

Table 6: Construction noise management levels at receivers^{1, 2}

Receiver type	Time of Day ²	Noise Management Level	Sleep Disturbance
Residential	Day (Standard – 7am-6pm)	74dB(A) _{L_{eq}(15min)} 75dB(A) _{L_{eq}(15min)} – Highly Noise Affected Threshold	N/A
	Day (Outside of Standard Hours – Saturday Morning/Afternoon)	69dB(A)_{L_{eq}(15min)} (ICNG) 74dB(A)_{L_{AvMax}} (C of S)	N/A
	Evening (OOH)	66dB(A)_{L_{eq}(15min)} (ICNG) 64dB(A)_{L_{AvMax}} (C of S)	N/A
	Night (OOH) (after 10pm)	63dB(A) _{L_{eq}(15min)}	N/A
Commercial	When in use	70dB(A) _{L_{eq}(15min)}	N/A

5.5 Sleep Disturbance – Night Time Works

Given the proposed works will not extend after 10pm or commence before 7am, an assessment of sleep disturbance is not required.

5.6 Construction vibration criteria

5.6.1 Disturbance to Buildings Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's 'Assessing Vibration; a technical guideline' (DECC, 2006). 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 8 provides definitions and examples of each type of vibration.

Table 8: Types of Vibration

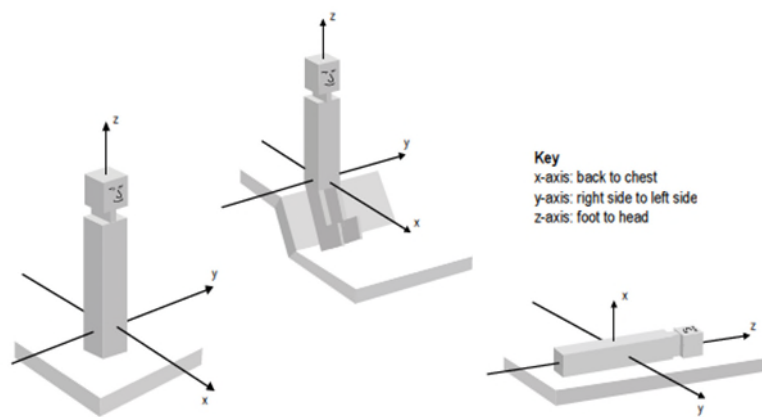
Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak 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, i.e. 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 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 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 in Table 5.1.

Table 5.1: 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 (Station Box)	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
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 (Station Box)	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

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 9.

Table 9: Acceptable Vibration Dose Values for Intermittent Vibration (m/s^{1.75})

Location	Daytime ¹		Night-time ¹	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas ²	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

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. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous of impulsive criteria for critical areas.
 Source: BS 6472-1992

5.6.2 Building Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- **Cosmetic** - *The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- **Minor** - *The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- **Major** - *Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

"7.4.2 Guide values for transient vibration relating to cosmetic damage

Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."

Within DIN4150-3, damage is defined as *"any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

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

These effects are deemed 'minor damage.' (DIN4150.3, 1990, p.3)

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 10 sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that *"a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive"* (p.5).

To determine whether the site buildings are structurally unsound, we recommend a dilapidation survey be conducted. The results of the survey will determine the adoption of the criteria for major or minor damage, rather than cosmetic damage.

Table 10: BS 7385 Structural Damage Criteria

Group	Type of Structure	Damage Level	Peak Component Particle Velocity ¹ , mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic		50	
		Minor ²		100	
		Major ²		200	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor ²	30 to 40	40 to 100	100
		Major ²	60 to 80	80 to 200	200
Notes:	1. Peak Component Particle Velocity is the maximum peak particle velocity (PPV) in any one direction (x, y, z) as measured by a tri-axial vibration transducer 2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2				

German Standard

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases.

The structural damage vibration criteria adopted for this project is presented in Table 11.

Table 11: DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

6 Construction Noise Assessment

6.1 Proposed construction noise sources

The schedule of items of plant and equipment likely to be used during the construction of the proposed development is presented in the table below.

Table 12: Equipment Sound Power Levels

Scenario	Plant Items	Sound power levels – dB(A) _{Leq}
1. General Construction (Saturday 1pm-5pm) - <u>Erection of Structure</u>	Formwork:	
	-Tower Crane (electric)	95*
	-Powered hand Tools	100
	-Alimak	100*
	Scaffolding:	
	-Tower Crane (electric)	95*
	-Powered Hand Tools	100
	-Alimak	100*
	Concreting Works:	
	-Tower Crane (electric)	95*
	-Vibrator	105
	-Concrete Pump/truck	104*
	-Slab Finishing (Helicopter float)	105
	Façade Installation:	
2. General Construction (Saturday 1pm-5pm) - <u>External Works</u>	-Tower Crane (electric)	95*
	- Mini Crawler Crane	97**
	-Powered Hand Tools (no rattle gun)	95
	-Alimak	100*
4. General Construction (Saturday 1pm-5pm) <u>Site Deliveries</u>	Crane (Electric)	95*
	Hand Tools (façade)	100
	Alimak	100
5. Weekday Evening: Internal Works	Crane – as marked in App G.	95*
	Forklift	95
	Alimak	100*
5. Weekday Evening: Internal Works	Crane (Electric)	95
	Hand Tools (façade)	100
	Alimak	100*

*Based on on-site measured operational noise proposed equipment items.

**Based on equipment sound data and crane engine being under power approximately 40% of 15 minute period.

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' and are generally consistent with the

noise levels for equipment items set out in the *Sydney Metro Out of Hours Work Application Form* document.

6.2 Predicted noise levels

Noise levels at any receiver location resulting from construction works depends on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken.

The table below presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site.

Noise levels were calculated taking into consideration the distance between the construction works and the receiver locations using noise prediction software for this project.

Where a range in noise levels is predicted, this is because the proposed work activity will occur in multiple locations (across the site/street frontages). The variation in predicted noise level reflects the fact that the work may be conducted close to the noise receiver, or at the opposite end of the site.

6.2.1 Noise Impact Assessment – General Construction Works (Saturday – 7am-8am and 1pm-5pm)

Table 13: Noise Emission Assessment – Saturday (7am-8am and 1pm-5pm)

Noise Criteria	Time	Criteria Noise Levels (dB(A) _{Leq(15min)})					
		Residential*			Commercial Receivers*		
		R1	R2	R3	C1	C2	C3
Noise Management (Leve)	City of Sydney – 7am-8am	69	69	69	N/A	N/A	N/A
	City of Sydney – 1pm-5pm	74	74	74	N/A	N/A	N/A
	EPA ICNG (For guidance purposes)	69	69	69	70	70	70
Work Item	Location / Plant Description	Predicted Construction Noise Levels - External (dB(A) _{Leq(15min)})					
		Residential*			Commercial Receivers*		
		R1	R2	R3	C1	C2	C3
Erection of Structure - Concrete Pours	Tower Crane – as marked in App F.	62	58	60	60	65	57
	Vibrator/Helicopter float – Across Floor Plate	60-80	60-75	60-80	60-80	60-80	60-70
	Alimak – as marked in App F.	70	60	65	65	72	60
	Concrete truck - as marked in App F.	65	65	70	70	75	72
	Cumulative	62-80*	60-75*	60-80*	60-80*	65-81*	60-74*
Erection of Structure - Formworking, Blockwork, Scaffolding	Tower Crane – as marked in App F.	62	58	60	60	65	57
	Hand tools – Across Floor Plate	55-78	50-66	55-75	55-75	55-75	50-66
	Alimak – as marked in App F.	70	60	65	65	72	60
	Cumulative	62-79	58-67	60-75	60-75	65-75	57-66
External Works – (Façade, External Plant)	Tower Crane – as marked in App F.	62	58	60	60	65	57
	Hand tools – Across Floor Plate	55-78	50-66	50-75	55-75	55-75	55-66
	Alimak – as marked in App F.	70	60	65	65	72	60
	Mini Crawler Crane	55-75	50-63	50-72	55-72	55-72	55-63
	Cumulative	62-79	58-67	60-76	60-76	65-76	57-68
		62-66**		60-66**			
Internal Works – (Fit out – after façade installation)	Tower Crane – as marked in App F.	62	58	60	60	65	57
	Hand tools – Across Floor Plate	<60	<50	<55	<55	<55	<45
	Alimak – as marked in App F.	70	60	65	65	72	60
	Cumulative	71	63	68	68	73	63

*Maximum noise levels occur when vibrator used in close proximity to slab edge. Noise level typically 5dB(A) lower when vibrator used away from slab edge.

**The louder cumulative noise level occurs when mini crawler crane located on southern or eastern façade (immediately adjacent R1 and R3 apartments). When working on the northern and western facades, noise level at R1 and R3 are lower (shown as ** levels)

Looking at the table above:

- Noise from activities such as use of hand tools, concrete vibrators and use of a crawler crane will intermittently exceed ICNG Noise Management Levels if the work location is close to residential property boundaries.
- Noise emissions are typically compliant with the City of Sydney noise guidelines for Saturday (1pm-5pm) periods, with exception being during use of a concrete vibrator, mini crawler crane or powered hand tools on the southern and eastern edge of the floor plate directly adjacent to an apartment in R1 and R3. Apartments that are 1-2 storeys above/below the work zone, or when work area is located away from the east/south slab edge will have lower noise levels (compliant with City of Sydney guidelines).
- Use of hand tools, use of concrete vibrators:
 - o These works can occur across the floor plate of any given level of the development so there is a significant range in noise emission predictions.
 - o Additionally, the predicted noise level from these works will vary based on the level within the building itself. For the noise impact on a given level on the adjacent apartment towers, the highest predicted levels occur only during the construction of the one or two levels immediately adjacent. The noise from works on levels above/below will be lower.
 - o While there are exceedances of noise goals when working at close proximity on the slab immediately adjacent a residential window, this worst case scenario only occurs for the works on 1-2 levels immediately adjacent to the apartment window.
- Reasonable and feasible noise mitigation is required. Given the potential intermittent exceedance of the EPA outside of Standard Hours criteria, noise management should be inclusive of consultation with neighbouring properties. See section 7.
- Ground Borne Noise - This is not anticipated to be an issue at the above site:
 - o Being over station development, there are no vibration intensive works proposed such as excavation or demolition.
 - o There are no buildings other than the Station Box that are physically connected to the OSD component of the site. While the Station Box is located immediately below, the Levels 4 and 5 of Station Box South consist primarily of ventilation plant rooms, and are not noise and vibration sensitive.

Taking the above into account - refer to Section 7 for recommended noise mitigation measures.

6.2.2 Noise Impact Assessment – Weekday Evening (6pm-10pm)

These works consist of:

- Internal works (behind building façade). For the purpose of calculation, for internal works, it is assumed that a 20dB(A) noise reduction occurs as a result of the noise loss through the completed building façade.

Table 14: Noise Emission Assessment – Weekdays (6pm-10pm)

Noise Criteria	Time	Criteria Noise Levels (dB(A) _{Leq(15min)})					
		Residential			Commercial Receivers		
		R1	R2	R3	C1	C2	C3
Noise Management Level	City of Sydney	64	64	64	N/A	N/A	N/A
	EPA ICNG (for guidance purposes only)	66	66	66	70	70	70
Work Item	Location / Plant Description	Predicted Construction Noise Levels - <u>External</u> (dB(A) _{Leq(15min)})					
		Residential			Commercial Receivers		
		R1	R2	R3	C1	C2	C3
Internal Works – (Fit out – after façade installation)	Crane – as marked in App F.	63	55	60	60	65	55
	Hand tools – Across Floor Plate	<60	<50	<55	<55	<55	<45
	Alimak – as marked in App F.	70	60	65	65	72	60
	Cumulative	70	61	66	66	72	61

*Maximum noise levels occur when vibrator used in close proximity to slab edge. Noise level typically 5dB(A) lower when vibrator used away from slab edge.

**The louder cumulative noise level occurs when mini crawler crane located on southern or eastern façade (immediately adjacent R1 and R3 apartments). When working on the northern and western facades, noise level at R1 and R3 are lower (shown as ** levels)

Looking at the table above:

- Internal Works - Internal works and crane use are predicted to comply with both EPA and City of Sydney Evening time construction noise guidelines. Exceedance are only anticipated in the event that hoist use is required in the evening time period – this will be avoided when feasible.

Consideration of both reasonable and feasible noise mitigation is required, as is detailed in section 7.

7 Construction noise mitigation measures and recommendations

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

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.

7.1 General noise management measures

The following general noise management measures are recommended for all receiver locations:

- Plant and equipment must be properly maintained.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel where feasible and reasonable. For the works the subject of this report, this will relate to the positioning of a concrete pump truck, which should be positioned as far from buildings R1 and R3 as possible if used during Saturday afternoon works.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work must be switched off. Plant used intermittently to be throttled down or shut down when not in use where practicable.
- Non-tonal reversing beacons for trucks and bobcats will be considered if feasible (depending on OH&S requirements).
- In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints – refer to section 9.
- Line of communication 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. Keeping people informed of progress and 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.

7.2 Site Specific Noise Management Measures

The following site specific noise management practices are required during after hours works:

- Neighbour notification:
 - o Notification (letterbox drop) to be made to developments physically adjoining the site. Key items that should be identified with respect to the proposed Outside of ours Works:
 - Dates of proposed concrete pours (particularly on Saturday afternoon).
 - Advising that works in evening periods will be constrained to internal areas behind façade on an as required basis.
- Internal works:
 - o Work in the 6pm-10am weekday period is only to be conducted on levels where the façade is complete (such that the façade provides noise mitigation to the nearby residences).
 - o As much as practicable, use of crane and internal lifts (once operational) as opposed to hoist is recommended.
 - o No use of hoist or crane after 10pm.
 - o Workers to be briefed not to take breaks in external areas during evening time periods.
- Respite periods:
 - o There is no rock breaking, rock hammering, sheet piling, pile driving or similar activities proposed. The automatic respite period required of condition of consent D7 is not expected to apply.
 - o The 7am-8am period on Saturday morning should be used for site set up and work in internal areas. Concreting work and external work using powered tools should not be conducted prior to 8am on a Saturday unless agreed with the residences at R1 and R3.
- Saturday afternoon works:
 - o Use of concrete vibrators and powered hand tools (facade work and form working) in very close proximity to residential properties boundaries to R1 and R3 have a risk in creating noise levels exceeding 69-74dB(A) management levels. There are no viable alternative equipment selections.
 - o In the case of a concrete pour, scaffolding and formworking - there will be only a small number of pours that will bring the construction work to close proximity to a given residence. Other pours will typically be further way on the floor plate, or two or more levels above or below the apartment, and the exceedance of the Noise Management Levels is less likely to occur.

- o In the case of powered hand tools (form working and façade work) – this work is typically intermittent in nature in any event. The benefits in respite would be relatively small and need to be balanced with the prolonging of the work period that will occur if they are introduced for this activity.
- o In the event of sustained complaint (more than two complaints, not vexatious and related to the works) - a respite period (or other form of respite such as meal voucher) can be negotiated with the adjoining residents (Receivers R1, R3 for South Site).
- Façade work (weekday evenings) – recommended that for nights when works on the southern or eastern facades are proposed, the residents at R1 and R3 are notified (letter box drop), with notification schedule of what level in the OSD building the façade works are proposed for.
- In the event that a generator is required to operate outside of standard work hours, manufacturers details of any proposed generator will be provided to determine if any form of acoustic enclosure (or specific equipment location to minimise noise) is required.
- All employees, contractors and subcontractors are to receive site induction and toolbox talks and ongoing training so that the above noise management measures are implemented accordingly. Content within toolboxes will include, location of nearest sensitive receivers; relevant project specific and standard noise and vibration mitigation measures; permissible hours of work, truck route and truck loading restrictions and construction employee parking areas.

7.3 Verification measurements/noise monitoring

- An on-site attended noise measurement will be conducted at Receivers R1 and R3 of:
 - o Typical noise level generated during internal works.

to verify if the noise impact is consistent with what has been predicted in this report. In the event that noise levels are significantly higher than anticipated (3dB(A) or higher), further mitigation is to be investigated. This will involve:

 - o Identification if a higher than expected noise level is expected to be consistent or a one off event.
 - o If expected to be ongoing, identification of additional mitigation measures such as alternative equipment or respite periods.
 - o Results of measurement and recommendations to be included in measurement report.
- On-going unattended noise monitoring is not recommended in the first instance as:
 - o The noise impact of the works is expected to be relatively small, and the highest noise impacts (structural work in close proximity to east and south boundaries) will not impact a given resident for extended periods.

- o Attended noise measurements will be more effective in determining suitable mitigation options compared to long term monitoring.
- In the event that either attended or long term noise monitoring is conducted, the procedures outlined in Appendix B are to be adopted.

8 Construction vibration assessment

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building's construction and structure. Unlike noise, vibration cannot be 'predicted' due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

Tactile vibration is not anticipated to be an issue at the above site:

- Being over station development, there are no vibration intensive works proposed such as excavation or demolition.
- The most vibration intensive works would be expected to be used of concrete saws or jackhammers at concrete penetrations or similar.
- There are no buildings other than the Station Box that are physically connected to the OSD component of the site.
- While the Station Box is located immediately below, the Levels 4 and 5 of Station Box South consist primarily of ventilation plant rooms, and are not noise and vibration sensitive.

In the event that machine mounted percussive demolition equipment is required within the development (eg – for slab penetrations), vibration monitoring should be conducted on Level 5 of the Station Box. Refer to Appendix C.

8.1 Vibration Mitigation Measures

The following vibration mitigation measures are recommended to minimise vibration impact from construction activities to the nearest affected receivers:

1. Penetrations or rectification work to slabs to be conducted using rotary equipment (saws) whenever feasible. If this is not feasible - percussive hand held equipment (jackhammer) should be used. Machine mounted percussive equipment should only be used in the event the other options are not viable. If machine mounted percussive equipment is required, refer to Appendix C for vibration monitoring requirements.

2. A management procedure must be implemented to deal with vibration complaints. Each complaint must be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures must be put in place to mitigate future occurrences.
3. Where vibration is found to be excessive, management measures must 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 and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.
4. Where construction activity occurs in close proximity to sensitive receivers or on material that will cause vibration to all identified receivers, vibration testing of actual equipment on site must be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

9 Complaints Management and Community Liaison

9.1 Communication with Nearby Land Users

9.1.1 Communication Generally

Communication with nearby land users to be conducted as follows:

- Regular communication with residents and business surrounding the site, including:
 - o Weekly email updates to subscribed stakeholder email distribution list outlining construction activities and planned work, during standard construction hours, proposed extended hours, and any other approved OOH work separate to this proposal
 - o offering project briefings to interested project stakeholders
 - o the provision of project contact details to make enquiries or complaints about the work
 - o the provision of project website details to find out more information about the work.
 - o Monthly letterbox drop community notifications, updates and out of hours work information delivered to properties within 200m radius from site.

9.1.2 Activity Specific Communication

Notification to nearby residents and businesses of works anticipated to extend outside of standard hours is required.

This should be done by letter box drop, email (or other method agreed pursuant to section 7) to R1, R2, R3, C1 and C2.

Construction work to take place during proposed extended hours (the subject of this plan), to be notified for by:

- Monthly community letterbox notification\.
- Weekly email update outlining planned work to take place during standard construction hours, extended hours (subject of this proposal) and other works outside of standard construction hours that may be approved to take place subject to separate approvals by the ER and AA.

9.2 Complaints Management

A complaint is defined as any communication received from a stakeholder expressing dissatisfaction. This is a purposely broad definition and is used to ensure that matters of concern to stakeholders are addressed promptly.

Stakeholders will be able to register enquiries and complaints through several channels including:

- Sydney Metro City & Southwest 24-hour, 1800 community information line (1800 171 386 which is run by Sydney Metro for the Project as a whole)

- Email to CPB project team or through Sydney Metro
- Dedicated website www.sydneymetro.info
- Post

The CPB complaints management process is outlined in Section 10 of the CPB Community Communications Strategy which has been approved by Sydney Metro.

Specific details on the above communication channels are made available within the project CPB *Community Communications Strategy*. Complaints may be received directly or referred by Sydney Metro or other contractors.

All calls to the 1800-number will be answered and responded to 24 hours a day, seven days a week. A call centre reception service managed by Sydney Metro records contact details and basic information about the nature and location of the complaint. The complainant is made aware that an on-call officer will contact them shortly to address the issue. With this approach, the caller is not placed on hold or referred to a recorded message. If the rostered officer cannot receive a call (e.g. they are on the phone responding to another caller), calls can be directed to an alternate rostered on-call officer.

Translators will be arranged if a stakeholder or community member is unable to communicate their concerns in English. Email and other contact options will assist those with disabilities.

Specific protocols and procedures have been arranged to ensure a consistent approach to managing enquires and complaints, including systems for recording and monitoring stakeholder contact. All staff and work crews will be informed that all contact from the community must be referred to the community relations team for action. To facilitate this everyone will be provided with community contact cards to direct enquiries to the community information line or email address.

Each stakeholder contact is an opportunity to build understanding about the Project and allay concerns. Complaints provide important feedback to improve project processes and mitigation measures to avoid or minimise further complaints. All reasonable measures will be taken to prevent the reoccurrence of stakeholder and community complaints.

The strategic approach to managing complaints consists of:

- Courtesy
- Accessibility
- Responsiveness
- Delegation of authority to resolve the issue
- Access to accurate information.

All employees and subcontractors are required to respond to stakeholders with courtesy and professionalism. This will be reinforced during Project inductions. Specific toolbox talks will further consolidate the approach.

The Contractor will immediately report all environmental complaints to the Project Environment Manager and relevant Environment Co-ordinator to confirm any required action, including but not limited to:

- Noise, and/or vibration monitoring.
- Subject to monitoring results consideration of options to reduce impacts including:
- Scheduling activities to minimise impacts
- Targeted inspection to determine if it is reasonable and to install additional controls (i.e. noise barriers/blankets if feasible)
- Respite offers (for example, coffee vouchers, movie tickets, meal vouchers or alternative accommodation)
- Site visit with complainant to assist in understanding our operations and mitigation strategies.

The complaint is escalated to the Contractor Project Director and Sydney Metro representative if the complainant remains unsatisfied. Further escalation will be in line with the Sydney Metro Overarching Community Communications Strategy (Sydney Metro Document Reference: A5732897) and the Sydney Metro Construction Complaints Management System and may include the:

- Environmental Representative required under Project Planning Approval Condition A22,
- Acoustic Advisor required under Project Planning Approval Condition A25,
- Community Complaints Mediator required under Project Planning Approval Conditions B11 to B14 or
- Independent Property Impact Assessment Panel (IPIAP) required under Project Planning Approval Condition E62 as appropriate.

10 Conclusion

This report has been prepared to address proposed Out of Standard Construction Hours works for the proposed Pitt Street Metro Station Over Station development (South) project.

The expected construction noise levels have been predicted and presented in Section 6.

Noise mitigation and management measures have been presented in Section 7 to aid in providing additional noise reduction benefits where exceedance of the objective occurs.

Vibration impacts and management measures have been presented in Section 8 to aid in minimising any potential vibration impacts.

APPENDIX A Glossary of terminology

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

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

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

APPENDIX B Specification for Construction Noise Monitoring

B.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

B.2 Referenced Standards and Guidelines

- Australian Standard AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters - Specifications*'
- Australian Standard AS 1259.2-1990 '*Acoustics - Sound Level Meters*'
- Australian Standard AS 1055-1997 '*Acoustics - Description and Measurement of Environmental Noise*'
- NSW '*Interim Construction Noise Guideline*' (Department of Environment and Climate Change 2009)
- NSW '*Industrial Noise Policy*' (Environment Protection Authority 2000)

B.3 Testing 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 Type 2 instruments as described in AS 1259.2-1990 and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). 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).

B.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).

Noise levels are to be recorded at a minimum rate of 10 samples per second. 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: L_{min} , L_{90} , L_{eq} , L_{10} , L_1 and L_{max} .

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. Presence of impulsive and tonal noise, and subsequent penalty, is to be determined in accordance with the provisions of Table 4.1 Modifying Factor Corrections of INP. Attended measurements may be required to determine modifying factor corrections in the first instance.

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.

Reporting of results to be provided monthly. Report to be provided to CPB within 1 week of the end of the monthly monitoring period.

Reporting to present:

- o Monitoring Location
- o Relevant equipment details such as make, model, serial number, photo, date of last NATA accredited laboratory calibration, photo of equipment in use.
- o Details of baseline data (L_{90} and $L_{eq(15min)}$).
- o Details of ambient (L_{90} and $L_{eq(15min)}$) and construction noise ($L_{eq(15min)}$) as measured during the construction monitoring period. Commentary with respect to other (non-construction) noise source if relevant (to the extent that they impact any construction noise measurement).
- o Assess noise levels with respect to the criteria identified in section 6.1.
- o In the event of exceedances of criteria, and if the exceedances are expected to be ongoing, identify further noise mitigation measures to be implemented.

B.5 Short-Term (Attended) Monitoring

Where noise complaints or requests from relevant authorities are received, 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.

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. Noise levels are to be recorded at a minimum rate of 10 samples per second. 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: L_{min} , L_{90} , L_{eq} , L_{10} , L_1 and L_{max} .

In addition to measuring and reporting overall A-weighted noise levels, statistical L_{90} , L_{eq} , L_{10} noise levels shall be measured in third-octave band frequencies from 31.5Hz to 8kHz.

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. Presence of impulsive and tonal noise, and subsequent penalty, is to be determined in accordance with the provisions of Table 4.1 Modifying Factor Corrections of INP.

Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 – 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 1m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and 1.5m from windows.

APPENDIX C **Specification for Construction Vibration Monitoring**

C.1 **Scope**

This document specifies methods for undertaking vibration monitoring during the construction phase of the project, where it may be deemed to be required. The vibration monitoring shall be conducted in accordance with DIN 4150.3 Structural Vibration in Buildings – Effects on Structures.

C.2 **Referenced Standards and Guidelines**

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- DECC NSW Assessing Vibration: A Technical Guideline
- DIN 4150.3 Structural Vibration in Buildings – Effects on Structures
- 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 Groundborne Vibration
- ISO 4866 Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings

C.3 **Testing Procedures**

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

All vibration monitoring equipment used must be calibrated at least once every two years to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The monitoring system should also have a measurement frequency range down to 1Hz.

C.3.1 **Short-Term (Attended) Monitoring**

Vibration monitoring shall be undertaken:

- at the commencement of operation for each plant or activity on site, which has the potential to generate significant vibration levels, so to refine the indicative minimum working distances and provide a site-specific table of minimum working distances

- vibration sensitive locations determined to fall within the 'buffer distances' established for each item of plant. Areas likely to require vibration monitoring are identified in this report; and
- 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.

Vibration monitoring shall be undertaken over the following period(s):

- for plant operating within the 'buffer distances', during the commencement of use of each plant on site until site-specific minimum working distances are established; and
- for complaints or requests from relevant authorities, during the of use of requested plant until site-specific minimum working distances are established.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. The magnitude of vibration is to be recorded at a minimum rate of 10 samples per second. The minimum range of vibration metrics to be stored in memory and reported are the following:

- Vibration Dose Values (VDVs)
- root-mean-square (rms) – maximums and statistical levels
- peak-particle velocity (ppv) – maximums and statistical levels.

In addition to measuring and reporting overall vibration, statistical vibration shall also be measured and reported in third-octave band frequencies from 1Hz to 250Hz.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;
- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using either bees wax or a magnetic mounting plate onto a steel washer, plate or bracket which shall be either fastened or glued to the surface of interest; and
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation; and
- Possible vibration influences from other sources (eg domestic vibrations, other mechanical plant, traffic, etc).

C.3.2 Long-Term (Unattended) Monitoring

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'minimum working distances' established for each item of plant during the commencement of use of each plant on site.

Vibration monitoring shall be undertaken over the following period(s):

- continuously whilst the vibrating plant is operational within the pre-determined 'minimum working distance' from the potentially affected building.

Vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.

Vibration is to be recorded at a minimum rate of 10 samples per second. The data is to be processed statistically and stored in memory. The minimum range of vibration metrics to be stored in memory for later retrieval is the following:

- Vibration Dose Values (VDVs)
- vector-sum root-mean-square (rms) – maximums and statistical metrics; and
- vector-sum peak-particle velocity (ppv) – maximums and statistical metrics.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;

- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using bees wax or a magnetic mounting plate onto a steel plate or bracket either fastened or glued to the surface of interest;
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that; and
- a flashing light alarm should be attached in a visible position from the construction work area. When vibration exceeds the set threshold, the light will flash notifying the operator that works in that area should cease immediately.

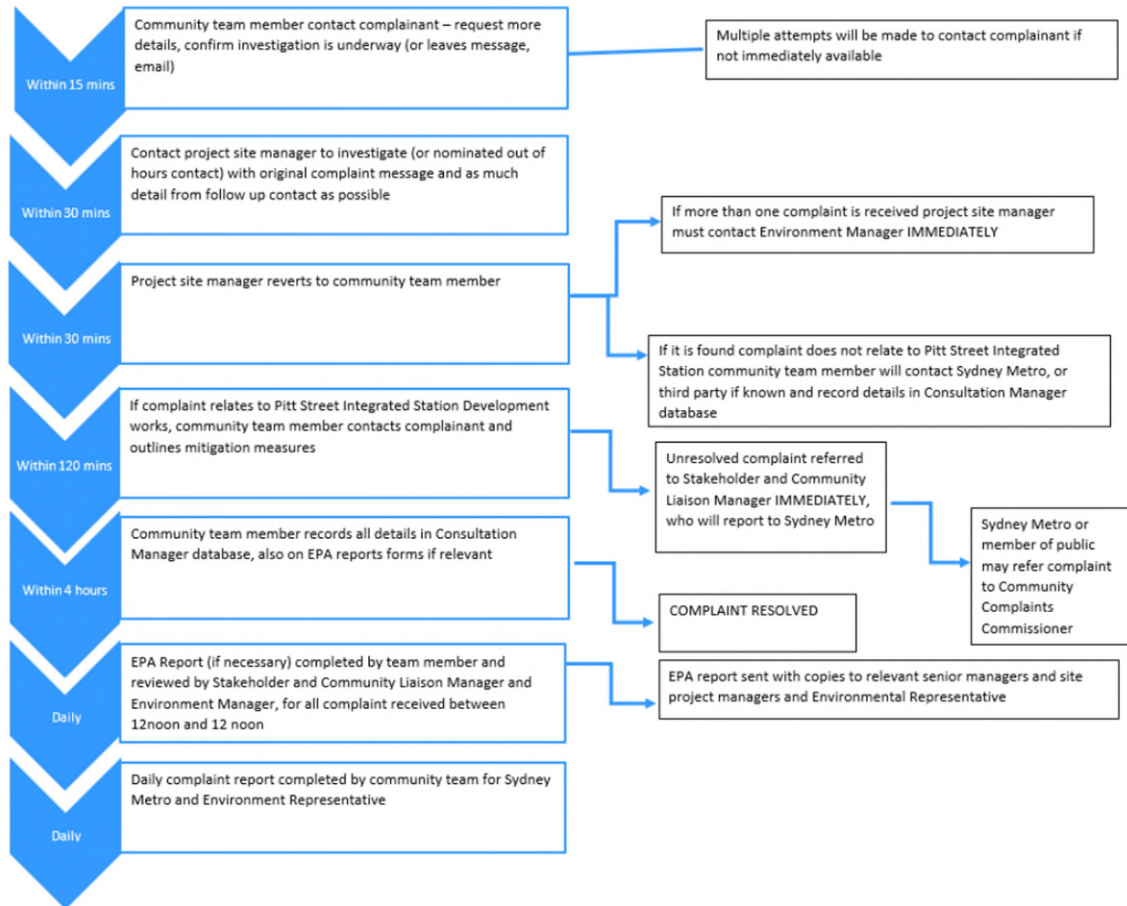
Vibration Monitor Set up and Reporting

- This is recommended only in the event that there is significant use excavator mounted hydraulic hammer or a vibratory roller and would be conducted on Level 5 of the Station Box Building.
- In the event that the construction works produce vibration levels well below the triggers outlined above, and there is no more vibration intensive equipment proposed, monitoring can cease (to be determined by Acoustic Consultant).
- Vibration monitoring results are to be made available in real time to CPB.
- Monitors will have real time SMS warning capability. SMS warning notification will be sent to the Contractor and their Acoustic Consultant in the event that the following thresholds are reached:
 - o 3mm/s Peak Particle Velocity for monitors at a Heritage Building.
 - o 8mm/s Peak Particle Velocity for monitors on other buildings, including Station Box.
- Reporting of results to be provided monthly. Report to be provided to CPB within 1 week of the end of the monthly monitoring period.
- Reporting to present:
 - o Monitoring Location.
 - o Relevant equipment details such as make, model, serial number, photo, date of last NATA accredited laboratory calibration, photo of equipment in use.
 - o Graphs of Peak Particle Velocity as measured during the construction monitoring period.
 - o Assess noise levels with respect to the criteria identified in section 6.2.
 - o In the event of exceedances of criteria, and if the exceedances are expected to be ongoing, identify further noise mitigation measures to be implemented.

APPENDIX D Noise/Vibration Complaint Management Procedure

Complaints management procedures as set out in the CPB *Community Communications Strategy* (17/7/620) document are to be adopted. Relevant sections are extracted below:

Enquiries / Complaints Management Flowchart:



Complaint Escalation:

Complaints should be escalated when:

- The complaint cannot be resolved using the procedure outlined in figure 4 or within a timeframe agreed to by the complainant.
- The nature of the complaint falls into one of the following categories:
 - an activity generates three complaints within a 24-hour period (separate complainants)
 - any construction site receives three different complaints within a 24-hour period
 - a single complainant reports three or more complaints within the 3 days period
 - a complainant threatens to escalate their issue to the media or government representative
 - the complaint was avoidable
 - the complaint relates to a compliance matter.

Complaints would first be escalated to the Sydney Metro Director, Communications (for Sydney Metro City & Southwest) as the designated complaints handling management representative for the relevant project.

Complaint Mediation:

In some circumstances where the complaints handling management representative for the project is unable to resolve the complaint, the complaint may be escalated to the project Community Complaints Mediator.

The role of the Community Complaints Mediator (CCM) is to facilitate communication between parties in conflict with the view to guiding/assisting these parties to reach a voluntary mutually agreeable outcome to the dispute. It is acknowledged that the role of the community complaints mediator is to mediate and not arbitrate. The mediator can actively encourage and facilitate discussion to move toward an outcome, however cannot order or decide an outcome for the parties.

The Community Complaints Mediator will provide information as to the mediation process during initial consultation, these actions will be dependent upon the complaint escalated, however may include;

- Through facilitation or other process(es) provide guidance, skills transfer and other services that aim to assist with any internal escalation mechanism
-
- Meet with aggrieved parties to understand concerns and suggest/implement methods as appropriate with the view to provide an opportunity to resolve and/or work through issues
 - Seek involvement of various internal and external subject matter experts such as, but not limited to the Environmental Representative and/or the acoustic advisor (in relation to SSI_7400 projects only).
 - Provide a proposal, developed by the parties which is facilitated by the mediator that clearly reflects a narrative that all parties agree upon in regard to the complaint mediation with due consideration to confidentiality requirements.

In instances where a complainant remains unsatisfied, the Secretary will be advised. The CCM will not act before;

- Sydney Metro has provided an initial response to an escalated complaint.

The CCM will not consider issues such as:

- Property acquisition where other dispute processes are provided for
- Where clear Government policy and associated resolution processes are available
- Where matter are not within the scope of the CSSI Project.

If the complainant states that the Department of Planning, Industry and Environment, NSW Environment Protection Authority, other TfNSW agencies and/or a local council have contributed to, or have a role in a particular complaint, the CCM may refer back to Sydney Metro for guidance and utilise their established interface pathways to liaise with either party.

APPENDIX E Construction Plan

