Appendix K

Construction Noise and Vibration Standard

Integrated Management System

Sydney Metro Construction Noise and Vibration Standard

SM-20-00098866

Sydney Metro Integrated Management System (IMS)

Applicable to:	Sydney Metro
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1. PURPOSE AND SCOPE

This Standard applies to the construction phase of all Sydney Metro projects. Design decisions on route selection, at-grade or underground rail systems and tunnel depth which effect operational noise are considered, amongst many other factors, during options assessment, stakeholder consultation, concept and detailed design.

Operational noise is an outcome of the design and is controlled by other standards.

The purpose of this Standard is to manage consistency in assessing construction noise and vibration impacts across Sydney Metro projects by filling the gap between industry guidelines, community & stakeholder perceptions and Sydney Metro's experience.

1.1. Distribution and Use

This document may be used in the development of, or referred to in:

- Environmental Impact Assessment documents;
- Design and construction environmental management documents;
- Contract documents; or
- Approvals and licences (subject to the agreement of the relevant regulatory authority).

1.2. Strategic Objectives

Sydney Metro recognise that sources of Noise and Vibration originating from our activities have a significant impact to local communities. We have adopted several strategic objectives to understand and manage these impacts:

- Applying a risk-based approach and implementing an appropriate hierarchy of controls at each stage of the project lifecycle to minimise impacts.
- Building an approach to reducing Noise and Vibration risks within each stage of the project lifecycle through active collaboration with internal and external stakeholders.
- Developing a clear understanding of our Construction Noise and Vibration Impacts and applying best practice management techniques.
- Valuing genuine community engagement that is sensitive to the needs and expectations of local communities and businesses.
- Committing to the continual improvement of Noise and Vibration management.

1.3. Construction Noise and Vibration Terminology

Decibel (dB): Decibel, often expressed as an 'A – weighted' sound pressure level, which has been found to correlate well with human subjective reactions to moderate noise levels. For steady, broadband noise, an increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness and a change of 2 to 3 dB is subjectively barely perceptible.

Sound Pressure Level (SPL or Lp): Expressed in dB, it is the level of noise measured by a standard sound level meter. It must be accompanied by a description of the measurement distance from the source, if used in any noise predictions or calculations. In a free field (eg outside on flat ground), each doubling of distance results in approximately 6dB reduction in airborne sound pressure level due to distance attenuation.

Sound Power Level (SWL or Lw): Expressed in dB, it is the total acoustic energy radiated by a plant or equipment to the environment. Sound power level is independent of distance from the source of the noise.

Rating Background Level (RBL): Rating background level is the overall single-figure background level representing each assessment period (day/evening/night) over a measurement period. As defined in the EPA "Noise Policy for Industry" dated October 2017.

Vibration: Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity (mm/s), acceleration (m/s^2) and Vibration Dose Value (VDV, $m/s^{1.75}$) are most commonly used when assessing human comfort issues respectively. Peak Particle Velocity (PPV, mm/s) is typically used to assess impacts on structures.

Ground borne noise and Structure-borne noise: The transmission of noise energy as vibration travelling through the ground and / or structures and re-radiated as audible noise.

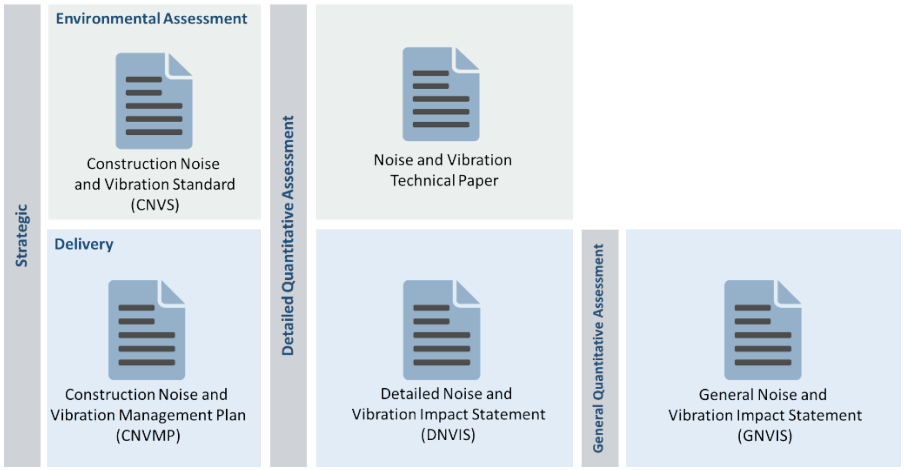
The three primary noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(1minute)}$	The typical 'maximum noise level for an event', used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level
$L_{Aeq(15minute)}$	The 'energy average noise level' evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.
L_{A90}	The 'background noise level' in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The LAeq(15minute) construction noise management levels are based on the LA90 background noise levels.

1.4. Documentation Framework

There are five main documents as illustrated in Figure 1 which comprise the noise and vibration documentation framework. Together they provide a comprehensive approach to the assessment and delivery of works which generate noise and vibration while mitigating the impacts.

Figure 1 - Noise and Vibration Documentation Framework



1.4.1. Construction Noise and Vibration Standard (CNVS)

The CNVS (this document) establishes a consistent strategy for the assessment, mitigation and monitoring of noise and vibration generated by construction activities. It defines a minimum standard for managing noise and vibration impacts that considers currently best practice guidelines and other regulatory requirements. It is included in all Sydney Metro Environmental Assessments.

1.4.2. Construction Noise and Vibration Management Plan (CNVMP)

Where works will cause significant noise and vibration impacts upon sensitive receivers Principal Contractors will be required to prepare and implement a CNVMP. These documents form part of the Construction Environmental Management Plan (CEMP) suite of documentation.

The function of the CNVMP is to provide a strategic overview of how the requirements of the CNVS will be applied to activities or locations under the control of the Principal Contractor. This overview includes an outline of how quantitative noise and vibration assessments will be undertaken across worksites and/or activities, and an indicative construction schedule.

The CNVMP also links to Community and Stakeholder consultation processes and explains how commercial and residential receivers will be consulted throughout the construction phase with regard to mitigating impacts upon them.

Further detail on the requirements for CNVMP's can be found in Sydney Metro's Construction Environmental Management Framework.

1.4.3. Noise and Vibration Technical Paper

The Noise and Vibration Technical Paper is produced as part of the Environmental Assessment carried out in the planning phase of Sydney Metro projects. This document is a Quantitative Noise Assessment based on information known at the time the assessment is undertaken and makes recommendations for mitigation.

Typically, it will include a range of assumptions on equipment lists and construction methodologies on the basis of which the impact upon sensitive receivers will be determined. As such, these Quantitative Assessments are generally conservative and may over predict actual impacts during construction.

1.4.4. Detailed Noise and Vibration Impact Statements (DNVIS)

While quantitative noise assessments are documented in environmental assessments, Principal Contractors will have a better understanding of the exact equipment list and construction methodology to be used in carrying out their works. As a result, certain assumptions made in the Noise and Vibration Technical Paper can be clarified in a secondary quantitative assessment undertaken by the Principal Contractor. These documents are referred to as either Detailed Noise and Vibration Impact Statements (DNVIS) or Construction Noise and Vibration Impact Statements (CNVIS). For the purpose of this document, terms DNVIS and CNVIS will be used interchangeably.

A DNVIS is typically prepared with a focus on noise-intensive construction sites and activities and considers works carried out inside and outside of standard working hours. A separate DNVIS will be prepared specifically for 24/7 works approved under an SSI approval.

Work described in a DNVIS cannot proceed until the DNVIS is approved by an Acoustic Advisor appointed under an SSI approval or other delegate approved by Sydney Metro. Should the scope of work or the timing of works change, the Principal Contractor must update the DNVIS and seek subsequent approval for the new version. See Section **3.1** for more detail on DNVIS's.

1.4.5. General Noise and Vibration Impact Statements (GNVIS)

General Noise and Vibration Impact Statements are also secondary assessments and have the same purpose as DNVIS's except that the assessment process is simplified. A GNVIS may be undertaken for works not being carried out under an SSI Approval.

Work described in a GNVIS cannot proceed until the GNVIS is approved by Sydney Metro. Should the scope of work or the timing of works change, the Principal Contractor must update the GNVIS and seek subsequent approval for the new version. See Section **3.2** for more detail on GNVIS's.

2. NOISE AND VIBRATION GUIDELINES

2.1. Construction Hours

Where possible, works will be completed during the standard day time construction hours of:

- Monday to Friday 7.00 am to 6.00 pm; and
- Saturdays 8.00 am to 1.00 pm

However, the nature of infrastructure projects means evening and night works are likely to be required throughout construction due to various considerations including avoiding sensitive periods for sensitive receivers, delivery of oversized plant or structures, emergency works, or other activities that require the temporary closure of roads. In some cases, these standard working hours may be varied by the project planning approval in recognition that works will need to be consistently undertaken during certain times such as morning shoulders or Saturday afternoons. For other situations the impacts of works outside standard construction hours may be approved via:

- Updates to the relevant activities' DNVIS or GNVIS;
- Out of Hours Works Application (OOHW) in line with Sydney Metro's Out of Hours Works Assessment Procedure; or
- An Environment Protection License (EPL), where Sydney Metro works comprise a 'scheduled activity' under the *NSW Protection of the Environment Operations Act 1997* (POEO); or
- Activation of emergency response procedures; or
- An approved alternative protocol developed by a delivery partner.

In other cases, there may be a need to assess activities that require 24 hour works for a significant portion of the construction period. Examples of construction scenarios that will require 24/7 works include:

- Excavation of station shafts;
- Truck movements to manage spoil;
- Excavation of the station caverns;
- Operation of tunnel boring machines;
- Spoil removal and transport from site; or
- Tunnel support works, including materials delivery.

Works requiring 24/7 activity are usually proposed in the environmental assessment and will be subsequently assessed in a secondary quantitative assessment during delivery. Where the need for 24 hour works arises post approval, a consistency assessment would be undertaken to determine if a modification to the planning approval is required.

2.2. Construction Noise Management Levels (NML)

Construction Noise Management Levels (NML) for all Sydney Metro projects are determined in accordance with the EPA's *Interim Construction Noise Guideline*, July 2009 (ICNG) unless the planning approval recommends an alternate approach, or sets different NMLs. The following sections supplement this guideline with respect to Sydney Metro projects.

2.2.1. Residences and Other Sensitive Land Uses

Noise Management Levels based on Rating Background Level (RBL) (as defined in the NSW EPA's *Noise Policy for Industry*, October 2017) for residences and how they are applied is set out in Table 1.

Table 1: Noise Management Levels for different times of day and considerations on their application

Time of Day	Noise Management Level $L_{Aeq\ (15minute)}$[1]	Management Considerations
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15minute)}$ is greater than the noise affected level, the proponent would apply all feasible and reasonable work practices to minimise noise. The proponent would also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent would consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent would communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent would 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 5 dBA above the noise affected level, the proponent would negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

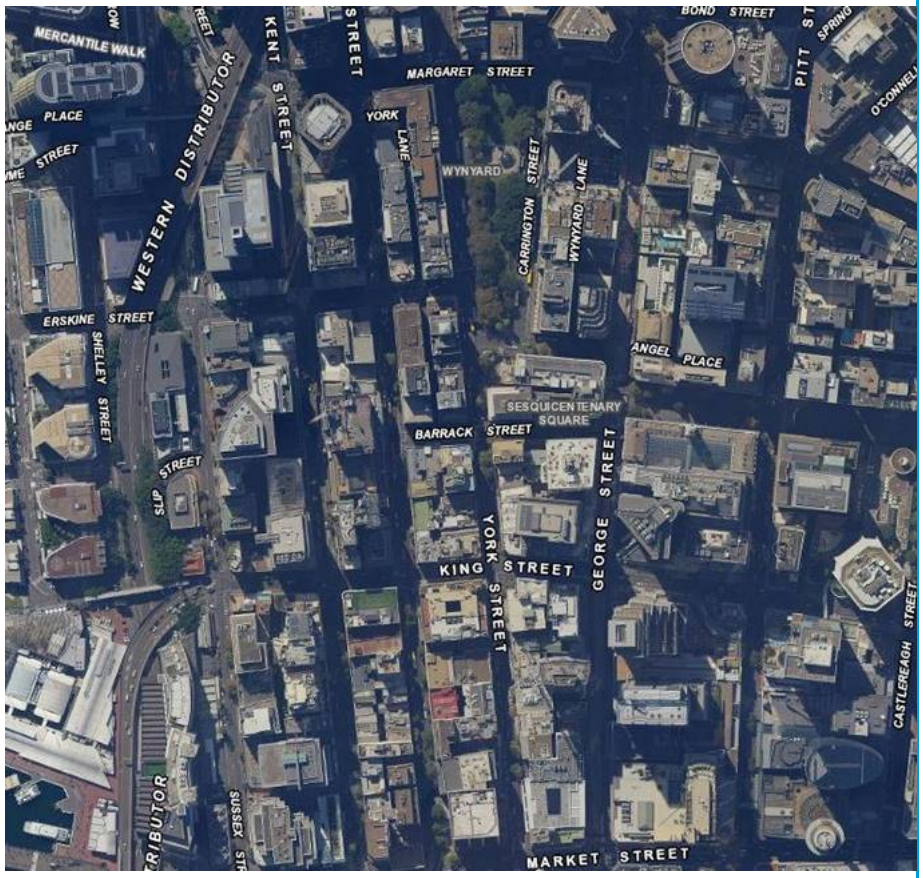
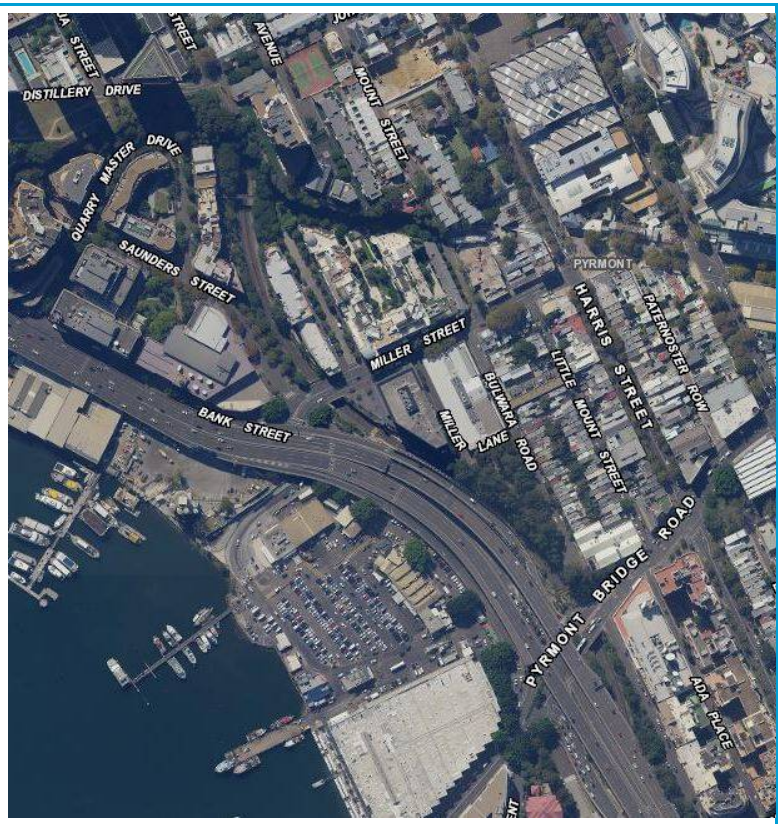
Note 1: Noise levels apply at the property boundary that is most exposed to construction noise. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

Where data is not available to calculate an applicable RBL, default RBL's derived from AS1055.2:1997 '*Acoustics – Description and measurement of environmental noise'* can be used as presented in **Table 2** for the appropriate noise area categories indicated by the building density and road use intensity (Average Annual Daily Traffic, AADT) versus open space examples shown in **Table 3**.

Table 2: Default Rating Background Noise Levels

Noise Area Category	Default RBLs (dBA) (external)		
Residential	**Standard Hours**	**Day/ Evening OOH**	**Night Time OOH**
Inner Urban (e.g. high density city hubs, near busy roads, near commercial/ industrial activity)	**60**	**55**	**50**
Outer Urban (e.g high traffic density roads, some commercial/ industrial activity	**55**	**50**	**45**
Suburban	**50**	**45**	**40**
Quiet, rural or isolated	**45**	**40**	**35**

Table 3: Noise Management Levels for certain sensitive receivers

Inner Urban	 Sydney City CBD	 Pyrmont Area: Western distributor ~110,000 AADT

Outer Urban	 Outer Parramatta area.	 Homebush: Residents adjacent to Centenary Drive (~ 80,000AADT) and the rail track.

Suburban	 Mays Hill, near Westmead (~ 30,000 AADT)	 Homebush: Residents away from Centenary Drive and the rail track.

Quiet, rural or isolated	 St Mary's: < 20,000 AADT	 Fairfield; Low density, shielded from and road noise (< 20,000 AADT)

Management levels for noise near properties which are sensitive to noise impacts are presented in **Table 4.** These values are set and based on the principle that the characteristic activities for each would not be unduly disturbed. The noise management levels apply only when the property is being used, for example, classrooms during school hours. Internal noise levels are to be assessed at the centre of the occupied room. External noise levels are to be assessed at the most-affected point within 50 m of the area boundary.

Table 4: Noise Management Levels for certain sensitive receivers

Land Use	Management Level, $L_{Aeq\ (15minute)}$ (Applies When Land Use is being Utilised)
Classrooms at schools and other educational institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas (such as parks and sports grounds or playgrounds)	External noise level 65 dB
Passive recreation areas (such as outdoor grounds used for teaching, outdoor cafes or restaurants)	External noise level 60 dB

Other noise-sensitive businesses require separate specific noise goals, and it is suggested in the ICNG that the internal construction noise levels at these premises are to be referenced to the recommended 'upper limit' internal levels presented in AS 2107:2016 *"Acoustics – Recommended design sound levels and reverberation times for building interiors"*. Recommended 'upper limits' for internal noise levels from AS 2107 are reproduced in **Table 5** for other sensitive receiver types.

The ICNG and AS 2107 do not provide specific criteria for childcare centres which generally have internal play areas and sleep areas. For these facilities, where feasible and reasonable the objective should be to achieve levels for sleeping of 45 dB(A) (consistent with hospital wards/places of worship) and for play areas of 65 dB(A) (consistent with playgrounds). These noise levels are also included in **Table 5**.

The proponent may undertake a special investigation to determine suitable noise levels on a project-by-project basis. The recommended internal noise levels presented in Table 1 of AS 2107 "*Acoustics - Recommended design sound levels and reverberation times for building interiors*" (Standards Australia 2016) may assist in determining relevant noise levels; however, an acoustic consultant would be engaged in order to determine corresponding external noise levels based on the published internal noise levels.

Table 5: Recommended 'Upper Limit' Internal Noise Levels

Land Use	Time Period	AS 2107 Classification	Recommended "Upper Limit" Internal LAeq (dBA)
Hotel	Daytime & Evening	Bars and Lounges	50
	Night-time	Sleeping Areas: - Hotels near major roads	40
Café	When in use	Coffee bar	50
Bar/Restaurant	When in use	Bars and Lounges / Restaurant	50
Library	When in use	Reading Areas	45
Recording Studio	When in use	Music Recording Studios	25
Theatre / Auditorium	When in use	Drama Theatres	30
Childcare Centres	Play areas when in use	N/A	65
	Sleeping periods	N/A	45

2.2.2. Commercial and Industrial Premises

Due to the broad range of sensitivities that commercial and industrial land can have to construction noise, the process of defining NML's is separated into three categories. The external noise levels would be assessed at the most-affected occupied point of the premises:

- Industrial premises (external): 75 dB $L_{Aeq(15minute)}$
- Offices, retail outlets (external): 70 dB $L_{Aeq(15minute)}$
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed in Section 2.2.1.

The proponent would assess construction noise levels for the project and consult with occupants of commercial and industrial premises prior to lodging an application where required. During construction, the proponent would regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.

2.3. Ground-Borne Vibration

The effects of vibration in buildings can be divided into three main categories;

1. Occupants or users of the building are inconvenienced or possibly disturbed;
2. Building contents or fit out may be affected; and
3. The integrity of the building or the structure itself may be prejudiced.

2.3.1. Human Comfort Vibration

"Assessing Vibration: a technical guideline" (DEC, 2006) recommends the use of BS 6472-1992 for the purpose of assessing vibration in relation to human comfort.

British Standard 6472-1992 "*Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration*" nominates guideline values for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependent upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period.

The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 6**.

Table 6: Vibration Dose Value Ranges above which various degrees of Adverse Comment may be expected in Residential Buildings

Place and Time	Low Probability of Adverse Comment ($m/s^{1.75}$)	Adverse Comment Possible ($m/s^{1.75}$)	Adverse Comment Probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.13	0.26	0.51

Intermittent vibration is measured as a Vibration Dose Value (VDV)

2.3.2. Cosmetic Damage Vibration

To achieve vibration criteria recommended in BS 7385 Part 2-1993 "*Evaluation and measurement for vibration in buildings Part 2*" as they are "applicable to Australian conditions", conservative vibration damage screening levels per structure type are:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

NB. Consistent with the Standard, levels have been conservatively reduced by 50% to reflect any dynamic loading caused by continuous vibration.

Landowners and occupiers of properties at risk of exceeding the screening criteria for cosmetic damage would be identified in a Noise and Vibration CEMP Sub-plan and would also be notified prior to commencing works that generate vibration near those properties.

If such works are to extend over a period of 24 hours, landowners and occupiers are to be provided a schedule of potential exceedances on a monthly basis for the duration of the potential exceedances, unless otherwise agreed by the landowner and occupier.

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, dominant frequencies and dynamic characteristics of the structure and vibration sources, would be required to determine the applicable safe vibration level.

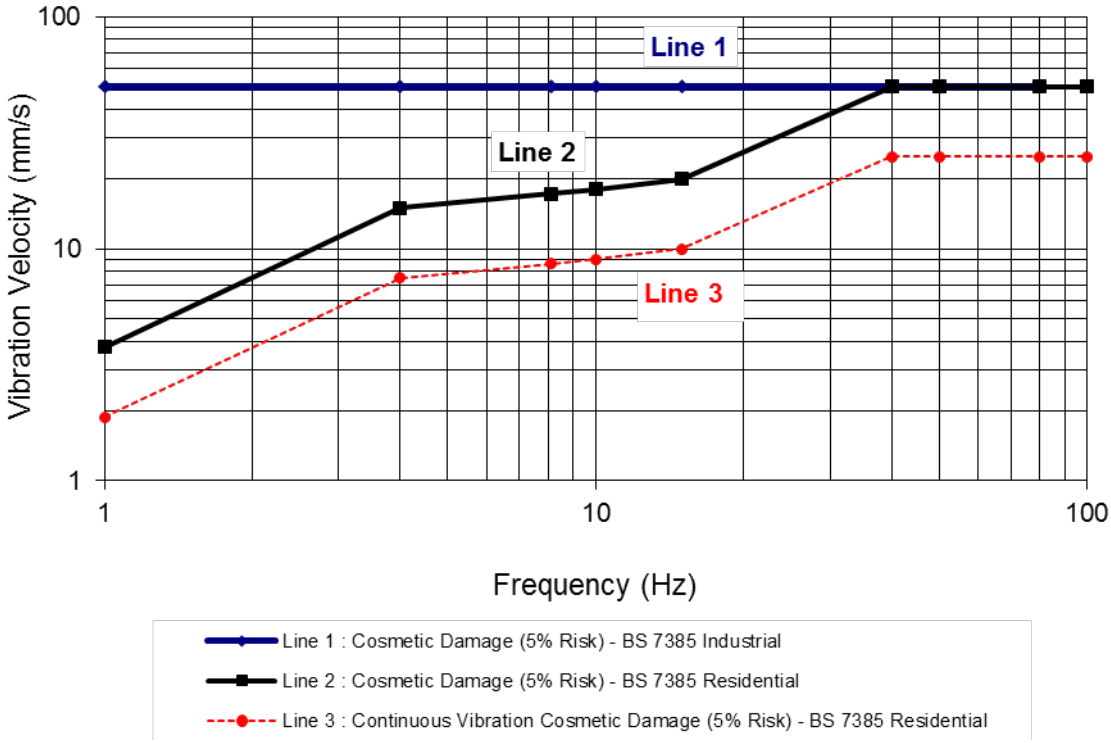
For residential and industrial building structures, detailed analysis of dominant frequencies and dynamic characteristics are guided by BS 7385 Part 2-1993 *"Evaluation and*

measurement for vibration in buildings Part 2" which recommends the limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage as presented numerically in **Table 7** and graphically in **Figure 2**.

Table 7: Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

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

Figure 2: Graph of Transient Vibration Guide Values for Cosmetic Damage



The Standard states that the guide values in **Table 7** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 7** may need to be reduced by up to 50%.

Note: rock breaking/hammering, and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g., residences) and it may therefore be appropriate to reduce the transient values by 50%.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measured would be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) would be compared with the guidance curves presented in **Figure 2**.

2.3.3. Heritage

Heritage buildings and structures would be assessed as per the screening criteria in section 2.3.2 as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection documented in a report) a more conservative cosmetic damage criterion of 2.5mm/s peak component particle velocity (from DIN 4150) must be applied, unless an alternative criterion is specified by a suitably qualified and experienced structural engineer with heritage expertise.

2.3.4. Sensitive Scientific and Medical Equipment

Some scientific equipment (e.g., electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use inside the premises of an identified vibration sensitive receiver, objectives for the satisfactory operation of the instrument would be sourced from manufacturer's data. Where manufacturer's data is not available, generic vibration criterion (VC) curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon - 28 September 1999) may be adopted as vibration goals. These generic VC curves are presented below in **Table 8** and **Figure 3**.

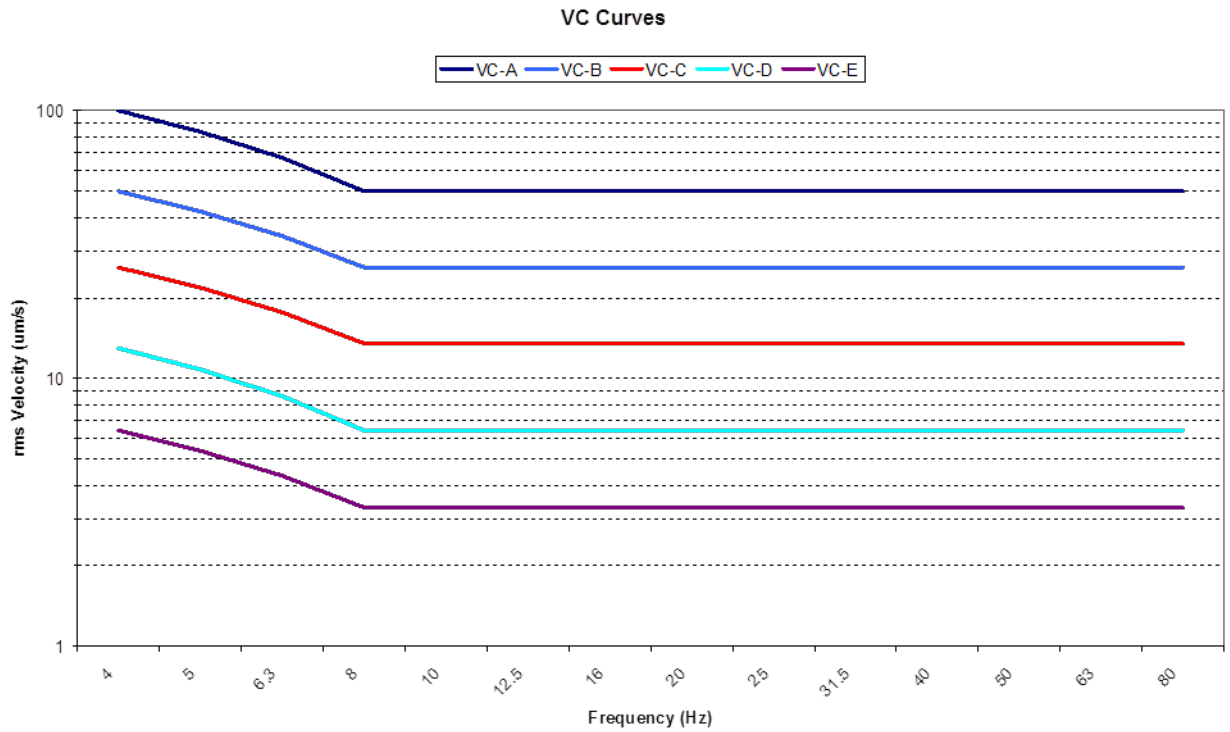
Table 8: Application and Interpretation of the Generic Vibration Criterion (VC) Curves (as shown in Figure 3)

Criterion Curve	Max Level (µm/sec, rms)[1]	Detail Size (microns)[2]	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note 1: As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

Note 2: The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation requirements of many items depend upon the detail size of the process.

Figure 3: Vibration Criterion (VC) Curves



2.3.5. Other Vibration Sensitive Structures and Utilities

Transport for NSW *'Construction Noise and Vibration Management Strategy'* (2019) provides the following guidance based on German and British Standards.

Buried pipework and services
The British Standard BS 7385-2:1993 'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground-borne vibration' notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition (British Standard BS 7385-2:1993, p5).

Further guidance is taken from the German Standard DIN 4150: Part 3-1999.02 'Structural vibration in buildings – Effects on Structures'. Section 5.3 of DIN 4150: Part 3 sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values are reproduced and presented in **Table 9**, below.

Table 9: DIN 4150-3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe
1	Steel (including welded pipes)	100 mm/s
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80 mm/s
3	Masonry, plastic	50 mm/s

Note: rock breaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures and it may therefore be appropriate to reduce the transient values by 50%.

Other Vibration Sensitive Structures and Utilities
Some structures and utilities located a project may be particularly sensitive to vibration. A vibration goal which is more stringent than structural damage objectives presented in Table 9 may need to be adopted. Examples of such structures and utilities include:

- Tunnels
- Gas pipelines
- Fibre optic cables

Specific vibration objectives should be determined on a case-by-case basis. An acoustic consultant should be engaged by the construction contractor to liaise with the structure or utility's owner to determine acceptable vibration levels.

2.4. Vibration and Overpressure from Blasting

The DECC's ICNG recommends that vibration and overpressure from blasting be assessed against the levels presented in the Australian and New Zealand Environment Council's (ANZEC) Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZEC, 1990).

The criteria set by this standard were based on practices undertaken more than 30 years ago and were targeted at operations that occur for long periods of time such as those at mining sites and hence are targeted at protecting human comfort vibration levels. As a result the vibration levels are conservative and can introduce unnecessary constraints when applied to construction projects which typically occur for much shorter time periods. Recent NSW infrastructure project approvals have recognised the restrictive nature of these blasting criteria when applied to construction projects and have therefore allowed the following vibration and overpressure limits:

- Vibration (PPV): 25 mm/s
- Overpressure: 125 dBL

These upper limits are deemed acceptable where the proponent has a written agreement with the relevant landowner to exceed the criteria and the Secretary has approved the terms of the written agreement. These upper limits to vibration and overpressure are intended to target the protection of building structures from cosmetic damage rather than human comfort criteria as construction works are considered short-term.

2.5. Ground-Borne (Regenerated) Noise

Ground-borne (regenerated) noise is noise generated by vibration transmitted through the ground into a structure. Ground-borne noise caused, for example by underground works such as tunnelling, can be more noticeable than airborne noise. The following ground-borne noise levels for residences are nominated in the ICNG and indicate when management actions would be implemented. These levels recognise the temporary nature of construction and are only applicable when ground-borne noise levels are higher than airborne noise levels. Any levels exceeding objectives should be considered in the context of any existing exposure to ground-borne noise.

The ground-borne noise management levels are given below:

- Evening (6.00 pm to 10.00 pm)
  Internal Residential: 40 dB $L_{Aeq(15minute)}$
- Night-time (10.00 pm to 7.00 am)
  Internal Residential: 35 dB $L_{Aeq(15minute)}$

The evening and night-time criteria are only applicable to residential receivers.

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, the L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts. The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays).
- Is prepared to accept a longer construction duration in exchange for days of respite.

2.6. Traffic Noise Assessment Goals

When trucks and other vehicles are operating within the boundaries of the various construction sites, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. When construction related traffic moves onto the public road network a different noise assessment methodology is appropriate, as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site.

The ICNG does not provide specific guidance in relation to acceptable noise levels associated with construction traffic. For assessment purposes, guidance is taken from the DECCW's NSW Road Noise Policy (RNP).

One of the objectives of the RNP is to apply relevant permissible noise increase criteria to protect sensitive receivers against excessive decreases in amenity as the result of a proposal. In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

On this basis, construction traffic NMLs set at 2 dB above the existing road traffic noise levels during the daytime and night-time periods are considered appropriate to identify the onset of potential noise impacts. Where the road traffic noise levels are predicted to increase by more than 2 dB as a result of construction traffic, consideration would be given to applying feasible and reasonable noise mitigation measures to reduce the potential noise impacts and preserve acoustic amenity.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration would also be given to the actual noise levels associated with construction traffic and whether or not these levels comply with the following road traffic noise criteria in the RNP:

- 60 dB $L_{Aeq(15hour)}$ day and 55 dB $L_{Aeq(9hour)}$ night for existing freeway/ arterial/ sub-arterial roads.
- 55 dB $L_{Aeq(1hour)}$ day and 50 dB $L_{Aeq(1hour)}$ night for existing local roads.

2.7. Sleep Disturbance and Maximum Noise Events

Maximum noise level events from construction activities during the night-time period can trigger both awakenings and disturbance to sleep stages. The approach to managing events that cause sleep disturbance shall be consistent with the Noise Policy for Industry (EPA, 2017). Where night-time noise levels at a residential location exceed the:

- LAeq,15min 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or the
- LAFmax 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

a detailed maximum noise level event assessment is to be undertaken.

The detailed assessment will cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the number of times this happens during the night-time period.

Maximum noise level event assessments should be based on the LAFmax descriptor on an event basis under 'fast' time response. The detailed assessment will consider all feasible and reasonable noise mitigation measures with a goal of achieving the above trigger levels for night-time activities.

3. CONSTRUCTION NOISE & VIBRATION ASSESSMENT METHODOLOGY

There are planning processes at all levels of government that may apply to works carried out by Sydney Metro, some of these processes (particularly State and Federal planning processes) require a detailed Environmental Assessment of the construction phases for the proposal. As construction contractors are not typically appointed until later in a project's timeline, the exact construction methodology they will use for a particular project may not be known when the environmental assessment is being carried out (see **Table 10**).

With respect to the assessment of noise and vibration impacts in environmental assessments they are to include a detailed quantitative assessment that adopts conservative assumptions to account for uncertainty in the precise delivery methodology. In most circumstances the noise and vibration impacts predicted by an environmental assessment will overestimate real impacts during delivery. As a result, this strategy requires secondary quantitative assessments to be undertaken during delivery by the Principal Contractor to verify impacts and better inform how to mitigate impacts.

For works approved under Division 5.2 of the EP&A Act, further quantitative noise and vibration assessments in the form of a DNVIS will be undertaken for activities and/or locations where work will occur. Works subject to a DNVIS will not proceed until the DNVIS has been approved by an Acoustic Advisor appointed under an SSI approval, or where there is no SSI approval, approved by Sydney Metro. Section 3.1 of this Standard provides information on the requirements for a DNVIS.

For construction works approved under any other planning approval pathway, the secondary quantitative noise assessment may take a less detailed approach in the form of a GNVIS. Section 3.2 of this Standard provides information on the requirements for a GNVIS.

In order to develop a comprehensive secondary assessment framework specific details of the construction methodology is required. Detailed design, construction and engineering solutions are progressively developed and applied throughout the life-span of the project and consequently secondary assessments are to be updated to reflect changing design and/or construction methodologies. Secondary assessments may take one of two forms and each are updated when a change occurs:

- General Construction Activity for construction scenarios that are consistently the same and progressively move along the project alignment e.g. tunnelling, retaining walls.
- Location Specific for construction scenarios that are specific to a location.

How these statements are distributed across the scope of work is to be articulated in the CNVMP, or where one is not required, the CEMP. The scope of Low Impact Works are according to the definition and is articulated in the DNVIS if triggered.

In all cases the overriding objective of noise and vibration assessments is to firstly identify impact reduction techniques to reduce noise and vibration impacts below the NML using Standard Mitigation Measures (refer to Section 4) so that the reliance upon impact offset measures is removed or minimised (refer to Section 5).

Table 10: Summary of Assessment Detail Required During the Various Stages of the Project

Assessment Input	Environmental Impact Statement / Environmental Assessment	In Delivery
Construction Scenarios / Equipment List	Construction scenarios defined by project team, based on potential construction methodologies known at the time.	Construction scenarios defined by construction team. These are expected to include finalised equipment lists, itemising the realistic worst-case plant proposed to be used at any one time, and in any one location.
Modelled works location	Works location by scenario (or group of scenarios) i.e. different locations for different works.	Works location by works scenario i.e. specific locations for each works.
Background noise monitoring	Background noise monitoring required to determine RBL and other noise metrics at locations representative of worst-affected receiver areas adjacent to the works areas.	Supplementary noise monitoring may be required to determine in more detail the RBL or other noise metrics required by the planning approval at locations representative of worst-affected receiver areas adjacent to the works areas where noise survey data is not current (i.e. more than 5 years old).
Study Area	The study area will be justified in the assessment document(s).	Predict noise and vibration levels to the sensitive receivers within the area surrounding the works, to include all receivers where the $L_{Aeq(15minute)} \geq$ RBL +5dB and the vibration screening criteria are exceeded during the applicable time periods.
Assessment of mitigation	Demonstration that assessment of this stage includes reasonable and feasible mitigation measures if required.	Based on these predictions the Construction Noise and Vibration Management Plan (CNVMP) shall identify all feasible and reasonable mitigation measures to minimise noise and vibration from construction. Sections 4 and 5 identify the standard and additional mitigation measures to be included where applicable in the CNVMP. Eg. Detailed vibration assessments to include dilapidation surveys, continuous vibration monitoring and accurate vibration transfer measurements (site law measurements) for all buildings with the potential to exceed the screening criteria for vibration.
Documentation	Environmental Assessment and associated documentation	Activity or location specific Construction Noise Impact Statements Construction Noise and Vibration Management Plans OOHW Applications

3.1. Detailed Noise and Vibration Impact Statements

Works requiring SSI approval require a secondary noise and vibration assessment via a DNVIS when further details regarding specific equipment and construction methods are known.

The purpose of the DNVIS is to provide a detailed overview of noise and vibration impacts of associated works, mitigation measures and community consultation required to effectively manage noise and vibration impacts on nearby receivers both during and outside standard construction hours. **Table 11** provides an overview of the objectives of a DNVIS, including additional considerations.

Table 11: Objectives of a DNVIS

Objective	To be coordinated by a suitably experienced noise specialist	Additional Considerations
To assess the noise and vibration impact of a package of work based on a detailed understanding of the work methodology and the affected community.	Yes	Requires collaboration with: • The construction team regarding construction scenario, work methodology, available scheduling options, required equipment, application of mitigation measures. • The stakeholder management team to provide details of Noise and Vibration Sensitive Receivers (NSRs) which may be affected by the project.
To demonstrate how "feasible and reasonable" mitigation will be implemented to mitigate and manage the impacts.	Yes	
To document the above in a form that: • The site supervisor can use to plan and manage the work • The stakeholder management team can use to plan and manage consultation and communication with the community	N/A	
To comply with the applicable requirements of the approval and the requirements derived from the approval (such as the CNVS and the ICNG)	Yes	N/A
To promote a consistent approach across Sydney Metro's construction projects, contracts and sites.	N/A	
To capture and build on lessons learnt	N/A	

In coordinating a DNVIS, the following should be considered:

- A risk-based approach, with more detailed assessment of activities that are predicted to generate higher impacts.

- Realistic assessment scenarios based on detailed knowledge of the way the work will be done.
- Consideration of the way noise and vibration will impact the community, such as by:
    - Focussing on typical noise and vibration levels (rather than absolute and/or hypothetical worst-case outcomes), with notes regarding realistic worst case levels relative to typical levels
    - Being clear about the timing, duration and characteristics of the predicted levels
    - Applying the subjective impact categories in accordance with section 3.1 of the CNVS
- Be succinct. For example:
    - Provide a meaningful summary of the predicted impacts and a clear statement about how they will be mitigated and managed.
    - Where necessary, attach detailed prediction results (tables, contours etc) as appendices
- Demonstrate compliance with the applicable requirements of the approval.

Information to include to achieve the above objectives include:

- Unless already stated in a CNVMP, identify all Noise and Vibration Sensitive Receivers (NSRs) which may be affected by the project and determine appropriate noise and vibration management levels for each NSR depending on the proposed period of works, and reference the source of the management levels (i.e EIS Tables, additional background monitoring, Australian Standard (AS1055.2)).
- Determine the source noise levels (Sound Power Levels) of each noise generating plant and equipment item required to undertake the construction scenario. Note: Sound Power Levels for each plant and equipment must be less than the maximum allowable levels found in **Table 13** and
- **Table** 14.
- Clearly indicate which mitigation measures identified in Section 4 have been incorporated into the noise assessment. Noise mitigation measures to be implemented will vary for reasons such as safety and space constraints, these are to be identified and the calculations adjusted accordingly.
- For location specific construction scenarios and where applicable for generic scenarios, include the effects of noise shielding provided by site offices, residential fences, noise barriers or natural topographic features.
- Where applicable include the effects of noise reflections and ground attenuation.
- Calculate the L_{Aeq} noise or range of levels from construction scenarios at sensitive receiver groups, with the use of noise contour maps where appropriate
- Compare these against the goals identified for each NSR and identify predicted exceedances.
- Subjective classification of the noise impact evaluated and the reasoning behind the impact assessment documented as:
    - Low Impact

- Moderate Impact
- High Impact

The reasoning behind the impact assessment is to be determined on a case-by-case basis with consideration of the following points:

- The location of the works in relation to NSRs with consideration of noise attenuation features such as noise barriers including topographical features (earth-mounds), buildings, dividing fences etc (distance of works from sensitive receiver(s)).
- The type and sensitivity of the NSRs:
  - Low Impact: e.g. Commercial buildings/ Scattered Residential (low density)
  - Moderate Impact: e.g. Standard residential (typical density)
  - High Impact: e.g. Residential home for the elderly/high density unit blocks/persistent complainers/residents deemed to have “construction noise fatigue”.
- Land use zoning and planning amenity objectives for the area.
- Construction and architectural design of impacted building, particularly the presence of any existing noise mitigation including that provided under a Noise Abatement Program or required by the ISEPP, Council DCP or other planning instrument.
- Existing ambient levels.
- The extent of noise exceedance above Noise Management Level.
- Assessment of potential sleep disturbance for night-time activities, calculated as exceedances over:
  - LAeq,15min 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and
  - LAFmax 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater.

  Where exceedances are predicted to occur, undertake a detailed maximum noise level event assessment in accordance with the Noise Policy for Industry (EPA, 2017).
- The type of and intensity of noise emitted from works (i.e. tonal or impulsive):
  - Lower Impact: No high noise and/or vibration intensive activities
  - Moderate Impact: Short/intermittent high noise and/or vibration intensive activities
  - High Impact: Prolonged high noise and/or vibration intensive activities.
- Day of the week, starting time, duration and noise level of any OOHW required
- Time frames for any OOHW:
  - Lower Impact: 6.00 pm till 10.00 pm weekdays and Saturday, 8.00 am till 6.00 pm Sundays or Public Holidays.
  - Moderate Impact: 10.00 pm to 7.00 am Weekday Nights, 10.00 pm to 12:00pm Friday and Saturday nights, to 8.00 am Saturdays.

  - High Impact: 6.00 pm to 7.00 am Sundays and Public Holidays.

- As a result of noise classification and/or the noise level exceedances at sensitive receivers provided by the DNVIS reports, appropriate reasonable and feasible noise mitigation is to be adopted and implemented. For sites where works are predicted to significantly exceed noise goals and impact on receivers for a significant period of time, additional reasonable and feasible noise mitigation measures such as those outlined in Section 5 would be considered if practical to reduce the noise levels and impact on sensitive receivers.
- 10 or more occurrences to same NSR
- Traffic and cumulative assessment of noise impacts associated with the operation of construction related vehicles both within and outside construction boundaries in accordance with Section 2.6

3.2. General Noise and Vibration Impact Assessments

For works other than those carried out under an SSI Approval a more generalised approach to assess impacts in the form of a GNVIS is adopted. These assessments rely upon indicative Sound Power Level's (SWL's) from typical plant and equipment, auditing of plant and equipment during delivery, and typical variables that modify the transmission of noise and vibration to determine a predicted impact at the most affected NSR.

Where a change occurs in relation to works described in a GNVIS, it will be updated and resubmitted to Sydney Metro for approval. For example, works during standard working hours being rescheduled outside standard working hours.

Preparation of a GNVIS is generally broken down into the following four steps:

1. Determine the relevant period of time during which the works will occur. This is either during standard working hours, or outside standard working hours during daytime, evening or night. Depending on the timeframe there will be differing Noise Management Levels for the activity. Section 2.2 outlines how Noise Management levels (NML) are calculated.
2. Determine the SWL of the Noisiest piece of Plant or Equipment. Each piece of plant or equipment is required by this standard to be audited regularly and the SWL confirmed to fall within the range indicated in **Table 13** or **Table 14**.
3. Identify residential and non-residential sensitive receivers closest to the point at which the noisiest piece of plant or equipment will be operated.
4. A series of factors are considered which have either exacerbating or mitigating effects on the transmission of noise and vibration to arrive at a predicted noise level at both the residential and non-residential receiver/s. The predicted level is then compared against the NML and an exceedance is calculated. The receiver with the highest exceedance determines the level of Additional Mitigation Measures which must be considered (see **Section 5**).

Further information including minimum requirements in the preparation of a GNVIS are outlined in Sydney Metro's General Noise and Vibration Impact Statement template.

3.3. Noise and Vibration Sensitive Receivers

The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities performed within the affected premises. For example, recording studios are more sensitive to vibration and ground borne noise than residential premises, which in turn are more sensitive than typical commercial premises.

Specific noise and vibration sensitive receivers (NSRs) relevant to individual construction sites would be identified and addressed in the Environmental Assessment of each Sydney Metro project. Each receiver would be identified as falling into one of the following categories:

- Commercial
- Educational
- Industrial
- Mixed residential/commercial
- Residential
- Residential occupied by shift workers
- Place of Worship
- Medical facilities
- Other sensitive receivers

3.4. Ground-Borne (Regenerated) Noise

Ground-borne noise as a result of construction activities is usually associated with tunnelling projects where equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. It is therefore anticipated that ground-borne noise may be an issue during the construction of Sydney Metro projects.

If NSR's are predicted to be affected by ground-borne noise as a result of construction activities, a DNVIS or GNVIS report specifically in relation to the assessment of ground-borne construction noise would be undertaken.

In undertaking a DNVIS or GNVIS report for ground-borne construction noise the following steps are to be taken:

- Identify and quantify if necessary, any significant extraneous sources of ground-borne noise.
- Determine the location of each plant and equipment item in relation to each receiver.
- On the basis of ground-borne noise versus distance prediction algorithms for each plant item, determine the level of ground-borne noise at each building location. For highly sensitive building occupancies, such as recording studios, the assessment may need to incorporate the acoustic properties of the building space and the structural response of the building. This is to be determined by a qualified acoustic consultant, should ground-borne noise be a potential issue.
- Include the effect of all relevant standard mitigation measures as part of the construction scenario.

- Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction actives at each receiver and compare these to the ground-borne noise management levels.

3.5. Ground-Borne Vibration

Vibration as a result of construction activities is usually associated with tunnelling projects where equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. It is therefore anticipated that ground-borne vibration may be an issue during the construction of Sydney Metro projects.

If vibration impacts are anticipated as a result of construction activities, a DNVIS or GNVIS report specifically in relation to the assessment of construction vibration would be undertaken.

In undertaking a DNVIS or GNVIS report for ground-borne construction vibration the following steps are to be taken:

1. Determine the location of each plant and equipment item in relation to each receiver.
2. On the basis of ground-borne vibration versus distance prediction algorithms for each plant item, determine the level of ground-borne vibration at each building location. For highly sensitive building occupancies, such as recording studios, the assessment may need to incorporate the vibration properties of the building space and the structural response of the building. This is to be determined by a qualified acoustic consultant, should ground-borne vibration be a potential issue.
3. Include the effect of all relevant standard mitigation measures as part of the construction scenario.
4. Calculate the vibration levels from the proposed construction actives at each receiver and compare these to the ground-borne vibration criteria.

3.6. Vibration and Overpressure from Blasting

Vibration and overpressure as a result of construction activities is usually associated with tunnelling projects where blasting is required. If this construction is implemented then vibration and overpressure may be an issue during the construction of Sydney Metro projects.

If vibration and overpressure impacts are anticipated as a result of construction blasting, a DNVIS report, specifically in relation to the assessment of construction blasting would be undertaken regardless of the projects planning approval pathway.

In undertaking a DNVIS report for blasting vibration and overpressure the following steps are to be taken:

1. Determine the location of blast charge in relation to each receiver.
2. On the basis of vibration / overpressure versus distance prediction algorithms for blasting determine the level of vibration / overpressure at each receiver (building) location.
3. Include the effect of all relevant standard mitigation measures as part of the construction scenario.
4. Calculate the vibration and overpressure levels from the proposed blasting activities at each receiver and compare these to the blasting criteria.

4. STANDARD NOISE AND VIBRATION MITIGATION MEASURES

4.1. Minimum Requirements

The Construction Environmental Management Framework sets out the standard construction noise and vibration mitigation measures to be implemented on all Sydney Metro projects and delivered via relevant procedures, systems, environmental assessment, construction environmental management and all relevant contract documentation.

For all Sydney Metro construction projects, the standard mitigation measures outlined in Appendix B of the Construction Environmental Management Framework shall be applied by default where feasible and reasonable in order to minimise the potential noise and vibration impacts at the surrounding Noise Sensitive Receivers. The effect of applying standard mitigation measures may be considered in noise and vibration assessments to achieve NML's.

This section provides the minimum requirements in relation to construction methods and the maximum allowable plant sound power levels.

Table 12: Minimum Requirements for Construction Methods

Method	Minimum Requirements
Excavator	Ensure SWL's specified in **Table 13** have been met.
Truck	Ensure SWL's specified in **Table 13** have been met.
Rock breakers and jackhammers	Ensure SWL's specified in **Table 13** have been met. Noise and vibration monitoring would be conducted at the nearest identified NSR where exceedances of the criteria have been predicted.
PCF / Blasting	Where it has been predicted that vibration / overpressure is likely to be in excess of the nominated goals, all NSRs will be notified at least 2 weeks prior to a shot being fired. Vibration and overpressure monitoring would be conducted at the nearest identified NSR.
TBM	Noise and vibration monitoring would be conducted at the nearest identified NSR where levels are expected to exceed the relevant noise and vibration goals.
Road headers	Noise and vibration monitoring would be conducted at the nearest identified NSR where levels are expected to exceed the relevant noise and vibration goals.

4.2. Maximum Allowable Plant Sound Power Levels

Plant or equipment operating on Sydney Metro project construction sites shall have an operating SWL which is no higher than the corresponding SWL presented in **Table 13** unless justified. The SWLs presented in **Table 13** have been compiled from a selection of field measurements conducted between 2004 and 2008 of plant and equipment operating on large construction projects throughout NSW. These measurements are considered representative of plant and equipment SWLs which are readily achieved by current plant and equipment typically used in the construction industry.

Table 13: Maximum Allowable Sound Power Levels for Construction Equipment

Equipment	Maximum Allowable Sound Power Level (dB) LAeq	Maximum Allowable Sound Pressure Level (dB) LAeq at 7 m
Excavator Hammer	118	93
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Excavator (approx. 40 tonne)	115	90
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Skidsteer Loaders (approx. 1 tonne)	110	85
Dozer (tracking) - equiv. CAT D8	118	93
Dozer (tracking) - equiv. CAT D9	120	95
Dozer (tracking) - equiv. CAT D10	121	96
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

Where an item of construction equipment is not listed in **Table 13**, generic sound power levels presented in **Table 14** may be adopted.

Table 14: Generic Equipment or System Sound Power Level Limit[1]

Equipment	Maximum Allowable Sound Power Level (dB) L_{Aeq}	Maximum Allowable Sound Pressure Level (dB) L_{Aeq} at 7 m
Motorised (<25kW)	90	65
Motorised (<50kW)	95	70
Motorised (<100kW)	100	75
Motorised (<200kW)	105	80
Motorised (>200kW)	110	85
All other Auxiliary Equipment or Systems	90	65

Note 1: Sound Power Levels in dBA relative to 10 pW.

5. ADDITIONAL NOISE AND VIBRATION MITIGATION MEASURES

The implementation of the standard management measures, compliance with maximum sound power levels for plant and equipment, construction hour management and standard community consultation measures in this Standard should significantly reduce the noise and vibration impacts on nearby sensitive receivers.

Nevertheless, due to the highly variable nature of construction activities and the likelihood of work outside the standard construction hours on Sydney Metro projects, some exceedances of the construction noise and vibration management levels are likely to be unavoidable.

Where there is a potential exceedance of the construction noise and vibration management levels, a number of additional measures to mitigate such exceedances – primarily aimed at pro-active engagement with affected sensitive receivers – would be explored and have been included in this Standard. The additional management measures to be considered are outlined in **Table 15**.

Table 15: Additional Management Measures

Measure	Description	Abbreviation
Letter box drops	Letter box drops collectively consist of the following Standard Mitigation Measures a) Newsletters of work activities and progress b) Notification letters prior to especially noisy activities and out-of-hours works. These are distributed to local communities, stakeholders and businesses via letterbox drop and/or email to subscribers where relevant email addresses are known, as well as made available on the Sydney Metro website.	LB a) b)
Monitoring	Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals, noise or vibration monitoring may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver have been identified). Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be implemented.	M
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives would deliver specific notification, visit in person and/or email / call contact by phone identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project and specific needs etc. Individual briefings may be undertaken when specific contact details of impacted stakeholders are available, or where access to deliver specific notifications or visit is achievable.	IB
Project specific respite offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact.	RO
Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts over an extended period of time. Alternative accommodation will be determined on a case-by-case basis.	AA

5.1. Applying Additional Mitigation Measures

In circumstances where following application of the standard mitigation measures, the $L_{Aeq(15minute)}$ construction noise and vibration levels are still predicted to exceed the Noise Management Level, the relevant Additional Mitigation Measures (AMM) are considered to determine any offset strategies for these impacts (**Table 16, Table 17,Table 18)**.

The following steps need to be carried out to determine the additional mitigation measures to be implemented:

1. Determine the duration (time period) when the work is to be undertaken.
2. Determine the level of exceedance above the NML.
3. Using **Table 16, Table 17** and **Table 18** identify the additional mitigation measures to be implemented (abbreviation codes are explained in **Table 15**).

Table 16: Additional Mitigation Measures – Airborne Construction Noise

Time Period		Mitigation Measures				
		Predicted $L_{Aeq\ (15minute)}$ noise level Above NML				Predicted $L_{Aeq\ (15minute)}$ noise level
		0 to 10 dB	11 to 20 dB	21 to 30 dB	> 30 dB	> 75 dBa
Standard	Mon-Fri (7.00 am - 6.00 pm)	-	LB a)	LB a) and b), M	LB a) and b), M	Must not commence before 8.00am NOTE 1
	Sat (8.00 am - 6.00 pm)					NOTE 1 Must be complete by 1.00pm
	Sun/Pub Hol (Nil)					Additional approval required
OOHW Period 1 DAY	Saturday (7.00 am – 8.00 am)	LB a)	LB a), M	LB a) and b), M	LB a) and b), M, IB, RO	Additional approval required
	Sunday and Public Holidays (8.00 am - 6.00 pm)					
OOHW Period 1 EVENING	Mon-Sat (6.00 pm - 10.00 pm)	LB a)	LB a), M	LB a) and b), M, RO	LB a) and b), M, IB, RO	Additional approval required
OOHW Period 2 NIGHT	Mon-Fri (10.00 pm - 7.00 am)	LB a)	LB a) and b), M, RO	LB a) and b), M, IB, RO, AA	LB a) and b), M, IB, RO, AA	Additional approval required
	Sat (10.00 pm - 8.00 am Sunday morning)					
	Sunday (6.00 pm - 7.00 am Monday morning)					
	Public Holidays (Before 8.00 am or after 6.00 pm)					

NOTE 1: Except under an EPL or alternate approval, high impacts works must not exceed three (3) hours, with a minimum cessation of work of not less than one (1) hour.

Table 17: Additional Mitigation Measures – Ground Borne Construction Noise

Time Period		Mitigation Measures				
		Predicted LAeq (15minute) noise level Above NML			Internal Residential Objective LAeq(15minute)	
		0 to 10 dB	11 to 20 dB	> 20 dB	> 40 dB	> 35 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	No NML for GBN during standard hours, refer to Table 18				
	Sat (8.00 am - 1.00 pm)					
	Sun/Pub Hol (Nil)					
OOHW Period 1 DAY	Saturday (7.00 am – 8.00 am)	LB a)	LB a) and b), M	LB a) and b), M, IB, RO	Nothing additional	
	Sunday and Public Holidays (8.00 am - 6.00 pm)					
OOHW Period 1 EVENING	Mon-Sat (6.00 pm - 10.00 pm)	LB a)	LB a) and b), M	LB a) and b), M, IB, RO	LB a) and b), M, IB, RO	Nothing additional
OOHW Period 2 NIGHT	Mon-Fri (10.00 pm - 7.00 am)	LB a) and b), M,	LB a) and b), M, IB, RO, AA	LB a) and b), M, IB, RO, AA	LB a) and b), M, IB, RO, AA	
	Sat (10.00 pm - 8.00 am)					
	Sunday (6.00 pm - 7.00 am Monday morning)					
	Pubic Holidays (Before 8.00 am or after 6.00 pm)					

Table 18: Additional Mitigation Measures – Ground Borne Vibration

Time Period		Mitigation Measures
		Predicted Vibration Levels Exceed the maximum levels predicted to cause adverse comment (See Table 6)
Standard	Mon-Fri (7.00 am - 6.00 pm)	LB a), M, RO
	Sat (8.00 am - 6.00 pm)	
	Sun/Pub Hol (Nil)	
OOHW Period 1 DAY	Saturday (7.00 am – 8.00 am)	LB a) and b), M, IB, RO
	Sunday and Public Holidays (8.00 am - 6.00 pm)	
OOHW Period 1 EVENING	Mon-Sat (6.00 pm - 10.00 pm)	LB and b), M, IB, RO
OOHW Period 2 NIGHT	Mon-Fri (10.00 pm - 7.00 am)	LB a) and b), M, IB, RO, AA
	Sat (10.00 pm - 8.00 am)	
	Sunday (6.00 pm - 7.00 am Monday morning)	
	Public Holidays (Before 8.00 am or after 6.00 pm)	

6. MONITORING, AUDITING AND REPORTING

6.1. Plant Noise Auditing, Compliance Evaluation and Reporting

In order to compare the noise levels of plant and equipment with the values in **Section 4.2**, the following guidelines are recommended:

- Measurements of Sound Pressure Level (SPL) at 7 m (with plant or equipment stationary) shall be undertaken using procedures that are consistent with the requirements of Australian Standard AS 2012.1–1990 Acoustics – Measurement of Airborne Noise Emitted by Earthmoving Machinery and Agricultural Tractors – Stationary Test Condition Part 1: Determination of Compliance with Limits for Exterior Noise.
- Measurements of Sound Power Level (SWL) shall be determined using procedures that are consistent with the requirements of International Standard ISO 9614-2 1996 Acoustics – Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning.
- If measuring the SPL at 7 m of moving plant, compliance measurements would be guided by the requirements of Australian Standard AS 2012–1977 Method for Measurement of Airborne Noise from Agricultural Tractors and Earthmoving Machinery.

For all measurements, the plant or equipment under test would be measured while operating under typical operating conditions. If this is not practical, it may be appropriate to conduct a stationary test at high idle.

In the case of an exceedance in SWL the item of plant would either be replaced, or the advice of an acoustic consultant would be sought to provide suitable mitigation measures, which may include:

- ensuring all bolts are tightened and no parts are loose
- cleaning and/or lubricating moving parts
- replacing old or worn parts
- implementing additional or upgrading existing muffling devices
- building enclosures around items of stationary plant (e.g. pumps or generators).

A register of measured SWL's for each item of plant would be kept for reference where future noise audits are conducted. The register would be reviewed on a regular basis in conjunction with this standard and corresponding revisions made to the SWL's presented in **Section 4.2** to represent contemporary plant noise emission levels.

6.2. Noise Monitoring

Where a DNVIS or GNVIS has been prepared for a Sydney Metro construction site and it has been predicted that noise levels may be in excess of the nominated construction noise goals at a noise sensitive receiver, noise monitoring would be conducted at:

- the affected receiver; or

- if more than one affected receiver has been identified, at the nearest affected receiver; or
- where the nearest affected receiver refuses noise monitoring on their property, at the near point to that receiver within the site boundary.
- If it can be demonstrated that direct measurement of noise from the construction site is impractical, alternative means of determining construction noise levels may be adopted in accordance with Chapter 7 of the NSW EPA's Noise Policy for Industry 2017.

All noise monitoring should be assessed against the nominated noise goals before being compiled into a report to be forwarded to the construction contractor and project manager. Reporting would be submitted to the construction contractor and project manager within one week of being undertaken or at weekly intervals for continuous monitoring. All noise monitoring reports would also be made available to the public through a publicly accessible website.

6.3. Vibration Monitoring

Where it is anticipated that an item of plant will exceed the cosmetic damage criteria given in Section 2.3.2 , vibration monitoring would be required at the nearest affected receiver.

Where it is anticipated that an item of plant will exceed the human response / ground borne noise criteria and concerns have been raised regarding vibration, vibration monitoring would also be required at the receiver(s) under question.

All vibration monitoring results would be assessed against the nominated vibration goals and compiled into a report to be forwarded to the construction contractor and project manager. Reporting would be submitted to the construction contractor and project manager within one week of being undertaken or at weekly intervals for continuous monitoring. All vibration monitoring reports would also be made available to the public through the publicly accessible website.

6.4. Blast Monitoring

As specified in the minimum requirements presented in **Section 3.6**, vibration and overpressure monitoring would be conducted for all Penetrating Cone Fracture (PCF) and blasting activities which take place on Sydney Metro construction sites.

Monitoring would be conducted as a minimum at the sensitive receiver(s) likely to receive the maximum vibration and/or overpressure emissions from the blast as identified by an acoustic consultant.

All blast monitoring results would be assessed against the nominated goals and compiled into a report to be forwarded to the construction contractor and project manager. All blast monitoring reports would also be made available to the public through the Sydney Metro website.

As the effect of vibration and overpressure from blasting have the potential to cause structural damage to buildings and services, accurate records of all blasts are required to be maintained. Such records would describe the location of the blast and all the blast holes, the design of the blast in terms of type of explosives, mass of explosives, initiating system used, ground vibration and overpressure measurement data.

Records of every blast would be kept for a minimum of seven years. A longer period of retention of the records may be warranted if a construction project is blasted over an extended or disrupted period.

For any section of tunnel construction where blasting is proposed, a series of initial trials at reduced scale shall be conducted prior to production blasting to determine site-specific blast response characteristics and to define allowable blast sizes to meet the airblast overpressure and ground vibration limits.

6.5. Dilapidation Surveys

If construction activities have the potential to cause damage through vibration to nearby public utilities, structures, buildings and their contents, an Existing Condition Inspection of these items is required to be undertaken in accordance with AS 4349.1 except where a planning approval specifies an alternate process.

Prior to conducting the Existing Condition Inspections, the property owners will be advised of the inspection scope and methodology and the process for making a property damage claim. At the same time, maintain a register of all properties inspected and of any properties where owners refused the inspection offer.

The findings of all dilapidation surveys conducted for each Sydney Metro construction site would be complied into a report to be forwarded to the construction contractor and project manager. Follow-up Condition Inspections would be required at the completion of certain major works (e.g. completion of shaft bulk excavation works).

7. COMPLAINT HANDLING

All complaints handling would be in accordance with the Sydney Metro Construction Complaints Management System.

8. COMMUNITY CONSULTATION AND LIAISON

All community consultation would be in accordance with:

- Sydney Metro's Overarching Community Communication Strategy (OCCS); and
- Relevant project communication plans.

9. DOCUMENTATION REQUIREMENTS

Any acoustic assessment, DNVIS or CNVMP undertaken for the Sydney Metro project must document the following as a minimum (where applicable):

- □ Acoustic Terminology / Glossary
- □ Overview of the Project / Works
- □ Secretary's Environmental Assessment Requirements
- □ EPL conditions (if applicable)
- □ Site Plan and Sensitive Receivers
- □ Ambient Noise Monitoring: methodology, locations, analysis and results
- □ Construction Noise and Vibration Criteria
  - □ Construction Airborne Noise Criteria
  - □ Construction Tunnelling Ground-borne Noise Criteria (if applicable)
  - □ Construction Ground-borne Noise Criteria
  - □ Construction Vibration Criteria
- □ Construction Noise and Vibration Assessment
  - □ Construction Airborne Noise Methodology / Predictions
  - □ Construction Tunnelling Ground-borne Noise Methodology / Predictions (if applicable)
  - □ Construction Ground-borne Noise Methodology / Predictions
  - □ Construction Vibration Methodology / Predictions
- □ Summary of Noise and Vibration Impacts
- □ Summary of all Standard and Additional Mitigation Measures
- □ References

All noise and vibration predictions are to be presented (as a minimum) as facade noise maps for a distance of at least 300 m in all directions from each work site / project area under assessment.

10. REFERENCES

Related Documents and References
• ANZEC, 1990, Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration. Australian and New Zealand Environment Council.
• APTA, 1981, Guidelines for Design of Rapid Transit Systems. American Public Transit Association.
• AS 2107, 2016, Acoustics - Recommended design sound levels and reverberation times for building interiors. Standards Australia.
• AS 2012 Part 1, 1990, Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - Stationary test condition - Determination of compliance with limits for exterior noise. Standards Australia.
• AS 2187, Part 2, 2006, Explosives - Storage and Use - Part 2: Use of Explosives. Standards Australia.
• AS 2436, 2010, Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites. Standards Australia.
• AS 4349, 2007, Inspection of buildings - General requirements. Standards Australia.
• BS 6472, 1992, Evaluation of Human Exposure Vibration in Buildings. The British Standards Institution.
• BS 7385 Part 2, 1993, Evaluation and Measurement for Vibration in Buildings Part 2. The British Standards Institution.
• Colin G. Gordon, 1999, Generic Vibration Criteria for Vibration-Sensitive Equipment. International Society for Optical Engineering.
• The Association of Australian Acoustical Consultants (AAAC) Technical Guideline on Child Care Centre Noise Assessments
• DECC, 1999, Environmental Criteria for Road Traffic Noise. NSW Environment Protection Authority.
• DEC, 2006, Assessing Vibration: a technical guideline. NSW Environment Protection Authority.
• DECC, 2009, Interim Construction Noise Guideline. NSW Environment Protection Authority.
• EN ISO 9641, Part 2, 1996, Acoustics - Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning. International Organization for Standardization.
• EPA, 2017, NSW Noise Policy for Industry. NSW Environment Protection Authority.
• RTA, 2001, Environmental noise management manual, NSW Roads and Traffic Authority.
• DECCW 2011, Road Noise Policy, NSW Department of Environment, Climate Change and Water
• TfNSW 2019, Construction Noise and Vibration Strategy. Transport for NSW