15 Operational noise and vibration

A comprehensive noise and vibration impact assessment was undertaken for the project and is presented as Technical Paper 3 *Noise and vibration*. This chapter summarises the key findings of this assessment in relation to operational noise and vibration.

The Director-General's requirements
The Environmental Assessment must include consideration of, and a management framework for operational noise and vibration impacts, including:

- *An assessment of the noise and vibration impacts associated with the operation of the project, including rail operations, the operation of stabling and maintenance facilities, relevant ancillary facilities (such as substations and venting sites), and ongoing maintenance to the metro line.*
- *Consideration of airborne and regenerated noise and vibration impacts, having regard to both human receivers and structures. The assessment must include specific consideration of impacts to sensitive receivers (schools, hospitals, aged care facilities) and sensitive structures (particularly heritage structures and key utilities/ infrastructure.*
- *The assessment must take into account the following guidelines as relevant: NSW Industrial Noise Policy, Assessing Vibration: A Technical Guideline, and Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects.*

15.1 Overview

15.1.1 Existing environment and sensitive receivers

Existing noise environment
The existing noise environment within the CBD Metro project area is described in section 5.1 of Technical Paper 3 *Noise and vibration*.

However, by 2015, the future noise environment at Barangaroo and at White Bay is expected to change due to the proposed redevelopment of both these sites. Barangaroo is planned to be renewed as an extension of Sydney's CBD. Future background noise levels would therefore be expected to be similar to the noise levels measured in other similar parts of the CBD.

The current use of the Bays Precinct (White Bay, the former Rozelle Marshalling Yard, Rozelle Bay and Glebe Island) is related to industrial activities. Redevelopment of this locality could also significantly alter the ambient noise environment.

Sensitive receivers
During operation of the CBD Metro, noise and vibration impacts may be experienced by receivers near the stations, receivers near the Rozelle stabling and maintenance depot, and receivers located above the metro rail tunnels.

Receivers at these locations were identified and categorised as residential, commercial, educational, industrial, mixed residential/commercial, place of worship, museum, heritage item and special sensitive (for more detail, refer Chapter 11).

The assessment of potential noise and vibration impacts from the operation of the CBD Metro is divided into four main operational components:

- Ground-borne noise and vibration from train operations within the tunnels.
- Airborne noise from train operations along surface track (between tunnel portal and stabling area).
- Airborne noise from stabling and maintenance operations.
- Airborne noise from ancillary facilities, such as ventilation shafts.

15.1.2 Assessment methodology

For each of the four main operational components (as numbered below), the key noise- and/or vibration-generating activities were identified and the relevant design goals determined, as summarised below. A more detailed account of how the noise and vibration emissions and the relevant design goals were determined is provided in Chapters 12 to 16 of Technical Paper 3 *Noise and vibration*.

Ground-borne noise and vibration (1)
Ground-borne vibration from train operations is generated by wheel/rail interaction and is transmitted from the trackbed, through the tunnel structure, via the ground and into the adjacent building structures. Vibrations in buildings may cause the walls and floors to vibrate faintly and hence to radiate noise (commonly termed 'ground-borne noise'). Vibrations, if felt by a building's occupants, may cause disturbance to human comfort.

Potential ground-borne noise levels were determined using an acoustic model specifically developed for the CBD Metro. In determining these levels, track design, train type, train speed, wheel condition, ground conditions and tunnel design were all taken into consideration. The model also assumed that stringent maintenance standards would be adopted to ensure that the condition of the train wheels and rails would be maintained within the specific roughness limits. A more detailed description of the modelling methodology is provided in sections 12.3 and 13.3 of Technical Paper 3 *Noise and vibration*.

Once the ground-borne noise levels have been determined, the potential impacts are assessed based on agreed noise design goals. As the CBD Metro represents an entirely new rail infrastructure project incorporating new metro trains and trackform designs, the noise 'trigger' levels in the Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (IGANRIP) (DECC 2007a) have been adopted as 'design goals' which are to be achieved at all locations where it is considered to be reasonable and feasible. For commercial receivers, shopping centres and residential buildings, IGANRIP does not provide guidance on acceptable levels. Table 15.1 provides a summary of the ground-borne noise design goals for the CBD Metro.

Table 15.1 CBD Metro ground-borne noise design goals for sensitive receivers

Receiver	Time of day	Noise trigger level (dBA)
Residential	Day (7am–10pm)	40 dBA
	Night (10pm–7am)	35 dBA
Schools, educational institutions, places of worship[1]	When in use	40–45 dBA
Retail areas	When in use	50–55 dBA
General office areas	When in use	45 dBA
Private offices and conference rooms	When in use	40 dBA
Theatres	When in use	35 dBA

1 The lower value of the range is most applicable where low internal noise levels are expected, such as in areas assigned to studying, listening and praying. In addition to ground-borne noise, potential vibration impacts during train operations must also be considered.

The vibration design goals for human comfort are outlined in Table 15.2. Vibration design goals for building damage have not been set as the human comfort vibration design goals are more stringent. Compliance with these goals would ensure compliance with the building damage criteria.

Table 15.2 Human comfort vibration design goals

Receiver type	Period	Vibration design goal (dB_V re 10^{-9} m/s)[1]
Residential	Day/night	106 (0.2 mm/s)
Commercial (including schools and places of worship)	When in use	112 (0.4 mm/s)
Industrial	When in use	118 (0.8 mm/s)

1 The vibration design goals are based on the maximum one-second rms vibration level, not to be exceeded by more than 5 per cent of train pass-bys.

Airborne noise from train operations along surface track (2)

Train operations at the surface would occur between the tunnel portals and the stabling area. The calculation of expected noise emissions from these operations was based on the following assumptions:

- There would be a fleet of 13 CBD Metro trains (11 stabled at the Rozelle stabling and maintenance depot and two stabled within the tunnels).
- There would be a maximum speed of 30 kilometres per hour for train movements within the stabling depot, and 40 kilometres per hour for the tracks to/from the tunnel portals.
- All trains would depart the facility from 5:30am to 6:30am for the morning peak period with about half of the fleet returning at about 9:00am. These trains would then depart again for the afternoon peak and return to the depot at about 7:00pm. The remaining trains would return to stabling at about midnight.
- Infrastructure maintenance trains would leave the depot at about midnight and return at about 5:00am. Three daily maintenance train movements have been assumed.
- Metro trains would typically travel at 40 kilometres per hour.

Once the airborne noise levels were determined, the potential impacts were assessed based on agreed noise design goals. A summary of the noise design goals for residential receivers, in accordance with the requirements of IGANRIP, is provided in Table 15.3.

Table 15.3 Airborne noise design goals for residential land uses

Type of development	Noise design goals dBA[1]	
	Day (7am–10pm)	Night (10pm–7am)
New rail line development	Development increases existing rail noise levels and resulting rail noise levels exceed:	
	60 $L_{Aeq(15h)}$	55 $L_{Aeq(15h)}$
	80 L_{Amax}	80 L_{Amax}

1 The noise trigger levels within IGANRIP are expressed as non-mandatory 'trigger levels' which, if exceeded, will trigger the need to consider feasible and reasonable mitigation measures.

Airborne noise from the Rozelle stabling and maintenance operations (3)

The Rozelle stabling and maintenance depot would operate on a 24-hour basis. The calculation of noise emissions takes into account the main noise-emitting activities and facilities, namely:

- Train stabling (including the operation of train auxiliary systems only when trains are being cleaned).
- Train maintenance activities (including the train wash).
- Infrastructure maintenance activities.
- The operation of two substations near the tunnel portal.

A summary of the operational noise design goals for train stabling and maintenance operations, in accordance with the requirements for industrial facilities in the Industrial Noise Policy (INP) (DECC 2000), is provided in Table 15.4. The noise catchment areas are based on residential areas surrounding the depot site.

Table 15.4 Summary of operational noise design goals for train stabling and maintenance operations

Noise catchment area	Time of day[1]	Existing noise levels (dBA)		Operational noise design goals (dBA)		
		RBL Noise levels	$L_{Aeq(Period)}$	$L_{Aeq(15\ min)}$ Intrusive	$L_{Aeq(Period)}$ Amenity[2]	$L_{A1(1\ minute)}$ Sleep disturbance
A (Hutcheson Street)	Day	57	65	62	60	-
	Evening	57	64	62	54	-
	Night	49	60	54	50	64
B (Lamb Street)	Day	56	66	61	60	-
	Evening	55	64	60	54	-
	Night	47	59	52	49	62
C (Starling Street)	Day	49	58	54	60	-
	Evening	49	57	54	50	-
	Night	42	51	47	45	57
D (Pritchard Street)	Day	53	59	58	60	-
	Evening	51	58	56	50	-
	Night	44	54	49	45	59
E (Burt Street)	Day	45	60	50	60	-
	Evening	46	58	51	50	-
	Night	36	48	41	45	51

1 DECCW governing periods are Day: 7.00am–6.00pm, Evening: 6.00pm–10.00pm, Night: 10.00pm–7.00 am.
2 Noise design goals are for residences in an urban area.

Airborne noise from ancillary facilities (4)

Mechanical services plant used to ventilate underground areas and surface buildings would be located at each of the stations, either within the station entrance buildings, or within a separate building above the station cavern (e.g. at Town Hall Square Station).

At this stage, the exact location and specification of the ancillary equipment has not been determined. The noise assessment therefore establishes maximum allowable noise levels at each location. In general, these types of noise sources lend themselves readily to mitigation by appropriate equipment selection, design techniques and provision of engineering noise controls such as silencers, acoustic louvres and enclosures.

A summary of the operational noise design goals for mechanical services plant, in accordance with the INP, is provided in Table 15.5. As a result of the general reduction in ambient existing noise levels during the latter periods of the day, the night-time Industrial Noise Policy noise design goals are the most stringent and are, therefore, the limiting design goals at all locations for noise generated by ancillary equipment.

Table 15.5 External noise design goals for noise from ancillary facilities

Location	Shaft	Receiver	Address	Distance	External noise design goals (dBA)[1]
Central	Shaft 1 E	Residential	509 Pitt Street	25 m	56
	Shaft 1 W	Residential	2 Lee Street	25 m	56
	Shaft 3	Commercial	Central Station	50 m	65
		Residential	505 Pitt Street	100 m	56
		Recreation area	Belmore Park	<10 m	55
Town Hall Square	Shaft 1	Commercial	Pitt Street	10 m	65
	Shaft 2	Commercial	115 Bathurst Street	20 m	65
		Residential	300 Pitt Street	30 m	58
Martin Place	Shaft 1	Commercial	Martin Place	10 m	65
	Shaft 2	Commercial	4 Castlereagh Street	10 m	65
Barangaroo-Wynyard	Shaft 1 E	Residential	44 Margaret Street	50 m	53
	Shaft 1 W	Commercial	30 Clarence Street	10 m	65
	Shaft 2	Commercial	10 Shelley Street	30 m	65
		Commercial	56 Sussex Street	30 m	65
Pyrmont	Shaft 1	Residential	103 Pyrmont Street	< 10 m	41
		Commercial	13 Union Street	20 m	65
	Shaft 2	Residential	104 Miller Street	20 m	41
		Commercial	108 Miller Street	20 m	65
Depot	Tunnel portals	Residential	Lilyfield Road	30–40 m	49[2]
Rozelle	Shaft 1	Residential	91 Victoria Road	< 10 m	47
		Childcare centre	668 Darling Street	15 m	45[3]
		Place of worship	St. Thomas, 668 Darling St	30 m	50[3]
	Shaft 2	Place of Worship	St. Paul's, 665A Darling St	10 m	50[3]
		Educational	Rozelle Primary School	25 m	45[3]
		Residential	669 Darling Street	30 m	49

1 Noise goals for places of worship as well as commercial and educational premises are absolute levels, and are not relative to existing background noise levels.
2 All other industrial noise sources that form part of the CBD Metro project are predicted to have an insignificant contribution to the overall noise level at this location.
3 Assuming windows are partially open and 10 dB noise reduction between outside and inside.

Noise generated during train pass-bys also has the potential to escape from tunnels via tunnel ventilation shafts. Train pass-by noise emitted from ventilation shafts or other openings has been considered with regard to the following $L_{Amax\ (fast)}$ noise design goals:

- 55–60 dBA at residential facades.
- 65 dBA at commercial facades.

15.2 Objectives and strategy

The operational noise and vibration objectives for the project are:

- Objective 1: Avoid the impact of ground-borne noise on sensitive receivers.
- Objective 2: Comply with the noise goals outlined in the Environmental Assessment for the Rozelle stabling and maintenance depot.
- Objective 3: Comply with noise goals outlined in the Environmental Assessment at facilities surrounding metro stations.

To achieve these objectives, the following strategies are proposed:

- Develop and implement a design strategy that would influence the design and ensure that noise generated from the project is minimised. This strategy would primarily focus on reasonable and feasible noise mitigation measures.
- Prepare an Operational Noise and Vibration Management Sub-Plan, including a summary of the operational noise and vibration design goals and project commitments, predicted impacts, monitoring procedures, and proposed management measures, reporting requirements and complaints management.
- Develop a Construction Stakeholder and Involvement Plan to ensure that the community is well informed, and that positive and cooperative relationships are maintained with local residents.

15.3 Specific issues

15.3.1 Ground-borne noise and vibration

Ground-borne noise
The ground-borne noise levels from train operations within the tunnels were modelled under two main scenarios.

The first scenario assumed a standard track incorporating resilient rail supports to reduce noise and vibration emissions. Under this scenario, a number of locations in Rozelle and Pyrmont were identified where the ground-borne noise design goals were close to or marginally higher than the design goals.

The second scenario assumed the use of a higher performance track at these critical locations and the standard track for less sensitive areas. As shown in Figure 15.1, with a combination of the proposed standard and higher performance track designs, compliance with the ground-borne noise goals is predicted at all sensitive receivers across the project area.

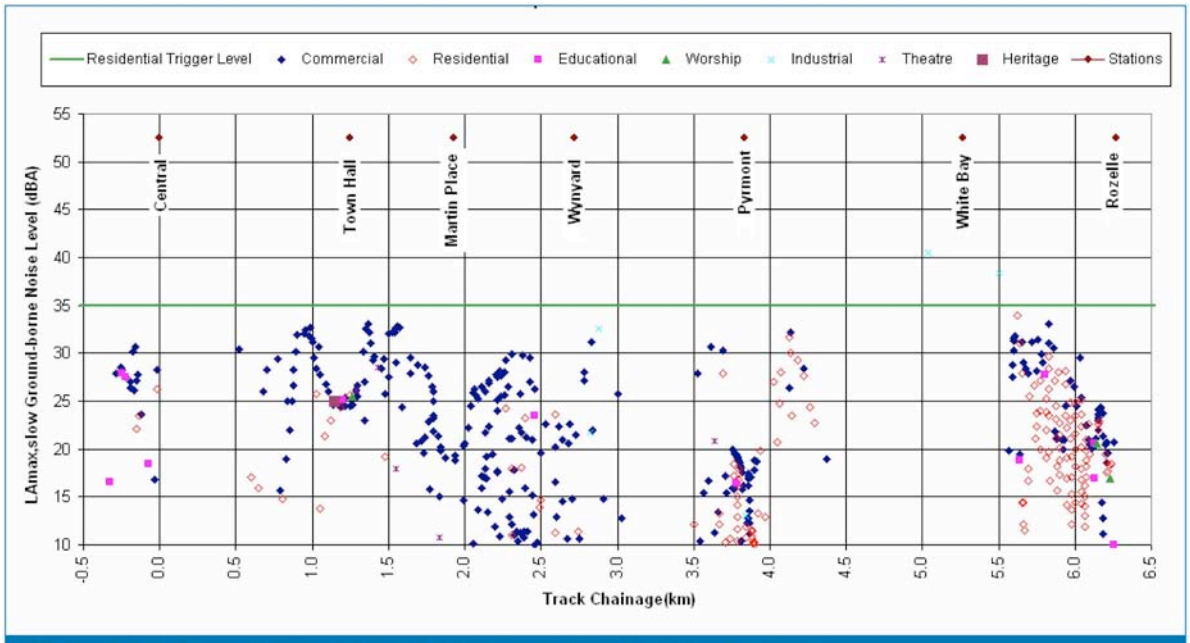

Figure 15.1 Predicted ground-borne noise levels for the proposed trackform (combination of standard and higher performance track)

At the proposed Barangaroo and White Bay development sites, the track would be located about 20 metres and 15 metres below the existing ground surface, respectively. At these locations, it is likely that the future land use will incorporate mixed-use residential/commercial developments. On the basis of the likely train speeds, alignment and other relevant parameters, a higher performance track should be considered in these areas in order to avoid the potential need to mitigate ground-borne noise levels as part of future building designs.

Ground-borne vibration

Ground-borne vibration modelling was undertaken to determine whether the operation of the project would comply with the human comfort vibration level goals outlined in Table 15.2. The results of the modelling indicated that compliance would be achieved at all sensitive receiver locations above or near the tunnels. As the vibration level goals for human comfort are more stringent than the building damage vibration goals, it can also be assumed that the operation of the project would not result in any damage to nearby buildings, including heritage structures.

15.3.2 Airborne noise

Train operations along surface track

As shown in Table 15.6, noise levels from the operation of metro trains between the tunnel portal and the stabling area are predicted to comply with the appropriate noise design goals at all locations surrounding the Rozelle stabling and maintenance depot. The noise levels are calculated at the heights of two metres and 4.8 metres above ground level, indicative of first-floor and second-floor receivers. These noise levels are considered conservative for single-storey houses, as the noise levels are likely to be higher at an upper floor height.

Table 15.6 Airborne noise levels from the operation of metro trains between the tunnel portal and the stabling area

Noise catchment area	Noise design goals (dBA)			Predicted noise levels (dBA)		
	LAeq(15 hour)	LAeq(9 hour)	LAmax	LAeq(15 hour)	LAeq(9 hour)	LAmax
Area A	60	55	80	44	47	72
Area B				45	48	74
Area C				29	32	56
Area D				34	37	62
Area E				47	50	76

The above assessment considers the stabling and daily movements of up to 13 metro trains. As the proposed Rozelle stabling and maintenance depot may facilitate up to 30 metro trains as part of a possible expansion, additional noise modelling has been undertaken to estimate the increase in L_{Aeq} noise levels from these additional train movements (the L_{Amax} noise levels would remain unchanged). The potential increase in L_{Aeq} noise levels associated with the additional trains is about three to four dBA. On this basis, it is anticipated that the airborne noise levels would remain compliant with the design goals should the proposed Rozelle stabling and maintenance depot be expanded to accommodate additional metro trains.

Rozelle stabling and maintenance operations

As shown in Table 15.7, the predicted steady and intermittent noise levels for stabling and maintenance activities are likely to comply with the $L_{Aeq(15min)}$ intrusive noise goals and the $L_{Aeq(period)}$ amenity noise goals at all residential receiver locations. The noise levels are calculated at the heights of two metres and 4.8 metres above ground level, indicative of first-floor and second-floor receivers. These noise levels are considered conservative for single-storey houses, as the noise levels are likely to be higher at an upper floor height.

Table 15.7 Airborne noise levels from the Rozelle stabling and maintenance depot operations

Noise catchment area	Time of day	Noise design goals (dBA)		Predicted noise levels (dBA)[1]	
		$L_{Aeq(15min)}$ Intrusive [2]	$L_{Aeq(Period)}$ Amenity	$L_{Aeq(15min)}$ Intrusive [2]	$L_{Aeq(Period)}$ Amenity
A Hutcheson Street, Rozelle	Day	62	60	54	53
	Evening	62	54	54	53
	Night	54	50	52	49
B Lamb Street, Lilyfield	Day	61	60	51	50
	Evening	60	54	51	50
	Night	52	49	48	41
C Starling Street, Lilyfield	Day	54	60	43	42
	Evening	54	50	43	42
	Night	47	45	<39	<34
D Pritchard Street, Annandale	Day	58	60	51	50
	Evening	56	50	51	50
	Night	49	45	<44	<43
E Burt Street, Rozelle	Day	50	60	<40	<39
	Evening	51	50	<40	<39
	Night	41	45	<38	<37

Note 1: Outdoor noise level predicted at the worst-affected residential receivers.
Note 2: Representing the noise level during the worst-case 15-minute period.

For the noise emissions from the air dryers on trains and brake testing during night-time periods, the predicted noise levels are predicted to comply with the sleep disturbance screening criteria at all residential receiver locations (refer Table 15.8). While only marginal compliance with the criteria is predicted at some locations (e.g. noise catchment area B), the noise emissions from the air dryer and the brake release activities are likely to be lower than the existing average ambient L_{A15min} noise levels. Therefore, the potential noise impact of these activities is regarded to be minimal.

However, if future brake release noise levels should be significantly higher than predicted, there may be a requirement for some form of noise mitigation in order to minimise potential sleep disturbance at the nearest residences during the night-time period. In such a case, acoustic silencers on the noise sources would be the preferred option. Mitigation could also include an option of stabling the early-arrival trains on the outermost tracks so that they effectively form a noise barrier for other trains.

Table 15.8 Airborne noise levels from air dryers and brake release at the stabling depot

Noise catchment area	Existing average ambient noise level $L_{A1(15\ minute)}$ (dBA)	Sleep disturbance screening criterion $L_{A1(1\ minute)}$ (dBA)	Predicted $L_{A1(1\ minute)}$ night-time noise levels (dBA) [1]	
			Air dryer noise	Brake release noise
A	65	64	59	58
B	67	62	61	61
C	55	57	<50	<50
D	59	59	<45	<45
E	52	51	<35	<35

Note 1: Outdoor noise level predicted at the worst-affected residential receivers.

The noise emissions from the substations near the tunnel portal are likely to be negligible considering the masking effects of road traffic noise from Lilyfield Road and the Western Distributor, which would be much higher than the noise from the substations. Likewise, the potential noise emissions arising from the car park near the Gordon Street entrance would be minimal.

Ancillary facilities
In order to comply with the Industrial Noise Policy (DECC 2000) noise design goals, the maximum allowable mechanical services sound power levels emitted at each location range from 60 dBA to 100 dBA. It is likely that mitigation measures would be required for some station and tunnel ventilation equipment/locations in order to comply with these noise design goals.

With the application of appropriate mitigation measures (typically in-duct noise attenuation), train noise break-out through the tunnel ventilation shafts from trains operating within the tunnel is not expected to exceed the noise design goals at the nearby sensitive receivers.

15.4 Mitigation and management

As indicated in section 15.2, the operator would be required to prepare an Operational Noise and Vibration Management Sub-Plan. This plan would include:

- A summary of the operational noise and vibration design goals and project commitments.
- Predicted operational noise and vibration impacts (as documented in the detailed design).
- Monitoring procedures and locations for regular ground-borne noise, airborne noise and ground-borne vibration measurements.
- A description of the proposed management procedures for dealing with and resolving complaints relating to noise and vibration issues.
- A procedure for ongoing reporting of measurement results and changes to the Sub-Plan.

The following specific mitigation measures are proposed to be included in the Sub-Plan and considered during detailed design.

15.4.1 Ground-borne noise and vibration

The IGANRIP recommends the selection of representative noise monitoring locations in order to later assess compliance with the noise design goals. The following representative receiver locations are proposed:

- Pilgrim Theatre, Town Hall.
- 102 Miller Street, Pyrmont.
- Star City development, Pyrmont.
- 45–47 Crescent Street, Rozelle.
- 10–22 Lilyfield Road, Rozelle.

A combination of standard track and high-performance track would be used. The high-performance track would be used at locations where the standard track would not meet the ground-borne noise design goals.

Wheel and track maintenance procedures would be adopted to ensure that source vibration levels are within the specified limits. Monitoring systems would be implemented to measure the condition of the wheels and track. A wheel lathe and track-grinding machine would be used to restore the wheel and track condition to specified limits when required. If wheel flats or other wheel defects do occur, these would be rectified using a wheel lathe or other measures to return the wheel condition to an acceptable degree of smoothness. A permanent wheel monitoring station would be established to detect wheel flats.

Compliance monitoring would be undertaken at the commencement of train operations at selected receiver locations to determine if any additional feasible and reasonable measures are required.

15.4.2 Airborne noise

As the noise emissions from the operation of metro trains between the tunnel portal and the stabling area are expected to comply with the noise goals, it is unlikely that further noise mitigation measures would be required. However, during the detailed design stage, careful attention would be paid to:

- Ensuring that the risk of curve flanging and curve squeal does not occur at locations where the curve radius is less than about 300 metres.
- The maintenance regime required to maintain the wheel and rail profiles within tight tolerances through regular wheel turning and rail grinding to minimise curve squeal.
- Investigating whether gauge-face lubrication and top-of-rail friction modification is required near the tunnel portals to minimise the risk of curving noise.
- Installing noise barriers near the portals and/or portal extensions if the detailed assessment indicates a curving noise is likely.
- Considering additional feasible and reasonable mitigation measures where source noise levels from auxiliary equipment on trains do not meet the noise design goals.
- Ensuring all audible alarm systems within Rozelle stabling and maintenance depot are non-tonal.
- Fitting ventilation shafts with in-duct noise attenuation to minimise train noise break-out, where necessary.

15.5 Conclusions

The assessment of potential noise and vibration impacts from the operation of the CBD Metro found that noise and vibration would not cause significant impacts. In particular, it is predicted that:

- The project would comply with the ground-borne noise goals at all sensitive receivers across the project area.
- The ground-borne vibration levels from train pass-bys would not likely be perceptible within nearby buildings.
- The operation of the project would not result in any vibratory damage to nearby buildings.
- Train operations between the tunnel portal and the stabling area would comply with the appropriate noise design goals at all locations surrounding the Rozelle stabling and maintenance depot.
- The operation of the Rozelle stabling and maintenance depot would comply with the intrusive and amenity noise goals at all residential receiver locations.

However, if future brake release noise levels should be significantly higher than those predicted, there may be a requirement for some form of noise mitigation in order to minimise potential sleep disturbance at the nearest residences during the night-time period.

Measures to minimise noise impacts would continue to be developed during the detailed design phase of the project. An Operational Noise and Vibration Management Sub-Plan would be developed to ensure that these measures are incorporated into the operational phase of the project.