

13 Noise and Vibration

13.1 Overview

This chapter provides an assessment of the noise and vibration impacts associated with the construction and operation of Melbourne Metro. The chapter is based on the impact assessment presented in Technical Appendix I *Noise and Vibration*. All relevant references are provided in the technical appendices.

As a large, busy and dynamic city, Melbourne hosts a range of activities – such as major construction projects, heavy vehicle traffic, train and tram operations and outdoor events – that generate varying types and levels of noise and vibration. Across the Melbourne Metro alignment, many buildings, facilities and places already experience continuous or intermittent levels of noise and vibration associated with being located near to major arterial roads, tram or train lines. The construction and operation of Melbourne Metro would occur within this context.

Noise and vibration may be perceptible at receivers near the Melbourne Metro alignment as:

- Airborne noise (noise propagated through the air from source to receiver)
- Ground-borne vibration (vibration propagated through the ground and into building structures)
- Ground-borne noise (noise heard within a building that is generated by vibration propagated through the ground and into the structure).

The extent of the project's noise and vibration impacts would depend upon a range of factors. Some factors would be influenced by the design of the project (such as the construction methodologies adopted and the measures implemented to meet the Environmental Performance Requirements). Other factors would depend upon the sensitivity of particular receivers to noise and vibration (such as the structural condition of an affected building or the nature of the activities undertaken at a particular receiver).

The detailed assessment of the predicted noise and vibration impacts of Melbourne Metro undertaken for the EES has used conservative assumptions and models to predict the levels of noise and vibration that would be generated by the construction and operation of the Concept Design developed for Melbourne Metro. Assessment criteria have been determined by reference to Victorian, Australian and international standards and guidelines. Background monitoring has been undertaken to measure existing noise and vibration conditions along the project alignment.

The assessment has determined noise and vibration Guideline Targets for the project to minimise adverse impacts on residents, communities, structures and sensitive equipment and places, as far as practicable.

These Guideline Targets are specified in the recommended Environmental Performance Requirements for the project. Appropriate mitigation measures and management actions would be taken during the construction and operation of Melbourne Metro to meet the targets and achieve the Environmental Performance Requirements.

The key findings of the impact assessment are summarised below.

13.1.1 Construction

Airborne noise generated by construction activities would be managed in accordance with the applicable EPA Guidelines, which are based on protecting residential premises from unreasonable noise. Construction is expected to be audible at times but – with appropriate mitigation – is not anticipated to give rise to unreasonable impacts on nearby residents in any of the Melbourne Metro precincts.

For tunnelling and station construction, the vibration Guideline Targets for structural damage set by the Environmental Performance Requirements are predicted to be achieved with the adoption of appropriate mitigation measures and construction techniques. Accordingly, no damage to buildings and structures is anticipated due to vibration arising from the construction of Melbourne Metro. Pre-construction structural condition assessments and ongoing vibration monitoring would provide the basis for managing potential structural damage.

Tunnelling works also have the potential to generate vibration and ground-borne noise that may impact on human comfort and amenity. Guideline Targets have been identified for Melbourne Metro to manage these potential impacts (with thresholds set far below the vibration levels that would cause any damage to buildings and structures). There are anticipated to be limited periods of time during the construction program when these targets may not be met at some locations in the Tunnels precinct and in the Parkville, CBD North, CBD South and Domain station precincts.

The progress of the TBM would mean that the most-affected sensitive receivers (being locations immediately above or in very close proximity to the tunnel alignment) may experience vibration levels above the Guideline Targets for up to 10 days on two occasions (once for the TBM passing in each tunnel) over the course of the entire Melbourne Metro construction program. The vibration levels would slowly increase as the TBM approaches a sensitive receiver, then reach a peak level for a couple of days when the TBM is closest to the receiver. Vibration levels would then slowly reduce as the TBM moves on.

As roadheader-mined tunnels progress more slowly than TBM-bored tunnels, sensitive receivers at a limited number of locations within the CBD may experience vibration levels higher than the Guideline Targets on one occasion of up to 32 days in the course of the construction program.

Roadheader excavation of station caverns has the potential to generate vibration and ground-borne noise that may impact on amenity. Guideline Targets may not be met at several locations in the CBD North and CBD South station precincts for periods of up to six weeks, up to three times over the course of the station cavern construction.

Appropriate management actions would be taken to address these temporary impacts, including a thorough community consultation and notification process. Where impacts are deemed to be excessive, or where residents are identified as being particularly affected by vibration and ground-borne noise impacts, offers for temporary respite accommodation may be made.

Specific Guideline Targets have been set in relation to vibration-sensitive equipment, Bio-resources facilities and Highly Sensitive Areas (such as hospital wards and operating theatres) in the Parkville and CBD North station precincts. These sites are already exposed to a level of vibration and in some cases already have measures in place to protect sensitive equipment. The Melbourne Metro contractor would work closely with the relevant stakeholders to determine how the predicted levels of vibration from the project would be best managed to limit impacts on these sensitive areas and equipment. Management actions may include additional vibration attenuation, monitoring of impacts, close collaboration with equipment operators and/or the temporary relocation of vibration-sensitive equipment.

13.1.2 Operation

The recommended Environmental Performance Requirements specify Guideline Targets that would need to be met during Melbourne Metro's operation. Airborne noise, vibration and ground-borne noise levels would need to meet these targets, which align with Victorian, NSW and international criteria and standards.

The use of conventional and suitably attenuated track could be adopted to achieve compliance with the operational vibration and ground-borne noise Guideline Targets and meet the Environmental Performance Requirements. Airborne noise during operation would only be experienced as trains enter and exit the tunnel portals and at the western turnback. The effects of this noise would be mitigated where required through measures such as noise barriers in accordance with the *Victorian Passenger Rail Infrastructure Noise Policy (PRINP)*.

Accordingly, the long-term noise and vibration effects of Melbourne Metro are predicted to be low to negligible.

13.1.3 Further monitoring and modelling

A series of Environmental Performance Requirements have been recommended for the project that specify Guideline Targets for noise and vibration. These requirements would need to be met in the design, construction and operation of Melbourne Metro. Guideline Targets are proposed to be used as criteria for triggering a management action or mitigation response to address the effects of noise and vibration.

To provide further confidence in the management of these impacts, the Environmental Performance Requirements also mandate the appointment of an acoustic and vibration consultant to update noise and vibration modelling for the project, determine appropriate mitigation measures to achieve the Environmental Performance Requirements and undertake further noise and vibration measurements to assess ongoing compliance with the Environmental Performance Requirements.

13.2 EES Objective

The EES Scoping Requirements set the following draft evaluation objective for noise and vibration:

- *Amenity – To minimise adverse ... noise or vibration effects on the amenity of nearby residents and local communities, as far as practicable, especially during the construction phase.*

In accordance with this objective, potential noise and vibration risks and impacts associated with the construction and operation of Melbourne Metro have been assessed. Using this information, Environmental Performance Requirements have been recommended to manage adverse noise and vibration impacts associated with the project.

13.3 Legislation and Policy

As discussed in Chapter 4 *EES Assessment Framework and Approach*, noise and vibration impacts associated with the construction and operation of Melbourne Metro would be managed and monitored in accordance with Commonwealth and Victorian legislation, policies and guidelines (where these are available). International and State guidelines have also been considered in determining appropriate noise and vibration levels. The main legislation, policies and guidelines for noise and vibration are set out in Table 13–1. Further details are provided in Section 3 of Technical Appendix I *Noise and Vibration*.

Local laws relating to noise from construction and the duration of construction activities are not covered in Table 13–1 as section 258A of the *Major Transport Projects Facilitation Act 2009* provides that local law permits are not required when a project is declared under the Act. Compliance with EPA Guidelines 1254 and 480 would ensure the appropriate management of noise impacts during construction.

Table 13–1 Noise and vibration legislation and policy relevant to Melbourne Metro

Legislation	Policy/guideline	Comment
State		
<i>Environment Protection Act 1970</i>	State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1)	SEPP N-1 provides a methodology to determine the applicable mandatory Noise Limits for a Noise Sensitive Area that may be affected by commercial, industrial or trade noise. A Noise Sensitive Area is defined in SEPP N-1 and consists of dwellings, residential buildings and similar types of accommodation. SEPP N-1 does not apply to construction and demolition activities on building sites; nor does it apply to noise emanating from roads or railway lines. However, it would apply to noise from fixed plant and equipment such as ventilation systems.
	Environment Protection Authority Noise Control Guidelines Publication 1254 (EPA 1254)	Provides a framework for the management of construction noise and has been used for determining Guideline Noise Levels
	Victorian Passenger Rail Infrastructure Noise Policy (Victorian Government, 2013)	Provides Investigation Thresholds for the redevelopment of existing rail infrastructure
Other relevant documents		
	EPA Publication 480, Environmental Guidelines for Major Construction Sites, 1996	Provides guidance for construction noise; however, EPA 1254 would be the primary document
	NSW Interim Construction Noise Guideline, Department of Environment and Climate Change, 2009	Provides Guideline Targets for management of ground-borne construction noise in the absence of Victorian or Commonwealth criteria
	Australian Standard AS2436-2010, Guide to noise and vibration control on construction, demolition and maintenance sites. (AS 2436)	Reference document
	German Standard DIN 4150-3 <i>Structural Vibration Part 3: Effects of vibration on structures</i> (DIN 4150)	Provides Guideline Targets for construction vibration with respect to damage to buildings in the absence of Victorian or Commonwealth criteria. Used for determining Guideline Targets
	American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE), Chapter 48, Sound and Vibration Control	Provides Guideline Targets for management of vibration with respect to vibration-sensitive equipment in the absence of Victorian or Commonwealth criteria

Legislation	Policy/guideline	Comment
	NSW Rail Infrastructure Noise Guideline, May 2013	Provides Guideline Targets for management of ground-borne noise from trains in the absence of Victorian or Commonwealth criteria. Used for determining Guideline Targets
	Australian Standard AS2187.2-2006 Explosives – Storage and Use Part 2: Use of explosives	Provides Guideline Targets for management of blasting activities
	AS/NZS 2107:2000 Australian/New Zealand Standard Acoustics-Recommended design sound levels and reverberation times for building interiors	Provides Guideline Targets for internal noise levels
	British Standard BS6472-1:2008. Guide to Evaluation of Human Exposure to Vibration in Buildings. Part 1: Vibration sources other than blasting	Provides Guideline Targets for continuous, intermittent or impulsive vibration. Used for determining Guideline Targets
	NSW Assessing Vibration: a technical guideline, Department of Environment and Conservation, 2006	Provides guidance on the values to be used use in assessing human responses to vibration, based on BS6472
	<i>Transit Noise and Vibration Impact Assessment</i> , Federal Transit Administration (FTA), US Department of Transportation, FTA-VA-90-1003-06, 2006	Considered in developing a model for predicting vibration and ground-borne noise associated with proposed mass transit projects

13.4 Methodology

13.4.1 Assessment Approach

Study Area

Noise and vibration has been assessed in the vicinity of all Melbourne Metro precincts. The assessment has also considered the effects of noise along the proposed construction vehicle routes and along the Sunshine – Dandenong Line outside the Melbourne Metro precinct boundaries.

Assessment Methodology

The noise and vibration impact assessment has considered the potential effects of Melbourne Metro on sensitive receivers (people, buildings and sensitive equipment or processes) through the following pathways:

- Airborne noise: noise propagated through the air from source to receiver
- Ground-borne vibration (tactile vibration): vibration propagated through the ground and into building structures that, if sufficiently high, can cause rattling
- Ground-borne noise: airborne noise within a building that is generated by vibration through the ground and into the structure and, if audible, is generally heard as a 'rumble'.

The impact assessment focused on construction airborne noise, vibration and ground-borne noise, operational airborne noise (from trains and fixed infrastructure such as fans) and operational vibration and ground-borne noise from trains.

The assessment adopted the following approach:

- Undertake noise and vibration baseline measurements in the vicinity of Melbourne Metro to determine existing conditions, including:
 - External ambient noise and internal noise measurements
 - External and internal vibration measurements
 - Underwater noise measurements (in the Yarra River)
- Determine appropriate criteria and Guideline Targets, taking into consideration existing measured noise and vibration levels (see Section 13.4.2 below)
- Undertake modelling to predict if these criteria and Guideline Targets would be achieved
- Recommend Environmental Performance Requirements (and potential mitigation and management actions to satisfy these requirements) to manage adverse noise and vibration impacts associated with the project, including measures to reduce noise and vibration levels where the predictions show that levels could be higher than the Guideline Targets.

The key aspects of the assessment methodology are summarised below. Further details of the methodology are provided in Section 4 of Technical Appendix I *Noise and Vibration*.

The noise and vibration impact assessment was independently peer reviewed.

Assessing vibration and ground-borne noise

The following approach was used to predict construction vibration and ground-borne noise levels and impacts:

- The type of occupancy (residential, commercial, utilities and other sensitive uses) was identified for each affected location (receiver).
- A model was developed based on the US Federal Transit Administration's predictive methodology for assessing noise and vibration impacts of proposed mass transit projects.
- Vibration sources levels for the TBM and roadheader were estimated using a combination of literature-based data and the specialists' library of test data.
- The ground vibration attenuation characteristics for the project alignment were derived from a combination of literature-based data and interpretation of geotechnical measurements at boreholes on the alignment.
- The model was used to predict vibration and ground-borne noise levels for receivers in the vicinity of the alignment. For the purpose of calculating Vibration Dose Values (VDV) – which is the accumulation of vibration energy received over either the day-time or night-time periods – day has been defined as 7:00am to 10:00pm and night has been defined as 10:00pm to 7:00am (as per BS6472-1:2008).
- The predicted vibration and ground-borne noise levels were then compared to the proposed Guideline Target for each occupancy type.
- Where Guideline Targets would potentially be exceeded, further analysis was carried out at one or more of the most affected receivers to quantify the duration of the exceedance for tunnelling and station construction activities.

13.4.2 Baseline and Background Data

Noise and vibration baseline measurements were undertaken to help determine the appropriate Guideline Targets to set for Melbourne Metro. These measurements enabled the predicted noise and vibration levels associated with the construction and operation of Melbourne Metro to be considered within the context of the existing conditions in the vicinity of the project.

Within each precinct, specific baseline/background data was obtained to establish existing local noise and vibration levels. This involved taking measurements at representative locations in the vicinity of anticipated noise and vibration generating activities for Melbourne Metro (for both construction and operation).

The locations where baseline noise measurements were taken are shown in Figure 13-1. Vibration measurement locations are shown in Figure 13-2.

Discussion about these measurements is included in Section 13.6 where they are relevant to predicted impacts in the individual precincts. The detailed results of the baseline noise and vibration measurements are provided in Appendix F of Technical Appendix I *Noise and Vibration*.

Figure 13-1 Baseline noise measurement locations

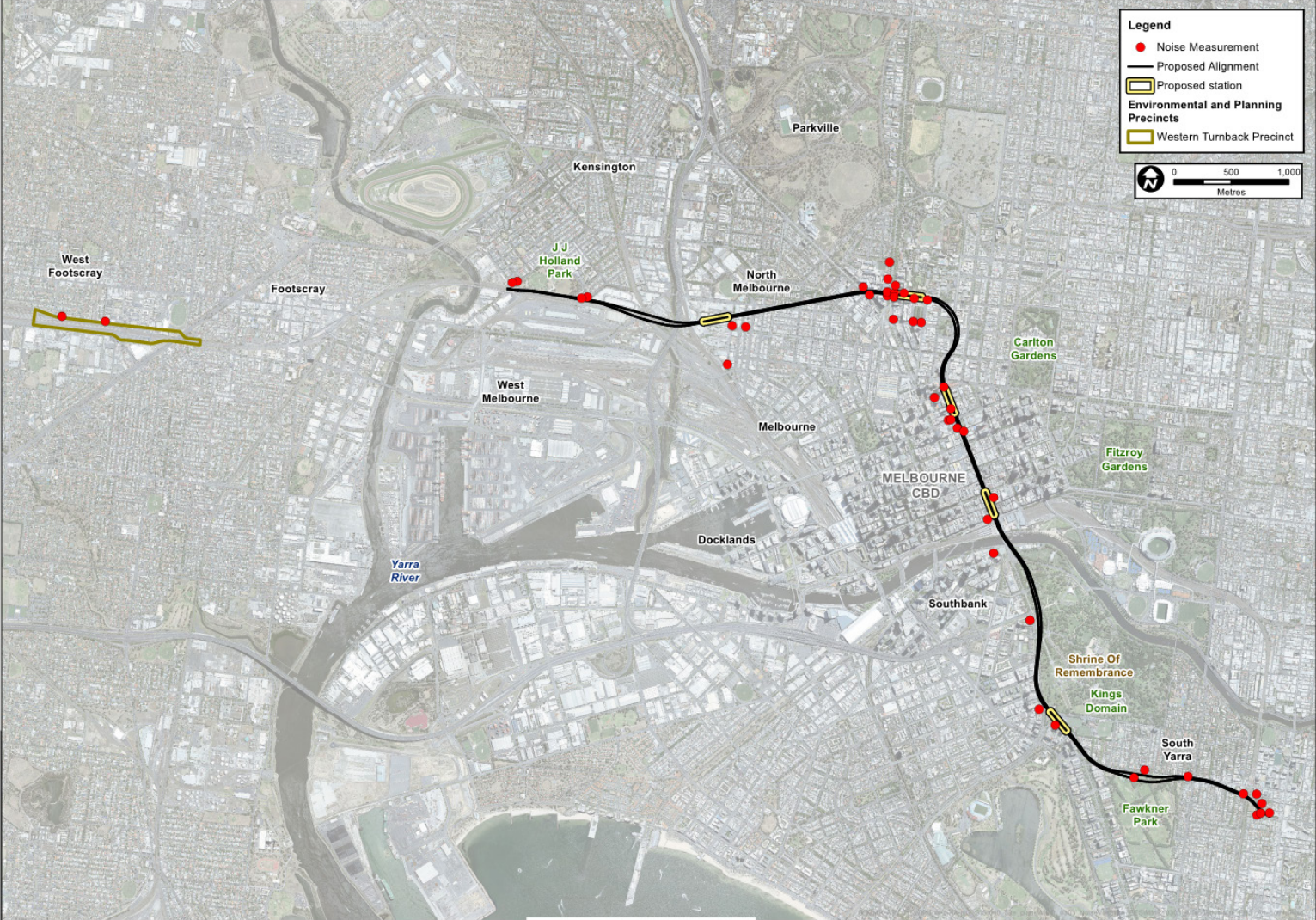
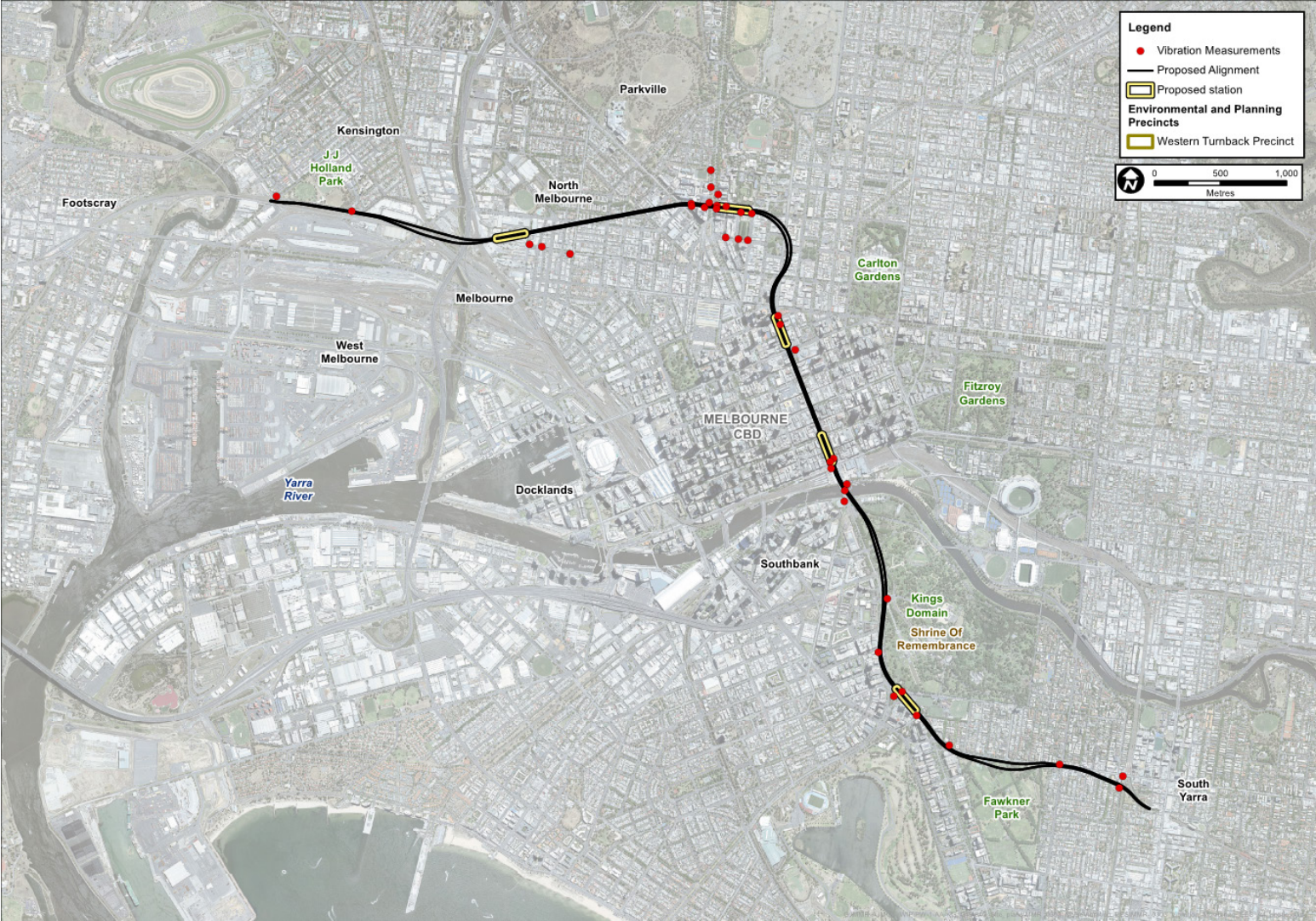


Figure 13-2 Baseline vibration measurement locations



13.5 Noise and Vibration Levels and Criteria

Noise and vibration impacts for Melbourne Metro have been assessed against the criteria specified by Victorian, Australian and international guidelines and standards.

Guideline Targets have been set for the project using these criteria and the baseline measurements of existing conditions taken along the Melbourne Metro alignment. The Guideline Targets have been incorporated into the recommended Environmental Performance Requirements.

In some instances, the criteria are predicted to be achieved without mitigation measures being required. In other instances, appropriate mitigation measures would need to be implemented to achieve the Environmental Performance Requirements and meet the Guideline Targets.

The Environmental Performance Requirements also provide for ongoing modelling and monitoring of noise and vibration levels to ensure that management actions and mitigation measures are appropriate during the project's construction.

13.5.1 Airborne Noise

Airborne Noise from Construction

Airborne noise was modelled using the acoustic modelling software SoundPLAN, based on a number of indicative construction scenarios. The construction airborne noise predictions assumed that all construction plant would be operating concurrently – a conservative approach that would be unlikely to occur in practice.

Construction of Melbourne Metro would be managed in accordance with the requirements of EPA's Noise Control Guidelines, EPA Publication 1254 (EPA 1254). To meet the recommended Environmental Performance Requirements for the project, the Melbourne Metro contractor would need to develop and implement a plan to manage construction noise in accordance with EPA 1254 (summarised in Table 13–2).

Accordingly, predicted airborne noise levels from construction activities were assessed with respect to EPA 1254 and giving consideration to existing measured noise levels.

Table 13–2 EPA 1254 Guideline Noise Levels

Time Period	Applicable Hours	Guideline Noise Levels, $L_{Aeq,15 \text{ minutes}}$	
		Up to 18 months after project commencement	18 months or more commencement
Normal Working Hours	7am to 6pm Monday to Friday 7am to 1pm Saturday	No specified Guideline Noise Levels – noise reduction measures apply	
Weekend/ Evening work	6pm to 10pm Monday to Friday 1pm to 10pm Saturday 7am to 10 pm Sunday and Public Holidays	Noise level at any residential premises not to exceed background noise (L_{A90}) by 10 dB(A) or more.	Noise level at any residential premises not to exceed background noise (L_{A90}) by 5 dB(A) or more.
Night	10pm to 7am Monday to Sunday	Noise is to be inaudible within a habitable room of any residential premises.	

As indicated in the table, no Guideline Noise Levels are specified in relation to construction during the day. However, noise emissions must be controlled during the day-time to ensure they are not unreasonable.

Exceptions to the EPA 1254 Guideline Noise Levels include Unavoidable Works, which are works that cannot practicably meet the time schedule requirements because the work involves continuous work (such as a concrete pour) or would otherwise pose an unacceptable risk to life or property, or risk a major traffic hazard. Affected premises should be notified of such works, their duration and times of occurrence.

Airborne Noise from Trains

Operational rail noise levels were evaluated against the Investigation Thresholds set in the *Victorian Passenger Rail Infrastructure Noise Policy (PRINP)* for the redevelopment of existing rail infrastructure. The Environmental Performance Requirements for the project would require rail noise to be avoided, minimised or mitigated where the PRINP Investigation Thresholds are exceeded. These thresholds are summarised in Table 13–3.

The day, night and maximum noise levels have been predicted for Melbourne Metro at sensitive receivers in the vicinity of the railway line as it emerges from the western and eastern tunnel portals and at the western turnback.

Table 13–3 PRINP Investigation Thresholds

Time	Type of receiver	Investigation Thresholds
Day (6am – 10pm)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks Noise sensitive community buildings, including schools, kindergartens, libraries 	65 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more
Night (10pm – 6am)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks 	60 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more

Notes:

1. If an investigation shows that the thresholds are not exceeded then no further action is considered under this policy.
2. For this assessment, L_{Amax} is defined as maximum A-weighted sound pressure level and is the 95 percentile of the highest value of the A-weighted sound pressure level reached within the day or night.
3. For Melbourne Metro, the location of assessment is at 1m from the centre of the window of the most exposed external façade. All levels of buildings are included.

The train airborne noise predictions for Melbourne Metro were undertaken in SoundPLAN for the following scenarios:

- Scenario 1: existing rail noise levels (for the eastern and western portal precincts)
- Scenario 2: train noise levels in 2026 assuming Melbourne Metro does not proceed (base case)
- Scenario 3: train noise levels in 2036 assuming Melbourne Metro does proceed (with Melbourne Metro).

The year 2036 was selected for the assessment as it is 10 years after the anticipated opening of Melbourne Metro.

The assessment results are summarised under Precinct 2 – Western Portal, Precinct 8 – Eastern Portal and Precinct 9 – Western Turnback. Full details are provided in Appendix C of Technical Appendix I *Noise and Vibration*.

Airborne Noise from Fixed Infrastructure

To meet the recommended Environmental Performance Requirements for the project, noise from fixed infrastructure (such as extraction fans and ventilation systems) during the operation of Melbourne Metro must comply with the mandatory noise criteria at sensitive receptors determined under SEPP N-1.

13.5.2 Vibration and Ground-borne Noise

The vibration and ground-borne noise impacts of construction activities have been assessed in the context of:

- Tunnelling works – which would be undertaken by a TBM in all locations except between CBD North and CBD South stations, where a roadheader would undertake these works. Roadheaders would also be used to excavate the station caverns at CBD North and CBD South
- General construction works (also referred to in Technical Appendix I *Noise and Vibration* as Additional Construction Works) – comprising all construction work other than tunnelling and roadheader excavation, such as the construction of stations and portals that would be undertaken by a variety of equipment.

Vibration from Construction

There are no published guidelines or standards for evaluating the effects of vibration from tunnelling and construction activities in Victoria. The Guideline Targets set in the recommended Environmental Performance Requirements for the project have been based on:

- A German standard (DIN 4150-3) for vibration impacts on buildings and utilities
- A Technical Guideline published by the NSW Department of Environment and Conservation in 2006 for assessing the effects of vibration on human comfort (based on British Standard BS6472-1:1992 which is now superseded)
- Guidance for vibration-sensitive equipment published by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) in 2011. The ASHRAE guideline has been applied to assessing the impacts on vibration-sensitive equipment in the Parkville and CBD North station precincts (except where the measured ambient vibration levels are higher than the ASHRAE levels).

The Guideline Targets adopted for the vibration assessment are precautionary. Higher levels of vibration than the targets does not necessarily mean that the vibration effects would be unacceptable; rather, the extent of exceedance above the target would inform the management or mitigation responses that may need to be deployed to mitigate the effects of Melbourne Metro's construction or operation on residents and businesses.

People perceive vibration at levels well below where structural damage occurs to buildings. The degrees of human perception of vibration are summarised in the German Standard DIN 4150 (Part 2– 1975) and presented in Table 13–4.

Table 13–4 Human perception of continuous vibration, based on DIN 4150.2

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1.0 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Guideline Targets for vibration impacts on human comfort, structures and vibration-sensitive equipment are summarised in Tables 13-5 to 13-8.

The levels outlined in Table 13–5 are vibration dosage values that are a calculation of the accumulation of vibration energy received over the day-time and night-time periods – day is defined as 7:00am to 10:00pm and night is defined as 10:00pm to 7:00am (as per BS6472-1:2008). Below the table are notes that indicate the probability of complaints that could be received with different vibration levels. The probability of complaints being received has been used as the basis for assessing the predicted vibration impacts from the proposed construction methodology for Melbourne Metro.

For unoccupied buildings or infrastructure (where personal amenity is not a concern), the criteria have been based on protecting against cosmetic damage (such as plaster cracking and paint flaking) or on no loss of integrity for below ground assets such as pipelines and cables.

The Guideline Targets have formed the basis for the vibration impact assessment conducted for this EES. Under the recommended Environmental Performance Requirements, management and mitigation measures would be implemented in instances where the recorded vibration levels are higher than these Guideline Targets. Predicted levels of vibration based on detailed design and the associated construction program would be used to inform management measures and consultation prior to construction of main works.

Table 13–5 Guideline Targets for human comfort: Vibration Dose Values (VDV) for construction vibration with respect to adverse comment

Location	Vibration Dose Values (m/s ^{1.75})			
	Day 7:00 am to 10:00 pm		Night 10:00 pm to 7:00 am	
	Value	Maximum Value	Preferred Value	Value
Residences	0.20	0.40	0.10	0.20
Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. The vibration Guideline Targets for human comfort are based on BS6472-1:2008.
2. BS6472-1:2008 states that:
 - Adverse comments (complaints received) are not expected at VDV's less than the Preferred Value
 - There is a low probability of adverse comments at VDV's between the Preferred and Maximum Values
 - Adverse comments are possible at VDV's in the range Maximum Value to 2 x the Maximum Value
 - Adverse comment is probable at VDV's in the range 2 x Maximum Value to 4 x Maximum Value
 - Adverse comment is very likely at VDV's greater than 4 x Maximum Value.
3. Activities should be designed to meet the Preferred Values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the Maximum Value may be used if they can be justified. For values beyond the Maximum Value, the operator should negotiate directly with the affected community.
4. The Guideline Targets are not mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures. If exceeded, then management measures would be required.
5. The VDV values may be converted to peak particle velocities within a future noise and vibration construction management plan.

Table 13–6 Guideline Targets for structural damage to buildings: short-term vibration on structures

Type of structure	Vibration at the foundation, mm/s (Peak Component Particle Velocity)			Vibration at horizontal plane of highest floor at all frequencies mm/s (Peak Component Particle Velocity)
	1 to 10 Hz	10 to 50 Hz	50 to 100 Hz ¹	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
Structures that have a particular sensitivity to vibration, such as heritage buildings	3	3 to 8	8 to 10	8

Notes:

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values.
2. Vibration levels slightly exceeding the vibration levels in the table would not necessarily mean that damage would occur.
3. For civil engineering structures (such as structures with reinforced concrete constructions used as abutments or foundation pads), the values for Type 1 buildings may be increased by a factor of two.
4. For buildings, short-term vibration is defined as vibration that does not occur often enough to cause structural fatigue and that does not produce resonance in the structure being evaluated.

Table 13–7 Guideline Targets for structural damage to buildings: long-term vibration on structures

Type of structure	Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies
Buildings used for commercial purposes, industrial buildings and similar design	10
Dwellings and buildings of similar design and/or occupancy	5
Structures that have a particular sensitivity to vibration, such as heritage buildings	2.5

Notes:

1. Vibration levels slightly exceeding those in the table would not necessarily mean that damage would occur.
2. In this context long-term means vibration events that may result in resonant structural response.

The Guideline Targets for vibration-sensitive equipment are based on ASHRAE criteria and are very low. As such, this type of equipment would typically include protection against the effects of vibration. Guideline Targets would be considered with respect to existing vibration levels and built-in protection and controls.

Table 13–8 Guideline Targets for vibration-sensitive equipment (ASHRAE)

Equipment requirements	VC (vibration criteria) Curve
Bench microscopes up to 100x magnification; laboratory robots	Operating Room
Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc.	VC-A
Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3 mm line widths	VC-B
Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; microelectronics manufacturing equipment such as lithography and inspection equipment to 1 mm detail size	VC-C
Electron microscopes at magnification greater than 30,000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ½ micro metres; includes electron beam systems	VC-D
Un-isolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro metres; includes electron beam systems	VC-E

Note: The VC curves take the form of a set of one-third octave band RMS vibration velocity spectra that define allowable vibration levels for various pieces of equipment.

Ground-borne Noise from Construction

As with vibration, there are no published Victorian standards or guidelines for evaluating the effects of ground-borne noise. However, the NSW Department of Environment and Climate Change has published guidelines that recommend evening and night-time trigger levels that apply if ground-borne noise levels are audible and exceed existing airborne noise levels. These guidelines have been applied successfully to recent projects in NSW.

These levels recognise the temporary nature of construction and are designed to protect the amenity and sleep of people when they are at home. For Melbourne Metro, the Guideline Targets would also be applied to sleeping areas in hospital wards, student accommodation and hotel rooms.

To comply with the recommended Environmental Performance Requirements, management actions would be taken (as discussed with potentially affected land owners prior to construction) where higher levels of ground-borne noise than the levels set out in Table 13–9 are experienced during construction.

Table 13–9 Guideline Targets for construction ground-borne noise

Time Period	Internal $L_{Aeq,15min}$, dB
Evening, 6pm to 10pm	40
Night, 10pm to 7am	35

Notes:

1. Levels are only applicable when ground-borne noise levels are higher than airborne noise levels.
2. The noise levels are assessed at the centre of the most affected habitable room.
3. Management actions include extensive community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances.

Vibration and Ground-borne Noise from Operation

There are also no published Victorian standards or guidelines for vibration and ground-borne noise levels from rail operations.

The NSW Rail Infrastructure Noise Guideline (RING), issued in May 2013, has been applied to the assessment of operational ground-borne emissions from Melbourne Metro. RING assumes feasible and reasonable mitigation to reduce noise towards the Guideline Targets.

Track isolation could be provided to comply with the recommended Environmental Performance Requirements and protect amenity at sensitive receptors where the ground-borne noise Guideline Targets set out in Table 13–10 are predicted to be exceeded during operation.

What is ground-borne noise?

Ground-borne noise is noise caused by ground vibration (produced by construction activities or a train or tram passing) re-radiated (by the building structure) as noise inside a building (typically characterised as low frequency 'rumbling' noise). A common cause of ground-borne noise is from construction activities such as blasting and driven piling.

Table 13–10 Guideline Targets for operational ground-borne noise

Sensitive land use	Time of day	Internal noise trigger levels
Residential	Day (7am-10pm)	40 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more
	Night (10pm-7am)	35 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more
Schools, educational institutions, places of worship	When in use	40–45 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more
Hospitals (bed wards and operating theatres)	24 hours	35 dB(A) L _{ASMax}
Offices	When in use	45 dB(A) L _{ASMax}
Cinemas and public halls	When in use	30 dB(A) L _{ASMax}
Drama theatres	When in use	25 dB(A) L _{ASMax}
Concert halls, television and sound recording studios	When in use	25 dB(A) L _{ASMax}

Notes:

1. RING provides trigger levels for residential and schools, educational institutions and places of worship, but does not provide guidance on acceptable ground-borne noise levels for other types of sensitive receivers. Ground-borne noise trigger levels for other types of sensitive occupancies have been proposed for Melbourne Metro based on RING and industry knowledge.
2. Specified noise levels refer to noise from heavy or light rail transportation only (not ambient noise from other sources).
3. Assessment location is internal near to the centre of the most affected habitable room.
4. L_{ASMax} refers to the maximum noise level not exceeded for 95% of the rail pass-by events.
5. For schools, educational institutions, places of worship the lower value of the range is most applicable where low internal noise levels is expected.
6. The values for performing arts spaces may need to be reassessed to address the specific requirements of a venue.

For vibration from rail operations, the Guideline Targets have been based on the British Standard BS6472-1:2008. The recommended Environmental Performance Requirements apply the targets shown in Table 13–11 for the operation of Melbourne Metro.

Table 13–11 Guideline Targets for operational vibration

Location	Vibration Dose Values (m/s ^{1.75})			
	Day 7:00 am to 10:00 pm		Night 10:00 pm to 7:00 am	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.10	0.20
Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures.
2. Compliance with these values implies no structural damage due to operation.

13.6 Existing Conditions

As described in Section 13.4.2, baseline measurements were undertaken at a number of locations in the vicinity of the Melbourne Metro alignment to determine existing noise and vibration levels. The measurements for external ambient noise and external vibration are summarised below. Detailed results of the measurements taken at each representative location are provided in Appendix F of Technical Appendix I *Noise and Vibration*.

Internal measurements were taken at locations where vibration-sensitive equipment is present. These are discussed under Precinct 4 – Parkville station and Precinct 5 – CBD North station.

13.6.1 External ambient noise

Monitoring of external ambient noise undertaken for the EES impact assessment generally found that existing background (L_{A90}) and ambient (L_{Aeq}) noise levels are typical for locations in a busy, inner urban area. The range of background noise levels recorded for Precincts 1 to 8, and the locations with the highest recorded levels, are outlined in Table 13–12.

As discussed in Section 13.5.1, EPA 1254 would require the noise level at any residential premises during weekday evenings and weekends not to exceed background noise by 10dB(A) or more for up to 18 months after the project's construction commences, reducing to 5dB(A) after 18 months. Night-time noise from construction works in habitable rooms must be inaudible. The exception to this is noise from Unavoidable Works, as described in Section 13.5.1.

Table 13–12 Existing conditions: background (L_{A90}) noise levels

Precinct	Evening range (L _{A90} , dB)	Night range (L _{A90} , dB)
	Receiver with highest level	Receiver with highest level
Precinct 1 – Tunnels	49 – 54 The Melburnian, 250 St Kilda Road	40 – 44 68 Toorak Road, South Yarra
Precinct 2 – Western portal	41 – 50 138 Kensington Road, Kensington	38 – 46 3 Childers Street, Kensington
Precinct 3 – Arden station	42 – 52 2/3 Miller Street, West Melbourne	43 – 51 2/3 Miller Street, West Melbourne
Precinct 4 – Parkville station	49 – 59 Victorian Comprehensive Cancer Centre and Royal Melbourne Hospital	42 – 55 Royal Melbourne Hospital and Howard Florey Laboratories
Precinct 5 – CBD North station	57 – 63 200 La Trobe Street, Melbourne	50 – 58 200 La Trobe Street, Melbourne
Precinct 6 – CBD South station	58 – 60 Westin Hotel (level 10) and Uni Lodge Apartments (ground level)	52 – 56 Westin Hotel (level 10)
Precinct 7 – Domain station	53 Hallmark Apartments and The Domain	45 – 47 The Domain
Precinct 8 – Eastern portal	38 – 46 139 Osborne Street, South Yarra	33 – 44 139 Osborne Street, South Yarra

13.6.2 External vibration

Monitoring of external vibration levels undertaken for the EES impact assessment found that existing maximum peak particle velocity levels were generally typical for inner city locations, with higher levels recorded in locations close to major arterial roads and tram and train lines. The maximum external vibration levels recorded for Precincts 2 to 8 are outlined in Table 13–13. The representative locations with the highest recorded levels and the reasons for the measurement are also shown in the table.

As shown in the table, a number of locations currently experience external vibration levels approaching or exceeding the construction vibration Guideline Targets for human comfort (refer to Table 13–5). This indicates that receivers at or near these locations are accustomed to vibration.

Table 13–13 Existing conditions: maximum external vibration levels

Precinct	Maximum peak particle velocity levels (mm/s) Receiver with highest level
Precinct 2 – Western portal	1.5 148 Kensington Road, Kensington (truck 15 m away travelling over a road imperfection)
Precinct 3 – Arden station	4.2 760 Queensberry Street, North Melbourne (truck 3 m away travelling over a road imperfection)
Precinct 4 – Parkville station	2.9 Grattan Street, Parkville (between Flemington Road and Royal Parade) (bus and dump truck at 1 m)
Precinct 5 – CBD North station	5.2 Microelectronics and Material Technology Centre, RMIT (420 Swanston Street, Melbourne) (dual carriage tram at 10 m travelling over rail joints)
Precinct 6 – CBD South station	7 Young and Jackson Hotel (1 Swanston Street, Melbourne) (tram at 5 m, tram at 10 m travelling over rail joints)
Precinct 7 – Domain station	3.2 Tram shelter, 340 St Kilda Road, Melbourne (tram at 5 m)
Precinct 8 – Eastern portal	2 162 Toorak Road, South Yarra (tram at 5 m)

13.6.3 Internal vibration

Monitoring of internal vibration levels was undertaken at sensitive receivers in the Parkville, CBD North and CBD South station precincts to help determine the appropriate Guideline Targets to set for vibration-sensitive equipment and Highly Sensitive Areas.

Measurements were taken at Royal Melbourne Hospital, Royal Women’s Hospital, Walter and Eliza Hall Institute, Peter Doherty Institute, Howard Florey Laboratories, Melbourne Private Hospital, Kenneth Myer Building, Bio21 Institute and a range of facilities at the University of Melbourne and RMIT University.

The monitoring indicated that these facilities currently experience levels of internal floor vibration that extend from very low (less than 10µm/s RMS – for example, where sensitive equipment such as MRI machines are operating) to higher levels (up to 88µm/s RMS – for example, in operating rooms).

Details of the results of this monitoring are provided in Section 10 and Appendix H of Technical Appendix I *Noise and Vibration*.

13.7 Risk Assessment

An Environmental Risk Assessment has been completed for impacts of Melbourne Metro in relation to noise and vibration. Further information about the risk assessment approach adopted for Melbourne Metro is included in Chapter 4 *EES Assessment Framework and Approach*.

Impact assessment must be informed by a risk assessment so that the level of mitigation action relates to the likelihood of an adverse impact occurring.

Given the intensely developed inner urban area in which the proposed underground excavation and construction activities would be undertaken for Melbourne Metro, high and very high initial risk ratings were assigned to a number of noise and vibration risks. The initial very high risk ratings were associated with the potential impacts of vibration on human comfort and vibration-sensitive equipment operated by the hospitals and research institutes located in the Parkville station precinct.

The impact assessment focused on those risks that were assessed as having an initial risk level of medium or above. As a result of the impact assessment, project-specific Environmental Performance Requirements have been recommended and potential mitigation measures proposed to demonstrate how these impacts could be managed.

Achieving these Environmental Performance Requirements would be expected to reduce the residual risk ratings of most potential events to medium, low or very low.

Potential events that would continue to have high residual risk ratings relate to:

- The potential for vibration impacts during tunnelling and general construction activities to exceed the Guideline Targets for human comfort in the CBD North and CBD South station precincts
- The potential for vibration impacts from general construction activities (other than tunnelling) to exceed the Guideline Targets for vibration-sensitive equipment in the Parkville station precinct
- The potential for ground-borne noise from tunnelling to be higher than the Guideline Targets in the Tunnels precinct and in the Parkville, CBD North and CBD South station precincts.

Noise and vibration risks associated with Melbourne Metro with a residual risk rating of medium or above are shown in Table 13–14. A full list of noise and vibration risks, showing the initial and residual risk rating of each risk, is provided in Technical Appendix B *Environmental Risk Assessment Report* and Technical Appendix I *Noise and Vibration*.

The recommended Environmental Performance Requirements are listed in Section 13.18.

Table 13–14 Noise and vibration risks

Impact pathway		Project phase	Precincts	Residual risk rating
Category	Potential event			
Vibration Construction of Melbourne Metro – tunnelling	Vibration levels from tunnelling exceeding Guideline Targets for human comfort	Construction	1 – Tunnels 4 – Parkville station	Medium
Vibration Construction of Melbourne Metro – tunnelling	Vibration levels from tunnelling exceeding Guideline Targets for human comfort	Construction	5 – CBD North station 6 – CBD South station	High
Vibration Construction of Melbourne Metro – tunnelling	Vibration levels from tunnelling exceeding Guideline Targets for vibration-sensitive equipment	Construction	4 – Parkville station	Medium
Vibration Construction of Melbourne Metro – tunnelling	Vibration levels from tunnelling impacting on Highly Sensitive Areas (hospital wards, operating theatres)	Construction	4 – Parkville station	Medium
Vibration Construction of Melbourne Metro – general construction activities (not including tunnelling)	Vibration levels from general construction exceeding Guideline Targets for structural damage	Construction	4 – Parkville station	Medium
Vibration Construction of Melbourne Metro – general construction activities (not including tunnelling)	Vibration from general activities exceeds Guideline Targets for human comfort	Construction	1 – Tunnels 4 – Parkville station 5 – CBD North station 6 CBD South station	Medium
Vibration Construction of Melbourne Metro – general construction activities (not including tunnelling)	Vibration exceeds Guideline Targets for vibration-sensitive equipment	Construction	4 – Parkville station	High

Impact pathway		Project phase	Precincts	Residual risk rating
Category	Potential event			
Vibration Construction of Melbourne Metro – general construction activities (not including tunnelling)	Vibration exceeds Guideline Targets for vibration-sensitive equipment	Construction	5 – CBD North station	Medium
Ground-borne Noise Construction of Melbourne Metro – tunnelling	Ground-borne noise exceeds Guideline Targets	Construction	1 – Tunnels	High
Ground-borne Noise Construction of Melbourne Metro – tunnelling	Ground-borne noise exceeds Guideline Targets	Construction	4 – Parkville station 5 – CBD North station 6 – CBD South station	High

As Table 13–14 indicates, all risks with a residual risk rating of medium or above are project construction risks. All operational risks have been assessed as low or very low. Low or very low residual risk ratings have been assigned to airborne noise generated by the construction and operation of Melbourne Metro in all precincts.

13.8 Impact Assessment

As shown in Table 13–14, the main noise and vibration impact pathways from Melbourne Metro would be associated with temporary vibration and ground-borne noise generated by tunnelling and general construction works.

The main impacts identified in the noise and vibration impact assessment are described below. Sections 13.9 to 13.17 describe these impacts as they apply specifically to each of the Melbourne Metro precincts.

13.8.1 Construction

Construction activities with the potential to generate noise and vibration impacts include tunnelling, tunnelling support, demolition works, excavation works, rock breaking, bored piling and construction of station boxes and other structures.

Tunnelling impacts have been assessed assuming the TBM moves at a rate of approximately 11.5m per day and the roadheader at a rate of 5m per day. Heavy vehicles accessing the construction sites would be expected to increase traffic noise in some areas for the duration of the proposed construction.

Noise and vibration from construction activities would be managed in accordance with the contractor's CEMP and the Guideline Targets specified by the Environmental Performance Requirements (as outlined in Section 13.5).

The Environmental Performance Requirements would require the appointment of an acoustic and vibration consultant to update the noise and vibration modelling to reflect the contractor's construction methodology, site conditions and specific equipment sound power levels and vibration levels for Melbourne Metro. This model would then be used to determine appropriate mitigation measures to achieve the Environmental Performance Requirements.

The consultant would also be required to undertake noise and vibration monitoring to enable a comparison to be made between measured levels and the Guideline Targets specified in the Environmental Performance Requirements. Should this monitoring indicate levels higher than the Guideline Targets, appropriate management measures would be applied as soon as possible.

Airborne Noise Impacts from Construction Activities

As discussed in 13.5.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254.

EPA 1254 aims to protect residents from unreasonable noise generated by construction activities. It specifies Guideline Noise Levels in respect of construction work undertaken outside of Normal Working Hours and identifies work practices and mitigation measures that should be adopted for construction projects undertaken in Victoria. To meet the Environmental Performance Requirements, the Melbourne Metro contractor would need to develop and implement a plan to manage construction noise in accordance with EPA 1254.

The types of mitigation measures that would satisfy the proposed Environmental Performance Requirements are conventional and fall into two broad classes:

- *General mitigation* would include preparing and implementing a noise and vibration management plan that satisfies EPA 1254, undertaking community consultation about when an activity might increase airborne noise levels and implementing standard mitigation measures such as scheduling noisy activities for day-time where possible, stockpiling material overnight for day-time removal and planning for day-time deliveries where possible.
- *Specific mitigation* would include measures that are tailored to a particular acoustic impacts, such as high performance acoustic construction sheds and temporary noise barriers (up to 6m in height) at selected sites. If noise levels cause impacts to residents, localised noise treatments (such as improved glazing) could be adopted.

A more detailed description of potential noise mitigation measures that could be adopted to achieve the Environmental Performance Requirements is provided in Section 4.8.1 of Technical Appendix I *Noise and Vibration*.

EPA 1254 allows for Unavoidable Works to be undertaken outside of Normal Working Hours, as described in Section 13.5.1. Examples of Unavoidable Works likely to be undertaken in constructing Melbourne Metro are described in Section 6.6.5 of Chapter 6 *Project Description*. While Guideline Noise Levels do not apply to Unavoidable Works, the range of mitigation measures identified in EPA 1254 would limit airborne noise emissions from such works.

In general, adopting the proposed mitigation measures would mean that the expected construction airborne noise levels for Melbourne Metro would be similar to existing ambient noise levels across the alignment and would comply with the applicable Guideline Noise Levels across all precincts.

Table 13–15 outlines the construction airborne Guideline Noise Levels for each precinct, matched against the existing conditions as measured at locations across the alignment (see Section 13.6.1).

Table 13–15 Existing and predicted airborne noise levels by precinct

Precinct	Time period	Existing background noise levels dBL _{A90}	Construction Guideline Noise Levels dBL _{Aeq,15 minutes}	
			Up to 18 months after project commencement	18 months or more after project commencement
Precinct 1 – Tunnels	Weekend/evening	49 to 54	Fawkner Park, South Yarra 61 56	
			250 St Kilda Road, Melbourne 64 59	
	Night	40 to 44	Fawkner Park, South Yarra 55	
			250 St Kilda Road, Melbourne 58	
Precinct 2 – Western portal	Weekend/evening	41 to 50	138 Kensington Road, Kensington 60 55	
			1 Altona Street, Kensington 53 48	
	Night	38 to 46	138 Kensington Road, Kensington 51	
			1 Altona Street, Kensington 43	
Precinct 3 – Arden station	Weekend/evening	42 to 52	60	55
	Night	38 to 46	46	
Precinct 4 – Parkville station	Weekend/evening	49 to 59	69	64
	Night	42 to 55	51	
Precinct 5 – CBD North station	Weekend/evening	57 to 63	70	65
	Night	50 to 58	48	
Precinct 6 – CBD South station	Weekend/evening	48 to 60	70	65
	Night	40 to 44	55	

Precinct	Time period	Existing background noise levels dBL _{A90}	Construction Guideline Noise Levels dBL _{Aeq,15 minutes}	
			Up to 18 months after project commencement	18 months or more after project commencement
Precinct 7 – Domain station	Weekend/evening	53	63	58
	Night	45 to 47	49	
Precinct 8 – Eastern portal	Weekend/evening	38 to 46	139 Osbourne Street, South Yarra 56	51
			6 William Street, South Yarra 51	46
			16 William Street, South Yarra 48	43
	Night	33 to 44	139 Osbourne Street, South Yarra 44	
			6 William Street, South Yarra 52	
			16 William Street, South Yarra 35	

Notes:

1. Construction noise levels determined in accordance with EPA 1254
2. Baseline locations where existing noise levels were measured are shown in Figure 13-1.

Airborne Noise Impacts from Construction Vehicles

Significant numbers of construction vehicles associated with spoil removal and material and equipment delivery are anticipated as part of Melbourne Metro. Of these construction vehicles, approximately 340,000 one-way spoil truck movements are anticipated across the construction work sites over the whole construction program. Airborne noise from construction vehicles has the potential to impact residents in close proximity to haul routes, especially if trucks travel at night when ambient noise levels are lower. Spoil truck movements would operate 24-hours per day, where possible, at the Arden, Domain and potential Fawkner Park construction work sites and all station precincts.

Spoil movements at the eastern and western portals would be undertaken during Normal Working Hours (where possible), except during rail occupations (24-hour site services that will occasionally occur at each portal). There would be minimal requirement for spoil removal from the western turnback and none anticipated to occur at night.

Spoil trucks would use 'preferred traffic routes' and the use of local roads would be restricted to Normal Working Hours (where possible). If a resident in the vicinity of a construction site is adversely impacted by construction vehicles, consideration could be given to offering suitable noise mitigation, such as improved glazing or respite as appropriate.

Vibration Impacts to Structures

For tunnelling and station construction, the relevant Guideline Targets for structural damage set by the Environmental Performance Requirements (see Section 13.18) are predicted to be achieved with the adoption of appropriate mitigation measures. It is therefore unlikely for damage to be caused to buildings and structures due to vibration arising from the construction of Melbourne Metro.

Structural condition assessments (see box below) and ongoing vibration monitoring would monitor and allow management of the risk of structural damage occurring.

Structural condition assessments

Structural condition assessments may be conducted on buildings identified as potentially being impacted by vibration.

A structural condition assessment is conducted by a Professional Building Surveyor. It comprises an inspection of the existing structural condition of the surrounding buildings and structures before the commencement of a demolition, construction or development and a further inspection after completion of the relevant development.

The assessment should reassure building owners that vibration from constructing Melbourne Metro has not caused any damage.

Vibration and Ground-borne Noise Impacts on Human Comfort

Tunnelling works have the potential to generate vibration and ground-borne noise that may impact on human comfort and amenity.

As outlined in Section 13.5.2, Guideline Targets have been identified for Melbourne Metro to manage the potential vibration impacts on human comfort. Vibration levels lower than these targets have a 'low probability of adverse comments' (that is, a low probability of complaints being made) or 'adverse comment not expected' (see Table 13–5).

The construction contractor would aim to meet the Guideline Targets by applying reasonable mitigation measures. The modelling undertaken for the EES noise and vibration impact assessment predicts that this would generally be sufficient in respect of tunnelling activities for Melbourne Metro. However, the modelling predicts there would be limited periods during which the Guideline Targets for vibration (human comfort) and ground-borne noise may not be met.

The progress of the TBM would mean that the most-affected sensitive receivers (being locations immediately above or in very close proximity to the tunnel alignment) may experience vibration levels above the Guideline Targets for up to 10 days on two occasions (once for each TBM) over the course of the Melbourne Metro construction program. Over the 10 days, vibration levels would slowly increase, then reach a peak when the TBM is closest to the receiver and then slowly decrease.

Roadheader mined tunnels progress more slowly than TBM-bored tunnels. Accordingly, sensitive receivers at a limited number of locations within the CBD may experience vibration levels higher than the Guideline Targets on one occasion of up to 32 days in the course of the construction program.

The extent of impact would vary over these periods depending upon, amongst other factors, the proximity of the TBM or roadheader to the affected location.

As specified in the Environmental Performance Requirements, where levels of vibration and ground-borne noise cause effects during the project's construction, appropriate management actions would be taken to address these temporary impacts.

This would include a thorough community consultation and notification process. Where impacts are deemed to be excessive, or where residents are identified as being particularly affected by vibration and/or ground-borne noise impacts, offers for temporary respite accommodation may be made.

Station excavation has the potential for longer periods of disturbance than tunnelling. Any impacts would be managed by the adoption of an appropriate suite of mitigation measures. In addition to community consultation, these measures may include restrictions on work practices (including the establishment of buffer distances) and offers for respite accommodation where appropriate.

Vibration and human comfort

Responses to vibration by people vary widely due to differences in physical sensitivity as well as psychological and environmental factors.

As with noise, human responses to vibration are determined through social surveys. These studies show that people may perceive and make adverse comment about vibration levels that are only slightly above the threshold of perception.

Vibration targets that trigger management action aim to preserve amenity (human comfort) for the overwhelming majority of the population and are set at a level of 'low probability of adverse comment'. For residential receivers, the 'preferred' vibration threshold is set only slightly above the threshold of perception of vibration, whereas other occupancies – such as commercial/work environments – have thresholds for management action based on a 'low probability of adverse comment' in relation to the context being considered.

Human response to vibration and the potential for adverse comment are also influenced by the duration over which the vibration occurs, with vibration experienced for a limited duration being more acceptable than the same vibration level experienced over a longer period. Building vibration impacts on people are often assessed using the concept of 'vibration dosage' (as in BS6472-1:2008), which links the probability of adverse comment to both the duration and magnitude of vibration.

The concept of time-related influences on human perception of vibration is relevant when considering the duration of construction works, with people more accepting of temporary higher vibration levels over a relatively short period when accompanied by appropriate – and well-communicated – management processes.

In all cases, vibration thresholds aimed at preserving human comfort are far below vibration levels that would cause any damage to structures. This applies to the Guideline Targets specified for Melbourne Metro.

This approach to managing and mitigating vibration and ground-borne noise impacts on human comfort is consistent with other major tunnelling projects undertaken in inner urban environments.

Vibration Impacts on Sensitive Equipment

Following consultation with the health and research institutions in the Parkville and CBD North precincts, an inventory of the location and type of vibration-sensitive equipment was prepared. A vibration Guideline Target (outlined in Table 13–8) was allocated to each piece of equipment based on either the ASHRAE guidelines or the results of a baseline vibration measurement.

As there are existing levels of vibration in these precincts (see Sections 13.6.2 and 13.6.3), some of this equipment is understood to be protected to some extent from vibration impacts by measures taken by the equipment owners, users and/or manufacturers.

There may be times when the Guideline Targets cannot be achieved for some vibration-sensitive equipment in the Parkville precinct during tunnelling and station construction, particularly at the Peter Doherty Institute, Royal Women’s Hospital, Royal Melbourne Hospital, University of Melbourne, Howard Florey Laboratories and the Victorian Comprehensive Cancer Centre. Predicted vibration levels are lower than the vibration Guideline Targets for all but three of the assessed items of vibration-sensitive equipment at RMIT in the CBD North precinct.

Further detailed consultation would be undertaken with these facilities prior to determining the actions that would be taken to manage potential impacts on the operation of this equipment. Actions could include additional vibration attenuation, the timing of works or the relocation of sensitive equipment.

During tunnelling, the TBM (and roadheaders at CBD North station) would be constantly moving, so impacts would be temporary (lasting up to two weeks at the most affected sensitive receiver within the Parkville station precinct) and could be managed through notification and liaison with potentially affected facilities. This might result in the facilities being able to schedule their activities around the times when the TBM passes or, in some instances, it might mean that the TBM needs to slow down to accommodate the facilities’ needs. Slowing of the TBM could reduce the extent of the impact, but would extend the duration of the works and therefore the duration of the corresponding impact.

For general construction works (other than tunnelling), predictions for the Concept Design are that vibration levels would sometimes be above Guideline Targets for some equipment. Measures to reduce impacts and comply with the Environmental Performance Requirements would be determined in consultation with facilities housing sensitive equipment prior to construction of main works. Possible mitigation could be a combination of measures such as applying buffer distances for the most vibration-intensive equipment, using less-vibration intensive techniques (such as smaller rock crushers or hydraulic splitting) in closer proximity to sensitive receivers or using controlled charges that could be scheduled at times which cause the least inconvenience.

Monitoring of vibration levels and close collaboration to keep the relevant stakeholders informed of the timing of the potential impacts in all precincts would be important during the construction of Melbourne Metro.

Vibration Impacts on Highly Sensitive Areas and Bio-resources

There are number of Highly Sensitive Areas within the Parkville station precinct such as hospital wards, operating theatres, ICUs and Bio-resources facilities. The potential effect of ground-borne noise and vibration on each of these areas has been assessed.

In general terms, the construction of Parkville station is not predicted to have a detrimental effect on the Highly Sensitive Areas, as the predicted ground-borne noise and vibration levels are lower than the specific Guideline Target set for these areas in the Environmental Performance Requirements.

However, vibration and ground-borne noise emissions from the TBM during tunnelling are predicted to be higher than the Guideline Targets at the Royal Melbourne Hospital and the Victorian Comprehensive Cancer Centre. As outlined above, the TBM would be constantly moving, so impacts would be temporary and could be managed through consultation with the facilities and notification measures and liaison. Detailed consultation about the equipment, construction program and predicted vibration levels would be undertaken with these facilities to determine appropriate actions to manage the magnitude and duration of potential impacts.

Ground-borne noise emissions are predicted to comply with the Guideline Targets for all of the Bio-resources locations. The vibration Guideline Targets are predicted to be exceeded at one location each at the Royal Melbourne Hospital, Howard Florey Laboratories and the Victorian Comprehensive Cancer Centre.

13.8.2 Operation

Airborne Noise

Airborne rail noise from trains operating on the Sunshine – Dandenong Line would be managed in accordance with the PRINP in the vicinity of the tunnel portals and the proposed western turnback. The Investigation Thresholds from the PRINP are predicted to be met with the installation of noise barriers at the western and eastern portals. Noise barriers are not expected be required for the western turnback.

Fixed infrastructure such as station and railway tunnel ventilation would generate airborne noise and would be required to comply with the SEPP N-1. SEPP N-1 applies to noise from train station plant such as ventilation or air conditioning systems. It does not apply to noise emanating from trains or motor vehicles. Compliance with the SEPP N-1 Noise Limits would be achieved with standard mitigation techniques, such as low noise fans, acoustic attenuators, lined ductwork or acoustic screens.

Melbourne Metro would allow for an increase in the number of trains able to operate on the Sunshine – Dandenong Line. Taking into consideration this increase, an assessment of the source noise level on this line (outside the proposed project boundary) found that in all cases the increase in source noise level is predicted to be less than 3 dB. Consequently, the Investigation Thresholds from the PRINP would not trigger further action.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business, and that would comply with the Guideline Targets.

Consequently, the operation of trains on the Sunshine – Dandenong line is predicted to comply with the Guideline Targets and is not anticipated to cause inconvenience to business or residents or damage any buildings or structures.

13.9 Precinct 1: Tunnels

Precinct 1 includes the alignment of the tunnels between the western portal at Kensington and the eastern portal at South Yarra, with the exception of the stations and portals. The TBM launch sites would be at Arden and at Domain or Domain and Fawkner Park. The potential noise and vibration impacts at these launch sites are discussed under the Arden and Domain station precincts.

The tunnels would be constructed using TBMs and/or roadheaders, which would potentially generate ground-borne noise and vibration, while airborne noise would be generated from the above ground construction works.

During operation, the trains would be underground but would have the potential to generate vibration and ground-borne noise.

13.9.1 Construction

Airborne Noise

As discussed in Section 13.8.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254. Potential airborne noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–16).

Table 13–16 Example airborne noise mitigation – Tunnels precinct

Site	Specific noise mitigation	General noise mitigation
Potential Fawkner Park construction work site	<ul style="list-style-type: none"> Noise barrier surrounding most of the construction site of height up to 6m Acoustic construction shed over the TBM launch site. 	<ul style="list-style-type: none"> Preparation of a noise and vibration management plan Community consultation Other requirements as per EPA 1254
Linlithgow Avenue emergency access shaft	None required	
Fawkner Park emergency access shaft	<ul style="list-style-type: none"> Noise barrier surrounding most of the construction work site up to a height of up to 6m 	
Alternative design option – Fawkner Park emergency access shaft	<ul style="list-style-type: none"> Noise barrier surrounding most of the construction site of height up to 6m 	
Alternative design option – Tom’s Block emergency access shaft	<ul style="list-style-type: none"> None required 	

As a result of compliance with the Environmental Performance Requirements, construction airborne noise levels at sensitive receivers in this precinct would be similar to or lower than existing ambient noise levels for both the Concept Design and the alternative design options.

Vibration Impacts to Structures

As discussed in Section 13.8.1, tunnelling is predicted to comply with the relevant Guideline Targets for structural damage to commercial and residential receivers. Consequently, no structural damage to buildings is predicted.

Tunnel boring over the CityLink tunnels is predicted to result in vibration levels approaching or just exceeding the DIN 4150 continuous vibration Guideline

Target (as specified in the Environmental Performance Requirements). This does not mean that the CityLink tunnels would be subject to damage, as DIN 4150 is a conservative target. Ways to achieve the Environmental Performance Requirements may include reducing vibration levels by slowing the rotational speed and advance rate of the TBM when it is in the vicinity of the CityLink structure, while monitoring vibrations on the structure.

The potential Fawkner Park TBM launch site, the Fawkner Park emergency access shaft and the Linlithgow Avenue emergency access shaft would involve vibration-inducing activities, including bored piling, excavation and rockbreaking (underground works only). The DIN 4150 Guideline Targets for structures specified in the Environmental Performance Requirements are predicted to be achieved for all of these activities.

Vibration Impacts on Human Comfort

TBM Tunnelling

Impacts on human comfort at residential receivers for the majority of the construction program would be insignificant. However, during TBM operations, vibration is predicted to reach or exceed 'high probability of adverse comment' at locations closest to the tunnels. This vibration is expected to be strongly noticeable and would be for a limited period of time (up to two days). Vibration would be noticeable at lower levels for many residential receivers within 55 m of the tunnels alignment as the TBM passes by (over two periods of up to 10 days), but these receivers would be unlikely to be disturbed for the full period.

The greatest number of exceedances would occur between the Arden and Parkville station precincts. As discussed in Sections 13.5.2 and 13.8.1, vibration levels higher than the Guideline Targets would trigger management actions that could include notifying residents along the alignment about the tunnelling works and advising of the potential impacts.

The predicted vibration levels would exceed the 'adverse comment probable' Guideline Target during the day and night at a number of residential properties – again, mostly between Arden and Parkville stations, although some residents in the Domain, CBD North, CBD South and eastern portal precincts would potentially also be affected. Vibration is predicted to be at these levels for up to four days at the most significantly affected receivers. In these instances, one way to address the Environmental Performance Requirements could be to make offers of respite to residents who are particularly affected by or sensitive to vibration levels or whose sleep is expected to be disturbed by tunnelling operations.

CBD Roadheader Tunnelling

During roadheader tunnelling between CBD North and CBD South stations, residential receivers within 30 m to 45 m of the proposed tunnels alignment are predicted to experience vibration levels that reach or are higher than the 'low probability of comment' Guideline Target during the day and within 40m to 60m during the night. Some residential receivers are also expected to exceed the 'adverse comment probable' Guideline Target for a period of approximately two weeks at night.

The distance between the roadheader and the receiver changes relatively quickly as the roadheader progresses along the tunnel. As the roadheader approaches the receiver, the vibration would increase to a peak and then reduce again as the roadheader moves away. This would result in vibration levels higher than the Guideline Targets for one period of up to 32 days during the Melbourne Metro tunnel construction program between CBD North and CBD South stations.

A number of options have been considered to achieve the Environmental Performance Requirements relating to human comfort. While it may be possible to reduce vibration levels by slowing the rotational speed and advance rate of the roadheader, this would extend the construction timeframe. The consequent longer period of community disruption would need to be balanced against a shorter duration and higher level of vibration impact experienced at a relatively small number of locations.

Accordingly, prior notice, advice and assistance to residents and businesses in the vicinity of the alignment is considered the best and most effective way to mitigate the temporary inconvenience caused by tunnel excavation.

As noted above, respite could be offered in particular circumstances, such as where a person is identified as being particularly affected by or sensitive to vibration and ground-borne noise impacts or where potential disturbance to sleep is anticipated.

Fawkner Park and Queen Victoria Gardens

For other construction activities, compliance with the Guideline Targets for human comfort is predicted in the vicinity of the Queen Victoria Gardens (Linlithgow Avenue) construction work site. At Fawkner Park, rockbreaker works are predicted to exceed the 'low probability of adverse comment' target during the day-time at one dwelling on Toorak Road. Residents at this dwelling would be consulted ahead of the works commencing. However, as the vibration level is lower than the maximum Guideline Targets, no additional mitigation is proposed beyond keeping the resident informed about the extent and duration of the works.

Ground-borne Noise Impacts to human comfort

Along the tunnels alignment, ground-borne noise is predicted to be higher than the Guideline Targets in the evening and night at a number of locations above and in the vicinity of the tunnels alignment during TBM and roadheader tunnelling operations.

The maximum predicted ground-borne noise from tunnelling would extend up to 65 dB(A), which would be 25 dB(A) and 30 dB(A) higher than the Guideline Targets for evening and night respectively. While this level of ground-borne noise is expected to be highly intrusive, such levels are only predicted to occur for up to five days (for both TBM passes combined). Lower levels, while still noticeable, would occur for up to 10 days in total.

Levels above the ground-borne noise Guideline Targets are expected to last up to 10 days on two occasions as the TBM passes receivers within 35m to 50m for the evening period and 45m to 60m for the night period. For the roadheader construction of the CBD tunnels, these exceedances are expected to last up to 22 days for receivers within 40 m to 55 m for the evening period and 50m to 65m for the night period. Maximum roadheader ground-borne noise levels are predicted to be lower than the levels predicted for the TBM – although these ground-borne noise levels are predicted to be moderately intrusive for a period of up to 12 days.

As with vibration, giving prior notice and advice to residents and businesses about the pass-by of tunnelling activities is considered the best and most effective way to mitigate the temporary inconvenience caused by tunnel excavation and to achieve the recommended Environmental Performance Requirements. Respite could also be offered in particular circumstances.

Vibration-intensive construction activities are not proposed to be undertaken outside of Normal Working Hours at either the Linlithgow Avenue or the potential Fawkner Park construction work sites. Consequently, these activities are predicted to comply with the ground-borne noise Guideline Targets at sensitive receivers in the vicinity of these sites.

13.9.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains on the Sunshine – Dandenong Line and the operation of fixed infrastructure such as fans and ventilation systems.

Airborne rail noise would be managed in accordance with the PRINP and is not expected to trigger any further management action. Fixed infrastructure (such as emergency stair pressurisation fans located in Fawkner Park and Linlithgow Avenue) would be designed to meet the SEPP N-1 Noise Limits.

Vibration and Ground-borne Noise

Vibration caused by operating trains through the Melbourne Metro tunnels is not predicted to be higher than the Guideline Targets specified in the Environmental Performance Requirements for human comfort, buildings and infrastructure.

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels outlined in Section 13.5.2).

13.9.3 Alternative Design Options

Airborne Noise

An alternative to developing an emergency access shaft in Queen Victoria Gardens is to develop it in Tom's Block, on Linlithgow Avenue. Airborne noise impacts associated with the construction of the emergency access shaft at Tom's Block are expected to be greater at The Melburnian apartments (at 250 St Kilda Road) than if the shaft is located at the Queen Victoria Gardens. However, as construction would only be undertaken during Normal Working Hours, EPA 1254 Guideline Noise Levels do not apply. It is predicted that noise associated with these works would be similar to existing ambient noise levels at the nearest residences. Nevertheless, in line with EPA 1254, construction works would need to keep noise emissions to reasonable levels.

Vibration and Ground-borne Noise

The alternative design option considers the Melbourne Metro tunnels crossing under the CityLink tunnels. Vibration levels due to Melbourne Metro tunnel boring within 3m of the bottom of the CityLink tunnels are predicted to comply with the DIN 4150 continuous vibration Guideline Target of 10mm/s peak particle velocity. While this is a conservative target, it is still proposed to monitor vibration levels at the CityLink structure.

The potential alternative design options would not alter the predicted operational vibration impacts stated in Section 13.9.2.

In all other respects, the vibration impacts of the alternative design options do not differ from the Concept Design. The ground-borne noise impacts of the alternative design options also do not differ from the predicted construction and operation impacts associated with the Concept Design.

13.10 Precinct 2: Western Portal (Kensington)

The main components in the western portal precinct include connection to the existing tracks, lowering the existing Sunbury Line tracks, a decline structure and tunnel entrance structure and relief shaft in the western corner of the 50 Lloyd Street Business Estate. The precinct includes residences, public open space, industry and a freight terminal.

13.10.1 Construction

Airborne Noise

Rail occupation works (track and bridge works, excavation and spoil removal) would be classified as Unavoidable Work and could be undertaken 24 hours/day to minimise impacts on rail services. Construction of the decline structure, TBM removal, track work preparation and cut and cover construction would be undertaken during Normal Working Hours.

As discussed in Section 13.8.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254. While Guideline Noise Levels do not apply to the construction activities in this precinct (as the works would be undertaken during Normal Working Hours or would be Unavoidable Work), potential noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–17).

Table 13–17 Example airborne noise mitigation – Western Portal precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> Construction noise barrier adjacent to the construction work site on Hobsons Road of height up to 6 m Construction noise barrier in the car park on Childers Street at the western end near Kensington Road of height up to 6 m Construction noise barrier along Childers Street between Ormond Street and Tennyson Street of height up to 6 m 	<ul style="list-style-type: none"> Preparation of a noise and vibration management plan Community consultation Other requirements as per EPA 1254

The proposed indicative locations for specific mitigation are shown in Figure 13-3. These barriers would mitigate construction and train noise, but are proposed to be temporary and for the purpose of mitigating construction noise only.

Figure 13-3 Proposed construction noise mitigation



With appropriate mitigation such as outlined in this section, construction noise levels for all works in this precinct are predicted to be similar to or no greater than the existing noise levels at the nearest residential sensitive receivers. Should these works extend to the night period, noise levels are predicted to be higher than the existing average levels by up to 6 dB. However, these higher levels would not be higher than existing maximum levels and would comply with EPA 1254. Community consultation would be undertaken ahead of construction commencing and a construction noise and vibration management plan would be prepared and implemented.

Vibration Impacts to Structures

As discussed in Section 13.8.1, tunnelling is predicted to comply with the relevant Guideline Targets for structural damage to commercial, residential and heritage receivers. Vibration levels from general construction works are also predicted to comply with the targets in Precinct 2. Consequently, no structural damage to buildings is expected.

Vibration and Ground-borne Noise Impacts on Human Comfort

Vibration levels from tunnelling are predicted to comply with the Guideline Targets for human comfort specified in the Environmental Performance Requirements. For general construction works (such as construction of the decline structure), the Guideline Targets are predicted to be achieved when less vibration-intensive methods are used as a mitigation measure.

13.10.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains on the Sunshine – Dandenong Line and the operation of fixed infrastructure such as fans.

Where houses/buildings are proposed to be demolished (in Childers and Ormond Streets, Kensington), this would expose other residential locations to additional train noise. Levels at some of these residences are predicted to exceed the PRINP Investigation Thresholds. The construction of a permanent noise barrier would result in compliance with PRINP and achieve the Environmental Performance Requirement for operational airborne noise. The noise barriers required for the Concept Design would be approximately 4.5 m high and 150 m long (shown in Figure 13-4). Noise barrier requirements would be confirmed by the contractor and by noise modelling of the detailed design.

Figure 13-4 Example operational noise mitigation for Concept Design



Fixed items of plant are not currently proposed in Precinct 2. Any fixed infrastructure included in detailed design would be designed to meet the SEPP N-1 Noise Limits.

Vibration and Ground-borne Noise

No exceedances of the vibration Guideline Targets have been predicted for structural damage to buildings or human comfort.

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels outlined in Section 13.5.2).

13.10.3 Alternative Design Option

The alternative design option for the western portal has the portal located slightly further west than the Concept Design. The TBM access shaft would be located in Childers Street immediately west of its junction with Ormond Street and the decline structure and associated widening of the railway embankment would extend to Kensington Road. A widened railway bridge would be required at Kensington Road. The construction work sites would be in the Childers Street road reserve, 135–143 Ormond Street and 1–39 Hobsons Road. No construction works would be located in the 50 Lloyd Street Business Park, 1–15 Childers Street or 124–126 Tennyson Street.

The Environmental Performance Requirements proposed for construction of the Concept Design would apply equally to the alternative design option.

In relation to airborne noise during operation, the PRINP Investigation Thresholds are predicted to be exceeded at one residence (due to the demolition of an existing building). Consequently, noise mitigation in the form of a permanent noise barrier would be required. For the alternative design option, the noise barrier could be approximately 3 m high and 75 m long.

Vibration and ground-borne noise impacts associated with construction and operation are predicted to be similar to the Concept Design.

13.11 Precinct 3: Arden Station

The proposed Arden station and construction work site would be located on a large publicly owned site managed by VicTrack, surrounded by low-rise development and a mix of land uses. Extensive urban renewal of the precinct is expected over the next 20 years and this has been considered in assessing the operational noise and vibration impacts.

13.11.1 Construction

Airborne Noise

The main works with the potential to impact upon sensitive receivers in this precinct are the construction of the station box with no roof deck (Normal Working Hours), TBM launch preparation and TBM launch (24 hours, Unavoidable Work) and site works (24 hours).

The nearest noise sensitive receivers are dwellings to the east and south-east of the proposed Arden station on Laurens Street, Queensberry Street and on the corner of Queensberry Street and Munster Terrace. These dwellings are located in a Mixed Use Zone of residential and commercial properties.

As discussed in Section 13.8.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254. Guideline Noise Levels would not apply to most of the construction works in this precinct as the works would be undertaken during Normal Working Hours or would be Unavoidable Work. The exceptions are works that would occur over 24 hours and any other avoidable work that is undertaken outside of Normal Working Hours.

Potential noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 or measures specific to particular locations and precincts (as shown in Table 13–18).

In general, with these measures in place, construction noise levels would not exceed existing noise levels. However, it is predicted that the internal noise requirement for inaudibility may not be achieved in two nearby apartment buildings (levels 2 and 3 of 142–144 Laurens Street and level 3 of 731–735 Queensberry Street). If the construction noise level causes impacts to residents, then localised noise treatments, such as improved glazing, could be adopted to achieve the Environmental Performance Requirements.

Table 13–18 Example airborne noise mitigation – Arden station precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> • Construction noise barrier adjacent to the construction site along a portion of Laurens Street with a height of up to 6 m • Acoustic construction sheds over the concrete batching plant and TBM launch area 	<ul style="list-style-type: none"> • Preparation of a noise and vibration management plan • Community consultation • Other requirements as per EPA 1254

For the site works and any other avoidable work undertaken outside of Normal Working Hours, the Guideline Noise Levels set in accordance with EPA 1254 would apply.

Vibration Impacts to Structures

As discussed in Section 13.8.1, tunnelling is predicted to comply with the relevant Guideline Targets for structural damage to commercial, residential and heritage receivers. Vibration levels from general construction works are also predicted to comply with the targets in Precinct 3. Consequently, no structural damage to buildings is expected.

Vibration and Ground-borne Noise Impacts on Human Comfort

Vibration levels from tunnelling operations and general construction works are predicted to comply with Guideline Targets for human comfort specified in the Environmental Performance Requirements.

Ground-borne noise levels are predicted to comply with the Guideline Targets at sensitive receivers in the vicinity of the construction site.

13.11.2 Operation

As noted above, the assessment has considered the potential operational impacts on the proposed future urban renewal of the Arden-Macaulay area adjacent to the Arden station site.

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains and the operation of fixed infrastructure.

Airborne noise from trains in this precinct would be insignificant as the trains would be below ground in the tunnel.

Ventilation and other fixed plant, including fans, back of house ventilation systems and a chiller plant (at a location yet to be determined), may operate 24 hours and would be designed to meet the relevant SEPP N-1 Noise Limits at the nearest Noise Sensitive Areas.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2). These measures would need to take into consideration that higher track attenuation may be required given the future residential and commercial development in the precinct anticipated as a result of planned urban renewal.

13.12 Precinct 4: Parkville Station

The Parkville station precinct is a highly developed urban area near the edge of the CBD with busy tram lines running along Royal Parade and Flemington Road. It forms part of a broader area that is undergoing urban renewal and substantial built form change. Major construction projects, such as the Victorian Comprehensive Cancer Centre, have been undertaken in recent times.

The precinct has major health, research and education institutions. These institutions contain equipment that is particularly sensitive to the effects of vibration. The impact of Melbourne Metro upon that equipment, and upon the sensitive activities conducted within these institutions (such as within hospital wards, ICUs and Bio-resource facilities), is an important component of the noise and vibration assessment undertaken for the precinct.

Proposed infrastructure in the precinct comprises the underground station, station entrances and a pedestrian tunnel under Royal Parade. The Concept Design proposes to construct the station using the top-down cut and cover method, with Grattan Street closed to traffic between Royal Parade and Leicester Street during construction. The proposed construction method assessed assumed a 'roof deck' would be in place over the cut and cover area early in the construction to contain noise and allow for 24-hour construction.

13.12.1 Construction

Airborne Noise

The main works with the potential to impact upon sensitive receivers in this precinct are the construction of the station box with no roof deck (Normal Working Hours) and with roof deck (24 hours), works for access across Royal Parade (Normal Working Hours) and concrete pouring (Unavoidable Work).

Nearby Noise Sensitive Areas include the ward areas of the Royal Melbourne Hospital (corner of Grattan Street and Royal Parade) and residential areas to the south of Parkville station on Berkeley Street, Barry Street and Leicester Street.

As discussed in Section 13.8.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254. Guideline Noise Levels would only apply to the 24-hour works associated with the station box (with the roof deck). These levels are predicted to be met.

While Guideline Noise Levels do not apply to the other construction works (as they would be undertaken during Normal Working Hours or would be Unavoidable Work), potential noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–19).

Table 13–19 Example airborne noise mitigation – Parkville station precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none">• Roof deck over the station box• Acoustic construction sheds over opening in the roof deck• Construction noise barrier on the outside of the roof deck to be a height of up to 6 m (trucks would service the site within the noise barrier)• Construction noise barrier between the construction site on University Square and the residences on Leicester Street to be a height of up to 6 m• Construction noise barrier between the construction site on University Square and the residences on Barry Street to be a height of up to 6 m	<ul style="list-style-type: none">• Preparation of a noise and vibration management plan• Community consultation• Other requirements as per EPA 1254

If required, airborne noise impacts at the Bio-resources facilities at the University of Melbourne’s Faculty of Medicine and the Peter Doherty Institute could be mitigated further by additional measures, such as treatment to the façade of the building.

Construction noise would not be anticipated to have any material adverse impact (beyond existing noise levels) for the Bio-resources facilities at the Victorian Comprehensive Cancer Centre or the Royal Melbourne Hospital.

Vibration Impacts to Structures

As discussed in Section 13.8.1, tunnelling is predicted to comply with the relevant Guideline Targets for structural damage to commercial, residential and heritage receivers. Vibration levels from general construction works are also predicted to comply with the targets in this precinct. Consequently, no structural damage to buildings is expected.

However, as an added precaution, vibration monitoring would be undertaken in this precinct to verify vibration levels, particularly when construction equipment is operating within 5m of a building.

Vibration Impacts on Human Comfort

Vibration impacts on human comfort in the Parkville precinct relate primarily to Highly Sensitive Areas (see below). Vibration levels as a result of tunnelling are predicted to trigger 'adverse comment' (see Table 13–5) at the following medical institutions situated within the precinct:

- Royal Melbourne Hospital
- Victorian Comprehensive Cancer Centre.

These impacts are expected to be limited to less than nine days. Detailed consultation would be undertaken with these facilities to determine appropriate actions and advance notice periods to manage the potential impacts on human comfort at these facilities.

The Guideline Targets associated with tunnelling are anticipated to be met at all other sensitive receivers within the precinct.

For general construction works, management actions are predicted to be triggered with respect to human comfort at several locations in close proximity to the excavation. The extent of impact would be relatively minor and is predicted to occur only for a period of approximately one day (if ripping works were conducted within 6.5m of the receiver). Consultation, notice and advice about the scheduling of ripping works are expected to adequately manage this impact.

Vibration Impacts on Sensitive Equipment, Highly Sensitive Areas and Bio-resources

The Parkville station precinct contains a significant amount of vibration-sensitive equipment as well as Highly Sensitive Areas such as hospital wards, ICUs and Bio-resources facilities.

Equipment within the following locations may experience vibration levels higher than the Guideline Targets for relatively short periods of time (up to two weeks on two occasions):

- Royal Women's Hospital
- Royal Melbourne Hospital
- Victorian Comprehensive Cancer Centre
- Peter Doherty Institute
- The University of Melbourne Faculty of Medicine
- Howard Florey Laboratories.

As noted in 13.8.1, further consultation would be undertaken with these institutions to determine appropriate actions to manage the predicted levels of vibration to limit impacts on sensitive equipment. Management actions may include notification and liaison with the institutions, additional vibration attenuation, temporary rescheduling of the use of the equipment or temporary relocation of the equipment.

Vibration impacts on sensitive equipment associated with general construction works are expected to be limited primarily to rock-breaking works associated with the station box excavation, bored piling and ripping works. There is scope to limit the extent of these impacts by adopting a range of management actions, including scheduling works at appropriate times or adopting low vibration methods of rock removal. While restricting the scheduling of construction activities could reduce the extent of the impact, it would extend the duration of the works and therefore, the duration of the corresponding impact.

Further detailed consultation would be undertaken with these facilities to determine appropriate actions to manage potential impacts on the operation of this equipment. Actions could include additional vibration attenuation, the timing of works or the relocation of sensitive equipment. A detailed monitoring program would assist in keeping impacts to acceptable levels.

In relation to impacts on Highly Sensitive Areas, certain wards within the Royal Melbourne Hospital and the Victorian Comprehensive Cancer Centre are predicted to experience elevated levels of vibration from tunnelling for limited durations (up to nine days) during construction. The contractor would work closely with both facilities to manage potential impacts.

Ground-borne Noise Impacts on Human Comfort

The range of ground-borne noise from tunnelling in this precinct is predicted to extend up to 58 dB(A), which would be 18 dB(A) and 23 dB(A) higher than the Guideline Targets for evening and night respectively. Levels 20 dB above the Guideline Targets would be highly intrusive. These highly intrusive levels are predicted to occur for approximately two days (for both TBM passes combined) at the closest receiver, and would be less at receivers further from the tunnelling. The Guideline Targets are predicted to be exceeded (clearly audible) for approximately one week at the most affected locations.

Noise levels higher than the Guideline Targets specified in the Environmental Performance Requirements would require management actions to be taken in respect of the following medical institutions situated within the precinct:

- Royal Women's Hospital (wards and staff accommodation)
- Royal Melbourne Hospital (ICU, south wards and cardiology ward)
- Victorian Comprehensive Cancer Centre (country patient accommodation and wards).

These facilities are predicted to experience low levels of ground-borne noise as the TBM passes. Detailed consultation would be undertaken with these facilities to determine appropriate actions to manage potential impacts and ensure they are notified of the timing and duration of potential elevated ground-borne noise levels. Monitoring would also be undertaken at these facilities.

Management actions would only be required for a limited time as the TBM progresses through the tunnels. These actions may include consultation with the affected institutions and giving prior notice about the timing and duration of tunnelling activities.

The Guideline Targets associated with the general construction works are otherwise anticipated to be met at all sensitive receivers, other than a single residence on Barry Street (where the extent of impact would be relatively small).

Consultation with these facilities and communication about the timing and duration of works would be a key management action.

Controlled Charges

The use of controlled charges has been considered as an alternative construction technique to reduce the duration of vibration and ground-borne noise impacts associated with excavating the Parkville station box.

Controlled charges are multiple small explosive charges set off in a short sequence to remove a segment of rock while minimising the duration of vibration and ground-borne noise impacts. Potential impacts are limited to a short time window (a few seconds) and can be scheduled well in advance to allow surrounding facilities to be notified.

Controlled charges would be required if the rock is more resistant than expected and the use of other construction methods would extend the construction program and therefore the duration of higher vibration levels.

If this technique is adopted, controlled charges would be used once the concrete cover (roof deck) of the station box is placed over the excavation and therefore would not involve air overpressure, dust and fly rock impacts.

An assessment of the use of controlled charges was carried out to determine the potential impacts – including in respect of structures, human comfort, sensitive equipment, Bio-resources and Highly Sensitive Areas – as well as any likely restrictions in terms of maximum charge weight size, buffer zones and other measures.

The results of the assessment indicate that the use of controlled charges (using productive charge weights) could be feasible in respect of the Parkville station box excavation. Vibration and ground-borne noise impacts from using controlled charges are expected to be manageable using appropriate mitigation measures. Potential mitigations required to limit vibration and ground-borne noise impacts on nearby receivers may include:

- Restricting charges to outside the hours when nearby research buildings are normally occupied
- Observing exclusion zones or reducing charge weights close to the perimeter of the excavation, heritage and residential structures and within 20m of the western end of the excavation
- Detailed consultation to determine appropriate measures to manage potential impacts to sensitive instrument calibration and/or damage at Peter Doherty Institute and the University of Melbourne's Faculty of Medicine Building.

13.12.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains and the operation of fixed infrastructure.

Airborne noise from trains in this precinct would be insignificant as the trains would be below ground in the tunnel.

Ventilation and other fixed plant may operate 24 hours and would be designed to meet the relevant SEPP N-1 Noise Limits at the nearest Noise Sensitive Areas.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2).

13.13 Precinct 5: CBD North Station

Precinct 5 is characterised by a range of land uses including RMIT University, residential apartment towers, Melbourne Central Shopping Centre and station, the State Library of Victoria and the Melbourne City Baths. It is a highly developed area that features modern and heritage buildings, with the busiest tram line in Melbourne passing through the centre of the precinct.

The station would be constructed under Swanston Street using the mined cavern construction method. The proposed construction methodology assessed was based on the use of roadheaders for up to 18 months for tunnelling and station cavern construction. The main construction activities would include demolition, excavation, station structural works and construction of station entrances, trackworks and station fit out.

As the tunnel alignment is relatively deep at CBD North, much of the construction work would be deep underground and, for much of the time, the noise and vibration impacts would be minimal. Where vibration and ground-borne noise impacts have been predicted, they mostly relate to activities occurring closest to the surface and would be of limited duration.

13.13.1 Construction

Airborne Noise

The main works with the potential to impact upon sensitive receivers in this precinct are demolition works (Normal Working Hours), shaft construction (24 hours), cavern construction (24 hours) and concrete pouring (24 hours, Unavoidable Work).

Nearby Noise Sensitive Areas include residential buildings located at 483 Swanston Street, 87 Franklin Street, 31 A'Beckett Street, 30 Little La Trobe Street and 200 La Trobe Street.

As discussed in Section 13.8.1, the Environmental Performance Requirements mandate the management of construction noise in accordance with EPA 1254.

Guideline Noise Levels would apply to the 24-hour works associated with the shaft and cavern construction. Once the roadheaders are below the roof deck within the cavern or tunnels, compliance is predicted with these levels.

Guideline Noise Levels would not apply to the demolition works and shaft construction, which would be undertaken during Normal Working Hours. While noise associated with these works is predicted to be higher than existing average noise levels, it would be similar to noise from other construction works and short-term events that occur regularly within the CBD.

Concrete pours would be undertaken predominantly during Normal Working Hours. However, there may be times when this work cannot be completed during these hours. This work would be Unavoidable Works to which the Guideline Noise Levels do not apply. The predicted noise levels generated by the Unavoidable Works are lower than existing night-time noise levels at most of the nearby residences. At some locations, noise levels are predicted to be marginally higher than existing levels. Management actions would be required to mitigate the impact on receivers of the noise associated with these works.

For all construction works, potential noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–20).

Table 13–20 Example airborne noise mitigation – CBD North station precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> Acoustic construction sheds (with noise lock lobbies and two sets of doors so that when trucks enter and leave the sheds there would always be one set of doors between the outside and the construction works). Alternative options that achieve compliance with Guideline Noise Levels. 	<ul style="list-style-type: none"> Preparation of a noise and vibration management plan. Community consultation Other requirements as per EPA 1254

Vibration Impacts to Structures

As discussed in Section 13.8.1, the operation of tunnelling equipment is predicted to comply with the relevant Guideline Targets for structural damage to commercial, residential and heritage receivers, provided appropriate buffer distances are maintained. Vibration levels from general construction works are also predicted to comply with the Guideline Targets. Consequently, no structural damage to buildings is expected.

However, as an added precaution, vibration monitoring would be undertaken in this precinct to verify vibration levels whenever rippers, rock-breakers and piling rigs are operated within 5m of a building. If necessary, low-vibration construction methods could be deployed in close proximity to buildings.

Vibration and Ground-borne Noise Impacts on Human Comfort

As discussed in Section 13.9.1 in respect of the Tunnels precinct, vibration from tunnelling is predicted to exceed the day-time and night-time human comfort Guideline Targets at a number of locations along Swanston Street.

These levels of vibration would trigger management actions as outlined in relation to the Tunnels precinct (see Section 13.9.1). However, it should be noted that relatively high existing external vibration levels – up to 5.2 mm/s peak particle velocity along Swanston Street – have been recorded in this precinct. Residents currently exposed to high vibration levels may experience less disturbance.

Based on the proposed construction methodology for the concept design, the vibration levels at CBD North station are predicted to be higher than the day-time and night-time human comfort Guideline Targets at a number of residential locations in Franklin Street when rippers and rockbreakers are working in close proximity to those buildings. These higher levels are expected to potentially impact residents in the lower levels of residential buildings (up to level 4).

For the night-time period, vibration impacts could be managed through maintaining buffer distances and scheduling ripping and rockbreaking west of Swanston Street for during day-time hours only. This would result in night-time vibration levels being lower than the Guideline Targets and avoid night-time vibration impacts due to ripping and rockbreaking activities.

For the day-time period, vibration impacts could be managed by prior notification and advice to residents, and scheduling excavation works. It is anticipated that day-time vibration impacts due to rockbreaking would be for limited periods associated with removing localised zones of harder rock. Vibration impacts due to ripping, which is a less vibration-intensive activity, are predicted to only occur where the ripper is working within 12 m of residential buildings.

Construction of CBD North Station is expected to comply with the vibration Guideline Targets for human comfort at commercial and educational receivers where works are greater than 7 m from receivers in the RMIT Buildings on Franklin Street, as well as other receivers on Swanston Street, Little La Trobe Street and La Trobe Street. Where construction works with rippers occur within a 7 m slope distance of these receivers, impacts could be managed by scheduling works to either use lower vibration methods or be undertaken when buildings are not occupied.

The range of ground-borne noise from CBD cavern construction is predicted to be up to 39 dB(A), which would comply with the evening Guideline Target and exceed the night-time Guideline Target by 4 dB(A) (which is considered to be clearly audible but not intrusive in many urban settings).

Ground-borne noise levels from station cavern roadheader excavation are predicted to be higher than the Guideline Targets for sensitive receivers in the vicinity of the alignment within the CBD North precinct for approximately two weeks, up to three times during the construction program (overlapping with the period of exceedances of vibration Guideline Targets). Respite could be offered to residents who are identified as being particularly vulnerable to the effects of ground-borne noise or whose sleep is anticipated to be affected. In addition, careful scheduling of activities may reduce impacts; however, this could also extend the construction program and the corresponding duration of the vibration levels.

The construction of CBD North station is predicted to achieve compliance with the ground-borne noise Guideline Targets if a minimum buffer distance of 25m for the ripper and 55 m for the rockbreaker is maintained during the night-time period. As a result, any ripping and rockbreaking works within these buffer distances would need to be scheduled during the day-time period.

Restricting the scheduling of construction activities could reduce the extent of the impact; however, this could extend the duration of the works and therefore the corresponding impact.

Vibration Impacts on Sensitive Equipment

Construction of the tunnel and station is predicted to comply with the vibration Guideline Targets for vibration-sensitive equipment at RMIT for all but three items of equipment (based on modelling of the rockbreaker and ripper working at the eastern end of Franklin Street).

Further detailed consultation would be undertaken with RMIT to determine appropriate actions to manage potential impacts on the operation of this equipment. Actions could include additional vibration attenuation, the timing of works or the relocation of sensitive equipment. While restricting the scheduling of construction activities could reduce the extent of the impact, it could extend the duration of the works and therefore the corresponding impact.

A detailed monitoring program would assist in managing impacts to acceptable levels.

13.13.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains and the operation of fixed infrastructure.

Airborne noise from trains in this precinct would be negligible as the trains would be below ground in the tunnel.

Ventilation and other fixed plant may operate 24 hours and would be designed to meet the relevant SEPP N-1 Noise Limits at the nearest Noise Sensitive Areas, which are the residential buildings identified in Section 13.13.1.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2).

13.14 Precinct 6: CBD South Station

Precinct 6 is a highly urbanised and dense inner urban area with a range of land uses, including significant heritage locations such as Flinders Street Station, St Paul's Cathedral, Young and Jackson Hotel, the Nicholas Building and Melbourne Town Hall. The busiest tram corridor in Melbourne passes through the centre of the precinct.

CBD South station would be constructed under Swanston Street using the mined cavern construction method. The proposed construction method is based on the use of a roadheader for a period of up to 18 months for both tunnelling and station cavern construction.

The main construction activities would include demolition, station structural works, construction of station entrances, excavation and station fit out. Temporary construction work sites are proposed to be located at City Square, at the southern entrance of the proposed CBD South station (near the northwest corner of Swanston and Flinders Streets) and at the north-west corner of Federation Square.

13.14.1 Construction

Airborne Noise

The main works with the potential to impact upon sensitive receivers in this precinct are demolition works (Normal Working Hours), shaft construction (Normal Working Hours), cavern construction (24 hours), cut and cover construction of access across Flinders Street (24 hours), Flinders Street Station access works (24 hours, Unavoidable Works) and concrete pouring (24 hours, Unavoidable Works).

Nearby residential Noise Sensitive Areas include the Westin Hotel and residential apartments at 205 Collins Street, 228 Flinders Lane and 228 Flinders Street.

As discussed in Section 13.8.1, the Environment Performance Requirements mandate the management of construction noise in accordance with EPA 1254.

Guideline Noise Levels would apply to all works other than demolition works, which would be undertaken during Normal Working Hours. While noise associated with these works is predicted to be higher than existing noise levels, it would be similar to noise from other construction works within the CBD.

As noted in CBD North station precinct, once the roadheaders are submerged within the cavern or tunnels, compliance is predicted with the Guideline Noise Levels outside of Normal Working Hours.

For all construction works, potential noise and vibration impacts would be managed through the implementation of mitigation measures to achieve the Environment Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–21).

Table 13–21 Example airborne noise mitigation – CBD South station precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> • Noise barrier surrounding the concrete pour of height 2.5m • Acoustic construction sheds (with noise lock lobbies and two sets of doors so that when trucks enter and leave the sheds there would always be one set of doors between the outside and the construction works) at station entrances. • Alternative construction options that achieve compliance with Guideline Noise Levels. 	<ul style="list-style-type: none"> • Preparation of a noise and vibration management plan • Community consultation • Other requirements as per EPA 1254

Vibration Impacts to Structures

As discussed in Section 13.8.1, with the adoption of management measures to meet the Environmental Performance Requirements, the operation of tunnelling equipment is predicted to comply with the relevant Guideline Targets for structural damage to commercial and residential receivers.

As the vibration Guideline Targets are lower for heritage buildings – and are lower than the current peak vibration levels (associated with passing trams) that have been measured on Swanston Street – the following heritage structures would require greater buffer distances than other buildings during the construction of CBD South station:

- The Nicholas Building
- Young and Jackson Hotel
- Ross House

- Flinders Street Railway Station Complex
- Some heritage graded buildings within the Flinders Gate Precinct Heritage Overlay
- Some heritage graded buildings within The Block Precinct Heritage Overlay.

At these locations, a buffer distance of 5 m would be required if ripping of rock is undertaken.

As an added precaution, vibration monitoring would be undertaken in this precinct to verify vibration levels whenever higher vibration activities such as ripping, rockbreaking, piling and diaphragm wall construction are being undertaken within 5m of a heritage building.

Vibration Impacts on Human Comfort

As discussed in Section 13.9.1 in respect of the Tunnels precinct, vibration from tunnelling is predicted to exceed the day-time and night-time human comfort Guideline Targets at a number of locations along Swanston Street. These exceedances would trigger management actions as outlined in relation to the Tunnels precinct.

The proposed construction method is based on a roadheader excavating the station cavern. It is predicted to result in vibration levels exceeding the Guideline Targets up to three times, for up to six weeks at each time, at the most affected residential locations over the duration of construction. The timing of higher vibration levels may be managed through careful scheduling of excavation, although this may also extend the overall construction program and corresponding impacts.

Vibration from the construction of CBD South station is predicted to meet the human comfort vibration Guideline Targets if the ripper and rockbreaker maintain buffer distances of 12 m and 30 m respectively for day-time and 18 m and 45 m respectively for night-time.

Based on the Concept Design and proposed construction methodology, night-time vibration Guideline Targets could be met by maintaining an 18 m buffer between the ripper and residential buildings, and rockbreaking works would need to be scheduled for day-time hours for the majority of the excavation. For the day-time period, vibration impacts could be managed by prior notification and advice to residents, or respite could be offered in particular circumstances.

Night-time vibration Guideline Targets would be met by scheduling rockbreaking works in City Square for day-time hours only. If required, the day-time and night-time vibration Guideline Targets could be met by using lower vibration methods of rock removal.

Exceedances of the Guideline Targets for human comfort are predicted when rippers are working within 7 m of commercial buildings. A small number of commercial buildings fall within 7 m of the Flinders Street/Swanston Street excavation (including the Nicholas Building and Young and Jackson Hotel). There are also a small number of commercial buildings that would fall within 7 m of the potential station entrance at 65–73 Swanston Street. It is expected that these impacts would be managed by maintaining a 7 m buffer zone when these commercial buildings are occupied. Alternatively, the use of lower vibration methods to remove material within this buffer zone could be an option.

Possible adverse comments due to vibration are predicted for receivers in the Australian Centre for the Moving Image (ACMI) when rippers are working in the Federation Square excavation. This could be mitigated either by using lower vibration methods of excavation or by scheduling the work for outside of opening hours.

It may be possible to schedule construction activities so that the times at which higher vibration levels occur would avoid or reduce interference with the use of commercial buildings. This would manage potential impacts, but may also extend the overall construction program and reduce efficiency.

Ground-borne Noise Impacts on Human Comfort

Ground-borne noise levels from station cavern roadheader excavation are predicted to exceed the Guideline Targets at a number of sensitive receivers in the CBD South station precinct up to three times during the construction program, for up to five weeks at each time (overlapping with the period of exceedances of vibration Guideline Targets). The ground-borne noise levels are predicted to be up to 45 dB(A), which is considered to be moderately intrusive. This would occur for approximately three days, with lower levels for the remaining period.

These exceedances would trigger management actions as previously described in relation to the Tunnels and CBD North station precincts. If required, night-time Guideline Targets could be met by construction sequencing or reduced hours of operation of the roadheader.

General construction activities associated with the construction of CBD South station are predicted to achieve compliance with the Guideline Targets if a buffer distance of 25 m for the ripper and 55 m for the rockbreaker is maintained during the evening and night-time periods. As a result, ripping and rockbreaking works would need to be scheduled within these buffer distances during the day-time period.

13.14.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains and the operation of fixed infrastructure.

Airborne noise from trains in this precinct would be negligible as the trains would be below ground in the tunnel.

Ventilation and other fixed plant may operate 24 hours and would be required to meet the relevant SEPP N-1 Noise Limits at the Noise Sensitive Areas, including the Westin Hotel and residential areas at 205 Collins Street, 228 Flinders Lane and 228 Flinders Street.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2).

13.15 Precinct 7: Domain Station

Precinct 7 contains parks and gardens, the Shrine of Remembrance, Melbourne Grammar School, offices and residential apartments. There is a tram superstop within the precinct that services the busiest tram line in Melbourne.

Domain station would be constructed using the top-down cut and cover construction method. This would involve the establishment of a construction work site and site compounds at Edmund Herring Oval and Albert Road reserve. The main construction activities would include TBM launch operations, station structural works, excavation, tram stop relocation and station fit out.

13.15.1 Construction

Airborne Noise

The main works with the potential to impact upon sensitive receivers in this precinct are shaft construction (Normal Working Hours), TBM launch preparation (24 hours, Unavoidable Work) and TBM launch (24 hours, Unavoidable Work).

Nearby Noise Sensitive Areas include residential apartments at 2–14 Albert Road, 29 Albert Road and 402 St Kilda Road.

As discussed in Section 13.8.1, the Environment Performance Requirements mandate the management of construction noise in accordance with EPA 1254.

Guideline Noise Levels would not apply to shaft construction as all work would occur during Normal Working Hours.

TBM preparation and TBM launch would also be predominantly undertaken during these hours from the Domain station box. However, if these works cannot be completed during Normal Working Hours, then construction work would need to continue. This would be Unavoidable Work, to which the Guideline Noise Levels do not apply. Nevertheless, measures would be required to mitigate the noise impact of these works at the nearest receivers.

It is anticipated that Unavoidable Work could occur twice for a period of four to five weeks over the duration of the project. Noise levels associated with these works are predicted to be similar to existing average levels at nearby residences, except for those at higher floors where the noise levels would be marginally higher than the average noise levels but less than the noise generated by short-term events that regularly occur in this precinct.

For all construction works, potential noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could be general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–22).

Table 13–22 Example airborne noise mitigation – Domain station precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> • Noise barrier of height up to 6 m • Acoustic construction shed over the TBM launch site with a noise lock for truck access 	<ul style="list-style-type: none"> • Preparation of a noise and vibration management plan • Community consultation • Other requirements as per EPA 1254

Vibration Impacts to Structures

The operation of tunnelling equipment and the construction of Domain station is predicted to comply with the vibration Guideline Targets for structural damage to commercial, residential and heritage receivers. Consequently, no damage to buildings or structure would be expected to occur.

Vibration and Ground-borne Noise Impacts on Human Comfort

As discussed in Section 13.10 in respect to the Tunnels precinct, vibration from tunnelling is predicted to exceed the day-time and night-time Guideline Targets for human comfort at a number of locations near the corner of St Kilda Road and Dorcas Street and at the southern end of the precinct near the corner of St Kilda Road and Toorak Road. These exceedances would trigger management actions as outlined in relation to the Tunnels precinct.

General construction activities associated with the construction of Domain Station are predicted to comply with the vibration Guideline Targets for human comfort at all but five locations: four buildings on St Kilda Road and the Melbourne Grammar School building on the corner of St Kilda and Domain Roads. These exceedances would occur for a short period of the construction works where rockbreakers are working within 20 m (day-time) of the residential buildings and the school and 40 m (night-time) of the residential buildings. Low-vibration rockbreaking techniques could be deployed within 20 m of residences.

Due to the short-term nature of these impacts and for the reasons discussed in relation to the Tunnels precinct, prior notification and advice about the tunnel and station construction activities would be given to residents and businesses along the tunnel alignment and to Melbourne Grammar School.

Ground-borne noise generated by constructing the Domain station is predicted to comply with the Guideline Targets for human comfort at all but four locations within the precinct. However, compliance with the Guideline Targets could be achieved by maintaining a buffer distance of 40 m between the 20-tonne rockbreaker and residential buildings during the evening and at night-time or by using a smaller rockbreaker or alternative rockbreaking methods.

13.15.2 Operation

Airborne Noise

As discussed in Section 13.8.2, airborne noise during the operation of Melbourne Metro would be generated by trains and the operation of fixed infrastructure.

Airborne noise from trains in this precinct would be negligible as the trains would be below ground in the tunnel.

Ventilation and other fixed plant may operate 24 hours and would be designed to meet the relevant SEPP N-1 Noise Limits at the nearest Noise Sensitive Areas in Albert Road and St Kilda Road.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2).

13.16 Precinct 8: Eastern Portal (South Yarra)

The eastern portal precinct is highly urbanised and comprises a diverse range of housing from low density detached housing to large-scale residential apartment blocks. The existing rail corridor within the precinct includes the Sandringham, Cranbourne/Pakenham and Frankston rail lines.

Construction in this precinct would include demolition, cut and cover excavation of the tunnel portal, widening of the existing rail corridor, construction of a ventilation shaft, emergency access shaft and substation, retrieval of the TBM and reinstatement of the William Street bridge, South Yarra Siding Reserve and Lovers Walk. Construction work sites would be located at the South Yarra Siding Reserve and the Osborne Street Reserve.

13.16.1 Construction

Airborne Noise

While the construction works for rail occupation and TBM retrieval would be classified as Unavoidable Work (and could be undertaken 24 hours/day), these works would be undertaken predominantly during Normal Working Hours. However, if they cannot be completed during these hours, then construction work would need to continue until complete. This is expected to occur twice for a period of four weeks over the duration of the construction program for Melbourne Metro.

As discussed in Section 13.8.1, the Environment Performance Requirements mandate the management of construction noise in accordance with EPA 1254.

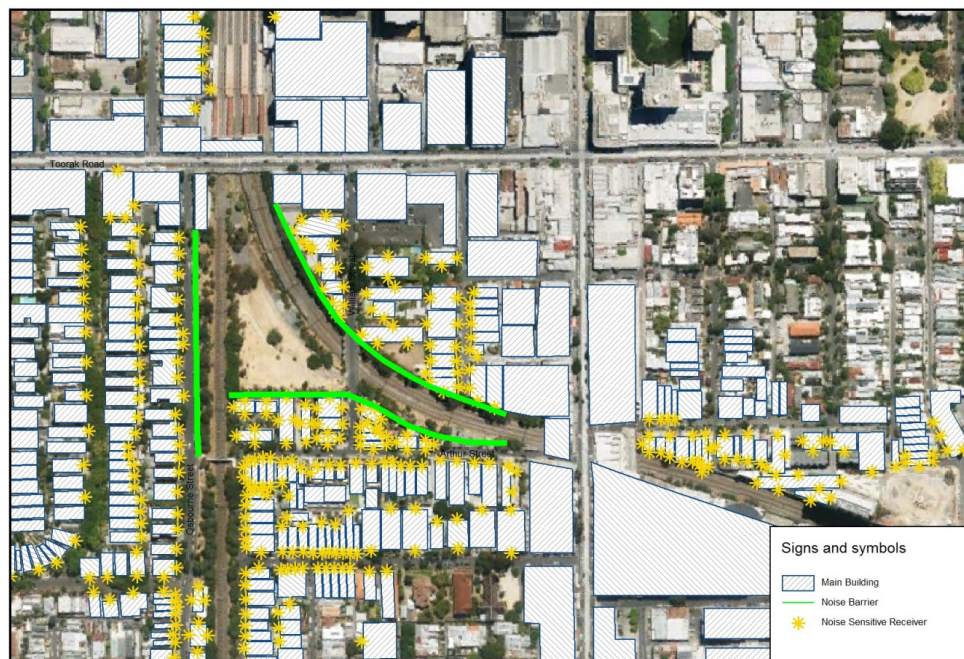
While Guideline Noise Levels do not apply to the construction activities in this precinct (as they would be Unavoidable Work), potential airborne noise impacts would be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–23).

Table 13–23 Example airborne noise mitigation – Eastern Portal precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none"> Up to 6 m high noise barriers surrounding most of the construction area 	<ul style="list-style-type: none"> Preparation of a noise and vibration management plan Community consultation Other requirements as per EPA 1254

The potential locations for noise barriers are shown in Figure 13-5. These barriers would mitigate construction noise and train noise, but are proposed to be used to address construction noise only.

Figure 13-5 Proposed mitigation at Eastern Portal for construction



With the mitigation proposed, construction noise levels for works in this precinct are predicted to be higher at times than existing average noise levels. However, these noise levels are not expected typically to be greater than the noise levels from current short-term events (such as trains passing by). Community consultation, including prior notice and advice about construction activities, is considered the most practicable approach to managing construction airborne noise. In particular circumstances, further measures –including temporary respite – may be appropriate.

Vibration Impacts on Structures

As discussed in Section 13.8.1, tunnelling is predicted to comply with the relevant Guideline Targets for structural damage to commercial, residential and heritage receivers. Consequently, no structural damage to buildings is expected.

Vibration and Ground-borne Impacts on Human Comfort

Vibration levels associated with tunnelling are predicted to comply with the vibration Guideline Targets for human comfort specified in the Environmental Performance Requirements.

For general construction works, the vibration Guideline Targets for human comfort are predicted to be achieved at all but four residential addresses on Osborne Street. Community consultation is considered the most effective and practical way of managing the temporary inconvenience, which is only anticipated to occur over a period of days. This would include notifying and advising residents about planned construction activities.

Ground-borne noise levels associated with tunnelling and general construction works are predicted to comply with the Guideline Targets.

13.16.2 Operation

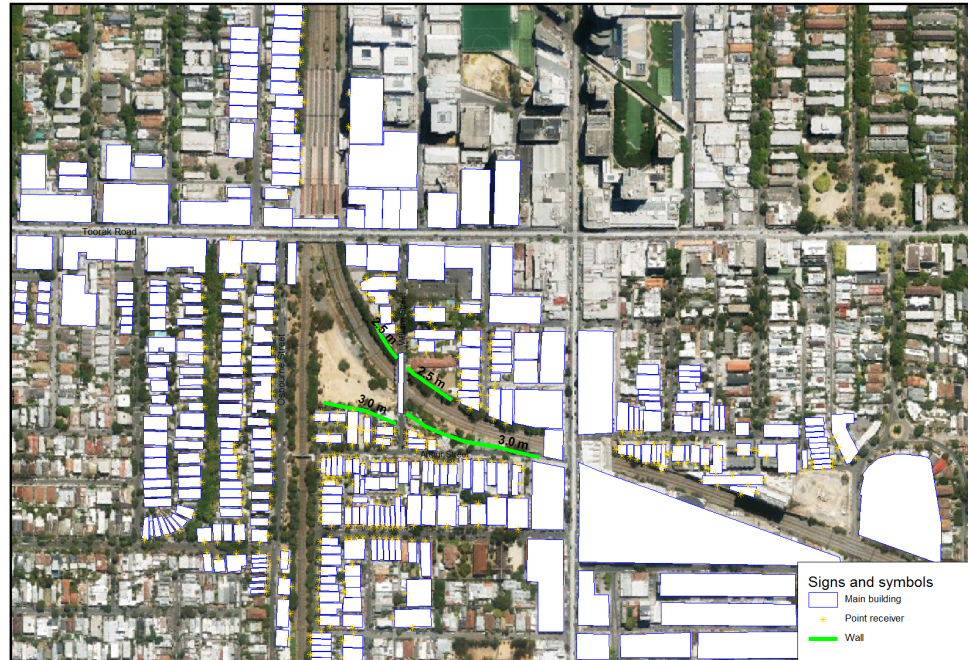
Airborne Noise

Airborne noise generated by trains would be associated with a combination of changes in the precinct including:

- Increased rail traffic
- Widening of the tracks to the south
- Ramps for the Frankston Line and regional tracks
- Removal of properties on Arthur Street and William Street that would otherwise have provided shielding from train noise.

Based on the Concept Design, noise barriers are predicted to be required to achieve compliance with PRINP for properties on Arthur Street and William Street, South Yarra. The barriers would potentially be located along the northern side of the tracks (two barriers 50 m and 70 m in length) and southern side of the tracks (two barriers 100 m and 170 m in length), as shown in Figure 13-6. Barrier heights would range from 2.5 m to 3 m above the ground height of the houses and would be located at the top of the cutting. Noise barrier requirements would be confirmed by the contractor and noise modelling of the detailed design.

Figure 13-6 Potential barriers for rail noise at the Eastern Portal



With the adoption of noise barriers, operational noise levels are predicted to be higher than the PRINP Investigation Thresholds at the upper floors of 4 William Street, 10 William Street, 1 Arthur Street and 3 Arthur Street. As it is not considered practical to provide barriers to mitigate noise impacts for residents at these levels, off-reservation acoustic treatment (such as an upgrade of the building façade) could be applied at these properties.

Vibration and Ground-borne Noise

The recommended Environmental Performance Requirements specify the Guideline Targets that would need to be met during Melbourne Metro's operation (outlined in Tables 13–10 and 13–11).

The vibration Guideline Targets for human comfort and structural damage are predicted to be met in the absence of mitigation measures.

Achieving the Environmental Performance Requirements for ground-borne noise could require the use of measures such as suitably attenuated track to mitigate noise to levels that do not adversely affect residents and business and that would comply with the Guideline Targets (based on the trigger levels as outlined in Section 13.5.2).

13.17 Precinct 9: Western Turnback (West Footscray)

The proposed turnback at West Footscray would include realignment of regional, suburban and freight lines, construction of new track and turnouts, construction of a new passenger platform and alterations to the existing concourse. The works are proposed within an existing rail corridor and no tunnelling would occur within the precinct. The location is in the vicinity of industrial sites, residential sites and the Whitten Oval.

13.17.1 Construction

Airborne Noise

Construction activities with the potential to impact on sensitive receivers in this precinct are associated with rail occupation works (24 hours, Unavoidable Work).

As discussed in Section 13.8.1, the Environment Performance Requirements mandate the management of construction noise in accordance with EPA 1254. While Guideline Noise Levels do not apply for these rail occupation works, potential noise and vibration impacts could be managed through the implementation of mitigation measures to achieve the Environmental Performance Requirements. These measures could include general noise mitigation measures required to comply with EPA 1254 and measures specific to particular locations and precincts (as shown in Table 13–24).

Table 13–24 Example airborne noise mitigation – Western Turnback precinct

Specific noise mitigation	General noise mitigation
<ul style="list-style-type: none">Up to 2.5 m high noise barriers surrounding most of the construction area	<ul style="list-style-type: none">Preparation of a noise and vibration management planCommunity consultationOther requirements as per EPA 1254

The noise barriers described above would mitigate both construction noise and train noise.

With the implementation of these or similar mitigation measures, the likely impacts on receivers would be noise levels marginally higher than existing average levels and lower than the noise levels from current short-term events.

Vibration and Ground-borne Noise Impacts

Vibration levels for the proposed construction activities are predicted to comply with the Guideline Targets for structural damage. Ground-borne noise is expected to be insignificant compared to airborne noise, as no tunnelling works are proposed.

13.17.2 Operation

Airborne Noise

Train noise levels have been predicted and assessed in accordance with the PRINP. As the Investigation Thresholds are predicted to be achieved, mitigation is not proposed.

Trains idling on the Turnback Track and Pocket Track are proposed to occur during peak periods only. Noise emissions from the idling trains are expected to be negligible compared to other noise sources during these periods.

Vibration and Ground-borne Noise

Vibration would not be expected to increase as a result of the project. Ground-borne noise would be insignificant, as the trains would not be operating in tunnels.

13.18 Environmental Performance Requirements

As discussed in Section 13.5, existing Victorian, Australian and international regulations, standards and guidelines are available – and are used regularly – to avoid or minimise the effects of noise and vibration during the construction and operation of major infrastructure projects.

The following table shows the recommended Environmental Performance Requirements for Melbourne Metro in relation to managing potential noise and vibration impacts.

The risk numbers listed in the final column align with the list of noise and vibration risks provided in Technical Appendix B *Environmental Risk Assessment Report*.

Table 13–25 Environmental Performance Requirements for Noise and Vibration

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.
<p>Amenity: To minimise adverse air quality, noise or vibration effects on the amenity of nearby residents and local communities, as far as practicable, especially during the construction phase</p>	<p>Develop and implement a plan to manage construction noise in accordance with EPA Publication 1254 Noise Control Guidelines.</p>	<p>Requirements as per EPA 1254 Community consultation Noise barriers Construction methodology/ equipment Respite/temporary relocation Prepare and implement a construction noise and vibration management plan Noise monitoring Off-reservation treatment (where applicable)</p>	<p>All</p>	<p>Construction</p>	<p>NV001</p>

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.
	<p>For construction works conducted between CBD South station and Domain station, comply with the requirements of the Notification of Referral Decision for the Melbourne Metro Rail Project (EPBC 2015/7549, dated 22 September 2015) under the EPBC Act for vibration monitoring and measurement, as follows:</p> <ul style="list-style-type: none"> • Conduct preconstruction dilapidation surveys of the nearest Commonwealth Heritage listed structures to the construction activity, including the Former Guardhouse (Block B), to record structural condition and structural integrity prior to commencement of tunnelling • Conduct vibration monitoring at the commencement of tunnelling in geological conditions that are similar to those at Victoria Barracks in order to quantify the actual tunnel boring machine vibration characteristics (level and frequency) for comparison to the values derived from the literature and the German DIN (DIN 4150) target • Conduct continuous vibration monitoring at the nearest Victoria Barracks heritage structures to the construction activity, including the Former Guardhouse (B Block), to assess the actual tunnelling vibration for acceptability, taking into account both the vibration frequency and condition of structures, until monitoring of vibration at the Former Guardhouse (B Block) shows measurements equivalent to preconstruction vibration readings at the Former Guardhouse (B Block) • If monitoring conducted according to the above demonstrates the condition of heritage structures may be degraded as a result of vibration, ground vibration must be reduced by adjusting the advance rate of the tunnel boring machine until monitoring of vibration at the Former Guardhouse (B Block) shows consistent measurements equivalent to preconstruction vibration readings at the Former Guardhouse (B Block). 		1 – Tunnels (between CBD South station and Domain station)	Construction	NV002 NV014
	<p>Appoint an acoustic and vibration consultant to predict construction noise and vibration (through modelling) and update the modelling to reflect current construction methodology, site conditions and specific equipment noise and vibration levels (this will require noise and vibration measurements). The model would be used to determine appropriate mitigation to achieve the Environmental Performance Requirements.</p> <p>The acoustic and vibration consultant will also be required to undertake noise and vibration monitoring to assess levels with respect to Guideline Targets specified in the Environmental Performance Requirements. Where monitoring indicates exceedances of Guideline Targets, apply appropriate management measures as a soon as possible.</p>		All	Construction	NV001 - NV029

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.									
	Develop and implement a communications plan to liaise with potentially affected community stakeholders and land owners regarding potential noise and vibration impacts. The plan shall include procedures for complaint management.		All	Construction	NV001 - NV029									
	<p>Construction Airborne Noise Guideline Targets (Internal)</p> <p>Implement management actions if construction noise exceeds the internal noise levels below for Highly Sensitive Areas (based on AS/NZS 2107:2000) and a noise sensitive receptor is adversely impacted.</p> <table border="1" data-bbox="392 584 1021 865"> <thead> <tr> <th data-bbox="392 584 645 683">Highly Sensitive Area</th> <th data-bbox="651 584 1021 683">Maximum Internal Construction Noise Level L_{Aeq, 15 mins}</th> </tr> </thead> <tbody> <tr> <td data-bbox="392 687 645 727">Intensive Care Wards</td> <td data-bbox="651 687 1021 727">45</td> </tr> <tr> <td data-bbox="392 732 645 772">Operating Theatres</td> <td data-bbox="651 732 1021 772">45</td> </tr> <tr> <td data-bbox="392 777 645 817">Surgeries</td> <td data-bbox="651 777 1021 817">45</td> </tr> <tr> <td data-bbox="392 821 645 865">Wards</td> <td data-bbox="651 821 1021 865">40</td> </tr> </tbody> </table>	Highly Sensitive Area	Maximum Internal Construction Noise Level L _{Aeq, 15 mins}	Intensive Care Wards	45	Operating Theatres	45	Surgeries	45	Wards	40	Community consultation Acoustic construction sheds Construction methodology/ equipment Prepare and implement a construction noise and vibration management plan Internal noise monitoring	All	Construction
Highly Sensitive Area	Maximum Internal Construction Noise Level L _{Aeq, 15 mins}													
Intensive Care Wards	45													
Operating Theatres	45													
Surgeries	45													
Wards	40													

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.																									
	<p>Vibration Guideline Targets for Structures</p> <p>Implement management actions if due to construction activity, the following DIN 4150 Guideline Targets for structural damage to buildings (for short-term vibration or long-term vibration) are not achieved.</p> <p>Short-term vibration on structures</p> <table border="1" data-bbox="394 517 1288 1070"> <thead> <tr> <th data-bbox="394 517 719 655"></th> <th data-bbox="728 517 837 655"></th> <th data-bbox="846 517 956 655"></th> <th data-bbox="965 517 1075 655"></th> <th data-bbox="1084 517 1288 655"></th> </tr> </thead> <tbody> <tr> <td data-bbox="394 662 719 746"></td> <td data-bbox="728 662 837 746"></td> <td data-bbox="846 662 956 746"></td> <td data-bbox="965 662 1075 746"></td> <td data-bbox="1084 662 1288 746"></td> </tr> <tr> <td data-bbox="394 753 719 863">Type 1: Buildings used for commercial purposes, industrial buildings and buildings of similar design</td> <td data-bbox="728 753 837 863">20</td> <td data-bbox="846 753 956 863">20 to 40</td> <td data-bbox="965 753 1075 863">40 to 50</td> <td data-bbox="1084 753 1288 863">40</td> </tr> <tr> <td data-bbox="394 869 719 954">Type 2: Dwellings and buildings of similar design and/or occupancy</td> <td data-bbox="728 869 837 954">5</td> <td data-bbox="846 869 956 954">5 to 15</td> <td data-bbox="965 869 1075 954">15 to 20</td> <td data-bbox="1084 869 1288 954">15</td> </tr> <tr> <td data-bbox="394 960 719 1070">Type 3: Structures that have a particular sensitivity to vibration, such as heritage buildings</td> <td data-bbox="728 960 837 1070">3</td> <td data-bbox="846 960 956 1070">3 to 8</td> <td data-bbox="965 960 1075 1070">8 to 10</td> <td data-bbox="1084 960 1288 1070">8</td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> At frequencies above 100 Hz, the values given in this column may be used as minimum values. Vibration levels marginally exceeding those vibration levels in the table would not necessarily mean that damage would occur and further investigation would be required to determine if higher vibration levels can be accommodated without risk of damage. For civil engineering structures (such as those with reinforced concrete constructions used as abutments or foundation pads) the values for Type 1 buildings may be increased by a factor of 2. Short-term vibration is defined as vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated. 											Type 1: Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	Type 2: Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	Type 3: Structures that have a particular sensitivity to vibration, such as heritage buildings	3	3 to 8	8 to 10	8	<p>Selection of construction equipment/ construction methodology</p> <p>Bored piling</p> <p>Community consultation</p> <p>Building/Structural Condition Assessment prior to starting works</p> <p>Vibration monitoring if vibration Guideline Targets are predicted to be exceeded</p> <p>Minimum buffer distances</p>	All	Construction	<p>NV002</p> <p>NV003</p> <p>NV014</p> <p>NV015</p> <p>NV016</p> <p>NV017</p>
Type 1: Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40																										
Type 2: Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15																										
Type 3: Structures that have a particular sensitivity to vibration, such as heritage buildings	3	3 to 8	8 to 10	8																										

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.								
	<p>Long-term vibration on structures</p> <table border="1" data-bbox="394 386 1285 721"> <thead> <tr> <th data-bbox="394 386 976 507">Type of Structure</th> <th data-bbox="981 386 1285 507">Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies</th> </tr> </thead> <tbody> <tr> <td data-bbox="394 513 976 577">Buildings used for commercial purposes, industrial buildings and similar design</td> <td data-bbox="981 513 1285 577">10</td> </tr> <tr> <td data-bbox="394 584 976 647">Dwellings and buildings of similar design and/or occupancy</td> <td data-bbox="981 584 1285 647">5</td> </tr> <tr> <td data-bbox="394 654 976 718">Structures that have a particular sensitivity to vibration, such as heritage buildings</td> <td data-bbox="981 654 1285 718">2.5</td> </tr> </tbody> </table> <p>Notes</p> <p>1 Vibration levels marginally exceeding those in the table would not necessarily mean that damage would occur and further investigation is required would be required to determine if higher vibration levels can be accommodated without risk of damage.</p> <p>2 Long-term vibration means vibration events that may result in a resonant structural response.</p>	Type of Structure	Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies	Buildings used for commercial purposes, industrial buildings and similar design	10	Dwellings and buildings of similar design and/or occupancy	5	Structures that have a particular sensitivity to vibration, such as heritage buildings	2.5				
	Type of Structure	Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies											
Buildings used for commercial purposes, industrial buildings and similar design	10												
Dwellings and buildings of similar design and/or occupancy	5												
Structures that have a particular sensitivity to vibration, such as heritage buildings	2.5												
<p>Undertake condition assessments of above and below ground utility assets and establish construction vibration limits with asset owners.</p> <p>Monitor vibration during construction to demonstrate compliance with agreed vibration guideline targets. Take remedial action if limits are not met.</p>		All	Construction	NV002, NV003, NV014, NV015, NV016, NV017									

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.								
	<p>Vibration Guideline Targets for Underground Structures</p> <p>Implement management actions if the following DIN 4150 Guideline Targets for buried pipework/underground infrastructure from construction are not achieved.</p> <table border="1" data-bbox="392 448 1288 687"> <thead> <tr> <th data-bbox="392 448 974 523">Pipe material</th> <th data-bbox="981 448 1288 523">Vibration Velocity, mm/s peak particle velocity</th> </tr> </thead> <tbody> <tr> <td data-bbox="392 528 974 571">Steel</td> <td data-bbox="981 528 1288 571">100</td> </tr> <tr> <td data-bbox="392 576 974 639">Clay, concrete, reinforced concrete, prestressed concrete, metal</td> <td data-bbox="981 576 1288 639">80</td> </tr> <tr> <td data-bbox="392 644 974 687">Masonry, plastic</td> <td data-bbox="981 644 1288 687">50</td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> 1 These values may be reduced by 50% when evaluating the effects of long-term vibration on buried pipework. 2 It is assumed pipes have been manufactured and laid using current technology (however it is noted that this is not the case for the majority of buried pipework potentially affected by Melbourne Metro). 3 Compliance is to be achieved with asset owner's Utility Standards. 	Pipe material	Vibration Velocity, mm/s peak particle velocity	Steel	100	Clay, concrete, reinforced concrete, prestressed concrete, metal	80	Masonry, plastic	50	<p>Selection of methodology/ equipment</p> <p>Building/Structural Condition Assessment prior to starting works</p> <p>Vibration monitoring if vibration Guideline Targets are predicted to be exceeded</p> <p>Minimum buffer distances</p>	All	Construction	NV002, NV003, NV014, NV015, NV016, NV017
Pipe material	Vibration Velocity, mm/s peak particle velocity												
Steel	100												
Clay, concrete, reinforced concrete, prestressed concrete, metal	80												
Masonry, plastic	50												

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.																												
	<p>Vibration Dose Values (VDVs) (Human Comfort)</p> <p>Implement management actions if the following Guideline Targets (VDVs) (based on Table 1 in BS6472-1:2008) for continuous (as for TBMs and road headers), intermittent, or impulsive vibration are not achieved.</p> <table border="1" data-bbox="394 475 1391 836"> <thead> <tr> <th rowspan="3">Location</th> <th colspan="4">VDV (m/s^{1.75})</th> </tr> <tr> <th colspan="2">Day 7:00am to 10:00pm</th> <th colspan="2">Night 10:00pm to 7:00am</th> </tr> <tr> <th>Preferred Value</th> <th>Maximum Value</th> <th>Preferred Value</th> <th>Maximum Value</th> </tr> </thead> <tbody> <tr> <td>Residences</td> <td>0.20</td> <td>0.40</td> <td>0.10</td> <td>0.20</td> </tr> <tr> <td>Offices, schools, educational institutions, places of worship</td> <td>0.40</td> <td>0.80</td> <td>0.40</td> <td>0.80</td> </tr> <tr> <td>Workshops</td> <td>0.80</td> <td>1.60</td> <td>0.80</td> <td>1.60</td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures. If exceeded then management actions would be required. The VDVs may be converted to peak particle velocities within a future noise and vibration construction management plan. 	Location	VDV (m/s ^{1.75})				Day 7:00am to 10:00pm		Night 10:00pm to 7:00am		Preferred Value	Maximum Value	Preferred Value	Maximum Value	Residences	0.20	0.40	0.10	0.20	Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80	Workshops	0.80	1.60	0.80	1.60	<p>Feasible and reasonable mitigation</p> <p>Community consultation</p> <p>Provision of respite/ temporary relocation</p> <p>Selection of methodology/ equipment</p> <p>Minimum buffer distances</p> <p>Timing of activities</p>	All	Construction	NV004, NV005, NV006, NV018, NV019, NV020, NV021
Location	VDV (m/s ^{1.75})																																
	Day 7:00am to 10:00pm		Night 10:00pm to 7:00am																														
	Preferred Value	Maximum Value	Preferred Value	Maximum Value																													
Residences	0.20	0.40	0.10	0.20																													
Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80																													
Workshops	0.80	1.60	0.80	1.60																													

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.														
	<p>Vibration-sensitive Equipment Guideline Targets</p> <p>Implement management actions if the following ASHRAE equipment vibration Guideline Targets or measured background levels (whichever is higher) are exceeded for vibration-sensitive equipment during construction and operation at Parkville and CBD North stations.</p> <table border="1" data-bbox="392 478 1388 1129"> <thead> <tr> <th data-bbox="392 478 1243 526"></th> <th data-bbox="1249 478 1388 526"></th> </tr> </thead> <tbody> <tr> <td data-bbox="392 531 1243 595">Bench microscopes up to 100x magnification; laboratory robots</td> <td data-bbox="1249 531 1388 595">Operating Room</td> </tr> <tr> <td data-bbox="392 600 1243 691">Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc</td> <td data-bbox="1249 600 1388 691">VC-A</td> </tr> <tr> <td data-bbox="392 695 1243 818">Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3mm line widths</td> <td data-bbox="1249 695 1388 818">VC-B</td> </tr> <tr> <td data-bbox="392 823 1243 914">Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; microelectronics manufacturing equipment such as lithography and inspection equipment to 1mm detail size</td> <td data-bbox="1249 823 1388 914">VC-C</td> </tr> <tr> <td data-bbox="392 919 1243 1042">Electron microscopes at magnification greater than 30,000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for phot-lithography with line widths of ½ micro m; includes electron beam systems</td> <td data-bbox="1249 919 1388 1042">VC-D</td> </tr> <tr> <td data-bbox="392 1046 1243 1129">Unisolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems</td> <td data-bbox="1249 1046 1388 1129">VC-E</td> </tr> </tbody> </table> <p>Notes</p> <p>1. The proponent may undertake consultation with the users and agree alternative Guideline Targets.</p>			Bench microscopes up to 100x magnification; laboratory robots	Operating Room	Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc	VC-A	Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3mm line widths	VC-B	Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; microelectronics manufacturing equipment such as lithography and inspection equipment to 1mm detail size	VC-C	Electron microscopes at magnification greater than 30,000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for phot-lithography with line widths of ½ micro m; includes electron beam systems	VC-D	Unisolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems	VC-E	Stakeholder consultation Isolated track form	4 – Parkville station 5 – CBD North station	Construction/ Operation	NV008, NV009
Bench microscopes up to 100x magnification; laboratory robots	Operating Room																		
Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc	VC-A																		
Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3mm line widths	VC-B																		
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Unisolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems	VC-E																		

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.						
	<p>Ground-borne (internal) Noise Guideline Targets for Amenity</p> <p>Implement management actions as determined in consultation with potentially affected land owners to protect amenity at residences, sleeping areas in hospital wards, student accommodation and hotel rooms where the following ground-borne noise Guideline Targets (from the NSW Interim Construction Noise Guideline) are exceeded during construction.</p> <table border="1" data-bbox="392 507 1391 647"> <thead> <tr> <th data-bbox="392 507 891 555">Time Period</th> <th data-bbox="891 507 1391 555">Internal L_{Aeq,15min}, dB</th> </tr> </thead> <tbody> <tr> <td data-bbox="392 555 891 603">Evening, 6pm to 10pm</td> <td data-bbox="891 555 1391 603">40</td> </tr> <tr> <td data-bbox="392 603 891 647">Night, 10pm to 7am</td> <td data-bbox="891 603 1391 647">35</td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> 1 Levels are only applicable when ground-borne noise levels are higher than airborne noise levels. 2 The noise levels are assessed at the centre of the most affected habitable room. 3 Management actions include extensive community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances. 	Time Period	Internal L _{Aeq,15min} , dB	Evening, 6pm to 10pm	40	Night, 10pm to 7am	35	<p>Feasible and reasonable mitigation</p> <p>Community consultation</p> <p>Provision of respite/ temporary relocation</p> <p>Selection of methodology/ equipment</p> <p>Bored piling</p> <p>Minimum buffer distances</p> <p>Timing of activities</p>	All	Construction	NV025, NV026, NV027, NV028, NV029
Time Period	Internal L _{Aeq,15min} , dB										
Evening, 6pm to 10pm	40										
Night, 10pm to 7am	35										
	<p>Blasting</p> <p>Comply with Australian Standard AS2187.2-2006, Explosives – Storage and use Part 2 – Use of explosives for all blasting</p> <p>For Highly Sensitive Areas, hospital wards, operating theatres and Bio-resources and areas with vibration-sensitive equipment which are not covered in AS2187.2-2006, develop a plan in consultation with facilities owners that:</p> <ul style="list-style-type: none"> • Avoids damage to vibration-sensitive equipment • Minimises adverse impact on Highly Sensitive Areas and Bio-resources. 	<p>Stakeholder consultation</p> <p>Selection of methodology/ equipment</p> <p>Minimum buffer distances</p>	4 – Parkville station	Construction	NV017, NV019						

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.
	<p>To protect the amenity of Bio-resources and sensitive research during construction and operation the following criteria apply:</p> <ul style="list-style-type: none"> • Background noise should be kept below 50 dB and should be free of distinct tones (internal) • Short exposure should be kept to less than 85 dB (internal). <p>Notes</p> <p>1 The levels above should take into consideration the frequency threshold for the Bio-resource under consideration.</p> <p>2 Higher levels may be acceptable if it can be shown that the Bio-resource under consideration is exposed to higher levels and is not adversely impacted by them.</p>	<p>Stakeholder consultation</p> <p>Selection of methodology/ equipment</p> <p>Noise monitoring</p>	<p>4 – Parkville station</p> <p>5 – CBD North station</p>	<p>Construction/ operation</p>	<p>NV012</p>
	<p>Appoint an acoustic and vibration consultant to predict noise and vibration and determine appropriate mitigation to achieve the Environmental Performance Requirements. The acoustic and vibration consultant would also be required to undertake commissioning noise and vibration measurements to assess levels with respect to the Environmental Performance Requirements.</p>		<p>All</p>	<p>Operation</p>	<p>NV030 to NV038</p>

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.									
	<p>Victorian Passenger Rail Infrastructure Noise Policy (PRINP)</p> <p>Avoid, minimise or mitigate rail noise where the following PRINP (April 2013) Investigation Thresholds are exceeded during operation:</p> <table border="1" data-bbox="394 450 1388 903"> <thead> <tr> <th data-bbox="394 450 595 497">Time</th> <th data-bbox="604 450 1003 497">Type of Receiver</th> <th data-bbox="1012 450 1388 497">Investigation Thresholds</th> </tr> </thead> <tbody> <tr> <td data-bbox="394 504 595 737">Day (6am – 10pm)</td> <td data-bbox="604 504 1003 737"> <ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks Noise sensitive community buildings, including schools, kindergartens, libraries </td> <td data-bbox="1012 504 1388 737"> 65 dBL_{Aeq} and a change in 3 dB(A) or more or 85 dBL_{Amax} and a change in 3 dB(A) or more </td> </tr> <tr> <td data-bbox="394 743 595 903">Night (10pm – 6am)</td> <td data-bbox="604 743 1003 903"> <ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks </td> <td data-bbox="1012 743 1388 903"> 60 dBL_{Aeq} and a change in 3 dB(A) or more or 85 dBL_{Amax} and a change in 3 dB(A) or more </td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> If an investigation shows that the thresholds are not exceeded, then no further action is considered under the PRINP. L_{Amax} is defined as maximum A-weighted sound pressure level and is the 95 percentile of the highest value of the A-weighted sound pressure level reached within the day or night. For Melbourne Metro the location of assessment is at 1m from the centre of the window of the most exposed external façade. 	Time	Type of Receiver	Investigation Thresholds	Day (6am – 10pm)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks Noise sensitive community buildings, including schools, kindergartens, libraries 	65 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more	Night (10pm – 6am)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks 	60 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more	Noise barriers Off-reservation treatment (where applicable)	All	Operation	NV031
Time	Type of Receiver	Investigation Thresholds												
Day (6am – 10pm)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks Noise sensitive community buildings, including schools, kindergartens, libraries 	65 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more												
Night (10pm – 6am)	<ul style="list-style-type: none"> Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks 	60 dBL _{Aeq} and a change in 3 dB(A) or more or 85 dBL _{Amax} and a change in 3 dB(A) or more												

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.
	For operation, comply with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1). This does not apply to trains and trams.	Selection of low noise equipment Attenuators Lined ductwork/plenums Acoustic barriers/screens	All	Design/ Operation	NV032, NV035

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.																										
	<p>Ground-borne Noise Guideline Targets for Operation</p> <p>Where operational ground-borne noise trigger levels are exceeded for sensitive occupancies as shown in the table below (trigger levels are based on the Rail Infrastructure Noise Guideline, 17 May 2013 (RING⁽¹⁾), assess feasible and reasonable mitigation to reduce noise towards the relevant ground-borne noise trigger level.</p> <table border="1" data-bbox="394 504 1388 1054"> <thead> <tr> <th data-bbox="394 504 757 555">Sensitive land use</th> <th data-bbox="766 504 931 555">Time of day</th> <th data-bbox="940 504 1388 555">Internal noise trigger levels</th> </tr> </thead> <tbody> <tr> <td data-bbox="394 561 757 695" rowspan="2">Residential</td> <td data-bbox="766 561 931 625">Day (7am-10pm)</td> <td data-bbox="940 561 1388 625">40 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td> </tr> <tr> <td data-bbox="766 632 931 695">Night (10pm-7am)</td> <td data-bbox="940 632 1388 695">35 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td> </tr> <tr> <td data-bbox="394 702 757 766">Schools, educational institutions, places of worship</td> <td data-bbox="766 702 931 766">When in use</td> <td data-bbox="940 702 1388 766">40-45 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td> </tr> <tr> <td data-bbox="394 772 757 836">Hospitals (bed wards and operating theatres)</td> <td data-bbox="766 772 931 836">24 hours</td> <td data-bbox="940 772 1388 836">35 dB(A) L_{ASMax}</td> </tr> <tr> <td data-bbox="394 842 757 887">Offices</td> <td data-bbox="766 842 931 887">When in use</td> <td data-bbox="940 842 1388 887">45 dB(A) L_{ASMax}</td> </tr> <tr> <td data-bbox="394 893 757 938">Cinemas and Public Halls</td> <td data-bbox="766 893 931 938">When in use</td> <td data-bbox="940 893 1388 938">30 dB(A) L_{ASMax}</td> </tr> <tr> <td data-bbox="394 944 757 989">Drama Theatres</td> <td data-bbox="766 944 931 989">When in use</td> <td data-bbox="940 944 1388 989">25 dB(A) L_{ASMax}</td> </tr> <tr> <td data-bbox="394 995 757 1054">Concert halls, Television and Sound Recording Studios</td> <td data-bbox="766 995 931 1054">When in use</td> <td data-bbox="940 995 1388 1054">25 dB(A) L_{ASMax}</td> </tr> </tbody> </table> <p>Notes</p> <ol style="list-style-type: none"> <li data-bbox="394 1110 1429 1209">RING provides trigger levels for residential and schools, educational institutions and places of worship, but does not provide guidance on acceptable ground-borne noise levels for other types of sensitive receivers. Ground-borne noise trigger levels for other types of sensitive occupancies have been devised based on RING and industry knowledge. <li data-bbox="394 1216 1429 1265">Specified noise levels refer to noise from heavy or light rail transportation only (not ambient noise from other sources). 	Sensitive land use	Time of day	Internal noise trigger levels	Residential	Day (7am-10pm)	40 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more	Night (10pm-7am)	35 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more	Schools, educational institutions, places of worship	When in use	40-45 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more	Hospitals (bed wards and operating theatres)	24 hours	35 dB(A) L _{ASMax}	Offices	When in use	45 dB(A) L _{ASMax}	Cinemas and Public Halls	When in use	30 dB(A) L _{ASMax}	Drama Theatres	When in use	25 dB(A) L _{ASMax}	Concert halls, Television and Sound Recording Studios	When in use	25 dB(A) L _{ASMax}	Isolated track form	All	Operation	NV038
Sensitive land use	Time of day	Internal noise trigger levels																													
Residential	Day (7am-10pm)	40 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more																													
	Night (10pm-7am)	35 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more																													
Schools, educational institutions, places of worship	When in use	40-45 dBL _{ASmax} and an increase in existing rail noise level by 3 dB(A) or more																													
Hospitals (bed wards and operating theatres)	24 hours	35 dB(A) L _{ASMax}																													
Offices	When in use	45 dB(A) L _{ASMax}																													
Cinemas and Public Halls	When in use	30 dB(A) L _{ASMax}																													
Drama Theatres	When in use	25 dB(A) L _{ASMax}																													
Concert halls, Television and Sound Recording Studios	When in use	25 dB(A) L _{ASMax}																													

Draft EES Evaluation Objective	Environmental Performance Requirement	Proposed mitigation measures	Precinct	Timing	Risk No.																												
	<p>3 Assessment location is internal near to the centre of the most affected habitable room.</p> <p>4 L_{ASmax} refers to the maximum noise level not exceeded for 95% of the rail pass-by events.</p> <p>5 For schools, educational institutions, places of worship the lower value of the range is most applicable where low internal noise levels is expected.</p> <p>6 The values for performing arts spaces may need to be reassessed to address the specific requirements of a venue.</p>																																
	<p>Vibration Guideline Targets for Operation</p> <p>During operation, achieve the Guideline Targets (based on Table 1 in BS6472-1:2008) or background levels (whichever is higher) for vibration as follows:</p> <table border="1" data-bbox="389 667 1391 1026"> <thead> <tr> <th rowspan="3">Location</th> <th colspan="4">VDV ($m/s^{1.75}$)</th> </tr> <tr> <th colspan="2">Day 7:00am to 10:00pm</th> <th colspan="2">Night 10:00pm to 7:00am</th> </tr> <tr> <th>Preferred Value</th> <th>Maximum Value</th> <th>Preferred Value</th> <th>Maximum Value</th> </tr> </thead> <tbody> <tr> <td>Residences</td> <td>0.20</td> <td>0.40</td> <td>0.10</td> <td>0.20</td> </tr> <tr> <td>Offices, schools, educational institutions, places of worship</td> <td>0.40</td> <td>0.80</td> <td>0.40</td> <td>0.80</td> </tr> <tr> <td>Workshops</td> <td>0.80</td> <td>1.60</td> <td>0.80</td> <td>1.60</td> </tr> </tbody> </table> <p>Notes</p> <p>1 The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures.</p> <p>2 Compliance with these values implies no structural damage due to operation.</p>	Location	VDV ($m/s^{1.75}$)				Day 7:00am to 10:00pm		Night 10:00pm to 7:00am		Preferred Value	Maximum Value	Preferred Value	Maximum Value	Residences	0.20	0.40	0.10	0.20	Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80	Workshops	0.80	1.60	0.80	1.60	Isolated track form	All	Operation	NV034
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13.19 Conclusion

The specialist assessment of the noise and vibration impacts of Melbourne Metro found that, following the adoption of possible mitigation measures to comply with the Environmental Performance Requirements, the majority of risks would be reduced to medium or lower. The high residual risks that remain are associated with potential impacts on vibration-sensitive equipment located in the Parkville station precinct and vibration and ground-borne noise impacts on human comfort in the Tunnels precinct and in the Parkville, CBD North, CBD South and Domain station precincts.

These impacts would be temporary and would occur for limited periods of time and at a limited number of locations during construction. As specified in the Environmental Performance Requirements, where levels of vibration and ground-borne noise cause impacts during the project's construction, appropriate management actions would be taken to address these temporary impacts. These actions could include close collaboration with the institutions operating vibration-sensitive equipment, additional vibration attenuation for the equipment, an extensive community consultation process and notification and advice to potentially affected receivers about the timing and duration of construction activities and anticipated noise and vibration impacts. Where impacts are deemed to be excessive, or where residents are identified as being particularly affected by vibration and ground-borne noise impacts, offers for temporary respite or alternative accommodation may be made.

The impact assessment found that Melbourne Metro would be consistent with the EES draft evaluation objective as the proposed construction methodologies and compliance with the recommended Environmental Performance Requirements would minimise adverse noise and vibration effects on the amenity of nearby residents and local communities as far as practicable. This conclusion also applies for the operational phase of Melbourne Metro.

Achievement of the recommended Environmental Performance Requirements would also result in compliance with the requirements of SEPP N-1, EPA 1254 and the *Victorian Passenger Rail Infrastructure Noise Policy*.