12. Construction noise and vibration

This chapter provides a summary of the construction noise and vibration assessment. A full copy of the assessment report is provided as Technical paper 2 – Noise and vibration. The Secretary's environmental assessment requirements relevant to noise and vibration, together with a reference to where the results of the assessment are summarised in this chapter and in the Environmental Impact Statement, are provided in Table 12.1.

Table 12.1 Secretary's environmental assessment requirements – noise and vibration

Ref	Secretary's environmental assessment requirements – noise and vibration	Where addressed
8. Noise and vibration - amenity		
8.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including small businesses, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	A summary of the results of the construction noise assessment is provided in this chapter. The full results are provided as Technical paper 2. Operational noise impacts are considered in Chapter 13. Construction amenity and sleep disturbance impacts to sensitive receivers are considered in Section 12.5. The characteristics of noise and vibration are explained in Technical paper 2, and no modifying factors need to be used in this assessment.
8.2	The EIS must include a framework for both an Out of Hours Works Strategy and the development of an Out of Hours Works Plan which incorporates community consultation.	Section 12.6.1
9. Noise and vibration - structural		
9.1	The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	A summary of the results of the construction vibration assessment is provided in this chapter. The full results are provided as Technical paper 2. Operational vibration impacts are considered in Chapter 13. Consideration of potential construction impacts to structural integrity (including heritage items) is provided in Section 12.5
9.2	The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Blasting would not be required.

12.1 Assessment approach

A summary of the approach to the construction noise and vibration assessment is provided in this section. Further information is provided in Technical paper 2.

12.1.1 Legislative and policy context to the assessment

The guidelines and standards relevant to the construction noise and vibration assessment include:

- *Interim Construction Noise Guideline* (DECC, 2009)
- *Road Noise Policy (DECCW, 2011)*
- *NSW Industrial Noise Policy* (EPA, 2000)
- *Assessing Vibration: A Technical Guideline* (DEC, 2006)
- British Standard (BS) *5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration* and *BS 6472:1992 Evaluation of human exposure to vibration in buildings*
- *DIN 4150:Part 3-1999 Structural vibration – Effects of vibration on structures* (Deutsches Institute fur Normung, 1999).

12.1.2 Methodology

The assessment methodology involved:

- identifying and classifying sensitive receivers
- characterising the existing noise environment based on attended and unattended noise measurements at representative locations in the study area
- determining noise and vibration management levels in accordance with relevant guidelines
- modelling to quantify predicted noise and vibration levels
- assessing the significance of predicted noise and vibration levels
- examining the proposed construction methodologies and identifying mitigation measures to minimise construction noise and vibration impacts.

The construction noise assessment has been prepared with reference to the *Interim Construction Noise Guideline* ('the ICNG') (DECC, 2009) and the Sydney Metro Construction Noise and Vibration Strategy (Appendix E). SoundPLAN computer modelling software was used to predict airborne noise levels.

Construction (airborne) noise

Airborne noise is considered to be an amenity issue. Airborne noise would be generated at all construction sites, and would mainly be associated with surface activities where there is a path between the source and receiver. Airborne noise generated by construction machinery and works has the potential to result in amenity impacts for sensitive receivers.

An assessment of the potential for construction noise (amenity) impacts was undertaken in accordance with the ICNG.

The guideline sets out ways to address the impacts of construction noise on residential receivers and other sensitive land uses, by presenting assessment approaches that are tailored to the scale of construction projects.

The ICNG quantitative assessment method involves:

- specifying project-specific noise management levels (NMLs) for potentially affected noise sensitive receivers
- predicting noise levels at sensitive receivers
- comparing them with the specified NMLs.

Where noise levels are predicted to exceed the NMLs, reasonable and feasible mitigation and work practices need to be investigated and implemented to minimise noise impacts.

Construction noise levels have been predicted based on indicative construction activities and durations (refer Table 12.8).

Some plant and equipment emit high noise levels; referred to as highly noise intensive plant. Examples include: hydraulic rock breakers, concrete saws and ballast tampers. Use of these highly noise intensive items of plant can result in noise levels exceeding the relevant assessment criteria, even though they may be used for only short periods. Adopting the methodology in the ICNG, all construction plant and equipment is assumed to be operating at full power and at the same time resulting in 'worst-case' noise level predictions, as documented later in this chapter. In practice, these levels are unlikely to be representative of noise levels experienced by the majority of the community or over the majority of the construction period.

In response to these issues, an alternative construction scenario has been assessed which does not include the use of this highly noise intensive equipment – particularly during the night-time period. Comparison of these respective scenarios – with and without the use of the highly noise intensive equipment, provides an indication of the reduction in noise levels that could be achieved when the highly noise intensive equipment is not in use. This approach allows informed decisions to be made about restricting certain activities in the night-time period. Further discussion about the basis of the construction noise assessment and use of highly noise intensive equipment is included in Section 12.4.1.

Construction traffic noise

Modelling of potential noise impacts from construction traffic movements included consideration of heavy vehicles and personnel movements to/from the identified construction compounds as well as rail replacement bus services required during track and station closures (refer to the Temporary Transport Strategy in Appendix G). A cumulative noise assessment was also undertaken to identify the potential impacts where different types of vehicle movements occur concurrently in the same location.

The assessment assumed that the majority of construction traffic vehicle movements would occur during the daytime and evening periods, although some movements would also be required at night-time, generally due to rail replacement buses operating.

Construction vibration

The construction vibration assessment considered the potential for vibration levels to occur which exceed the criteria. Vibration from construction plant and equipment was predicted and assessed with consideration given to the vibration guidelines listed in Section 12.2. Mitigation measures have been identified where vibration levels are predicted to exceed the vibration criteria.

Groundborne noise

Groundborne noise (also referred to as low-frequency noise) is noise where vibration causes objects (e.g. the floor or walls of a building) to vibrate, which generates a low frequency rumble. Groundborne noise can result in noise levels which exceed both amenity and structural criteria.

The ICNG defines internal groundborne noise goals for residential receivers during the evening (6pm to 10pm) and night-time (10pm to 7am) construction periods. It also notes that groundborne noise is only considered when the potential groundborne noise levels are likely to be higher than airborne noise levels.

Construction airborne noise levels for the project are predicted to be higher than groundborne noise levels. As a result, groundborne noise is not considered further in this assessment.

Identification of noise sensitive receivers and noise catchment areas

Potentially sensitive receivers are those that may be affected by changes in noise and vibration levels. Noise and vibration sensitive receivers were identified based on the type of use, the activities undertaken, and the nature of the building. Sensitive receivers for the project are described in Section 12.3 and are shown in Figure 12.1.

Noise catchment areas (NCAs) are areas where receivers have a similar land use and ambient noise environment. The study area for the assessment was divided into 13 NCAs, as shown in Figure 12.1.

Ambient noise surveys and monitoring locations

Ambient noise monitoring was undertaken to establish the 'background' noise environment across each noise catchment area. Noise monitoring was undertaken at sensitive receiver locations selected to be representative of a wider area. Background noise, described by the 'rating background level' (RBL) for each catchment area, is the underlying level of noise present in an area once transient and short-term noise events are filtered out.

Noise monitoring was carried out at 23 representative locations in June and July 2016 at the locations shown in Figure 12.1.

12.2 Construction noise and vibration criteria

12.2.1 Amenity

Noise management levels

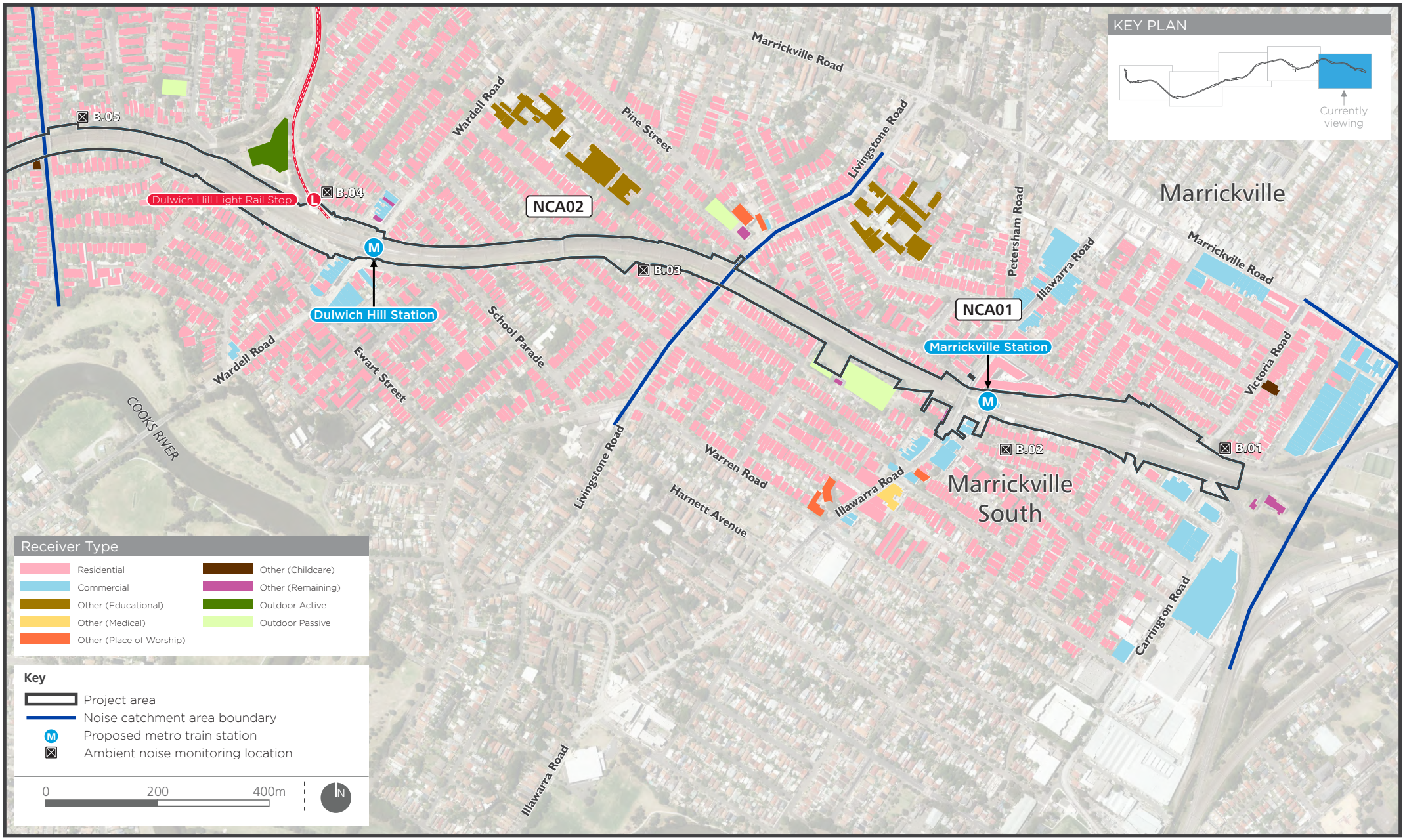
Residential receivers

People's reaction to noise from construction will depend on the time of day that works are undertaken. Residents are usually most annoyed by work at night-time as it has the potential to disturb sleep. Noise from work during the evenings, Saturday afternoons, Sundays and public holidays can also be annoying to most residents as it may interrupt leisure activities.

Based on the ICNG, the:

- 'noise affected' management level represents the level above which there may be some community reaction to noise (calculated by adding 10 dB to the RBL during recommended standard work hours and by adding five dB to the RBL for works outside of recommended standard work hours)
- 'highly noise affected' management level represents the level above which there may be strong community reaction to noise.

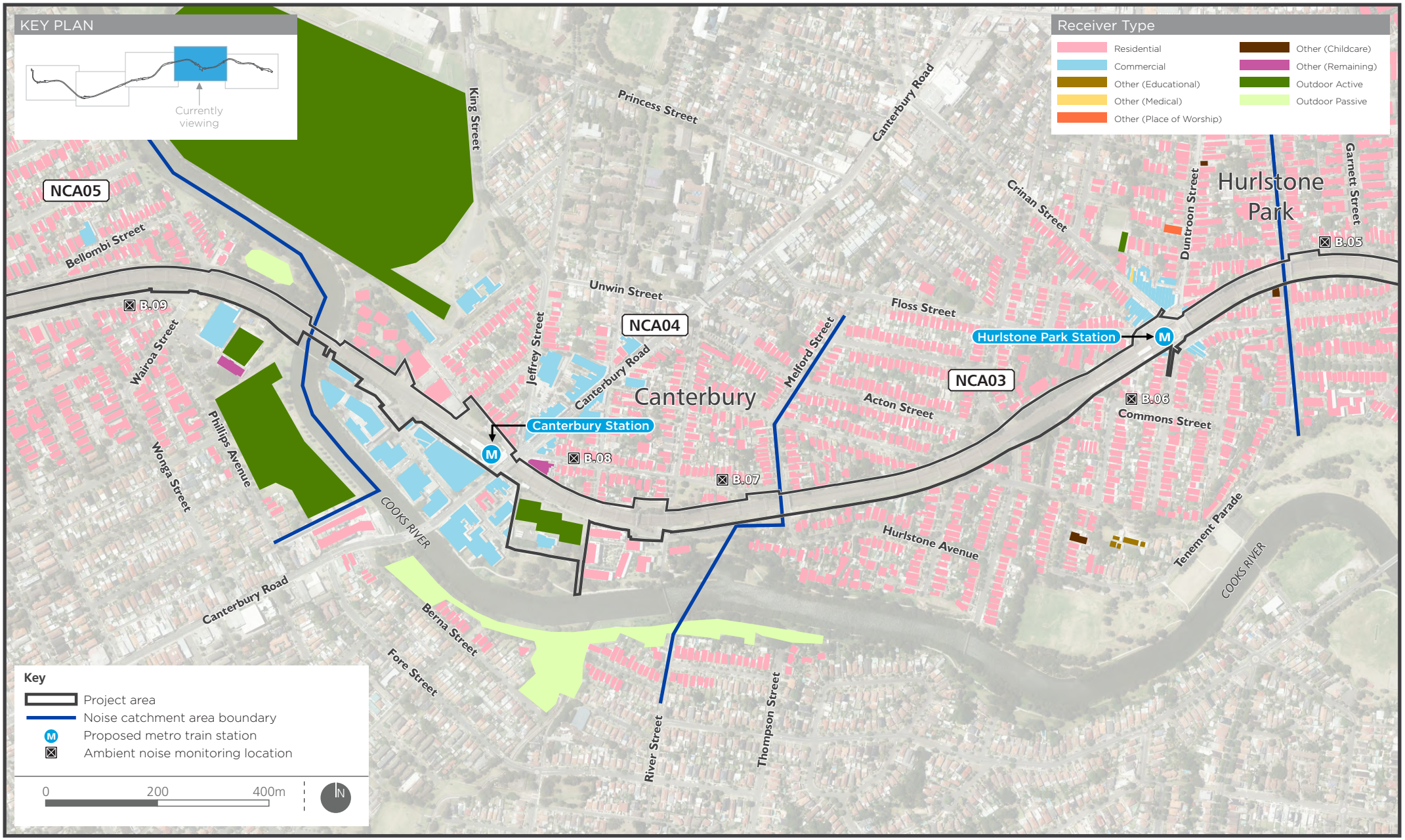
The project-specific NMLs for residential receivers in each of the noise catchment areas are provided in Table 12.3. These represent the 'noise affected' NMLs. A NML of 75 dB or above is considered 'highly noise affected'.



sydney METRO | city & southwest

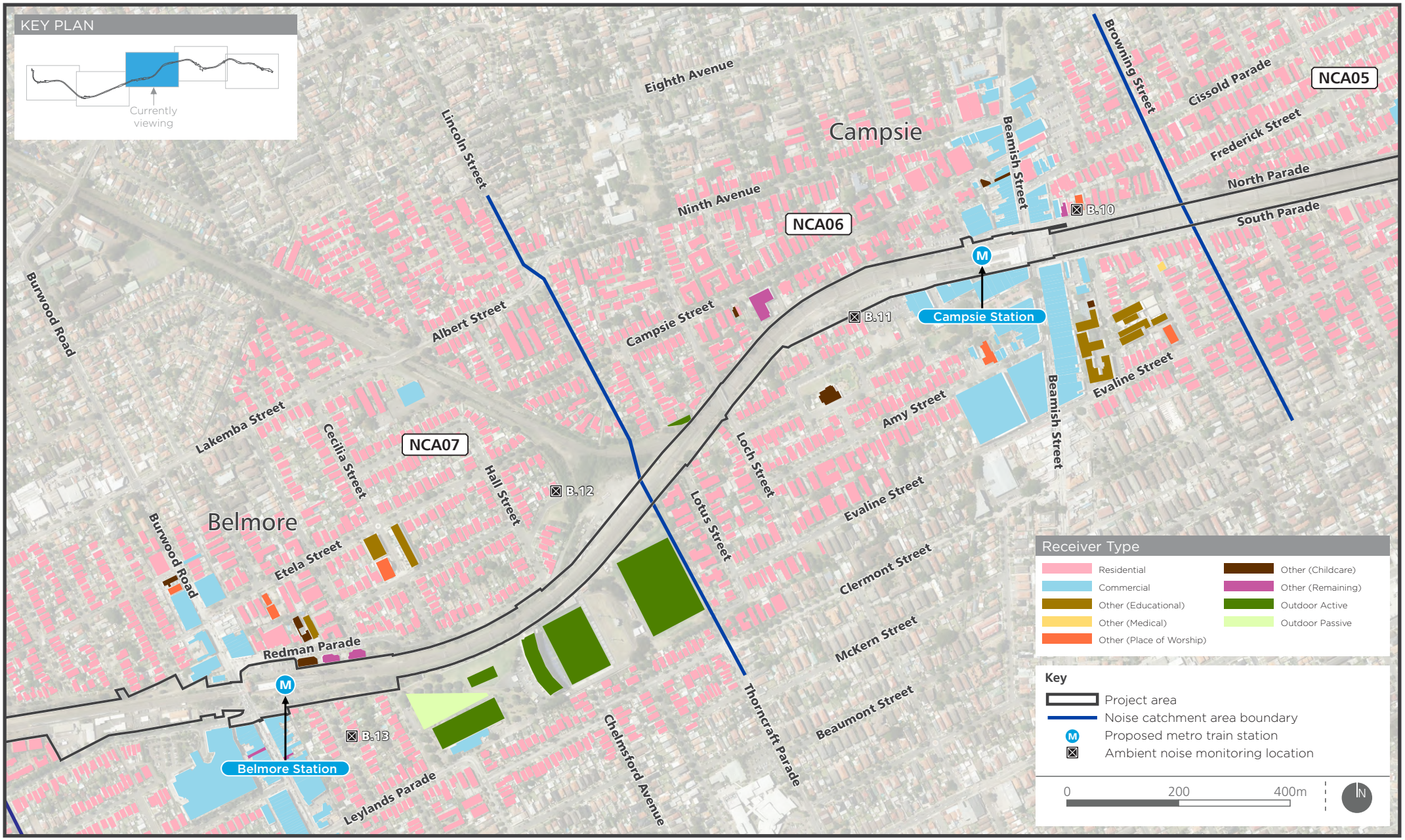
Noise catchment areas, sensitive receivers and ambient noise monitoring locations - map 1

FIGURE 12.1



Noise catchment areas, sensitive receivers and ambient noise monitoring locations - map 2

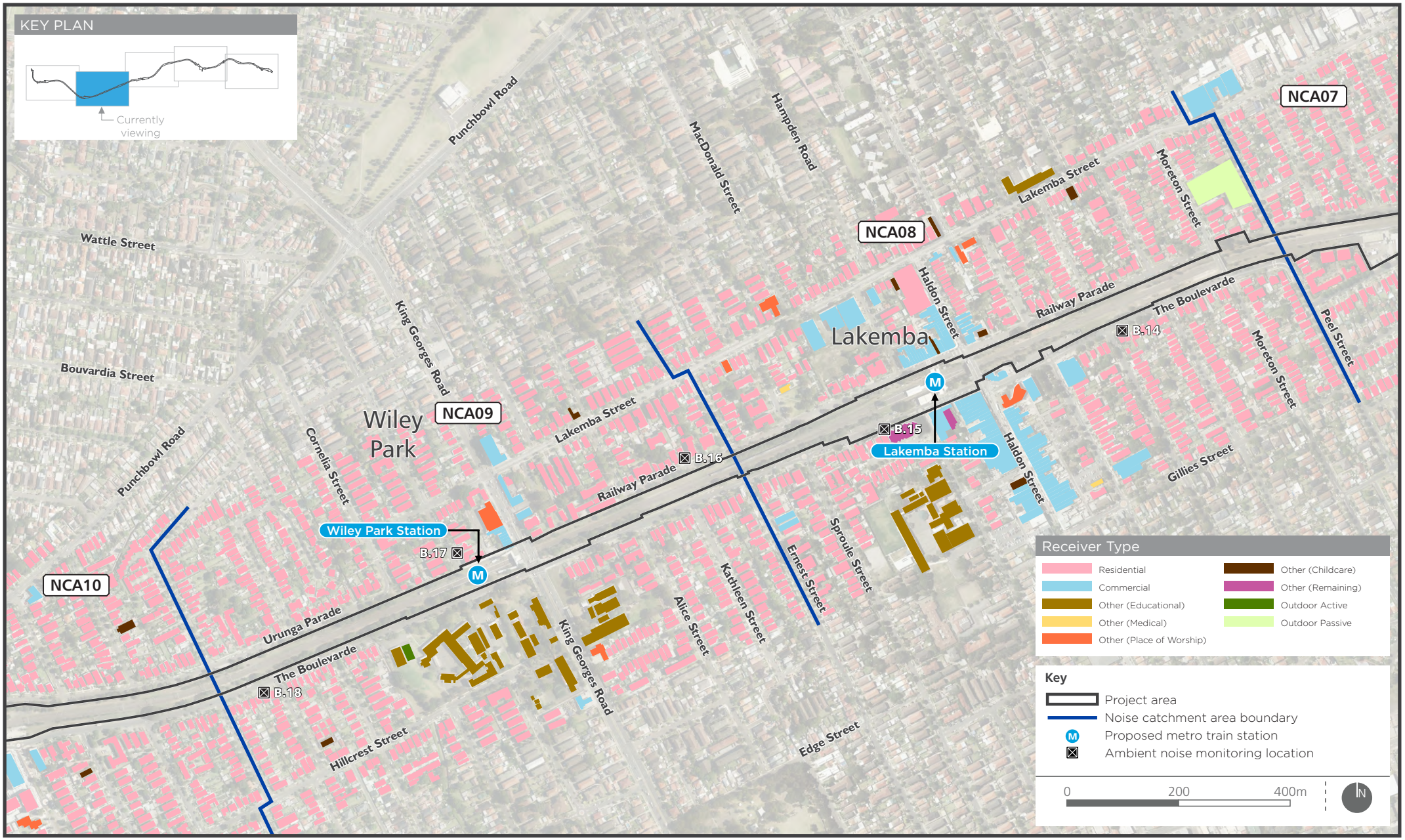
FIGURE 12.1



sydney METRO | city & southwest

Noise catchment areas, sensitive receivers and ambient noise monitoring locations - map 3

FIGURE 12.1



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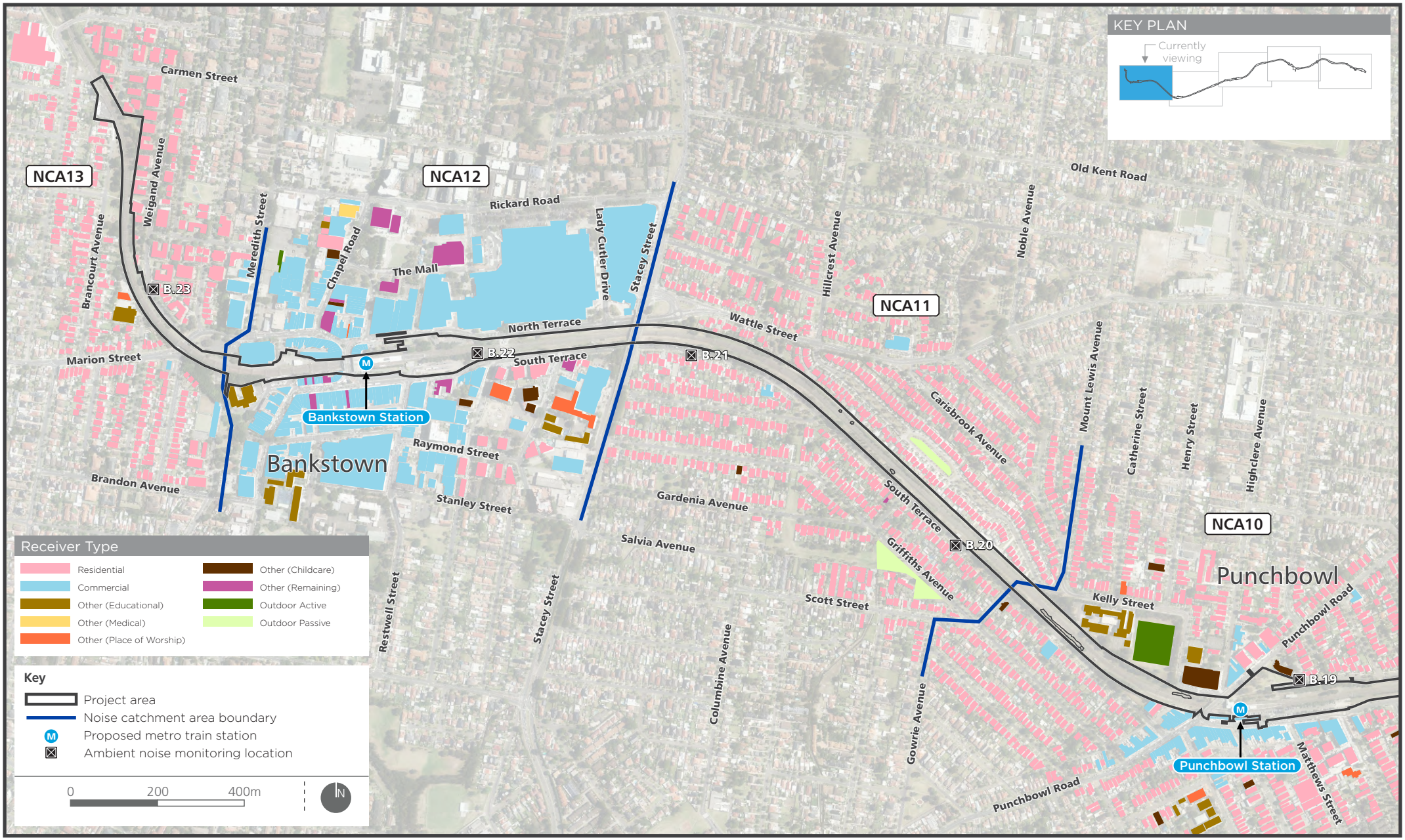
Noise catchment areas, sensitive receivers and ambient noise monitoring locations - map 4

FIGURE 12.1



Noise catchment areas, sensitive receivers and ambient noise monitoring locations - map 5

FIGURE 12.1

Other sensitive receivers

The project-specific $L_{Aeq(15minute)}$ NMLs for non-residential noise sensitive receivers are provided in Table 12.2.

Table 12.2 Construction NMLs for other sensitive receivers

Land use	NMLs $L_{Aeq(15minute)}$ (applied when the land is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. reading, meditation)	External noise level 60 dB
Community centres	Depends on the intended use of the centre (refer to the recommended 'maximum' internal levels in Australian Standard 2107- Acoustics- Recommended design sound levels and reverberation times for building interiors for specific uses).
Commercial buildings, including offices, retail and small commercial properties	External noise level 70 dB

Other noise-sensitive businesses require separate noise goals. The ICNG recommends that the internal construction noise levels at these types of premises are determined based on the 'maximum' internal levels presented in *AS:2107 – Recommended Design Sound Levels and Reverberation Times for Building Interiors.* For this project, exceedances of NMLs would also be managed by the procedures contained in the Sydney Metro Construction Noise and Vibration Strategy.

The ICNG and AS2107 do not provide specific guideline noise levels for childcare centres. Childcare centres generally have internal play areas and sleeping areas. For these areas, an internal noise management level of 55 dBA $L_{Aeq(15minute)}$ has been adopted, together with an internal noise management level of 40 dBA $L_{Aeq(15minute)}$ (when in use) for sleeping areas.

On the assumption that windows and doors of childcare centres may be opened, an external noise management level of 65 dBA $L_{Aeq(15minute)}$ for play areas has been applied at the facade and would also apply to external play areas. For sleeping areas, assuming that windows are open, the external noise management level would be 50 dBA $L_{Aeq(15minute)}$).

Industrial premises

NMLs for commercial and industrial premises have been set based on the ICNG. An external noise management level of $L_{Aeq(15minute)}$ 75 dBA has been adopted for industrial premises. The external noise levels should be assessed at the most affected occupied point on the premises.

Sleep disturbance

The appropriate screening criterion for sleep disturbance is a maximum level of 15 dB above the RBL, during the night-time period (10pm to 7am). Where this criterion is met, sleep disturbance is

unlikely for the majority of people, but where it is not met, a more detailed analysis is required. Sleep disturbance screening levels for each NCA are provided in Table 12.3.

Table 12.3 Construction NMLs for residential receivers

NCA	Logger ID	Recommended standard hours[1] (RBL + 10dB)	Outside recommended standard hours (RBL + 5dBA)			Sleep disturbance screening (RBL + 15dBA)
		Daytime	Daytime (7am - 6pm)	Evening (6pm - 10pm)	Night-time (10pm - 7am)	
1	B.04	48	43	43	38	48
2	B.05	48	43	43	38	48
3	B.06	48	43	43	39	49
4	B.07	50	45	45	40	50
5	B.09	46	41	41	37	47
6	B.10	55	50	47	40	50
7	B.13	51	46	46	40	50
8	B.14	57	52	52	46	56
9	B.16	54	49	49	41	51
10	B.19	57	52	52	46	56
11	B.20	57	52	52	44	54
12	B.22	64	59	56	47	57
13	B.23	52	47	47	44	54

Note: 1. Recommended standard hours (defined in the ICNG) are Monday to Friday 7am to 6pm, Saturday 8am to 1pm and no time on Sundays or public holidays.

Construction traffic noise

As required by the *NSW Road Noise Policy* (DECCW, 2011), a screening test should be undertaken to evaluate whether noise levels would increase by more than two dB as a result of construction traffic. This includes for example, a temporary diversion due to a road closure. (As a general rule of thumb, a 60 per cent increase in the number vehicles would result in an about two dB increase in road traffic noise). Where increases are two dB or less, no further assessment is required. Where noise levels increase by more than two dB, further assessment is required using the criteria presented in the *Road Noise Policy* (refer to Table 12.4).

Table 12.4 Noise criteria for construction vehicles on public roads

Road category	Type of project/land use	Assessment criteria (dB)	
		Daytime (7am - 10pm)	Night-time (10pm - 7am)
Freeway/ arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads Generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

Vibration – human comfort

The vibration dose values recommended in *Assessing Vibration: a technical guideline* (DEC, 2006) (derived from British Standard 6472), for which various levels of adverse comment from occupants may be expected, are provided in Table 12.5.

Table 12.5 Vibration dose value ranges which may result in adverse comments from occupants within residential buildings

Place and time	Low probability of adverse comment ($m/s^{1.75}$)	Adverse comment possible ($m/s^{1.75}$)	Adverse comment probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices 16 hr day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshops 16 hr day	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

Minimum safe working distances for vibration intensive plant

Table 12.6 provides the minimum safe working distance for a range of vibration intensive plant. These distances are indicative and can vary depending on the plant used and the local geotechnical conditions.

Table 12.6 Minimum safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (m)	Human response (m)
Vibratory roller	< 50 kN (Typically 1-2t)	5	15 to 20
	< 100 kN (Typically 2-4t)	6	20
	< 200 kN (Typically 4-6t)	12	40
	< 300 kN (Typically 7-13t)	15	100
	> 300 kN (Typically 13-18t)	20	100
	> 300 kN (Typically > 18t)	25	100
Small hydraulic breaker	300 kg - 5 to 12t excavator	2	7
Medium hydraulic breaker	900 kg - 12 to 18t excavator	7	23
Large hydraulic breaker	1600 kg - 18 to 34t excavator	22	73
Jackhammer	Hand held	1 (nominal)	Avoid contact with structure

12.2.2 Structural

General

For construction activities involving intermittent vibration sources, such as hydraulic breakers, piling rigs, vibratory rollers and excavators, the predominant vibration energy occurs at frequencies greater than four hertz (Hz) (and usually in the 10 Hz to 100 Hz range). On this basis, the conservative vibration damage screening levels are as follows:

- reinforced or framed structures: 25 mm/s
- unreinforced or light framed structures: 7.5 mm/s.

Heritage structures

Heritage buildings were assessed on a case by case basis, with the 7.5 mm/s screening criterion to be applied to heritage structures. Where a building survey has found that the heritage structure is sensitive to vibration, a more conservative superficial cosmetic damage criterion of 2.5 mm/s peak component particle velocity (from DIN 4150) should be considered.

Contents damage - sensitive scientific and medical equipment

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent criteria than those applicable to human comfort. Where vibration sensitive scientific and/or medical instruments are likely to be used inside the premises of an identified vibration-sensitive receiver, criteria for the satisfactory operation of the instrument should be sourced from manufacturer's data. Where manufacturer's data is not available, generic vibration criterion curves may be used.

No usage of sensitive medical or scientific equipment was identified in close proximity to the works.

Utilities and other vibration sensitive structures

For structures and utilities that are particularly sensitive to vibration, a vibration goal which is more stringent than the above structural damage criteria may apply. Examples of such structures and utilities include tunnels, gas pipelines, and fibre optic cables.

Specific vibration goals would be determined on a case-by-case basis by an acoustic consultant prior to construction commencing.

12.3 Existing environment

The project area is described in Chapter 2 (Location and setting). The project area is located in an established urban environment, which is already subject to noise from the operation of trains along the rail corridor. The existing noise environment varies considerably along the length of the project area. In addition to rail noise, other noise sources include:

- road traffic noise
- operation of the freight line and diesel trains between east of Marrickville Station and west of Campsie Station
- industrial activities within industrial areas (particularly near Marrickville)
- other construction activities (such as building redevelopments, road, and housing construction)
- aircraft noise.

12.3.1 Sensitive receivers

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

Properties within about 100 metres of the rail corridor and about 200 metres from construction compounds and other work areas were classified into the following preliminary categories:

- residential
- commercial
- educational
- industrial

- mixed commercial/residential
- places of worship
- child care
- special sensitive (e.g. hospital, precision laboratories, recording studios).

Figure 12.1 shows the location and classification of sensitive receivers in the study area.

The preliminary categorisation of receivers was undertaken using a combination of site inspections and review of aerial imagery. The preliminary categorisation of receivers would be reviewed during detailed design to confirm the receiver categories and other pertinent details. This review would focus primarily on receivers where noise and vibration impacts are predicted.

12.3.2 Existing noise levels

As outlined in Section 12.1, ambient noise monitoring at representative sensitive receivers was undertaken to establish the 'background' noise environment across each noise catchment area. The results of the unattended noise survey are summarised in Table 12.7.

Table 12.7 Summary of unattended noise monitoring (June/July 2016)

Logger location ID	Noise level (dBA)[1]					
	Daytime 7am - 6pm		Evening[2] 6pm - 10pm		Night-time 10pm - 7am	
	RBL	LAeq	RBL	LAeq	RBL	LAeq
B.01	47	61	45	61	40	58
B.02	38	59	38	58	33	51
B.03	38	57	38[2]	57	33	53
B.04	41	54	41	55	34	50
B.05	40	57	40	56	33	52
B.06	38	56	38[2]	53	34	49
B.07	40	53	40	50	35	47
B.08	43	56	43	53	36	49
B.09	36	57	36[2]	57	32	54
B.10	45	55	42	55	35	54
B.11	44	59	44[2]	57	40	57
B.12	37	50	37[2]	48	33	46
B.13	41	49	41	47	35	46
B.14	47	65	47	63	41	60
B.15	50	63	50	64	43	63
B.16	44	56	44	55	36	51
B.17	44	52	44[2]	51	41	49
B.18	46	65	46[2]	65	39	61
B.19	47	57	47	54	41	53
B.20	47	65	47[2]	64	39	60
B.21	53	66	52	66	43	61
B.22	54	64	51	63	42	60
B 23	42	56	42[2]	55	39	52

Notes: 1. The RBL and LAeq noise levels have been obtained using the calculation procedures documented in the INP.
2. Where the evening RBL was found to exceed the daytime RBL, it has been reduced to equal the daytime RBL in accordance with INP application notes.

As shown in Table 12.7, daytime noise levels ranged from 36-54 dB with noise levels generally increasing to the west. Measured daytime noise levels were lowest at Campsie Station and loudest at Bankstown Station. At nine of the logger locations, measured evening noise levels were either the same or slightly louder than daytime levels.

Night-time noise levels ranged from 32 to 43 dB across the project area, with the lowest level at Campsie Station and highest between Lakemba and Wiley Park stations. Compared to daytime levels, the greatest change in noise levels was observed at Bankstown and Campsie stations.

12.4 Basis of the construction noise assessment

12.4.1 Construction activities and use of noise intensive plant

Table 12.8 provides the various construction scenarios and activities considered as part of the construction noise assessment. The list of plant and equipment expected to be used during each of these scenarios is outlined in Section 9.9.3 along with a more detailed outline of construction processes. The table also shows the expected duration of each activity at a typical project work area. This duration represents the overall time taken for the activity to be completed which may be longer than the duration for which individual plant items would be used. As an example, the earthworks phase at each work area might typically last for six weeks, however the use of a hydraulic breaker as part of that activity would be for a much shorter period estimated to be about three days.

To demonstrate the level of conservatism built into the construction noise assessment methodology (refer to Section 12.1.1), a separate noise assessment scenario has been defined to account for the use of particularly noise intensive equipment which is believed to dominate the noise level predictions. By comparing the scenarios, with and without the use of the noise intensive equipment, the reduction in noise levels that could be achieved when the highly noise intensive equipment is not in use and a noise level which is more likely to be heard for a majority of the time can be quantified.

Comments are also provided to indicate the timing of activities occurring, particularly in relation to works conducted in possession periods and outside of recommended standard hours. A number of construction work areas would be used 24 hours per day at times, in particular during possession periods. Where 24 hour works are required, the use of highly noise intensive equipment (e.g. hydraulic breakers and ballast tampers) would be limited to day time and evening periods (between 7am and 10pm), unless constraints exist such as:

- works requiring a rail shut down
- requirements of road authorities, emergency services or Sydney Coordination Office.

The use of hydraulic breakers and ballast tampers is not proposed during the night-time period (10pm to 7am), however some other highly noise intensive equipment would potentially need to be used during this period if unforeseen circumstances arise (such as unforeseen ground or weather conditions). Such works would only occur in accordance with the out of hours work framework outlined in Section 12.6.1.

Regardless of the above, the use of highly noise intensive equipment during the night-time period has been considered in the assessment in the event such works are required.

Table 12.8 Typical duration of construction activities and noise intensive plant

Work area[1]	Activity	Typical activity duration[2]	Indicative duration of noise-intensive works where relevant	Hours of work[3]					Additional comments
				Std. day	Possession/closedown works				
					Day	Day OOHW[4]	Eve	Night	
General work areas	Earthworks	6 weeks	n/a	●					-
	Earthworks w/breaker	6 weeks	3 days	●					Breaking works would only occur intermittently during a six week period between 7am and 10pm. Total duration of works would be about 3 days.
	Piling	6 weeks	2 weeks	●					Piling works would only occur intermittently during a six week period between 7am and 6pm. Total duration of works would be about 2 weeks.
	Site establishment	4 weeks	n/a	●					-
	Operations	52 weeks	n/a	●	●				-
Corridor works - ground & track	Earthworks	30 weeks	n/a	●	●	●	●	●	-
	Earthworks w/breaker	10 weeks	3 days	●	●	●	●		Breaking works would only occur intermittently during ten weeks of possession. Total duration of works would be about 3 days. Works are proposed to be undertaken between 7am and 10pm.
	Trackform	12 days	n/a	●	●	●	●	●	
	Trackform w/ballast tamper	4 days	n/a	●	●	●	●	●	
Corridor works - track support systems	OHW[5] modifications	3 weeks	n/a	●	●	●	●	●	Works would only occur intermittently during three weeks of possession over the 3 year total construction program.

Work area[1]	Activity	Typical activity duration[2]	Indicative duration of noise-intensive works where relevant	Hours of work[3]					Additional comments
				Std. day	Possession/closedown works				
					Day	Day OOHW[4]	Eve	Night	
	Communications & signalling works	12 weeks	n/a	●	●	●	●	●	Works would only occur intermittently during 12 weeks of possession over the total construction program.
	Segregation fencing	6 weeks	n/a	●	●	●	●	●	Works would only occur intermittently during six weeks of possession over the total construction program.
Station work areas	Site establishment	3 weeks	n/a	●	●				-
	Demolition	6 weeks	2 weeks	●	●	●	●	●	Demolition works would only occur for a total duration of about 2 weeks during a 6 week possession. Works are proposed to be undertaken between 7am and 10pm unless unforeseen site conditions are encountered which may require night work.
	Demolition w/breaker & saw	6 weeks	2 weeks	●	●	●	●		Demolition works would only occur for a total duration of about 2 weeks during a 6 week possession. Works are proposed to be undertaken between 7am and 10pm.
	Concrete & structural works	8 weeks	n/a	●	●	●	●	●	This includes construction of platform canopy structures and platform re-surfacing.
	Station installation & fitout	20 weeks	n/a	●	●	●	●	●	This includes construction of station canopies, lift shafts and concourse works.
Bridge work areas	Site establishment & impact protection	2 weeks	n/a	●	●	●	●	●	Works would be carried out intermittently over a two year period during possessions.
	Demolition	2 weeks/ possession	2 weeks/ possession	●	●	●	●	●	Works would be carried out intermittently over a two year period during possessions. Demolition

Work area[1]	Activity	Typical activity duration[2]	Indicative duration of noise-intensive works where relevant	Hours of work[3]					Additional comments
				Std. day	Possession/closedown works				
					Day	Day OOHW[4]	Eve	Night	
									works would only occur for a total duration of about 2 weeks during these possessions.
	Demolition w/breaker & saw	2 weeks/ possession	2 weeks/ possession	●	●	●	●		Works would be carried out intermittently over a two year period during possessions. Demolition works would only occur for a total duration of about 2 weeks during these possessions.
	Construction & installation	20 weeks	n/a	●	●	●	●	●	Works would be carried out intermittently over a two year period during possessions.
Substation work areas	Site establishment	2 weeks	n/a	●	●	●			-
	Construction & installation	6 weeks	n/a	●	●	●	●		-

Notes:
1. Certain work areas are also major construction compounds.
2. Durations should be regarded as indicative and represent a typical work area. There would be sites within each category that require works to be shorter or longer than indicated.
3. Noise intensive works outside of recommended standard hours would typically only be undertaken during possessions/closedowns.
4. OOHW - Out of hours works refers to work conducted outside the recommended standard hours as defined in the ICNG During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.
5. OHW – Overhead wiring.

12.5 Potential impacts

12.5.1 Risk assessment

Potential risks

The environmental risk assessment for the project, undertaken for the State Significant Infrastructure Application Report, identified the following as the main construction noise and vibration risks:

- noise impacts at sensitive receivers adjacent to construction works along the rail corridor
- noise impacts from works to stations and the stabling facility in the areas surrounding stations
- increases in vehicle movements along local streets from construction traffic
- amenity and structural vibration impacts due to construction works.

How potential impacts would be avoided/minimised

Potential noise and vibration (amenity) impacts would either be avoided or minimised by:

- designing and constructing the project to minimise the potential for noise and vibration impacts
- developing specific noise mitigation approaches in accordance with the strategy described in Section 12.6.1
- implementation of the mitigation measures listed in Section 12.6.1, where reasonable and feasible.

12.5.2 Overview of construction noise and vibration results

Predicted noise levels

Table 12.9, Table 12.10 and Table 12.11 show the results of noise level predictions for residential receivers within each NCA, during the daytime, evening and night-time periods respectively. Table 12.12 shows similar information for commercial receivers during the daytime. Noise level predictions for other categories of sensitive receivers are discussed in subsequent sections for each noise catchment area.

The tables indicate the highest predicted noise level at the most exposed receiver for each activity. Typically, these are receivers which are immediately adjacent to the railway corridor and/or station and are therefore already subject to elevated levels of railway noise whether from existing operations or maintenance activities.

Consistent with other major transport infrastructure projects constructed in an urban environment, exceedances of the NMLs are predicted across the daytime, evening and/or night-time periods at residential receivers under the worst-case scenarios assessed. Exceedances of the NMLs during the evening and night-time periods were found to be higher than during the daytime which is partly as a result of lower noise criteria at these times. Exceedances of the NMLs are also predicted at commercial receivers but are generally less substantial.

While construction activities are predicted to result in noise levels at some residential receivers above the NMLs, the highest noise levels are predicted in NCA01 (Marrickville), NCA02 (Dulwich Hill), NCA07 (Belmore) and NCA11, NCA12 and NCA13 (Bankstown and surrounds), mainly as a result of the close proximity of receivers to the project area in these locations.

The highest noise levels were generally found to result from activities which require the use of noise intensive plant items such as a hydraulic breaker, rock saw and ballast tamper. This includes the following activities:

- general work areas – earthworks with hydraulic breaker
- corridor works – ground and track – earthworks with hydraulic breaker
- corridor works – ground and track – trackform with ballast tamper
- station work areas – demolition with hydraulic breaker and rock saw
- bridge work areas – demolition with hydraulic breaker and rock saw.

The predicted noise levels reduce considerably (between seven and 12 dBA) when the highly noise intensive equipment is not in use.

The use of highly noise intensive equipment is therefore proposed to be limited to the recommended standard work hours wherever possible. To reduce impacts, activities involving the use of hydraulic breakers and ballast tampers would not be scheduled during the night-time period (10pm to 7am), unless constraints exist such as: works requiring a rail shut down or due to the requirements of road authorities, emergency services or Sydney Coordination Office.

For most construction activities, it is expected that noise levels experienced during the construction period would frequently be lower than predicted at the most exposed receiver due to the conservative nature of the noise prediction methodology. Noise levels at receivers other than at these most exposed receivers for which results have been predicted would decrease with distance from the works.

Due to the requirement for construction within an operational rail corridor, there is a need to undertake works during possession periods when the trains are not operating. Due to the infrequent availability of these periods, some construction activities, including those using noise intensive plant outlined above would need to be undertaken during these periods. This would result in the highest impacts being mostly aligned with these possession periods, which would occur intermittently over the construction period. Between possession periods, the level of construction activity would be reduced and therefore the predicted maximum noise levels would also reduce.

Table 12.9 Predicted maximum noise level at the most exposed residential receiver during the daytime

NCA No.	Criteria	General work areas					Corridor work – ground and track				Corridor work – track support systems			Station work areas					Bridge work areas				Substation work areas	
		Earthworks	Earthworks - breaker	Piling	Site establishment	Operations	Earthworks	Earthworks - breaker	Trackform	Trackform - ballast tamper	OHW[1] modifications	Comms[2] & signalling works	Segregation fencing	Site establishment	Demolition	Demolition - breaker & saw	Concrete & structural	Station installation & fitout	Site establishment	Demolition	Demolition - breaker & saw	Construction & installation	Site establishment	Construction & installation
NCA 01	48	**76**	**84**	**75**	**72**	**69**	**77**	**85**	**75**	**82**	**76**	**76**	**73**	**68**	**72**	**81**	**70**	**68**	**74**	**72**	**84**	**69**	**53**	48
NCA 02	48	**80**	**88**	**79**	**76**	**73**	**78**	**86**	**76**	**83**	**76**	**76**	**73**	**70**	**74**	**83**	**72**	**70**	**79**	**77**	**89**	**74**	**78**	**73**
NCA 03	48	**80**	**88**	**79**	**76**	**73**	**80**	**88**	**78**	**85**	**76**	**76**	**73**	**63**	**67**	**76**	**65**	**63**	**78**	**76**	**88**	**73**	**65**	**60**
NCA 04	50	**58**	**66**	**57**	**54**	**51**	**78**	**86**	**76**	**83**	**74**	**74**	**71**	**67**	**71**	**80**	**69**	**67**	**75**	**73**	**85**	**70**	**69**	**64**
NCA 05	46	**70**	**78**	**69**	**66**	**63**	**70**	**78**	**68**	**75**	**71**	**71**	**68**	46	**50**	**59**	**48**	46	**74**	**72**	**84**	**69**	38	33
NCA 06	55	**76**	**84**	**75**	**72**	**69**	**79**	**87**	**77**	**84**	**75**	**75**	**72**	**65**	**69**	**78**	**67**	**65**	**78**	**76**	**88**	**73**	**67**	**62**
NCA 07	51	**76**	**84**	**75**	**72**	**69**	**73**	**81**	**71**	**78**	**72**	**72**	**69**	**73**	**77**	**86**	**75**	**73**	**72**	**70**	**82**	**67**	48	43
NCA 08	57	**61**	**69**	**60**	57	54	**70**	**78**	**68**	**75**	**69**	**69**	**66**	**68**	**72**	**81**	**70**	**68**	**70**	**68**	**80**	**65**	**71**	**66**
NCA 09	54	45	53	44	41	38	**77**	**85**	**75**	**82**	**73**	**73**	**70**	**73**	**77**	**86**	**75**	**73**	43	41	53	38	41	36
NCA 10	57	**60**	**68**	**59**	56	53	**71**	**79**	**69**	**76**	**68**	**68**	**65**	**62**	**66**	**75**	**64**	**62**	41	39	51	36	56	51
NCA 11	57	**68**	**76**	**67**	**64**	**61**	**76**	**84**	**74**	**81**	**73**	**73**	**70**	49	53	**62**	51	49	**75**	**73**	**85**	**70**	**71**	**66**
NCA 12	64	**72**	**80**	**71**	**68**	**65**	**72**	**80**	**70**	**77**	**68**	**68**	**65**	**66**	**70**	**79**	**68**	**66**	59	57	**69**	54	38	33
NCA 13	52	**62**	**70**	**61**	**58**	**55**	**70**	**78**	**68**	**75**	**74**	**74**	**71**	43	47	**56**	45	43	39	37	49	34	<30	<30

Notes: 1. OHW - overhead wiring.
2. Comms – communications systems.
3. Bold indicates exceedance of criteria predicted.

Table 12.10 Predicted maximum noise level at the most exposed residential receiver during the evening

NCA No.	Criteria	General work areas					Corridor work – ground and track				Corridor work – track support systems			Station work areas					Bridge work areas				Substation work areas	
		Earthworks	Earthworks - breaker	Piling	Site establishment	Operations	Earthworks	Earthworks - breaker	Trackform	Trackform - ballast tamper	OHW[1] modifications	Comms[2] & signalling works	Segregation fencing	Site establishment	Demolition	Demolition - breaker & saw	Concrete & structural	Station installation & fitout	Site establishment	Demolition	Demolition - breaker & saw	Construction & installation	Site establishment	Construction & installation
NCA 01	43	-	-	-	-	-	**77**	**85**	**75**	**82**	**76**	**76**	**73**	-	**72**	**81**	**70**	**68**	**74**	**72**	**84**	**69**	-	48
NCA 02	43	-	-	-	-	-	**78**	**86**	**76**	**83**	**76**	**76**	**73**	-	**74**	**83**	**72**	**70**	**79**	**77**	**89**	**74**	-	73
NCA 03	43	-	-	-	-	-	**80**	**88**	**78**	**85**	**76**	**76**	**73**	-	**67**	**76**	**65**	**63**	**78**	**76**	**88**	**73**	-	60
NCA 04	45	-	-	-	-	-	**78**	**86**	**76**	**83**	**74**	**74**	**71**	-	**71**	**80**	**69**	**67**	**75**	**73**	**85**	**70**	-	64
NCA 05	41	-	-	-	-	-	**70**	**78**	**68**	**75**	**71**	**71**	**68**	-	**50**	**59**	**48**	**46**	**74**	**72**	**84**	**69**	-	33
NCA 06	47	-	-	-	-	-	**79**	**87**	**77**	**84**	**75**	**75**	**72**	-	**69**	**78**	**67**	**65**	**78**	**76**	**88**	**73**	-	62
NCA 07	46	-	-	-	-	-	**73**	**81**	**71**	**78**	**72**	**72**	**69**	-	**77**	**86**	**75**	**73**	**72**	**70**	**82**	**67**	-	43
NCA 08	52	-	-	-	-	-	**70**	**78**	**68**	**75**	**69**	**69**	**66**	-	**72**	**81**	**70**	**68**	**70**	**68**	**80**	**65**	-	66
NCA 09	49	-	-	-	-	-	**77**	**85**	**75**	**82**	**73**	**73**	**70**	-	**77**	**86**	**75**	**73**	43	41	**53**	38	-	36
NCA 10	52	-	-	-	-	-	**71**	**79**	**69**	**76**	**68**	**68**	**65**	-	**66**	**75**	**64**	**62**	41	39	51	36	-	51
NCA 11	52	-	-	-	-	-	**76**	**84**	**74**	**81**	**73**	**73**	**70**	-	**53**	**62**	51	49	**75**	**73**	**85**	**70**	-	**66**
NCA 12	56	-	-	-	-	-	**72**	**80**	**70**	**77**	**68**	**68**	**65**	-	**70**	**79**	**68**	**66**	**59**	**57**	**69**	54	-	33
NCA 13	47	-	-	-	-	-	**70**	**78**	**68**	**75**	**74**	**74**	**71**	-	47	**56**	45	43	39	37	**49**	34	-	<30

Notes: 1. OHW - overhead wiring.
2. Comms – communications systems.
3. Bold indicates exceedance of criteria predicted.

Table 12.11 Predicted maximum noise level at the most exposed residential receiver during the night-time

NCA No.	Criteria	General work areas					Corridor work – ground and track				Corridor work – track support systems			Station work areas					Bridge work areas				Substation work areas	
		Earthworks	Earthworks - breaker	Piling	Site establishment	Operations	Earthworks	Earthworks - breaker	Trackform	Trackform - ballast tamper	OHW[1] modifications	Comms[2] & signalling works	Segregation fencing	Site establishment	Demolition	Demolition - breaker & saw	Concrete & structural	Station installation & fitout	Site establishment	Demolition	Demolition - breaker & saw	Construction & installation	Site establishment	Construction & installation
NCA 01	38	-	-	-	-	-	**77**	-	**75**	**82**	**76**	**76**	**73**	-	**72**	-	**70**	**68**	**74**	**72**	-	**69**	-	-
NCA 02	38	-	-	-	-	-	**78**	-	**76**	**83**	**76**	**76**	**73**	-	**74**	-	**72**	**70**	**79**	**77**	-	**74**	-	-
NCA 03	39	-	-	-	-	-	**80**	-	**78**	**85**	**76**	**76**	**73**	-	**67**	-	**65**	**63**	**78**	**76**	-	**73**	-	-
NCA 04	40	-	-	-	-	-	**78**	-	**76**	**83**	**74**	**74**	**71**	-	**71**	-	**69**	**67**	**75**	**73**	-	**70**	-	-
NCA 05	37	-	-	-	-	-	**70**	-	**68**	**75**	**71**	**71**	**68**	-	**50**	-	**48**	**46**	**74**	**72**	-	**69**	-	-
NCA 06	40	-	-	-	-	-	**79**	-	**77**	**84**	**75**	**75**	**72**	-	**69**	-	**67**	**65**	**78**	**76**	-	**73**	-	-
NCA 07	40	-	-	-	-	-	**73**	-	**71**	**78**	**72**	**72**	**69**	-	**77**	-	**75**	**73**	**72**	**70**	-	**67**	-	-
NCA 08	46	-	-	-	-	-	**70**	-	**68**	**75**	**69**	**69**	**66**	-	**72**	-	**70**	**68**	**70**	**68**	-	**65**	-	-
NCA 09	41	-	-	-	-	-	**77**	-	**75**	**82**	**73**	**73**	**70**	-	**77**	-	**75**	**73**	**43**	41	-	38	-	-
NCA 10	46	-	-	-	-	-	**71**	-	**69**	**76**	**68**	**68**	**65**	-	**66**	-	**64**	**62**	41	39	-	36	-	-
NCA 11	44	-	-	-	-	-	**76**	-	**74**	**81**	**73**	**73**	**70**	-	**53**	-	**51**	**49**	**75**	**73**	-	**70**	-	-
NCA 12	47	-	-	-	-	-	**72**	-	**70**	**77**	**68**	**68**	**65**	-	**70**	-	**68**	**66**	**59**	**57**	-	**54**	-	-
NCA 13	44	-	-	-	-	-	**70**	-	**68**	**75**	**74**	**74**	**71**	-	**47**	-	**45**	43	39	37	-	34	-	-

Notes: 1. OHW - overhead wiring.
2. Comms – communications systems.
3. Bold indicates exceedance of criteria predicted.

Table 12.12 Predicted maximum noise level at the most exposed commercial receiver during the daytime

NCA No.	Criteria	General work areas					Corridor work – ground and track				Corridor work – track support systems			Station work areas					Bridge work areas				Substation work areas	
		Earthworks	Earthworks - breaker	Piling	Site establishment	Operations	Earthworks	Earthworks - breaker	Trackform	Trackform - ballast tamper	OHW[1] modifications	Comms[2] & signalling works	Segregation fencing	Site establishment	Demolition	Demolition - breaker & saw	Concrete & structural	Station installation & fitout	Site establishment	Demolition	Demolition - breaker & saw	Construction & installation	Site establishment	Construction & installation
NCA 01	70	**74**	**82**	**73**	70	67	**72**	**80**	70	**77**	68	68	65	69	**73**	**82**	**71**	69	**75**	**73**	**85**	70	41	36
NCA 02	70	52	60	51	48	45	67	**75**	65	**72**	63	63	60	61	65	**74**	63	61	62	60	**72**	57	46	41
NCA 03	70	63	**71**	62	59	56	**78**	**86**	**76**	**83**	**74**	**74**	**71**	**76**	**80**	**89**	**78**	**76**	**71**	69	**81**	66	36	31
NCA 04	70	59	67	58	55	52	**76**	**84**	**74**	**81**	**72**	**72**	69	65	69	**78**	67	65	70	68	**80**	65	46	41
NCA 05	70	**77**	**85**	**76**	**73**	70	56	64	54	61	69	69	66	46	50	59	48	46	60	58	70	55	31	<30
NCA 06	70	**80**	**88**	**79**	**76**	**73**	**74**	**82**	**72**	**79**	70	70	67	**75**	**79**	**88**	**77**	**75**	56	54	66	51	48	43
NCA 07	70	**85**	**93**	**84**	**81**	**78**	**79**	**87**	**77**	**84**	**76**	**76**	**73**	66	70	**79**	68	66	53	51	63	48	44	39
NCA 08	70	**84**	**92**	**83**	**80**	**77**	**79**	**87**	**77**	**84**	**75**	**75**	**72**	69	**73**	**82**	**71**	69	**84**	**82**	**94**	**79**	59	54
NCA 09	70	38	46	37	34	31	54	62	52	59	65	65	62	64	68	**77**	66	64	37	35	47	32	<30	<30
NCA 10	70	**77**	**85**	**76**	**73**	70	**79**	**87**	**77**	**84**	**75**	**75**	**72**	**72**	**76**	**85**	**74**	**72**	38	36	48	33	49	44
NCA 11	70	48	56	47	44	41	**73**	**81**	**71**	**78**	69	69	66	37	41	50	39	37	67	65	**77**	62	45	40
NCA 12	70	**79**	**87**	**78**	**75**	**72**	**81**	**89**	**79**	**86**	**80**	**80**	**77**	**71**	**75**	**84**	**73**	**71**	67	65	**77**	62	41	36
NCA 13	70	66	**74**	65	62	59	68	**76**	66	**73**	65	65	62	42	46	55	44	42	38	36	48	33	<30	<30

Notes: 1. OHW - overhead wiring.
2. Comms – communications systems.
3. Bold indicates exceedance of criteria predicted.

Highly noise affected receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or above (an absolute noise level not based on measured ambient noise) to be 'highly noise affected'. This is generally consistent with the 'highly intrusive' noise impact category outlined in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (described in Section 12.6.1 and provided in Appendix E).

Table 12.13 provides a summary of the duration of key noise intensive works which directly contribute to the number of highly noise affected receivers in each catchment. A more detailed breakdown of all exceedances of the highly noise affected criteria is provided in Sections 12.5.3 to 12.5.12 specific to each station area.

The table shows that the potentially greatest number of residential receivers affected is NCA02 (Dulwich Hill). This is due to the large number of dwellings in this area and their close proximity to the works. Other noise catchment areas such as NCA03 (Hurlstone Park) and NCA06 (Campsie) are also predicted to result in relatively high numbers of residential receivers affected.

For other sensitive receivers, NCAs 09, 10, 11, 12 and 13 are predicted to have the most number of receivers affected. NCA04 and NCA05 would experience fewer impacts and mostly during the daytime. No commercial receivers are predicted to be highly noise affected.

The use of highly noise intensive equipment (such as hydraulic breakers and ballast tampers) would generally be limited to day time and evening periods (between 7am and 10pm), unless constraints exist such as:

- works requiring a rail shut down
- specific requirements of relevant road authorities, emergency services, or the Sydney Coordination Office.

Ballast tamping would be restricted where reasonable and feasible however there may be times when this is required during night-time periods. Not using this item of plant during the night-time would reduce predicted noise levels by up to seven dB and substantially reduce the number of receivers highly noise affected in all catchments.

The use of noise intensive equipment would only occur infrequently during the construction period as outlined in Table 12.8. The predicted noise levels reduce considerably (between seven and 12 dBA) when the highly noise intensive equipment is not in use.

Table 12.13 Duration of noise intensive works resulting in greatest number of 'highly noise affected' residential receivers

Station	Construction activity	Indicative total duration of noise intensive activities	Maximum number of exceedances
Marrickville (NCA01)	Corridor works - ground & track, earthworks with breaker	3 days	21
	Corridor works - ground & track, trackform with ballast tamper	4 days	16
	Bridge work areas, demolition with breaker & saw	2 weeks	20
Dulwich Hill (NCA02)	General work areas, earthworks with breaker	3 days	24
	Corridor works - ground & track, earthworks with breaker	7 days	36
	Corridor works - ground & track, trackform with ballast tamper	4 days	20
	Bridge work areas, demolition with breaker & saw	2 weeks	106
Hurlstone Park (NCA03)	General work areas, earthworks with breaker	3 days	23
	Corridor works - ground & track, earthworks with breaker	7 days	48
	Corridor works - ground & track, trackform with ballast tamper	4 days	34
	Bridge work areas, demolition with breaker & saw	2 weeks	39
Canterbury (NCA04 & 05)	General work areas, earthworks with breaker	3 days	30
	Corridor works - ground & track, earthworks with breaker	3 days	7
	Station work areas, demolition with breaker & saw	2 weeks	8
	Bridge work areas, demolition with breaker & saw	2 weeks	14
Campsie (NCA06)	General work areas, earthworks with breaker	3 days	26
	Corridor works - ground & track, earthworks with breaker	3 days	37
	Corridor works - ground & track, trackform with ballast tamper	4 days	23
	Station work areas, demolition with breaker & saw	2 weeks	13
	Bridge work areas, demolition with breaker & saw	2 weeks	22
Belmore (NCA07)	General work areas, earthworks with breaker	3 days	22
	Corridor works - ground & track, earthworks with breaker	3 days	23
	Corridor works - ground & track, trackform with ballast tamper	4 days	12

Station	Construction activity	Indicative total duration of noise intensive activities	Maximum number of exceedances
	Station work areas, demolition with breaker & saw	2 weeks	8
	Bridge work areas, demolition with breaker & saw	2 weeks	10
Lakemba (NCA08)	Corridor works - ground & track, earthworks with breaker	3 days	19
	Corridor works - ground & track, trackform with ballast tamper	4 days	4
	Station work areas, demolition with breaker & saw	2 weeks	8
	Bridge work areas, demolition with breaker & saw	2 weeks	7
Wiley Park (NCA09)	Corridor works - ground & track, earthworks with breaker	3 days	27
	Corridor works - ground & track, trackform with ballast tamper	4 days	12
	Station work areas, demolition with breaker & saw	2 weeks	7
Punchbowl (NCA10)	Corridor works - ground & track, earthworks with breaker	3 days	15
	Corridor works - ground & track, trackform with ballast tamper	4 days	7
Bankstown (NCA11,12 & 13)	Corridor works - ground & track, earthworks with breaker	3 days	32
	Corridor works - ground & track, trackform with ballast tamper	4 days	24
	Bridge work areas, demolition with breaker & saw	2 weeks	30

Note: Highly noise affected is based on the ICNG definition ie predicted $LAeq_{(15minute)}$ noise at residential receiver is 75 dBA or greater.

Consideration of multiple work area activities occurring simultaneously

As outlined in Section 12.1.1, there is potential for a number of construction activities to occur simultaneously and a receiver may potentially experience noise from more than one work area and/or activity at the same time.

However, since the works are anticipated to be of a similar nature at each work area, the effect of concurrent construction works and activities would likely have only a limited effect on the noise level experienced at receivers. In practice, the noise levels experienced at receivers would vary over time due to plant and equipment moving about each work area and not all of it operating concurrently or at full power for the majority of the time as assumed by the noise prediction methodology.

The use of all work areas or construction compounds would also not necessarily occur simultaneously as, for example, works at numerous bridge sites would not occur at the same time due to the potential impacts on traffic.

Construction traffic noise

Existing traffic volumes on roads proposed to be used for construction vehicles or temporary transport services were identified either from desktop searches, information provided by road owners or by traffic counts. This enabled the determination of a background volume of road traffic and associated road noise levels. The introduction of construction traffic to these roads, including workers vehicles, haulage vehicles and rail replacement buses, is likely to influence existing traffic noise levels on these roads, and in some circumstances, may result in road traffic noise levels that exceed the applicable road traffic noise criteria.

With regard to the movement of construction vehicles to and from work areas, the assessment concluded that there would be an increase in road traffic noise of less than two dB on the majority of identified construction routes. However, construction traffic noise levels would exceed the criteria on some roads in Marrickville, Dulwich Hill, Hurlstone Park, Canterbury, and Bankstown, with the majority of exceedances occurring during the night-time, due to temporary bus services during possession periods. Table 12.14 outlines the roads where road traffic noise is predicted to exceed the road traffic noise criteria due to construction vehicles, rail replacement buses and operation of both construction vehicles and buses simultaneously. All other roads are not considered to exceed criteria.

Table 12.14 Road traffic noise exceedances for construction traffic and buses - summary

Road	Construction traffic	Rail replacement buses	Construction traffic and rail replacement buses
Marrickville			
Myrtle Street	●		●
Dulwich Hill			
Bayley Street - between Ewart Street and Dudley Street	●	●	●
Terrace Road - between New Canterbury Road and Consett Street	●		●
Ewart Street - between Wardell Road & Ness Avenue		●	●

Road	Construction traffic	Rail replacement buses	Construction traffic and rail replacement buses
Hurlstone Park			
Garnet Street - between Canterbury Road and Hampden Street)	●		●
Duntroon Street	●		●
Crinan Street - between Melford Street & Dunstaffenage Street)	●		●
Canterbury			
Close Street	●		●
Broughton Street - between Canterbury Road & Robert Street)	●		●
Campsie			
Gould Street -between Canterbury Road and Redman Street)		●	●

Further modelling of all routes would be carried out during the detailed design stage when construction traffic volumes and haulage routes are confirmed by the construction contractor. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be applied.

Construction vibration

In the majority of cases, the separation distance between the construction works and the nearest sensitive receiver would be sufficient such that cosmetic damage to structures would be unlikely. However, there is the potential for some items of construction equipment to be operated closer than the minimum safe working distances, due to the way in which the work areas are arranged and the activities are likely to be undertaken. This is relevant for equipment such as large hydraulic breakers which have the potential to generate some of the highest vibration levels.

The assessment indicated that some receivers would be potentially affected by vibration sufficient to cause cosmetic damage and human comfort impacts. These receivers would be located within the minimum safe working distance of a large hydraulic breaker if it were to be used at the outer extent of the works area closest to the receiver. This is considered a conservative estimate however as a large rock breaker would be unlikely to be required in this manner at all work areas.

The potential for heritage buildings to be damaged due to vibration would be considered on a case by case basis, with detailed inspections and condition assessments being undertaken prior to works commencing. Up to 39 heritage buildings have been preliminarily identified to be within the recommended safe working distances for cosmetic damage. During detailed design, the location and use of vibration-intensive equipment would be reviewed to ensure the potential for cosmetic damage and human comfort impacts are minimised.

Mitigation measures

A Construction Noise and Vibration Strategy (provided in Appendix E) has been developed to manage construction noise and vibration for the Sydney Metro City & Southwest project as a whole. The strategy provides a framework for managing construction noise and vibration impacts in accordance with the ICNG and to provide a consistent approach to management and mitigation across all Sydney Metro projects.

The ICNG defines the terms ‘feasible’ and ‘reasonable’ with respect to mitigation measures for construction noise. A measure is feasible if it can be engineered and is practical to build, given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves judging whether the overall benefits of the measure outweighs the potentially adverse social, economic, and environmental effects (including costs).

Section 12.6 outlines the approach to management and mitigation of identified noise and vibration impacts, including measures which have been effective in reducing impacts on similar projects in the Sydney region. The measures also include a process for further investigations and consultation to be undertaken should an adaptive response be required during construction.

Of particular importance to the assessment are potential exceedances of the noise criteria during the evening and night-time periods, referred to as being outside of recommended standard work hours. As described in Chapter 9 (Project description – construction), the approach to out of hours work involves the preparation of an Out of Hours Work Strategy.

The Out Of Hours Work Strategy would be developed to guide the assessment, management, and approval of works outside the recommended standard working hours. The strategy would be developed to ensure that out of hours works are managed effectively during construction, to minimise impacts to the community. The strategy would provide guidance for the preparation of out of hours work plans for each construction work area and for key works (including for each station), would be prepared in consultation with key stakeholders (including the EPA).

The proposed mitigation measures, including the above, are provided in Section 12.6.

12.5.3 Marrickville (NCA01)

The Marrickville noise catchment area (NCA01) is dominated by residential receivers (as shown in Figure 12.1). There is a large passive recreation area west of the station (McNeilly Park) and a small commercial corridor along Illawarra Road south of the rail corridor. The freight rail line runs on the northern edge of the rail corridor.

There are a number of residential receivers on Arthur Street, Jersey Street, Leofrene Avenue, Warburton Street, Myrtle Street, and Brynes Street that are located close to the rail corridor. Bridge works and general site works would be undertaken close to these receivers. Additionally, station works are required near Charlotte Avenue, O’Hara Street, and Illawarra Road.

Predicted construction noise levels for the construction activities resulting in the highest number of ‘highly noise affected’ residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10, and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- **corridor works - ground and track, trackform with ballast tamper**

- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works
- station work areas, demolition.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the Track Support Systems activities - OHW modifications and communications and signalling works. While these works are not particularly noise intensive, they would be required along the length of the corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.2 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB for 20 per cent of affected receivers, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

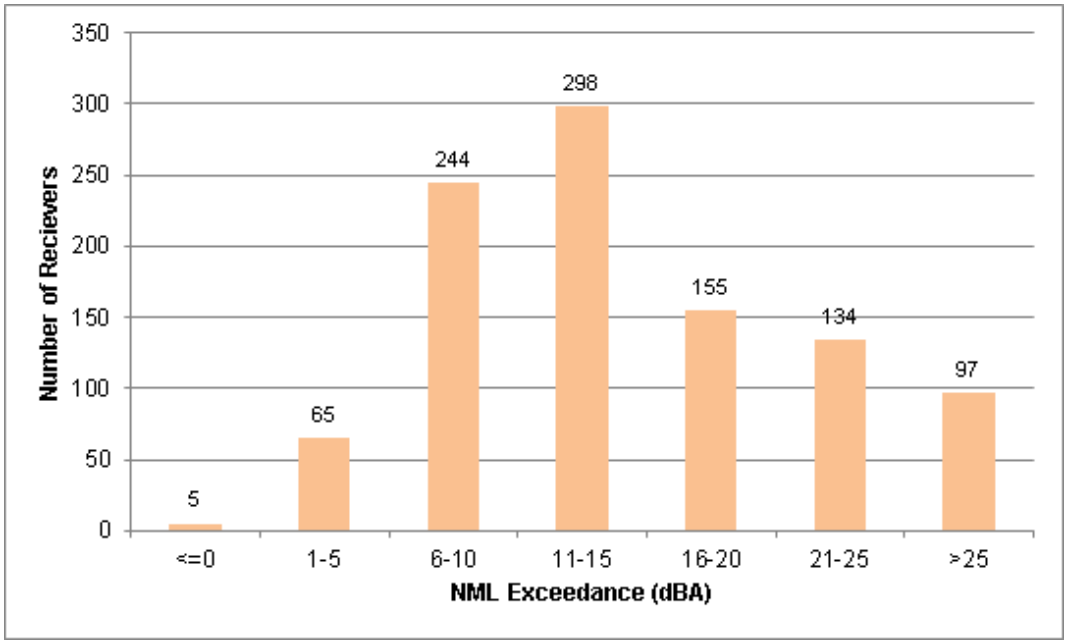


Figure 12.2 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.3 shows that when this noise intensive plant item (ballast tamper) is not in use, number of exceedances greater than 20 dB above the noise management level reduces to about six per cent of noise affected receivers in the precinct.

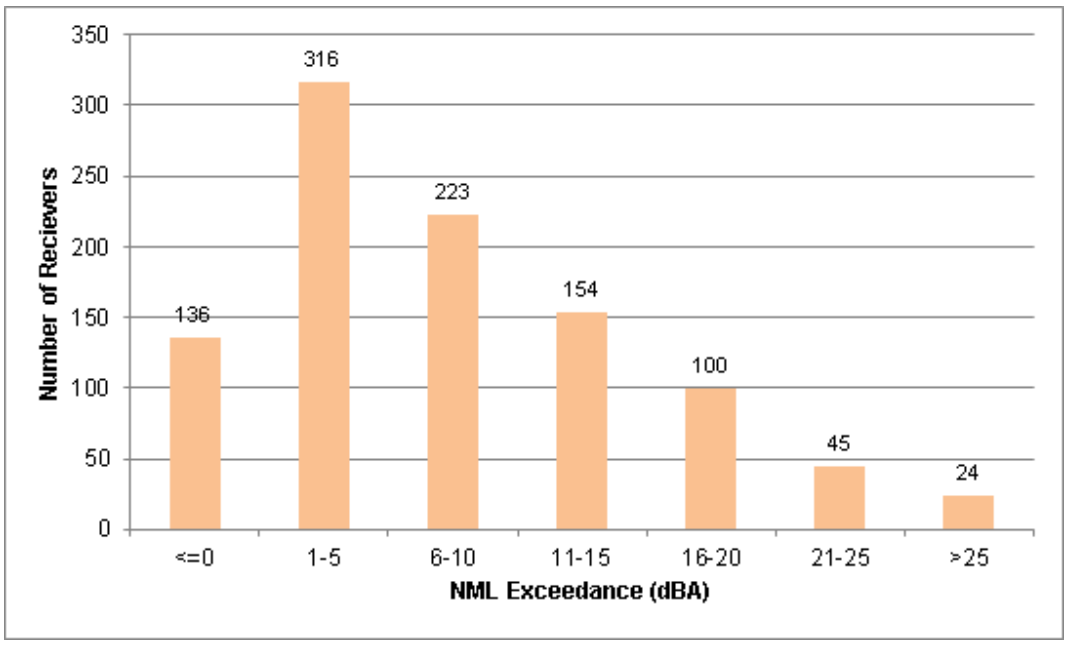


Figure 12.3 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.15 shows the number of receivers within NCA01 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

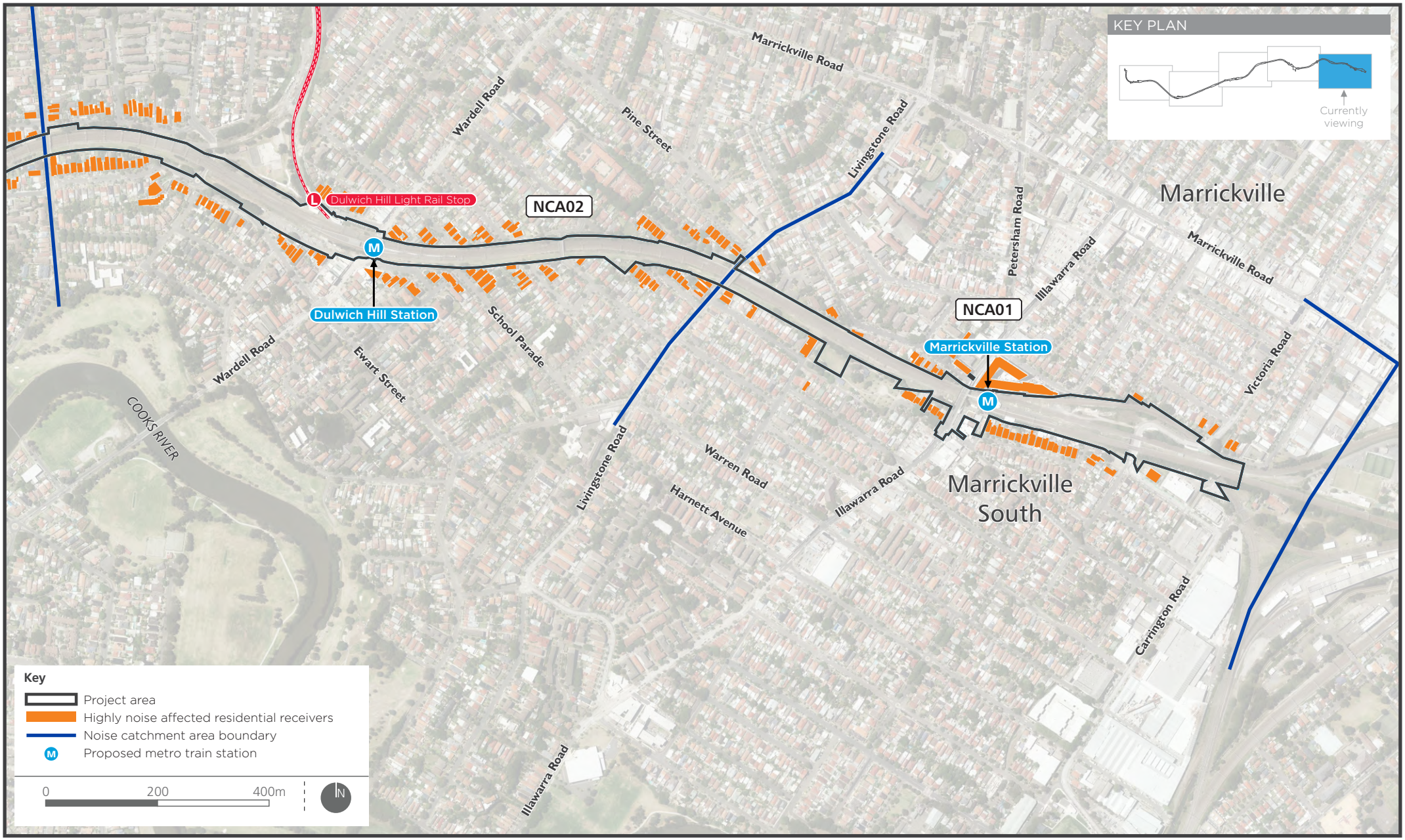
- Corridor works - ground and track, earthworks with breaker, where 21 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 16 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, this would reduce to five receivers being highly noise affected during this period.
- Bridge work areas, demolition with breaker and saw, where 20 receivers are predicted to be highly noise affected during the daytime and evening, which results from the large number of bridge work areas in this precinct. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.4 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.15 Activities and durations which result in 'highly noise affected' residential receivers in Marrickville

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Marrickville (NCA01)	General work areas, earthworks	6 weeks	n/a	1		
	General work areas, earthworks with breaker	6 weeks	3 days	4		
	General work areas, piling	6 weeks	2 weeks	1		
	Corridor works - ground and track, earthworks	30 weeks	n/a	4	4	4
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**21**	**21**	
	Corridor works - ground & track, trackform	12 days	n/a	1	1	1
	Corridor works - ground & track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**16**	**16**	**16**
	Corridor works – track support systems – OHW modifications	3 weeks	n/a	4	4	4
	Corridor works – track support systems – communications and signalling works	12 weeks	n/a	4	4	4
	Station work areas, demolition with breaker & saw	6 weeks	2 weeks /6 week possession	7	7	
	Bridge work areas, demolition with breaker & saw	**2 weeks/ possession**	**2 weeks/ possession**	**20**	**20**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.



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Location of highly noise affected residential receivers – Marrickville and Dulwich Hill

FIGURE 12.4

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in any exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- public building – 129-130 Meeks Road, Marrickville
- public building – 3-5 Carrington Road, Marrickville
- public building – McNeilly Park buildings.

One sensitive receiver, a café/bar at 1 Warburton Street, Marrickville is predicted to experience noise levels greater than 20 dB above the NMLs.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.16. Given the assessment approach, the identified impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes. The key finding was that collectively, both the construction vehicles and buses required as part of the alternative transport arrangements would result in an increase of less than two dB on a majority of roads used for construction traffic.

The movement of construction traffic along Myrtle Street in Marrickville is predicted to result in an increase of more than two dB and result in road traffic noise levels that exceed the criteria during the night-time period. No additional (cumulative) impacts would result from the operation of buses as part of the alternative transport arrangements outlined in the Temporary Transport Strategy.

Table 12.16 Activities which result in sleep disturbance exceedance in Marrickville - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Marrickville (NCA01)	Corridor works - ground and track, earthworks with breaker	10 weeks	3 days	36
	Corridor works - ground & track, trackform	12 days	n/a	17
	Corridor works - ground & track, trackform with ballast tamper	4 days	Less than 4 days	257
	Corridor works – track support systems – OHW modifications	3 weeks	n/a	73
	Corridor works – track support systems – communications and signalling works	12 weeks	n/a	78
	Corridor works – track support systems – segregation fencing	6 weeks	n/a	68
	Station work areas, demolition	6 week	n/a	19
	Station work areas, concrete and structural work	8 weeks	n/a	6
	Station work areas, station installation and fitout	20 weeks	n/a	1
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	16
	Bridge work areas, demolition	2 weeks	n/a	13
	Bridge work areas, construction and installation	20 weeks	n/a	12

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project specific information regarding the duration of construction activities and equipment would become available following the detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 40 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage are provided in Table 12.17.

Table 12.17 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA01	Marrickville Station	Commercial	Masonry
NCA01	Carrington Road, Marrickville	Public Building	Masonry (Brick)
NCA01	1 Myrtle Street, Marrickville	Residential	Masonry (Brick)

Notes: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 – Non-Aboriginal heritage assessment for further information on heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.4 Dulwich Hill (NCA02)

The Dulwich Hill noise catchment area (NCA02) is dominated by residential receivers (as shown in Figure 12.1). There is also a small commercial corridor along Wardell Road south of the station. The terminus stop for the L1 Dulwich Hill light rail line is located to the west of Dulwich Hill Station and the light rail line heads north away from the station. The freight rail line runs on the northern edge of the rail corridor.

Residential receivers on Livingstone Road, Randall Street, Kays Avenue, School Parade, Ewart Street, and The Parade would be located near bridge works, while substation works would also potentially affect residential receivers on Randall Street. Around Dulwich Hill Station, track realignment and station works would be undertaken near residential receivers on Ewart Lane and commercial receivers facing Wardell Road.

Predicted construction noise levels for the construction activities resulting in the highest number of ‘highly noise affected’ residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10, and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- **corridor works - ground and track, trackform with ballast tamper**
- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works
- bridge work areas, site establishment and impact protection
- bridge work areas, demolition.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities - OHW modifications and communications and signalling works. While these works are not particularly noise intensive, they would be required along the length of the corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform - ballast tamper. Figure 12.5 indicates the distribution of exceedances for this activity for receivers within this precinct during the night-time. The graph shows that, while the activity may result in exceedance of the night-time NMLs greater than 20 dB for 17 per cent of affected receivers, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

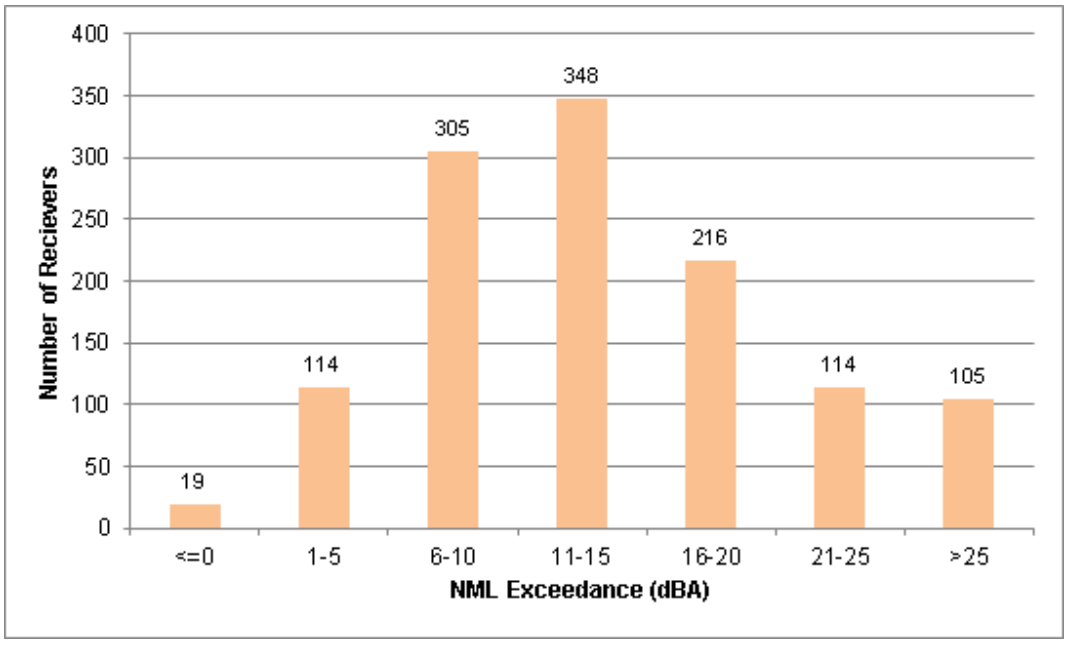


Figure 12.5 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.6 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to seven per cent of affected receivers.

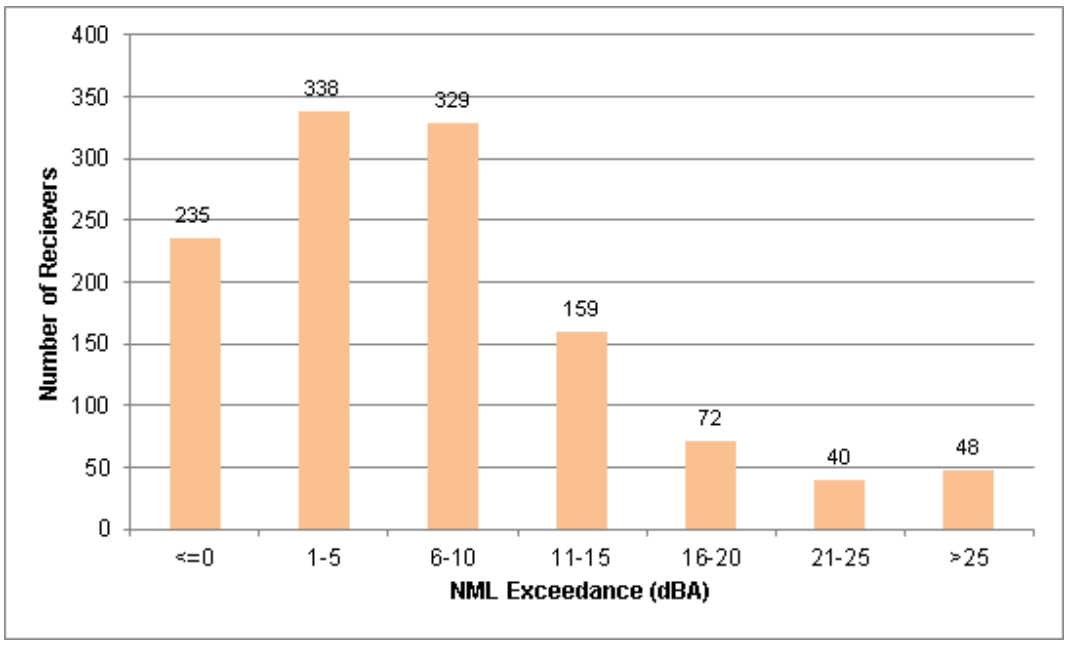


Figure 12.6 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.18 shows the number of receivers within NCA02 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- General work areas, earthworks with breaker, where 24 receivers are predicted to be highly noise affected during the daytime only and would only be undertaken for about three days at any site.
- Corridor works - ground and track, earthworks with breaker, where 36 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 20 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, this would reduce to five receivers being highly noise affected during this period.
- Bridge construction areas, demolition with breaker and saw, where 106 receivers are predicted to be highly noise affected during the daytime and evening, which results from the large number of bridge work areas in this precinct. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works would only occur for a total duration of about two weeks during these possessions.

Figure 12.4 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.18 Activities and durations which result in 'highly noise affected' residential receivers in Dulwich Hill

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Dulwich Hill (NCA02)	General work areas, earthworks	6 weeks	n/a	9		
	General work areas, earthworks with breaker	**6 weeks**	**3 days**	**24**		
	General work areas, piling	6 weeks	2 weeks	6		
	General work areas, site establishment	4 weeks	n/a	1		
	Corridor works - ground and track, earthworks	30 weeks	n/a	11	11	11
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**36**	**36**	
	Corridor works - ground & track, trackform	12 days	n/a	5	5	5
	Corridor works - ground & track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**20**	**20**	**20**
	Corridor works – track support systems, OHW modifications	3 weeks	n/a	5	5	5
	Corridor works - track support systems, communications and signalling	12 weeks	n/a	5	5	5
	Station work areas, demolition with breaker & saw	6 weeks	2 weeks /6 week possession	9	9	
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	13	13	13
	Bridge work areas, demolition	2 weeks/ possession	2 weeks/ possession	5	5	5
	Bridge work areas, demolition with breaker & saw	**2 weeks/ possession**	**2 weeks/ possession**	**106**	**106**	
	Substation work areas, site establishment	2 weeks	n/a	1		

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- Place of worship – St Nicholas Greek Orthodox Church, 205 Livingstone Road, Marrickville
- Public buildings – 209 Livingstone Road, Marrickville
- Café/bar – 245 Wardell Road, Dulwich Hill.

No sensitive receivers in this area are likely to experience noise levels more than 20 dB above NMLs.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.19. Given the assessment approach used, the identified impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction would be subject to this strategy.

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes. The key finding was that collectively, the construction vehicles and buses required as part of the alternative transport arrangements would result in an increase of less than two dB on a majority of roads used for construction traffic.

Table 12.19 Activities which result in sleep disturbance exceedance in Dulwich Hill - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of exceedances greater than 20 dB
Dulwich Hill (NCA02)	Corridor works - ground and track, earthworks	30 weeks	n/a	69
	Corridor works - ground & track, trackform	12 days	n/a	23
	Corridor works - ground & track, trackform with ballast tamper	4 days	Less than 4 days	254
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	82
	Corridor works - track support systems, communications and signalling	12 weeks	n/a	101
	Corridor works – track support systems – segregation fencing	6 weeks	n/a	51
	Station work areas, demolition	6 weeks	n/a	16
	Station work areas, concrete and structural work	8 weeks	n/a	6
	Station work areas, station installation and fitout	20 weeks	n/a	1
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	96
	Bridge work areas, demolition	2 weeks/ possession	2 weeks/ possession	70
	Bridge work areas, construction and installation	20 weeks	n/a	43

The roads shown in Table 12.20 are predicted to experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria during the night-time.

As outlined in Table 12.20, consideration of both construction traffic and rail replacement buses operating simultaneously would result in additional exceedances during the day time at Ewart Street (between Wardell Road & Ness Avenue).

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if addition mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Table 12.20 Road traffic noise exceedances from construction traffic and buses – Dulwich Hill

Road	Construction traffic	Rail replacement buses	Construction traffic and rail replacement buses
Bayley Street - between Ewart Street and Dudley Street	●	●	●
Terrace Road - between New Canterbury Road and Consett Street	●		●
Ewart Street - between Wardell Road & Ness Avenue		●	●

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings located within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 74 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage are listed in Table 12.21.

Table 12.21 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/address	Building occupancy	Construction type
NCA02	Dulwich Hill Station	Commercial	Weatherboard
NCA02	217 Livingstone Road, Marrickville	Residential	Masonry (Brick)
NCA02	219 Livingstone Road, Marrickville	Residential	Masonry (Brick)
NCA02	2 Hollands Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	4 Hollands Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	6 Hollands Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	242 Wardell Road, Dulwich Hill	Residential	Masonry (Brick)
NCA02	240 Wardell Road, Dulwich Hill	Residential	Masonry (Brick/Rendered)
NCA02	5 Wilga Avenue, Dulwich Hill	Residential	Masonry (Brick)
NCA02	7 Wilga Avenue, Dulwich Hill	Residential	Masonry (Brick)
NCA02	14 Wilga Avenue, Dulwich Hill	Residential	Masonry (Brick)
NCA02	47 School Parade, Marrickville	Residential	Masonry (Brick)
NCA02	43 School Parade, Marrickville	Residential	Masonry (Brick)
NCA02	41 School Parade, Marrickville	Residential	Masonry (Brick)
NCA02	22 Kays Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	26 Kays Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	28 Kays Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	37 Kays Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	39 Kays Avenue, Marrickville	Residential	Masonry (Brick)
NCA02	34 Challis Avenue, Dulwich Hill	Residential	Masonry (Brick)
NCA02	36 Challis Avenue, Dulwich Hill	Residential	Masonry (Brick)
NCA02	35 Challis Avenue, Dulwich Hill	Residential	Masonry (Brick)

NCA	Item/address	Building occupancy	Construction type
NCA02	39 Challis Avenue, Dulwich Hill	Residential	Masonry (Brick/Rendered)
NCA02	116 Ewart Street, Dulwich Hill	Residential	Masonry

Notes: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.5 Hurlstone Park (NCA03)

The Hurlstone Park noise catchment area (NCA03) is dominated by residential receivers (as shown in Figure 12.1) with a small commercial corridor leading away from the station to the north along Crinan Street. The freight rail line runs on the northern edge of the rail corridor.

Bridge works would be undertaken near residential receivers on Floss Street, Foord Avenue and Hurlstone Avenue while around Hurlstone Park Station, track realignment and station works would be undertaken in proximity to a mix of commercial and residential receivers.

Predicted construction noise levels for the construction activities resulting in the highest number of 'highly noise affected' residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of the recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- **corridor works - ground and track, trackform with ballast tamper**
- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities - OHW modifications and communications and signalling works. While these works are

not particularly noise intensive, they would be required along the length of the corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.7 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB for 25 per cent of receivers in this precinct, a much greater percentage of receivers are subject to lower levels of noise.

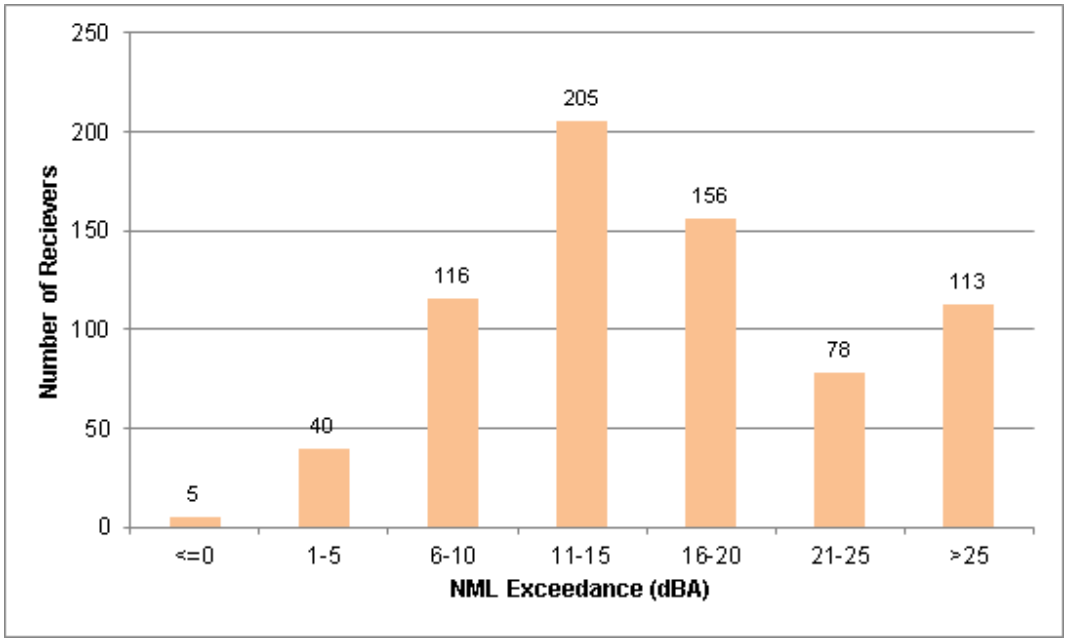


Figure 12.7 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.8 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to about 11 per cent of noise affected receivers in this precinct.

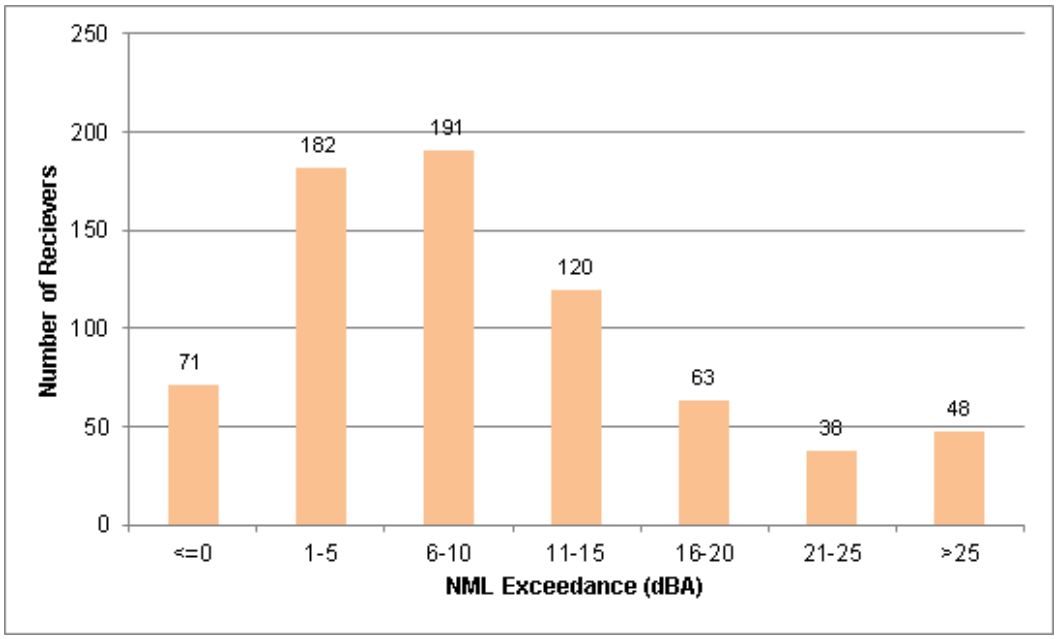


Figure 12.8 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.22 shows the number of receivers within NCA03 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- General work areas, earthworks with breaker, where 23 receivers are predicted to be highly noise affected during the daytime only and would only be undertaken for about three days at any site.
- Corridor works - ground and track, earthworks with breaker, where 48 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 34 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, this would reduce to three receivers being highly noise affected during this period.
- Bridge work areas, demolition with breaker and saw, where 39 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.9 shows the predicted location of residential receivers who are likely to experience exceedances of the highly noise affected criteria.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

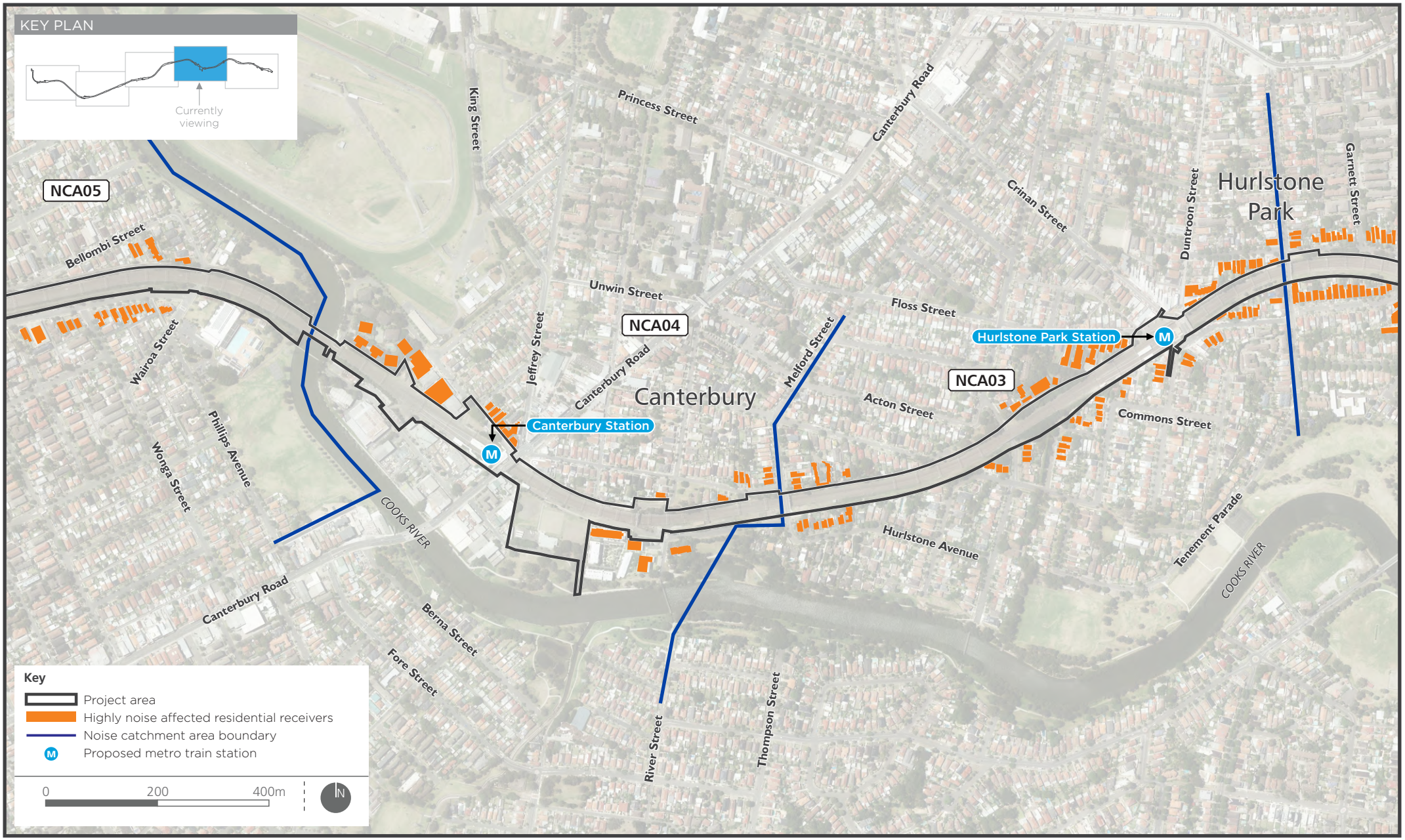
One sensitive receiver is likely to experience exceedances of 11 to 20 dB above NMLs during the higher noise generating activities, namely Hurlstone Park Children's Centre, at 12 Smith Avenue, Hurlstone Park (child care facility).

Only one sensitive receiver, Dulwich Hill Child Care Centre, 66 Garnet Street, Hurlstone Park is predicted to experience noise levels greater than 20 dB above NMLs.

Table 12.22 Activities and durations which result in 'highly noise affected' residential receivers in Hurlstone Park

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of residential receivers highly noise affected		
				Day	Eve	Night
Hurlstone Park (NCA03)	General work areas, earthworks	6 weeks	n/a	3		
	General work areas, earthworks with breaker	**6 weeks**	**3 days**	**23**		
	General work areas, piling	6 weeks	2 weeks	3		
	General work areas, site establishment	4 weeks	n/a	1		
	Corridor works - ground and track, earthworks	30 weeks	n/a	8	8	8
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**48**	**48**	
	Corridor works - ground & track, trackform	12 days	n/a	3	3	3
	Corridor works - ground & track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**34**	**34**	**34**
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	2	2	2
	Corridor works - track support systems, communications and signalling	12 weeks	n/a	2	2	2
	Station work areas, demolition with breaker & saw	6 weeks	2 weeks /6 week possession	1	1	
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	2	2	2
	Bridge work areas, demolition	2 weeks/ possession	2 weeks/ possession	2	2	2
	Bridge work areas, demolition with breaker & saw	**2 weeks/ possession**	**2 weeks/ possession**	**39**	**39**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.



Location of highly noise affected residential receivers – Hurlstone Park and Canterbury

FIGURE 12.9

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.23. Given the assessment approach used, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction would be subject to this strategy.

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes. The key finding was that collectively the construction vehicles and buses required as part of the alternative transport arrangements would result in an increase of less than two dB on a majority of roads used for construction traffic.

The movement of construction traffic along the following streets would result an increase of more than two dB and result in road traffic noise levels that exceed the criteria at night:

- Garnet Street (between Canterbury Road and Hampden Street)
- Duntroon Street
- Crinan Street (between Melford Street & Dunstaffenage Street).

The introduction of buses as part of the alternate transport arrangements would not result in exceedances additional to those above.

Construction traffic volumes and routes (including rail replacement buses as part of the alternative transport arrangements outlined in the Temporary Transport Strategy) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Table 12.23 Activities which result in sleep disturbance exceedance in Hurlstone Park - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Hurlstone Park (NCA03)	Corridor works - ground and track, earthworks	10 weeks	3 days	60
	Corridor works - ground and track, trackform	12 days	n/a	34
	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	216
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	64
	Corridor works - track support systems, communications and signalling works	12 weeks	n/a	72
	Corridor works - track support systems, segregation fencing	6 weeks	n/a	46
	Station work areas, demolition	6 week	n/a	2
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	30
	Bridge work areas, demolition	2 weeks	n/a	23
	Bridge work areas, construction and installation	20 weeks	n/a	17

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings that may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 45 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Only one heritage listed building was identified in this assessment within the minimum offset distances for cosmetic damage as shown in Table 12.24.

Table 12.24 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA03	Hurlstone Park Railway Station	Commercial	Masonry (Brick)

Note: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.6 Canterbury (NCA04 and NCA05)

The Canterbury noise catchment areas (NCA04 and NCA05) are dominated by commercial premises north of the rail corridor and a mix of commercial and residential premises south of the rail corridor (as shown in Figure 12.1). The freight rail line runs on the northern edge of the rail corridor.

In NCA04, receivers on Canberra Street, Church Street and Hutton Street would be located near bridge works, while residential receivers on Hutton Street would also potentially be affected by substation works. Around Canterbury Station, track realignment and station works would be undertaken near commercial receivers and some residential receivers to the north.

In NCA05, receivers on South Parade and Wairoa Street would be located near bridge works on the southern side of the rail corridor, while receivers on South Parade would also potentially be affected by general work areas.

Predicted construction noise levels for the construction activities resulting in the highest number of 'highly noise affected' residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10, and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, trackform with ballast tamper
- **corridor works - track support systems, OHW modifications**
- corridor works - track support systems, communications and signalling works
- corridor works - track support systems, segregation fencing.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the Track Support Systems activities. While these works are not particularly noise intensive, they would be required along the length of corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - track support systems, OHW modifications. Figure 12.10 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB for the 21 per cent of affected receivers in this precinct, a much greater percentage of receivers are subject to lower levels of noise.

It is noted that the duration of these impacts at a particular receiver are likely to be relatively short as the works typically progress at a reasonably fast rate.

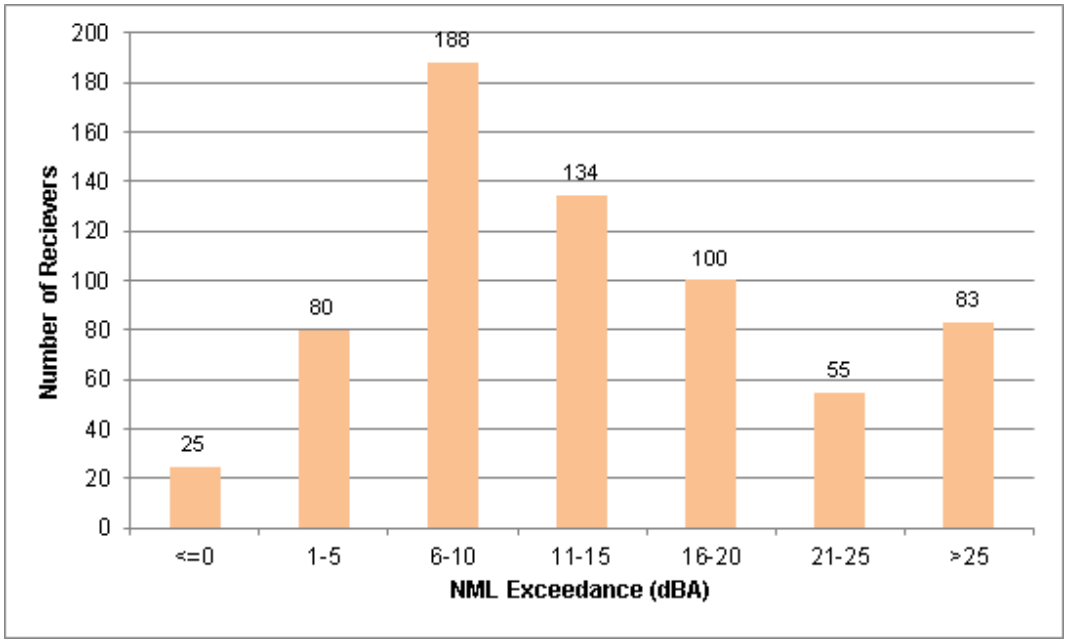


Figure 12.10 Number of night-time noise exceedances from corridor works - track support systems, overhead wiring modifications

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.25 shows the number of receivers within NCA04 and NCA05 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- General work areas, earthworks with breaker, where 30 receivers are predicted to be highly noise affected in NCA05 during the daytime only and would only be undertaken for about three days at any site. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist.

- Corridor works - ground and track, earthworks with breaker, where six receivers in NCA04 and one receiver in NCA05 are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Station work areas, demolition with breaker and saw, where eight receivers in NCA04 are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.
- Bridge work areas, demolition with breaker and saw, where 14 receivers in NCA04 and eight receivers in NCA05 are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.9 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

One commercial sensitive receiver is predicted to be subject to noise levels of 11 to 20 dB above NMLs during the higher noise generating activities, namely a café/bar at 208 Canterbury Road, Canterbury.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.26. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction would be subject to this strategy.

Table 12.25 Activities and durations which result in 'highly noise affected' residential receivers in Canterbury

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Canterbury (NCA04)	Corridor works - ground and track, earthworks	30 weeks	n/a	4	4	4
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**6**	**6**	
	Corridor works - ground & track, trackform	12 days	n/a	1	1	1
	Corridor works - ground & track, trackform with ballast tamper	4 days	Less than 4 days	5	5	5
	Station work areas, demolition with breaker & saw	**6 weeks**	**2 weeks /6 week possession**	**8**	**8**	
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	1	1	1
	Bridge work areas, demolition with breaker & saw	**2 weeks/ possession**	**2 weeks/ possession**	**14**	**14**	
Canterbury (NCA05)	**General work areas, earthworks with breaker**	**6 weeks**	**3 days**	**30**		
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**1**	**1**	
	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	1	1	1
	Bridge work areas, demolition with breaker and saw	**2 weeks/ possession**	**2 weeks/ possession**	**8**	**8**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.

Table 12.26 Activities which result in sleep disturbance exceedance in Canterbury - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Canterbury (NCA04 and NCA05)	Corridor works - ground and track, earthworks	10 weeks	3 days	11
	Corridor works - ground and track, trackform	12 days	n/a	6
	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	92
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	75
	Corridor works - track support systems, communications and signalling works	12 weeks	n/a	83
	Corridor works - track support systems, segregation fencing	6 weeks	n/a	38
	Station works, demolition	6 week	n/a	8
	Station works, concrete and structural works	8 weeks	n/a	2
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	17
	Bridge work areas, demolition	2 weeks	n/a	12
	Bridge work areas, construction and installation	20 weeks	n/a	6

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes. The key finding was that collectively, both the construction vehicles and buses required as part of the alternative transport arrangements would result in an increase of less than two dB on a majority of roads used for construction traffic.

The roads shown in Table 12.27 are predicted to experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria during the night-time (and day time at Close Street).

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Table 12.27 Road traffic noise from construction traffic and buses – Canterbury

Road	Construction traffic	Rail replacement buses	Construction traffic and rail replacement buses
Close Street	●		●
Broughton Street (between Canterbury Road & Robert Street)	●		●

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a number substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 23 buildings (including heritage-listed train stations) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage are listed in Table 12.28.

Table 12.28 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA04	Canterbury Station	Commercial	Masonry (Brick)
NCA04	2 Sugar House Road, Canterbury	Residential	Masonry
NCA04	193 Canterbury Road, Canterbury	Residential	Masonry (Brick)
NCA04	3 Broughton Street, Canterbury	Residential	Masonry (Brick)

Notes: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.7 Campsie (NCA06)

The Campsie noise catchment area (NCA06) is dominated by residential receivers (as shown in Figure 12.1) aside from areas surrounding the station along Beamish Street which comprise a mix of commercial and residential receivers. The freight rail line runs on the northern edge of the rail corridor through the station and diverts northward about mid-way between Campsie and Belmore stations.

Bridge works would be undertaken in the eastern and western ends of the noise catchment area near receivers on South Parade and Lilian Lane, while receivers on Lilian Lane would also be located near substation works. Around Campsie Station, track realignment and station works would be undertaken near a mix of commercial receivers and residential receivers.

Predicted construction noise levels for the construction activities resulting in the highest number of 'highly noise affected' residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However, out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- **corridor works - ground and track, trackform with ballast tamper**
- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities - OHW modifications and communications and signalling works. While these works are not particularly noise intensive, they would be required along the length of the corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.11 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB for the 26 per cent of receivers in this precinct, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

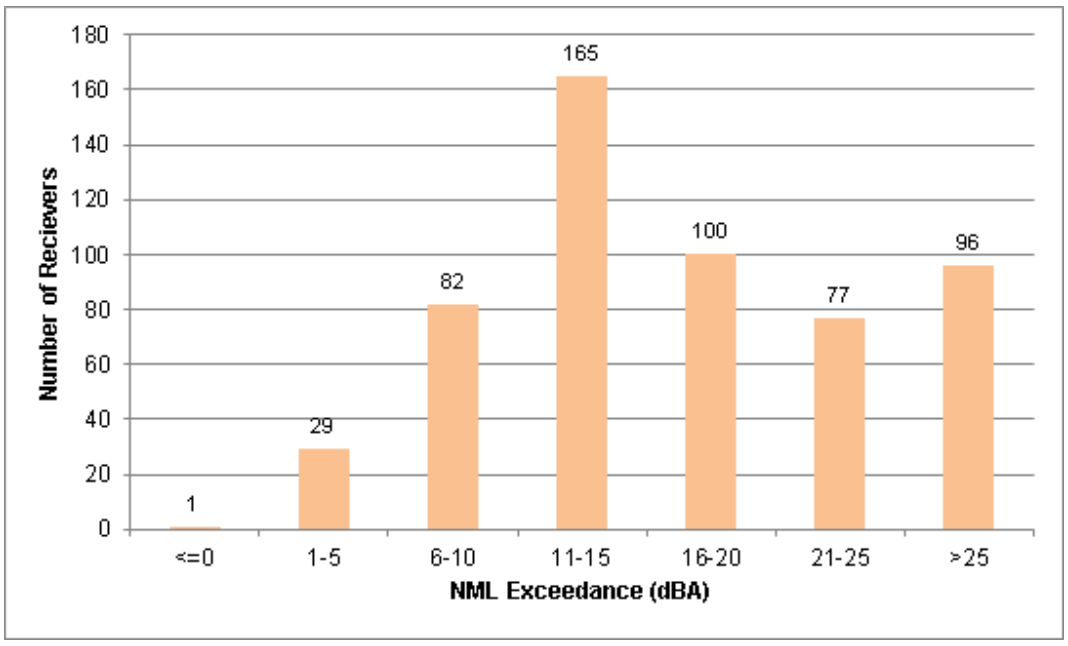


Figure 12.11 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.12 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to 11 per cent of affected receivers.

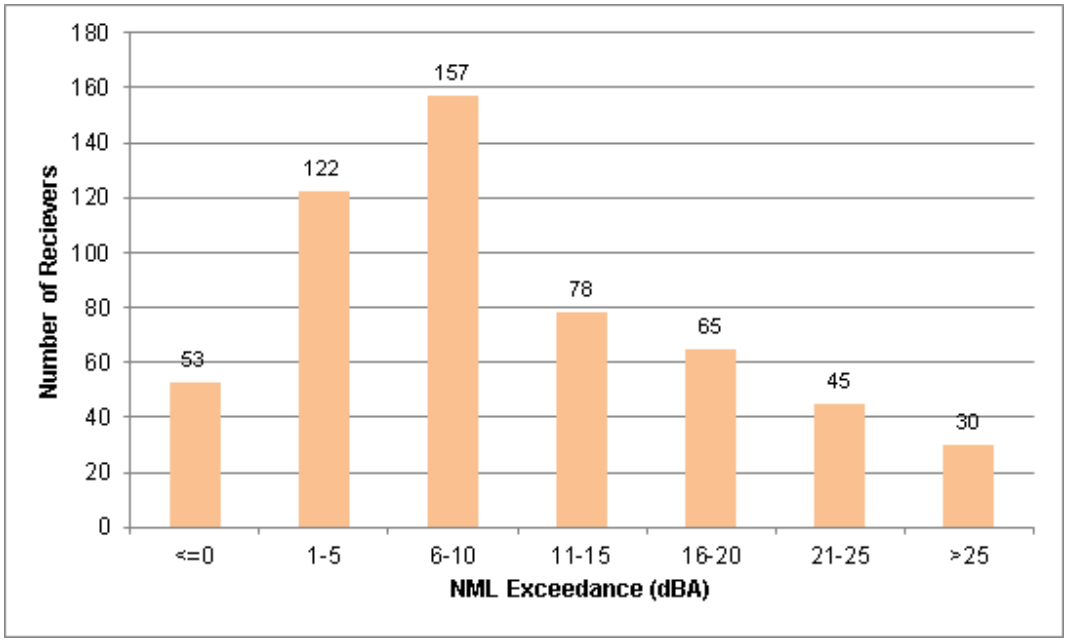


Figure 12.12 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected receivers

The ICNG considers residential receivers within NCA06 that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.29 shows the number of receivers predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

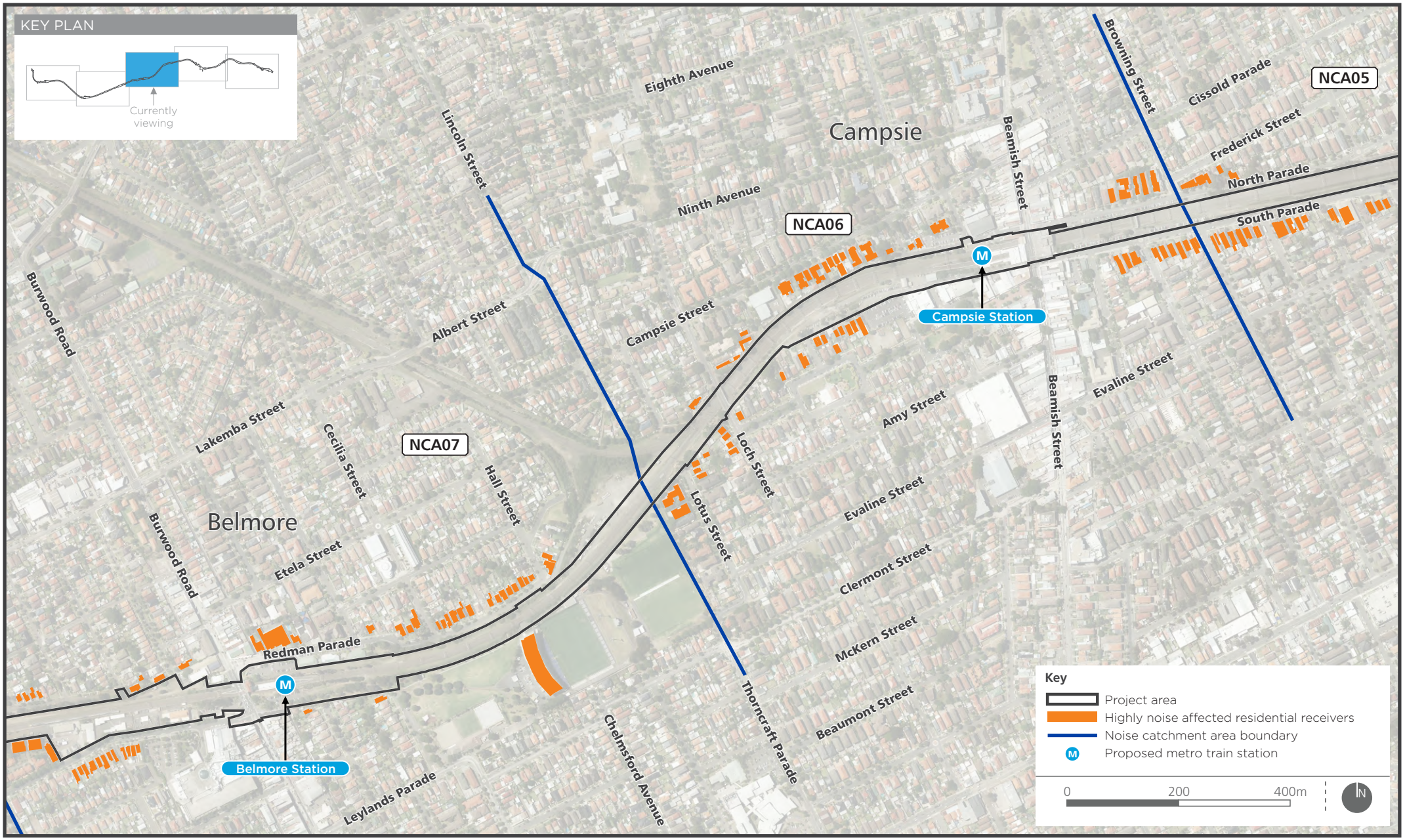
- General work areas, earthworks with breaker, where 26 receivers are predicted to be highly noise affected during the daytime only and would only be undertaken for about three days at any site. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist.
- Corridor works - ground and track, earthworks with breaker, where 37 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 23 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, this would reduce to two receivers being highly noise affected during this period.
- Station work areas, demolition with breaker and saw, where 13 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.
- Bridge work areas, demolition with breaker and saw, where 22 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.13 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.29 Activities and durations which result in 'highly noise affected' residential receivers in Campsie

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Campsie (NCA06)	General work areas, earthworks	6 weeks	n/a	1		
	General work areas, earthworks with breaker	**6 weeks**	**3 days**	**26**		
	General work areas, piling	6 weeks	2 weeks	1		
	Corridor works, ground and track, earthworks	30 weeks	n/a	6	6	6
	Corridor works, ground and track, earthworks with breaker	**10 weeks**	**3 days**	**37**	**37**	
	Corridor works, ground & track, trackform	12 days	n/a	2	2	2
	Corridor works, ground & track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**23**	**23**	**23**
	Corridor works, track support systems – OHW modifications	3 weeks	n/a	1	1	1
	Corridor works, track support systems – communications and signalling works	12 weeks	n/a	1	1	1
	Station work areas, demolition with breaker & saw	**6 weeks**	**2 weeks /6 week possession**	**13**	**13**	
	Bridge work areas , site establishment and impact protection	2 years	Intermittently during possessions	3	3	3
	Bridge work areas , demolition	2 years	2 weeks	1	1	1
	Bridge work areas , demolition with breaker & saw	**2 weeks/ possession**	**2 weeks/ possession**	**22**	**22**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.



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Location of highly noise affected residential receivers – Campsie and Belmore

FIGURE 12.13

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- Medical – 7 Duke Street, Campsie
- Place or worship – St John's Anglican Church, Campsie
- Childcare – 3 Harold Street, Campsie
- Childcare – Carrington Occasional Child Care Centre, 2 Carrington Street, Campsie.

Other sensitive receivers in this area which are predicted to be subject to noise levels of more than 20 dB above NMLs are:

- Childcare – 70 Campsie Street, Campsie
- Public building – Campsie Police Station.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.30. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction would be subject to this strategy.

Table 12.30 Activities which result in sleep disturbance exceedance in Campsie - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Campsie (NCA06)	Corridor works - ground and track, earthworks	10 weeks	3 days	46
	Corridor works - ground & track, trackform	12 days	n/a	13
	Corridor works - ground & track, trackform with ballast tamper	4 days	Less than 4 days	184
	Corridor works – track support systems – OHW modifications	3 weeks	n/a	20
	Corridor works – track support systems – communications and signalling works	12 weeks	n/a	40
	Corridor works – track support systems – segregation fencing	6 weeks	n/a	14
	Station work areas, demolition	6 week	n/a	13
	Station work areas, concrete and structural work	8 weeks	n/a	4
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	13
	Bridge work areas, demolition	2 weeks	n/a	6
	Bridge work areas, construction and installation	20 weeks	n/a	5

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes. The key finding was that collectively, both the construction vehicles and buses required as part of the alternative transport arrangements would result in an increase of less than two dB on a majority of roads used for construction traffic.

The operation of buses as part of the alternate transport arrangements is predicted to result in an increase of more than two dB and result in road traffic noise levels that exceed the criteria on Gould Street (between Canterbury Road and Redman Street) during the day time.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 29 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage are listed in Table 12.31.

Table 12.31 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA06	Campsie Station	Commercial	Masonry
NCA06	203 Beamish Street, Campsie	Commercial	Masonry (Brick/Rendered)

Note: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.8 Belmore (NCA07)

The Belmore noise catchment area (NCA07) is dominated by residential receivers north of the rail corridor. Between the rail corridor and Redman Parade, there are a number of other sensitive receivers, including commercial, north and south of the station along Burwood Road. A sports stadium is located south of the rail corridor and east of the station (as shown in Figure 12.1).

Track realignment works would be undertaken between the eastern and western ends of Belmore Station, near commercial and residential receivers. Station works at Belmore Station would also be undertaken near commercial and residential receivers. Receivers on Redman Parade, consisting of a mix of residential and other sensitive (sports stadium) uses, would be located near bridge works while residential receivers on Bridge Road and Lark Street would be in proximity to general works.

Predicted construction noise levels for the construction activities resulting in the highest number of highly noise affected residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended

standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- **corridor works - ground and track, trackform - ballast tamper**
- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the Track Support Systems activities. While these works are not particularly noise intensive, they would be required along the length of corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.14 indicates the distribution of exceedances during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB for 13 per cent of receivers in this precinct, a much greater percentage of receivers, in this precinct are subject to lower levels of noise.

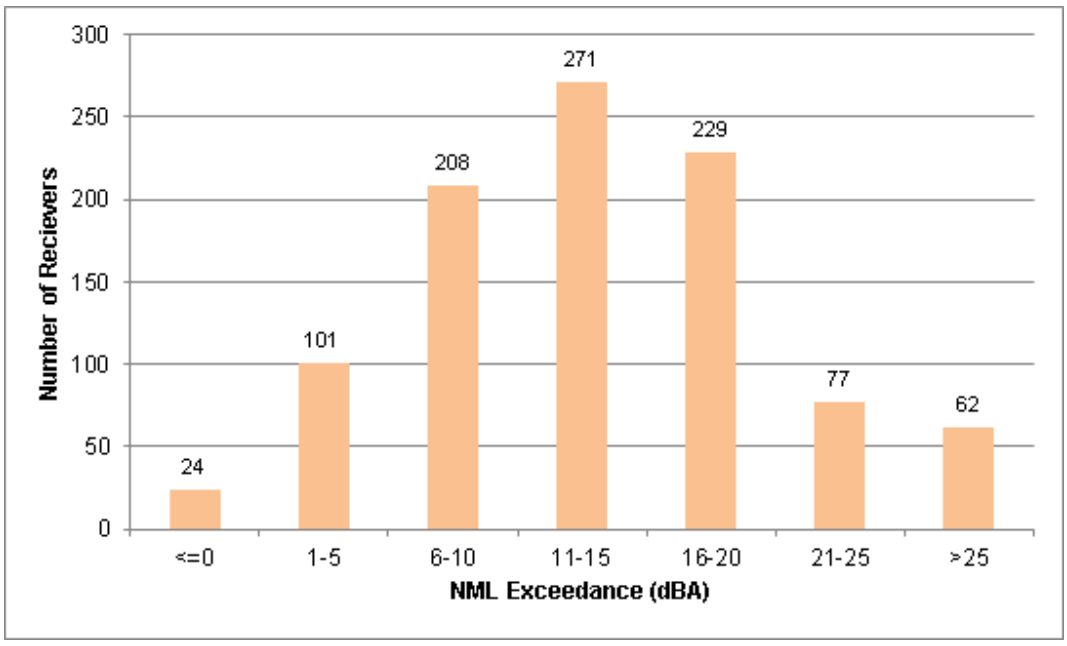


Figure 12.14 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.15 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to four per cent of affected receivers.

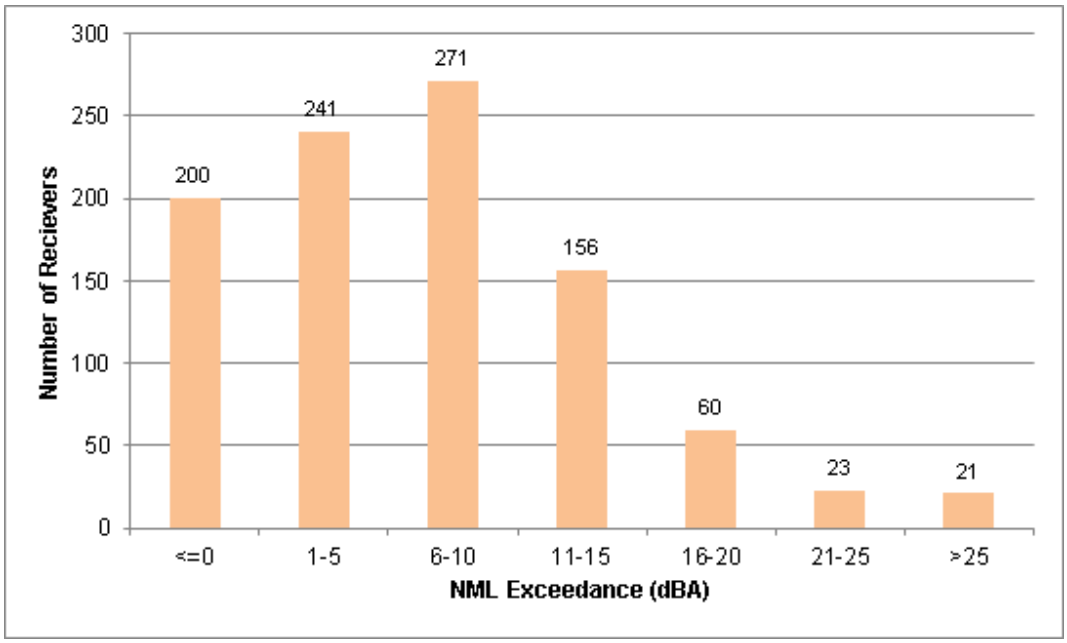


Figure 12.15 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.32 shows the number of receivers within NCA07 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- General work areas, earthworks with breaker, where 22 receivers are predicted to be highly noise affected during the daytime only and would only be undertaken for about three days at any site.
- Corridor works - ground and track, earthworks with breaker, where 23 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 12 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, no receivers would be highly noise affected during this period.
- Station work areas, demolition with breaker and saw, where eight receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.
- Bridge work areas, demolition with breaker and saw, where 10 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.13 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- educational – Montessori Preschool, 24 Redman Parade, Belmore
- childcare – Montessori Child Care, 24 Redman Parade, Belmore.

Table 12.32 Activities and durations which result in 'highly noise affected' residential receivers in Belmore

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Belmore (NCA07)	General work areas, earthworks	6 weeks	n/a	1		
	General work areas, earthworks with breaker	**6 weeks**	**3 days**	**22**		
	General work areas, piling	6 weeks	2 weeks	1		
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**23**	**23**	
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than four days**	**12**	**12**	**12**
	Station work areas, demolition	6 weeks	2 weeks/6 week possession	1	1	1
	Station work areas, demolition - breaker and saw	**6 weeks**	**2 weeks /6 week possession**	**8**	**8**	
	Station work areas, concrete and structural works	8 weeks	n/a	1	1	1
	Bridge work areas, demolition with breaker and saw	**2 weeks/ possession**	**2 weeks/ possession**	**10**	**10**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.

Other sensitive receivers which are predicted to experience noise levels of more than 20 dB above NMLs are:

- educational – 10 Redman Parade Belmore
- medical – 38-40 Redman Parade, Belmore
- childcare – 38 Redman Parade, Belmore
- public building – Belmore Community Centre.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.33. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes.

The assessment concluded that no roads in the precinct would experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Table 12.33 Activities which result in sleep disturbance exceedance in Belmore - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Belmore (NCA07)	Corridor works - ground and track, earthworks	10 weeks	3 days	28
	Corridor works - ground and track, trackform	12 days	n/a	8
	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	170
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	23
	Corridor works - track support systems, communications and signalling works	12 weeks	n/a	29
	Corridor works - track support systems, segregation fencing	6 weeks	n/a	9
	Station work areas, demolition	6 week	n/a	8
	Station work areas, concrete and structural works	8 weeks	n/a	2
	Station work areas, station installation and fitout	20 weeks	n/a	1
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	9
	Bridge work areas, demolition	2 weeks	n/a	7
	Bridge work areas, construction and installation	20 weeks	n/a	3

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would not become available following detailed design and construction planning. Recommended safe working distances have been used to conservatively estimate the number of dwellings that may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 41 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Only one heritage listed building was identified in this assessment within the minimum offset distances for cosmetic damage as shown in Table 12.34.

Table 12.34 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA07	Belmore Station	Commercial	Weatherboard

Note: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.9 Lakemba (NCA08)

The Lakemba noise catchment area (NCA08) is dominated by residential receivers with commercial areas both north and south of the station along Haldon Street (as shown in Figure 12.1).

Station and track realignment works about Lakemba Station would be undertaken near residential and commercial receivers on The Boulevarde and Railway Parade, while residential receivers on The Boulevarde would also be located near substation works to the east of the station.

Predicted construction noise levels for the construction activities resulting in the highest number of highly noise affected residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- corridor works - ground and track - trackform
- **corridor works - ground and track, trackform with ballast tamper.**

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.16 indicates the distribution of exceedances for this activity for receivers within this precinct during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB at seven per cent of receivers in this precent, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

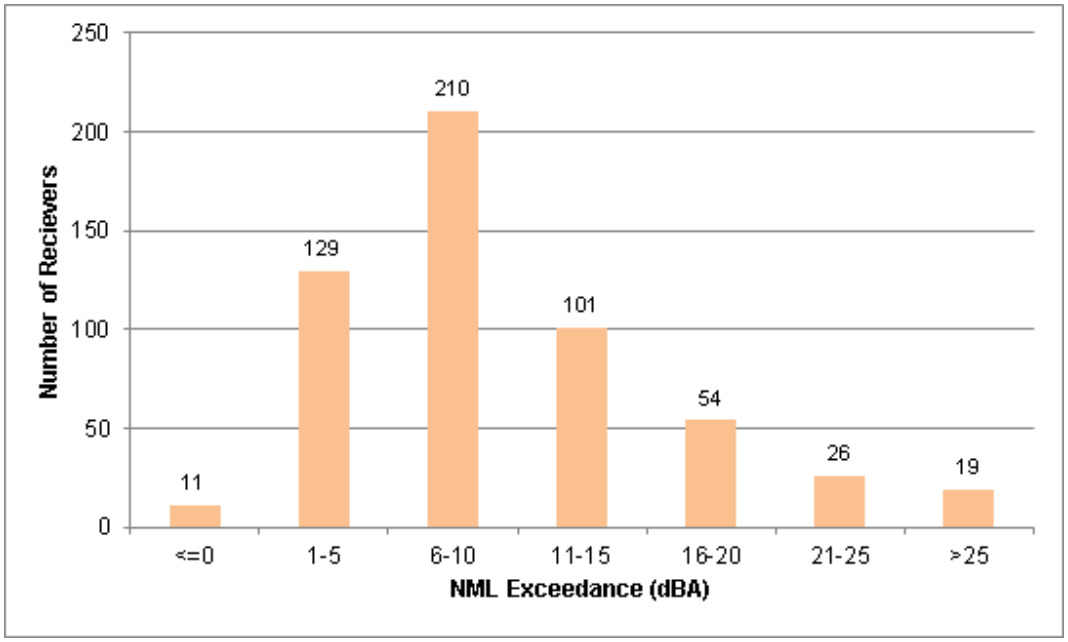


Figure 12.16 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.17 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to one per cent of affected receivers.

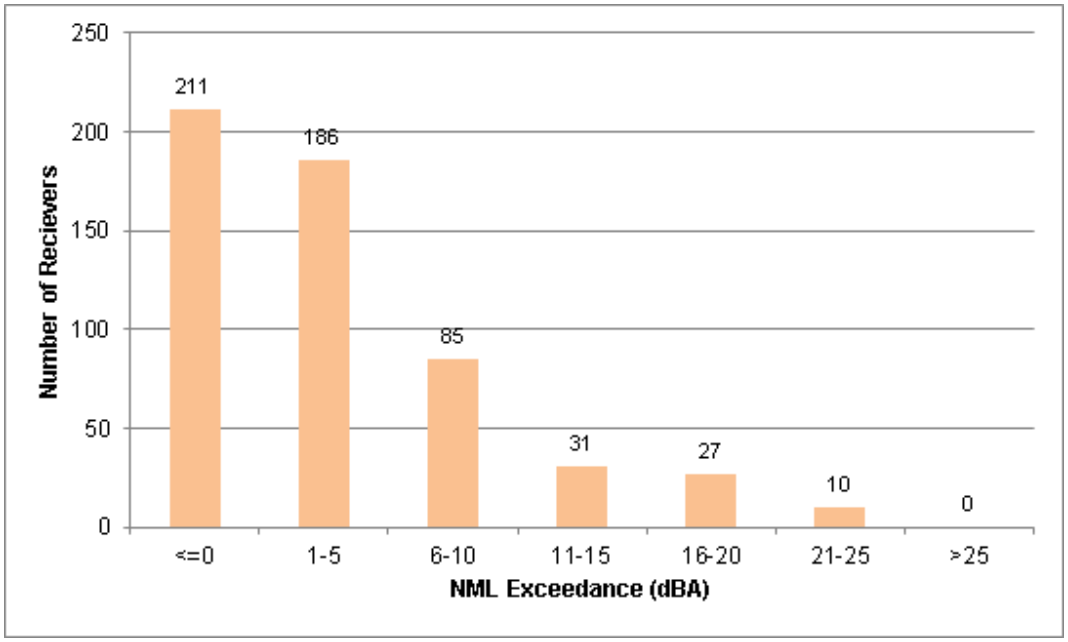


Figure 12.17 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.35 shows the number of receivers within NCA08 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

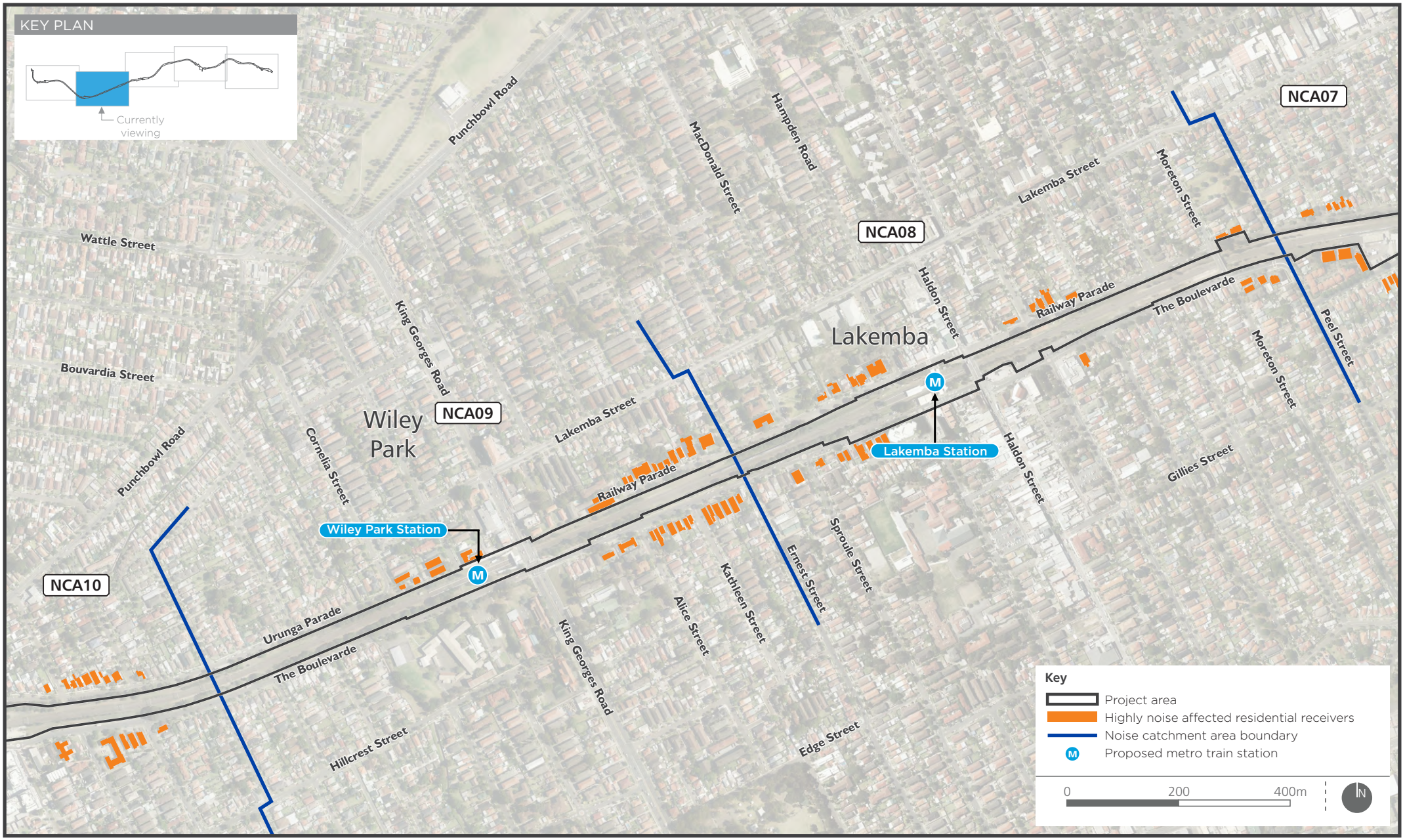
- Corridor works - ground and track, earthworks with breaker, where 19 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where four receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, no receivers would be highly noise affected during this period.
- Station work areas, demolition with breaker and saw, where eight receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.
- Bridge work areas, demolition with breaker and saw, where seven receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.18 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.35 Activities and durations which result in 'highly noise affected' residential receivers in Lakemba

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Lakemba (NCA08)	**Corridor works – ground and track, earthworks with breaker**	**10 weeks**	**3 days**	**19**	**19**	
	Corridor works – ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**4**	**4**	**4**
	Station work areas, demolition with breaker and saw	**6 weeks**	**2 weeks /6 week possession**	**8**	**8**	
	Bridge Work areas, demolition with breaker and saw	**2 weeks/ possession**	**2 weeks/ possession**	**7**	**7**	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.



Location of highly noise affected residential receivers – Lakemba and Wiley Park

FIGURE 12.18

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

One sensitive receiver is likely to experience exceedances of 11 to 20 dB above NMLs during the higher noise generating activities, namely a medical facility at 10 Bellevue Avenue, Lakemba.

Other sensitive receivers in this area which are predicted to be subject to noise levels of more than 20 dB above NMLs are:

- place of worship – Lakemba Uniting Church, 69 Haldon Street, Lakemba
- childcare – 27 Railway Parade, Lakemba
- childcare – 44 Railway Parade, Lakemba
- public building – Canterbury City Community Centre, 130 Railway Parade, Lakemba.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.36. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Table 12.36 Activities which result in sleep disturbance exceedance in Lakemba - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Lakemba (NCA08)	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	52
	Station work areas, demolition	6 week	n/a	1

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes

- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes.

The assessment concluded that no roads in the precinct would experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a substantial number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 36 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage are listed in Table 12.37.

Table 12.37 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA08	Lakemba Station	Commercial	Masonry (Brick)
NCA08	60 The Boulevarde, Lakemba	Commercial	Masonry (Brick)

Note: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.10 Wiley Park (NCA09)

The Wiley Park noise catchment area (NCA09) is dominated by residential receivers but with educational facilities south of the corridor along King Georges Road (as shown in Figure 12.1).

Station works about Wiley Park Station would be undertaken near residential, education and commercial receivers, while corridor works undertaken to the east of the station would be near residential receivers on The Boulevarde and Railway Parade.

Predicted construction noise levels for the construction activities resulting in the highest number of 'highly noise affected' residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However, out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- corridor works - ground and track, trackform with ballast tamper

- **corridor works - track support systems, OHW modifications**
- corridor works - track support systems, communications and signalling works
- corridor works - track support systems, segregation fencing.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities - OHW modifications and communications and signalling works. While these works are not particularly noise intensive, they would be required along the length of the corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - track support systems, overhead wiring modifications. Figure 12.19 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB at 15 per cent of affected receivers in this precinct, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

It is noted that the duration of these impacts at a particular receiver are likely to be relatively short as the works typically progress at a reasonably fast rate.

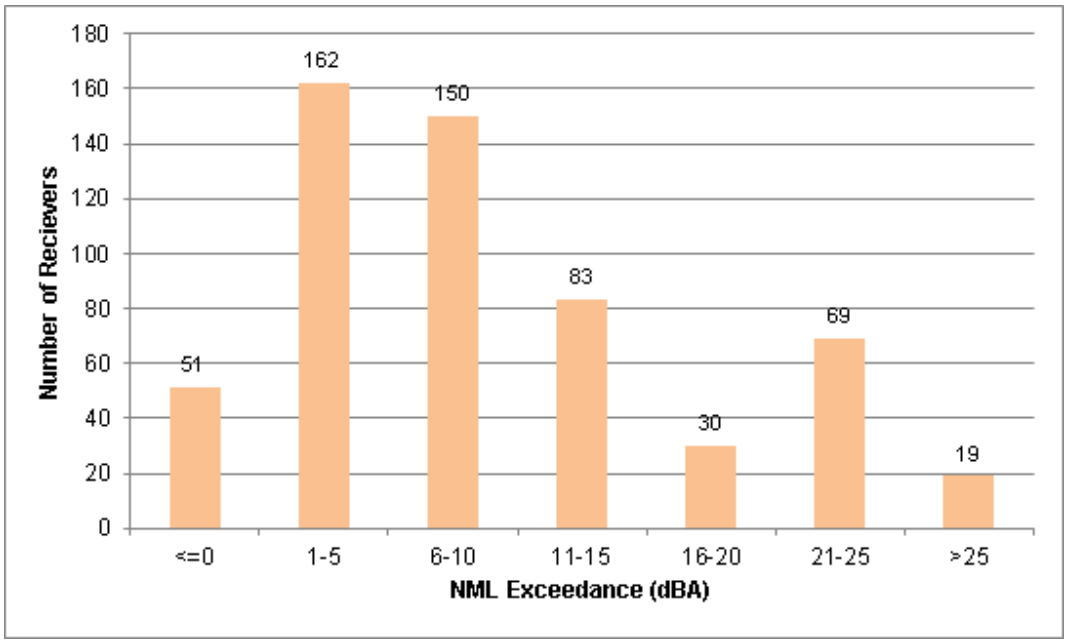


Figure 12.19 Number of night-time noise exceedances from corridor works - track support systems, overhead wiring modifications

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.38 shows the number of receivers within NCA09 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- Corridor works - ground and track, earthworks with breaker, where 27 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 12 receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, this would reduce to one receiver being highly noise affected during this period.
- Station work areas, demolition with breaker and saw, where seven receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.18 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11-20 dB above the NMLs during the higher noise generating activities are:

- educational – Wiley Park Girls High School (buildings shielded from the rail corridor)
- educational – Lakemba Public School.

One sensitive receiver, namely an educational facility – Wiley Park Girls High School (buildings fronting the rail corridor) is predicted to experience noise levels greater than 20 dB above the NMLs.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.39. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Table 12.38 Activities and durations which result in 'highly noise affected' residential receivers in Wiley Park

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use, where relevant	Number of residential receivers highly noise affected		
				Day	Eve	Night
Wiley Park (NCA09)	Corridor works - ground and track, earthworks	30 weeks	n/a	1	1	1
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**27**	**27**	
	Corridor works - ground and track, trackform	12 days	n/a	1	1	1
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**12**	**12**	**12**
	Station work areas, demolition	6 weeks	2 weeks/6 week possession	4	4	4
	Station work areas, demolition with breaker and saw	**6 weeks**	**2 weeks /6 week possession**	**7**	**7**	
	Station work areas, concrete and structural works	8 weeks	n/a	1	1	1

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.

Table 12.39 Activities which result in sleep disturbance exceedance in Wiley Park - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Wiley Park (NCA09)	Corridor works – ground and track, earthworks	30 weeks	n/a	27
	Corridor works – ground and track, trackform	12 days	n/a	2
	Corridor works – ground and track, trackform with ballast tamper	4 days	Less than 4 days	82
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	11
	Corridor works - track support systems, communications and signalling works	12 weeks	n/a	19
	Corridor works - track support systems, segregation fencing	6 weeks	n/a	4
	Station work areas, demolition	6 week	n/a	7
	Station work areas, concrete and structural works	8 weeks	n/a	4
	Station work areas, station installation and fitout	20 weeks	n/a	4

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes.

The assessment concluded that no roads in the precinct would experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 12 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or

other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Only one heritage listed building was identified in this assessment within the minimum offset distances for cosmetic damage as shown in Table 12.40.

Table 12.40 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA09	Wiley Park Station	Commercial	Weatherboard

Notes: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.11 Punchbowl (NCA10)

The Punchbowl noise catchment area (NCA10) is dominated by residential receivers with commercial premises in the vicinity and south of the station. As shown in Figure 12.1, west of the station (north of the rail corridor), there are a number of other sensitive receivers including education and child care.

Station and track realignment works about Punchbowl Station would be undertaken near residential receivers on Urunga Parade, The Boulevarde and South Terrace and near commercial receivers surrounding the station. General work areas would also be located near commercial and residential receivers on South Terrace and Punchbowl Road.

Predicted construction noise levels for the construction activities resulting in the highest number of 'highly noise affected' residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- **corridor works - ground and track, trackform with ballast tamper**
- corridor works - track support systems, OHW modifications
- corridor works - track support systems, communications and signalling works.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities. While these works are not particularly noise intensive, they would be required along the length of corridor in this precinct with many receivers potentially being affected.

The activity likely to result in the highest number of noise level exceedances during the night-time is corridor works - ground and track, trackform with ballast tamper. Figure 12.20 indicates the distribution of exceedances for this activity for receivers within this precinct during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB at six per cent of receivers in this precinct, a much greater percentage of receivers, in this precinct are subject to lower levels of noise.

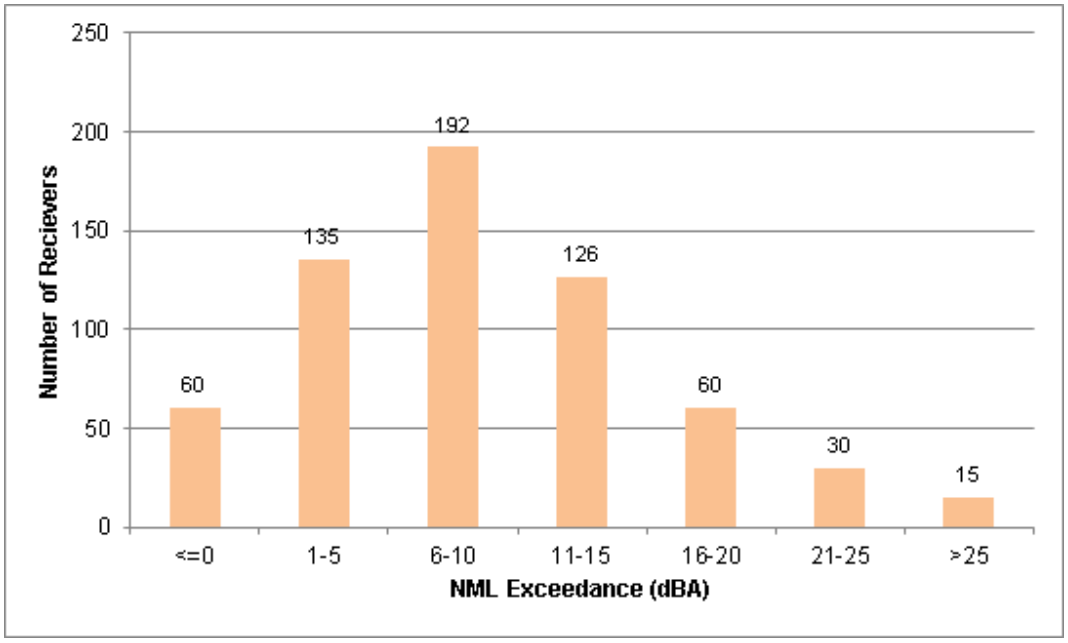


Figure 12.20 Number of night-time noise exceedances from corridor works, ground and track, trackform with ballast tamper

Figure 12.21 shows that when this noise intensive plant item (ballast tamper) is not in use, the number of exceedances greater than 20 dB above the noise management level reduces to about two per cent of noise affected receivers in the precinct.

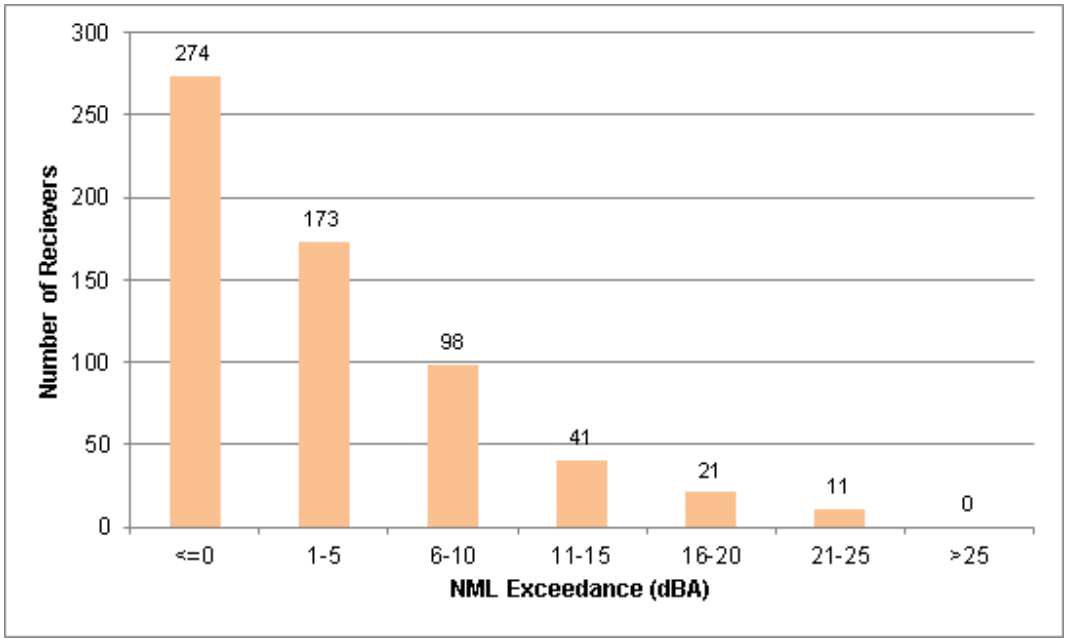


Figure 12.21 Number of night-time noise exceedances from corridor works, ground and track, trackform without ballast tamper

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.41 shows the number of receivers within NCA10 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

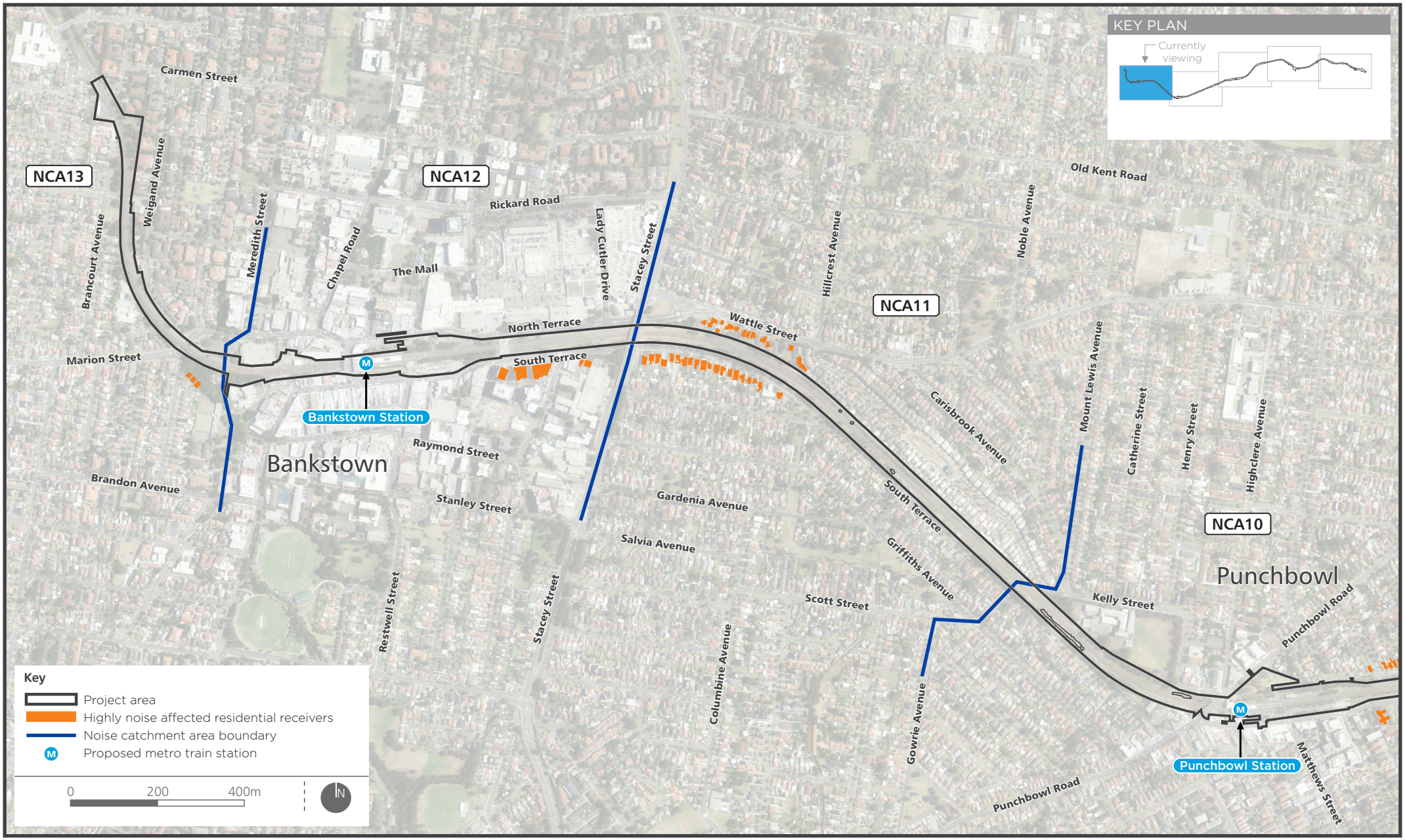
- Corridor works - ground and track, earthworks with breaker, where 15 receivers are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where seven receivers are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, no receivers would be highly noise affected during this period.

Figure 12.22 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.41 Activities and durations which result in 'highly noise affected' residential receivers in Punchbowl

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of residential receivers highly noise affected		
				Day	Eve	Night
Punchbowl (NCA10)	**Corridor works - ground and track, earthworks with breaker**	**6 weeks**	**3 days**	**15**	**15**	
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**7**	**7**	**7**
	Station work areas, demolition - breaker and saw	6 weeks	2 weeks /6 week possession	1	1	

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.



Location of highly noise affected residential receivers – Punchbowl and Bankstown

FIGURE 12.22

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- educational – Punchbowl Boys High School (buildings shielded from the rail corridor)
- educational – Church of Jesus Christ of Latter Day Saints
- childcare – Long Day Pre-School, 21 Dudley Street, Punchbowl.

Other sensitive receivers in this area which are predicted to be subject to noise levels of more than 20 dB above NMLs are:

- educational – Punchbowl Boys High School (buildings fronting the rail corridor)
- medical – 15 South Terrace, Punchbowl
- childcare – Baby Health Centre, 748 Punchbowl Road, Punchbowl
- childcare – Breust Place, Punchbowl.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.42. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Table 12.42 Activities which result in sleep disturbance exceedance in Punchbowl - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Punchbowl (NCA10)	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	50

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes.

The assessment concluded that no roads in the precinct would experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation could include alternate traffic routes or reducing the maximum number of movements.

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There are predicted to be a number of buildings within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have therefore been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 25 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or

other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Heritage buildings and structures

Heritage buildings would be considered on a case by case basis, with detailed inspections and condition assessments of potentially affected heritage structures undertaken to determine sensitivity prior to the commencement of works. Only one heritage listed building was identified in this assessment within the minimum offset distances for cosmetic damage as shown in Table 12.43.

Table 12.43 Heritage buildings and structures within the minimum recommended offset to avoid cosmetic damage

NCA	Item/ address	Building occupancy	Construction type
NCA10	Punchbowl Station	Commercial	Weatherboard

Note: Estimated from photographic information only. The inclusion of items is not a reflection of the heritage significance of the item. Refer to the Technical paper 3 for further discussion of heritage items. Some items listed above may contain more than one building or structure.

The construction fabric of the building (i.e. timber, masonry) and the structural integrity of these buildings would be confirmed during detailed design. If the building is considered structurally unsound or more susceptible to damage, a more stringent 2.5 mm/s vibration criteria would be applied for works in the vicinity of these buildings.

Measures to minimise the potential for vibration impacts are provided in Section 12.6.

12.5.12 Bankstown (NCA11, NCA12 and NCA13)

The Bankstown noise catchment areas (NCA11 and NCA13) are dominated by residential receivers (as shown in Figure 12.1). NCA12 which relates to the precinct immediately surrounding Bankstown Station is dominated by commercial premises and other sensitive receivers south of the rail corridor and east of the station.

Bridge and corridor works would be undertaken in the north of NCA11 near residential receivers on South Terrace and Wattle Street, while substation works in the south would be undertaken directly adjacent to residential receivers on South Terrace.

Station and corridor works would be undertaken throughout NCA12 and would predominantly be undertaken near commercial receivers located adjacent to the corridor, with some residential receivers on South Terrace also potentially affected.

With the exception of corridor works being undertaken in the eastern end of the catchment adjacent to commercial and residential receivers on Olympic Parade, minimal construction works are proposed in NCA13.

Predicted construction noise levels for the construction activities resulting in the highest number of ‘highly noise affected’ residential receivers during out of hours construction work are discussed below. Noise levels at residential receivers during out of hours construction activities have been

selected as they represent a higher sensitivity relative to noise generated during recommended standard hours. Noise level predictions during other time periods and other receiver classifications are provided in Table 12.9, Table 12.10 and Table 12.11.

Noise level exceedances during out of hours works

It is likely that construction activities will need to be undertaken outside of recommended standard hours (out of hours works) during possessions/closedowns of the rail corridor. However out of hours works are expected to be largely undertaken during possessions/closedowns of the rail corridor.

During out of hours construction works, the highest number of night-time noise level exceedances are predicted during the following activities, with the activity generating the highest number of exceedances during the night-time shown in bold:

- corridor works - ground and track, earthworks
- corridor works - ground and track, trackform with ballast tamper
- **corridor works - track support systems, OHW modifications**
- corridor works - track support systems, communications and signalling works
- corridor works - track support systems, segregation fencing.

Ballast tamping would be scheduled where reasonable and feasible during standard day time and evening hours however despite efforts to avoid this, there may be circumstances when these works must occur, for technical reasons, during night-time periods. This item of plant can produce relatively high noise levels, however the works typically progress at a reasonably fast rate, with individual receivers only likely to be affected for a short duration (i.e. up to four days).

Relatively large numbers of receivers are predicted to be affected during the track support systems activities. While these works are not particularly noise intensive, they would be required along the length of corridor in this precinct with many receivers potentially being affected.

The activity with potential for the highest number of noise level exceedances during the night-time is corridor works - track support systems, OHW modifications. Figure 12.23 indicates the distribution of exceedances for this activity during the night-time.

The graph shows that while the activity may result in exceedance of the night-time NMLs greater than 20 dB at 11 per cent of receivers in this precinct, a much greater percentage of receivers in this precinct are subject to lower levels of noise.

It is noted that the duration of these impacts at a particular receiver are likely to be relatively short as the works typically progress at a reasonably fast rate.

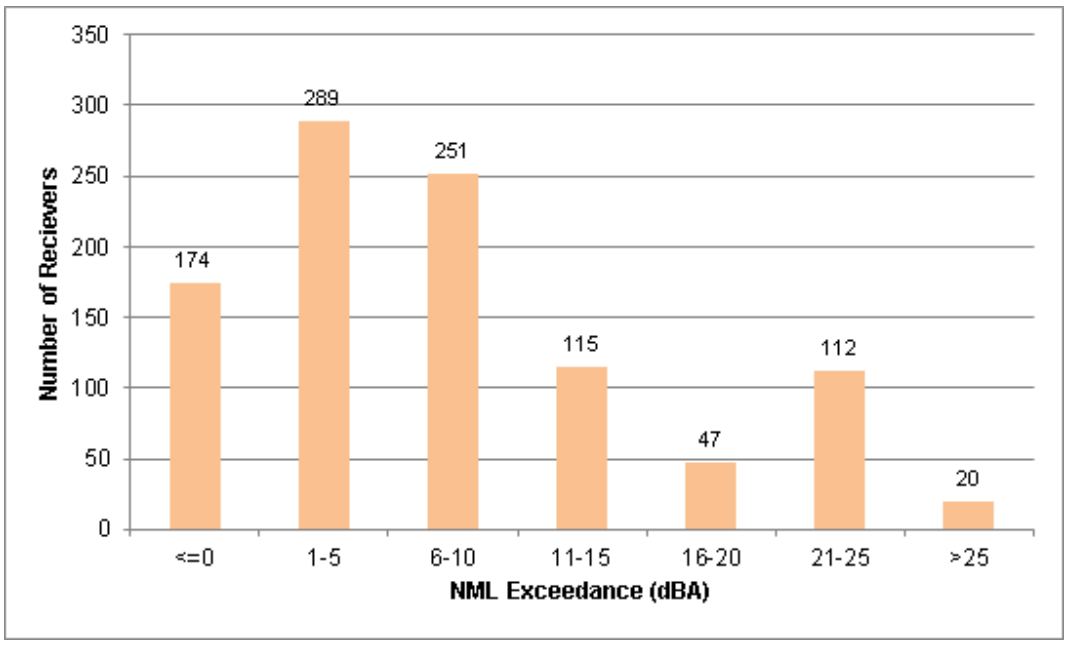


Figure 12.23 Number of night-time noise exceedances from corridor works - track support systems, overhead wiring modifications

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be highly noise affected.

Table 12.44 shows the number of receivers within NCA11, NCA12 and NCA13 predicted to be highly noise affected in this catchment during certain works activities. The highest numbers are apparent during the following activities:

- Corridor works - ground and track, earthworks with breaker, where 32 receivers in NCA11 are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist and would only be undertaken for about three days at any site.
- Corridor works - ground and track, trackform with ballast tamper, where 19 receivers in NCA11, three receivers in NCA12 and two receivers in NCA13 are predicted to be highly noise affected during the daytime, evening and night-time periods. If the ballast tamper were to not be used during the night-time, no receivers would be highly noise affected during this period.
- Bridge work areas, demolition - breaker and saw, where 30 receivers in NCA11 are predicted to be highly noise affected during the daytime and evening. The use of hydraulic breakers would generally be limited to day time and evening periods (between 7am and 10pm), unless technical constraints exist. Demolition works will only occur for a total duration of about two weeks during these possessions.

Figure 12.22 shows the location of residential receivers which are predicted to experience exceedances of the highly noise affected criteria.

Table 12.44 Activities and durations which result in 'highly noise affected' residential receivers in Bankstown

Station (NCA no.)	Construction activities resulting in exceedances above highly noise affected criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of residential receivers highly noise affected		
				Day	Eve	Night
Bankstown (NCA11)	General work areas, earthworks with breaker	6 weeks	3 days	1		
	Corridor works - ground and track, earthworks	30 weeks	n/a	1	1	1
	Corridor works - ground and track, earthworks with breaker	**10 weeks**	**3 days**	**32**	**32**	
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**19**	**19**	**19**
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	1	1	1
	Bridge work areas, demolition with breaker and saw	**2 weeks/ possession**	**2 weeks/ possession**	**30**	**30**	
Bankstown (NCA12)	General work areas, earthworks with breaker	6 weeks	3 days	5		
	Corridor works - ground and track, earthworks with breaker	10 weeks	3 days	5	5	
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**3**	**3**	**3**
	Station work areas, demolition with breaker and saw	6 weeks	2 weeks /6 week possession	2	2	
Bankstown (NCA13)	Corridor works - ground and track, earthworks with breaker	10 weeks	3 days	3	3	
	Corridor works - ground and track, trackform with ballast tamper	**4 days**	**Less than 4 days**	**2**	**2**	**2**

Note: Bold indicates the activities predicted to generate the largest number of highly noise affected receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have also been assessed against the relevant criteria.

The other sensitive receivers in this precinct are predicted to generally be subject to relatively minor impacts with many receiver types and works activities not resulting in exceedances of the NMLs.

Sensitive receivers which are predicted to be subject to exceedances of 11 to 20 dB above the NMLs during the higher noise generating activities are:

- educational – Al Amanah College, 4 Winspear Avenue, Bankstown
- place of worship – St Euphemia Greek Orthodox Church, 6 East Terrace, Bankstown
- childcare – Roly Poly Education Child Care, 9 East Terrace, Bankstown
- café/bar – three receivers on Bankstown City Plaza, Bankstown.

Other sensitive receivers in this area which are predicted to be subject to noise levels of more than 20 dB above NMLs are:

- educational – Bankstown Arts Centre, 5 Olympic Parade, Bankstown
- café/bar – three receivers on Chapel Road, Bankstown.

Sleep disturbance

Based on the preliminary list of plant and construction activities used in this assessment, exceedance of the sleep disturbance criteria is predicted to occur in each NCA during night works. A detailed breakdown for each time period is provided in Technical paper 2 and a summary shown in Table 12.45. Given the assessment approach, these impacts are considered to represent a conservative estimate of the likely impact.

The Sydney Metro Construction Noise and Vibration Strategy contains further details relating to potential sleep disturbance impacts. The strategy contains mitigation measures and procedures to address levels of adverse impact greater than 30 dB above the relevant criteria including periods of respite and alternative accommodation in specific circumstances and on a case by case basis. Construction of the project would be subject to this strategy.

Construction traffic noise

The project would result in two sources of potential traffic noise:

- construction vehicles such as heavy and light vehicles moving to and from construction compounds and work areas along identified haulage routes
- buses due to the alternative transport arrangements outlined in the Temporary Transport Strategy to service the T3 Bankstown Line during possession periods.

A construction traffic noise assessment was undertaken including the cumulative impact of both of these potential noise sources where they would share the same routes.

The assessment concluded that no roads in the precinct would experience an increase of more than two dB and result in road traffic noise levels that exceed the criteria.

Construction traffic volumes and routes (including rail replacement buses) would be reviewed and confirmed during subsequent stages of the project to determine if additional mitigation is required. Where compliance with the criteria is unable to be achieved, reasonable and feasible noise mitigation would be considered. Mitigation of could include alternate traffic routes or reducing the maximum number of movements.

Table 12.45 Activities which result in sleep disturbance exceedance in Bankstown - all receivers

Station (NCA no.)	Construction activities resulting in exceedances of sleep disturbance criteria	Indicative total duration of construction activity	Indicative total duration of noise intensive plant use	Number of exceedances greater than 20 dB
Bankstown (NCA11, NCA12, and NCA13)	Corridor works - ground and track, earthworks	30 weeks	n/a	21
	Corridor works - ground and track, trackform	12 days	n/a	1
	Corridor works - ground and track, trackform with ballast tamper	4 days	Less than 4 days	102
	Corridor works - track support systems, OHW modifications	3 weeks	n/a	16
	Corridor works - track support systems, communications and signalling works	12 weeks	n/a	20
	Corridor works - track support systems, segregation fencing	6 weeks	n/a	5
	Bridge work areas, site establishment and impact protection	2 weeks	n/a	2
	Bridge work areas, demolition	2 weeks	n/a	1

Vibration

Amenity

Large hydraulic breakers would have the highest potential to result in vibration levels above the amenity criteria. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels, occurring over shorter periods are likely to be tolerable. Project-specific information regarding the duration of construction activities and equipment would become available following detailed design and construction planning. Recommended safe working distances have therefore been used to conservatively estimate the number of dwellings which may experience vibration affecting human comfort.

There would be a number of buildings located within the minimum working distance of a large hydraulic breaker used at the edge of the work area. Receivers adjacent to the construction areas have been identified as likely to notice vibration impacts at times during construction works. This is expected to be primarily due to works associated with large hydraulic breakers but also other high vibration plant items. In practice, vibration impacts from most construction activities would be intermittent over the duration of construction, and more refined construction planning would seek to further reduce this impact.

Where vibration-intensive works need to be undertaken within the recommended minimum working distances, measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Cosmetic damage

The minimum recommended offset between the construction works and the nearest sensitive receivers are expected to be generally sufficient such that buildings are unlikely to experience cosmetic damage from the use of most construction equipment. However, there may be some instances where large hydraulic breakers would be required to be within the recommended minimum distances.

Up to 35 buildings (including the heritage-listed station) would be located within the minimum recommended offset based on the cosmetic criteria of 7.5 mm/s. This is considered to be a conservative estimate, as a hydraulic breaker would not be required in all locations, and would not necessarily be used at the edge of the construction area. Should the use of hydraulic breakers (or other vibration intensive plant) in these locations be unavoidable, alternative construction methods or other mitigation measures would be considered to minimise potential vibration effects.

During detailed design and construction planning, the use of vibration intensive plant would be reviewed to limit the potential for damage. Where vibration intensive works are required to be undertaken within the recommended safe working distances, vibration monitoring would be undertaken to ensure acceptable levels of vibration are not exceeded.

Where vibration-intensive works need to be undertaken within the recommended minimum offsets (refer to Table 12.6), measures including monitoring would be undertaken in line with the Construction Noise and Vibration Strategy (refer to Appendix E).

Table 12.46 Number of buildings within the minimum recommended offset from a hydraulic breaker to avoid cosmetic damage

Noise catchment area	Number of buildings within minimum working distance
NCA11	3
NCA12	32
NCA13	0
Total	**35**

Heritage buildings and structures

There are no heritage listed buildings identified in this assessment within the minimum offset distances for cosmetic damage within NCA11, NCA12, or NCA13.

12.5.13 Traction power supply cable

The project includes the construction of a new underground, traction power ('feeder') cable. The preliminary cable route would traverse South Parade at Campsie, along Phillips Avenue and Fore Street (crossing Canterbury Road), Burlington Street, Karool Avenue/River Street and Mooney Avenue to Ausgrid's Canterbury substation. The exact location of the cable within the roadways is subject to detailed design, however the works would likely be undertaken using typical construction equipment including 12 tonne excavator, truck and trailer, concrete saws and hydraulic breakers where necessary. The crossing of Canterbury Road would likely be undertaken at night to reduce impacts on traffic. The section along Karool Avenue/ River Street may require underboring or horizontal directional drilling due to the substantial changes in the ground level.

Table 12.47 shows the predicted noise levels at various distances from the works. The table shows that the highest noise levels at receivers within 15 metres of the project area (which is considered representative for most receivers along the cable route) would be in the vicinity of 85 dBA. If these works were undertaken during the night, noise levels may be greater than 30 dB above the noise management level if noise intensive plant items are used. It is proposed however that use of hydraulic breakers would not occur during the night-time period and where possible, their use during the evening period would also be avoided unless technical constraints exist.

Table 12.47 Predicted noise levels from traction power cable works

	Predicted noise level at distance LAeq(15minute) (dBA)			
Scenario/ activity	**10 m**	**15 m**	**30 m**	**50 m**
Excavation	88	85	82	77
Drilling	70	67	63	59
Cable laying	72	70	66	62
Cleaning	73	70	67	62

The results indicate that relatively high noise levels are likely where noise intensive plant items are used near to adjacent receivers, particularly during excavation activities. On typical streets surrounding the work areas, the closest residential receivers are likely to be situated about 15 metres from the road. In this situation, noise levels around 85 dBA are possible when noise intensive plant items are in use.

The work activities would be sequential at any one point and would progress relatively quickly from one end of the alignment to the other. The only exception would be the Canterbury Road crossing and the Karool Avenue/ River Street locations where the work activities or other constraints would likely require a longer presence in the order of a one month. Otherwise, the noise levels at other locations are unlikely to be sustained for more than a few days before the work advances.

12.5.14 Cumulative impacts

The study area is undergoing a large amount of development, including construction of the adjacent Chatswood to Sydenham project, the WestConnex project and individual urban renewal projects.

There is potential for cumulative construction noise impacts to occur in Marrickville, at the interface between the Chatswood to Sydenham project and the project (the Sydenham to Bankstown upgrade). These two projects are proposed to be undertaken over similar timeframes and potential

impacts would be similar in nature to those already ongoing in the Marrickville area in relation to the Chatswood to Sydenham project.

WestConnex is more remote from the project area, and construction noise levels are unlikely to increase the noise levels experienced in the project area.

Depending on the timing and location of future urban renewal, there is potential for airborne noise to be cumulative at specific locations. Such impacts are unable to be predicted due to the unknown nature and timing of these future urban renewal projects, and therefore the nature, location and timing of potential cumulative effects is unknown.

Cumulative impacts may also include potential increases in road traffic noise levels, due to an increase of construction vehicles on the road network. The haulage routes to be used by the project are also potentially required to be used for a number of other projects (including WestConnex and Chatswood to Sydenham) which require a much larger number of vehicle movements.

Measures to avoid, reduce or mitigate construction noise and vibration impacts to heritage items are provided in Section 12.6. These would reduce the likelihood and severity of cumulative impacts.

Co-ordination between the Sydney Metro projects would be facilitated by Traffic and Transport Liaison Group and more broadly, by the Roads and Maritime Transport Management Centre.

12.6 Mitigation measures

12.6.1 Approach to mitigation and management

Construction Noise and Vibration Strategy

The Construction Noise and Vibration Strategy (Appendix E) has been developed to manage construction noise and vibration for the Sydney Metro City & Southwest project as a whole. The strategy provides a framework for managing construction noise and vibration impacts in accordance with the ICNG, to provide a consistent approach to management and mitigation across all Sydney Metro projects.

Specifically, the Construction Noise and Vibration Strategy identifies the requirements and methodology to develop construction noise impact statements. These would be prepared prior to specific construction activities and based on a more detailed understanding of the construction methods, including the size and type of construction equipment and the expected duration and timing of works. Construction noise impact statements would include confirmation of the classification of sensitive receivers, including particularly sensitive receivers such as education and child care, and vibration sensitive medical, imaging, and scientific equipment, as well as heritage buildings. Also, the façade performance of some residential premises which may have been fitted with acoustic insulation to control aircraft noise.

The statements would also include:

- application of appropriate noise and vibration criteria for each receiver type
- an assessment of the potential noise and vibration impacts as a result of different construction activities proposed as well as potentially overlapping activities
- details of the standard and project-specific noise and vibration mitigation measures identified
- noise and vibration auditing and monitoring requirements
- additional mitigation measures to be implemented when exceedances to the NMLs are likely to occur following detailed construction planning and confirmation of noise impacts.

Mitigation measures to be included in the noise impact stations would be aimed at pro-active engagement with potentially affected receivers and may include provision of respite periods, and alternative accommodation for defined exceedance categories.

Where vibration levels are predicted to exceed the screening criteria, the Construction Noise and Vibration Strategy provides for a more detailed assessment of the structure and vibration monitoring, to ensure vibration levels remain below appropriate limits for that structure. For heritage structures, condition assessments would be undertaken and more stringent levels may be applied, taking in account the heritage values of the structure as part of the more detailed assessment completed.

Out of hours work framework

As described in Chapter 9, an Out Of Hours Work Strategy would be developed to guide the assessment, management, and approval of works outside the recommended standard hours. The strategy would be developed to ensure that out of hours works are managed effectively during construction, and to avoid incidents and impacts to the community as a result of out of hours works.

The strategy would be prepared in consultation with key stakeholders (including the EPA).

Further information on the Out of Hours Work Strategy and the criteria for out of hours work is provided in Section 9.7.4.

12.6.2 List of mitigation measures

The mitigation measures that would be implemented to address potential construction noise and vibration impacts are listed in Table 12.48.

Table 12.48 Mitigation measures – construction noise and vibration

ID	Impact/issue	Mitigation measures	Relevant location(s)
Design/pre-construction			
NVC1	Noise impacts	A construction noise and vibration review would be undertaken during detailed design. This would include noise modelling to confirm the results of modelling previously undertaken. Where changes in noise levels and exceedances are modelled, reasonable and feasible mitigation measures would be reviewed.	All
NVC2		In accordance with the *Construction Noise and Vibration Strategy*, all employees, contractors and subcontractors would receive an environmental induction. The induction must at least include: • relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • designated loading/unloading areas and procedures • site opening/closing times (including deliveries)	All
NVC3	Predicted vibration impacts	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure would be carried out to determine the appropriate vibration limits for that structure.	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
NVC4		For heritage items where screening vibration levels are predicted to be exceeded, the more detailed assessment would include condition assessment and specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	Heritage items along the project area
Construction			
NVC5	Construction noise and vibration management	The *Construction Noise and Vibration Strategy* would be implemented with the aim of achieving the noise management levels where feasible and reasonable. This may include the following example mitigation measures alone or in combination, where feasible and reasonable: • The provision of noise barriers around each construction site. • The coincidence of noisy plant working simultaneously close together would be avoided. • Offset distances between noisy plant and sensitive receivers would be increased. • Residential grade mufflers would be fitted to all mobile plant. • Dampened rock hammers would be used. • Non-tonal reversing alarms would be fitted to all permanent mobile plant. • High noise generating activities would be scheduled for less sensitive periods considering the nearby receivers, where reasonable and feasible. • The layout of construction sites would consider opportunities to shield receivers from noise. • Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. • Loading and unloading of materials/deliveries is to occur as far as possible from noise sensitive receivers. • Select site access points and roads as far as possible away from noise sensitive receivers. • Dedicated loading/unloading areas to be shielded if close to NSRs wherever feasible and reasonable. • Use quieter and less vibration emitting construction methods where feasible and reasonable. • The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in the *Construction Noise and Vibration Strategy.* • Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. • Where feasible and reasonable, the offset distance between noisy plant items and nearby noise sensitive receivers would be as great as possible. • Where reasonable and feasible heavy vehicle movements would be limited to daytime and evening hours, with night-time movements avoided where possible. • Active community consultation and the maintenance of positive, cooperative relationships with schools, local residents and building owners and occupiers, through: – periodic notification or work activities and progress (eg regular letterbox drops, e-consult) – specific notification (letter-box drop) prior to especially noisy activities – comprehensive website information – Project information and construction response telephone line	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
		– email distribution lists.	
NVC6		Ballast tamping and hydraulic breaking would not be undertaken during the night-time period (10pm to 7am). Other noise intensive construction activities such as platform demolition, earthworks and track works would generally be limited to day time and evening periods (between 7am and 10pm), unless constraints exist such as: • works requiring a rail shutdown • requirements of road authorities, emergency services or Sydney Coordination Office.	All
NVC7		When working adjacent to schools, medical facilities and childcare centres, particularly noisy activities would be scheduled outside normal working hours, where reasonable and feasible.	All
NVC8		When working adjacent to churches and places of worship, particularly noisy activities would be scheduled outside services, where reasonable and feasible.	All
NVC9		Alternative accommodation may be offered to residents living in close proximity to construction works, where detailed design investigations confirm unreasonably high noise impacts over a prolonged period. Alternative accommodation arrangements will be offered and discussed with residents on a case-by-case basis.	All
NVC10		High noise and vibration generating activities including rock breaking, ballast tamping, demolition and ground and track earthworks may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block and these works.	All
NVC11		Ongoing noise monitoring during construction at sensitive receivers during critical periods (ie times when noise emissions are expected to be at their highest - eg piling and hammering) to identify and assist in managing high risk noise events.	All
NVC12	Vibration monitoring	Where vibration levels are predicted to exceed the screening criteria, attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure.	All
NVC13	Groundborne noise	Reasonable and feasible measures would be implemented to minimise groundborne noise where exceedances are predicted.	All
NVC14	Utility adjustments/ relocation works	Reasonable and feasible mitigation measures would be implemented where power supply works would result in elevated noise levels at receivers. This would include: • carrying out works during the daytime period when in the vicinity of residential receivers • where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10pm) • use of portable noise barriers around particularly noisy equipment.	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
NVC15	Road traffic noise	The routes for construction haulage vehicles and bus services associated with the Temporary Transport Strategy would be selected on the basis of compliance with the relevant night-time road traffic noise criteria, where reasonable and feasible.	All

12.6.3 Consideration of the interactions between mitigation measures

Mitigation measures to control construction noise and vibration impacts generally do not overlap with other measures proposed for other environmental issues.

Measures to manage construction traffic would potentially assist in minimising road traffic noise by ensuring that haulage routes and vehicle numbers are minimised where possible, particularly along local streets.

12.6.4 Managing residual impacts

Even with the implementation of mitigation measures outlined in Section 12.6.1, there is potential that exceedances of the NMLs would occur in some locations along the corridor. Further mitigation measures would be considered in these locations, in accordance with the *Construction Noise and Vibration Strategy*, including, but not limited to, provision of respite periods and alternative accommodation for receivers where significant residual impacts are experienced.

13. Operational noise and vibration

This chapter provides a summary of the operational noise and vibration assessment. A full copy of the assessment report is provided as Technical paper 2 – Noise and vibration. The Secretary's environmental assessment requirements relevant to noise and vibration, together with a reference to where the results of the assessment are summarised in this chapter and in the Environmental Impact Statement, are provided in Table 13.1.

Table 13.1 Secretary's environmental assessment requirements – noise and vibration

Ref	Secretary's environmental assessment requirements – noise and vibration	Where addressed
8. Noise and vibration - amenity		
8.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including small businesses, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	A summary of the results of the operational noise and vibration assessment is provided in this chapter. The full results are provided as Technical paper 2. Construction noise and vibration impacts are considered in Chapter 12. Operational amenity and sleep disturbance impacts to sensitive receivers are considered in Section 13.4.2. The characteristics of noise and vibration are explained in Technical paper 2, and no modifying factors need to be used in this assessment.
8.2	The EIS must include a framework for both an Out of Hours Works Strategy and the development of an Out of Hours Works Plan which incorporates community consultation.	Section 9.7.4
9. Noise and vibration - structural		
9.1	The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Consideration of potential operational impacts to structural integrity (including heritage items) is provided in Section 13.4.3 Potential impacts to the heritage significance of items in considered in Chapter 14.
9.2	The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Blasting would not be required.

13.1 Assessment approach

A summary of the approach to the operational noise and vibration assessment is provided in this section. Further information is provided in Technical paper 2.

13.1.1 Legislative and policy context to the assessment

The guidelines and standards relevant to the operational noise and vibration assessment include:

- *Rail Infrastructure Noise Guideline* (EPA, 2013)
- *Assessing Vibration: A Technical Guideline* (DEC, 2006)

- International Standard ISO 14837-1 2005 *Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance*
- *NSW Industrial Noise Policy* (EPA, 2000).

13.1.2 Methodology

The assessment methodology involved:

- identifying and classifying sensitive receivers
- determining noise and vibration criteria in accordance with relevant guidelines, and where appropriate, based on the results of ambient noise monitoring (described in Chapter 12 (Construction noise and vibration))
- modelling to quantify the noise and vibration emissions likely to be experienced
- assessing the significance of noise levels which exceed the relevant guideline values
- identifying and assessing reasonable and feasible measures to mitigate predicted exceedances of the criteria.

The following operational noise and vibration sources were assessed:

- airborne noise from metro trains operating between east of Marrickville and west of Bankstown stations
- airborne noise from mechanical plant and other systems at stations and from ancillary facilities
- groundborne noise from metro trains operating between east of Marrickville and west of Bankstown stations
- vibration from metro trains operating between east of Marrickville and west of Bankstown stations.

Airborne noise

Rail noise

The NSW EPA provides guidance for the assessment and management of potential airborne noise from railways in the *Rail Infrastructure Noise Guideline* (EPA, 2013) (the RING). To assess and manage potential noise from rail projects, the RING provides non-mandatory airborne noise triggers for residential and other sensitive receivers. Where predicted rail noise levels are above the noise triggers, reasonable and feasible noise mitigation measures should be provided to achieve the trigger levels.

A computer software model SoundPLAN version 7.0 was used to predict airborne rail noise emissions. The input data used was chosen to reflect a metro fleet of single-deck trains. This included modelling using an assumed speed profile, including a maximum design speed of 100 kilometres per hour. Modelling was undertaken for the proposed metro track alignment and appropriate noise level corrections were used. Existing and future Sydney Trains operations and ARTC freight operations (including volumes and speeds) were also included in locations where they would operate close to the project.

The train volume estimates are outlined in Table 13.2. These train volume estimates are indicative and based on estimated passenger demand, minimum service levels, and the likely maximum metro service frequency.

Table 13.2 Train volume estimates

Rail line	Scenario	Train type	Trains per weekday period			
			Day 7am to 10pm		Night 10pm to 7am	
			Up	Down	Up	Down
T2 Airport Line	Existing 2017	Double-deck Sydney Trains	6	8	0	1
	Prior to opening 2024	Double-deck Sydney Trains	26	23	6	6
	After opening 2024	Double-deck Sydney Trains	26	23	6	6
	Future 2034	Double-deck Sydney Trains	26	23	6	6
	Future 2034 without project ('no build option')	Double-deck Sydney Trains	26	23	6	6
T3 Bankstown Line (including future metro services)	Existing 2017	Double-deck Sydney Trains	78	84	17	20
	Prior to opening 2024	Double-deck Sydney Trains	96	94	21	23
	After opening 2024	Single-deck Metro Trains	184	184	27	27
	Future 2034	Single-deck Metro Trains	202	202	30	30
	Future 2034 without project ('no build option')	Double-deck Sydney Trains	96	94	21	23
T4 Eastern Suburbs and Illawarra Line	Existing 2017	Double-deck Sydney Trains	96	85	26	23
	Prior to opening 2024	Double-deck Sydney Trains	111	101	28	26
	After opening 2024	Double-deck Sydney Trains	111	101	28	26
	Future 2034	Double-deck Sydney Trains	111	101	28	26
	Future 2034 without project ('no build option')	Double-deck Sydney Trains	111	101	28	26
Freight line	Existing 2017	Freight trains	27	27	9	9
	Prior to opening 2024	Freight trains	44	44	15	15
	After opening 2024	Freight trains	44	44	15	15
	Future 2034	Freight trains	63	63	21	21
	Future 2034 without project ('no build option')	Freight trains	63	63	21	21

Note: 1: Up direction refers to the direction toward Central Station. Down direction refers to the direction toward Bankstown Station.

For the purposes of the airborne noise assessment, the study area was divided into 13 noise catchment areas (NCA) as described in Chapter 12. Typically, each NCA is representative of a station area.

The RING requires noise to be assessed both at the time of opening of a project and at a future design year (typically ten years after opening). For this project, the two timeframes assessed are:

- at opening, anticipated to be in 2024
- a future scenario, based on forecasts for operations in 2034.

Stations and ancillary facilities

The *NSW Industrial Noise Policy* (EPA, 2000) provides two separate criteria to meet environmental noise objectives: one to account for intrusive noise, and the other to protect the amenity of particular land uses. These criteria are to be met at the boundary of the 'most affected' receiver. The more stringent of the criteria usually defines the project-specific noise limits. For both amenity and intrusiveness, night-time criteria are more stringent than daytime or evening criteria and these are therefore the focus for this assessment.

In addition to intrusiveness and amenity, the risk of sleep disturbance must be assessed. Sleep disturbance is assessed in accordance with the screening criterion described in the Application Notes to the *Industrial Noise Policy* and the more detailed review of sleep disturbance contained in the *Road Noise Policy* (DECCW, 2011).

According to the *Industrial Noise Policy*, where existing L_{Aeq} noise levels exceed the 'acceptable' noise level by 10 dB or more, and the existing noise level is unlikely to decrease in future, the noise criteria should be taken to be the existing noise level minus 10 dB. This approach also applies to areas with high traffic noise.

Groundborne noise and vibration

International Standard ISO 14837-1 2005 *Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance* provides relevant guidance in relation to the extent of assessment that is normally required for new rail systems. Further information about the types of models used is provided in Section 4.2.4 of Technical paper 2. It is noted that these methods are also used for the human comfort assessment.

The prediction of groundborne noise and vibration from rail systems is a complex and developing technical field. There are currently no modelling software packages available. Modelling for the project was undertaking using a modelling process developed by the noise consultant. This model has been successfully incorporated and validated for similar previous rail projects over the past ten years.

13.1.3 Definitions used in this chapter

Table 13.3 outlines a number of commonly used noise terms used within this chapter and the respective definitions of these terms.

Table 13.3 Definition of noise related terms

Term	Definition
L_{A90}(period)	The sound pressure level exceeded for 90 per cent of the measurement period
L_{Aeq}(1 hour)	The busiest 1-hour 'equivalent continuous noise level' – it represents the typical L_{Aeq} noise level from all the proposal noise events during the busiest 1-hour of the assessment period
L_{Aeq}(15 hour)	The daytime 'equivalent continuous noise level' - it represents the cumulative effects of all the proposal noise events occurring in the daytime period from 7am to 10pm
L_{Aeq}(24 hour)	The 'equivalent continuous noise level', sometimes also described as the 'energy-averaged noise level' – it represents the cumulative effects of all the proposal noise events occurring in one day

Term	Definition
L_{Aeq}(9 hour)	The night-time 'equivalent continuous noise level' - it represents the cumulative effects of all the proposal noise events occurring in the night-time period from 10pm to 7am
L_{Aeq}(time)	Typically used to described ambient (background) noise levels
L_{Amax}	The maximum sound level recorded during the measurement period

13.2 Operational noise and vibration criteria

13.2.1 Amenity

Airborne noise – rail noise

The relevant airborne noise trigger levels for residential land uses surrounding the project area are provided in Table 13.4. For residential receivers, the criteria have two components – L_{Aeq} (assessed over the day or night) and L_{Amax} (train pass by events).

Table 13.4 Airborne rail noise trigger levels for residential land use

Type of development	Noise trigger level (dBA)	
	Daytime 7am to 10pm	Night-time 10pm to 7am
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$[1] rail noise levels by 2 dB or more, or existing L_{Amax}[2] rail noise levels by 3 dB or more, and predicted noise levels exceed:	
	65 $L_{Aeq(15hour)}$ and 85 L_{Amax}	60 $L_{Aeq(9hour)}$ and 85 L_{Amax}

Notes: 1. $L_{Aeq(period)}$ means $L_{Aeq(15h)}$ for the day time period and $L_{Aeq(9h)}$ for the night-time period.
2. L_{Amax} refers to the maximum noise level not exceeded for 95 per cent of rail pass-by events and is measured using the 'fast' response setting on a sound level meter.

The RING noise trigger levels for non-residential sensitive receivers are provided in Table 13.5. These apply when the building or premise is in use. All noise trigger levels are external levels, except where stated. Commercial receivers are not considered sensitive to operational airborne noise impacts.

The RING acknowledges the need to protect the community from rail-noise related sleep disturbance at night and therefore encourages a greater volume of rail movements to take place during the daytime as reflected by the airborne rail noise trigger levels presented in Table 13.4 and Table 13.5.

Table 13.5 Airborne rail noise trigger levels for sensitive land uses other than residential

Sensitive land use	Noise trigger level (dBA)
Schools, educational institutions and child care centres	45 $L_{Aeq(1hour)}$ internal
Places of worship	45 $L_{Aeq(1hour)}$ internal
Hospital wards	40 $L_{Aeq(1hour)}$ internal
Hospital other uses	65 $L_{Aeq(1hour)}$
Open space – passive use (eg parkland, bush reserves)	65 $L_{Aeq(15hour)}$
Open space – active use (eg sports field, golf course)	65 $L_{Aeq(15hour)}$

Airborne noise – stations and ancillary facilities

The external amenity noise criteria based on the *Industrial Noise Policy 2000* are provided in Table 13.6.

No modifying factors have been applied (for low-frequency noise) for the stations and ancillary facilities as it assumed that these noise sources would not exhibit these characteristics if designed and constructed in accordance with industry best practice.

Table 13.6 Amenity criteria for industrial noise sources

Type of receiver	Indicative noise amenity area	Time of day	Recommended L_{Aeq} noise level (dBA)	
			Acceptable	Recommended maximum
Residence	Suburban[1]	Day	55	60
		Evening	45	50
		Night	40	45
Residence	Urban[2]	Day	60	65
		Evening	50	55
		Night	45	50
Commercial	All	When in use	65	70
Active recreation area	All	When in use	55	60
Educational	All	When in use	45[3]	50[3]
Place of worship	All	When in use	50[3]	55[3]

Notes:
1. Suburban area is characterised by local traffic with intermittent traffic flows, decreasing noise levels in the evening period, and/or evening ambient levels defined by the natural environment and infrequent human activity.
2. Urban areas are characterised by an acoustic environment dominated by 'urban hum' or industrial noise sources, through traffic with heavy and continuous traffic flows during peak hours, and/or located near commercial or industrial districts.
3. External levels, based on the internal levels specified in the Industrial Noise Policy plus 10 dB (assuming open windows).

Substations

Table 13.7 provides the operational noise criteria for the proposed substations.

Table 13.7 Industrial Noise Policy criteria for substation operation

Substation location	Logger ID	Period	Measured level, dBA		Noise criteria, dBA		
			RBL[1]	$L_{Aeq,period}$	Intrusive	Amenity	Overall
Dulwich Hill	B.03	Day	38	57	43	56	43
		Evening	39	57	43[2]	47	43
		Night	33	53	38	43	38
Canterbury	B.07	Day	40	53	45	60	45
		Evening	40	50	45	42	42
		Night	35	47	40	37	37
Campsie	B.11	Day	44	59	49	54	49
		Evening	45	57	49	47	47
		Night	40	57	45	46	45
Lakemba	B.14	Day	47	65	52	55	52
		Evening	47	63	52	53	52

Substation location	Logger ID	Period	Measured level, dBA		Noise criteria, dBA		
			RBL[1]	$L_{Aeq,period}$	Intrusive	Amenity	Overall
		Night	41	60	46	50	46
Punchbowl	B.20	Day	47	65	52	55	52
		Evening	49	64	52	54	52
		Night	39	60	44	50	44

Notes: 1. Rating background level.
2. For assessment purposes, the evening RBL has been reduced to equal the lower daytime RBL in accordance with INP application notes.

Stations

In addition to rail noise, stations would emit noise from mechanical services and public address (PA) systems which would need to comply with applicable criteria. Table 13.8 provides the noise criteria applicable to the operation of stations. The design of mechanical plant and PA systems would be confirmed during detailed design. Therefore, further modelling would be undertaken during detailed design to confirm that the operation of stations at opening would meet the specified criteria.

Table 13.8 Industrial Noise Policy criteria for station noise

Station	Representative noise logger	Period	Measured level dBA	Noise criteria dBA		
			RBL	Intrusive	Amenity	Overall
Marrickville	B.02	Day	38	42	54	42
		Evening	38	42	48	42
		Night	33	38	41	38
Dulwich Hill	B.04	Day	41	46	58	46
		Evening	41	46	45	45
		Night	34	39	40	39
Hurlstone Park	B.06	Day	38	43	58	43
		Evening	39	43	43	43
		Night	34	39	39	39
Canterbury	B.08	Day	43	48	58	48
		Evening	43	48	43	43
		Night	36	41	39	39
Campsie	B.10	Day	45	50	58	50
		Evening	42	47	45	45
		Night	35	40	44	40
Belmore	B.13	Day	41	46	60	46
		Evening	41	46	44	44
		Night	36	41	37	37
Lakemba	B.15	Day	50	55	53	53
		Evening	50	55	53	53
		Night	43	48	53	48
Wiley Park	B.17	Day	44	49	60	49
		Evening	46	49	42	42
		Night	41	46	39	39
Punchbowl	B.19	Day	47	52	56	52
		Evening	47	52	44	44

Station	Representative noise logger	Period	Measured level dBA	Noise criteria dBA		
			RBL	Intrusive	Amenity	Overall
		Night	41	46	43	43
Bankstown	B.22	Day	54	59	55	55
		Evening	51	56	53	53
		Night	60	47	50	47

Vibration – human comfort

Table 13.9 provides the human vibration criteria for the project as outlined in *Assessing Vibration: A Technical Guideline* (DEC, 2006).

Table 13.9 Acceptable maximum vibration dose values for intermittent vibration

Location	Daytime ($m/s^{1.75}$)	Night-time ($m/s^{1.75}$)
Critical areas	0.2	0.2
Residences	0.4	0.26
Offices, schools, educational institutions and places of worship	0.8	0.8
Workshops	1.6	1.6

Note: 1. No sensitive vibration equipment are identified in use in the vicinity of the project area. As a result, the more stringent vibration criteria relating to such equipment has not been applied.

13.2.2 Structural

Groundborne noise and vibration

Rail vibration is generated by dynamic forces at the wheel-rail interface and occurs due to surface irregularities at the point of contact. The vibration generated propagates through the rail mounts into the trackform, which then propagates into the surrounding ground. The vibration continues to propagate into adjacent areas including structures.

The RING outlines the groundborne noise vibration criteria for the operation of trains along the corridor. Table 13.10 provides a summary of the groundborne noise trigger levels which are relevant to the project.

The RING acknowledges that the World Health Organisation recommends avoiding individual noise events exceeding 45 dB L_{Amax} indoors in regards to sleep disturbance. This is reflected in the triggers for groundborne noise shown in Table 13.10.

Table 13.10 Groundborne noise trigger levels

Sensitive land use	Time of day	Internal noise trigger level dBA
	Development increases existing rail noise levels by 3 dBA or more, and resulting rail noise levels exceed:	
Residential	Day (7am to 10pm)	40 L_{ASmax}
	Night (10pm to 7am)	35 L_{ASmax}
Schools, educational institutions, places of worship	When in use	40 - 45 L_{ASmax}

Vibration impacts on structures

Design objectives for vibration impacts on building contents

The human comfort criteria provided in Table 13.9 are the vibration dose values for intermittent vibration considered for the project.

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent design goals than those that apply to human comfort. In such cases, vibration design objectives would be obtained from the specific equipment manufacturers or if unavailable, from generic vibration criteria within commonly referenced sources in the literature.

Design objectives for vibration impacts on structures

The levels of vibration required to cause damage to buildings tend to be at least an order of magnitude higher (10 times higher) than those at which people may consider the vibration to be intrusive or disturbing. It is therefore not necessary to set separate design objectives in relation to potential building damage from rail vibration, as compliance with the human comfort design objectives would ensure compliance with criteria related to potential structural damage.

13.3 Existing environment

The existing noise environment is described in Section 12.3, including figures which show the classification of different receivers and ambient noise monitoring locations along the corridor.

The existing noise environment varies considerably along the length of the project area. In addition to rail noise, other existing noise sources include:

- road traffic noise
- operation of the freight rail line and diesel trains between east of Marrickville Station and west of Campsie Station
- industrial activities within industrial areas (particularly near Marrickville)
- other construction activities (such as building redevelopments, road, and housing construction)
- aircraft noise.

Ambient noise monitoring was undertaken in June and July 2016 at 23 representative noise locations along the project area (refer Table 12.7). Daytime noise levels ranged from 36 to 54 dB with noise levels generally increasing to the west. Measured daytime noise levels were lowest at Campsie Station and loudest at Bankstown Station.

Evening noise levels were either the same or slightly quieter than daytime levels.

Night-time noise levels ranged from 32 to 43 dB across the project area, with the lowest level at Campsie Station and highest between Lakemba and Wiley Park stations. Compared with daytime levels, the greatest change in noise levels was observed at Bankstown and Campsie stations.

13.4 Potential impacts

13.4.1 Risk assessment

Potential risks

The environmental risk assessment for the project undertaken for the State Significant Infrastructure Application Report identified the following as the main operational noise and vibration risks:

- airborne noise impacts on surrounding sensitive receivers as a result of higher train speeds and higher service frequency
- airborne noise impacts from upgraded stations including new substations and upgraded systems such as public address systems
- airborne noise impact from fixed facilities such as traction substations.

Groundborne noise and vibration impacts during operation were also considered. These impacts were not considered to be a key risk, however they have been considered.

How potential impacts have been avoided or minimised

Potential noise and vibration impacts have been avoided/minimised by:

- designing the project to minimise the potential for noise and vibration impacts on surrounding receivers
- incorporating new noise barriers and adjustments (including lengthening or increasing the height), in addition to existing noise barriers located in areas where operational airborne noise is required to be mitigated in line with the RING.

13.4.2 Amenity

Airborne rail noise – normal operations

Table 13.11 provides the noise level predictions for 2024 (at opening) and 2034 (10 years after opening) at the most exposed residential receiver with and without the project. It is noted that the most exposed receiver may not necessarily be the closest to the corridor, because the most exposed location is commonly an upper storey for buildings with two or more levels. Lower floors receive more shielding from the intervening terrain and therefore noise levels are typically lower. A residential receiver with more than one storey may therefore be more affected by airborne noise then a single storey receiver located closer to the source. Rail noise levels at receivers other than the most exposed receiver would be lower and would reduce with distance from the source.

Table 13.11 indicates that predicted operational noise levels in 2024 and 2034 'without the project' generally exceed the RING L_{Aeq} and L_{Amax} noise trigger levels in NCA01 to NCA06. In NCA07, the only exceedance is the L_{Aeq} at night (in both 2024 and 2034), while there is an exceedance of L_{Amax} at both NCA10 and NCA11 in both 2024 and 2034.

The table also shows that there is only a slight increase in predicted noise levels between the 2024 and 2034 scenarios and this is limited to the section of the rail corridor where freight trains operate (NCA01 to NCA06). This reflects the modelling assumptions which indicate that freight services are likely to increase over the 10 year forecast period while passenger services are likely to remain closer to current levels.

In relation to the noise level prediction following the addition of the project ('with project'), and excluding predicted exceedances in NCA01 to NCA06 as explained above, exceedances are also predicted at NCA07, NCA09, NCA10 and NCA11. In most of these locations, the increases in noise

levels may be explained by the need to move track or implement new infrastructure such as a crossover which result in the existing tracks being moved closer to the edges of the corridor.

In total, noise levels at 85 and 105 receivers are predicted to exceed the RING trigger levels in 2024 and 2034 respectively as shown in Figure 13.1. The majority of exceedances are located in NCA11 (Bankstown), where there are more multi-level residential buildings near the rail line.

Table 13.12 provides noise level predictions for non-residential sensitive receivers in 2024 and 2034. The introduction of the project is considered to result in a relatively low number of exceedances for non-residential sensitive receivers. Exceedances of the RING trigger levels would be experienced at 14 receivers in both 2024 and 2034. These exceedances would only be located in NCA07, NCA08, NCA09 and NCA10.

Receivers with predicted exceedances of the RING trigger levels would be eligible for further consideration of noise mitigation during detailed design.

Figure 13.1 shows the locations of those receivers where exceedances of the airborne noise levels are predicted to occur and where, subject to detailed design and confirmation, reasonable and feasible noise mitigation would be considered. A description of the proposed approach to mitigation is provided in Section 13.5.

Table 13.11 Predicted 2024 and 2034 airborne noise levels at most exposed receiver – residential receivers

		Without project						With project						Noise level change with and without the project						No. of exceedances of RING trigger levels	
		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}			
NCA	**Side**	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034
NCA01	Up	**76**	**77**	**73**	**75**	**105**	**105**	**76**	**77**	**73**	**75**	**105**	**105**	0.0	0.0	0.0	0.0	0.0	0.0	0	0
	Down	63	64	**67**	**69**	**96**	**96**	**66**	**67**	**68**	**69**	**96**	**96**	3.0	2.6	0.5	0.5	0.0	0.0	1	1
NCA02	Up	**73**	**74**	**70**	**71**	**101**	**101**	**73**	**74**	**70**	**71**	**101**	**101**	0.2	0.2	0.0	0.0	0.0	0.0	0	0
	Down	**70**	**71**	**67**	**68**	**96**	**96**	**71**	**72**	**68**	**69**	**96**	**96**	1.2	1.0	0.5	0.4	0.0	0.0	0	0
NCA03	Up	**73**	**75**	**71**	**72**	**102**	**102**	**74**	**76**	**71**	**72**	**102**	**102**	1.2	1.0	0.5	0.4	0.0	0.0	0	0
	Down	**69**	**71**	**67**	**68**	**96**	**96**	**71**	**72**	**67**	**69**	**96**	**96**	1.8	1.6	0.8	0.7	0.0	0.0	0	0
NCA04	Up	**74**	**75**	**71**	**73**	**102**	**102**	**75**	**76**	**72**	**73**	**102**	**102**	1.2	1.0	0.5	0.4	0.0	0.0	0	0
	Down	**70**	**71**	**67**	**69**	**95**	**95**	**72**	**73**	**68**	**69**	**95**	**95**	2.0	1.7	0.9	0.8	0.0	0.0	1	0
NCA05	Up	**66**	**72**	**68**	**69**	**97**	**97**	**68**	**73**	**68**	**69**	**97**	**97**	2.1	0.7	0.3	0.2	0.0	0.0	1	0
	Down	**67**	**69**	65	**66**	**91**	**91**	**69**	**70**	**65**	**66**	**91**	**91**	2.1	1.6	0.7	0.6	0.0	0.0	6	0
NCA06	Up	**67**	**68**	**71**	**72**	**99**	**99**	**69**	**70**	**71**	**72**	**99**	**99**	2.2	2.1	0.1	0.1	0.0	0.0	2	1
	Down	**67**	65	61	**69**	**95**	**95**	**69**	**69**	**63**	**69**	**95**	**95**	2.3	3.5	2.0	0.2	0.1	0.1	4	3
NCA07	Up	61	61	**69**	**71**	83	83	**66**	**66**	**69**	**71**	**86**	**86**	4.7	5.1	0.0	0.0	3.0	3.0	4	7
	Down	63	63	59	59	82	82	**68**	**68**	**62**	**62**	**86**	**86**	4.6	5.0	2.7	3.1	3.3	3.3	2	2
NCA08	Up	61	61	57	57	82	82	65	65	59	59	83	83	3.7	4.1	1.8	2.3	1.3	1.3	0	0
	Down	60	60	56	56	82	82	64	64	58	58	83	83	3.5	3.9	1.5	2.0	1.2	1.2	0	0
NCA09	Up	61	61	58	57	84	84	**66**	**67**	**61**	**61**	**86**	**86**	4.9	5.3	2.8	3.5	1.4	1.4	1	2
	Down	60	60	56	56	81	81	65	**66**	59	60	84	84	5.3	5.7	3.4	3.9	2.4	2.4	0	1

		Without project						With project						Noise level change with and without the project						No. of exceedances of RING trigger levels	
		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}		L_{Aeq} Day		L_{Aeq} Night		L_{Amax}			
NCA	**Side**	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034
NCA10	Up	60	60	56	56	82	82	**66**	**66**	60	60	85	85	5.5	5.9	3.6	4.0	2.7	2.7	2	6
	Down	64	64	61	61	**86**	**86**	**66**	**67**	**61**	**62**	85	85	2.8	3.2	-0.2	0.3	0.0	0.0	4	9
NCA11	Up	63	63	61	60	**86**	**86**	**68**	**69**	**64**	**64**	**89**	**89**	5.1	5.5	2.6	3.7	3.0	3.0	34	37
	Down	62	62	57	57	82	82	**67**	**67**	60	**61**	**85**	**85**	5.1	5.5	3.0	3.5	2.9	2.9	23	38
NCA12	Up	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
	Down	60	60	56	56	81	81	63	63	57	57	81	81	2.8	3.2	0.8	1.3	0.0	0.0	0	0

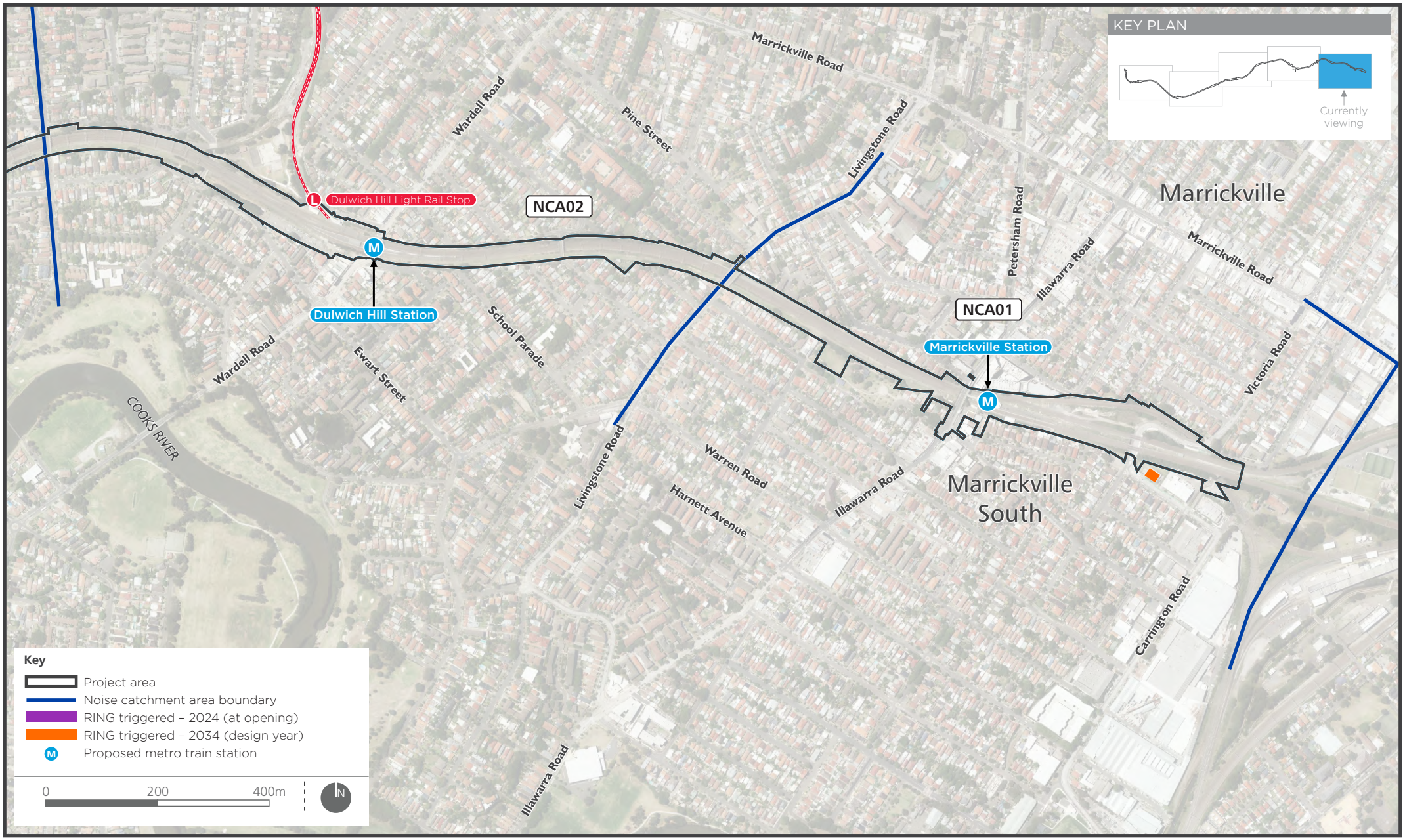
Notes: Shading and bold text indicates exceedances of the RING residential absolute noise trigger levels.
Noise level values have been rounded and noise level increases are based on additional significant figures.
A dash (-) indicates that sensitive receivers are not located close to the rail corridor in this NCA.
Up side refers to trains travelling towards Central Station. Down side refers to trains travelling away from Central (i.e. towards Bankstown in the case of the project).

Table 13.12 Predicted 2024 and 2034 airborne noise levels at most exposed receiver – non-residential receivers

		Without project				With project				Noise level change with and without the project				No. of exceedances due to the project	
		L_{Aeq} Day		L_{Aeq} Night		L_{Aeq} Day		L_{Aeq} Night		L_{Aeq} Day		L_{Aeq} Night			
NCA	Side	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034	2024	2034
NCA01	Up	-	-	-	-	-	-	-	-	-	-	-	-	0	0
	Down	68	69	66	67	70	71	66	67	1.5	1.3	0.4	0.4	0	0
NCA02	Up	68	70	66	67	69	70	66	67	0.6	0.5	0.2	0.2	0	0
	Down	-	-	-	-	-	-	-	-	-	-	-	-	0	0
NCA03	Up	50	51	47	49	50	52	48	49	0.3	0.3	0.1	0.1	0	0
	Down	-	-	-	-	-	-	-	-	-	-	-	-	0	0
NCA04	Up	-	-	-	-	-	-	-	-	-	-	-	-	0	0
	Down	68	70	66	67	70	71	66	68	1.6	1.3	0.7	0.6	0	0
NCA05	Up	67	68	65	66	68	69	65	66	1.0	0.8	0.4	0.3	0	0
	Down	65	66	62	63	67	68	63	64	1.9	1.7	0.7	0.7	0	0
NCA06	Up	78	79	75	77	78	80	75	77	0.3	0.3	0.1	0.1	0	0
	Down	58	60	56	57	59	60	56	57	0.3	0.2	0.1	0.1	0	0
NCA07	Up	47	47	44	44	49	50	44	45	2.8	3.2	0.3	0.7	0	0
	Down	65	65	62	62	69	70	64	65	4.5	4.6	2.1	2.4	2	2
NCA08	Up	55	55	52	52	58	59	53	53	3.0	3.4	0.4	0.9	1	1
	Down	54	54	51	51	57	57	52	52	2.9	3.3	0.4	0.8	1	1
NCA09	Up	47	47	44	44	52	52	47	47	5.0	5.4	2.6	2.9	0	0
	Down	59	59	56	56	62	63	57	58	3.7	4.1	1.2	1.7	5	5
NCA10	Up	65	65	62	62	69	69	63	64	3.6	4.0	1.1	1.5	5	5

		Without project				With project				Noise level change with and without the project				No. of exceedances due to the project	
		L_{Aeq} Day		L_{Aeq} Night		L_{Aeq} Day		L_{Aeq} Night		L_{Aeq} Day		L_{Aeq} Night			
NCA	**Side**	**2024**	**2034**	**2024**	**2034**	**2024**	**2034**	**2024**	**2034**	**2024**	**2034**	**2024**	**2034**	**2024**	**2034**
	Down	47	47	44	44	50	50	45	45	3.6	4.0	1.0	1.5	0	0
NCA11	Up	42	42	40	40	47	48	42	43	5.0	5.5	2.6	2.9	0	0
	Down	45	45	43	43	50	51	45	45	4.9	5.3	2.4	2.8	0	0
NCA12	Up	51	52	49	49	50	51	45	46	0.0	0.0	0.0	0.0	0	0
	Down	57	57	54	54	54	54	49	49	3.7	4.1	1.2	1.6	0	0

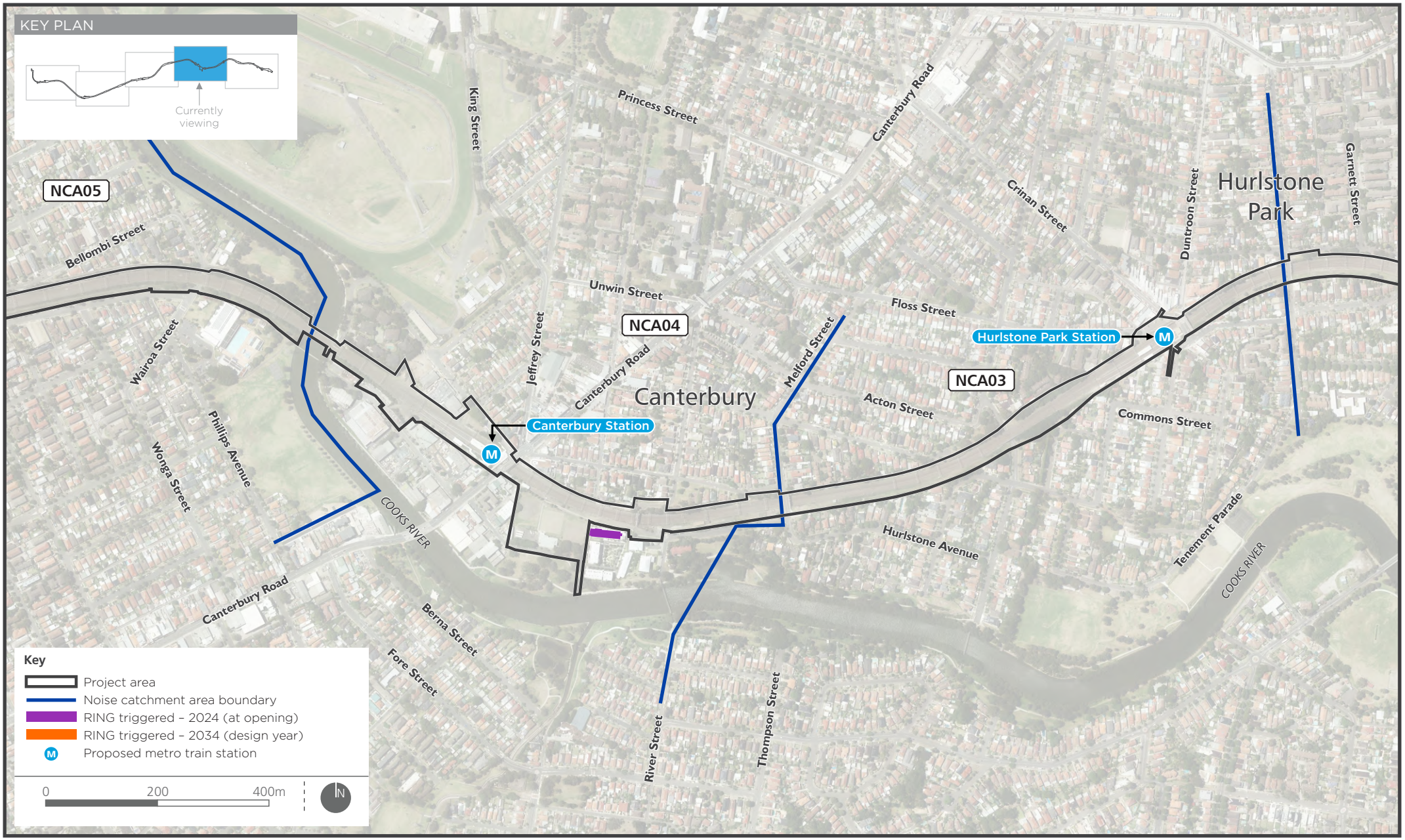
Notes: Noise predictions are external. A conservative outside-to-inside attenuation of 10 dB has been applied.
Noise level values have been rounded and noise level increases are based on additional significant figures.
A dash (-) indicates that sensitive receivers are not located close to the rail corridor in this NCA.
Up side refers to trains travelling towards Central Station. Down side refers to trains travelling away from Central (i.e. towards Bankstown in the case of the project).



sydney METRO | city & southwest

Location of receivers potentially affected by operational noise and exceeding RING criteria - map 1

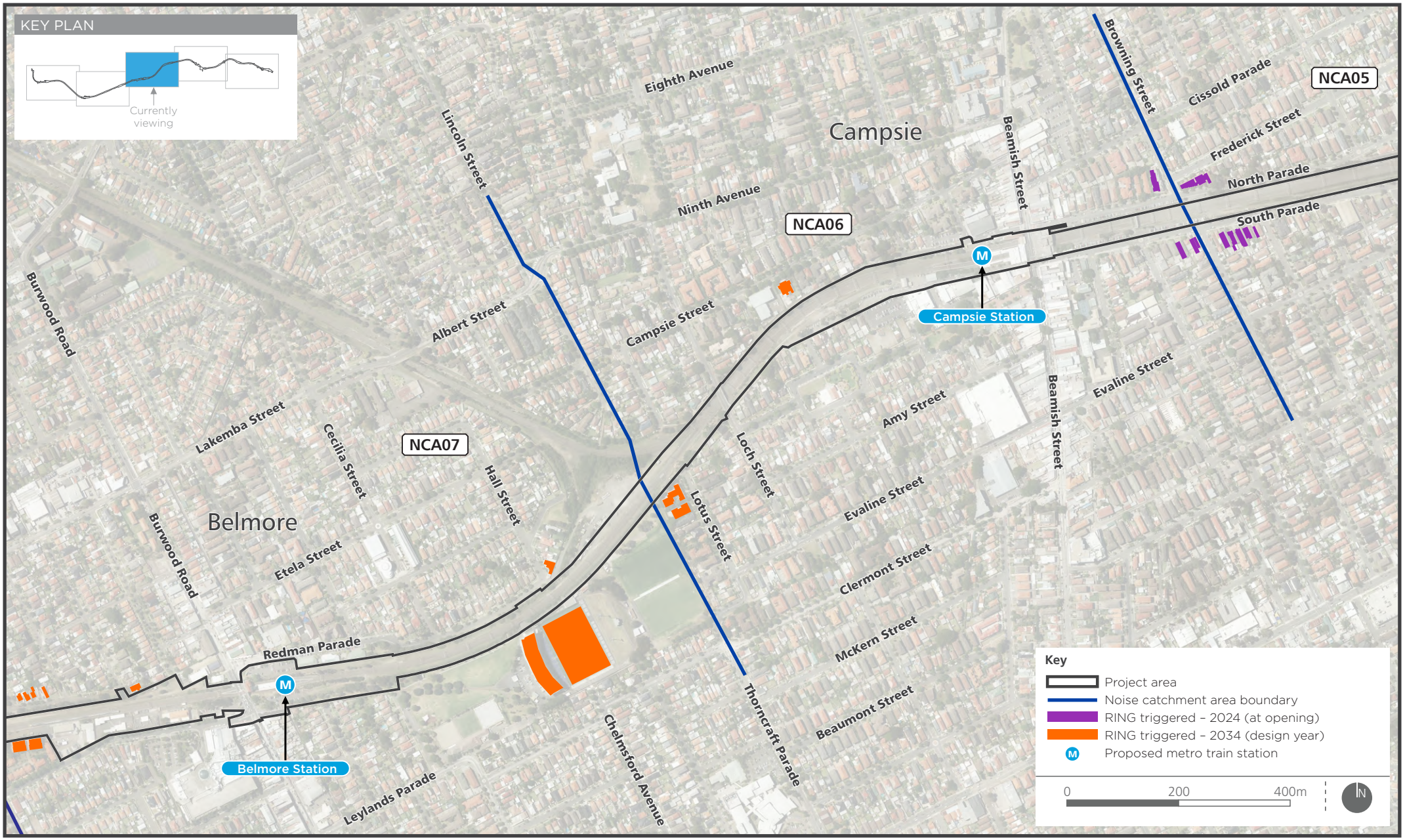
FIGURE 13.1



sydney METRO | city & southwest

Location of receivers potentially affected by operational noise and exceeding RING criteria - map 2

FIGURE 13.1



sydney METRO | city & southwest

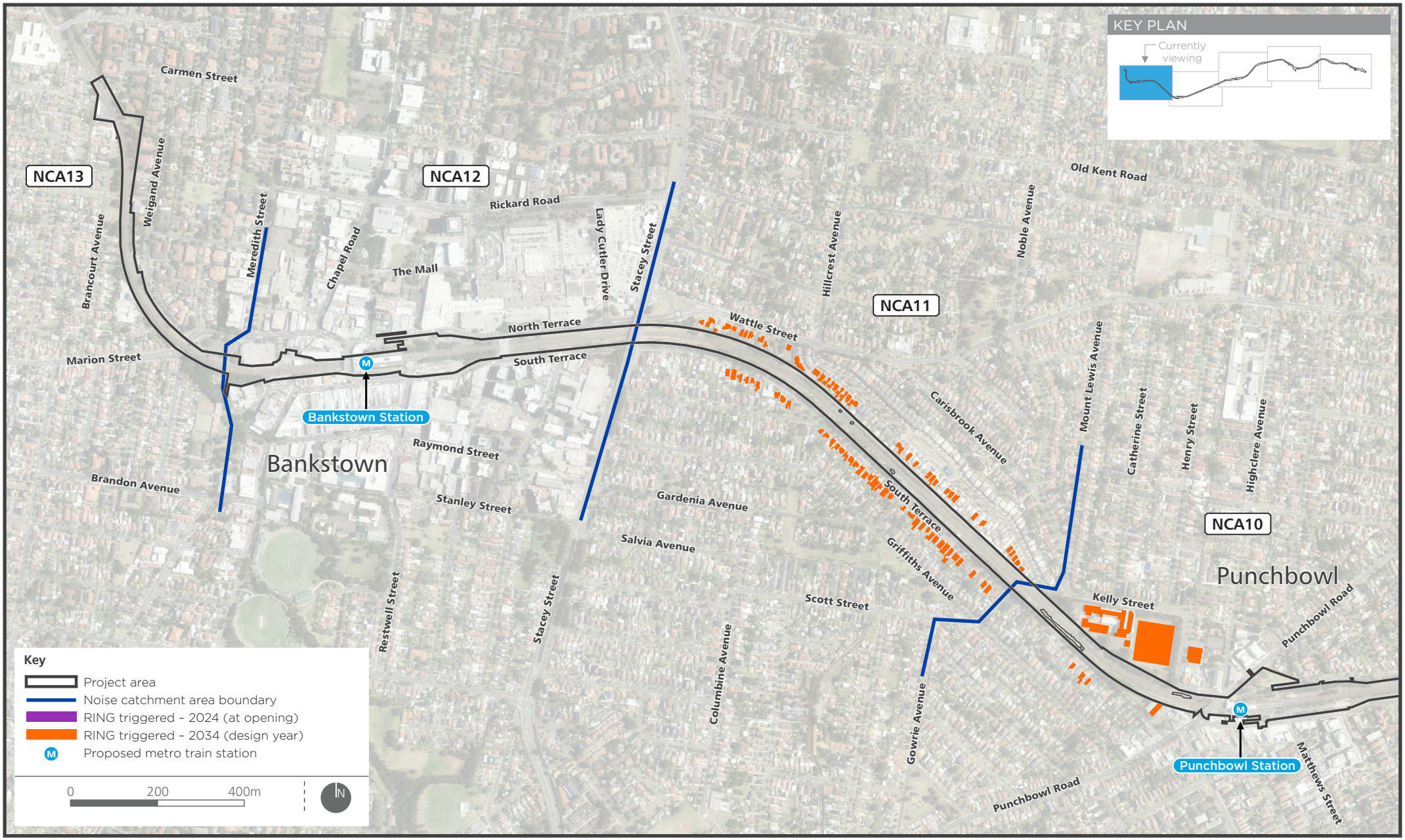
Location of receivers potentially affected by operational noise and exceeding RING criteria - map 3

FIGURE 13.1

sydney METRO | city & southwest

Location of receivers potentially affected by operational noise and exceeding RING criteria - map 4

FIGURE 13.1



Location of receivers potentially affected by operational noise and exceeding RING criteria - map 5

FIGURE 13.1

Table 13.13 provides a summary of the number of receivers, both residential and non-residential, which would be eligible for consideration of reasonable and feasible noise mitigation measures based on the preliminary modelling conducted. As described in Section 13.5.1, further more detailed review and confirmation of these modelling results would be undertaken during detailed design and subsequent project delivery stages prior to proceeding with mitigation application.

Table 13.13 Summary of locations eligible for consideration of mitigation

Precinct	NCA	Side of corridor	Number of exceedances of RING noise trigger levels[1]				Comments
			Residential receivers		Other sensitive receivers		
			2024	2034	2024	2034	
Marrickville	01	Up	0	0	0	0	n/a
		Down	1	1	0	0	Residential receiver building
Canterbury	04	Up	0	0	0	0	n/a
		Down	1	0	0	0	Residential receiver building
Campsie	05	Up	1	0	0	0	Residential receiver building
		Down	6	0	0	0	Residential receiver buildings
	06	Up	2	1	0	0	Residential receiver buildings
		Down	4	3	0	0	Residential receiver buildings
Belmore	07	Up	4	7	0	0	Residential receiver buildings
		Down	2	2	2	2	Residential receiver buildings and other sensitive receivers (active recreation)
Lakemba	08	Up	0	0	1	1	Other sensitive receiver (medical)
		Down	0	0	1	1	Other sensitive receiver (place of worship)
Wiley Park	09	Up	1	2	0	0	Residential receiver buildings
		Down	0	1	5	5	Residential receiver building and other sensitive buildings (educational)
Punchbowl	10	Up	2	6	5	5	Residential receiver buildings and other sensitive buildings (educational and place of worship)
		Down	4	9	0	0	Residential receiver buildings
Bankstown	11	Up	34	37	0	0	Residential receiver buildings
		Down	23	38	0	0	Residential receiver buildings
TOTAL			**85**	**105**	**15**	**15**	

Note: 1. The number of locations identified counts buildings once only, in the event that more than one facade or floor of the building is triggered. This number may be less than the number of individual dwellings triggered, for example where buildings contain multiple apartments.

Airborne rail noise – testing and commissioning

During the commissioning stage, prior to the line being open to the public, testing operations would be performed within the rail corridor. Train movements during the commissioning phase are unlikely to be more frequent than during normal operations. Additionally, the train speeds during the commissioning phase are not anticipated to be significantly higher than assumed in the earlier

assessment. It is therefore considered that noise impacts resulting from the testing of train operations would be equal to or lower than the predicted operational airborne noise results shown in Table 13.11 and Table 13.12.

Should vehicle testing be undertaken in a manner that differs from the assumptions in this assessment, further assessment may be required to be undertaken. If exceedances of the operational noise criteria are identified, then reasonable and feasible mitigation measures should be considered. These may include:

- scheduling unusually high noise events (such as traction, acceleration and brake testing) to less sensitive periods in consultation with the potentially affected community
- scheduling fewer commissioning operations in the same region during the same daytime or night-time period by dispersing tests throughout project area
- rescheduling commissioning operations from the night-time period to less sensitive periods eg daytime.

Substations

Table 13.14 provides the maximum predicted noise levels from substations operating, without mitigation, during the night-time period (the most stringent period) at the most affected receiver. The results show that, without mitigation, four of the five substations would result in exceedances of the night-time noise criteria.

Table 13.14 Predicted noise levels from substations at the most potentially affected receiver

Substation location	Approx. offset to nearest receiver (m)	L_{Aeq} noise level, dBA	
		Night-time criteria	Predicted
Dulwich Hill	12	38	**51**
Canterbury	35	37	**42**
Campsie	22	45	**46**
Lakemba	25	46	45
Punchbowl	24	44	**45**

Note: Shading and bold indicates predicted exceedance of criteria (without mitigation).

Predicted exceedances of the criteria range between one dB at Lakemba and Punchbowl and 13 dB at Dulwich Hill. Despite these exceedances, it is expected that noise levels can be readily reduced to acceptable levels by provision of shielding, enclosure of the noise source or locating the noise source further from the receiver as necessary. The use of acoustic louvres could be considered where ventilation is required. Such measures have been successfully used on other traction substations along the rail network in order to achieve the operational noise criteria.

Noise emitted from train stations

Train stations emit noise from mechanical services and public address systems which need to comply with the applicable noise criteria. At this stage of the design, mechanical plant and PA systems have not been identified, which means it is not possible to assess compliance with the applicable noise criteria. However given the nature of these sources and measures successfully applied to other projects, it is expected that potential impacts can be readily mitigated during the detailed phase through the selection of equipment that will not generate noise in excess of the design noise levels. The applicable criteria for operational noise from train stations is provided in Table 13.8.

Vibration – human comfort

Vibration modelling indicates that no locations would experience exceedances of the vibration (human comfort) criteria.

13.4.3 Structural

Vibration impacts on structures

As described in Section 13.2.2, compliance with human comfort criteria would ensure that the potential for structural impacts is minimal. This is because the levels of vibration required to cause damage to buildings tend to be at least an order of magnitude higher (10 times higher) than those at which people may consider the vibration to be intrusive or disturbing. As the predicted levels of vibration during operation would meet the relevant human comfort criteria, no structural impacts (including impacts to heritage structures) are expected.

Groundborne noise and vibration

The prediction modelling for groundborne noise has excluded the influence of freight traffic, which results in a more conservative assessment of groundbourne noise from Sydney Metro operations. The prediction results indicate that noise levels would be below the criteria for the majority of the project area. Minor exceedances of about one dB are predicted at four receivers near Marrickville Station. The assessment results at these four receivers are provided in Table 13.15. As the night-time criteria are the most stringent, only the night-time criteria is shown. No exceedances are predicted at non-residential receivers.

Table 13.15 Receivers in Marrickville where the groundborne noise criteria is exceeded

Address	Residential noise criteria dBA	Groundborne noise level dBA		
	Night-time	Existing situation	Future situation	Increase
30 Arthur Street	35	31	36	4.8
221 Livingstone Road	35	30	36	5.4
29 Albermarle Street	35	32	36	3.9
24 Arthur Street	35	31	36	4.7

For a receiver to be considered for mitigation, groundborne noise must dominate the internal noise environment. As indicated by the results of the airborne noise assessment in Section 13.4.2, the predicted external noise levels are much greater than those predicted for groundborne noise. Even including a moderate outdoor-to-indoor noise correction of -10 dB (assuming windows closed), airborne noise levels would be greater than groundborne noise inside the affected buildings. As such, these four receivers comply with the groundborne noise criteria, and do not require mitigation.

13.4.4 Cumulative impacts

Cumulative operational noise impacts as a result of the operation of the project combined with the operation of Sydney Trains (west of Bankstown) and ARTC freight trains between Marrickville and west of Campsie, were assessed. The results are provided in Section 13.4.

Future developments occurring in close proximity to the rail corridor that may be affected by noise emissions, must take into consideration the *Development Near Rail Corridors and Busy Roads – Interim Guideline* (Department of Planning, 2008).

13.5 Mitigation measures

13.5.1 Approach to mitigation and management

A review and iteration of predicted operational noise and vibration levels would be undertaken during detailed design, when more information is available and when specific mechanical plant and other project details have been confirmed. This would also include consideration of the mitigation options described in Section 13.5.2, and confirming reasonable and feasible mitigation approaches. The final form of mitigation would be determined during detailed design.

The operational noise and vibration review would:

- confirm predicted project noise and vibration levels at sensitive receivers, which may include a review of façade acoustic performance for non-residential receivers
- potentially include a review of the building envelopes for residential receivers, as many are located within areas subject to development requirements to mitigate aircraft noise
- assess reasonable and feasible noise and vibration measures in a hierarchical manner, consistent with the RING
- identify options for controlling noise and vibration at the source and/or receiver, including location, type, and timing of implementation (as described in Section 13.5.2)
- specify noise and vibration abatement measures for all relevant sensitive receivers
- include a consultation strategy to seek feedback from directly affected stakeholders on the proposed noise and vibration abatement measures
- include a timetable for delivery of abatement prior to operations commencing
- outline post-operational monitoring to verify noise and vibration predictions.

To validate the predicted noise levels, monitoring would be undertaken after the commencement of operation for Sydney Metro as a whole. Monitoring would confirm compliance with the predicted noise levels, as modified by the review of reasonable and feasible mitigation measures undertaken at the completion of detailed design.

If the results of monitoring indicate that the operational noise and vibration criteria are being exceeded, then additional reasonable and feasible mitigation measures would be implemented in consultation with affected property owners.

13.5.2 Reasonable and feasible mitigation options

Three main strategies are used to mitigate noise and vibration impacts:

- controlling noise and vibration at the source
- controlling noise and vibration on the source to receiver transmission path
- controlling noise and vibration at the receiver.

Section 4.1.8 of Technical paper 2 describes airborne noise mitigation options for locations where RING trigger levels are exceeded. The following reasonable and feasible mitigation options have been identified based on preliminary analysis, as summarised in Table 13.16:

- low profile noise barriers
- conventional noise barriers
- property treatment.

These mitigation options would be further considered as part of the detailed design, including further noise modelling to confirm eligibility for noise mitigation. Consideration would also be given

to cost effectiveness, constructability, visual impact, overshadowing, ecological impact, impact on maintenance and safety requirements.

Table 13.16 Preliminary reasonable and feasible noise mitigation options

NCA	Side of corridor	Potential mitigation option[1]
NCA01	Down	At property treatments, where required
NCA04	Down	At property treatments, where required
NCA05 and NCA06	Down	Noise barrier, as required
	Up	Noise barrier, as required
NCA06	Down	At property treatments, where required
	Up	At property treatments, where required
NCA07	Down	At property treatments, where required
	Up	Noise barrier, as required
	Down	At property treatments, where required
NCA08	Down	At property treatments, where required
	Up	At property treatments, where required
NCA09	Down	Noise barrier, as required
	Up	At property treatments, where required
NCA09 and NCA10	Down	Noise barrier, as required
	Up	Noise barrier, as required
NCA10	Up	Noise barrier, as required
	Down	At property treatments, where required
	Down	At property treatments, where required
NCA11	Down	Noise barrier, as required
	Up	Noise barrier, as required
	Up	Property treatments, where required

Note: 1. The form and details of all noise mitigation would be confirmed during detailed design with the aim of not exceeding trigger levels from the RING. At property treatments would also be offered where there are residual exceedances of the trigger levels.

13.5.3 List of mitigation measures

Mitigation measures that would be implemented to address potential operational noise and vibration impacts are listed in Table 13.17.

Table 13.17 Mitigation measures – operational noise and vibration

ID	Impact/issue	Mitigation measures	Relevant location(s)
Design/pre-construction			
NVO1	Predicted noise impacts	An operational noise and vibration review would be undertaken to guide the approach to identifying reasonable and feasible mitigation measures to incorporate in the detailed design. This would include noise modelling to confirm the results of modelling previously undertaken. Where changes in noise levels and exceedances are modelled, reasonable and feasible mitigation measures would be reviewed.	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
NVO2		The height and extent of noise barriers adjacent to the project would be confirmed during detailed design with the aim of not exceeding trigger levels from the *Rail Infrastructure Noise Guidelines* (EPA, 2013). At-property treatments would be offered either on their own or in combination with a noise barrier where there are exceedances residual exceedances of the noise trigger levels.	All
NVO3		Operational noise from substations would be controlled by inclusion of appropriate mitigation, such as shielding or enclosures, and specification of equipment selection, to comply with the *Industrial Noise Policy* (EPA, 2000).	All
Operation			
NVO4	Predicted vibration impacts	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items where screening vibration levels are predicted to be exceeded, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	All

13.5.4 Consideration of the interactions between mitigation measures

The construction of noise barriers as a mitigation measure (see NVO2 in Table 13.17) would potentially result in visual impacts for some visually sensitive receivers located in the areas surrounding any potential noise barriers. The landscape and visual assessment (Chapter 19 and Technical paper 7) has assessed the impact of the noise barriers identified in the noise and vibration assessment. Further consideration of these noise barrier locations would be undertaken as part of the operational noise and vibration review during detailed design. At this time, the visual impacts of any noise barriers may also be reconsidered.

13.5.5 Managing residual impacts

Monitoring would be undertaken to confirm the performance of the barriers and any other noise mitigation approaches. If the results of monitoring indicate that the operational noise and vibration criteria are being exceeded, then additional reasonable and feasible mitigation measures would be implemented in consultation with affected property owners.