Technical Paper

Operational noise and vibration

3

Sydney Metro West

Rail infrastructure, stations, precincts and operations

Environmental Impact Statement

Technical Paper 3: Operational Noise and Vibration

Project	Sydney Metro West
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Executive Summary

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD. Stations include Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD). This infrastructure investment will double the rail capacity of the Greater Parramatta to Sydney CBD corridor with a travel time target between the two centres of about 20 minutes.

This technical paper is one of a number of technical papers that form part of the Environmental Impact Statement. The purpose of this technical paper is to identify and assess the potential operational noise and vibration impacts of the proposal.

Ambient noise monitoring was completed as part of previous Sydney Metro West planning applications or as part of previous nearby developments. These measured noise levels have been used to establish operational noise criteria for fixed facilities in accordance with the Noise Policy for Industry. Fixed facilities include stations, the stabling and maintenance facility, the water treatment plant, and the services facility. Noise from over and/or adjacent station development has not been assessed explicitly but considered in setting appropriate criteria for the proposal so that cumulative noise achieves the relevant objectives.

Airborne rail noise

There is a short section of above ground track which runs from the tunnel portals to the west of Rosehill Gardens racecourse to the Clyde stabling and maintenance facility further to the south. Airborne noise generated by trains operating on this section of track was assessed against the Rail Infrastructure Noise Guideline. The predicted noise levels for residential and commercial receivers have been identified to be compliant with the applicable noise criteria and further consideration of noise mitigation was not required for this location. Notwithstanding, consultation regarding acceptable impacts on the horse stables (for which there is no criteria) would continue with Rosehill Gardens racecourse.

Ground borne rail noise

There is a potential for train-induced ground-borne noise and vibration impacts to be generated when trains operate in underground tunnels (or sometimes deep cuttings) near buildings. The vibration is generated from the interaction of train wheels rolling on rails which causes the wheels and the rails to vibrate and is transferred to surrounding buildings via the ground. Ground-borne noise generated from this interaction has been assessed against the Rail Infrastructure Noise Guideline. Vibration generated from this interaction was assessed against Assessing Vibration: A Technical Guideline.

A detailed ground-borne noise and vibration assessment identified a suitable trackform to control the vibration generated by the interaction. Further detailed study would be completed during later design stages.

Station, stabling and maintenance facility and services facility noise

The Clyde stabling and maintenance facility would stable up to 32 trains and provide a train wash, wheel lathe, maintenance facility and staff offices. Given the proximity to the Rosehill services facility (which includes tunnel ventilation and a traction substation), the two facilities have been assessed together against criteria derived from the Noise Policy for Industry. The predicted noise levels indicate that compliance with the noise criteria would be achieved at the most sensitive residential receiver locations with standard noise control measures. Exceedances have been identified at the Rosehill Gardens racecourse, with further mitigation measures to be investigated throughout detailed design.

Noise emissions from the stations have been assessed in accordance with the Noise Policy for Industry.

At all but one station, the predicted noise level at each sensitive receiver location indicates that compliance with the environmental noise criteria can be achieved using the feasible and reasonable noise attenuation measures included in the design.

Predicted noise levels at Burwood North Station show a minor exceedance of the applicable noise criteria. Existing residential receivers are located less than 15 metres from the eastern services building. Design options, such as modifications to the mechanical services arrangement, to achieve compliance with the applicable noise criteria would be considered as part of detailed design. This location is also expected to experience a land use change with these buildings potentially being redeveloped in the near future. In this case, compliance would be achieved by incorporating feasible and reasonable measures as part of the redevelopment.

1 Introduction

1.1 Context and overview

Sydney is expanding and the NSW Government is working hard to deliver an integrated transport system that meets the needs of customers now and in the future. Sydney Metro is Australia's biggest public transport program.

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD. This infrastructure investment will double the rail capacity of the Greater Parramatta to Sydney CBD corridor with a travel time target between the two centres of about 20 minutes.

The delivery of Sydney Metro West is critical to keeping Sydney moving and is identified in a number of key strategic planning documents including the Greater Sydney Region Plan: A Metropolis of Three Cities – connecting people (Greater Sydney Commission, 2018), Building Momentum: State Infrastructure Strategy 2018-2038 (Infrastructure NSW, 2018) and Future Transport Strategy 2056 (Transport for NSW, 2018).

Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of *the Environmental Planning & Assessment Act 1979* (EP&A Act). The previous Sydney Metro West planning applications included:

- The Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process, application number SSI-10038), was approved by the Minister for Planning and Public Places on 11 March 2021.
- Stage 2 of the planning approval process includes all major civil construction between The Bays and Sydney CBD. An Environmental Impact Statement for major civil construction between The Bays and Sydney CBD was exhibited between 3 November 2021 and 15 December 2021.

Stage 3 of the planning approval process is seeking planning approval to enable the approved Concept to be realised by carrying out the tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line (this proposal).

Major civil construction including station excavation and tunnelling work associated with the previous Sydney Metro West planning applications does not form part of this proposal. This proposal includes the activities required to complete construction ready for operations of Sydney Metro West.

The main elements of Sydney Metro West are shown in Figure 1-1.

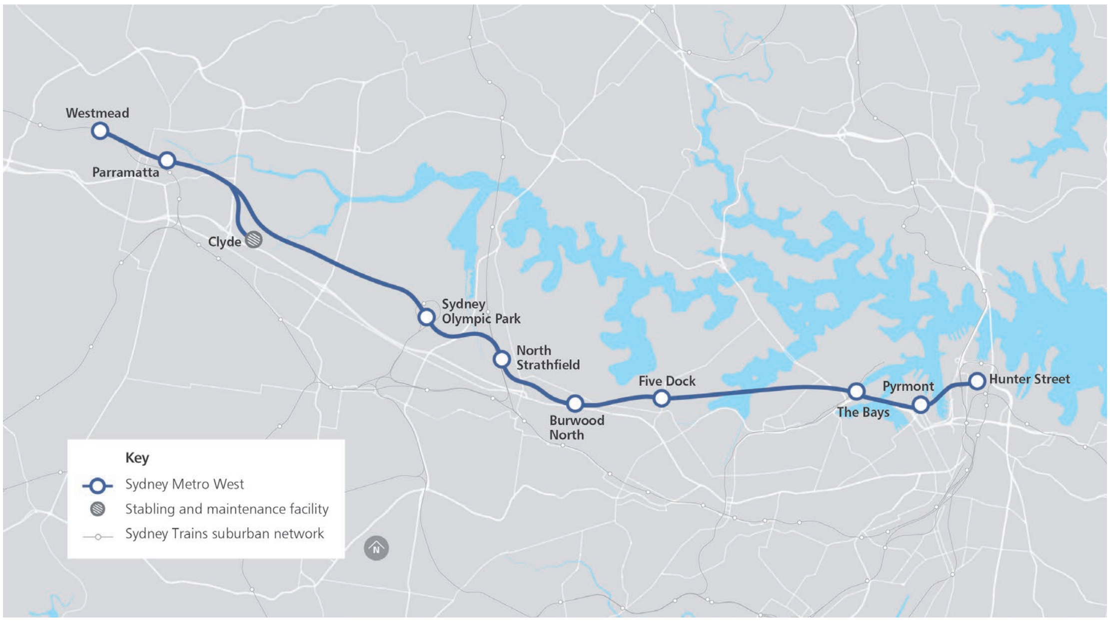


Figure 1-1 Sydney Metro West

1.2 Key features of this proposal

This proposal would involve:

- Fit-out of tunnels including systems for metro train operations
- Construction, fit-out and operation of:
  - Metro station buildings and the surrounding metro precincts
  - A services facility and traction substations
  - A control centre, test track and stabling and maintenance facility at Clyde
- Space for non-station uses at metro stations (e.g. retail, commercial and/or community facilities)
- Provisions for over and / or adjacent station development within metro precincts
- Rail interchange support works, including work to the existing T1 Western Line at Westmead and T9 Northern Line at North Strathfield
- Transport network modifications such as new interchange facilities and changes to public transport networks to serve metro stations
- Subdivision of sites
- Operation and maintenance of the Sydney Metro West line.

Components of this proposal are subject to further design development, and changes may be made during the ongoing design which take into account the outcomes of community and stakeholder engagement and environmental investigations.

Further details of the proposal are provided in Chapter 5 (Proposal description – construction) and Chapter 6 (Proposal description – operation) of the Environmental Impact Statement

1.3 Purpose and scope of this report

This technical paper, Technical Paper 3: Operational noise and vibration is one of a number of technical papers that form part of the Environmental Impact Statement. The purpose of this technical paper is to identify and assess the potential impacts of the proposal in relation to operational noise and vibration. It responds directly to the Secretary's environmental assessment requirements outlined in Section 1.3.1.

1.3.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements for the proposal were issued on 16 August 2021. The requirements are specific to operational noise and vibration, and where these requirements are addressed in this technical paper, are outlined in Table 1-1.

The Secretary's environmental assessment requirements also make reference to the Sydney Metro West Scoping Report – Rail infrastructure, stations, precincts and operations (Sydney Metro, 2021), which identified the proposed scope of investigations and assessment. This technical paper addresses these matters in the sections outlined in Table 1-2.

The relevant guidelines used to inform this technical paper are outlined in Table 1-3.

Table 1-1 Secretary's environmental assessment requirements – operational noise and vibration

Secretary's environmental assessment requirements	Where addressed
1. Construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. 2. The assessment must clearly differentiate between activities within the enclosed tunnels, activities below ground but not enclosed and activities on the surface and describe their impacts and proposed hours of work.	This technical paper addresses the operational noise impacts. Technical Paper 4 addresses construction noise impacts. Section 3 of this technical paper outlines the relevant NSW guidelines. Section 4 of this technical paper outlines the assessment methodology used for above and below ground activities. Section 5 of this technical paper outlines the predicted noise and vibration impacts of the proposal. Section 6 of this technical paper outlines the mitigation measures for operational noise and vibration impacts. Chapter 3 of the EIS provides the project Stakeholder and Community Engagement strategy.
4. The process for community engagement should be included or referenced in the noise and vibration assessment as part of the mitigation strategy and assessment.	Construction noise and vibration mitigation and management, including the process for community engagement, is outlined in Technical Paper 4. Further information is also provided in the Sydney Metro Overarching Community Communications Strategy, which provides the framework for communication and engagement during construction and the 12 months following the completion of construction. Feedback, questions and complaints during operations would be managed through the Transport for NSW (Sydney Metro) channels.

Table 1-2 Scoping report investigations and assessment – operational noise and vibration

Scoping report investigations and assessment	Where addressed
Description of the existing noise environment	Section 2
Explanation of the applicable standards, guidelines and environmental planning requirements	Section 1.5
Explanation of the construction methodology, design and operational procedures relevant to noise and vibration emissions	Section 4
Description of the methodology used to predict and assess the potential impacts	Section 4
Assessment of the potential cumulative impacts with other major projects	The setting of the operational assessment criteria allows for potential future projects and associated cumulative impacts. Refer to Section 3.4

Scoping report investigations and assessment	Where addressed
Assessment of potential operational noise and vibration impacts	Section 5
Identification of feasible and reasonable construction and operational mitigation measures.	Section 6

1.4 Structure of this report

This technical paper is structured as follows:

- Chapter 1 (this chapter) provides the context, overview and key features of this proposal
- Chapter 2 provides a summary of the baseline noise environment throughout the proposal area and details of the background noise measurement results
- Chapter 3 provides the noise and vibration assessment criteria used throughout the assessment
- Chapter 4 details the noise and vibration assessment approach
- Chapter 5 provides the predicted noise and vibration impacts
- Chapter 6 recommends appropriate noise and vibration management and mitigation measures.

1.5 Relevant guidelines

Table 1-3 Relevant guidelines and references

Guideline	Where guideline is used
Rail Infrastructure Noise Guideline, NSW Environment Protection Authority (EPA), 2013	Assessment of airborne noise and ground-borne noise impacts
Assessing Vibration: a technical guideline, Department of Environment and Conservation (DEC), 2006	Assessment of vibration impacts on sensitive receivers
Road Noise Policy (RNP), Department of Environment, Climate Change and Water (DECCW), 2011	Assessment of operational road traffic noise impacts
Noise Policy for Industry (NPfI), NSW Environment Protection Agency (EPA), 2017	Ambient noise monitoring and analysis procedures, assessment of sleep disturbance, and assessment of airborne noise from fixed facilities
Federal Transit Administration Transit Noise and Vibration Impact Assessment Manual, FTA Report No. 0123, dated September 2018	Assessment of vibration and ground-borne noise impacts from the operational underground trains
Nelson, 'Transportation Noise Reference Book', 1987	Assessment of vibration and ground-borne noise impacts from the operational underground trains
ISO14837:2005 Mechanical vibration — Ground-borne noise and vibration arising from rail systems	Assessment of vibration and ground-borne noise impacts from the operational underground trains

2 Baseline environment

2.1 Overview

The proposed alignment extends from the existing Westmead Station to Hunter Street in the Sydney CBD, and includes nine stations, a services facility and a stabling and maintenance facility. A plan showing the alignment, sensitive receiver locations and types, and station locations is provided in Appendix A.

The operational impacts from the tunnel have the potential to affect receivers across the extent of the proposal. The stations, services facilities and stabling and maintenance facility have the potential to impact discrete sites across the extent of this proposal.

2.2 Assessment areas

2.2.1 Westmead

The proposed metro station would be connected to the existing Westmead Station, with the station box located predominantly underground, to the south of the existing station.

The existing noise environment is controlled by a combination of road traffic on arterial roads including Hawkesbury Road, and Alexandra Avenue, and the railway corridor which services the T1 Western Line and the T5 Cumberland Line.

Existing sensitive receivers surrounding the proposed site are predominantly residential, primarily consisting of two to four storey apartment buildings. Education facilities including a school and university campus are located further away.

2.2.2 Parramatta

The site is in the Parramatta CBD, bounded by George Street, Smith Street, Macquarie Street, and Church Street.

The site is surrounded by high density commercial development, with some nearby educational uses and places of worship. Road traffic on the city streets surrounding the site is the controlling noise source in the existing environment. Parramatta Light Rail is currently under construction along Macquarie Street.

2.2.3 Sydney Olympic Park

The proposed station is located within Sydney Olympic Park, extending between Herb Elliot Avenue and Figtree Drive, approximately 120 metres east of Olympic Boulevard.

The site is currently surrounded by medium density commercial buildings, hotels, apartment buildings and educational buildings. Sydney Olympic Park is a nominated State Significant Precinct and the buildings and uses surrounding the site are likely to change in the short to medium term. These new developments are likely to include commercial, residential, and residential/commercial mixed use.

The roads surrounding the site are of a boulevard style with a 40 km/h speed limit, providing the primary noise source in the area. The site is also about 700 metres from the M4 Motorway, which is likely to control background noise levels, particularly during the night-time period.

While the proposed site is near the existing Olympic Park Station, the rail alignment and station are located underground so would not contribute to the ambient noise environment. The tunnel portal on the T7 Olympic Park line is located approximately 200 metres from the site.

The noise environment is occasionally impacted by high-noise sporting and entertainment events, primarily from Stadium Australia (approximately 350 metres from the site) or the Sydney Showground Stadium (approximately 450 metres from the site).

The primary existing sensitive receivers are existing hotels, such as the Pullman and Novotel Hotels.

2.2.4 North Strathfield

The North Strathfield site would be directly adjacent to the existing North Strathfield Station. The existing rail line splits the area into east and west halves. On the east side of the existing rail line is a small number of local community shops on Queen Street, surrounded by a residential area. Directly to the west is the McDonald College, with residential receivers further to the west, north, and south.

The existing rail line services passenger and freight trains, which are the main noise sources in the area. During daytime, ambient noise levels are controlled by the train movements, in addition to local road traffic. At North Strathfield, passenger trains do not operate during the early hours of the morning, and freight trains operate irregularly, with volumes forecasted to grow in the future.

The M4 Motorway is located approximately 650 metres to the south and controls the background noise environment when trains are not operating. During other periods, the M4 Motorway contributes to the background noise environment.

The existing noise environment is generally considered urban, with noise controlled by the rail corridor. Extending further back two to three blocks away from the existing rail line, the noise environment would become suburban.

2.2.5 Burwood North

Burwood North Station consists of a services building on the corner of Parramatta Road and Loftus Street, and station entries on the corner of Burwood Road and Parramatta Road (both to the north and south of Parramatta Road).

In this area, both the ambient and background noise environments are controlled by road traffic on Parramatta Road.

Residential receivers are located directly to the north of the services building and south-east of the station entry.

2.2.6 Five Dock

The proposed station at Five Dock is located on Great North Road between East Street and Second Avenue, spanning both sides of the road. While Great North Road is an arterial road, local traffic speeds are generally low due to nearby traffic lights and pedestrian crossings.

The area is characteristically urban, dominated by local traffic and pedestrians. During night-time periods when the local traffic noise drops, background noise levels are controlled by Parramatta Road which is approximately 700 metres to the south.

The St Albans Anglican Church is located directly to the north of the western building.

2.2.7 The Bays

The Bays Station would be located adjacent to the White Bay Power Station. The existing ambient noise environment is dominated by a combination of road traffic noise and port noise when the port is active.

The nearest residential receivers are located in Rozelle, to the west and north of the site. Residential receivers to the north are predominantly shielded by commercial receivers, however a small number of residential receivers rise above the commercial roofline.

2.2.8 Pyrmont

Pyrmont Station includes two above-ground station entry buildings, with the eastern building located on the corner of Union Street and Pyrmont Bridge Road, and the western building located on the corner of Pyrmont Bridge Road and Pyrmont Street. The station cavern is located directly below the station buildings.

The noise environment for both station buildings is controlled by road traffic noise on Pyrmont Bridge Road. Both buildings are surrounded by a mix of residential and commercial buildings.

The nearest receivers to the eastern station building would be commercial, however residential buildings are located on the southern side of Pyrmont Bridge Road overlooking the proposed eastern station building. The Sebel hotel is also located between the developments.

Residential receivers are located directly to the north of the western site, and opposite the site across Pyrmont Street. Directly across Pyrmont Bridge Road from the western site is a commercial building. Paternoster Row receivers are predominantly commercial, with an occasional residential receiver.

2.2.9 Hunter Street (Sydney CBD)

The existing noise environment in the Sydney CBD has the typical characteristic of an urban hum. While ambient noise is controlled by road traffic, the background noise cannot be attributed to a single dominant source. Background noise in the Sydney CBD generally comprises traffic noise at ground level, and cooling plant and other building services noise sources at higher levels above ground.

There are two sites associated with this station, the eastern and western sites. The proposed eastern site is located on Hunter Street, spanning from O’Connell Street to Bligh Street. The proposed western site is located on the corner of Hunter Street and George Street.

The sites are generally surrounded by commercial receivers. However, there are also existing hotels located nearby such as the Radisson Blu Hotel which is situated on the corner of O’Connell Street and Hunter Street (to the west of the eastern site).

The nearest receiver to the eastern site is the adjoining building on Bligh Street/O’Connell Street, however due to physical constraints the main noise sources would not be orientated towards this receiver. The nearest sensitive receiver to the western site is the new Adina Apartment Hotel, located directly opposite the site on the corner of George Street and Hunter Street.

2.2.10 Clyde and Rosehill

The stabling and maintenance facility would be located in Clyde, bound by Rosehill Gardens racecourse, an industrial area to the east, the M4 Motorway and James Ruse Drive. The area is exposed to substantial road traffic noise which controls the existing noise levels in this study area.

The nearest residential receivers front James Ruse Drive and are located along Penelope Lucas Lane and A'Beckett Street, east of the site. Racehorses are stabled at the Rosehill Gardens racecourse north of the site.

The Rosehill services facility would provide tunnel ventilation fans to the main alignment and is located to the north of the Clyde stabling and maintenance facility and south of the Rosehill Gardens racecourse. It has been assessed as part of the Clyde stabling and maintenance facility due to its proximity and its contribution to a combined impact of both facilities at the nearest sensitive receivers.

2.3 Ambient noise monitoring

Baseline noise monitoring at each site was undertaken as part of the previous Sydney Metro West planning applications or as part of previous Sydney Metro projects. The monitoring included ambient and background noise logging, and was completed in 2015 at Hunter Street, in 2021 at Pyrmont, and between March and July 2019 for the remaining sites.

A noise logger measures the noise levels in the local environment and records noise level statistics over the measurement period. For this proposal, the noise loggers were setup to measure the following noise levels at 15-minute intervals:

- L_{AFmax} – the maximum noise level over the measurement period. This level is the maximum noise due to an individual noise event
- L_{A10} – the noise level which is exceeded for 10% of the measurement period
- L_{Aeq} - the energy average noise level over the measurement period
- L_{A90} – the noise level which is exceeded for 90% of the measurement period. This is considered to be the background noise level over the measurement period.

All measured noise levels are A-weighted, which is used across Australian and international standards to account for the relative loudness perceived by the human ear.

Further details of the weather and data processing can be found in the relevant documents as noted in Table 2-1 for each site.

Table 2-1 provides a summary of the noise logging results. The measured noise levels have been used to define the intrusiveness noise criteria in accordance with the NPfI requirements.

The NPfI defines three separate assessment time periods: daytime (7am to 6pm); evening (6pm to 10pm); and night-time (10pm to 7am). For each time-period the assessment background level (ABL) has been established by determining the lowest 10th percentile of the background noise (the L_{A90}) over the defined period for each day. The rating background level (RBL) is the median ABL over the entire monitoring period.

Table 2-1 Ambient noise monitoring results

Location	Address	Rating background level, dB(A)			Ambient level, $L_{Aeq,period}$, dB(A)		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
Westmead[2]	8-12 Alexandra Avenue	49	47	37	67	67	62
Parramatta[2]	Arthur Phillip High School	58	53	43	69	67	62
Olympic Park[2]	1 Herb Elliot Avenue	48	48	46	55	54	52
North Strathfield[2]	131 Queen Street	51	47	39	61	60	55
Burwood[2]	8 Esher Street	48	48	44	57	56	55
Five Dock[2]	8 Waterview Street	43	43 (44)[4]	38	57	56	50
The Bays[2]	21 Mansfield Street, Rozelle	43	43	35	56	54	47
	22 Lilyfield Road, Rozelle	51	51	45	57	57	54
Pyrmont[3]	1-5 Harwood Street	52	49	46	61	59	56
	200 Paternoster Row	50	47	45	56	50	47
Hunter Street[1]	50 Martin Place	64	61	58	66	64	62
Clyde and Rosehill [2]	9 A'Beckett Street, Granville	50	49	45	56	55	53

Note 1: Source: Metro Martin Place Stage 1 Amending DA – Acoustic Assessment Report

Note 2: Source: Sydney Metro West Environmental Impact Statement Westmead to The Bays and Sydney CBD Technical Paper 2 Noise and Vibration

Note 3: Pyrmont noise logging has been completed as part of Sydney Metro West Environmental Impact Statement The Bays to Sydney CBD Technical Paper - Noise and Vibration.

Note 4: The measured noise level was 44 dB(A). In accordance with the NPfI the noise level has been reduced to 43 dB(A) to be no higher than the preceding time period.

3 Assessment criteria

3.1 Operational railway airborne noise

The NSW EPA's Rail Infrastructure Noise Guideline (RING) provides noise trigger levels for the assessment of noise for rail infrastructure. In the event a noise trigger level is exceeded, feasible and reasonable noise mitigation should be considered.

The above-ground section of new alignment would be located between the dive structure to the north-west of Rosehill Gardens racecourse and the Clyde stabling and maintenance facility. While there is an existing section of track in this area, it is currently closed for all rail movements. The RING identifies that a disused rail line that is brought back into service should be assessed against the redeveloped rail noise criteria.

Table 3-1 provides the RING airborne noise trigger levels for residential land uses.

Table 3-1 Airborne rail noise trigger levels – residential land uses

Type of development	Noise trigger levels, dB(A)	
	Daytime (7am – 10pm)	Night-time (10pm to 7am)
Redeveloped rail line	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing L_{Amax} noise levels by 3 dB or more And predicted rail noise levels exceed:	
	65 $L_{Aeq(15hr)}$ or 85 L_{AFmax}	60 $L_{Aeq(9hr)}$ or 85 L_{AFmax}

The noise criteria in Table 3-1 identified that rail noise needs to increase sufficiently above existing levels as one of the trigger conditions. However, the area is not currently exposed to existing rail noise and therefore the increase in noise triggers do not apply.

Table 3-2 provides the RING noise trigger levels for non-residential sensitive land uses. The $L_{Aeq(1h)}$ internal noise trigger levels only apply during the period when the space is in use.

Table 3-2 Airborne rail noise trigger levels – non-residential sensitive land uses

Other sensitive land uses	Redeveloped rail line
Schools, educational institutions and child care centres	45 $L_{Aeq(1h)}$ internal
Places of worship	45 $L_{Aeq(1h)}$ internal
Hospital wards	40 $L_{Aeq(1h)}$ internal
Hospital other uses	65 $L_{Aeq(1h)}$ external
Open space – passive use (e.g. parkland, bush reserves)	65 $L_{Aeq(15h)}$ external
Open space – active use (e.g. sports field, golf course)	65 $L_{Aeq(15h)}$ external

3.2 Operational railway ground-borne noise

Ground-borne noise is generated when vibration from an operational railway causes a building to vibrate. The vibrating walls and floors create low-frequency noise called ground-borne noise. The RING provides guidance on ground-borne noise. Similar to airborne noise, the guideline provides ground-borne noise trigger levels rather than design criteria.

Table 3-3 provides the RING ground-borne noise trigger levels.

Table 3-3 RING ground-borne noise trigger levels

Sensitive land use	Time of day	Internal noise trigger levels
		Development increases existing rail noise levels by 3 dB or more And Resulting ground-borne rail noise levels exceed:
Residential	Daytime 7am – 10pm	40 dB(A) L_{ASmax}
	Night-time 10pm – 7am	35 dB(A) L_{ASmax}
Schools, educational institutions, places of worship	When in use	40 – 45 dB(A) L_{ASmax}

Note 1: L_{ASmax} is not to be exceeded for 95% of train passbys over any 24-hour period

Note 2: The triggers are relevant only where ground-borne noise levels are audible and are of a higher level than airborne noise levels from rail operations.

The RING does not provide guidance on other sensitive land uses such as office space and television studios. Table 3-4 provides a summary of criteria for other sensitive use spaces. These criteria have been developed over previous Sydney Metro projects and have been replicated here.

Table 3-4 Ground-borne noise trigger levels

Sensitive land use	Time of day	Internal noise trigger levels
Medical institutions	When in use	40 to 45 dB(A)[1]
Retail areas	When in use	50 dB(A)[1]
General office areas	When in use	45 dB(A)[1]
Private offices and conference rooms	When in use	40 dB(A)[1]
Drama theatres	When in use	NR25[2]
Film / Television Studios and Sound recording studios	When in use	NR15[2]
Library	When in use	40 dB(A)[1]
Court	When in use	30 dB(A)[1]
Public Hall	When in use	35 dB(A)[1]
Child Care	When in use	35 dB(A)[1]

Note 1: L_{ASmax} is not to be exceeded for 95% of train passbys over any 24-hour period

Note 2: NR (Noise Rating) curves are used for rating noise levels and are a set of octave band curves which provide limiting sound pressure level values. NR 15 is equivalent to approximately 20 dB(A) and NR 25 is approximately 30 dB(A), when considering noise dominated at the middle range frequencies.

3.3 Operational railway vibration

The EPA guideline, Assessing vibration: a technical guideline (Department of Environment and Conservation, 2006), provides guidance on appropriate vibration goals for continuous, impulsive, and intermittent vibration. This document provides targets in terms of vibration dose values (VDVs). VDVs weight vibration root mean square (rms) acceleration levels based on human sensitivity and balance the magnitude of vibration levels with the total duration of exposure over the assessment period.

Assessing vibration: a technical guideline references British Standard 6472:1992 Guide to evaluation of human exposure to vibration in buildings. In 2008 the standard was revised with new frequency weightings. Nevertheless, the weightings provided in the 1992 version of the Standard have been incorporated in this assessment to be consistent with the EPA guideline.

Provided below in Table 3-5 is a summary of the VDV design goals.

Table 3-5 Vibration dose value design goals ($m/s^{1.75}$)

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

For particularly sensitive spaces, the vibration criterion (VC) curves have been used. These curves were originally presented in “Vibration Criteria for Microelectronics Manufacturing Equipment” by Gordon, C. G., and Ungar, E. E (Proceedings of Inter-Noise 83, pp. 487-490 (July 1983)) and have become the industry standard approach to the assessment of vibration in sensitive spaces. Sensitive spaces would be assessed on a case-by-case basis in accordance with the VC curves.

VC curves are provided below in Figure 3-1.

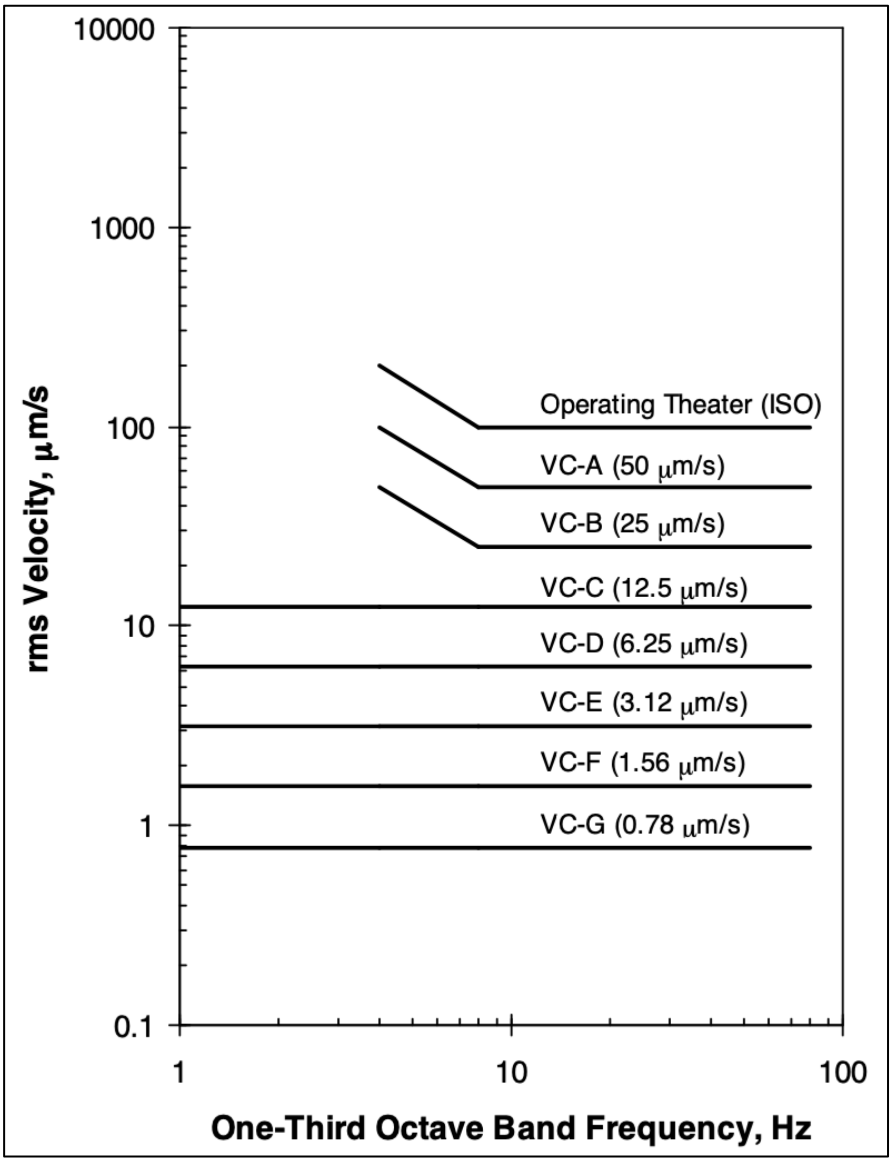


Figure 3-1 Vibration criteria (VC) curves

A description of the curves is provided below in Table 3-6.

Table 3-6 Vibration criteria curve description

Curve criterion	Amplitude µm/s	Detail size µm	Description of use
Op Theatre (ISO)	100	25	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100X and for other equipment of low sensitivity.
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	Appropriate for inspection and lithography (including steppers) to 3 µm line widths.
VC-C	12.5	1-3	Appropriate standard for optical microscopes to 1000X, inspection and lithography inspection equipment (including moderately sensitive electron microscopes) to 1 µm detail size, TFT-LCD stepper/scanner processes.
VC-D	6.25	0.1 – 0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems.
VC-E	3.12	< 0.1	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, E-Beam lithography systems working at nanometre scales, and other systems requiring extraordinary dynamic stability.

3.4 Fixed facility airborne noise

The NSW Noise Policy for Industry (NPfI) provides guidance on appropriate noise levels for external noise emissions from fixed facilities on surrounding sensitive receivers. The NPfI considers noise goals in terms of intrusiveness and amenity noise levels. The intrusiveness noise level protects against significant changes in noise, while the amenity noise level seeks to protect against cumulative noise impacts from industry. Together, these levels are used to assess the potential impact of noise and assess feasible and reasonable noise mitigation measures. Project noise trigger levels are developed through this process. They are not used directly as regulatory limits.

The NPfI provides guidance on noise criteria for new noise generating developments throughout NSW. The project noise trigger levels are defined as the lower level of the intrusiveness noise level and the amenity noise level.

3.4.1 Intrusiveness base noise criteria

The intrusiveness noise level protects against significant changes in noise levels and is applicable to residential receivers only. The criterion is defined by the formula below:

$$L_{Aeq,15min} = rating\ background\ noise\ level + 5\ dB$$

The rating background level (RBL) is the average background noise level over a measurement period of at least one week, discussed previously in Section 2.3.

Provided below is a summary of the measured RBLs and corresponding intrusiveness levels.

Table 3-7 Intrusiveness levels

Location	Address	Rating background level, L_{A90} dB(A)			Intrusiveness level, $L_{Aeq,15min}$ dB(A)		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
Westmead	8-12 Alexandra Avenue	49	47	37	54	52	42
Parramatta	Arthur Phillip High School	58	53	43	63	58	48
Olympic Park	1 Herb Elliot Avenue	48	48	46	53	53	51
North Strathfield	131 Queen Street	51	47	39	56	52	44
Burwood	8 Esher Street	48	48	44	53	53	49
Five Dock	8 Waterview Street	43	43	38	48	48	43
The Bays	21 Mansfield Street, Rozelle	43	43	35	48	48	40
	22 Lilyfield Road, Rozelle	51	51	45	56	56	50
Pyrmont	1-5 Harwood Street	52	49	46	57	54	51
	200 Paternoster Row	50	47	45	55	52	50
Hunter Street	50 Martin Place	64	61	58	69	66	63
Clyde and Rosehill	9 A'Beckett Street, Granville	50	49	45	55	54	50

3.4.2 Amenity base noise criteria

The amenity noise level seeks to protect against cumulative noise impacts from industry.

The NPfI uses project noise trigger levels measured over a 15-minute time period, assessed as an $L_{Aeq,15min}$. The night-time amenity noise criterion is the most stringent, hence the controlling time-period is the 9 hour long night-time period. To account for converting $L_{Aeq,period}$ to $L_{Aeq,15min}$, the NPfI accepts a default conversion factor of $L_{Aeq,15min} = L_{Aeq,period} + 3$ dB.

So that total industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise. The NPfI calculates this as follows:

> *Project amenity noise level for industrial developments = recommended amenity noise level minus 5 dB*

The NPfI contemplates the need for exceptions to the above method in certain circumstances. These circumstances include situations where it is unnecessary to consider cumulative industrial noise because there are either no other significant industrial sources, or it is unlikely that any additional industrial noise sources will be introduced into the area. In such cases the following objective may apply:

> *Project amenity noise level for industrial developments = recommended amenity noise level*

The NPfI is a non-mandatory document and amenity noise levels should not be used directly as regulatory limits. Rather, the regulatory limits should include consideration of a number of feasible and reasonable factors in determining achievable noise requirements.

Unmitigated noise sources associated with the Sydney Metro West stations include sound power levels greater than 130 dB(A) from sources such as ventilation fans. To attenuate these noise impacts creates appreciable challenges within the design of the station. While it is technically feasible to attenuate noise levels to below ambient, there are a number of constraints. Additional attenuators are required, which need additional space. This space is not in the order of few metres, but additional floors of the services buildings. The reasonableness of noise reduction needs to consider the potential impacts of increasing the physical extents of the buildings which would include visual, overshadowing and reduced activation opportunities around stations, as well as substantially increasing cost, and potential breaching of height objectives.

Most stations (except for Parramatta, Sydney Olympic Park, The Bays and Hunter Street) are located near existing residential receivers. These locations currently do not, and in the future would continue to not have industrial noise sources located in close proximity, due to the existing land zoning. In these circumstances, it is not considered reasonable to protect for future industrial sources which are not proposed and cannot be developed with the existing land zoning. In the absence of any future industrial developments, the NPfI requirement to set then amenity noise level 5 dB lower than the amenity targets would not apply.

Whilst it is not required by the NPfI, a conservative approach taken here is to set an ‘amenity noise level minus 5 dB’ as the aspirational target, and a level of ‘amenity noise level minus 0 dB’ as the maximum acceptance level. Table 3-8 provides a summary of the project amenity objectives. Where the project amenity target level cannot be feasibly or reasonably achieved within the physical constraints of the building, the project amenity acceptance level must be achieved.

Table 3-8 Project amenity objectives and noise levels

Project objective	Project amenity level
Target level	Recommended amenity noise level minus 5 dB
Acceptance level	Recommended amenity noise level

The amenity noise levels are reproduced in Table 3-9. This has been sourced from *Table 2.2 Amenity noise levels*, in the NPfI.

Table 3-9 Amenity noise levels

Receiver	Noise amenity area	Time of day	L_{Aeq}, dB(A)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakes quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom - internal	All	Noisiest 1-hour period when in use	35
Hospital ward - internal	All	Noisiest 1-hour	35
Hospital ward - external	All	Noisiest 1-hour	50
Place of worship - internal	All	When in use	40
Passive recreation area	All	When in use	50
Active recreation area	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface	All	All	Add 5dB(A) to recommended noise amenity area

The Rosehill Gardens racecourse does not fall directly into any category listed above in Table 3-9. The location has been deemed to be a passive recreation area and the criterion of L_{eq} 50 dB(A) applies to the stables housing horses and all occupied outdoor areas in the premises.

3.4.3 Sleep disturbance

The NPfI contains guidance on sleep disturbance and the following screening levels are used to identify where further investigation of sleep disturbance should be undertaken:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater.

This assessment has considered both the night-time $L_{Aeq,15min}$ noise levels and L_{AFmax} noise levels, where they are relevant. The applicable sleep disturbance noise criteria across the project are provided below in Table 3-10.

Table 3-10 Sleep disturbance noise criteria

Location	Address	Night-time RBL L_{A90}, dB(A)	$L_{Aeq,15min}$ criteria, dB(A)	L_{AFmax} criteria, dB(A)
Westmead	8-12 Alexandra Avenue	37	42	52
Parramatta	Arthur Phillip High School	43	48	58
Olympic Park	1 Herb Elliot Avenue	46	51	61
North Strathfield	131 Queen Street	39	44	54
Burwood	8 Esher Street	44	49	59
Five Dock	8 Waterview Street	38	43	53
The Bays	21 Mansfield Street, Rozelle	35	40	52
	22 Lilyfield Road, Rozelle	45	50	60
Pyrmont	1-5 Harwood Street	46	51	61
	200 Paternoster Row	45	50	60
Hunter Street	50 Martin Place	58	63	73
Clyde and Rosehill[1]	9 A'Beckett Street, Granville	45	50	60

Note 1: Clyde and Rosehill facilities are located in existing industrial areas. The neighbouring residential receivers (identified in Section 5.12) are considered to be an industrial interface, attracting a + 5dB correction to the amenity noise criteria.

3.4.4 Project airborne noise trigger levels

Table 3-11 provides the target amenity and intrusiveness noise criteria for residential receivers. Where the project amenity target level is the controlling criteria and cannot be feasibly or reasonably achieved within the physical constraints of the building, the lower of the project amenity acceptance level or the intrusiveness level must be achieved.

Table 3-11 Project airborne noise trigger level, $L_{Aeq,15min}$ dB(A)

Location	Address	Amenity target level			Intrusiveness level		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
Westmead	8-12 Alexandra Avenue	58	48	43	54	52	42
Parramatta	Arthur Phillip High School	58	48	43	63	58	48
Olympic Park	1 Herb Elliot Avenue	58	48	43	53	53	51
North Strathfield	131 Queen Street	58	48	43	56	52	44
Burwood	8 Esher Street	58	48	43	53	53	49
Five Dock	8 Waterview Street	58	48	43	48	48	43
The Bays	21 Mansfield Street, Rozelle	58	48	43	48	48	40
	22 Lilyfield Road, Rozelle	58	48	43	56	56	50
Pyrmont	1-5 Harwood Street	58	48	43	57	54	51
	200 Paternoster Row	58	48	43	55	52	50
Hunter Street	50 Martin Place	58	48	43	69	66	63
Clyde and Rosehill[1]	9 A'Beckett Street, Granville	63	53	48	55	54	50

Note 1: Clyde and Rosehill facilities are located in existing industrial areas. The neighbouring residential receivers (identified in Section 5.12) are considered to be an industrial interface, attracting a + 5dB correction to the amenity noise criteria.

3.4.5 Other noise sensitive receivers

There are a range of other noise sensitive receivers, including commercial receivers and hotels. Throughout the design process a detailed investigation of each site would be required to confirm that all sensitive receivers have been considered and appropriate noise mitigation incorporated in the design.

Commercial receivers attract an amenity noise criterion of 65 dB(A) during hours of use.

Hotel receivers attract an amenity noise criterion 5 dB(A) above the applicable residential noise receiver. In some locations this approach would yield noise criteria greater than the commercial criterion of 65 dB(A). In this instance, the highest noise criterion is limited to 65 dB(A).

3.4.6 Low frequency noise correction

A difference of 15 dB or more between the C and A weighted noise measurements, identifies the potential for an unbalanced spectrum and an increased likelihood of low frequency noise annoyance.

The difference between C and A weighted noise levels is typically used as a screening tool to determine if further investigation is required to determine potential annoyance (i.e. where the difference is 15 dB or more). Where further investigation confirms significant low frequency content, a low frequency noise correction is applied to the predicted or measured noise levels.

The NPfI identifies that the corrections should “reflect external assessment locations”, or sensitive receiver locations so the existing noise environment should be considered. The tunnel ventilation fans typically have a difference in weighted C and A noise levels of 15 dB to 20 dB (dependant on the attenuator), so have the potential to trigger the low frequency noise correction. However, for existing high noise environments the correction would often not be triggered in practice.

The existing average ambient noise level is 13 dB higher than the background noise level. For some locations this is as large as 20 dB. A review has identified that by complying with the project noise trigger levels, the low frequency noise correction would not be required.

3.4.7 Draught relief shaft breakout noise

The draught relief shaft (DRS) is adjacent, or sometimes part of the tunnel ventilation system (TVS) and provides an air pressure relief from the movement of trains operating within the tunnel. When a train passes through the tunnel, the noise generated in the tunnel travels up the DRS and can be audible at the outlet, usually over a period of less than 9 seconds per event.

There is currently a gap in policy and guidelines for noise emitted via the DRS. As this is noise generated by operational railways, the noise emitted via the DRS could be considered to fall within the scope of the RING. The RING requires consideration of a maximum ($L_{AFmax,95th\ percentile}$) noise criterion for train passbys. However, given the trains are underground and predominantly shielded from nearby sensitive receivers the application of this criterion is debatable.

The noise from the DRS is intermittent and occurs only for a short period (about 30 seconds overall) over a 15-minute period, so it would not be correct to apply the NPfI $L_{Aeq,15min}$ noise criteria either.

The NPfI sleep disturbance criterion is based on the background noise during the night-time, which is typically during the early hours of the morning when trains and the DRS would not be operating. The application of the sleep disturbance noise criterion based on the NPfI would be unduly stringent and it would also be not necessarily appropriate to apply to the DRS event directly.

The EPA's Road Noise Policy provides a review of noise impacts from short term noise events, associated with sleep disturbance noise impacts. The document identifies that:

- maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep
- one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

With windows open, the noise reduction from outside to inside is typically considered to be 10 dB. Therefore, external noise levels L_{AFmax} 60 – 65 dB(A) are considered unlikely to awaken people. With windows closed, these levels can be higher.

This assessment has proposed a noise objective of L_{AFmax} 65 dB(A) as being a feasible and reasonable level that will provide adequate protection from noise generated by DRS events. To facilitate consistent DRS design parameters and locations where setbacks to future sensitive receivers is unknown it is proposed that the level of L_{AFmax} 65 be applicable at a set reference distance of 15 metres, or at the nearest existing development, whichever is the closer. With a criterion of L_{AFmax} 65 dB(A) at 15 metres, the noise level at sensitive receiver locations would typically be 55 dB(A) to 60 dB(A) across the project and would incorporate a one metre attenuator at some stations.

3.4.8 Emergency plant noise

In the absence of any relevant NSW guidance for emergency generators and equipment, it is recommended that noise limits in Table 3-11 and in Section 3.4.5 be relaxed by 5 dB for emergency plant equipment (given the equipment is not normally used, and only operates during an emergency situation or infrequent scheduled maintenance).

Scheduled maintenance would be completed during the daytime when more lenient noise criteria apply. The emergency noise assessment has also considered all plant operating simultaneously which would not occur in practice during plant testing.

3.4.9 Road traffic noise

There are no changes to the road network as part of this proposal. Consideration of road noise impacts is therefore not required.

3.4.10 Noise impacts on horses

The Clyde stabling and maintenance facility and the Rosehill services facility would be located to the south of the Rosehill Gardens racecourse. There can be a large number of horses stabled here at any one time and potential noise impacts on the horses should be considered.

There is currently no definitive guidance on the impact that noise can have on horses. However, it is well known that noise can evoke a panic reaction from horses. This varies from suddenly lifting the head, directing their ears towards the source and then immediately turning their ears away to turning and bolting, possibly combined with kicking towards the perceived danger. This can result in dangerous situations for caretakers and riders.

For horses, it is important that they can see each other, and preferably touch each other as well. A horse that is startled will immediately run towards other horses, because of its herd instincts. A horse that is alone will become startled more easily and will not sleep nor eat as much in a noisy environment. Alongside this, horses learn which things are frightening, and which are not from each other.

A paper by Huybregts titled “Protecting Horses from Excessive Music Noise - A Case Study” observes that horses in stables exposed to $L_{Aeq,15min}$ of 54 to 70 dB generally show little response to music noise unless the noise is particularly impulsive. A noise criterion of L_{Aeq} 65 dB was recommended.

Importantly, the likelihood that a horse would have a panic reaction is dependent on the horse’s familiarity with the source. As per Huybregts’ paper, horses have been reported grazing in fields near airport runways with little reaction to planes taking off directly overhead.

For the purposes of this Environmental Impact Statement, the stabling area of the Rosehill Gardens racecourse has been assessed as a ‘passive recreation area’ (50 dBA) in accordance with the NPfI, or an ‘open area – passive use’ (65 dBA) in accordance with the RING. Based on the discussion above, achieving the NPfI noise levels means that it is unlikely that the proposal would generate a startle response in horses. However, further consultation with Rosehill Gardens racecourse and equine experts would be undertaken to better understand how any impacts from operational noise can be feasibly and reasonably managed.

4 Assessment methodology

4.1 Operational railway airborne noise

While the proposal is predominantly underground, there is a section of above ground track (approximately 530 metres long) connecting the main tunnels to the Clyde stabling and maintenance facility.

This track emerges from a dive structure to the west of the Rosehill Gardens racecourse and extends to the south. Once the alignment leaves the existing rail corridor, it enters the proposed Clyde stabling and maintenance facility (illustrated in Appendix D). The alignment from the dive structure to the Clyde stabling and maintenance facility perimeter must be assessed in accordance with the RING. All noise (including operational rail noise) generated within the Clyde stabling and maintenance facility is assessed as a fixed facility in accordance with the NPfI.

A noise assessment of the operational rail line has been completed in accordance with the RING. Notable sensitive receivers are the existing residential receivers on the west side of James Ruse Drive, and the Rosehill Gardens racecourse, which has been assessed as a passive use open space in accordance with the RING on the basis of discussion in Section 3.4.10.

4.1.1 Assessment approach

Airborne noise generated by the proposal has been modelled using SoundPLAN v8.2. This software uses ground elevation contour data, three-dimensional rail data, track features and train source noise information to develop a three-dimensional noise model.

The Nordic Prediction Method (Kilde Rep 130) noise propagation standard has been used to calculate the emission and propagation of airborne noise levels. This standard is commonly used in NSW due to its ability to calculate both $L_{Aeq,T}$ and L_{AFmax} noise levels. The algorithm has been validated across a wide range of projects and been proven to accurately predict noise at sensitive receivers for Australian conditions.

Two scenarios have been assessed, the year of opening (2030), and the design year (2040) ten years after opening.

4.1.1.1 Modelled scenario and rail volumes

The Clyde stabling and maintenance facility would provide capacity for 32 seven-car trains. The total length of each train is approximately 155 m.

Table 4-1 provides a summary of the predicted rail movements leaving and entering the stabling and maintenance facility during the daytime and night-time periods.

Table 4-1 Rail volumes

Track	Daytime (7am to 10pm)	Night-time (10pm to 7am)
Year of Opening – 2030		
Up (In)	6	12
Down (Out)	3	15
Year of Design – 2040		
Up (In)	36	12
Down (Out)	18	30

4.1.1.2 Train source noise levels

This proposal would use a new train fleet. It is currently too early in the design process for the train manufacturer to provide proposal-specific noise source levels to include in the noise model. In lieu of proposal-specific rolling stock noise levels, noise source data measured from the Metro North West Line has been used in the airborne noise model.

The Metro North West Line is a metro system which would likely incorporate a similar train type to Sydney Metro West. In the absence of supplier information, this is considered to be a reasonable base assumption. This data was also found to be generally consistent with the NSW Rail Noise Database for the newer EMU train types. Sydney Metro West would use a seven-car train.

The source levels are presented in Table 4-2.

Table 4-2 Source levels– reference 15 metre from ballasted track, 80 km/h

Type	Sound Exposure Level (SEL), dB(A)	$L_{AFmax,95th\ percentile}$, dB(A)
Metro	88	82

4.1.1.3 Tunnel openings

Train noise breakout from tunnel openings has been assessed in accordance with the Nord 2000 algorithm within SoundPLAN. The tunnel portal has been assumed to have a smooth concrete lining with little absorption. No sound absorptive walls are deemed to be required in tunnels on the approach to the portal opening.

The inputs associated with the connection tunnels which influence portal noise emissions are presented in Table 4-3.

Table 4-3 Portal noise model input parameters

Parameter	Correction, dB(A)
Shape	Semi-circle
Area	6 m wide, 3 m radius
Tunnel Lining	Smooth concrete surfaces; reflecting rail bed; 160 Hz to 1600 Hz – 0.08 sound absorption coefficient
Tunnel Length	Northbound: 743 m, Southbound: 796 m

4.1.1.4 Speed

Based on the current design, the design speeds are:

- 60 km/h in the connection tunnels
- 25 km/h in the stabling and maintenance facility.

Note that noise generated from the stabling and maintenance facility is assessed separately in Section 4.3.

4.1.1.5 Curves

No curves are present on the intervening above-ground alignment between the dive structure and the Clyde stabling and maintenance facility, which is the extent of the operational railway airborne noise assessment.

4.1.1.6 Turnouts

Discontinuities in the track due to turnouts create a localised increase in noise levels from the operational rail line. This increase in the noise source level is considered to act over 10 metres (five metres both sides of the turnout location). Table 4-4 provides a summary of standard crossings and applicable noise source corrections.

Table 4-4 Standard turnout corrections

Turnout type	Correction, dB
Standard	+6

Turnouts are present in the main alignment as trains enter or leave the main alignment through the connection tunnels. No turnouts are present on the intervening above-ground alignment between the dive structure and the Clyde stabling and maintenance facility.

4.1.1.7 Track

Standard ballasted track has been assessed between the dive structure and the Clyde stabling and maintenance facility. No correction factors which increase noise emissions are applicable to ballasted tracks.

4.2 Operational railway ground-borne noise and vibration

There is a potential for train-induced ground-borne noise and vibration impacts to be generated when trains operate on surface track or in underground tunnels near buildings. The interaction of train wheels rolling on rails causes the wheels and the rails to vibrate. The vibration in the rails propagates through the rail fasteners and sleepers into the tunnel wall and surrounding ground. This vibration can pass into building foundations and propagate throughout buildings. Impacts may manifest as disturbance to people due to tactile vibration and/or ground-borne noise, or interference with the functioning of vibration sensitive imaging equipment in medical and research facilities.

In most situations the ground-borne noise criteria are more difficult to meet than the vibration criteria and meeting the ground-borne noise criteria typically results in compliance with the vibration criteria. Both vibration and ground-borne noise impacts are assessed for the proposal.

4.2.1 Assessment approach

This section outlines the approach used to assess the potential operational ground-borne noise and vibration impacts of Sydney Metro West. The methodology closely follows the Federal Transit Administration (FTA) approach which is shown in Figure 4-1. Although the source and propagation model was developed using data from the Metro North West Line, it uses ground properties and building information from the Sydney Metro West alignment.

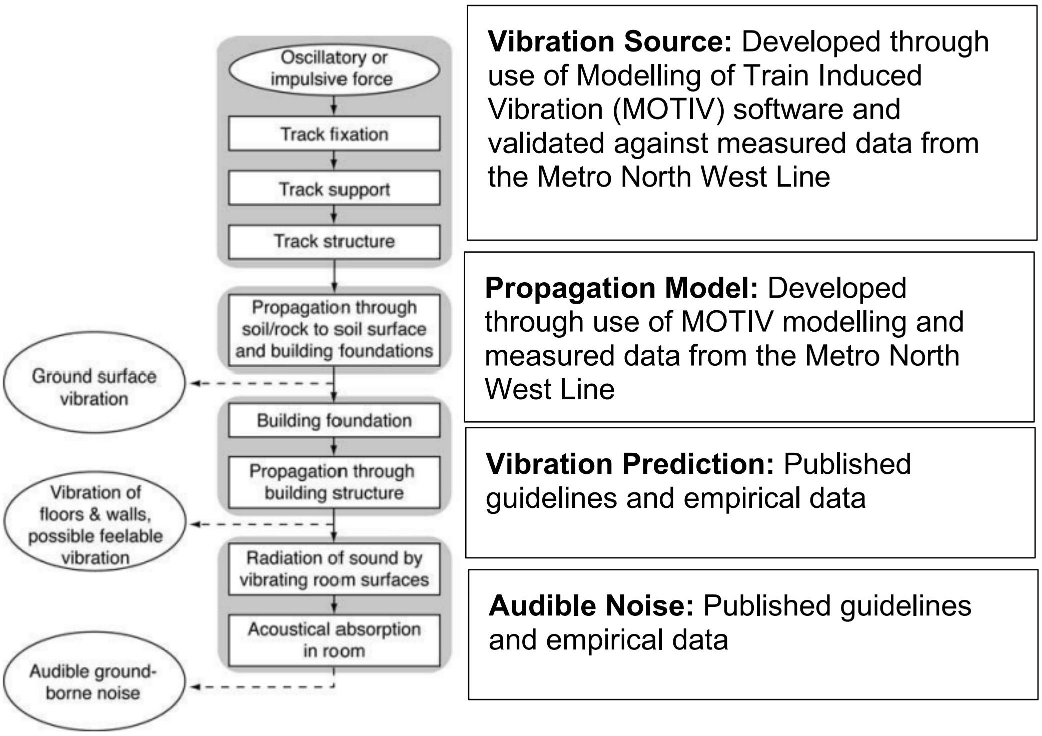


Figure 4-1: Flowchart of operational ground-borne noise and vibration modelling (source: FTA Guideline)

The following sections give a brief overview of the methodology and model inputs used in the operational ground-borne noise and vibration assessment.

4.2.2 Vibration source

The operational railway vibration source, used as an input to model and assess ground-borne noise and vibration impacts, is defined at a reference location 10 metres from the tunnel centre line in terms of its magnitude and frequency content. The vibration source is presented as a one-third-octave band vibration source spectrum with the vibration magnitude given as a function of frequency. The vibration source spectra for the project are dependent on several parameters such as track form types, source-receiver scenario (whether receiver buildings are located on the surface or have basements at subsurface level), train speed, and track features such as crossovers.

4.2.2.1 Track form types

The propagation of vibration from underground railway systems is primarily mitigated through the selection of an appropriate vibration isolating track form type. While the vibration isolation performance of a track form can provide benefits in terms of vibration attenuation, the trade-off is typically a higher cost, and for some systems, higher noise levels within the train carriage.

Figure 4-2 presents a summary of the track types (a – l) in order of increasing vibration isolation performance and cost. The track types considered in this report are:

- a) Ballast track systems – above ground sections only
- i) Resilient baseplates
- k) Floating slab track (continuous support) – also known as isolated slab track
- l) Floating slab track (discrete support).

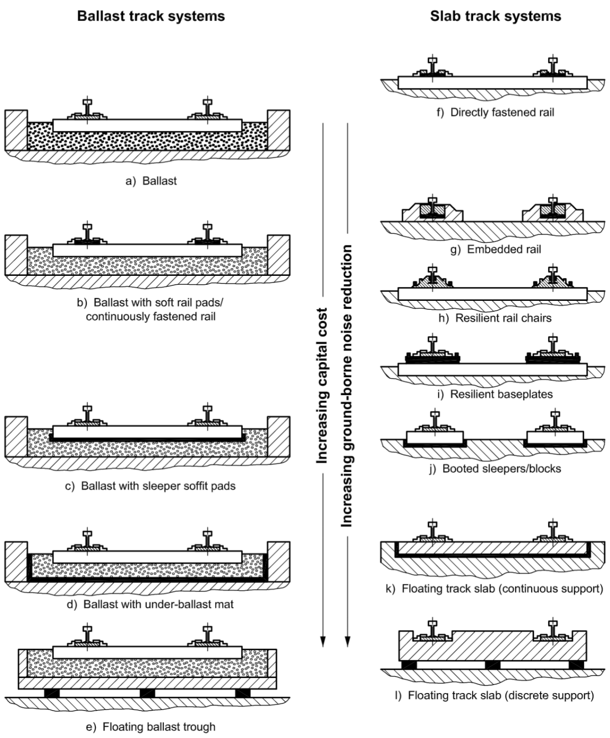


Figure 4-2: Generic track form layouts (Source: BS ISO 14837-1:2005 Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General guidance.

The track form types that have been considered in this ground-borne noise and vibration assessment are described in more detail as follows:

- **Surface track (Ballast):** Low-maintenance track fastening system will be utilised with reinforced concrete sleepers. The nominal stiffness of the HDPE rail pads is approximately 500 kN/mm. Shown in Figure 4-2 (a).
- **Standard Attenuation (Type 1):** Rail fasteners with static stiffness 22 kN/mm and dynamic stiffness 26.4 kN/mm. Rail pad stiffness in a range from 450 to 500 kN/mm. Shown in Figure 4-2 (i).
- **High Attenuation (Type 2):** Rail fasteners with static stiffness 6.5 kN/mm and dynamic stiffness 7.8 kN/mm. Rail pad stiffness in a range from 450 to 500 kN/mm. Shown in Figure 4-2 (i). Type 2A is a similarly performing system however constitutes a booted sleeper with similar stiffnesses. The system comprises Booted sleeper track form with mass of approximately 125 kg/block (approximately 250 kg/sleeper consisting of two blocks), in rigid plastic hulls. Block vertical support pads with a dynamic stiffness of 10 kN/mm per rails each. Rail pad stiffness in a range from 270 to 300 kN/mm. The fasteners are spaced at 650/700 mm centres. This system is illustrated in Figure 4-2 (j).
- **Very High Attenuation (Type 3A Track form):** Isolated Slab Track (IST) consists of rail fasteners with dynamic stiffness of 15 kN/mm, with each slab to sit on a ballast mat. The ballast mat shall have a dynamic bedding modulus of 0.03 N/mm^3. Shown in Figure 4-2 (k).

Additional track forms for Sydney Metro West which have been modelled:

- **Track form Type 1A:** Required due to limitations on static stiffness of fasteners at crossovers, a dynamic stiffness of 19.2 kN/mm has been modelled for the crossover sections of track. Shown in Figure 4-2 (i).

A type 60E1 (UIC60) rail was included in the model for each of the above track form types.

4.2.2.2 Source-receiver scenario

Vibration source reference spectra were developed for a location at 10 metre slant distance from the tunnel centreline using a MOTIV model for the track forms listed above and the different geotechnical conditions encountered along the alignment. Due to the presence of both buildings with foundations at surface and subsurface levels, separate vibration source reference spectra were used for the following source-receiver scenarios (Figure 4-3):

1. Tunnel to surface – used for receivers with building foundations located at surface level.
2. Tunnel to sub-surface – used for receivers with building foundations located subsurface with one or more levels of basement. Predictions to these receivers take into account the reduced transmission path length due to the presence of basements.

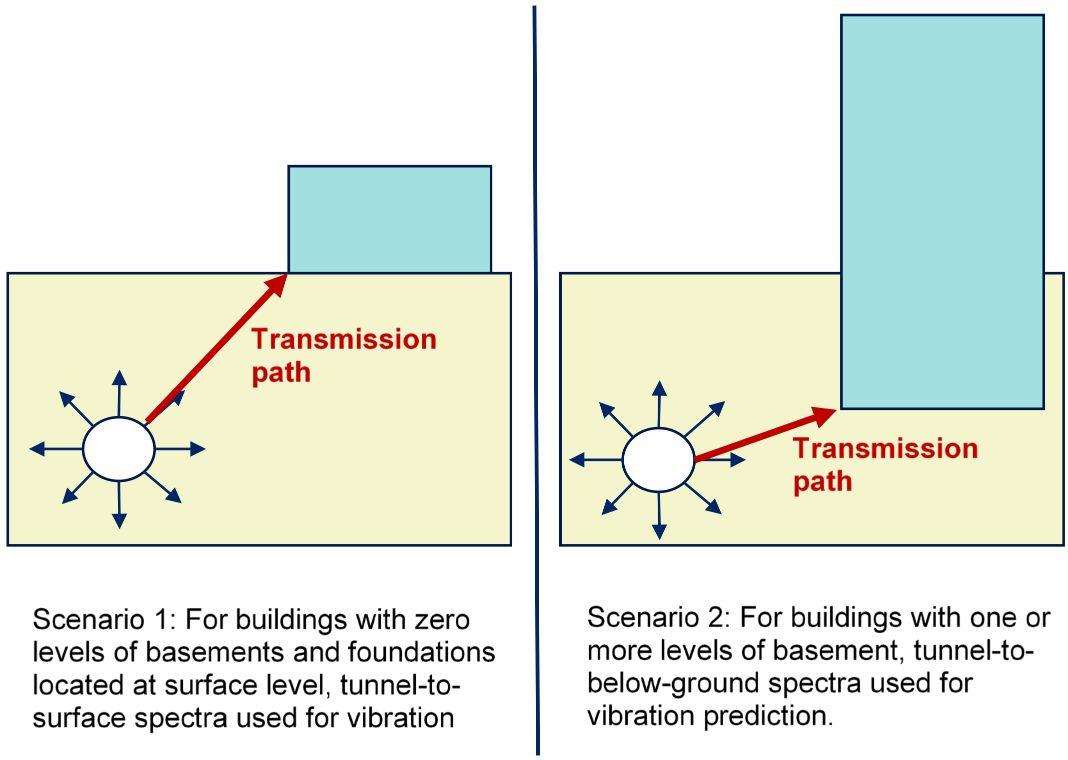


Figure 4-3: Vibration source level used based on presence of building basements

Vibration source spectra are shown below in Figure 4-4 to Figure 4-6.

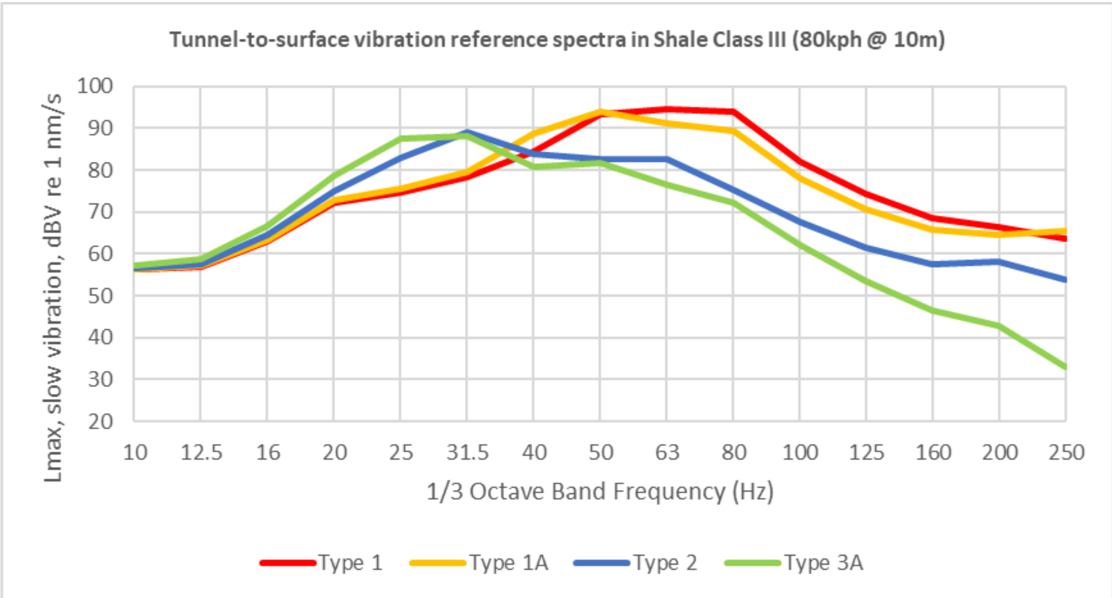


Figure 4-4: Tunnel-to-surface vibration reference spectra in Shale Class III

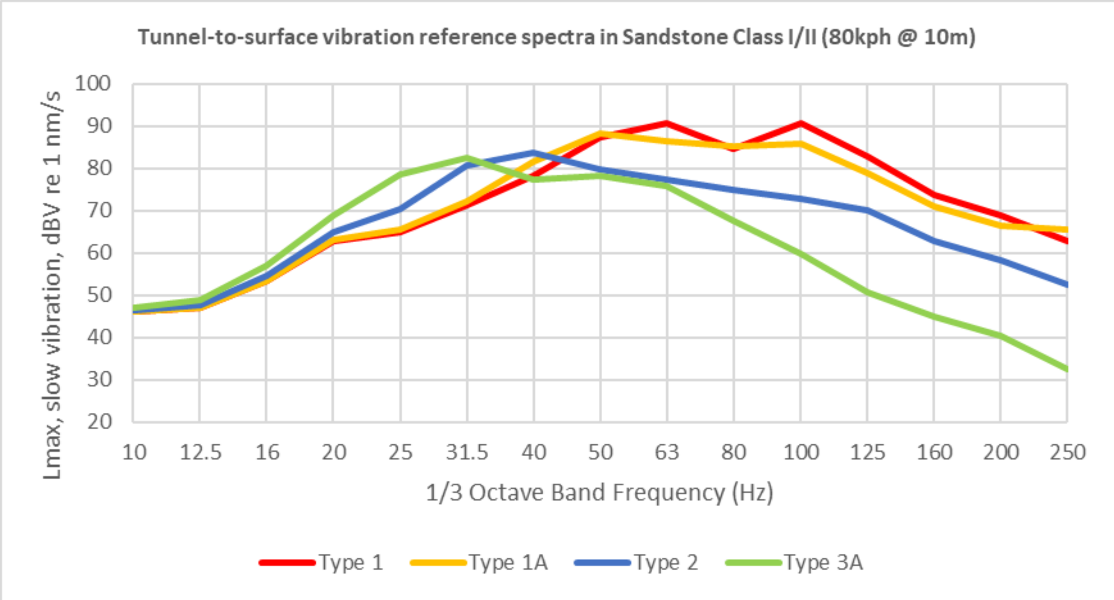


Figure 4-5: Tunnel-to-surface vibration reference spectra in Sandstone Class I/II

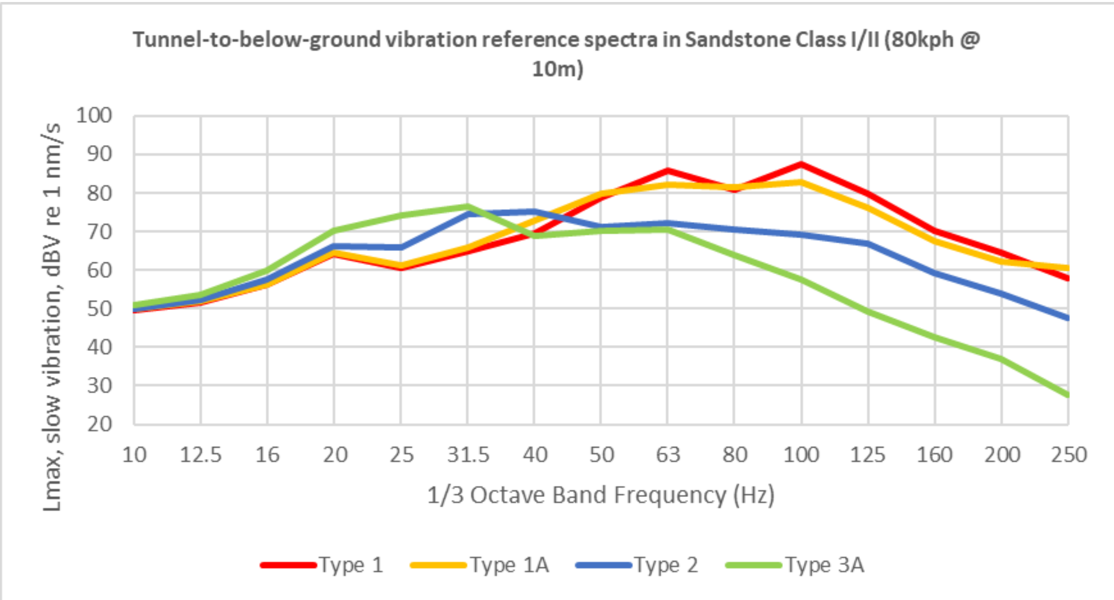


Figure 4-6: Tunnel-to-below-ground vibration reference spectra in Sandstone Class I/II

4.2.2.3 Speed profile and correction

The speed profile used in assessing the ground-borne noise and vibration impacts is illustrated in Figure 4-7. A minimum assessment speed of 60 km/h was used through stations.

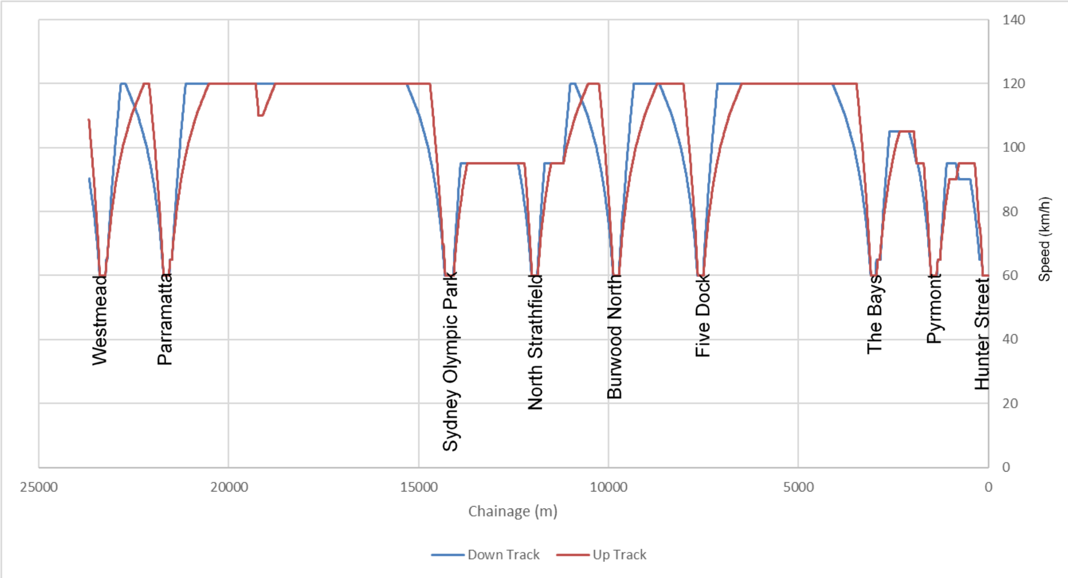


Figure 4-7: Operational speed profile

The vibration source spectra outlined in the previous section are for a train speed of 80 km/h. Adjustment for various speeds along the alignment has been made using the following formula based on the FTA Transit Noise and Vibration Impact Assessment Manual:

$$V_{adjusted} = V_{reference} + 20\log_{10}\left(\frac{speed}{80}\right)$$

4.2.2.4 Curve effect

A source adjustment of +5 dB was applied to all one-third-octave band centre frequencies to predict ground-borne noise and vibration levels for curved sections of track with a radius of less than 450 metres.

4.2.2.5 Turnout/crossovers

Turnouts and crossovers represent sections of track that introduce a discontinuity to the rail. This discontinuity at the crossing results in an increase in ground-borne noise and vibration compared to continuously welded rail. To account for this, a +5 dB crossing adjustment has been implemented within the model at one-third- octave band centre frequencies between 10 Hz and 200 Hz, with a +10 dB adjustment at 250 Hz based on measurements undertaken on the Metro North West Line at the Castle Hill crossover.

4.2.3 Vibration propagation

4.2.3.1 Ground properties

The geotechnical properties and ground lithology throughout the alignment have been represented in the MOTIV model based on the results of geotechnical investigations undertaken for Sydney Metro West and wave speeds from similar projects. The dynamic ground properties relevant to the MOTIV modelling of ground-borne noise and vibration are summarised in Table 4-5.

Table 4-5: Ground properties used within MOTIV for modelling of ground-borne noise and vibration

Layer	Density (kg/m^3)	Damping loss factor	P-wave speed (m/s)	S-wave speed (m/s)
Ashfield Shale Class III	2,200	0.05	1,400	800
Sandstone Class I/II	2,400	0.05	2,550	1,450

4.2.3.2 Geometric spreading

The vibration propagation methodology has been based on the principles of BS ISO 14837-1:2005 ‘Mechanical vibration -- Ground-borne noise and vibration arising from rail systems -- Part 1: General guidance’ and uses ISO 10137:2007 ‘Basis for design of structures – Serviceability of buildings and walkways against vibrations’ as a basis for decoupling the components of geometric attenuation and material damping.

The combined effects of both geometrical spreading and material damping can be described by the following equation (based on the propagation model in ISO 10137:2007):

$$A_2 = A_1 \left(\frac{r_1}{r_2}\right)^n e^{\propto(r_1 - r_2)}$$

Where A_1 is the amplitude of ground vibration at distance r_1, A_2 is the amplitude of ground vibration at distance r_2, n is the geometric spreading term and α is the material damping coefficient. A geometric spreading coefficient of n = 0.5 has been selected for the rail line source as part of the broad-scale vibration prediction.

4.2.3.3 Material damping loss

A review of material damping was previously undertaken as part of the Sydney Metro Chatswood to Sydenham Environmental Impact Statement (presented in Figure 4-8). These values have been adopted for Sydney Metro West.

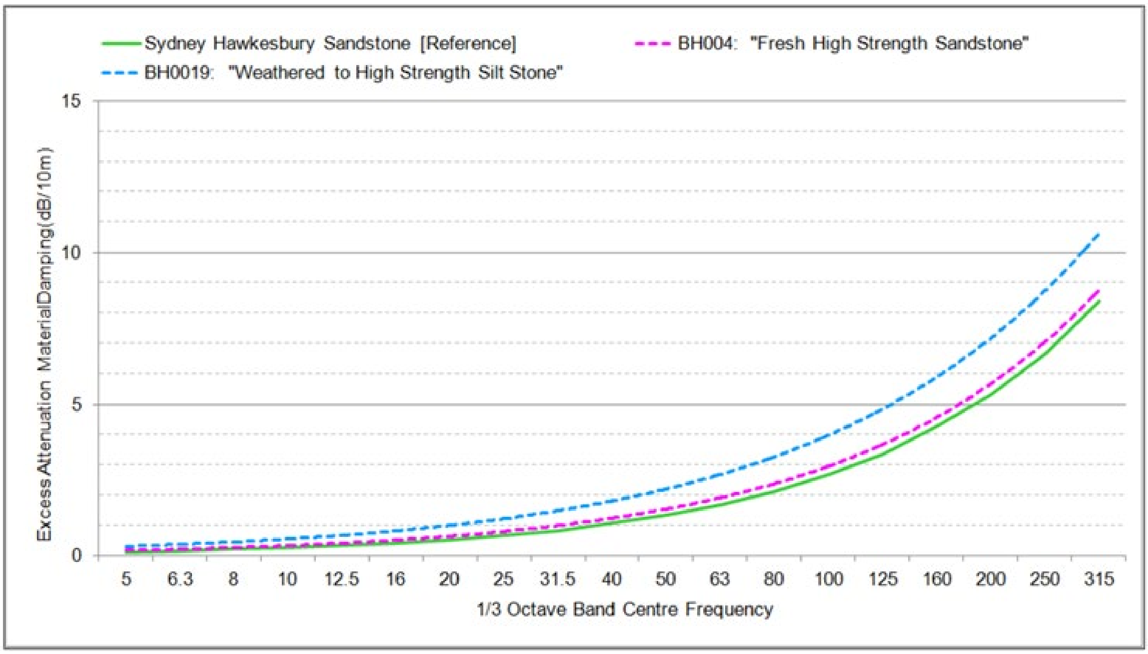


Figure 4-8: Material damping loss (Sydney Metro Chatswood to Sydenham Environmental Impact Statement, SLR 2016)

The above material damping has been applied up to distances of 40 metres from the tunnel centre line, beyond which material damping impact 'rolls-off' and will have reduced impact (i.e. non-linear effects mean that beyond 40 metres half of the Figure 4-8 values have been used) due to reduced attenuation at low strain values.

4.2.3.4 Reflection from lower layers

For a tunnel located in close proximity to a layer of harder ground below, there is a potential for vibration waves to be reflected from the harder soil layer towards receivers located on the surface (Figure 4-9).

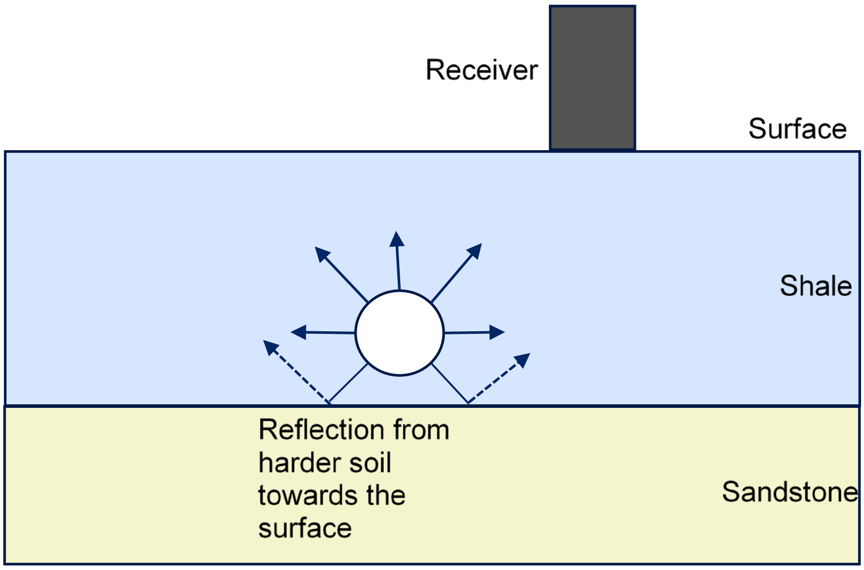


Figure 4-9: Reflection from lower layers

To account for this effect, a reflection gain of +2 dB has been included in this assessment where there is a hard reflective layer beneath the tunnel.

4.2.3.5 Amplification through upper layers

When the tunnel is located in a layer of relatively hard soil beneath a layer of softer soil, amplification may be generated when vibration passes from the harder soil to the softer soil on top. This is illustrated in Figure 4-10.

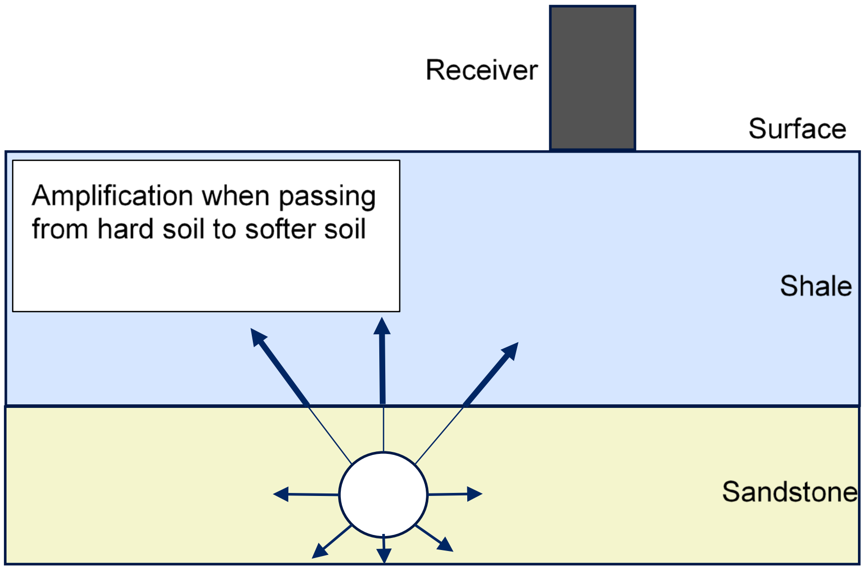


Figure 4-10: Amplification through upper layers

An amplification gain of +3 dB has been implemented in the broad-scale propagation model where there is a softer shale (or other similar residual layer) with a minimum depth of five metres above the ground layer in which the tunnel is located.

4.2.4 Vibration prediction

4.2.4.1 Building coupling loss

Building coupling loss factors have been referenced from the FTA Transit Noise and Vibration Impact Assessment Manual for residential receivers as shown in Table 4-6.

Table 4-6: Foundation vibration relative to ground vibration (FTA Manual)

	10 Hz	13 Hz	16 Hz	20 Hz	25 Hz	32 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz
Single family residential	2	3	4	5	5	5.5	5.5	5.5	5	5	4.5	4.5	4	3.5	3
1-2 storey residential	4.5	6	7	7.5	8	8.5	8.5	8	8	7.5	7.5	7	6.5	6	5
2-4 storey masonry on spread footing	7	8.5	10	11	11.5	12	12.5	12.5	12.5	12	11.5	11	10.5	9.5	8

The following approach has been implemented in the ground-borne noise and vibration prediction methodology when applying building coupling loss (Figure 4-11):

- A coupling loss of zero has been implemented for all buildings along the alignment with more than one basement level, assuming that the building foundations are founded in the same bedrock as the rail tunnel (irrespective of building use/type)
- A coupling loss corresponding to the most conservative 'Single Family Residential' curve of the FTA Manual (approximately -5 dB from 20 Hz to 125 Hz) has been implemented for all receptors (including residential, commercial, industrial, etc.) along the alignment with one or no basement level, assuming that the footings are not directly coupled into the same bedrock as the tunnel.

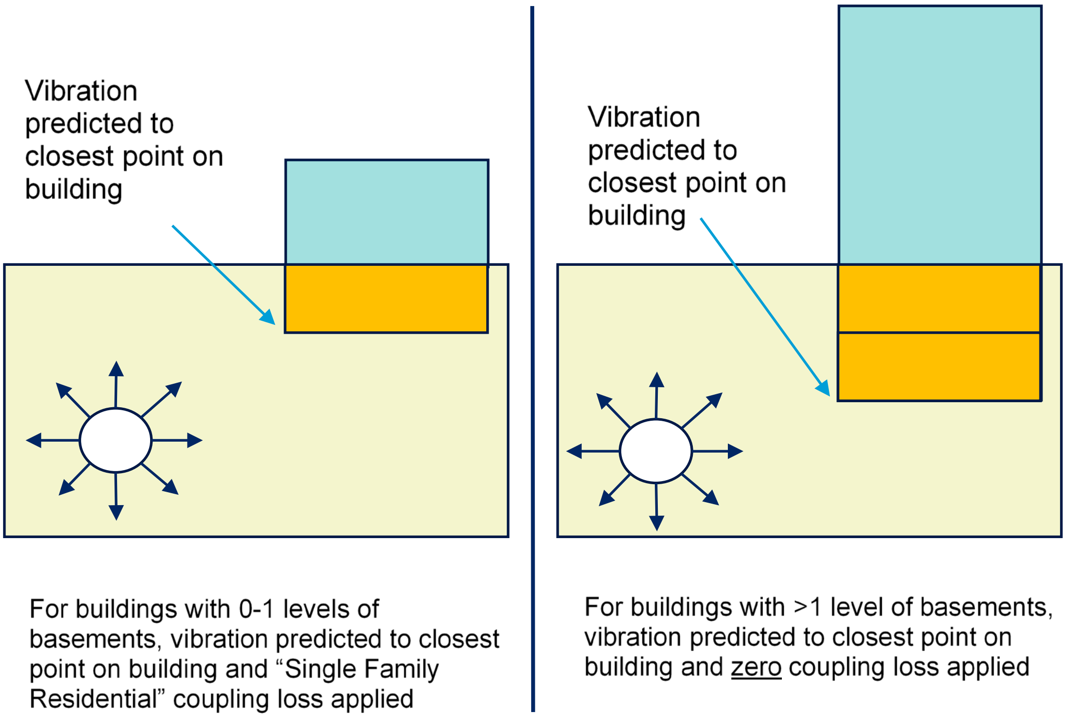


Figure 4-11: Application of building coupling loss for buildings based on number of basement levels

4.2.4.2 Floor amplification

The approach for building amplification is to use separate amplification adjustments for floor vibration and ground-borne noise based on Nelson (1987) 'Transportation Noise Reference Book', and FTA noise and vibration guideline. Floor vibration amplification adjustments are summarised in Table 4-7. These factors have been applied to all buildings.

Table 4-7: Floor vibration and ground-borne noise amplification adjustment factors, dB

	10 Hz	13 Hz	16 Hz	20 Hz	25 Hz	32 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz
Floor vibration	10	10	10	10	11	11	11	10	9	9	8	7	6	5	4
Ground-borne noise	6	6	6	6	7	7	7	6	6	5	5	4	3	2	1

4.2.4.3 Transmission through the building

Due to variability in reported vibration attenuation levels from floor to floor, a conservative approach where no attenuation or reduction in vibration for floors above the foundation has been used in this assessment (i.e. the predicted ground-borne noise and vibration level in the lowest basement of the building is assumed to be the same as for all other floors/levels).

4.2.5 Conversion from floor vibration to ground-borne noise

A conversion constant of -27 dB was applied at each one-third-octave centre frequency to convert predicted floor vibration levels to ground-borne noise based on the Association of Noise Consultants Guidelines (2012).

4.2.6 Vibration dose value

The methodology described in Assessing vibration: a technical guideline was used to estimate the vibration dose value (VDV) for comparison with human comfort criteria.

4.3 Clyde stabling and maintenance facility airborne noise

4.3.1 Overview

The Clyde stabling and maintenance facility would ultimately provide capacity for 32 trains for Sydney Metro West and would include a maintenance shed, wash plant, wheel lathe, and offices. The Clyde stabling and maintenance facility would operate 24 hours a day, seven days a week. The Rosehill services facility would provide tunnel ventilation fans to the main alignment, and a substation. This facility has been assessed combined with the Clyde stabling and maintenance facility due to their proximity to each other and combined impact on receivers.

4.3.2 Model

The noise modelling algorithm, The Propagation of Noise From Petroleum And Petrochemical Complexes To Neighbouring Communities (CONCAWE, 1981) has been implemented in the environmental noise modelling software SoundPLAN (Version 8.2) to develop a noise model of the site.

A three-dimensional representation of the physical environment within the study area was developed where modelling inputs included topography, ground and air absorption, locations of sensitive receivers, noise-generating equipment, and buildings.

4.3.3 Meteorology

As per the NPfI, meteorological conditions need to be considered for the assessment. Two types of meteorological conditions are defined in Table D1 of the NPfI and are reproduced in Table 4-8.

Table 4-8 Meteorological conditions as per NPfI

Meteorological conditions	Meteorological parameters
Standard meteorological conditions	Day/evening/night: stability categories A-D with wind speed up to 0.5 m/s at 10 m AGL
Noise-enhancing meteorological conditions	Daytime/evening: stability categories A-D with light winds (up to 3 m/s at 10m AGL) Night-time: stability categories A-D with light winds (up to 3 m/s at 10 m AGL) and/or stability category F with winds up to 2 m/s at 10 m AGL

In accordance with the NPfI, noise enhancing meteorological conditions have been assessed. A conservative approach has been taken which considers source-to-receiver wind vectors for all receivers and F class temperature inversions with wind speeds up to 2 m/s at night.

4.3.4 Noise sources

The noise sources and corresponding sound power levels used in this assessment under a worst-case 15-minute operational scenario are detailed in Table 4-9. These sources are based on noise levels from other recent Sydney Metro stabling and maintenance facility noise assessments.

Table 4-9 Clyde stabling and maintenance facility $L_{Aeq,15min}$ noise sources

Noise source	Sound Power Level per item	Details
Train noise sources		
Train air compressor	92 dB(A)	Under floor, two units for each train set at 0.5m height; Modelled along length of train; Operates for 5 min over a 15 min period; also known as APU compressor
Train static inverter	83 dB(A)	Top of train, two units per train set located at 4m height; also known as CVS
Train air-conditioner	86 dB(A)	Top of train; two units per car, located at 4m height; under 'high' cooling
Non-train noise sources		
Train lift noise[1]	74 dB(A)	Operates for 120 sec in any 15 min period; 1 per road per 15 min; 10 items for 10 roads
Impact wrench[1]	90 dB(A)	Ingersoll-Rand 8049 Unit; 2 items

Noise source	Sound Power Level per item	Details
Train Warning System[1]	110 dB(A)	Train Warning Alarm (BBS-107 per road; Ambient noise sensing (<15 dB(A) above background); 5min operation for a 15 min period; Value presented is corrected for 15 min 1 train entering per 15 min period; 2 items per train
Forklift[1]	90 dB(A)	Forklift (5 tonne with Broadband reverse alarm 'Quacker'; 2 items) Truck idling (Continuous source - no correction for duration; Truck in loading dock inside building)
Train wash plant	83 dB(A)	Level is applicable to each plant facade based on the following condition: The noise level emitted from the plant while operating under the worst conditions shall not exceed 75 dB(A) when measured at a distance of 1 m from any part of the train wash. This includes blowers to dry train after washing.
Wheel lathe	98 dB(A)	The noise level emitted from the wheel lathe under all working conditions shall not exceed 80 dB(A) when measured at a level of 1.5m above floor level and at any point 3 m away from the wheel lathe
Substation	105 dB(A)	1 unit - 3 phase transformer (SWL 101 dB(A)) and 1 phase transformer (SWL 96 dB(A); 2 units spread over the footprint of the substation; includes SFC container, cooling and control container, 3 phase filter and 1 phase filter and 2nd tuned reactor
Rosehill services facility	78 dB(A)	Tunnel ventilation fan exhaust: atmosphere side attenuator incorporated
Building AC Units	83 dB(A)	Liebert LSF70 Outdoor Air-cooled Condenser for Signal Equipment Room Maintenance Facility – 6 units on Roof OCC and Administration Building - 2 units on roof Infrastructure and Maintenance Building – 2 units on roof

Note 1: These sources are located within the maintenance facility shed; the shed is assumed to be of a solid construction with a sound insulation rating exceeding Rw 26 (e.g. sheet metal) with an assumed volume of 173,360m^3; the mean sound absorption coefficient, α of the building is assumed to be 0.1 based on the expected hard finishes; and the main train entry doors are left completely open for a worst-case noise break-out scenario.

The maximum noise sources for the sleep disturbance assessment is provided in Table 4-10.

Table 4-10 Clyde stabling and maintenance facility maximum noise sources

Noise source	Sound Power Level, L_{max}	Details
Brake air release	105 dB(A)	At end and underneath train

4.3.5 Scenarios

The two scenarios assessed are the year of opening and the year of design and noise sources at the stabling roads are described below in Table 4-11. For consistency with the rest of the proposal, Year 2040 is the design year.

Table 4-11 Train noise sources for a 15-min worst-case scenario at the stabling roads

Location	Year of opening - 2030	Year of design - 2040
Stabling roads	2 trains undergoing preparation or shutdown	3 trains undergoing preparation or shutdown
Track leading to stabling roads	2 trains leaving or entering the stabling roads	3 trains leaving or entering the stabling roads

In summary, the two worst-case scenarios have been modelled as follows:

- Year of opening – all the non-train sources in Table 4-9 and the year of opening train sources (including L_{max} noise as per Table 4-10) described in Table 4-11
- Year of design – all the non-train sources in Table 4-9 and the year of design train sources (including L_{max} noise as per Table 4-10) described in Table 4-11.

The need for noise mitigation measures was considered based on the year of design impacts at the nearest sensitive receivers.

4.3.6 Operations

To achieve the initial commencement of service frequency, trains would enter service from out-stabled locations at terminating stations. During normal operation, it is expected a total of six trains would be out stabled at the terminating stations stub tunnels and platforms (three trains at Westmead metro station and three trains at Hunter Street (Sydney CBD) Station.

The train launch strategy for the AM and PM peaks envisages trains departing the Clyde stabling and maintenance facility to commence operations at Westmead metro station and Hunter Street (Sydney CBD) Station at 10-minute intervals building up to a day one headway of four minutes between trains. The same process would be used at the end of the peak periods as trains return to the Clyde stabling and maintenance facility. All trains would be operational on the alignment by 7 am.

During the off-peak window, trains would undergo routine maintenance, cleaning and servicing in the Clyde stabling and maintenance facility. Trains arriving from revenue service would be automatically stabled in the stabling tracks where daily cleaning would take place. Trains scheduled for rotational exterior washing would be routed through the automatic train wash.

Stabled trains would be placed into ‘sleep’ mode on arrival at the stabling track berth. Upon receiving the command, the train would turn off the saloon lighting and air-conditioning and lower the pantographs, resulting in no noise emissions from stabled trains.

The Automatic Control Area (ACA) where trains would be under fully automatic operation controlled by the Depot Controller consists of:

- The access tracks from the main line including the wash shed
- The headshunt
- The stabling yard
- The trackwork as far as the changeover point.

The Manual Control Area (MCA) consists of the “maintenance” areas of the facility. This encompasses both the train and infrastructure maintenance sidings, the wheel lathe, the biological / graffiti cleaning area and the test track. Within this area trains would be driven manually at restricted speeds under ‘line of sight’ driving principles. It has been assumed that while operating within the MCA the use of horns would not be required and alternate safety practices would be used to warn of approaching trains.

Under a worst-case 15-minute noise scenario, it is assumed that 2 trains would undergo preparation at the stabling roads during the early morning period between 5 am and 7 am.

4.4 Stations airborne noise

4.4.1 Overview

There are a range of noise sources associated with the operation of an underground metro station. While the Tunnel Ventilation System (TVS) typically produces the highest noise impacts, other noise sources can add to the overall noise environment. Table 4-12 provides a summary of other noise sources associated with the operation of a station, in addition to the TVS. Note there are no airborne noise sources which would occur below ground, which are not enclosed.

Table 4-12 Typical noise sources

Element	Description
Thermal plant	A station thermal central plant, located within and dedicated to each above ground and underground station, would supply chilled water, condenser water, and refrigerant cooling for Environmental Control Strategies (ECS) services. The chilled water system would consist of three variable speed water cooled chillers and three dedicated variable speed primary-only chilled water pumps.
Air handling units	Air handling units would provide 100% outside air to platforms and enclosed concourse circulation areas. Variable speed fans would be used to achieve a constant full design volume airflow as static pressure increases with dirtier filters.
Air-conditioning of permanently occupied station staff areas	Permanently occupied spaces, such as back of house staff operational areas, would be served by dedicated variable refrigerant flow (VRF) local fan coil units with air-cooled VRF condensing units.
Critical equipment room	Critical equipment rooms, including emergency plan critical station rooms, signalling rooms, tunnel ventilation motor control centre rooms, communications rooms, and uninterruptable power supply/battery rooms, would be provided with duty and standby cooling only equipment, e.g. duty-standby chilled computer room air conditioning units.
Ventilation	Dedicated outside and exhaust air fans, risers, louvres, and outside air filtration would be utilised to ventilate the underground stations from open air at ground level. These systems include back of house outdoor air supply, general exhaust/spill air, toilet ventilation, and uninterruptable power supply/battery room exhaust systems.

The hours of operation would be aligned to the Sydney Trains suburban rail network and the Sydney Metro network. It is anticipated that Sydney Metro West would generally operate from early morning to late at night. To accommodate for planned special events, operating hours could be extended as required.

Final operating hours would be determined as part of the development of service schedules for the metro line, taking into account maintenance access requirements, customer requirements and broader network considerations.

4.4.2 Assessment approach

Calculations have been undertaken of the highest noise emitters for each operational facility. For the stations these include the TVS, cooling towers, stair pressurisation fans, and the DRS noise breakout. Attenuators and louvres that are currently incorporated in the design have been included in the calculations to determine the noise impacts at nearby sensitive receiver locations.

Existing sensitive receivers have been assessed against the noise criteria presented in Section 3.4. In many cases there are additional developments proposed in the areas which are features of over and/or adjacent station developments, which fall outside the scope of this assessment.

Mechanical services noise

During normal operation, trains have been assumed to run according to the planned schedule. The tunnel network ventilation would be achieved by the piston effect of train movement and operation of the trackway ventilation system in the stations. The tunnel ventilation system provides natural ventilation within the tunnels, keeping train-induced air flows and pressures at a safe level and achieving comfort within the tunnels.

Typically, one track supply fan (TSF) on one end of the station and two track exhaust fans (TEF) on the other end of the station would operate to provide suitable ventilation. While this system is only required when trains are at the station, given the timing between trains it would operate near continuously.

During congested operations, trains are assumed to operate out of train schedule with delays expected. It is foreseeable that trains can be stopped in the tunnel and the natural airflow induced by train movement reduces. The TVS would be operated to prevent tunnel temperatures in the vicinity of stalled trains rising to levels where the trains air conditioning system would degrade. Typically, the direction of ventilation would be the direction of train travel; however, the system would be designed to allow for ventilation in both directions.

In the congested mode one TVS fan would operate, in addition to the TEF and TSF.

The TVS would also be required to manage smoke in the event of a fire incident within the tunnel or trackway areas to ensure suitable conditions in the tunnel for safe egress of customers and safe access for emergency services personnel. In the event of a fire incident in the running tunnels, the tunnel ventilation fans would generate longitudinal flow in the incident tunnel to control the movement of smoke, to provide safe egress from the fire location and to stop smoke migration into the non-incident tunnel. Smoke would be discharged to the atmosphere via ventilation outlets at the stations, and portal depending on the location of the fire incident. In the event of a fire incident in the platform trackway, the trackway ventilation fans would extract smoke from above the train and induce air flow from the station platforms into the incident trackway to provide safe egress routes within the station. Smoke would be discharged to the atmosphere via ventilation outlets at the station.

Separate mechanical ventilation systems would be provided within each underground station for heat removal and to provide fresh air. Full height platform screen doors assist in controlling underground station temperatures by physically separating the tunnel and station environments.

In terms of operational fans, the emergency mode would be similar to the congested mode with one TVS, one TSF and two TEFs operational.

For the purposes of a worst-case assessment only the congested mode and emergency mode have been assessed against the station noise criteria. Compliance with these operating conditions would result in compliance with the normal operating mode which has lower noise levels.

Cooling towers would operate continuously, however the load would vary depending on the time and heat load. It has been assumed that during the daytime up to two cooling towers would operate at 100% load. During the night-time period only one cooling tower would operate at 50% load.

The stair pressurisation fans would operate in emergency conditions only.

Table 4-13 provides a summary of the source noise levels considered in this assessment at each station.

Table 4-13 Source noise levels, sound power level, dB

Source	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Total (dBA)
150m^3/s TVS Fan	119	124	129	132	127	124	117	110	132
40m^3/s TSF & TEF Fan	109	107	111	114	113	109	107	102	117
Cooling Towers 100%	97	87	83	81	81	80	78	79	87
Cooling Towers 50%	80	79	80	81	81	80	78	79	87
Stair pressurisation fan	99	95	98	94	92	90	87	83	98

Noise attenuation including attenuators and louvres have been incorporated in the design (refer Section 6.3) and have been included in the calculations of noise impacts for each station.

Draught relief shaft

DRSs allow an air path connection from the tunnels directly to the surface. They are a means for train driven pressure relief and a source of air exchange between the surface and the tunnels, during normal operation.

Each DRS (at either end of the station) connects each running tunnel to the atmosphere. Draught relief dampers have been provided to allow the draught relief air path to be isolated during operation of the TVF.

Noise breakout from the DRS has been calculated based on the in-tunnel source noise levels presented below in Table 4-14. The in-tunnel noise levels have been calculated for trains operating within the tunnels in the vicinity of the DRS. The source levels assume that the train does not shield the source noise generated by the passby of the train. In practice there is likely to be some shielding except for a very short period when the train is approaching or receding from the DRS location, therefore these in-tunnel noise levels are expected to be conservative.

Table 4-14 L_{AFmax}, 95th percentile in-tunnel noise levels, dB

Source	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	dBA
In-tunnel noise levels	100	93	99	105	102	96	91	90	106

Assessment location

The specific location of the ventilation outlets would be refined throughout the design process. To provide a conservative assessment of potential impacts, the site has generally been assessed assuming the worst-case placement of the vent for each sensitive receiver. In practice one receiver may be subjected to the noise levels presented in the assessment, which would locate the source further from other receivers and yield lower noise levels than those presented here.

Future receivers

The assessment of future receivers which have not been approved such as over and/or adjacent station development is outside the scope of this Environmental Impact Statement. However, the noise generating plant has been designed to not limit future development. Appropriate attenuators have been incorporated in the design that are considered suitable for the proposed use and location of development surrounding each site.

5 Impact assessment

5.1 Operational railway airborne noise

5.1.1 Predicted noise impacts

Operational airborne noise levels have been predicted for Sydney Metro West rail operations on at-grade tracks using the approach and inputs documented in the previous section.

Noise contours are presented in Appendix B, and the predicted noise levels at the nearest sensitive receivers are presented in Table 5-1.

Table 5-1 Year of opening airborne noise levels – nearest sensitive receivers

Receiver	$L_{Aeq,15hr}$, dB(A)		$L_{Aeq,9hr}$, dB(A)		L_{AFmax}, dB(A)		Complies (Yes/No)
	Criteria	Prediction	Criteria	Prediction	Criteria	Prediction	
65 Penelope Lucas Lane, Rosehill (residential)	65	21	60	27	85	48	Yes
35-43 Penelope Lucas Lane, Rosehill (residential)	65	27	60	33	85	56	Yes
Nesuto Parramatta Apartment Hotel, 110-114 James Ruse Drive, Rosehill	65	28	60	34	85	56	Yes
Rydges Parramatta Hotel, 116-118 James Ruse Drive, Rosehill	65	23	60	29	85	53	Yes
Rosehill Gardens racecourse	65	35	NA[1]	42	NA[1]	67	Yes

Note 1: The Rosehill Gardens racecourse has been assessed as a passive recreation area. Night-time and maximum noise criteria do not apply to this use.

Table 5-2 Year of design airborne noise levels – nearest sensitive receivers

Receiver	$L_{Aeq,15hr}$, dB(A)		$L_{Aeq,9hr}$, dB(A)		L_{AFmax}, dB(A)		Complies (Yes/No)
	Criteria	Prediction	Criteria	Prediction	Criteria	Prediction	
65 Penelope Lucas Lane, Rosehill (residential)	65	28	60	29	85	48	Yes
35-43 Penelope Lucas Lane, Rosehill (residential)	65	33	60	35	85	56	Yes
Nesuto Parramatta Apartment Hotel, 110-114 James Ruse Drive, Rosehill	65	35	60	37	85	56	Yes
Rydges Parramatta Hotel, 116-118 James Ruse Drive, Rosehill	65	30	60	31	85	53	Yes
Rosehill Gardens racecourse	65	42	NA[1]	44	NA[1]	67	Yes

Note 1: The Rosehill Gardens racecourse has been assessed as a passive recreation area. Night-time and maximum noise criteria do not apply to this use.

The results provided show that there are no predicted exceedances of the applicable trigger levels. As the rail line emerges from the portals within the dive structure it would be below the local ground level. The sides of the structure would provide noise attenuation to nearby sensitive receivers. The vehicles would also be decelerating into the Clyde stabling and maintenance facility. This decreasing speed, coupled with the low rail traffic volumes travelling to and from the facility, results in relatively low rail noise levels. Further consideration of noise mitigation is not required.

5.2 Ground-borne noise and vibration

5.2.1 Ground-borne noise

Ground-borne noise predictions (95th percentile passby) have been generated for each of the following track form scenarios:

- Scenario 1 – Standard Attenuation Type 1 track form throughout tunnelled alignment
- Scenario 2 – High Attenuation Type 2 track form throughout with the exception of Type 1A (slightly lower stiffness than Type 1) over crossovers due to track performance requirements at these locations
- Scenario 3 — Very High Attenuation Type 3A track form throughout tunnelled alignment

Long sections showing predicted ground-borne noise levels vs chainage for each receiver for the three scenarios above are shown in Appendix E. Maps showing predicted ground-borne noise levels along the alignment are also presented in Appendix C. A count of receivers predicted to exceed ground-borne noise criteria is given in Table 5-3.

Scenario 1 (Figure E-1) consists of Type 1 track form throughout the tunnelled portion of the alignment. Figure E-1 shows large sections of the alignment where residential and commercial receivers (1125 receivers in total) are predicted to exceed the ground-borne noise criteria listed in Section 3.2 with the use of Standard Attenuation Type 1 track form. Therefore, Standard Attenuation Type 1 track form is not recommended for use in tunnels due to the risk of ground-borne noise criteria exceedance.

Scenario 2 (Figure E-2) shows compliance throughout most of the alignment for residential and commercial receivers. There is a total of 84 receivers predicted to exceed ground-borne noise criteria with High Attenuation Type 2 track form. The exceptions requiring further mitigation are:

- Receivers in the vicinity of crossovers where Type 1A is not sufficient to mitigate the impacts from crossovers
- Recording studios in the Sydney CBD and Pyrmont where High Attenuation Type 2 track form is not sufficient to meet the NR15 criteria at 4 studios.

Scenario 3 (Figure E-3) shows compliance with ground-borne noise criteria throughout the alignment. No further mitigation is necessary.

These three scenarios (track forms) would be combined to generate an optimised track form design that would achieve compliance with the applicable criteria listed in Section 3.2 for all receivers. Recommended vibration attenuation is discussed further in Section 6.2.

Table 5-3: Number of receivers exceeding ground-borne noise criteria

Category	Criteria	Scenario 1	Scenario 2	Scenario 3
Child Care	35 dB(A)	10	-	-
Commercial	40 dB(A)	143	5	-
Courts	30 dB(A)	11	-	-
Educational institution / School	40 dB(A)	39	-	-
Library	40 dB(A)	1	1	-
Mixed Use	35 dB(A)	12	-	-
Public Hall	35 dB(A)	1	-	-
Residential	35 dB(A)	898	74	-
Recording Studio	NR15	7	4	-
Place of Worship	40 dB(A)	3	-	-
Total		1125	84	0

5.2.2 Vibration dose value

Vibration dose value (VDV) plots for the three track form scenarios described in Section 5.2 are shown below in Figure 5-1 to Figure 5-6.

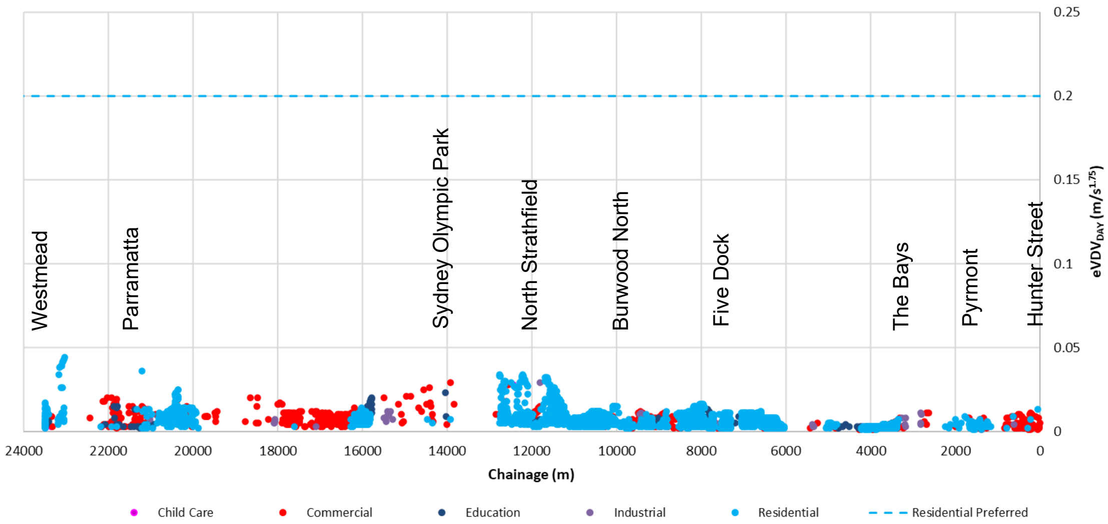


Figure 5-1: Scenario 1 day vibration dose value predictions

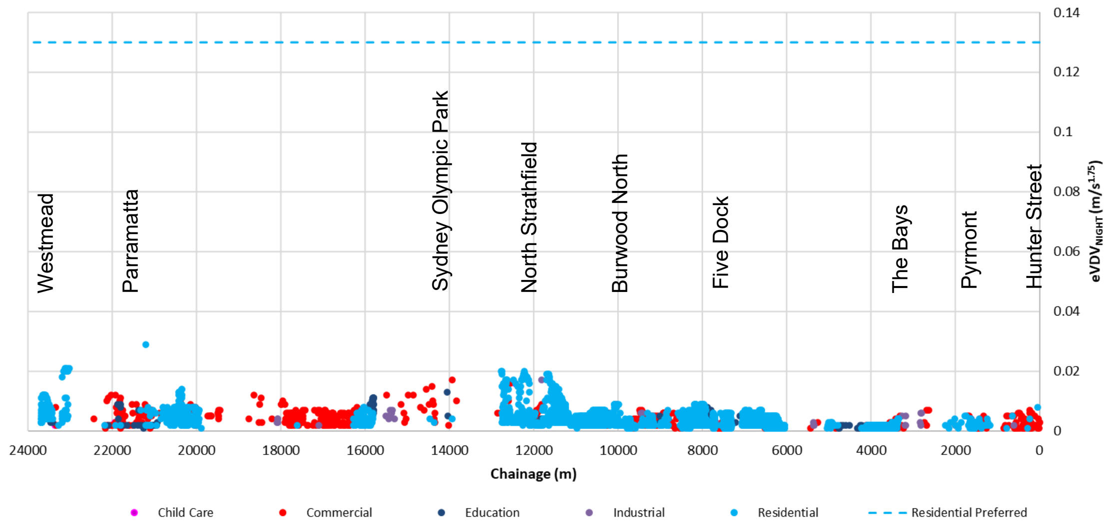


Figure 5-2: Scenario 1 night vibration dose value predictions

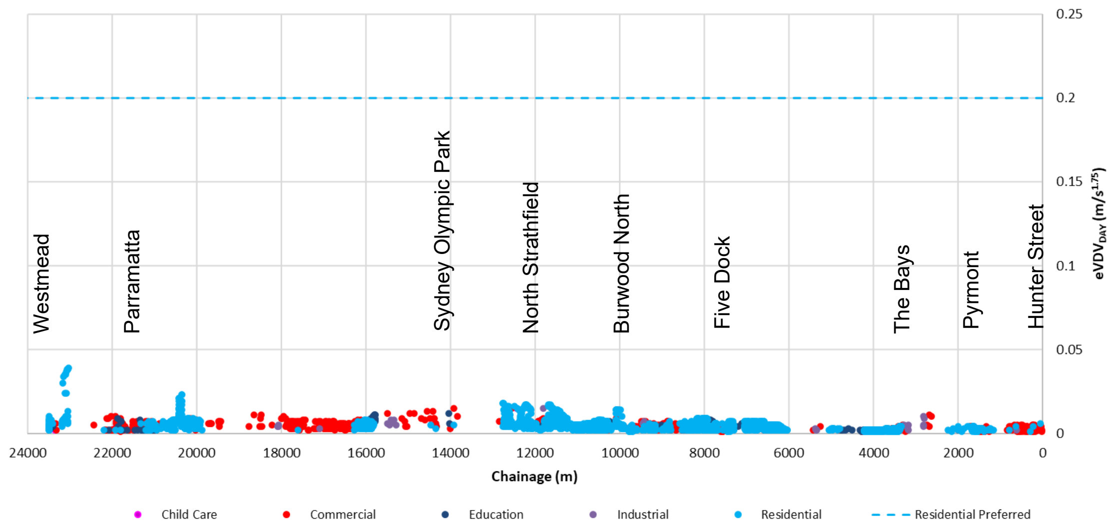


Figure 5-3: Scenario 2 day vibration dose value predictions

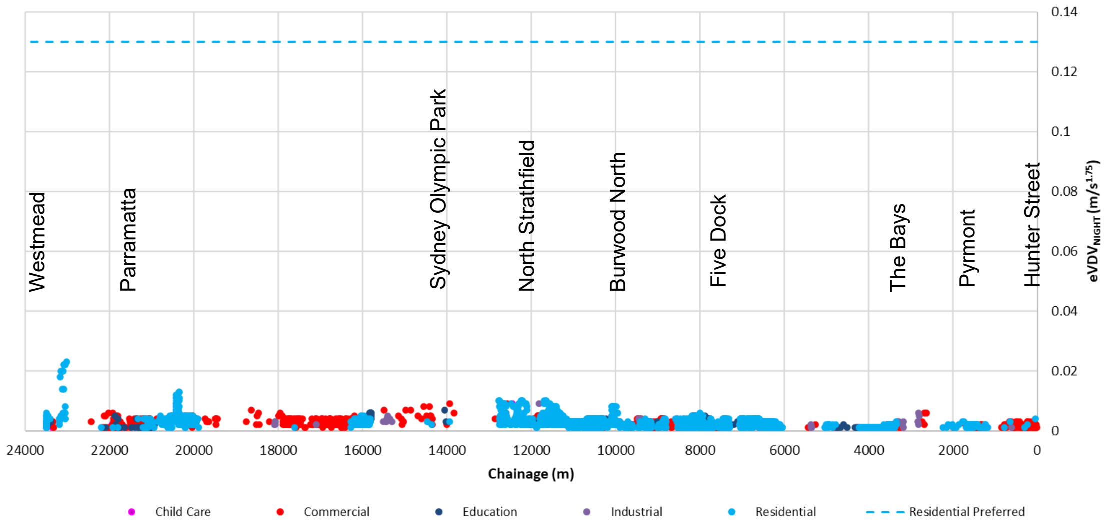


Figure 5-4: Scenario 2 night vibration dose value predictions

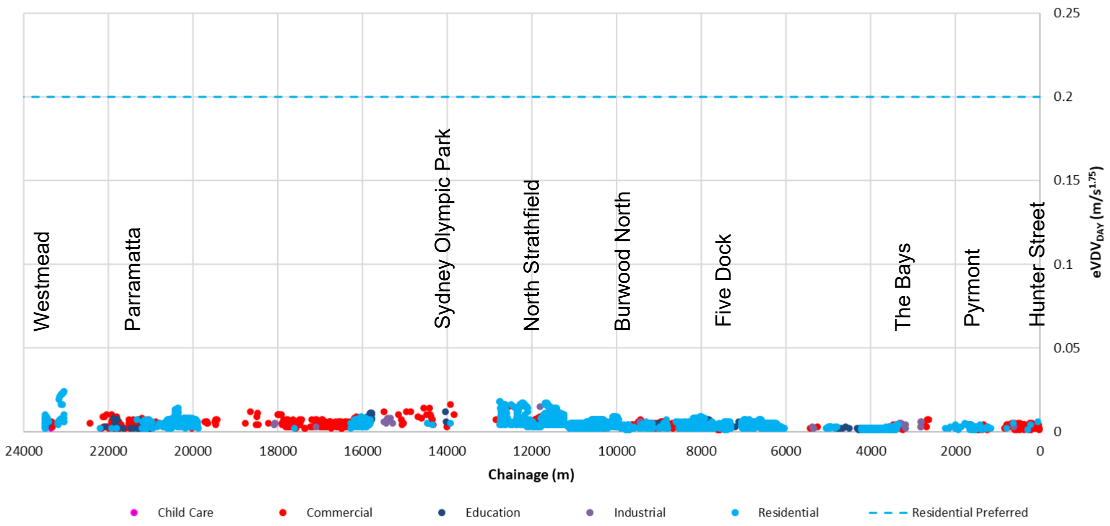


Figure 5-5: Scenario 3 day vibration dose value predictions

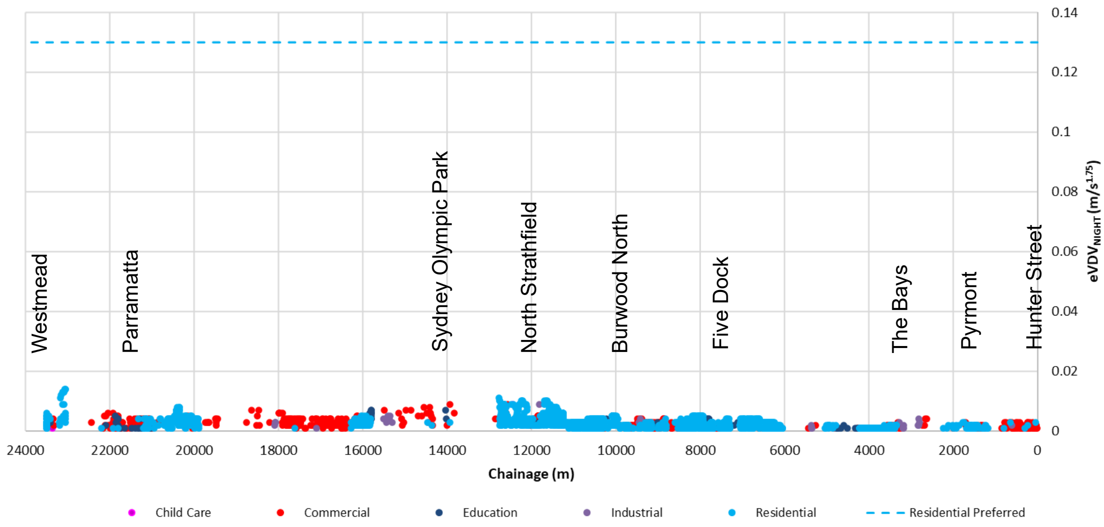


Figure 5-6: Scenario 3 night vibration dose value predictions

The results in Figure 5-1 to Figure 5-6 indicate the vibration dose values are well below the criteria for all track form scenarios. Mitigation measures would not need to be considered further. As identified in Assessing Vibration: A Technical Guideline, the level of vibration that affects amenity is much lower than that associated with building damage. No cosmetic damage is predicted due to metro operations.

5.3 Westmead metro station

5.3.1 Station overview

Westmead metro station would be located east of Hawkesbury Road and immediately south of the existing Westmead Station to provide a direct interchange with the T1 Western Line and the T5 Cumberland Line. The metro station would provide connectivity to the hospital precinct for pedestrians and through interchange with the future Parramatta Light Rail Stage 1.

Westmead metro station would provide increased accessibility to the Westmead employment, health and education precinct (which includes Westmead Hospital and Western Sydney University), as well as surrounding residential areas experiencing growth and renewal.

A pedestrian bridge located next to Hawkesbury Road would provide customers with access to the Sydney Trains and Sydney Metro platforms via entrance along Hawkesbury Road, from the west. The entrance would be connected via an unpaid pedestrian concourse located adjacent to the existing Hawkesbury Road bridge. Escalators and/or stairs and lifts would provide access to the Sydney Trains and Sydney Metro platforms. A paid underground concourse would be provided in a north-south orientation beneath Alexandra Avenue, connecting the aerial concourse, Sydney Metro and Sydney Trains services via lifts and escalators. Customers interchanging between the Sydney Metro network and the Sydney Trains network would do so within the paid area of the concourse.

Figure 5-7 provides the indicative layout of the station and surrounding precinct.

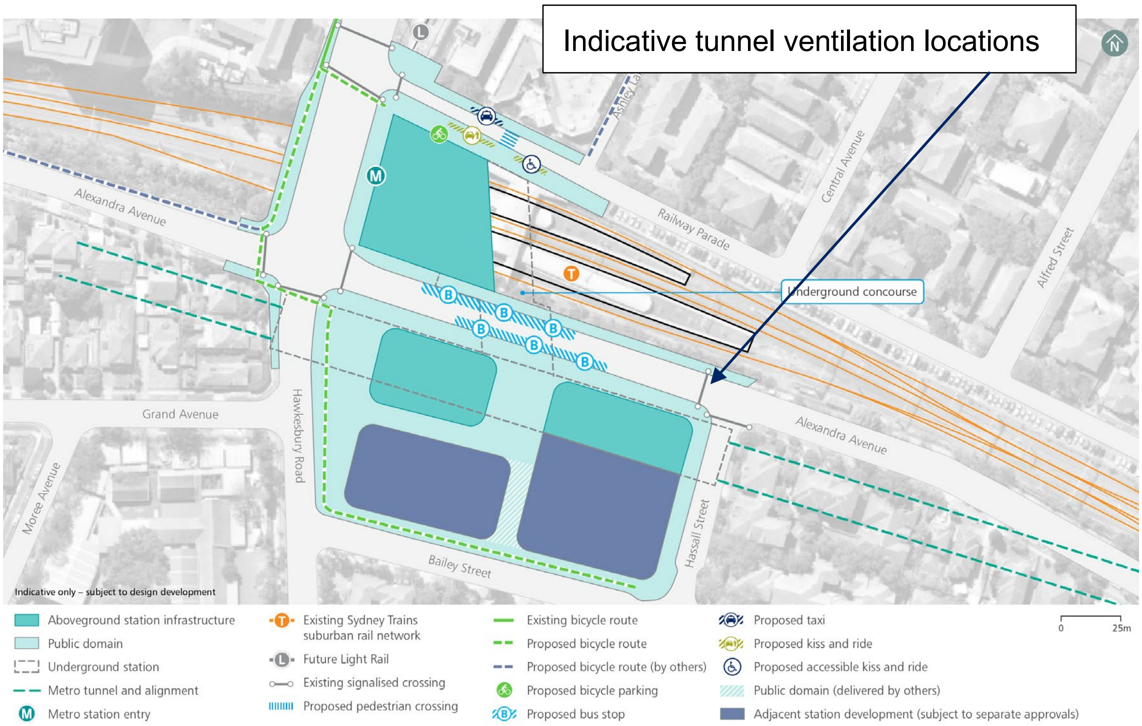


Figure 5-7 Westmead metro station indicative layout

5.3.2 Station noise criteria

Residential receivers are located to the north and south of Westmead metro station. Table 5-4 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-4 Westmead noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15 m, L_{AFmax}
Residential	Daytime	54	58	63	65
	Evening	52	48	53	65
	Night-time	42	43	48	65
Commercial	While in use	NA	60	65	NA

5.3.3 Predicted station noise impacts

Table 5-5 provides a summary of the predicted noise impacts from the main station generating noise sources.

Table 5-5 Westmead metro station noise impacts, $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draft relief shaft impacts at 15 m	65 L_{AFmax}	64
Railway Parade residential		
Daytime	54	43
Evening	48 (52[1])	43
Night-time	42	41
Emergency mode (all sources, including stair pressurisation fans)	47	42
Draught relief noise impacts	65 L_{AFmax}	50
Hassall Street residential		
Daytime	54	45
Evening	48 (52[1])	45
Night-time	42	41
Emergency mode (all sources, including stair pressurisation fans)	47	48
Draught relief noise impacts	65 L_{AFmax}	58
Bailey Street residential		
Daytime	54	42
Evening	48 (52[1])	42
Night-time	42	38
Emergency mode (all sources, including stair pressurisation fans)	47	43
Draught relief noise impacts	65 L_{AFmax}	52
Hawkesbury Road residential		
Daytime	54	45
Evening	48 (52[1])	45

Source	Criteria	Predicted noise level
Night-time	42	41
Emergency mode (all sources, including stair pressurisation fans)	47	47
Draught relief noise impacts	65 L_{AFmax}	56

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

The results indicate that noise levels are compliant with the applicable noise criteria. To achieve these noise levels noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

At Westmead metro station the sleep disturbance noise criteria is L_{AFmax} 52 dB(A). The noise from the DRS is predicted to exceed this criteria. It is noted that the DRS noise increases as a train approaches, and then decreases as a train passes. Therefore, it is not a typical source which would be assessed against the sleep disturbance noise criteria. This location is directly adjacent an existing rail network which has an L_{AFmax} noise criteria of L_{AFmax} 85 dB(A). Sensitive receivers are currently exposed to high L_{AFmax} noise levels from the existing railway.

At Hassall Street the noise from the DRS is predicted to exceed the sleep disturbance noise criteria by up to 8 dB(A), however it is considered unreasonable to design the DRS to a noise criteria over 30 dB more stringent than the noise criteria for the above ground rail line. The DRS noise criteria of 65 dB(A) at 15 metres is considered appropriate for Westmead metro station.

Sydney Metro is investigating the use, layout and grading of Alexandra Avenue between Hawkesbury Avenue and Hassall Street including the potential for this section of road to become bus, taxi and emergency vehicle only to improve the reliability of bus operations and the performance of the Alexandra Avenue / Hawkesbury Road intersection. This would require diversion of traffic via Hassall Street, Bailey Street and/or Priddle Street, and Hawkesbury Road. If this option was selected a traffic noise assessment would be required to determine the noise impacts. This option would change the functional class of the road which would reduce the applicable noise criteria. It is likely that some form of noise attenuation would be required. The nature of this noise mitigation would be dependent on the location of the impacted sensitive receivers, and the magnitude of the impacts.

5.4 Parramatta metro station

5.4.1 Station overview

Parramatta metro station would sit within the heart of the existing Parramatta CBD providing an additional piece of key transport infrastructure linking the Greater Parramatta and the Sydney CBD. The station would further reinforce Parramatta as Sydney's Central River City with a station located to support high-value employment growth and renewal in the commercial core.

The station design would accommodate the requirements of the metro station, respond sensitively and integrate to the context of the precinct and development above while offer an overall improved customer experience for commuters.

The Parramatta metro station would be an underground cut-and-cover station below the surface. An island platform would be oriented in an east west direction across the city block from Church Street in the west to Macquarie Lane in the east.

The indicative layout of the proposed station is illustrated below in Figure 5-8.

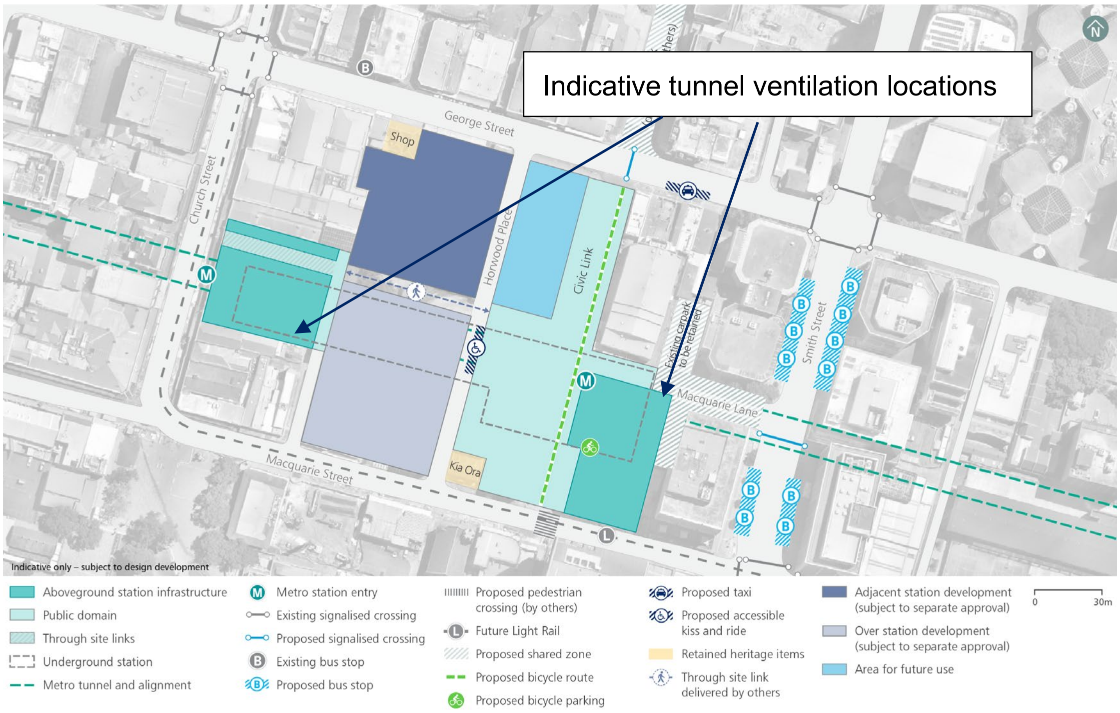


Figure 5-8 Parramatta metro station indicative layout

5.4.2 Station noise criteria

While the majority of receivers are commercial surrounding Parramatta metro station, there are a small number of other sensitive receivers. Leigh Memorial Church is located on the south side of Macquarie Street, and Western Sydney University is located on the corner of Macquarie Street and Smith Street.

Table 5-6 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-6 Parramatta noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15 m, L_{AFmax}
Residential	Daytime	63	58	63	65
	Evening	58	48	53	65
	Night-time	48	43	48	65
Commercial	While in use	NA	60	65	NA
Educational[1]	While in use	NA	40	45	NA
Worship[1]	While in use	NA	45	50	NA

Note 1: This criterion is internal, but has been assessed externally to be consistent with other receivers. An outside to inside noise reduction of 10 dB(A) has been assumed to account for a standard façade with windows open.

5.4.3 Predicted station noise impacts

Table 5-7 presents a summary of noise impacts from the proposed Parramatta metro station. Noise levels for the most affected receiver is presented below for each type and location.

Table 5-7 Parramatta metro station – $L_{Aeq,15min}$, dB(A) noise impacts

Source	Criteria	Predicted noise level
Draft relief shaft impacts at 15 m	65 L_{AFmax}	64
Adjacent commercial		
Daytime	60 (65[1])	58
Evening	60 (65[1])	58
Night-time	60 (65[1])	55
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	57
Macquarie Street church		
Daytime	45 (50[1])	48
Evening	45 (50[1])	48
Night-time	45 (50[1])	46
Emergency mode (all sources, including stair pressurisation fans)	50 (55[1])	47
Macquarie Street educational		
Daytime	40 (45[1])	41
Evening	40 (45[1])	41
Night-time	40 (45[1])	39
Emergency mode (all sources, including stair pressurisation fans)	45 (50[1])	40

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level.

The results indicate that noise levels slightly exceed the amenity target level at some receivers, however they are compliant with the amenity acceptance noise level. The educational facilities on Macquarie Street have sealed façade systems, so internal noise levels would be compliant with the amenity target noise levels in this instance.

The Macquarie Street Church may choose to leave its door open during services. However, as the exceedance is only marginal, it is likely that the final design can meet the internal noise amenity target level.

To achieve these noise levels, noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

5.5 Sydney Olympic Park metro station

5.5.1 Station overview

The Sydney Olympic Park metro station is located east of Olympic Boulevard between Herb Elliott Avenue and Figtree Drive, in close proximity to the heritage Abattoir Precinct to the north. The broader Sydney Olympic Park metro station precinct is proposed to be a thriving urban centre with a vibrant mix of homes and jobs as well as a premier destination for cultural, entertainment, recreation and sporting events.

Sydney Olympic Park metro station would consist of an underground cut-and-cover station with the platforms located below the existing surface level. The station would provide an island platform in a north-south orientation for day-to-day mode, and two side platforms that would provide increased capacity in event mode.

The services would be located on both the north and south station buildings. The indicative site layout is illustrated below in Figure 5-9.

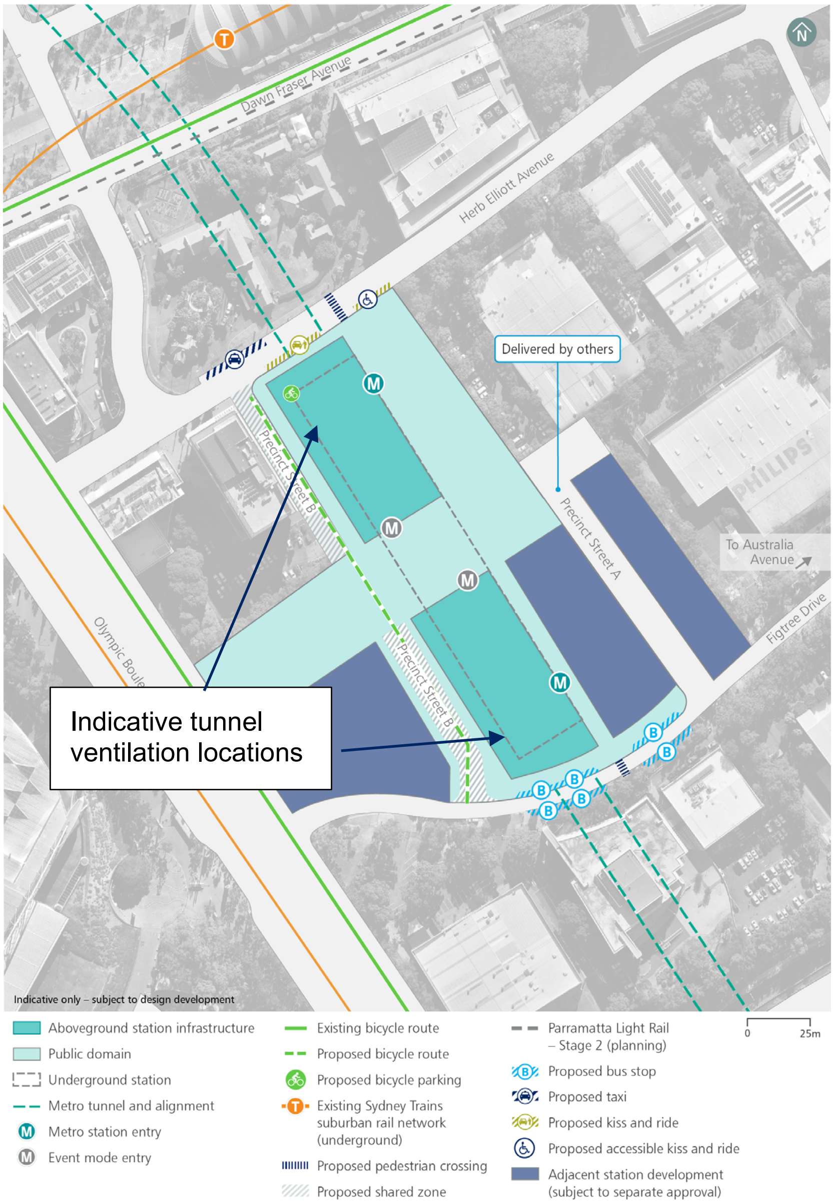


Figure 5-9 Sydney Olympic Park metro station indicative layout

5.5.2 Station noise criteria

Existing sensitive receivers are predominantly commercial, with some residential located further from the proposed site. The Ibis and Pullman hotels are also located in the general vicinity of the site, however they are shielded from the site by an existing commercial building.

Table 5-8 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-8 Sydney Olympic Park noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive criteria	Amenity target level	Amenity acceptance level	DRS at 15 m, L_{AFmax}
Residential	Daytime	53	58	63	65
	Evening	53	48	53	65
	Night-time	51	43	48	65
Commercial	While in use	NA	60	65	NA

5.5.3 Predicted station noise impacts

The nearest and most noise affected commercial and residential sensitive receivers have been assessed and results presented in Table 5-9. Noise levels for the most affected receiver are presented for each source type and location.

Table 5-9 Sydney Olympic Park metro station noise impacts - $L_{Aeq,15min}$, dB(A)

Source	Criteria	Predicted noise level
Draught relief noise impacts at 15m	65 L_{AFmax}	64
10 Herb Elliot Avenue, commercial		
Daytime	60 (65[1])	59
Evening	60 (65[1])	59
Night-time	60 (65[1])	55
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	60
2 Figtree Drive, residential		
Daytime	53	43
Evening	48 (53[1])	43
Night-time	43 (48[1])	40
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	48
Draught relief noise impacts	65 L_{AFmax}	40

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

The results indicate that noise levels are compliant with the applicable noise criteria. To achieve these noise levels, noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

At Sydney Olympic Park metro station the sleep disturbance noise criteria is L_{AFmax} 61 dB(A). At the nearest residential receivers, L_{AFmax} noise levels associated with the DRS are predicted to be 40 dB(A). Given compliance with the applicable noise criteria is achieved, further consideration of noise attenuation is not required at this location.

5.6 North Strathfield metro station

5.6.1 Station overview

North Strathfield metro station would consist of an underground cut-and-cover station with the platforms located below the existing surface level. The station box would be located to the west of Queen Street, directly east of the existing station.

An unpaid concourse located on Queen Street would provide customers with access to the Sydney Trains and Sydney Metro platforms. Escalators, stairs and lifts would provide access to the Sydney Trains and Sydney Metro platforms.

The station would be designed to provide natural light and ventilation to all front of house areas.

The North Strathfield metro station indicative layout is illustrated below in Figure 5-10. Areas for station services and utilities would be provided underground and within consolidated services buildings.

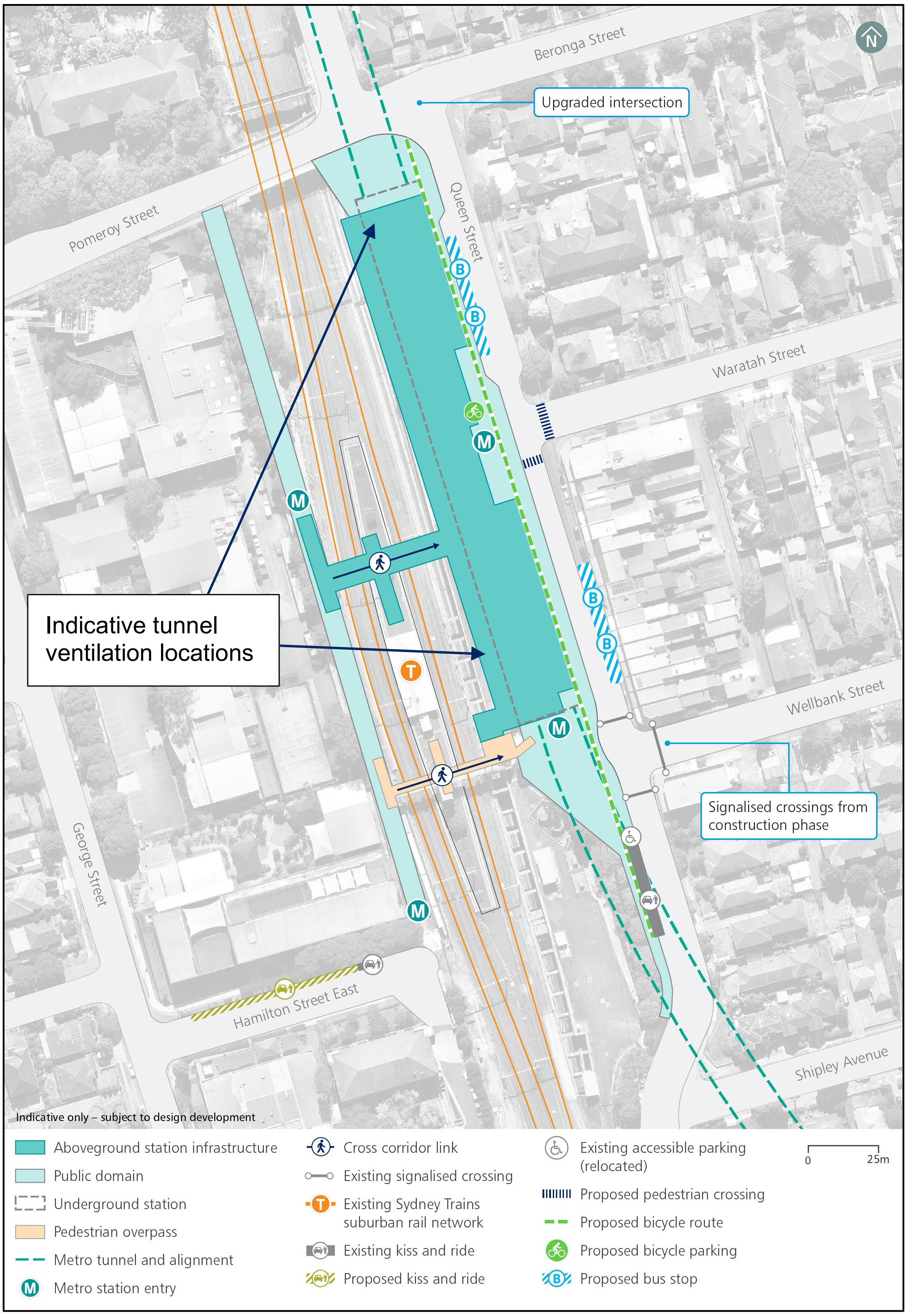


Figure 5-10 North Strathfield metro station indicative layout

5.6.2 Station noise criteria

Table 5-10 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

The most affected sensitive receivers are residential receivers located to the east on Queen Street. The McDonald College is located to the west on the other side of the existing rail line.

Table 5-10 North Strathfield noise criteria – $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15 m, L_{AFmax}
Residential	Daytime	56	58	63	65
	Evening	52	48	53	65
	Night-time	44	43	48	65
Commercial	While in use	NA	60	65	NA
Educational[1]	While in use	NA	40	45	NA

Note 1: The educational criteria is L_{Aeq} 35 dB(A) internal. An outside to inside noise reduction of 10 dB(A) has been assumed to account for a standard façade with windows open.

5.6.3 Predicted station noise impacts

The existing noise environment at North Strathfield is relatively quiet. The design process has concentrated on locating the noise sources so that the building structure provides suitable shielding, providing suitable noise attenuation to the most noise intensive plant.

Table 5-11 presents a summary of the predicted noise levels at North Strathfield. Noise levels for the most affected receiver is presented below for each type and location.

Table 5-11 North Strathfield metro station noise impacts – $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Queen Street residential		
Daytime	56	43
Evening	48 (52[1])	43
Night-time	43 (44[1])	37
Emergency mode (all sources, including stair pressurisation fans)	48 (49[1])	43
Draught relief noise impacts	65 L_{AFmax}	53
The McDonald College, George Street – education		
Daytime	40 (45[1])	39
Evening	NA	39
Night-time	NA	37
Emergency mode (all sources, including stair pressurisation fans)	45 (50[1])	45

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

The results indicate that noise levels are compliant with the applicable noise criteria. Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

At North Strathfield metro station the sleep disturbance noise criteria is L_{AFmax} 54 dB(A). The L_{AFmax} predicted noise levels associated with the DRS at the nearest sensitive receiver is 53 dB(A). Given compliance with the applicable noise criteria is achieved, further consideration of attenuation of the DRS noise path is not required.

5.7 Burwood North Station

5.7.1 Station overview

Burwood North Station would be located at the corner of Parramatta Road and Burwood Road with access from both the north and south sides of Parramatta Road. The site would be bound to the north by Burton Street and to the east by Loftus Street.

Burwood North Station would consist of an underground cut-and-cover station with the platforms located below the existing surface level. The station would provide an island platform in an east–west orientation. The station box would be located to the north of Parramatta Road.

Customers would access the station via two entrances on Burwood Road, one to the north and one to the south side of Parramatta Road. The two entrances would be connected via an unpaid pedestrian link below Parramatta Road open during station operational hours. Escalators, stairs and lifts would provide access from the platform to the below ground concourse areas, and onto the surface.

The station would be designed to provide natural light and ventilation. Areas for station services and utilities would be provided at the eastern and western ends of the station.

An indicative layout of Burwood North Station is provided below in Figure 5-11.

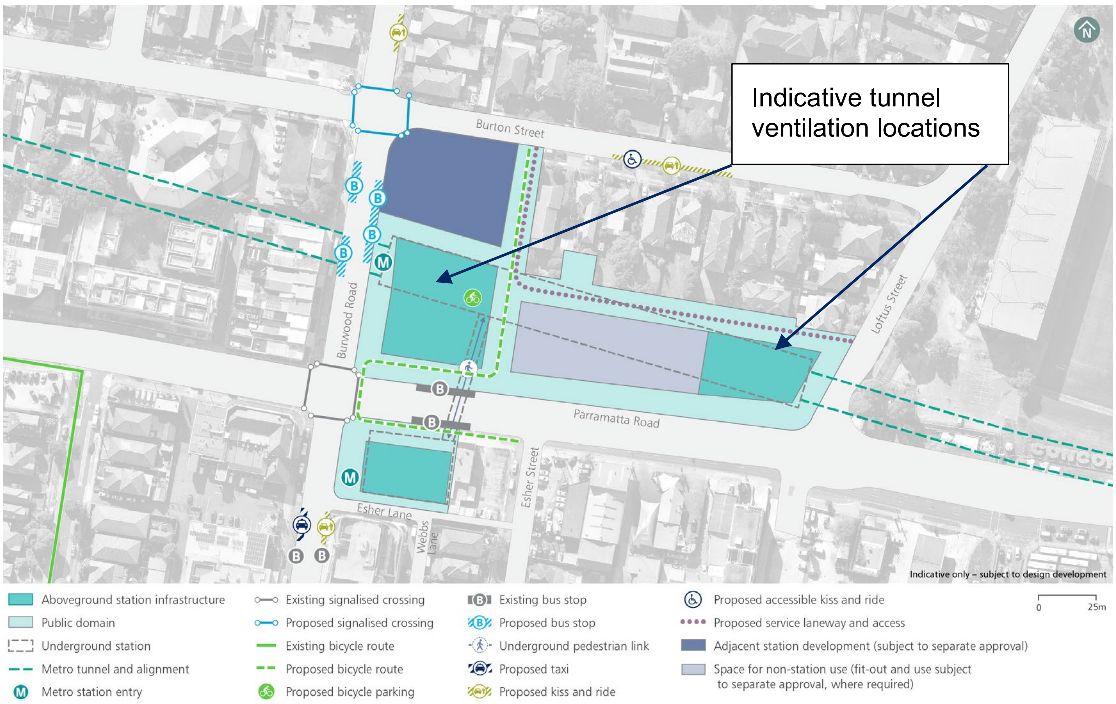


Figure 5-11 Burwood North Station indicative layout

5.7.2 Station noise criteria

The nearest sensitive receivers to the facility would be located to the north side on Burton Street, on the western side of Burwood Road, and a small number on the south side of Parramatta Road.

Table 5-12 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-12 Burwood North noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15m, L_{AFmax}
Residential	Day	53	58	63	65
	Evening	53	48	53	65
	Night	49	43	48	65
Commercial	When in use	NA	60	65	NA

5.7.3 Predicted station noise impacts

Table 5-13 provides the predicted noise levels at sensitive receiver locations surrounding the proposed facility. Noise levels for the most affected receiver is presented below for each type and location.

Table 5-13 Burwood North Station predicted noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Burwood Road Commercial (west)		
Daytime	60 (65[1])	50
Evening	60 (65[1])	50
Night-time	60 (65[1])	46
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	52
Burton Street Residential (north)		
Daytime	53	52
Evening	48 (53[1])	52
Night-time	43 (48[1])	50
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	52
Draught relief noise impacts	65 L_{AFmax}	53
North side of Burton Street Residential		
Daytime	53	42
Evening	48 (53[1])	42
Night-time	43 (48[1])	41
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	41
Draught relief noise impacts	65 L_{AFmax}	53
Paramatta Road Residential (south)		
Daytime	53	42
Evening	48 (53[1])	42
Night-time	43 (48[1])	41
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	44
Draught relief noise impacts	65 L_{AFmax}	52
Loftus Road Commercial (east)		
TVS (Including TVF, TSF, and TEF)	60 (65[1])	53
Mechanical Services – Daytime	60 (65[1])	53
Mechanical Services – Night-time	60 (65[1])	50
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	53

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level

The noise impacts for both sites are predicted to comply with the amenity target level at all but one location. Sensitive residential receivers directly to the north of the station are predicted to exceed the amenity target level, controlled by the cooling towers and TVS. Given the location and the proximity to the station building, it is very unlikely that there would be any other industrial noise sources introduced to the area in the future. There are considerable difficulties in achieving the amenity target level, including an additional floor being required for large attenuators. This may also lead to higher performance fans, with associated higher noise levels. The taller building is likely to lead to other issues such as over-shadowing and visual impacts. For this site it would be reasonable to use the amenity acceptance level, rather than the amenity target level. Noise levels at these receivers would comply with the amenity acceptance level, apart from a small exceedance during the night-time period.

These exceedances are due to the proximity of this receiver to the station services location at the eastern end of the northern site. The detailed design process would consider design solutions and measures to reduce these noise levels in order to comply with the amenity acceptance level. These measures may include re-positioning of plant and equipment locations, vent orientation, additional attenuators, acoustic louvres and at-property treatments. This location is expected to experience land use changes with these buildings potentially being redeveloped in the near future. In this case, compliance would be achieved by incorporating feasible and reasonable measures as part of the redevelopment.

Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

Further work would be undertaken throughout later design stages to confirm that compliance with the appropriate noise criteria is achieved as the design progresses.

At Burwood North Station the sleep disturbance noise criteria is L_{AFmax} 59 dB(A). The highest predicted noise impact is L_{AFmax} 53 dB(A), compliant with the noise criteria. This level is achieved predominantly by the arrangement of the TVS and directionality of the noise. Given compliance with the applicable noise criteria is achieved, further consideration of noise attenuation is not required.

5.8 Five Dock Station

5.8.1 Station overview

Five Dock Station would be located in the core of the Five Dock local centre off Great North Road with an entrance on Fred Kelly Place. Great North Road is the primary north-south spine through the locality leading from Parramatta Road to the peninsula suburbs of Abbotsford and Drummoyne.

Five Dock Station would consist of a mined cavern station with the platforms located below the existing surface level. The station would provide an island platform in an east–west orientation.

Five Dock Station would consist of two separate buildings, with the eastern building location on the corner of Waterview Street and Second Avenue and the western building located on Great North Road immediately south of St Albans Anglican Church. An indicative layout of Five Dock Station is provided in Figure 5-12.

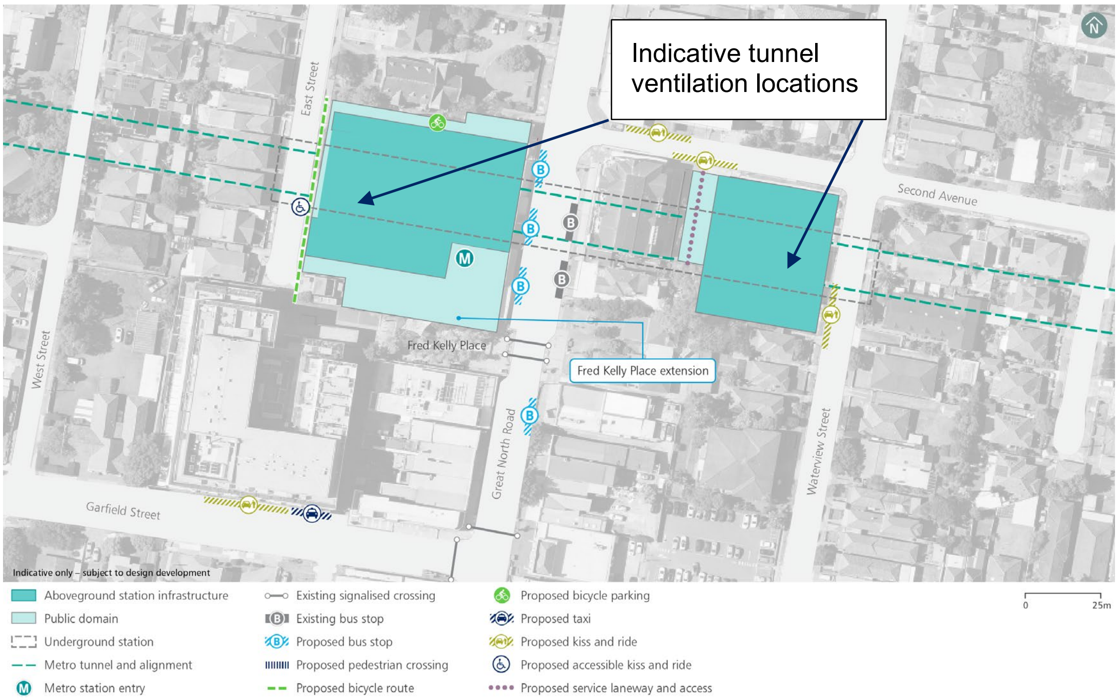


Figure 5-12 Five Dock Station indicative layout

Residential sensitive receivers are located on all sides of the facility. Noise mitigation in the form of attenuators and acoustic louvres has been included in the design to provide suitable attenuation of noise generated from the site.

5.8.2 Station noise criteria

The nearest and existing sensitive receivers are located on all sides of the eastern building, and to the east (Great Northern Road), south (Fred Kelly Place), and west (East Street) of the western station building.

Table 5-14 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-14 Five Dock Station noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15m L_{AFmax}
Residential	Day	48	58	63	65
	Evening	48	48	53	65
	Night	43	43	48	65
Commercial	When in use	NA	60	65	NA
Worship[1]	When in use	NA	45	50	NA

Note 1: This criterion is internal, but has been assessed externally to be consistent with other receivers. An outside to inside noise reduction of 10 dB(A) has been assumed to account for a standard façade with windows open.

5.8.3 Predicted station noise impacts

Table 5-15 provides a summary of the predicted noise impacts. Dominant services noise sources such as cooling towers are located on the western building, so have been excluded from the assessment of the eastern building. Noise levels for the most affected receiver is presented below for each type and location.

Table 5-15 Five Dock Station eastern site noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Second Avenue residential		
Daytime	48	40
Evening	48	40
Night-time	43	40
Emergency mode (all sources, including stair pressurisation fans)	48	48
Draught relief noise impacts	65 L_{AFmax}	53
Waterview Street residential		
Daytime	48	40
Evening	48	40
Night-time	43	40
Emergency mode (all sources, including stair pressurisation fans)	48	47
Draught relief noise impacts	65 L_{AFmax}	53
Waterview Street, southern residential		
Daytime	48	41
Evening	48	41
Night-time	43	41
Emergency mode (all sources, including stair pressurisation fans)	48	48
Draught relief noise impacts	65 L_{AFmax}	53
Great North Road residential receivers		
Daytime	48	41
Evening	48	41
Night-time	43	41
Emergency mode (all sources, including stair pressurisation fans)	48	48
Draught relief noise impacts	65 L_{AFmax}	53

Table 5-16 provides a summary of the predicted noise impacts of the western building. Based on the current design, the cooling towers are located on the eastern side of the building and tunnel ventilation exhausts vertically. Noise levels for the most affected receiver is presented below for each type and location.

Table 5-16 Five Dock Station western site noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
St Albans Anglican Church		
Daytime	45 (50[1])	45
Evening	45 (50[1])	45
Night-time	45 (50[1])	44
Emergency mode (all sources, including stair pressurisation fans)	50 (55[1])	50
Great North Road (east side) residential		
Daytime	48	42
Evening	48	42
Night-time	43	40
Emergency mode (all sources, including stair pressurisation fans)	48	48
Draught relief noise impacts	65 L_{AFmax}	53
Fred Kelly Place (south side) residential		
Daytime	48	42
Evening	48	42
Night-time	43	41
Emergency mode (all sources, including stair pressurisation fans)	48	46
Draught relief noise impacts	65 L_{AFmax}	53
East Street (west side) residential		
Daytime	48	38
Evening	48	38
Night-time	43	37
Emergency mode (all sources, including stair pressurisation fans)	48	48
Draught relief noise impacts	65 L_{AFmax}	53

Note 1: Where the amenity goal criteria cannot reasonably be achieved, the lower of the intrusive or maximum noise criteria is used.

Both the eastern and western station buildings would be located in close proximity to residential receivers. The design of the station has prioritised noise attenuation solutions to reduce the noise impacts to comply with the environmental noise criteria.

The noise impacts for both sites are predicted to comply with the design noise criteria, with the inclusion of appropriate noise attenuation measures. Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

At Five Dock Station the sleep disturbance noise criteria is L_{AFmax} 53 dB(A). The highest predicted noise impact is L_{AFmax} 53 dB(A), compliant with the noise criteria. his level is achieved predominantly by the arrangement of the TVS and directionality of the noise. Given compliance with the applicable noise criteria is achieved, further consideration of noise attenuation is not required.

5.9 The Bays Station

5.9.1 Station overview

The Bays Station is located within the heart of the Bays West urban regeneration area. This sits within the broader economic and Innovation Corridor stretching from the Central Station and the Sydney CBD, through Darling Harbour, Pyrmont, Ultimo, Rozelle and Balmain.

The Bays Station would consist of an underground cut-and-cover station with the platforms located below the existing surface level. The station would provide an island platform in an east–west orientation. The indicative layout and key design elements of The Bays Station are shown in Figure 5-13. A traction substation would be provided to the south west of the site.

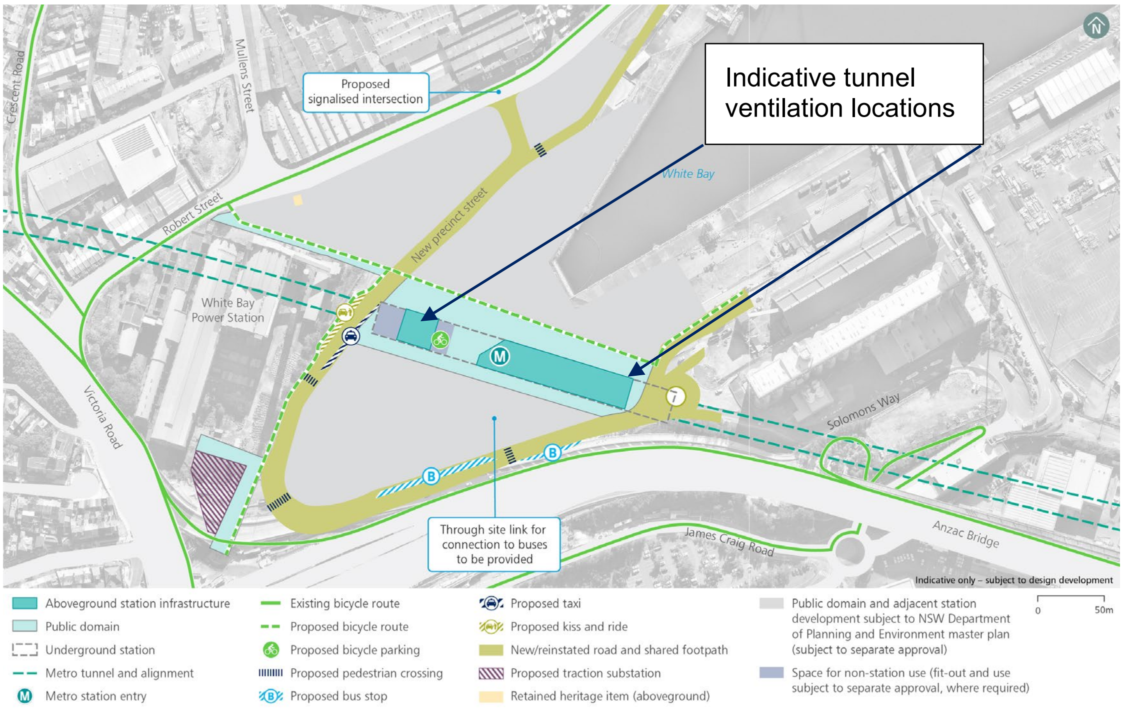


Figure 5-13 The Bays Station indicative layout

5.9.2 Station noise criteria

The nearest and most affected existing sensitive receivers are located to the north of the site on Mansfield Street in Rozelle, and to the west on Lilyfield Road and Hornsey Street, Rozelle.

Table 5-17 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-17 The Bays Station noise criteria - $L_{Aeq,15min}$ dB(A)

Location	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15m L_{AFmax}
North of station	Daytime	48	58	63	65
	Evening	48	48	53	65
	Night	40	43	48	65
West of station	Daytime	56	58	63	65
	Evening	56	48	53	65
	Night	50	43	48	65

5.9.3 Predicted station noise impacts

Table 5-18 provides a summary of the predicted noise impacts for the existing sensitive receivers. Noise levels for the most affected receiver is presented below for each type and location. Preliminary noise impacts for the traction substation have been included in these calculations.

Table 5-18 The Bays station predicted noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Lilyfield Road residential (west of station)		
Daytime	56	42
Evening	48 (53[1])	42
Night-time	43 (48[1])	42
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	43
Draught relief noise impacts	65 L_{AFmax}	35
Mansfield Street residential (north of station)		
Daytime	48	32
Evening	48	32
Night-time	40	31
Emergency mode (all sources, including stair pressurisation fans)	45	33
Draught relief noise impacts	65 L_{AFmax}	32

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Given the generous offset distances and existing high noise environment, the noise emissions from the station and substation are predicted to comply with the environmental noise criteria, with the inclusion of appropriate noise attenuation measures. Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection.

To control noise levels for the surrounding community the traction substation would also need attenuators on the exhaust for major plant such as the single and three phase transformers and the heat exchangers. These noise attenuation requirements would be developed throughout the detailed design phase.

Further details on noise mitigation are provided in Section 6. These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

At The Bays Station the sleep disturbance noise criteria is L_{AFmax} 52 dB(A) and 60 dB(A) to the north and west of the station, respectively. Given the offset distances to existing sensitive receivers, the highest predicted noise impact is L_{AFmax} 35 dB(A). Given the predicted noise impact does not exceed the criteria at the sensitive receivers, further consideration of noise attenuation is not required.

5.10 Pyrmont Station

5.10.1 Station overview

The proposed Pyrmont Station is positioned at the junction of a number of streets within the peninsula. Pyrmont Street is a key north-south route, Pyrmont Bridge Road is the primary east-west vehicular and pedestrian connection, and Union Street is the focus of east-west active transportation that connects Harris Street to the Pyrmont Bridge.

The station is proposed to have two separate station entrances: one on Union Street and the second on Pyrmont Bridge Road. These are in close proximity to a number of cultural and entertainment attractors, many of which are of regional and national significance including the Australian national maritime museum, The Star and the Sydney International Convention, Exhibition and Entertainment Precinct.

The station would provide an island platform in an east–west orientation. An indicative layout of Pyrmont Station is provided in Figure 5-14.

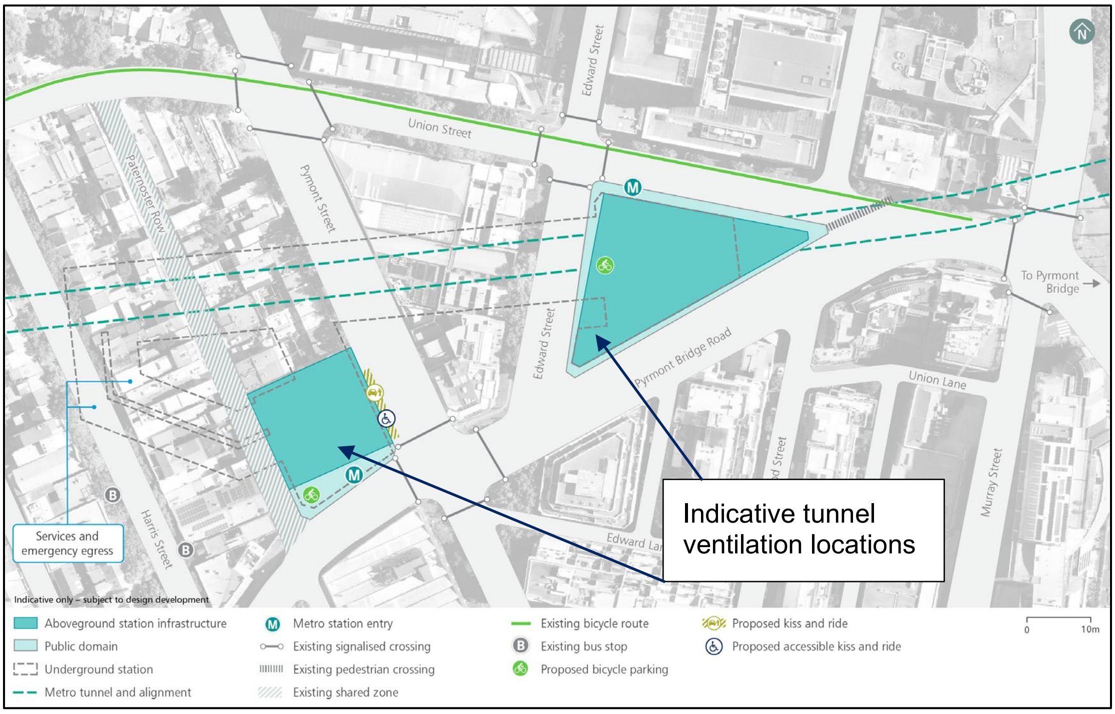


Figure 5-14 Pyrmont Station indicative layout

5.10.2 Station noise criteria

The nearest and most affected existing sensitive receivers are located on Edward Street, Pyrmont Bridge Road, Pyrmont Street, and Paternoster Row.

Table 5-19 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3.

Table 5-19 Pyrmont Station noise criteria - $L_{Aeq,15min}$ dB(A)

Location	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15m L_{AFmax}
Residential	Day	55	58	63	65
	Evening	52	48	53	65
	Night	50	43	48	65
Commercial	When in use	NA	60	65	NA

5.10.3 Predicted station noise impacts

Operation of Pyrmont Station would include noise emission from inlet and exhaust fans. Noise from the TVS is predicted to be the controlling contributor to environmental noise from the Pyrmont Station at the adjacent properties.

Detailed below in Table 5-20 and Table 5-21 are the predicted noise impacts at the nearest sensitive receivers surrounding each station building.

Table 5-20 Pyrmont Station eastern building noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Edward Street Residential (West)		
Daytime	55	47
Evening	48 (52[1])	47
Night-time	43 (48[1])	37
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	60
Union Street Residential (North)		
Daytime	55	45
Evening	48 (52[1])	45
Night-time	43 (48[1])	45
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	59

Pyrmont Bridge Road Residential (south)		
Daytime	55	45
Evening	48 (52[1])	45
Night-time	43 (48[1])	45
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	59

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level

Table 5-21 Pyrmont Station western building noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Harris Street Residential (West)		
Daytime	55	43
Evening	48 (52[1])	43
Night-time	43 (48[1])	42
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	59
Pyrmont Street Residential (North)		
Daytime	55	44
Evening	48 (52[1])	44
Night-time	43 (48[1])	43
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	59
Pyrmont Street Residential (East)		
Daytime	55	45
Evening	48 (52[1])	45
Night-time	43 (48[1])	45
Emergency mode (all sources, including stair pressurisation fans)	48 (53[1])	47
Draught relief noise impacts	65 L_{AFmax}	59
Pyrmont Street Commercial (South)		
TVS (Including TVF, TSF, and TEF)	60 (65[1])	50
Mechanical Services – daytime/evening	60 (65[1])	50
Mechanical Services – night-time	60 (65[1])	50
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	52

Note 1: Where the amenity goal criteria cannot reasonably be achieved, the lower of the intrusive or maximum noise criteria is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level

The noise impacts for both the eastern and western sites are predicted to comply with the design noise criteria during the daytime and evening period with the exception of minor non-compliances of the amenity target level during the night-time. Large attenuators have been included in the design to reduce the TVS to the current levels. To meet the amenity target level an additional floor would be required to accommodate another attenuator. Larger fans may also be required to account for the increased pressure loss from the additional attenuators. It is not considered reasonable to reduce this noise further considering there is no scope for future industrial developments in Pyrmont. As such the amenity acceptance level is considered to be more appropriate at Pyrmont. Noise levels at these receivers comply with the amenity acceptance level.

At Pyrmont Station the sleep disturbance noise criteria is L_{AFmax} 60 dB(A) and 61 dB(A) for the east and west services buildings respectively. The highest predicted noise level from the DRS is L_{AFmax} 59 dB(A), compliant with the noise criteria. Given compliance with the applicable noise criteria is achieved, further consideration of noise attenuation measures for the DRS is not required.

Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6.

These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

5.11 Hunter Street (Sydney CBD) Station

5.11.1 Station overview

Hunter Street Station (Sydney CBD) would be located in the north of the Sydney CBD. The metro station would comprise two sites, including a western site at the south-east corner of Hunter Street and George Street, and an eastern site bounded by O'Connell Street, Hunter Street and Bligh Street.

Hunter Street (Sydney CBD) Station would serve Sydney's financial and commercial core, its civic precincts, and key recreational and tourist destinations. The objective is to provide a new and direct access into the commercial core of the Sydney CBD and provide an efficient and seamless multi-modal interchange.

Hunter Street (Sydney CBD) Station consists of the western site and the eastern site. The station would provide an island platform in an east–west orientation. The indicative layout of the Hunter Street (Sydney CBD) Station is shown on Figure 5-15**.**

The majority of station plant and services would be located underground, with some plant and incorporated above the station entry buildings at each site.

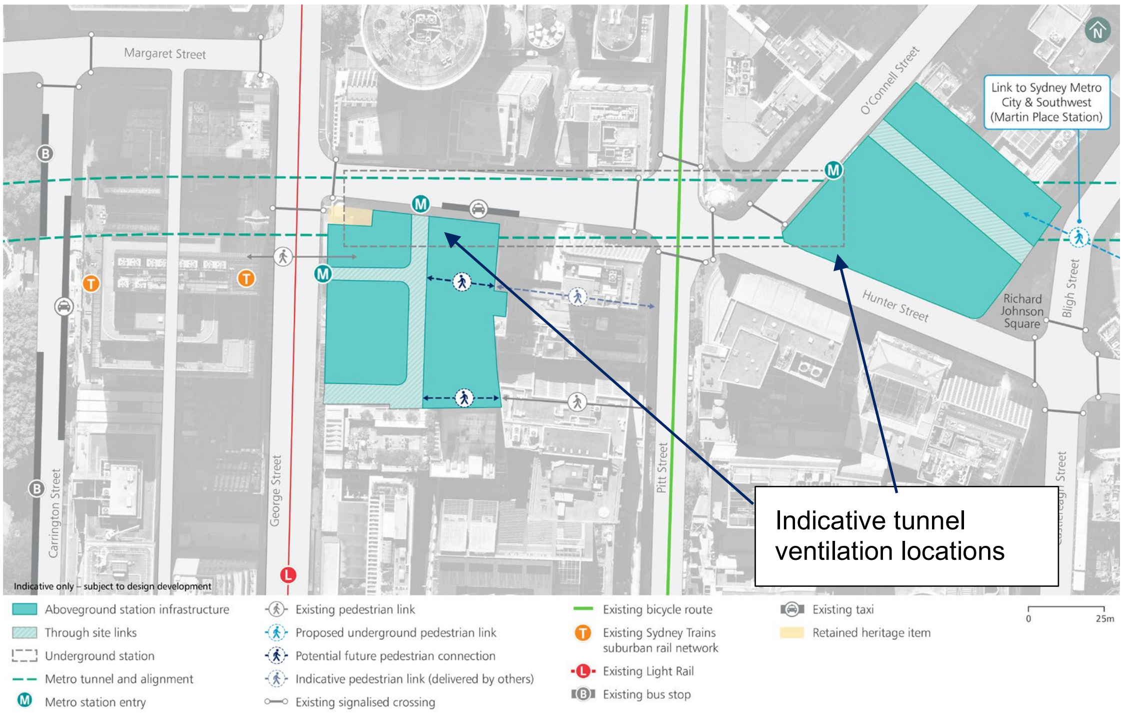


Figure 5-15 Hunter Street (Sydney CBD) Station indicative layout

5.11.2 Station noise criteria

Table 5-22 provides a summary of the noise criteria relevant to this station. It has been reproduced from Section 3. Note that residential receivers have not been identified in the vicinity of the Hunter Street (Sydney CBD) Station, so residential noise criteria have not been included below.

Table 5-22 Hunter Street Station noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS at 15m, L_{AFmax}
Hotel	Daytime	NA	63	68	65
	Evening	NA	53	58	65
	Night-time	NA	48	53	65
Commercial	When in use	NA	60	65	NA

5.11.3 Predicted station noise impacts

The nearest sensitive receiver to the eastern building is the commercial buildings on the other side of Hunter Street. Provided in Table 5-23 is a summary of the predicted noise levels.

Table 5-23 Hunter Street Station eastern site noise impacts – $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Hunter Street commercial		
Daytime	60 (65[1])	59
Evening	60 (65[1])	59
Night-time	60 (65[1])	57
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	70
Blight Street commercial adjacent		
Daytime	60 (65[1])	63
Evening	60 (65[1])	63
Night-time	60 (65[1])	62
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	68
O’Connor Street Hotel		
Daytime	63 (68[1])	50
Evening	53 (58[1])	50
Night-time	48 (53[1])	47
Emergency mode (all sources, including stair pressurisation fans)	53 (58[1])	53
Draught relief noise impacts	65 L_{AFmax}	61

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level.

The western site is located on the corner of Hunter Street and George Street. Based on the current design, the major noise sources would either be on the northern or western façade. Presented in Table 5-24 is a summary of the likely worst-case noise impacts from the site.

Table 5-24 Hunter Street Station western site noise impacts - $L_{Aeq,15min}$ dB(A)

Source	Criteria	Predicted noise level
Draught relief shaft noise impacts at 15m	65 L_{AFmax}	64
Hunter Street hotel opposite		
Daytime	63 (68[1])	54
Evening	53 (58[1])	54
Night-time	48 (53[1])	50
Emergency mode (all sources, including stair pressurisation fans)	53 (58[1])	56
Hunter Street/George Street commercial adjacent property		
Daytime	60 (65[1])	63
Evening	60 (65[1])	63
Night-time	60 (65[1])	62
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	68
George Street commercial opposite		
Daytime	60 (65[1])	59
Evening	60 (65[1])	59
Night-time	60 (65[1])	56
Emergency mode (all sources, including stair pressurisation fans)	65 (70[1])	65

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level.

The noise impacts for both the eastern and western sites are predicted to comply with the design noise criteria at most locations, except for receivers directly adjacent the TVS. Large attenuators have been included in the design to reduce the TVS to the current levels. To meet the amenity target level, an additional floor would be required to accommodate another attenuator. Larger fans may also be required to account for the increased pressure loss from the additional attenuators. It is not considered reasonable to reduce this noise further given that there is no scope for future industrial developments in the Sydney CBD. In the absence of future industrial development given the existing land use zoning, the -5dB correction which is typically applied to the amenity criteria is not necessarily warranted. As such the amenity acceptance level is considered to be more appropriate at this location. Noise levels at these receivers comply with the amenity acceptance level, with the inclusion of appropriate noise attenuation measures.

Noise attenuation has been incorporated in the design including large fan attenuators, vent orientation, acoustic louvres and appropriate plant selection. Further details are provided in Section 6.

These measures would be developed throughout the detailed design phase to comply with the environmental noise criteria.

5.12 Clyde stabling and maintenance facility and Rosehill services facility

5.12.1 Clyde stabling and maintenance facility overview

The Clyde stabling and maintenance facility would be located in the Clyde industrial area, to the north of the M4 Western Motorway and to the east of James Ruse Drive. This would be an integrated facility incorporating most operational and maintenance functions for Sydney Metro West including the operations control centre and infrastructure required to maintain the train fleet.

The stabling and maintenance facility would include the following components:

- stabling tracks to store trains
- train maintenance centre, sidings and depot
- workshops for the maintenance of railway infrastructure components
- train wash/bio wash and graffiti removal facility
- test tracks to undertake training, testing, commissioning and maintenance
- operations control centre and administration building
- train servicing and maintenance equipment
- fire control and security building, including the provision of fire hydrants, hoses and other firefighting equipment within the building
- operational water treatment plant to treat wastewater pumped from the tunnels, stations and other underground facilities
- offices, staff car parks, storage and internal vehicular and pedestrian access roads

The stabling and maintenance facility layout has been configured to allow for metro train access/egress from a dive structure (an open air structure which transfers the railway from above ground to underground leading to a tunnel portal where trains enter/exit the mainline tunnels) to the north of the site, adjacent to James Ruse Drive, which connects the facility into the mainline underground tunnels.

Vehicular access would be provided via separate access/egress points from Wentworth Street and Unwin Street (for general staff access). Large vehicle access to the stabling and maintenance facility would be via Wentworth Street. An internal access road network would provide for general circulation while appropriately separated from train movements. The site would also be fenced from general public access and lighting would be used at night for safety and security of the site.

The facility would operate 24 hours a day, seven days a week.

Stabling activities

Trains not in operation would be stored in the stabling facility. Trains would normally be shut down once they have been stabled and the interior cleaned. They would need to be powered up about one hour before their scheduled departure time. The stabling and maintenance facility could be used to store a powered standby train for use in the event that a train needs to be withdrawn from service at short notice, if required.

The installation of stabling roads would be staged throughout the life of this proposal. About nine stabling roads would be provided at the stabling and maintenance facility for initial operations, and space would be provided for about thirteen additional stabling roads to support ultimate operations.

Train maintenance activities

The infrastructure maintenance building would provide for both general and more substantial periodic maintenance activities (such as bogie/underframe inspections and other major equipment replacement).

The maintenance building would include workshops and storage areas, inspection pits and elevated walkways (for inspection of the train fleet) and crane lifting facilities. Maintenance operations would also include carrying out inspections, maintenance and component exchange on the train fleet.

Rail maintenance vehicles would be able to use the network and provide access for maintenance crews.

Administration and staff facilities as well as the operations control centre for the metro network would be provided at the stabling and maintenance facility.

Car parking for staff and visitor use (about 120 spaces) would be provided within the site, including maintenance vehicle parking.

5.12.2 Rosehill service facility

A services facility is proposed at Rosehill, to the north of Duck Creek and of the stabling and maintenance facility. This would include a services facility building and substation building. Unwin Street is located to the north of the facility and Shirley Street is located to the east.

The services facility building at Rosehill would include tunnel ventilation plant rooms and associated air distribution equipment, as well as a central open shaft over a track crossover to allow for open air ventilation.

The traction substation would supply power to Sydney Metro West during operation and would be located adjacent to the services facility building.

The facility would operate 24 hours a day, seven days a week. The indicative layout of the Clyde stabling and maintenance facility and the Rosehill services facility is illustrated below in Figure 5-16.

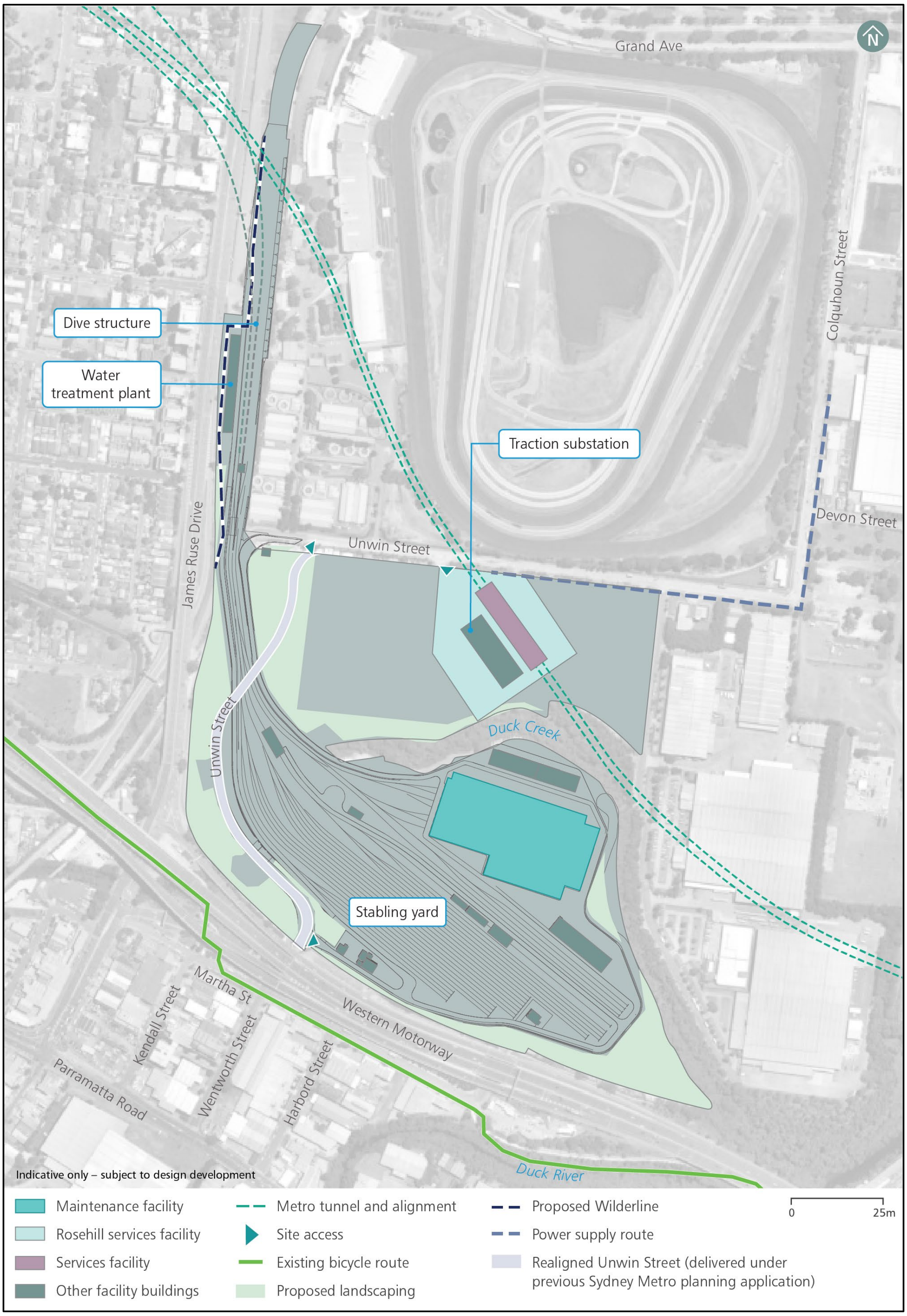


Figure 5-16 Clyde stabling and maintenance facility and Rosehill services facility indicative layout

The various noise sources and operations associated with this fixed facility are discussed in Section 4.3.

5.12.3 Fixed facility noise criteria

The nearest residential receivers front James Ruse Drive and are located along Penelope Lucas Lane and A'Beckett Street, east of the site. Racehorses are stabled at the Rosehill Gardens racecourse north of the site and that premise is considered as a passive recreational area.

Table 5-25 provides a summary of the noise criteria relevant to this facility. It has been reproduced from Section 3.

Table 5-25 Clyde and Rosehill noise criteria - $L_{Aeq,15min}$ dB(A)

Receiver use	Assessment	Intrusive level	Amenity target level	Amenity acceptance level	DRS L_{AFmax}
Residential	Daytime	55	63	68	65
	Evening	54	53	58	65
	Night-time	50	48	53	65
Commercial	While in use	NA	60	65	NA
Stables	While in use	NA	45	50	65

5.12.4 Predicted facility noise impacts

Noise modelling results for a worst-case scenario during the night-time period at the Clyde stabling and maintenance facility and Rosehill services facility are presented in Table 5-26. Predicted maximum noise levels are presented below in Table 5-27.

Noise contours displaying the propagation of noise from the Clyde stabling and maintenance facility and the Rosehill services facility to its surrounds are provided in Appendix D.

Table 5-26 Clyde stabling and maintenance facility and Rosehill services facility noise impacts – $L_{Aeq,15min}$, dB(A)

Receiver	Criteria	Year of opening	Year of design
4 A'Beckett Street, Granville (residential)	48 (53[1])	43	45
65 Penelope Lucas Lane, Granville (residential)	48 (53[1])	44	46
Rosehill Gardens racecourse stables	45 (50[1])	46	47

Note 1: Where the amenity target level is the controlling criterion and cannot reasonably be achieved, the lower of the intrusive or amenity acceptance noise level is used.

Note 2: Noise levels in bold identify predicted noise levels over the amenity target level.

Table 5-27 Clyde stabling and maintenance facility noise impacts – L_{AFmax}, dB(A)

Receiver	Criteria	Year of opening	Year of design
4 A'Beckett Street, Granville (residential)	60	35	37
65 Penelope Lucas Lane, Granville (residential)	60	36	38
Rosehill Gardens racecourse stables[1]	60	36	37

Note: 1: The Rosehill Gardens racecourse has been treated as a passive recreation area. Therefore, no sleep disturbance criteria exist for such premises. As an indicative assessment for the maximum noise impacts on horses, L_{max} sleep disturbance criteria from the NPfI have been utilised for this assessment.

The noise modelling results indicate that there is a minor (2 dB) exceedance of the applicable noise criteria at the Rosehill Gardens racecourse. Further work would be undertaken during detailed design to identify appropriate noise mitigation measures to mitigate impacts at the stabling facility.

6 Management and mitigation measures

6.1 Operational railway airborne noise

The operational railway airborne noise assessment in Section 5.1 identified that there were no sensitive receivers which exceed the applicable noise trigger level. Further consideration of noise mitigation is not required for airborne railway noise.

6.2 Operational railway ground-borne noise and vibration

The analysis in Section 5.2 identified that the ground-borne noise criteria would be achieved at all locations with the implementation of appropriate track form.

Table 6-1 and Table 6-2 present a summary of the track form selections required to meet the ground-borne noise design objectives based on the current design. These recommendations would need to be reviewed and refined as the design progresses.

The operational vibration criteria are predicted to be met throughout the alignment using a standard track form and would also be met using the track form selections recommended for ground-borne noise criteria presented in Table 6-1 and Table 6-2.

Table 6-1 Recommended track form attenuation – up track

Section	Track form	Chainage Start (m)	Chainage Finish (m)	Length (m)
CBDEast Turnback to Hunter Street	Type 2	-613	-175	438
	Type 3A	-175	-135	40
	Type 2	-135	0	135
Hunter Street Station	Type 2	0	150	150
Hunter Street to Pyrmont	Type 2	150	1362	1212
Pyrmont Station	Type 2	1362	1512	150
Pyrmont to The Bays	Type 2	1512	1725	213
	Type 3A	1725	2055	330
	Type 2	2055	2635	580
	Type 3A	2635	2825	190
	Type 2	2825	2947	122
The Bays Station	Type 2	2947	3097	150
The Bays to Five Dock	Type 2	3097	3545	448
	Type 3A	3545	3705	160
	Type 2	3705	7502	3797
Five Dock Station	Type 2	7502	7652	150
Five Dock to Burwood North	Type 2	7652	9729	2077
Burwood North Station	Type 2	9729	9879	150
Burwood North to North Strathfield	Type 2	9879	9900	21
	Type 3A	9900	10090	190
	Type 2	10090	11865	1775
North Strathfield metro station	Type 2	11865	12015	150
North Strathfield to Sydney Olympic Park	Type 2	12015	14148	2133
Sydney Olympic Park metro station	Type 2	14148	14298	150

Section	Track form	Chainage Start (m)	Chainage Finish (m)	Length (m)
Sydney Olympic Park to Parramatta	Type 2	14298	18965	4667
	Type 3A	18965	19085	120
	Type 2	19085	20360	1275
	Type 3A	20360	20420	60
	Type 2	20420	21566	1146
Parramatta metro station	Type 2	21566	21716	150
Parramatta to Westmead	Type 2	21716	22995	1279
	Type 3A	22995	23190	195
	Type 2	23190	23244	54
Westmead metro station	Type 2	23244	23394	150
Westmead to end of alignment	Type 2	23394	23684	290

Table 6-2 Recommended track form attenuation – down track

Section	Track form	Chainage Start (m)	Chainage Finish (m)	Length (m)
CBD East Turnback to Hunter Street	Type 2	-637	-382	255
	Type 3A	-382	-337	45
	Type 2	-337	-175	162
	Type 3A	-175	-135	40
	Type 2	-135	0	135
Hunter Street Station	Type 2	0	150	150
Hunter Street to Pyrmont	Type 2	150	1358	1208
Pyrmont Station	Type 2	1358	1508	150
Pyrmont to The Bays	Type 2	1508	1725	217
	Type 3A	1725	2055	330
	Type 2	2055	2635	580
	Type 3A	2635	2830	195
	Type 2	2830	2950	120
The Bays Station	Type 2	2950	3100	150
The Bays to Five Dock	Type 2	3100	3550	450
	Type 3A	3550	3705	155
	Type 2	3705	7505	3800
Five Dock Station	Type 2	7505	7655	150
Five Dock to Burwood North	Type 2	7655	9729	2074
Burwood North Station	Type 2	9729	9879	150
Burwood North to North Strathfield	Type 2	9879	9900	21
	Type 3A	9900	10090	190
	Type 2	10090	11879	1789
North Strathfield metro station	Type 2	11879	12029	150
North Strathfield to Sydney Olympic Park	Type 2	12029	14160	2131
Sydney Olympic Park metro station	Type 2	14160	14310	150
Sydney Olympic Park to Parramatta	Type 2	14310	18970	4660
	Type 3A	18970	19090	120
	Type 2	19090	20280	1190

Section	Track form	Chainage Start (m)	Chainage Finish (m)	Length (m)
	Type 3A	20280	20415	135
	Type 2	20415	21563	1148
Parramatta metro station	Type 2	21563	21713	150
Parramatta to Westmead	Type 2	21713	22995	1282
	Type 3A	22995	23185	190
	Type 2	23185	23243	58
Westmead metro station	Type 2	23243	23393	150
Westmead to end of alignment	Type 2	23393	23680	287

6.3 Metro station design

With the inclusion of feasible and reasonable noise attenuation measures, each station and services facility assessed in Section 5 would comply with the applicable noise criteria. Provided below is a summary of the main noise attenuation measures which have been included in the design. Other contributing factors are the tunnel ventilation shaft arrangement and the tunnel ventilation outlet orientation.

6.3.1 Tunnel ventilation system

Table 6-3, Table 6-4, and Table 6-5 presents a summary of the attenuators likely required to meet the applicable noise criteria.

Table 6-3 TVF attenuator insertion loss, dB

Attenuator length	Attenuator Face	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
4.8m	4.2m by 4.4m	11	29	57	60	60	60	53	34

Table 6-4 TEF/TSF attenuator insertion loss, dB

Attenuator length	Attenuator Face	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
3.9m	2.1m by 2.3m	9	25	50	60	60	58	46	30

Table 6-5 DRS attenuator insertion loss, dB

Attenuator length	Attenuator Face	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
1.5m	4.2m by 4.4m	5	15	19	26	24	16	14	12

Figure 6-1 presents a schematic illustrating the typical tunnel ventilation arrangement at stations, including attenuator locations.

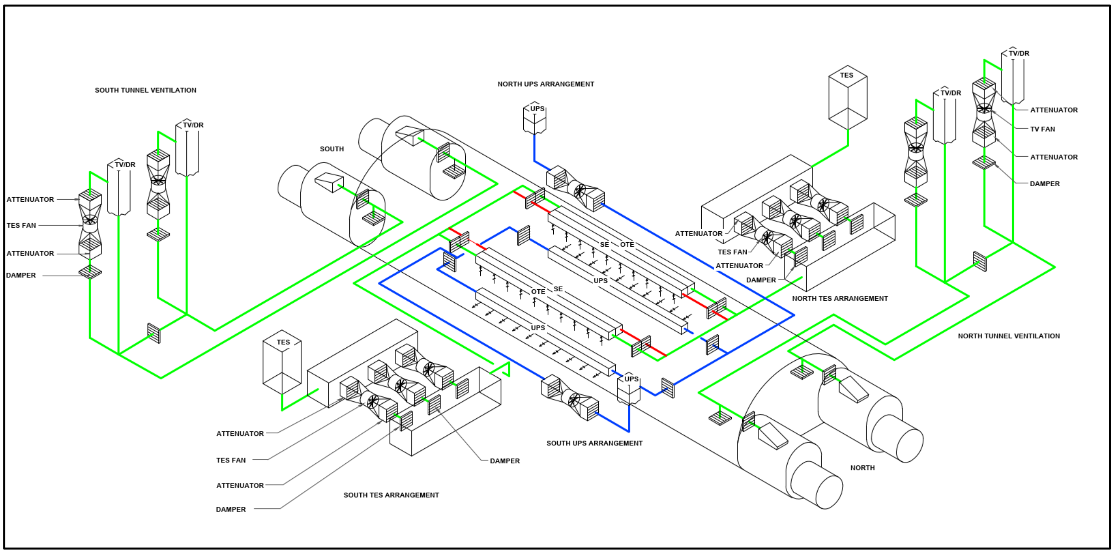


Figure 6-1 Typical tunnel ventilation schematic

6.3.2 Cooling towers

The cooling towers would be forced draught design with acoustic louvres. Table 6-6 presents a summary of the louvre likely required to meet the predicted noise levels.

Table 6-6 - Acoustic louvre insertion loss, dB

Type	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
Acoustic louvre	4	7	9	13	14	12	12	8

6.3.3 Stair pressurisation fans

Table 6-7 presents a summary of the attenuator likely required for the stair pressurisation fans.

Table 6-7 Attenuator insertion loss, dB

Attenuator length	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
2.4m	9	16	29	39	41	25	17	14

6.4 Clyde stabling and maintenance facility & Rosehill services facility

The noise assessment in Section 5.12 identifies a minor exceedance of the applicable noise criteria. Further investigation would be undertaken during detailed design to determine reasonable and feasible noise mitigation measures to comply with the applicable noise criteria.

6.5 Mitigation measures

The mitigation measures that would be implemented to address potential operational noise and vibration impacts are listed in Table 6-8.

Table 6-8 Mitigation measures – operational noise and vibration

Ref	Impacts/issue	Mitigation measures	Applicable location(s)[1]
EIS-NV1	Potential airborne noise from station and ancillary facilities	Stations and ancillary facilities would be designed to meet the applicable noise criteria derived from the Noise Policy for Industry (EPA, 2017). Train breakout noise from the draft relief shaft would be designed to meet a noise criterion of L_{AFmax} 65 dB(A) at 15 metres. The noise generated by stations and ancillary facilities would be reviewed during further design development to confirm that the noise levels predicted are achievable based on the final design of this proposal.	All except metro rail tunnels
EIS-NV2	Potential airborne-borne rail noise	Aboveground track section connecting to the Clyde stabling and maintenance facility would be designed to meet the relevant airborne noise criteria from the Rail Infrastructure Noise Guidelines (EPA, 2013).	CSMF
EIS-NV3	Potential ground-borne rail noise	Track form would be confirmed as part of design development in order to meet the relevant ground-borne noise and vibration criteria from the Rail Infrastructure Noise Guidelines (EPA, 2013).	Metro rail tunnels

Note 1: WMS: Westmead metro station; PMS: Parramatta metro station; SOPMS: Sydney Olympic Park metro station; NSMS: North Strathfield metro station; BNS: Burwood North Station; FDS: Five Dock Station; TBS: The Bays Station; PS: Pyrmont Station; HSS: Hunter Street Station; Metro rail tunnels: Metro rail tunnels not related to other sites.

6.6 Performance outcomes

Performance outcomes for Sydney Metro West were established as part of the concept assessment in the Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020). The performance outcome related to operational noise and vibration is:

- Operational noise and vibration levels comply with the rail noise trigger levels in the Rail Infrastructure Noise Guidelines (Environment Protection Authority, 2013) and external noise criteria in the Noise Policy for Industry (Environment Protection Authority, 2017), where applicable.

Further details regarding how this proposal would achieve the performance outcomes is provided in Chapter 20 (Synthesis) of the Environmental Impact Statement.

7 Conclusion

This report provides an assessment of potential operational noise and vibration impacts from the proposed Sydney Metro West.

The report has assessed potential operational noise and vibration impacts from:

- Operational rail airborne noise
- Operational rail ground-borne noise
- Operational rail vibration
- Nine stations
- Stabling and maintenance facility
- One services facility.

The proposal would have a short above ground section of railway where the rail emerges from the dive structure adjacent the Rosehill Gardens racecourse, to the south where it enters the Clyde stabling and maintenance facility. This section of rail has been assessed in accordance with the RING.

The current timetable sees all trains operational by 7 am. As such the majority of train movements exiting the Clyde stabling and maintenance facility are during the night-time period (10pm to 7am). Given the low volumes of train movement on this line (only used to access the Clyde stabling and maintenance facility), the noise levels are compliant with the applicable noise criteria. This is aided by shielding provided by the dive structure and low speeds on the entry to the Clyde stabling and maintenance facility. Further consideration of noise mitigation is not required for the Clyde stabling and maintenance facility.

Ground-borne noise has been assessed across the extent of the proposal in accordance with the RING. The ground-borne noise for a standard attenuation (Type 1) track was found to generally exceed the applicable criteria. A combination of high attenuation (Type 2) and very high attenuation (Type 3A) track form has been proposed to achieve the environmental ground-borne noise objectives. The track form design would be refined as the proposal progresses.

Ground-borne vibration has been assessed in accordance with Assessing vibration: a technical guideline. The assessment has identified that compliance with the ground-borne noise levels would also result in compliance with the vibration criteria. Further mitigation specifically for vibration is not required.

Noise emissions from the stations have been assessed in accordance with the NPfI. The predicted noise level at each sensitive receiver location indicates that compliance with the environmental noise criteria can generally be achieved using the feasible and reasonable noise attenuation measures included in the design. Exceedances of the applicable noise criteria have been identified at:

- Westmead metro station – Noise emitted from the DRS shaft has been identified to exceed the sleep disturbance criteria. It is noted that existing rail L_{AFmax} noise levels are significantly higher than the DRS noise criteria and the sleep disturbance criteria is not necessarily directly applicable. In the context of existing noise in the area, the predicted noise impacts are considered acceptable.

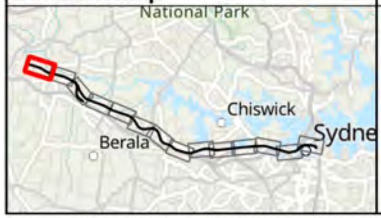
- Burwood North station – Exceedances of the noise criteria are predicted for the operation of the TVS. Existing residential receivers are located less than 15 metres from the eastern services building. Design options, such as modifications to the mechanical services arrangement, to achieve compliance with the applicable noise criteria would be considered as part of detailed design. This location is also expected to experience a land use change with these buildings potentially being redeveloped in the near future. In this case, compliance would be achieved by incorporating feasible and reasonable measures as part of the redevelopment.
- Pyrmont Station and Hunter Street Station – Minor exceedances of the amenity target noise level have been predicted, however the predicted noise impacts are compliant with the acceptance level. Given the context of the station with limited potential for future development, an exceedance of the amenity criterion is considered acceptable.

Design development would need to consider and identify the specific noise and vibration mitigation measures that would be incorporated to achieve the applicable noise limits.

The Clyde stabling and maintenance facility would stable up to 32 trains and provide a train wash, wheel lathe, maintenance facility and staff offices. Given the proximity to the Rosehill services facility (which includes tunnel ventilation and a traction substation), the two facilities have been assessed together. The predicted noise levels indicate that compliance with the noise criteria would be achieved at the nearest sensitive residential receivers. However a minor exceedance has been identified at the Rosehill Gardens Racecourse. Further work would be completed at the detailed design phase to identify suitable noise management or mitigation measures.

Appendix A Site plan and sensitive receivers

Location Map



Legend

Building Use Type

- Residential
- Child care
- Education
- Medical
- Commercial
- Industrial
- Garage
- Retail
- Worship
- Courts
- Drama theatre
- Public hall
- Library
- Mixed use
- Stable
- Studio

Alignment V4.2 Hybrid

Sydney Metro West

Building Use Type and Rail Alignment

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

Page 1 of 14

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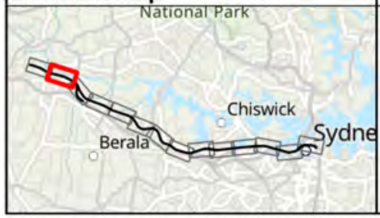
Location Map



Legend

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NSW GOVERNMENT | sydney METRO

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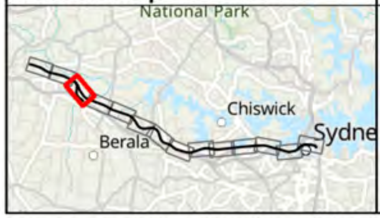

Legend

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Sydney Metro West

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NSW GOVERNMENT | sydney METRO

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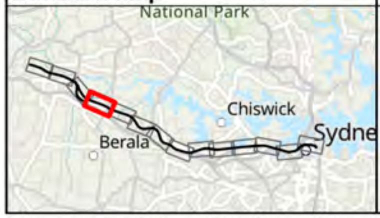

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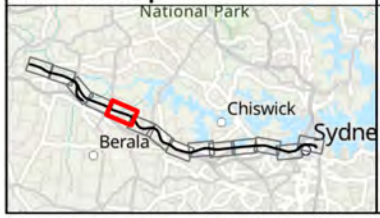

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Sydney Metro West

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NSW Government | sydney METRO

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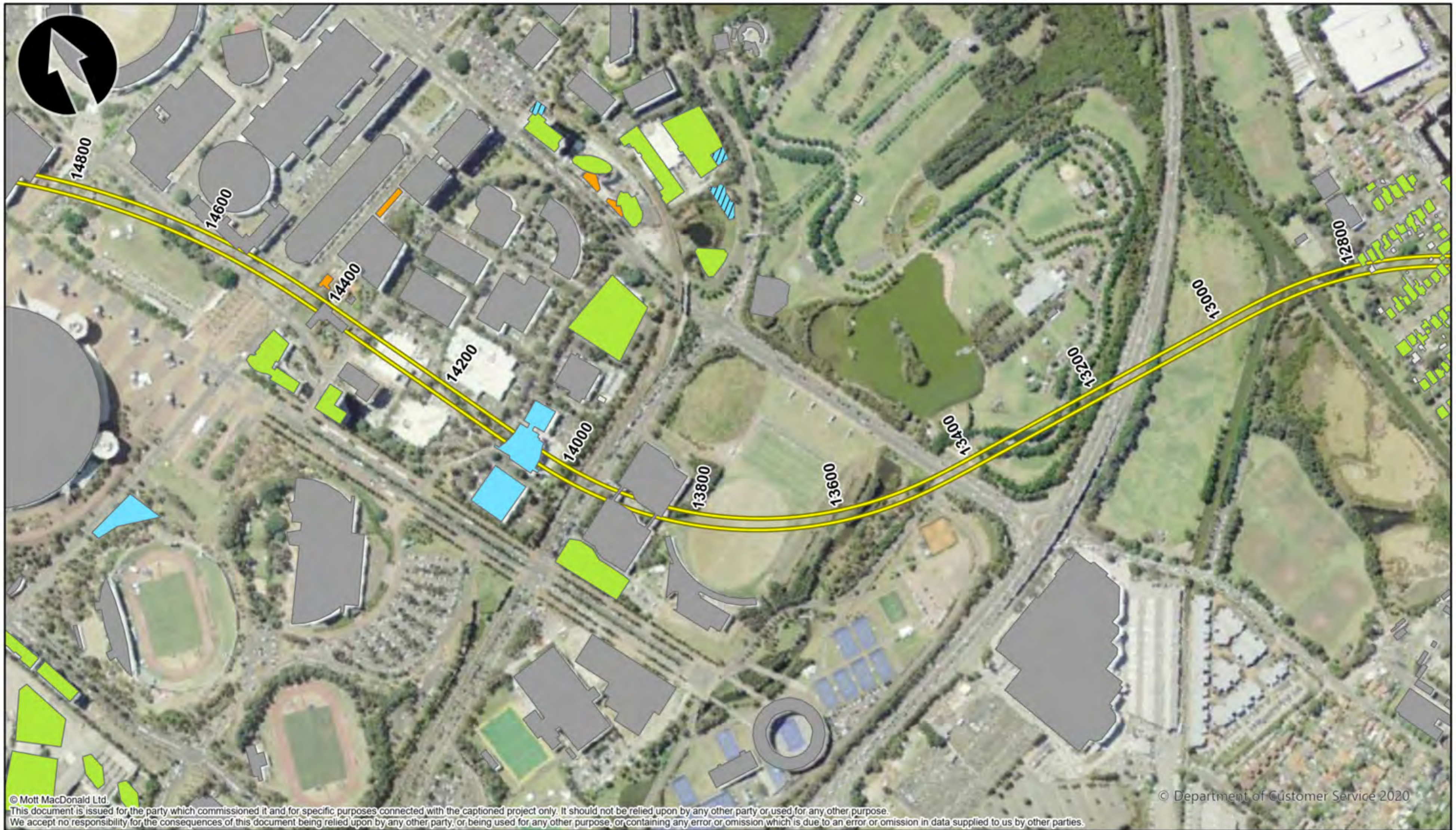

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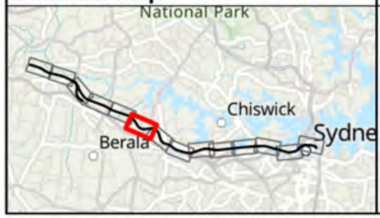

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Sydney Metro West

Building Use Type and Rail Alignment

NSW GOVERNMENT | sydney METRO

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Building Use Type and Rail Alignment

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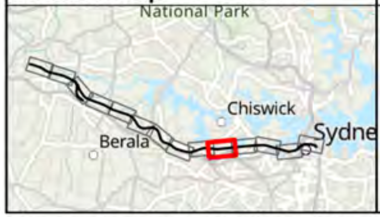

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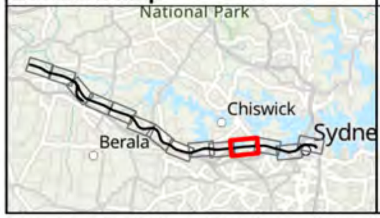

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Sydney Metro West

Building Use Type and Rail Alignment

NSW GOVERNMENT | sydney METRO

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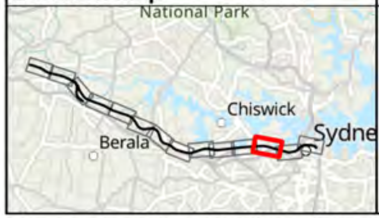

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Alignment V4.2 Hybrid

Sydney Metro West

Building Use Type and Rail Alignment

NSW GOVERNMENT | sydney METRO

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GDA 1994 MGA Zone 56
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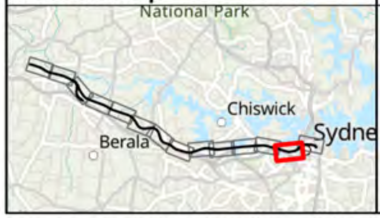

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Sydney Metro West

Building Use Type and Rail Alignment

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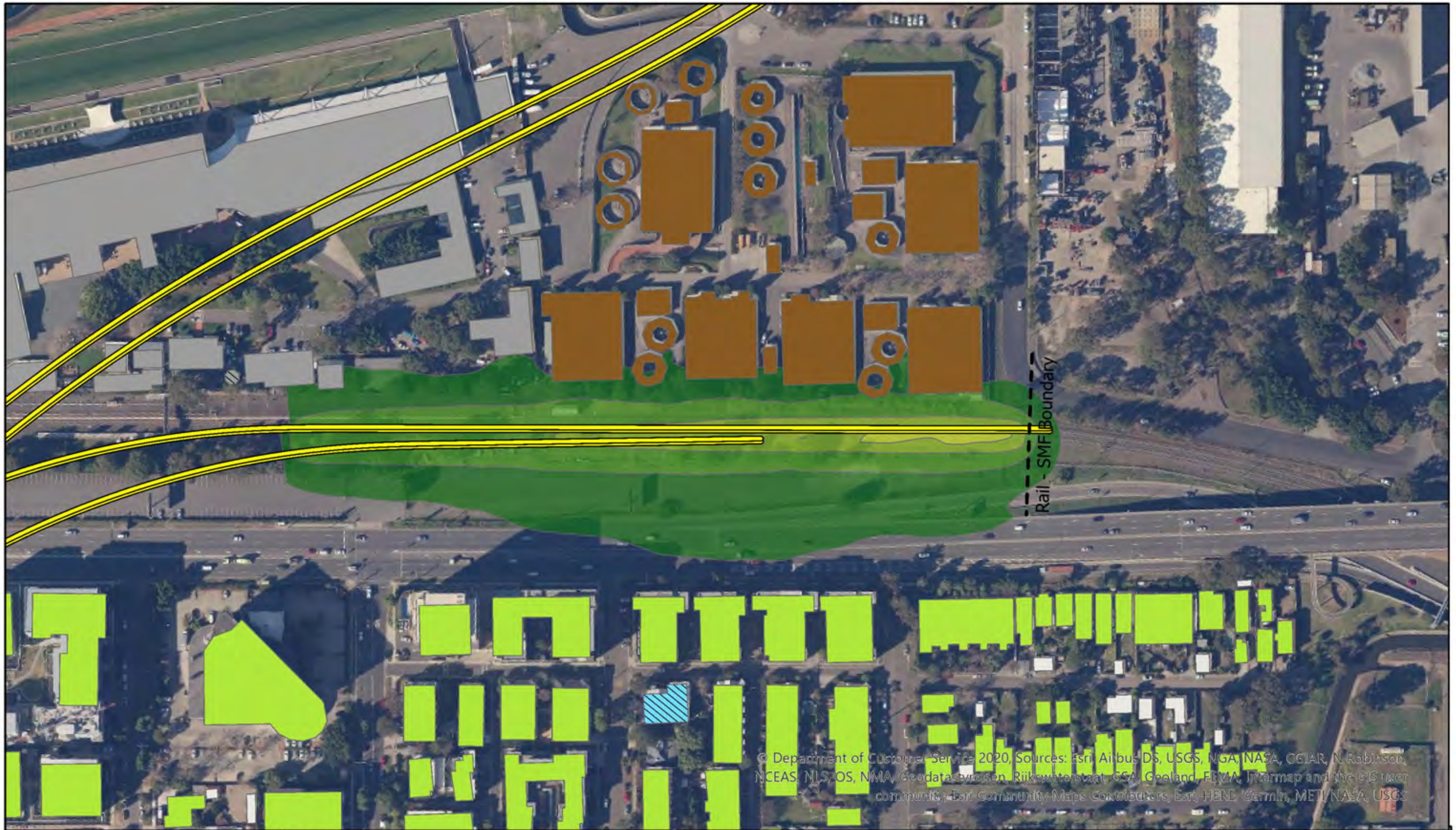
Appendix B Operational railway airborne noise contours



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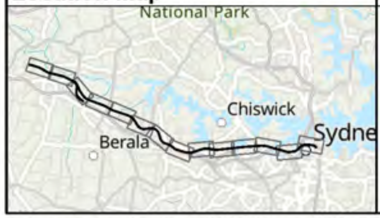

Legend

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- Studio
- Station_wall

$L_{Aeq,15hour}$ noise level, dB(A)

- 30 to 35
- 35 to 40
- 40 to 45
- 45 to 50
- 50 to 55
- 55 to 60
- 60 to 65
- > 65

Sydney Metro West

Clyde Railway Airborne Noise
Year of Opening
$L_{Aeq,15hour}$ daytime noise impacts

NSW GOVERNMENT | sydney METRO

Scale: 1 : 2,500 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 14/09/2021

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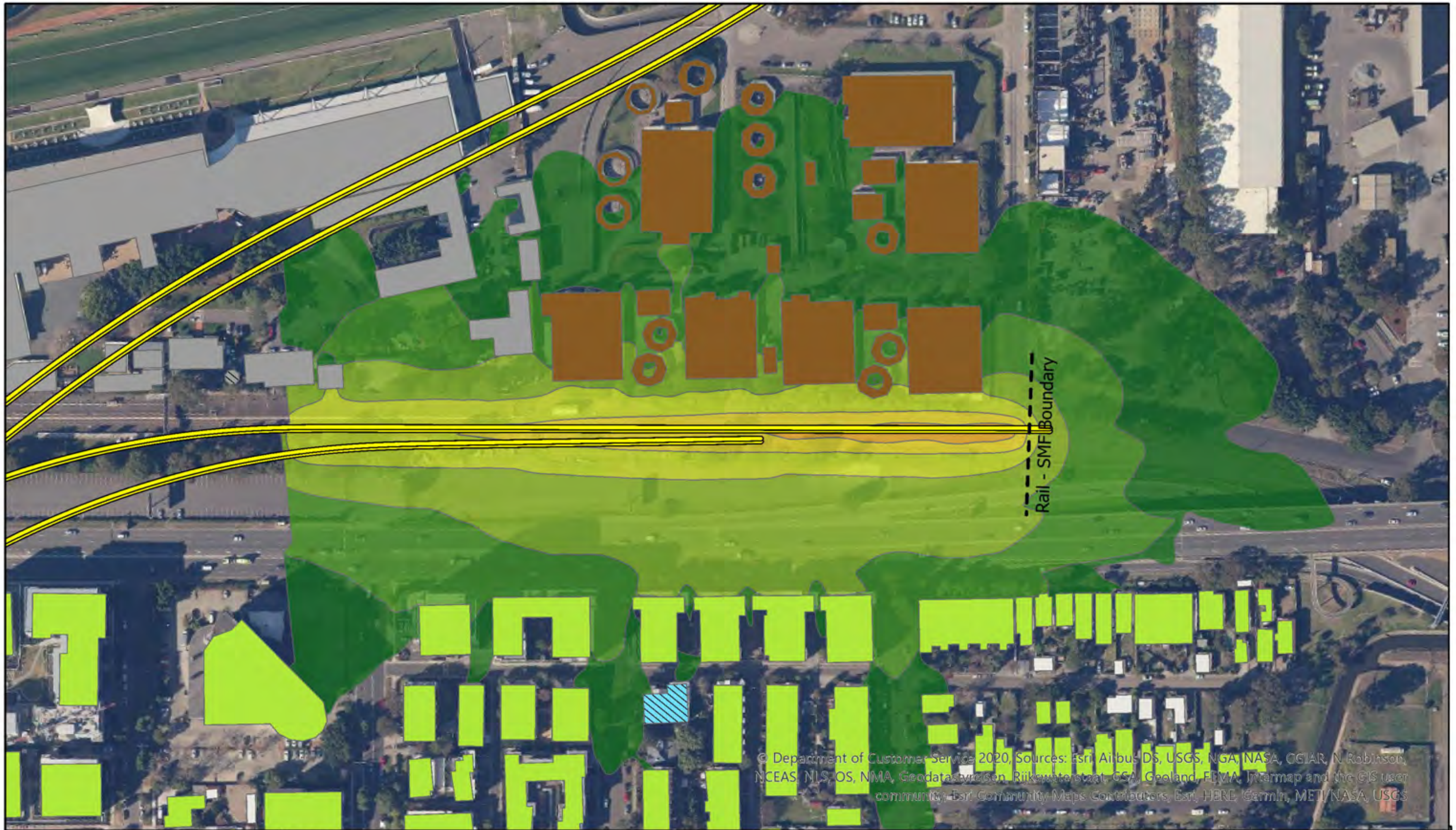

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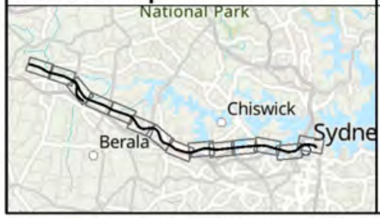

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- Studio
- Station_wall

$L_{Aeq,9hour}$ noise level, dB(A)

- 25 to 30
- 30 to 35
- 35 to 40
- 40 to 45
- 45 to 50
- 50 to 55
- 55 to 60
- > 60

Sydney Metro West

Clyde Railway Airborne Noise
Year of Opening
$L_{Aeq,9hour}$ night-time noise impacts

NSW GOVERNMENT | sydney METRO

Scale: 1 : 2,500 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 14/09/2021

Page 1 of 1

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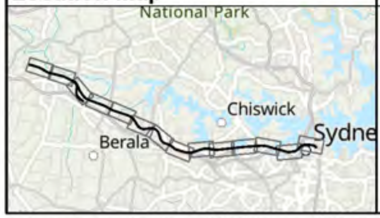
Location Map



Legend

Building Use Type

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- Station_wall

$L_{AFmax,95th\ percentile}$ noise level, dB(A)

- 50 to 55
- 55 to 60
- 60 to 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- > 85

Sydney Metro West

Clyde Railway Airborne Noise
Year of Design
$L_{AFmax,95th\ percentile}$ Noise Impacts

NSW GOVERNMENT | sydney METRO

Scale: 1 : 2,500 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 14/09/2021

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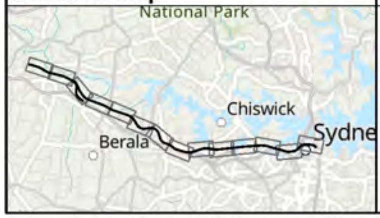
Location Map



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$L_{Aeq,15hour}$ noise level, dB(A)

- 30 to 35
- 35 to 40
- 40 to 45
- 45 to 50
- 50 to 55
- 55 to 60
- 60 to 65
- > 65

Sydney Metro West

Clyde Railway Airborne Noise Design Year

$L_{Aeq,15hour}$ daytime noise impacts

NSW GOVERNMENT | sydney METRO

Scale: 1 : 2,500 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56

Map Export Date: 14/09/2021

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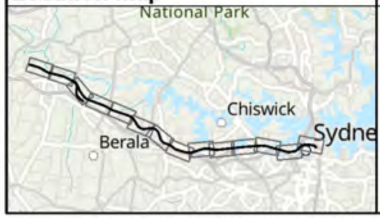

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Sydney Metro West

Clyde Railway Airborne Noise Design Year

$L_{Aeq,9hour}$ night-time noise impacts

NSW GOVERNMENT | sydney METRO

Scale: 1 : 2,500 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56

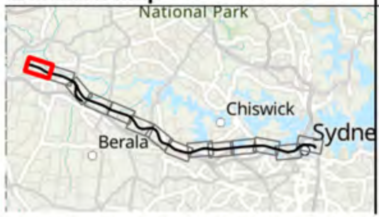
Map Export Date: 14/09/2021

Page 1 of 1

Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Appendix C Operational railway ground-borne noise contours

Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
- 45-50 dBA
- 40-45 dBA
- 35-40 dBA
- 30-35 dBA
- 25-30 dBA
- 20-25 dBA
- ≤20 dBA

Sydney Metro West

Scenario 1
Type 1 Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

Page 1 of 14

Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Location Map

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
- 45-50 dBA
- 40-45 dBA
- 35-40 dBA
- 30-35 dBA
- 25-30 dBA
- 20-25 dBA
- ≤20 dBA

Sydney Metro West

Scenario 1
Type 1 Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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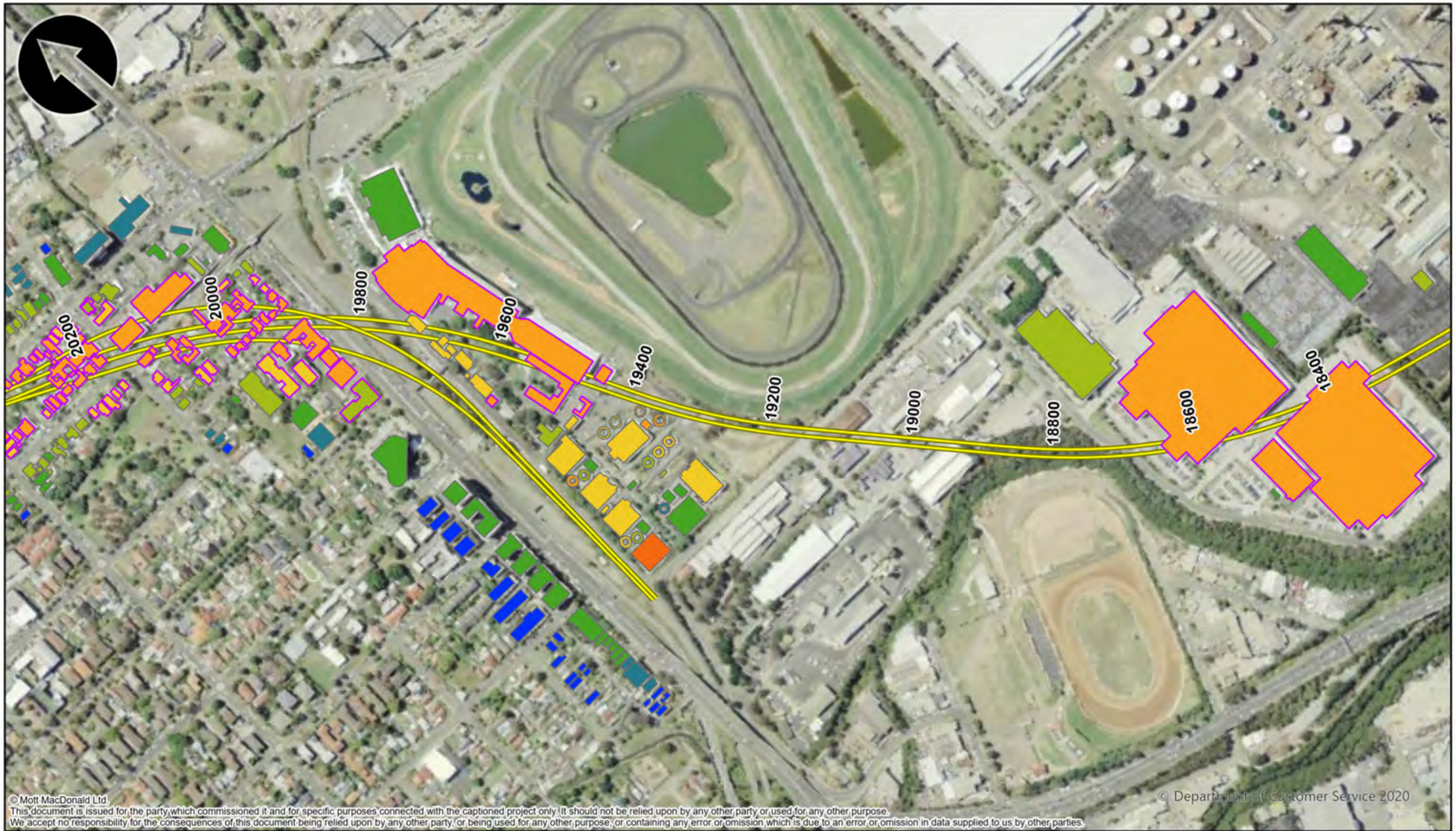
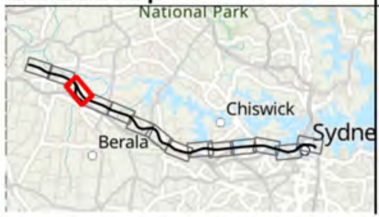
Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)



Location Map



Legend

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Sydney Metro West

Scenario 1
Type 1 Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | Sydney Metro

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GDA 1994 MGA Zone 56
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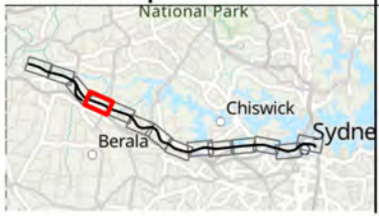

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Sydney Metro West

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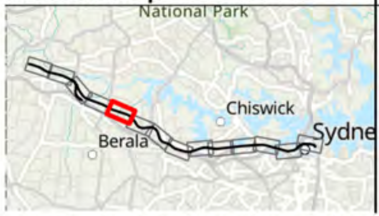

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NSW GOVERNMENT | sydney METRO

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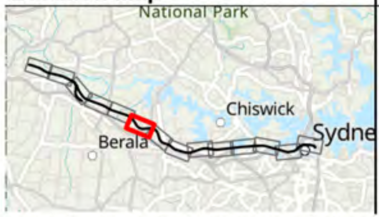

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Sydney Metro West

Scenario 1
Type 1 Track
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NSW GOVERNMENT | sydney METRO

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GDA 1994 MGA Zone 56
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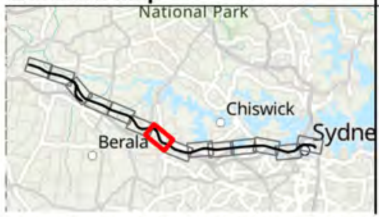

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NSW GOVERNMENT | sydney METRO

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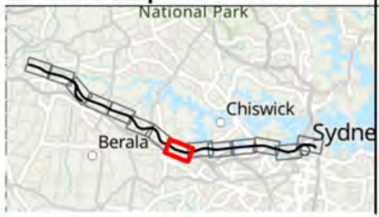

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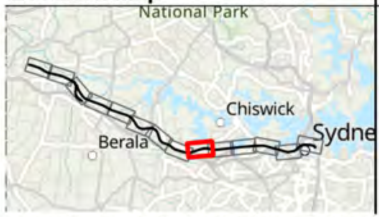

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Sydney Metro West

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NSW GOVERNMENT | sydney METRO

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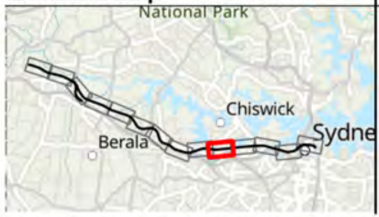

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Sydney Metro West

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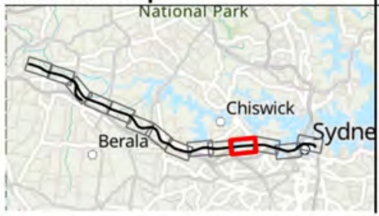

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Sydney Metro West

Scenario 1
Type 1 Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

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GDA 1994 MGA Zone 56
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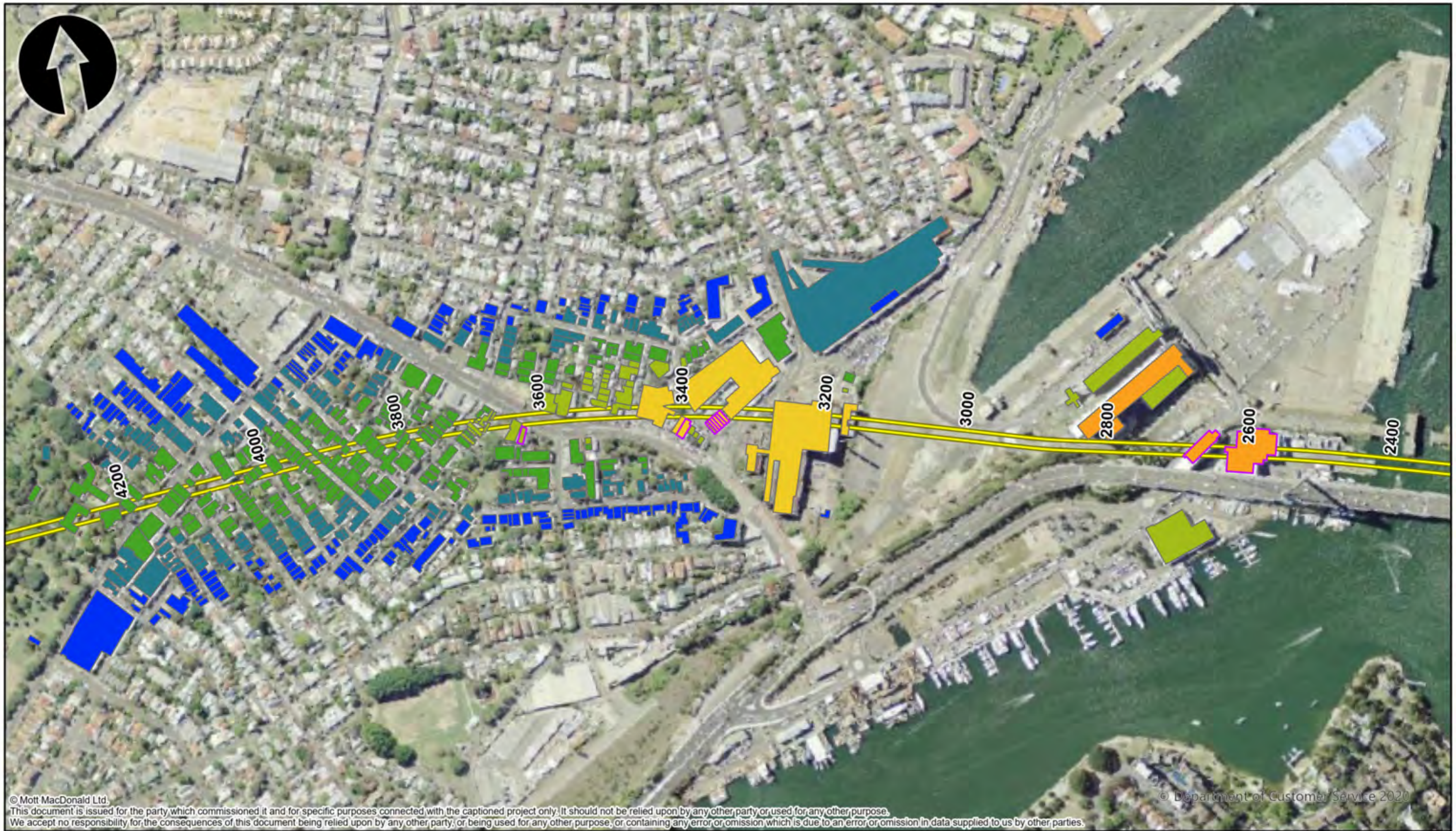

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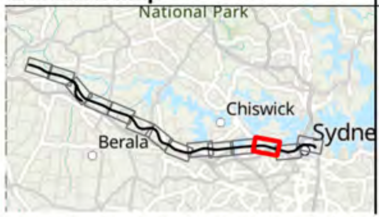

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Sydney Metro West

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95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

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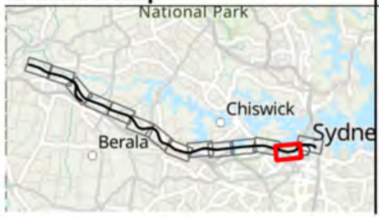
Location Map



Legend

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Sydney Metro West

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NSW GOVERNMENT | sydney METRO

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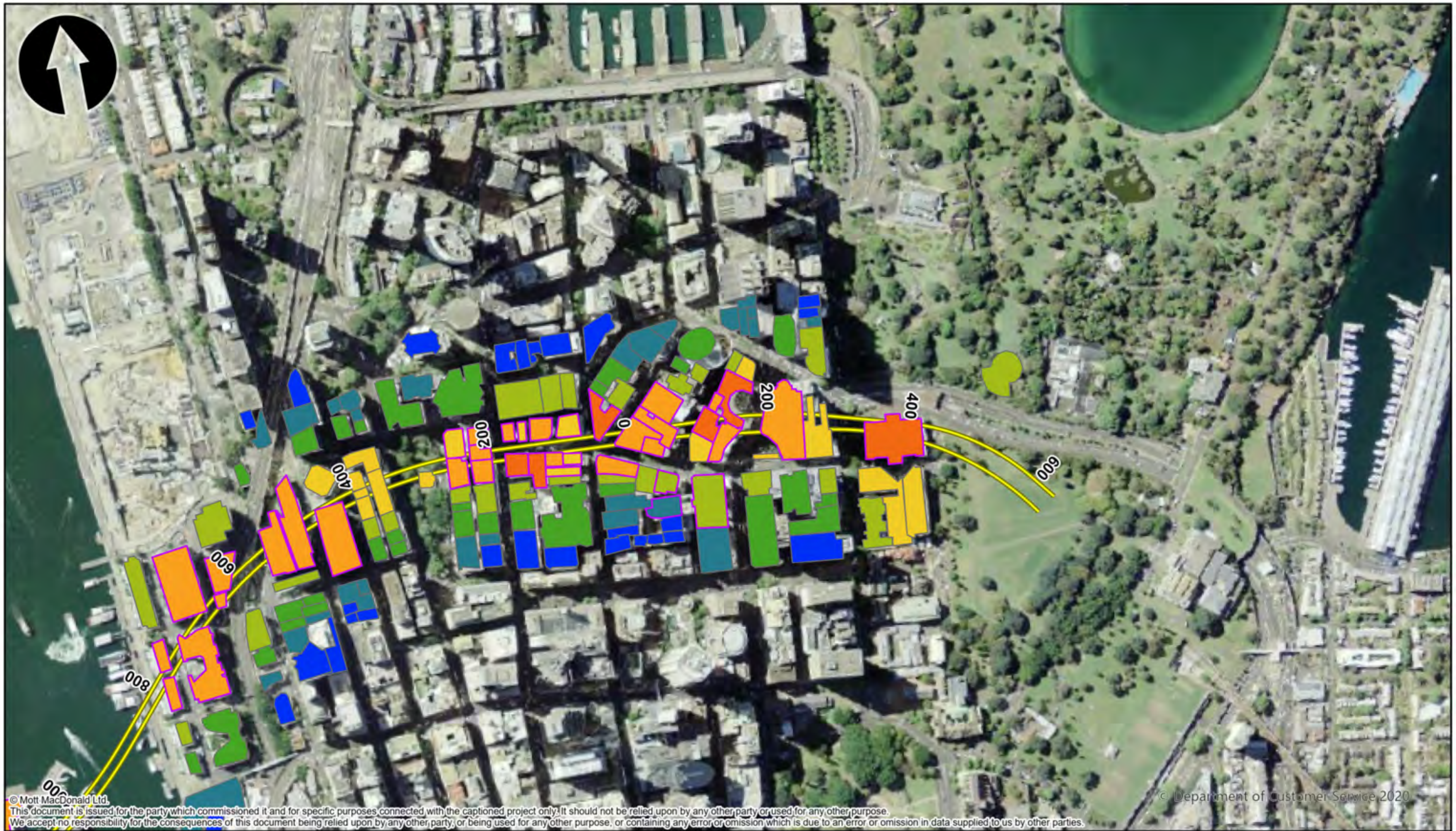

Location Map

Legend

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Sydney Metro West

Scenario 1
Type 1 Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

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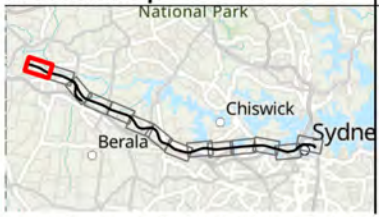

Legend

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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

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GDA 1994 MGA Zone 56
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Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Location Map

Legend

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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | sydney METRO

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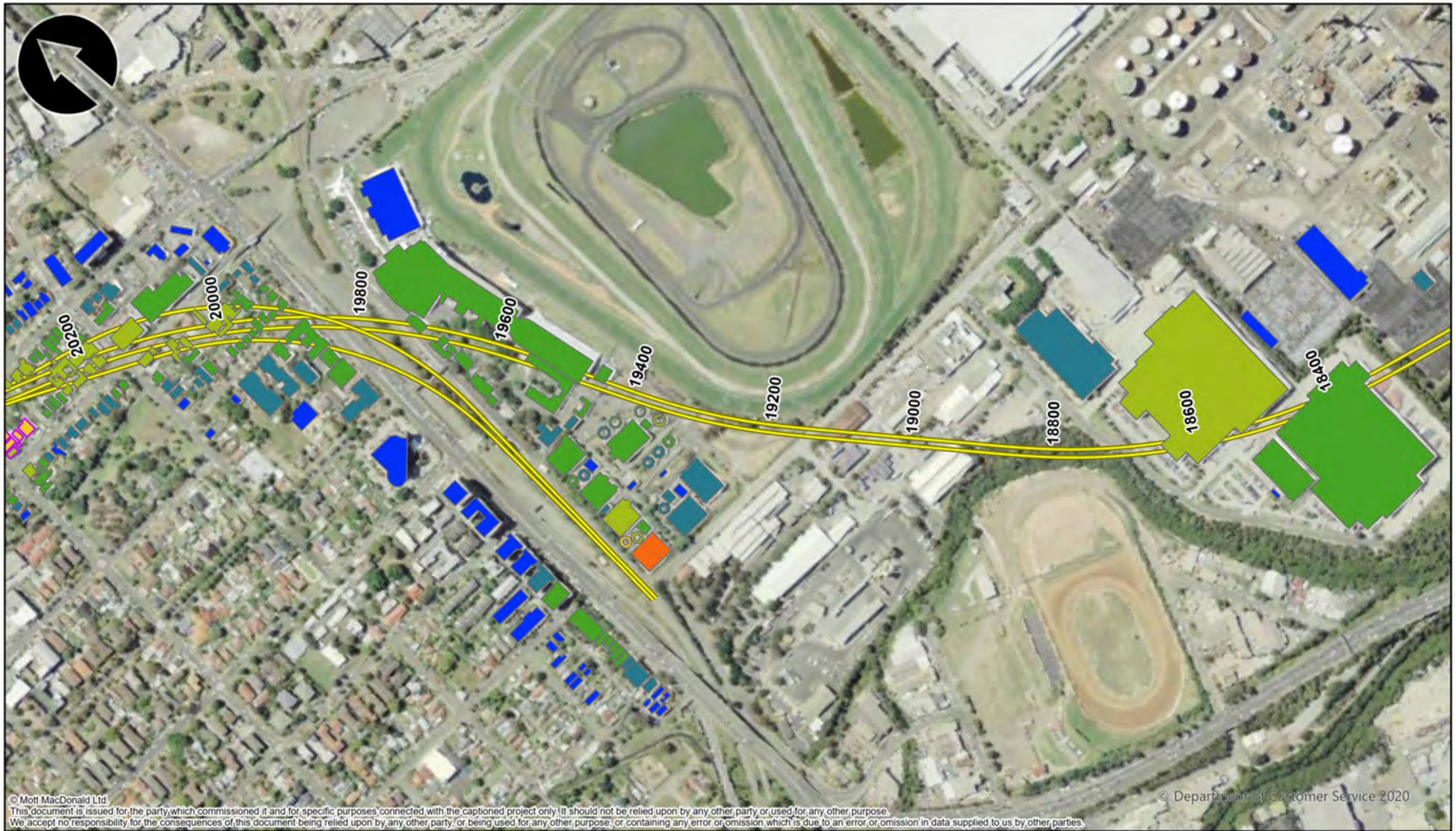

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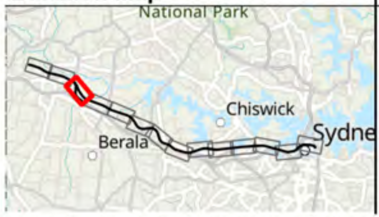

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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | Sydney Metro

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GDA 1994 MGA Zone 56
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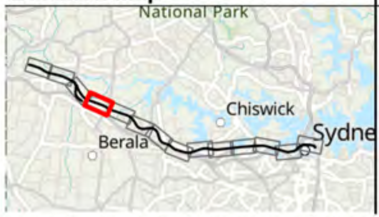

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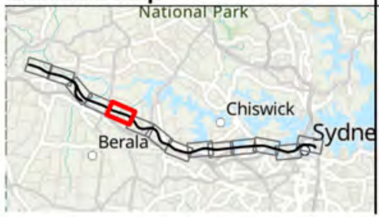

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NSW GOVERNMENT | sydney METRO

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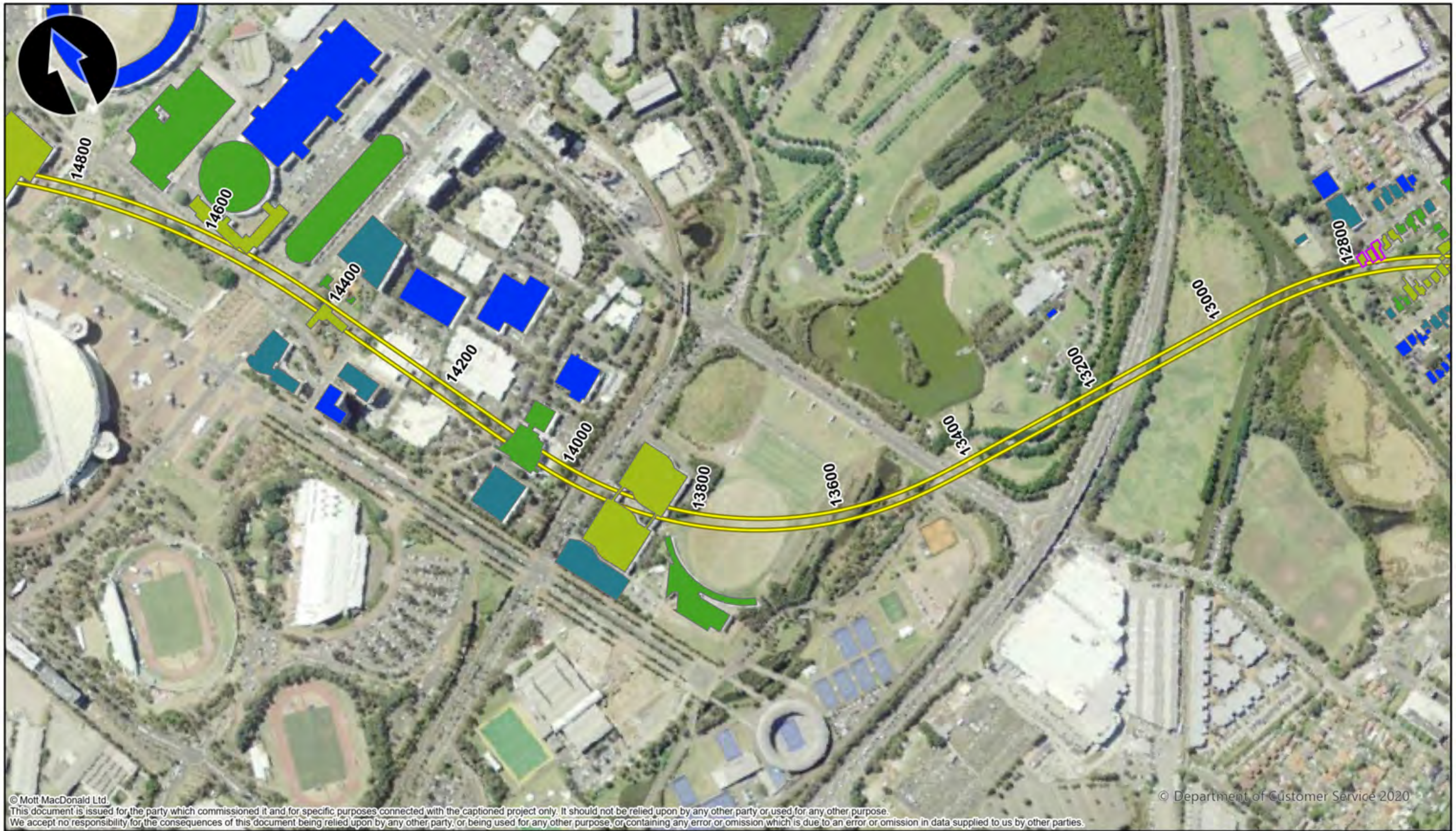

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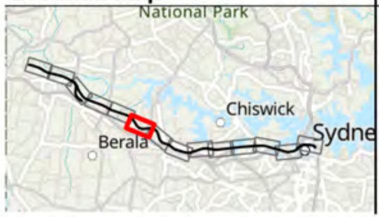

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NSW Government | sydney METRO

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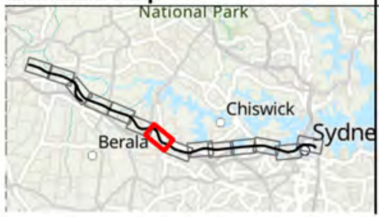

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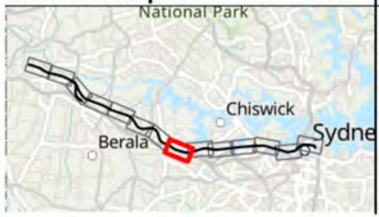

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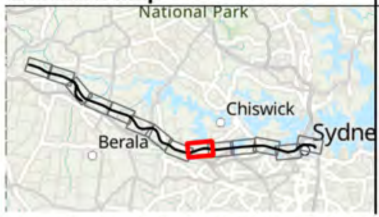

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NSW GOVERNMENT | sydney METRO

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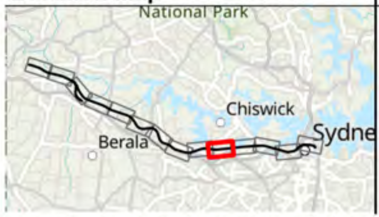

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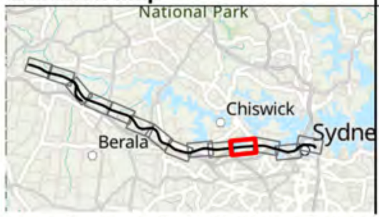
Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
- 45-50 dBA
- 40-45 dBA
- 35-40 dBA
- 30-35 dBA
- 25-30 dBA
- 20-25 dBA
- ≤20 dBA

Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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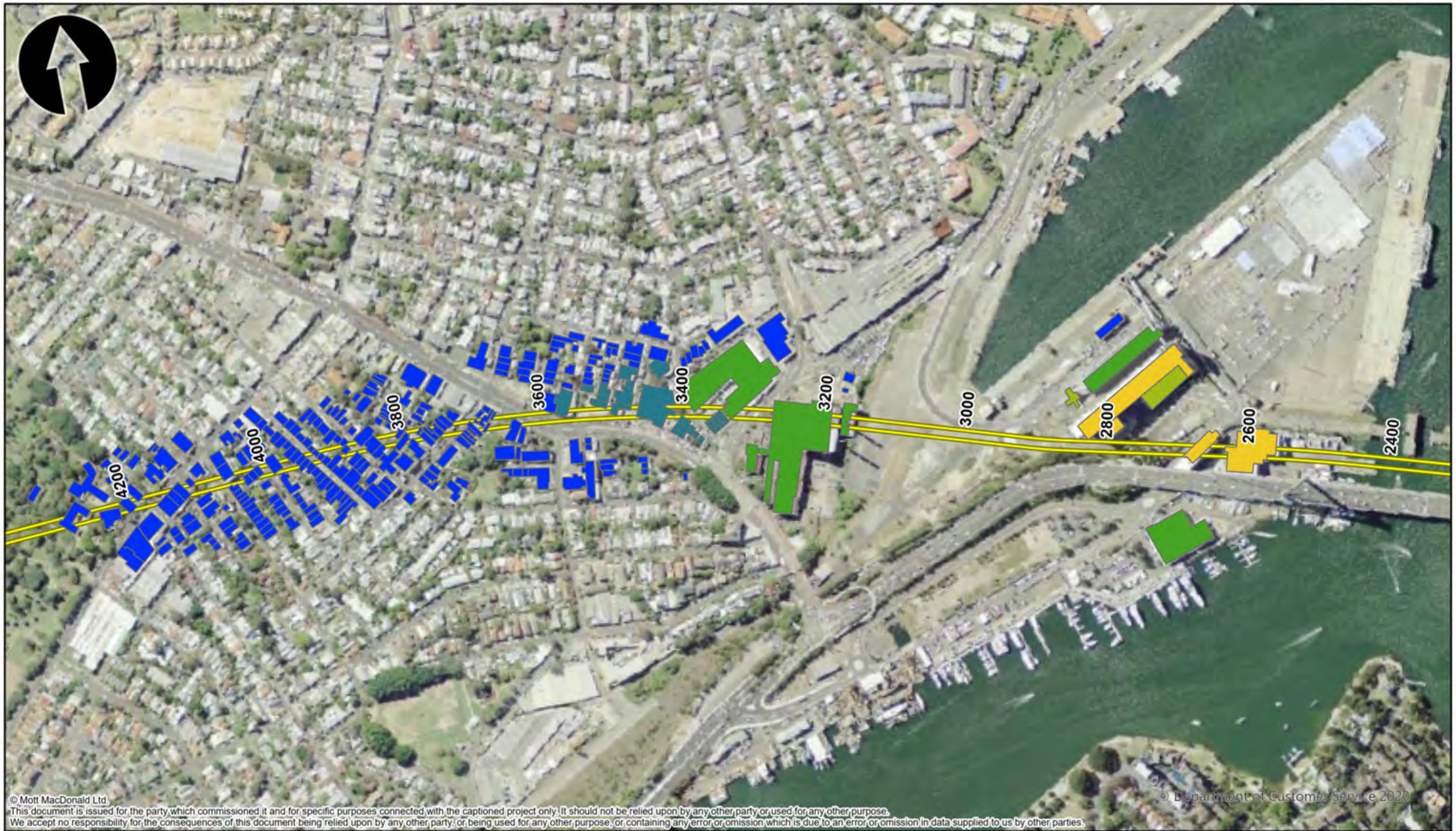
Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)



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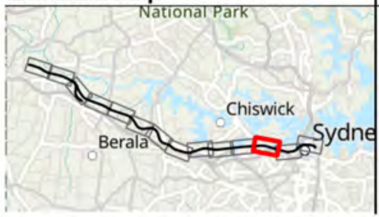

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
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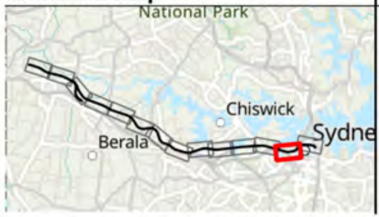

Legend

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- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
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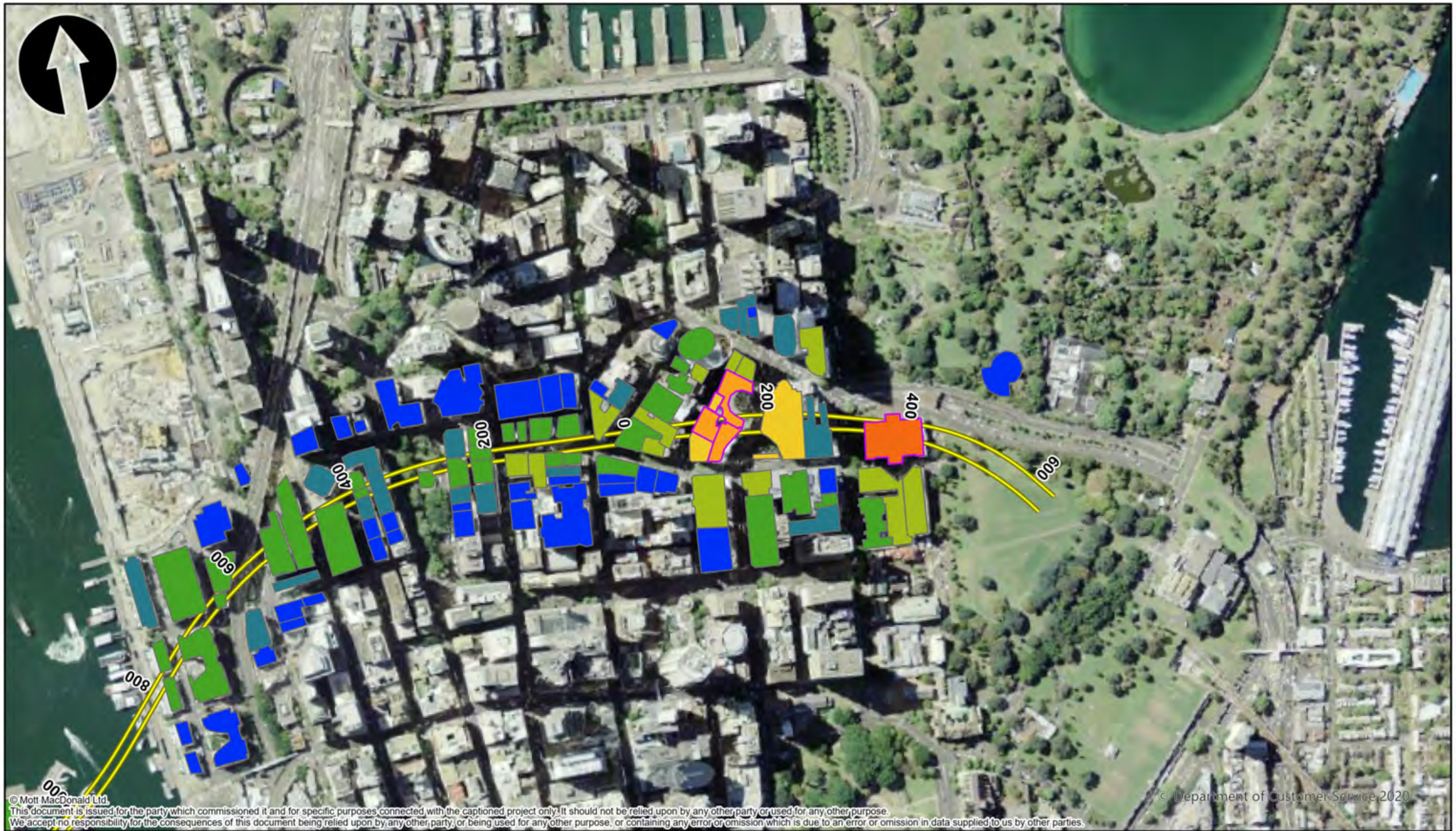

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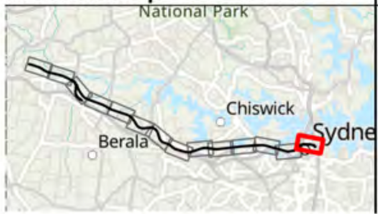

Legend

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- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 2
Type 2 & 1A Track
95th Percentile Ground-Borne Noise Prediction

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Scale: 1:7,000 at A4

0 250 500 Metres

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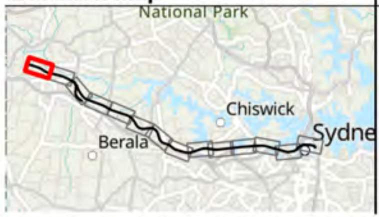
Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 | 250 | 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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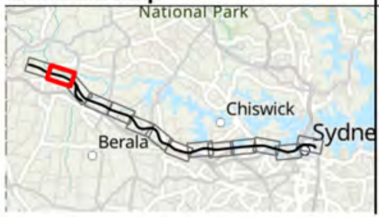
Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
- 45-50 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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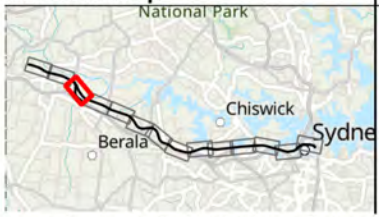
Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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- 30-35 dBA
- 25-30 dBA
- 20-25 dBA
- ≤20 dBA

Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

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Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

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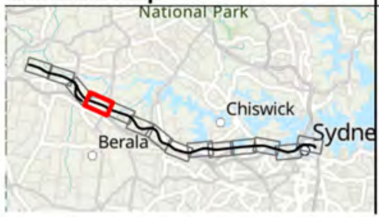

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

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Scale: 1:7,000 at A4

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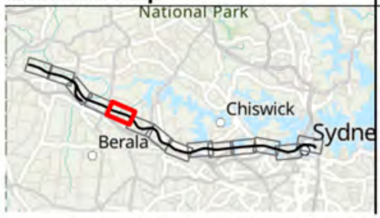
Location Map



Legend

Ground-Borne Noise Exceeds Criteria

Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
- 45-50 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

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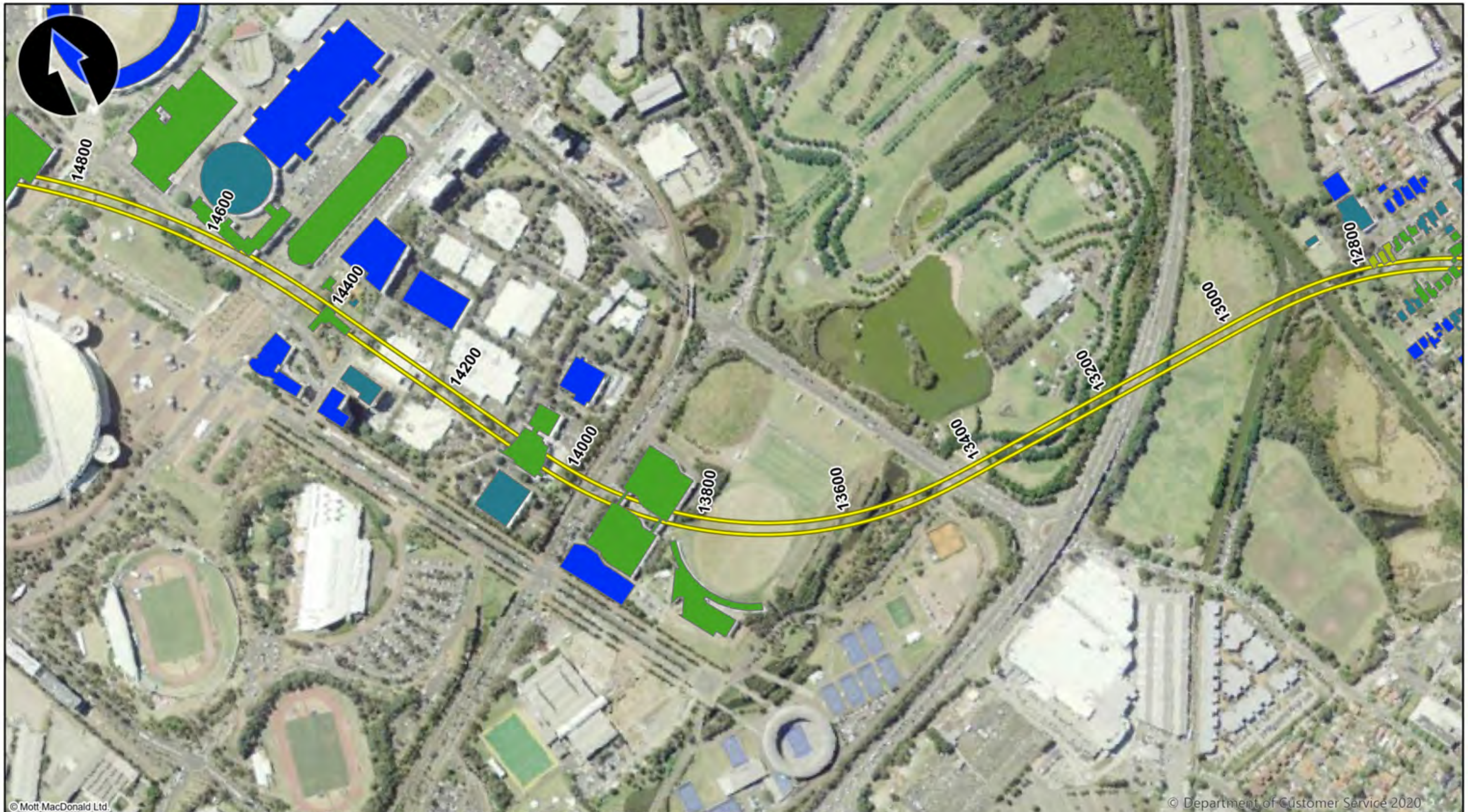

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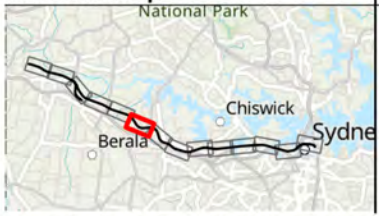

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

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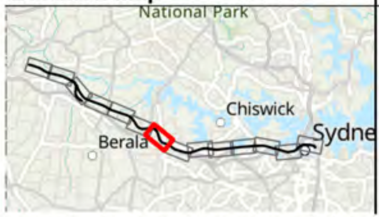

Legend

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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

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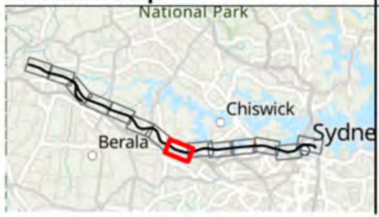
Location Map



Legend

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- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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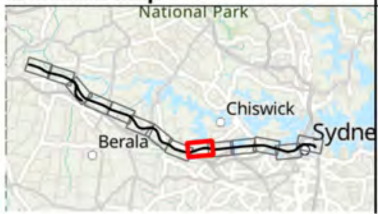

Legend

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- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | Sydney Metro

Scale: 1:7,000 at A4
0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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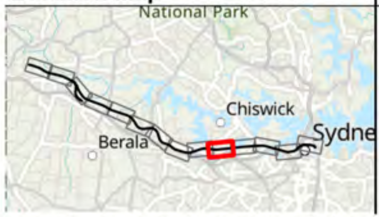
Location Map



Legend

Ground-Borne Noise Exceeds Criteria

Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
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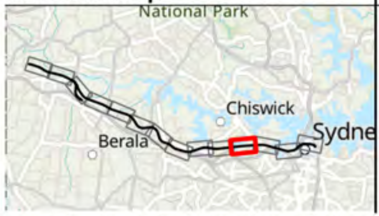
Location Map



Legend

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- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW Government | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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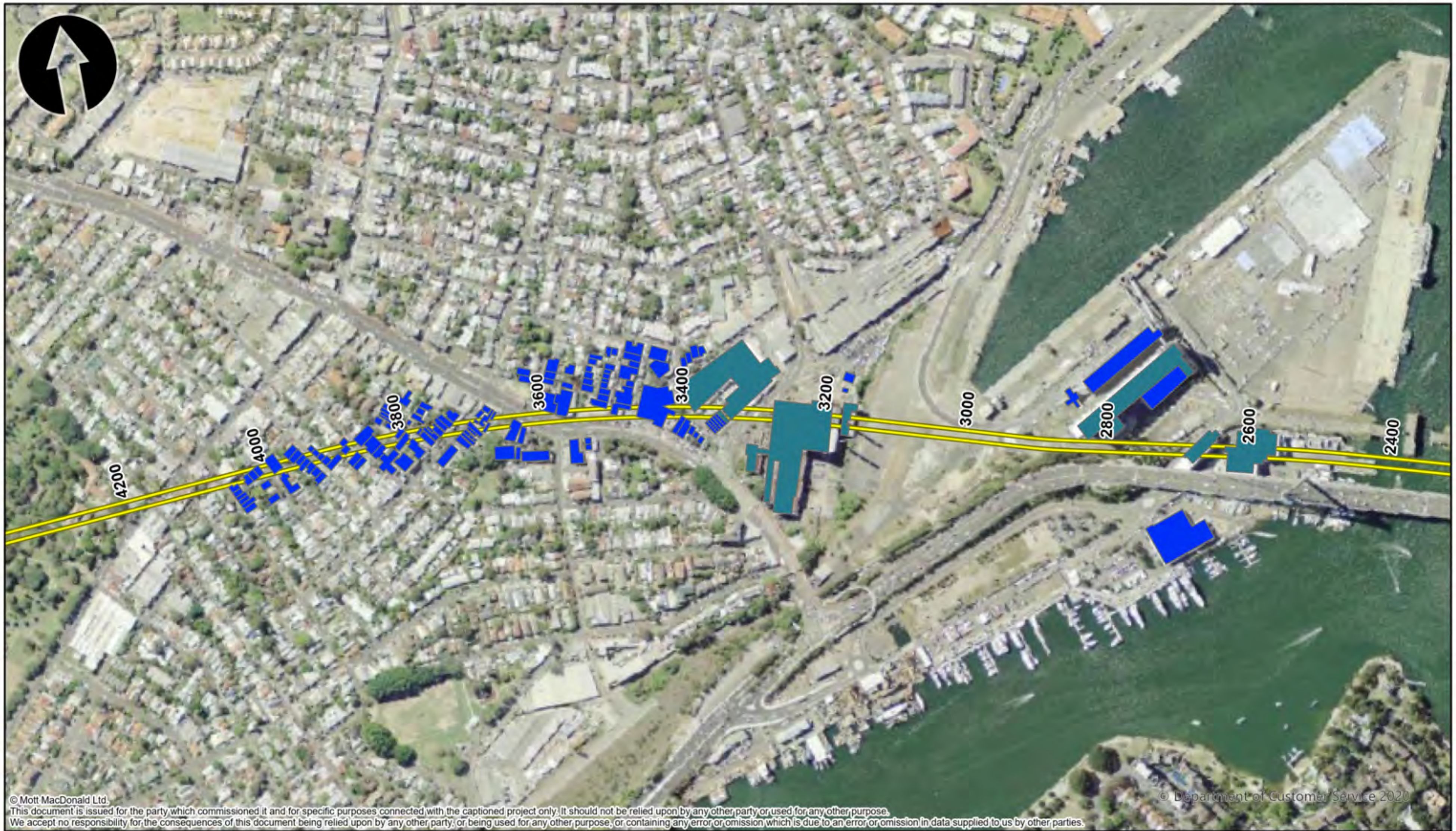

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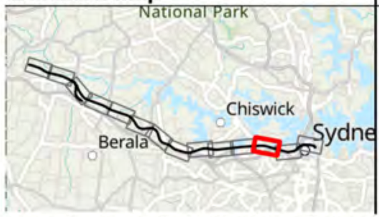

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
- 50-55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

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Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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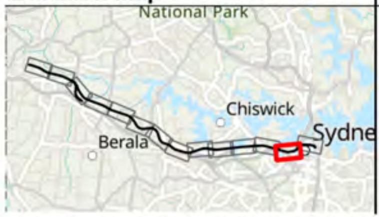

Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

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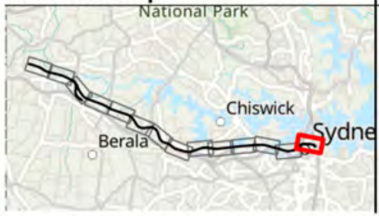
Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Location Map



Legend

- Ground-Borne Noise Exceeds Criteria
- Alignment V4.2 Hybrid

Predicted Ground-Borne Noise Level, L_{Amax}

- >55 dBA
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Sydney Metro West

Scenario 3
Type 3A Track
95th Percentile Ground-Borne Noise Prediction

NSW GOVERNMENT | sydney METRO

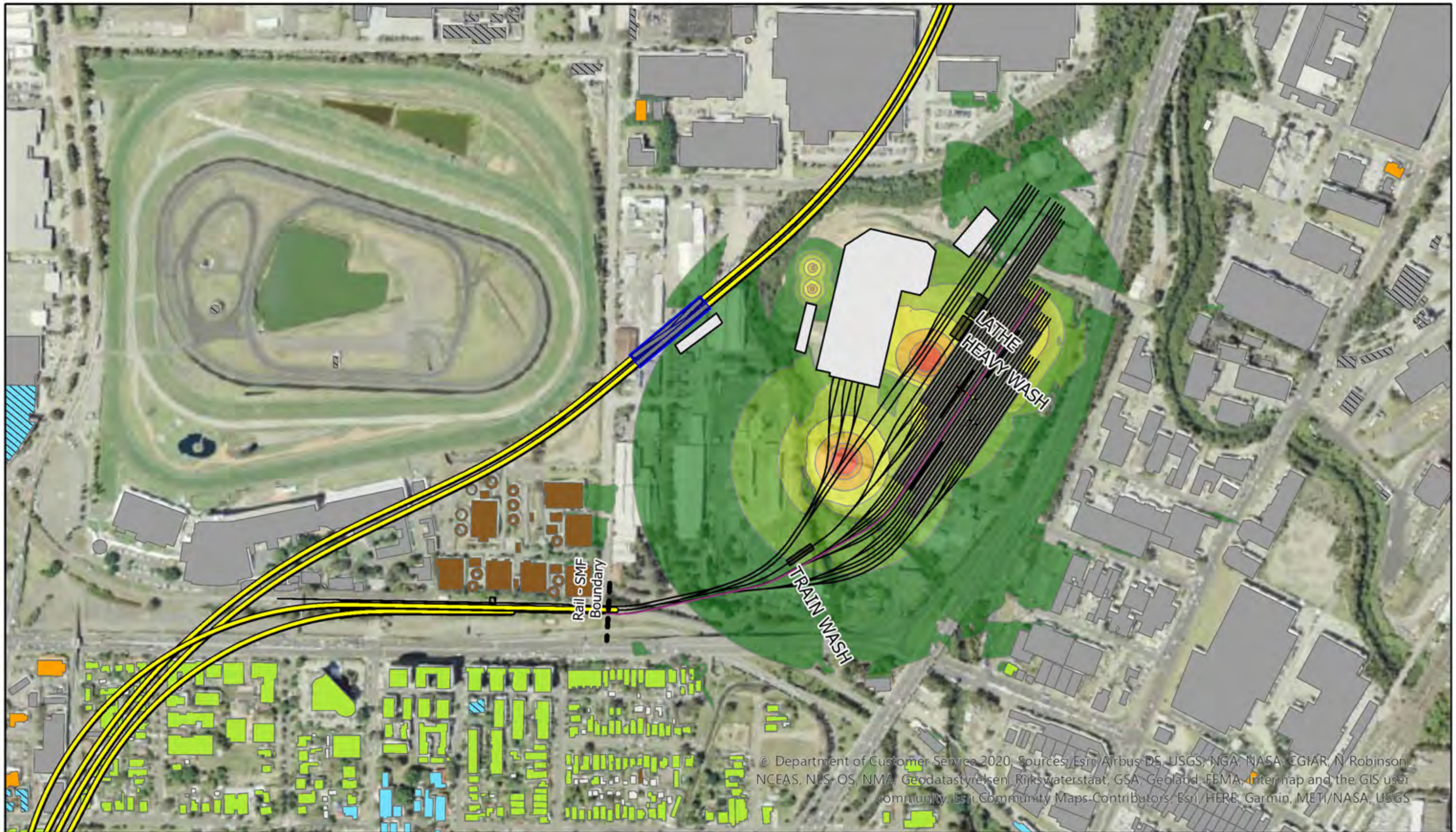
Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56
Map Export Date: 5/10/2021

Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Appendix D Stabling and maintenance facility noise contours



Location Map

Legend

Building Use Type

- Residential
- Child care
- Education
- Medical
- Commercial
- Industrial
- Garage
- Retail
- Worship
- Courts
- Drama theatre
- Public hall
- Library
- Mixed use
- Stable
- Studio
- Station_wall

L_{AFmax} noise level, dB(A)

- 45 to 50
- 50 to 55
- 55 to 60
- 60 to 65
- 65 to 70
- 70 to 75
- > 75

Sydney Metro West

Clyde Stabling and Maintenance Facility and Rosehill Services Facility L_{AFmax} maximum noise impacts

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56

Map Export Date: 14/09/2021

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Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Location Map

Legend

Building Use Type

- Residential
- Child care
- Education
- Medical
- Commercial
- Industrial
- Garage
- Retail
- Worship
- Courts
- Drama theatre
- Public hall
- Library
- Mixed use
- Stable
- Studio
- Station_wall

$L_{Aeq,15min}$ noise level, dB(A)

- 35 to 40
- 40 to 45
- 45 to 50
- 50 to 55
- 55 to 60
- 60 to 65
- > 65

Sydney Metro West

Clyde Stabling and Maintenance Facility and Rosehill Services Facility Design Year

$L_{Aeq,15min}$ Noise Impacts

NSW GOVERNMENT | sydney METRO

Scale: 1:7,000 at A4

0 250 500 Metres

GDA 1994 MGA Zone 56

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Basemap (Location Map) : ESRI World Topographic Map, Basemap (Map) SIX Maps Public NSW Imagery (Map Server)

Appendix E Ground-borne noise vs chainage long sections

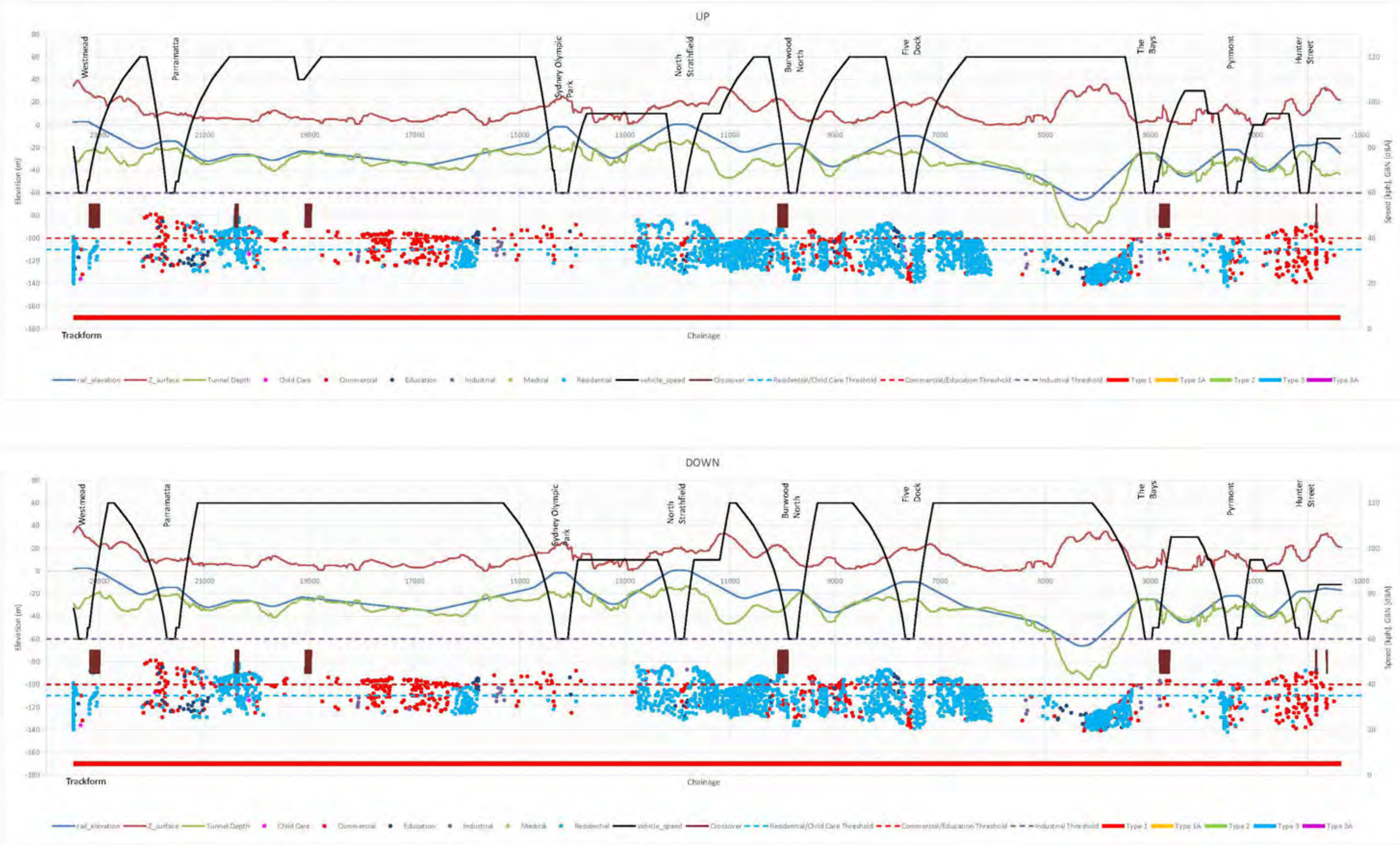
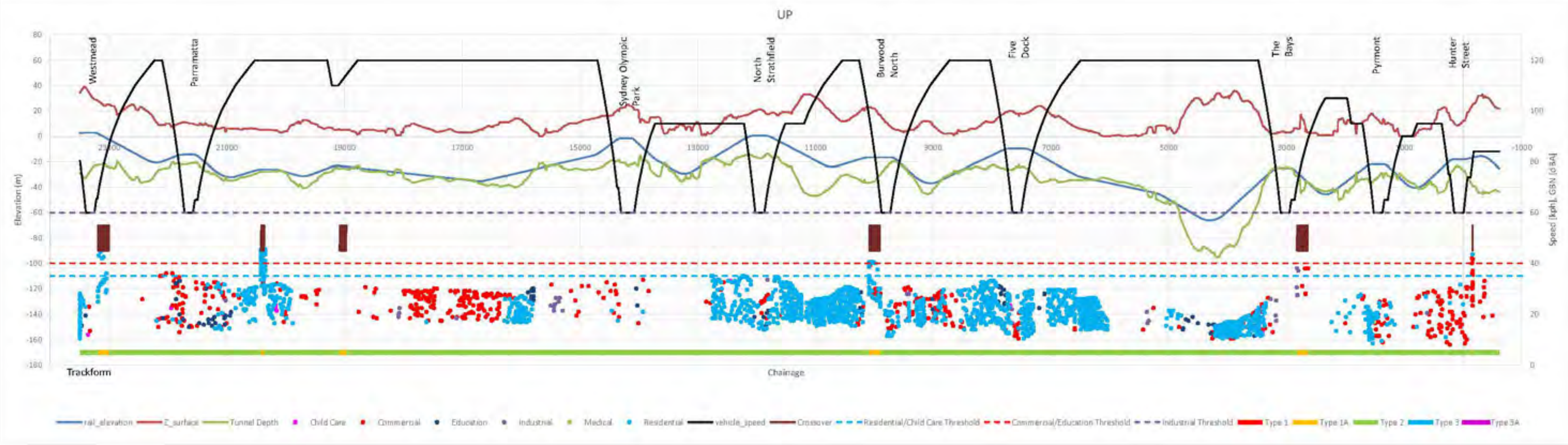


Figure E-1: Scenario 1 ground-borne noise predictions



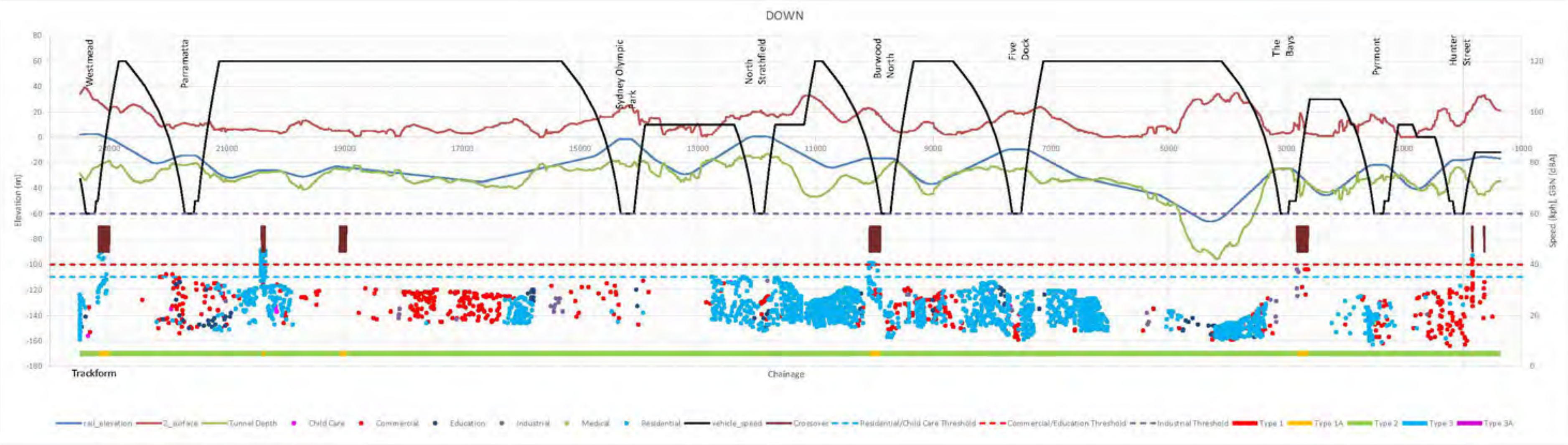
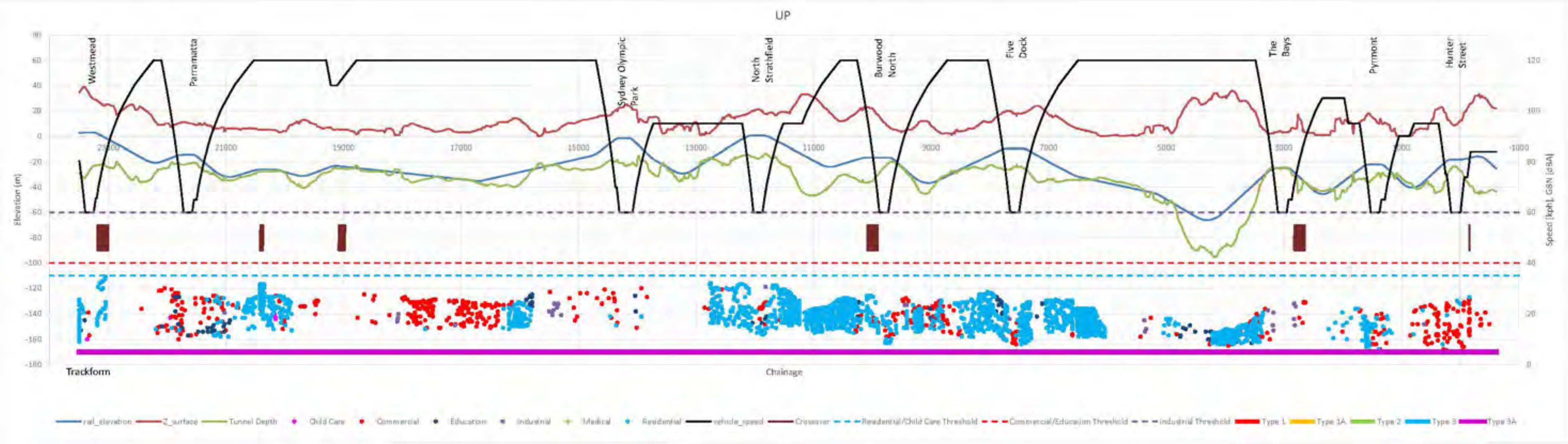


Figure E-2: Scenario 2 ground-borne noise predictions



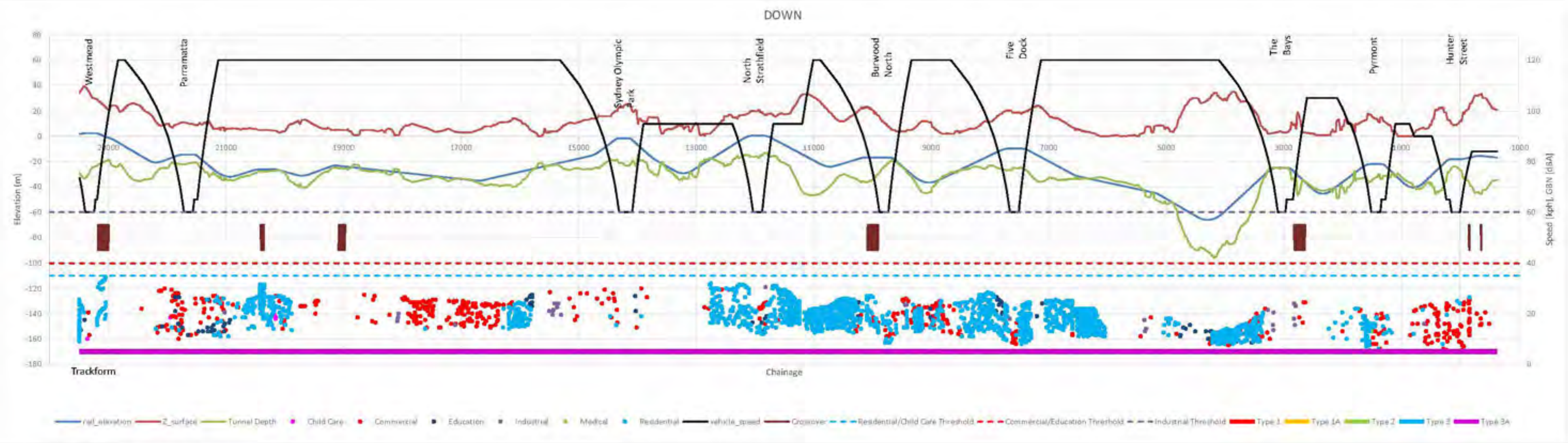


Figure E-3: Scenario 3 ground-borne noise predictions