Appendix C Noise and Vibration Impact Assessment

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Noise and Vibration Impact Assessment
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Hurstville Crossover

Noise and Vibration Impact Assessment

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Noise and Vibration Impact Assessment

Client: Transport for New South Wales

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Executive Summary

Transport for NSW (TfNSW) proposes to deliver service improvements on the T4 Illawarra Line, South Coast Line and T8 Airport Lines. The improvements would deliver greater capacity, reliability and connectivity for customers. To achieve this, TfNSW has developed the More Trains, More Services Program (the 'Program').

As part of the Program, Hurstville to Bondi Junction all station services will swap operation from the Illawarra Local tracks to the Illawarra Main tracks to optimise the capacity of the T4 corridor. The Hurstville Crossover Proposal (the 'Proposal') would introduce a crossover on the City side of Hurstville Station to enable all station services operating on the Down Illawarra Main track to terminate at Platform 4 at Hurstville Station and commence a service in the Up direction on the Up Illawarra Main track.

This noise and vibration impact assessment forms part of the Review of Environmental Factors (REF) which assesses the potential impacts of the Proposal on the environment. Relevant guidelines and assessment procedures have been followed to ensure all applicable State requirements have been considered.

A survey has been undertaken of the existing conditions throughout the Proposal area. Buildings throughout the Proposal area have been visually inspected (from the outside) to identify their likely use and the number of storeys. Background noise levels have been monitored at a residential receiver location to identify the existing noise environment throughout the Proposal area. The existing noise environment allows this assessment to define appropriate noise criteria.

A construction noise impact assessment has been conducted in accordance with the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2019). Reasonable worst-case construction scenarios have been assessed. Construction of the Proposal would occur both during standard construction hours and out of hours to minimise disruptions. The out-of-hours work would be subject to the processes outlined in Section 3.1.

The assessment of noise associated with the construction of the Proposal indicates some exceedances of the ICNG noise management levels at the most affected sensitive receivers. Exceedances of the noise management levels occur during the day and night at the most affected sensitive receivers during certain activities. The magnitude of these impacts is consistent with similar construction projects and highlights the need for effective noise mitigation and management planning.

Measures have been recommended to mitigate the construction noise impacts at adjacent sensitive receivers. Specific noise management and mitigation measures would be detailed in the Contractor's Construction Noise and Vibration Management Plan. The recommended management and mitigation measures which would be considered in the plan include:

- Effective community management
- Training of construction site workers
- Use of noise barriers
- Noise monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less sensitive time periods
- Situating plant in less noise sensitive locations
- Construction traffic management
- Respite periods.

Minimum working distances for vibration intensive construction works have been presented. Equipment size would be selected by the Contractor taking into account the minimum working distances and the distance between the construction works and the most affected sensitive receiver. If

works need to be undertaken within minimum working distances, vibration monitoring would be undertaken.

An assessment of the likely construction traffic indicated that the noise increases along construction traffic routes are predicted to be well below the 2 dB increase screening criteria. Therefore, no further assessment is required in accordance with the Environment Protection Authority's *NSW Road Noise Policy* (RNP) (DECCW, 2011).

An operational rail assessment has been completed in accordance with the Environment Protection Authority's *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013). Noise levels have been predicted at sensitive receiver locations throughout the Proposal area during the daytime and night-time scenarios for the 'Build' and 'No build' scenarios. The assessment of noise associated with railway traffic within the Proposal area showed that there were no exceedances of the relevant criteria outlined in the RING. As a result, no further mitigation of rail noise is considered.

1.0 Introduction

1.1 Overview

Transport for NSW (TfNSW) proposes to deliver service improvements in the T4 Illawarra Line, South Coast Line and T8 Airport Lines, including capacity, reliability and connectivity improvements for customers. To achieve this, TfNSW has developed the More Trains, More Services Program (the Program).

As part of the Program, Hurstville to Bondi Junction all station services will swap operation from the Illawarra Local tracks to the Illawarra Main tracks to optimise the capacity of the T4 corridor. The Hurstville Crossover Proposal (the 'Proposal') would introduce a crossover on the City side of Hurstville Station to enable all station services operating on the Down Illawarra Main track to terminate at Platform 4 at Hurstville Station and commence a service in the Up direction on the Up Illawarra Main track.

AECOM Australia Pty Ltd (AECOM) has been commissioned by TfNSW to carry out a noise and vibration impact assessment for the construction and operation of the Proposal.

A glossary of acoustic terminology is provided in Appendix A.

1.2 Background

The Proposal would contribute to the transformation of the rail network to provide customers with more reliable, high capacity turn up and go services. In response to growth in demand on these lines, the next stages of the program will deliver a 30 per cent uplift in the total number of peak services on the T4 Illawarra Line, reducing crowding and providing a more comfortable journey for customers in the Sutherland Shire, Illawarra and South Coast.

1.3 The Proposal

The Proposal would include the following key elements:

- construction of a new crossover (approximately 100 metres in length) between the existing Up and Down tracks of the Illawarra Main including minor adjustments to the vertical and horizontal elevation of the tracks
- modification and addition of overhead wiring (OHW) structures, including new OHW supports beneath the existing bridge
- installation of new signals, turnouts and associated trackside equipment
- modification of the existing combined services route (CSR) to accommodate the new signalling infrastructure
- minor modification of an existing drainage channel.

A detailed description of the Proposal is provided in Chapter 3 of the Hurstville Crossover Review of Environmental Factors (REF).

1.4 Relevant guidelines

The relevant policies and guidelines for noise and vibration assessments in NSW that have been considered during the preparation of this report include:

- *Interim Construction Noise Guideline* (ICNG), Department of Environment and Climate Change, 2009
- *Construction Noise and Vibration Strategy* (CNVS), Transport for New South Wales (TfNSW), 2018
- *Assessing Vibration: A Technical Guideline* (AVATG), Department of Environment and Conservation (DEC), 2006

- DIN 4150:Part 2-1999 *Structural vibration – Human exposure to vibration in buildings* (Deutsches Institut für Normung 1999)
- DIN 4150:Part 3-2015 *Structural vibration – Effects of vibration on structures* (Deutsches Institut für Normung 2015)
- *NSW Road Noise Policy* (RNP), Department of Environment, Climate Change and Water (DECCW), 2011
- *Noise Policy for Industry* (NPfI), Environment Protection Authority (EPA), 2017
- *Rail Infrastructure Noise Guideline* (RING), Environment Protection Authority (EPA), 2013.

2.0 Existing noise environment

2.1 Proposal area description

The Proposal is located in close proximity to Hurstville Station, Hurstville, approximately 15 kilometres south west of the Sydney CBD. The Proposal would be undertaken wholly within the suburb of Hurstville in the Hurstville Council Local Government Area (LGA).

The Proposal area, which includes the crossover location and associated construction compounds and laydown areas, extends from approximately 150 metres west of Hurstville Station to approximately 300 metres east of Hurstville Station. The Proposal is bounded by Hurstville CBD to the north, Hurstville Station to the west and residential premises to the south. An overview of the Proposal area showing the noise monitoring location and assessment receivers is shown in Figure 1 below. The acoustic environment is dominated by noise associated with traffic and commercial activities within Hurstville CBD and railway noise.

2.2 Receivers

Residential and non-residential receivers potentially affected by the construction and operation of the Proposal have been identified within the Proposal area (refer to Figure 1). Receivers comprise residential properties located to the south of the proposal and commercial premises located to the north. These noise sensitive receivers were identified using aerial photography, and their occupational uses were determined through a ground-truthing site survey exercise. This exercise, in conjunction with cadastral information, was used to determine the classification of any residential, commercial, industrial, educational and recreational buildings, as well as other uses (such as unoccupied sheds). Sensitive receivers in this area include multi-storey residential buildings in proximity to Hurstville CBD and one and two storey residential properties further from the railway line.

To provide a comprehensive assessment, 18 representative residential receivers surrounding the Proposal, as listed in Table 1, have been selected to describe the noise impacts in accordance with the ICNG. Residences located closest to the Proposal within each block were selected as the potentially worst affected receivers. Impacts were also assessed at representative non-residential sensitive receivers as listed in Table 2.

The locations of the residential and non-residential receivers identified for use in the assessment are presented in Figure 1. It is noted that other residential and non-residential sensitive receivers which could potentially be affected by the Proposal are also located in the vicinity of the Proposal, however as noted above, noise impacts have been assessed at representative worst-affected receivers.

Table 1 Representative receiver addresses – residential

Receiver ID	Receiver address	Approximate distance to Proposal works in metres
R1	12 Woniora Road, Hurstville	75
R2	23 Woniora Road, Hurstville	85
R3	44 Rosebank Crescent, Hurstville	100
R4	2-8 Bridge Street, Hurstville	500
R5	10 Gloucester Road, Hurstville	270
R6	12 Carrington Avenue, Hurstville	140
R7	384 Forest Road, Hurstville	100
R8	18 Woodville Street, Hurstville	180
R9	11-17 Woodville Street, Hurstville	240
R10	21 Treacy Street, Hurstville	45
R11	1 Hill Street, Hurstville	10
R12	1 Jack Brabham Drive, Hurstville	35
R13	512 Railway Parade, Hurstville	65
R14	1A Woids Avenue, Hurstville	55
R15	542 Railway Parade, Hurstville	90
R16	548 Railway Parade, Hurstville	40
R17	558 Railway Parade, Hurstville	40
R18	564-576 Railway Parade, Hurstville	60

Table 2 Representative receiver addresses – non-residential

Receiver ID	Receiver	Approximate distance to Proposal works in metres
N1	Col Jones Swim School Hurstville	200
N2	Southern Sydney Synagogue	110
N3	Hurstville Police Station	195
N4	Georges River Council	160
N5	Hurstville Public School	300
N6	Hurstville Library	210
N7	Hurstville Presbyterian Church	320
N8	St George's Hurstville Anglican Church	170

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Figure 1 Noise catchment areas and logger locations

2.3 Noise monitoring

Ambient noise monitoring was conducted at one location within the Proposal area during May 2019. This included both long term unattended monitoring and short term attended measurements.

The unattended noise measurements define the long term noise environment throughout the Proposal area and are used to define the construction and operational noise criteria. Attended noise measurements are carried out to determine what noise sources contribute to the local noise environment.

2.3.1 Instrumentation

Details of the equipment used for unattended long term noise monitoring are presented in Table 3. The noise monitoring location is shown graphically in Figure 1 above.

Table 3 Noise monitoring details

Address	Model	Serial number
550 Railway Parade, Hurstville	Svan 977	45417

The sound level meter used to conduct attended measurements was a Bruel & Kjaer 2250 (Serial Number 3009329). All acoustic instrumentation used for the assessment comply with the requirements of AS IEC 61672.1-2004 Electroacoustics – Sound level meters – Specifications and were calibrated before and after monitoring sessions with a drift in calibration not exceeding ± 0.5 dB.

All instruments used were within their current National Association of Testing Authorities, Australia (NATA) certified in-calibration period (i.e. calibration in the last two years).

2.3.2 Unattended background noise monitoring results

Unattended noise monitoring was carried out from 9 May 2019 to 17 May 2019 at one location considered to be representative of the noise sensitive receivers within the Proposal area (refer to Figure 1).

A sound level meter measures the noise level over the sample period and then determines L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample period respectively. The L_{A1} is indicative of maximum noise levels due to individual noise events. The L_{A90} is considered to be the background noise level. The L_{Aeq} parameter is the energy averaged sound level over the measurement period. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

The assessment background level (ABL) is established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each period of interest. The background noise level or rating background level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring duration. The RBL is representative of the average minimum background sound level, or simply the background level.

A noise logger report including graphical representations of the logging results, a summary of the results and the measurement location is provided in Appendix B. A summary of the measured L_{A90} background noise levels and existing L_{Aeq} ambient noise levels is presented in Table 4.

Table 4 Existing background and ambient noise levels, dB(A)

Address	Rating background level, dB(A)			Existing noise levels L_{Aeq}, dB(A)		
	Day	Evening	Night	Day	Evening	Night
550 Railway Parade, Hurstville	46	45	35	60	59	56

Notes:

1. *In accordance with the NPfI, time of day is defined as follows:*
   Day – the period from 7 am to 6 pm Monday to Saturday or 8 am to 6 pm on Sundays and public holidays
   Evening – the period from 6 pm to 10 pm
   Night – the remaining periods.

2.3.3 Attended noise monitoring

Attended noise monitoring was conducted at the unattended monitoring location on 9 May 2019. The measurement was conducted over a 15 minute period. Weather conditions were clear on the day of monitoring, with no wind. The monitoring results from the attended measurements are presented in Table 5.

Table 5 Attended noise monitoring details

Address	Date	Time	Description	$L_{Amax, 15min}$ dB(A)	$L_{A10, 15min}$ dB(A)	$L_{Aeq, 15min}$ dB(A)	$L_{A90, 15min}$ dB(A)
550 Railway Parade, Hurstville	9 May 2019	11:15 am	Noise environment dominated by road traffic noise from Railway parade and Hurstville CBD	73	63	60	50

3.0 Assessment criteria

3.1 Construction noise criteria

The ICNG is a NSW Government document that identifies ways to manage impacts of construction noise on residences and other noise sensitive land uses. It is the principal guideline for the assessment and management of construction noise in NSW and is used to establish construction noise management levels (NML). As the proposed works are expected to continue for a period of more than three weeks and are within relatively close proximity to noise sensitive receivers, a quantitative assessment, based on 'reasonable' worst case construction scenarios, has been carried out for these works.

Noise levels resulting from construction activities are predicted at nearby noise sensitive receivers using noise modelling software and are compared to the levels provided in the ICNG. Where an exceedance of the NMLs is predicted the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially affected residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details should they wish to make a complaint.

Where construction noise levels at the receiver reach 75 dB(A) residential receivers are considered to be 'highly noise affected' and the proponent should, in consultation with the community, consider restrictions to the hours of construction to provide respite periods.

The ICNG defines what is considered to be feasible and reasonable as follows:

- Feasible - a work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements
- Reasonable - selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

Additionally, the ICNG notes that strong justification is required for work that is proposed outside of standard working hours.

Residential receiver NMLs for this Proposal have been derived using the information presented below in Table 6.

Table 6 Construction noise management levels – Residential receivers

Time of day	Construction noise management level $L_{Aeq,15min}$	How to apply
Recommended standard hours: • Monday to Friday 7am to 6pm • Saturday 8am to 1pm • No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,15\ min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB(A)	• A strong justification would typically be required for works outside the recommended standard hours • The proponent should apply all feasible and reasonable work practices to meet the noise affected level • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community • For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Notes:

1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

3.1.1 Construction hours

The work required for the Proposal would be carried out both during standard construction hours and out-of-hours works (OOHW). The standard construction hours as recommended in the ICNG as follows:

- 7:00am to 6:00pm Monday to Friday
- 8:00am to 1:00pm Saturdays
- No work on Sundays or public holidays.

Night works will generally occur during routine scheduled closures where part of the rail network is temporarily shut down.

OOHW are required in some cases to minimise disruptions to customers, pedestrians, motorists and nearby sensitive receivers; and to ensure the safety of railway workers and operational assets. It is estimated that approximately four rail possessions would be required to facilitate the following:

- Delivery of oversized loads to the site such as construction plant and portable construction compound buildings, steel beams and precast concrete elements
- Works to upgrade the existing overhead wiring and construction of the new crossover.

Out-of-hours works may also be scheduled outside rail possession periods. The construction Contractor would require approval from TfNSW for any out-of-hours work. The affected community would be notified as outlined in TfNSW's CNVS.

3.1.2 Construction noise management levels

Provided in Table 7 are the applicable NMLs for the Proposal, based on the RBLs in Table 4 and NMLs in Table 6.

Table 7 Construction noise management levels - residential receivers

Period	RBL L_{A90}, dB(A)	Standard hours noise management levels, $L_{Aeq,15min}$, dB(A)	Out of hours noise management levels, $L_{Aeq,15min}$, dB(A)
Day	46	56	51
Evening	45	-	50
Night	35	-	40

NMLs recommended by the ICNG for non-residential sensitive land uses, such as schools, hospitals or places of worship are provided in Table 8. NMLs for commercial and industrial premises are provided in Table 9.

Table 8 Construction noise management levels – non-residential sensitive land uses

Land use	Noise management level, $L_{Aeq(15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended “maximum” internal levels in AS2107 for specific uses.

Table 9 Construction noise management levels – commercial and industrial land uses

Land use	Noise management level, $L_{Aeq(15min)}$
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

3.1.3 Sleep disturbance

The ICNG requires a sleep disturbance assessment to be undertaken where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the ECRTN, now superseded by the RNP, for the assessment of sleep disturbance.

The guidance provided in the RNP for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the $L_{A1(1\ min)}$ noise level outside a bedroom window should not exceed the $L_{A90(15\ min)}$ background noise level by more than 15 dB(A). The EPA considers it appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken that should include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The RNP contains a review of research into sleep disturbance which represents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes that having considered the results of research to date that, 'Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions'. Therefore, given that an open window provides around 10 dB(A) in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Table 10 presents the sleep disturbance screening and sleep disturbance awakening reaction criteria.

Table 10 Construction noise sleep disturbance criteria

Night time rating background level, dB(A)	Sleep disturbance screening $L_{A1(1min)}$ criteria, dB(A)	Sleep disturbance awakening reaction $L_{A1(1min)}$ criteria, dB(A)
35	50	65

3.1.4 Construction road traffic noise

Noise from construction traffic on public roads is not covered by the ICNG. However, the ICNG does refer to the ECRTN, which is now superseded by the RNP, for the assessment of noise arising from construction traffic on public roads.

To assess noise impacts from construction traffic, an initial screening test has been undertaken by evaluating whether existing road traffic noise levels would increase by more than 2 dB(A). Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. However, where the predicted noise level increase is greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion then noise mitigation should be considered for those receivers affected. The RNP does not require assessment of noise impact to commercial or industrial receivers.

3.2 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in Table 11.

Table 11 Standards/guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150)
Human comfort (tactile vibration)	*Assessing Vibration: A Technical Guideline* (AVATG)[1]

Notes:

1. *This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the Environment Protection Authority still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.*

Vibration, at levels high enough, has the potential to cause damage to structures and disrupt human comfort. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent as follows:

- continuous vibration continues uninterrupted for a defined period and includes sources such as machinery and continuous construction activities
- impulsive vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, with durations of typically less than two seconds and no more than three occurrences in an assessment period. This may include occasional dropping of heavy equipment or loading activities
- intermittent vibration occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, jack hammers.

3.2.1 Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration. The German standard (DIN 4150) provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 12. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

Table 12 Structural damage safe limits for building vibration (Vibration peak particle velocity)

Group	Type of structure	At foundation Less than 10 Hz	At foundation 10 Hz to 50 Hz	At foundation 50 Hz to 100 Hz[1]	Vibration at the horizontal plane of the highest floor for all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or use	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order/heritage listed)	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

Notes:

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values

3.2.2 Human comfort

The assessment of intermittent vibration outlined in the NSW EPA guideline AVATG is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the daytime and night-time periods.

Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in Table 13. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 13 Preferred and maximum vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Daytime [1] Preferred	Daytime Max	Night time Preferred	Night time Max
Critical areas[2]	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

Notes:

1. *Day is defined as 7:00 am to 10:00 pm. Night is defined as 10:00 pm to 7:00 am*
2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.*

3.3 Operational noise criteria – Rail noise

The RING provides the applicable noise trigger levels for the assessment of rail induced airborne noise. These trigger levels are considered non-mandatory and represent a point at which reasonable and feasible noise mitigation should be considered.

The RING provides noise trigger levels for both new and redeveloped rail lines. Since work associated with the Proposal comprises a redevelopment of the existing T4 and South Coast Lines, all sensitive receivers surrounding the project area are subject to the redeveloped noise criteria.

Provided below is a summary of the RING trigger levels for redeveloped corridors.

Table 14 Airborne heavy rail noise trigger levels for residential land uses

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

In accordance with the RING, sensitive land uses other than residential (e.g. hospitals, schools) have their own specific noise trigger levels for rail redevelopments, applicable when the facility or space is in use. These applicable criteria are shown in Table 15.

Table 15 Airborne heavy rail noise trigger levels for applicable non-residential land uses

Land use	Redevelopment of existing rail line noise criteria (dB(A)) (when in use)
	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, and resulting rail noise levels exceed:
Schools, educational institutions and child care centres	45 $L_{Aeq(1hr)}$ (internal)
Open space – Passive use	65 $L_{Aeq(15hr)}$ (external)

4.0 Construction noise assessment

4.1 Construction stages and scheduling

Construction activities to be carried out as part of the Proposal are outlined in Table 16. The work has been grouped into six distinct construction stages based on proposed construction activities.

Certain work would occur outside standard construction hours. This has been discussed further in Section 3.1.1. In the absence of information regarding which activities are proposed to occur outside of standard construction hours, this assessment has considered all scenarios to be conducted both during standard construction hours and outside standard construction hours.

Table 16 Proposed construction activities

Construction stage	Activities
Site establishment and enabling works	• Establishment and use of site compounds and temporary facilities (i.e. erect fencing, site offices, temporary toilets, hoarding, tree protection zones (TPZs), site offices, amenities and plant/material storage areas) • Establishment of weatherproof access roads, including installation of construction road signage as per Traffic Management Plan (TMP) • Installation of environmental controls (i.e. erosion and sediment control fencing)
Utility works	• Relocation of services • Overhead wiring adjustments • Installation of new overhead wiring structures • Relocation of remaining services including excavation and modifying the drainage channel as required.
New crossover	• Trenching and regrading works for new cross over route • Adjustment of track super-elevation to enable installation of crossover • Ballast reconstruction
Signal post	• Installation of signage as required • Services and fit-out works and electrical works (including any re-directed services/utilities).
Testing and commissioning	• Testing electrical, communications and signalling components
Demobilisation	• Remove temporary site fencing • Dismantling of temporary site compounds/hoarding areas • Remove temporary construction signage

4.2 Plant and equipment levels

Table 17 presents the typical sound power levels of the construction equipment to be used during each modelled construction scenario. The modelled scenarios include all equipment that could be reasonably assumed to be operating at the same time for an entire 15 minute period.

These sound power levels are typical values taken from data provided in Australian Standard AS2436-2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* and British Standard 5228: Part 1 2009 *Code of practice for noise and vibration control on construction and open sites*, 2009 as well as AECOM's noise database.

These sound power levels assume equipment is modern and in good working order. In AECOM's experience, L_{A1} sound power levels of construction activities are typically up to eight decibels above L_{Aeq} sound power levels.

During the detailed design local site conditions and changes in work practices may cause some variation in the equipment used. While the equipment may vary, other major infrastructure projects have shown that due to the conservative approach to noise predictions, received noise levels are unlikely to be appreciably higher than those predicted in this assessment.

This approach is used at this point in the assessment to ensure that identified impacts are not under-predicted and adequate noise management and mitigation measures are considered early in the Proposal.

Table 17 Construction staging and typical sound power levels of construction equipment

Work Packages	Equipment	Sound power level, dB(A)
1: Site establishment and enabling works	Bobcat	104
	Generator	101
	Hand tools	98
	Lighting tower	95
	Light vehicles	90
	Trucks	98
	Total	**107**
2: Utility works	Demolition Saw	110
	8t Excavator	99
	Hand tools	98
	Jackhammer	108
	Lighting tower	95
	Trucks	98
	Total	**113**
3: New Crossover	Generator	101
	Hand tools	98
	Lighting tower	95
	Work train	115
	Tamper	112
	Ballast regulator	115
	Hydrema	107
	Total	**119**
4: Signal Post	Generator	101
	Hand tools	98
	Lighting tower	95
	Trucks	98
	Total	**105**

Work Packages	Equipment	Sound power level, dB(A)
5: Testing and commissioning	Hand tools	98
	Lighting tower	95
	Trucks	98
	Light vehicles	90
	Total	**102**
6: Demobilisation	Bobcat	104
	Generator	101
	Hand tools	98
	Light vehicles	90
	Lighting tower	95
	Trucks	98
	Total	**107**

Two proposed construction compound/laydown locations have been identified for the site establishment and enabling works. The proposed construction compound/laydown locations are 450 metres east or 100 metres west from Hurstville Station. Both construction compound/laydown locations have been modelled in the construction noise assessment.

4.3 Noise modelling methodology

Noise levels due to the construction activities shown in Table 17 were predicted at nearby noise sensitive receivers using SoundPLAN v8.0 noise modelling software. The noise model was created to represent 'reasonable' worst periods of construction work.

The following features were included in the noise model:

- Ground topography
- Ground absorption and reflection.

Receivers as shown in:

- Figure 1
- Construction noise sources as outlined in Table 17.

Noise emissions from the construction sites have been modelled using an implementation of the ISO 9613-2:1996 propagation algorithm with neutral meteorological conditions.

It can be expected that there may be differences between predicted and measured noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment.

4.3.1 Construction modelling assumptions

The following assumptions were made in modelling the construction noise scenarios:

- all equipment would be operating simultaneously, which is unlikely hence a conservative assumption
- equipment was assumed to be operating at the closest point in the Proposal area to each receiver, in order to present the worst-case scenario.
- neutral atmospheric conditions i.e. relatively calm, no wind.

4.4 Construction noise assessment

The identified residential and non-residential receivers have been assessed against the standard hours noise management levels as appropriate. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required.

During construction it is likely that all equipment would not be operating simultaneously at all times and in the one location, which would result in reduced noise levels compared with those predicted. As each construction work package would be occurring discretely a cumulative noise impact is unlikely. Mitigation measures have been specified in Section 7.1 which may reduce the impact of these exceedances on receivers.

Noise results are presented graphically in Appendix C.

4.4.1 Summary of Impacts during Standard Hours at Residential Receivers

Results show construction noise levels are predicted to exceed the NMLs during standard hours for all construction work packages at the closest representative receivers, as shown in **bold** in Table 18.

Noise levels are predicted to exceed the NMLs during OOHW for all construction work packages. The largest number of exceedances of standard hours NML occur during work package 1. The greatest exceedances of the standard hours NMLs and the greatest overall impacts are likely to be experienced at R16 and R17. These locations are most affected as predicted exceedances would occur during several stages of work (due to the proximity of these receivers to the proposed work areas and the duration of the works). Residential receivers R10, R11, and R15, R16, R17 and R18 are predicted to be 'highly affected'.

Table 18 Predicted L_{Aeq} noise impacts at representative residential receivers for each work package during standard hours, dB(A)

Receiver ID	NML		Work Package					
	Standard hours	OOHW	1	2	3	4	5	6
R1	56	40	**65**	31	37	23	25	20
R2	56	40	**58**	30	36	22	24	19
R3	56	40	55	34	40	26	28	23
R4	56	40	43	39	45	31	33	28
R5	56	40	46	39	45	31	33	28
R6	56	40	50	26	32	18	20	15
R7	56	40	**60**	47	53	39	41	36
R8	56	40	46	52	**58**	44	46	41
R9	56	40	46	52	**58**	44	46	41
R10	56	40	**66**	**72**	**78**	**64**	**66**	**61**
R11	56	40	**66**	**72**	**78**	**64**	**66**	**61**
R12	56	40	**70**	52	**58**	44	46	41
R13	56	40	**64**	53	**59**	45	47	42
R14	56	40	**66**	56	**62**	48	50	45
R15	56	40	**63**	**69**	**75**	**61**	**63**	**58**
R16	56	40	**69**	**75**	**81**	**67**	**69**	**64**
R17	56	40	**68**	**74**	**80**	**66**	**68**	**63**
R18	56	40	**65**	**71**	**77**	**63**	**65**	**60**

Notes:

1. *Items in **BOLD** indicate the predicted noise levels at this receiver during this work stage exceed the daytime NMLs.*

4.4.2 Summary of impacts on non-residential receivers

Eight representative non-residential receivers were assessed to determine compliance with the daytime NMLs. N1 is predicted to be exposed to noise levels which exceed the NMLs as shown in bold in Table 19.

The representative non-residential receivers assessed are:

- N1 - Col Jones Swim School Hurstville;
- N2 - Southern Sydney Synagogue;
- N3 - Hurstville Police Station;
- N4 - Georges River Council;
- N5 - Hurstville Public School;
- N6 – Hurstville Library;
- N7 – Hurstville Presbyterian Church
- N8 - St George's Hurstville Anglican Church

Table 19 Predicted noise impacts at representative non-residential receivers, dB(A)

Receiver ID	NML	Work Package[1]					
		1	2	3	4	5	6
N1	55[2]	55	61	**67**	53	55	50
N2[2]	55[2]	50	46	52	38	40	35
N3	70	55	52	58	44	46	41
N4	70	48	32	38	24	26	21
N5	65	34	40	46	32	34	29
N6	55[2]	49	41	47	33	35	30
N7	55[2]	35	36	42	28	30	25
N8	65	38	38	44	30	32	27

Notes:

1. *Items in **BOLD** indicate predicted noise levels at this receiver during this work stage exceed the NML.*
2. *External noise level NMLs are based upon internal noise criteria in Table 8 and a 10 dB loss through an open window.*

4.5 Sleep disturbance assessment

Sleep disturbance is assessed using an $L_{A1(1\ min)}$ parameter, which is considered to be the maximum noise level excluding extraneous noise events. A sleep disturbance assessment has been undertaken for the proposed night works with the construction information available to date. The noise modelling results are provided in Table 20 below with predicted noise levels compared with the sleep awakening reaction criterion.

Table 20 Predicted sleep disturbance impacts at residential receivers

Receiver ID	Sleep disturbance awakening reaction $L_{A1(1min)}$ criteria, dB(A)	Work Package					
		1	2	3	4	5	6
R1	65	**70**	36	41	27	30	24
R2	65	63	35	40	26	29	23
R3	65	60	39	44	30	33	27
R4	65	48	44	49	35	38	32
R5	65	51	44	49	35	38	32
R6	65	55	31	36	22	25	19
R7	65	**65**	52	57	43	46	40
R8	65	51	57	62	48	51	45
R9	65	51	57	62	48	51	45
R10	65	**71**	**77**	**82**	**68**	**71**	**65**
R11	65	**71**	**77**	**82**	**68**	**71**	**65**
R12	65	**75**	57	62	48	51	45
R13	65	**69**	58	63	49	52	46
R14	65	**71**	61	**66**	52	55	49
R15	65	**68**	**74**	**79**	**65**	**68**	62
R16	65	**74**	**80**	**85**	**71**	**74**	**68**
R17	65	**73**	**79**	**84**	**70**	**73**	**67**
R18	65	**70**	**76**	**81**	**67**	**70**	64

Notes:

*1. Items in **BOLD** indicate the predicted noise levels at this receiver during this work stage exceed the sleep disturbance awakening reaction criteria.*

A number of exceedances of the awakening reaction screening criteria have been predicted due to the night-time construction works associated with the Proposal. However as noted in section 3.1.1 out-of-hours works are likely to be limited to the routine scheduled closures and a discrete number of other nights where out-of-hours works are unavoidable.

4.6 Construction traffic assessment

The numbers of construction vehicles have been estimated to be up to 15 heavy vehicles per day during peak construction periods. Vehicles would access the site by either Forest Road or The Avenue.

Road traffic noise levels during construction are unlikely to increase by more than 2 dB on Forest Road or The Avenue during the daytime due to the existing high volumes of traffic on these roads. Traffic noise levels may increase by more than 2 dB during the night-time, however the overall traffic noise level (including construction traffic) is expected to be less than 50 dB(A), which complies with the RNP criteria.

Construction activities were based on indicative construction movements and have been used in lieu of rigorously defined vehicle movements which would be determined during detailed design.

5.0 Construction vibration assessment

Vibration intensive work has the potential to occur as part of the construction work. Work may include jackhammering and ballast tamping activities.

Typical safe minimum distances for the construction equipment that may be part of this Proposal are provided in Table 21. Minimum working distances have been developed to meet the recommended levels of vibration in British Standard 6472-1992 and DIN 4150, and are developed based upon the safe working distances presented in TfNSW's CNVS and AECOM's library of vibration data. A ballast tamper has been assumed to produce similar levels of vibration as a jackhammer.

Minimum working distances should be adhered to when operating vibration intensive equipment near buildings in order to minimise the risk of discomfort to occupants and structural damage.

Table 21 Recommended minimum working distances for vibration intensive equipment

Equipment	Rating/description	Minimum working distance (metres)	
		Cosmetic damage[1]	Human response
Jackhammer	Hand held	1 (nominal)	Avoid contact with structure

Notes:

1. *More stringent conditions may apply to heritage or other sensitive structures*

The minimum working distances presented in Table 21 assume individual items of plant would be operating independently. Concurrent operation of vibration intensive equipment should be avoided, however if it is necessary to operate multiple items of equipment concurrently close to the safe working distance then vibration monitoring is recommended.

The minimum working distances for cosmetic damage are generally considered to be conservative and working within them would not necessarily result in damage. However, factors such as work practices and intervening ground conditions can affect vibration levels so vibration monitoring is recommended within these distances and should be carried out at the beginning of the work in order to refine the safe working distances for site specific conditions.

A discussion of vibration mitigation is provided in Section 7.0.

6.0 Operational noise assessment – Rail noise

An assessment of operational rail noise for the Proposal has been conducted in this section of the report.

6.1 Noise modelling methodology

Predicted noise levels were modelled using SoundPLAN v8.0 environmental noise modelling software. Rail noise sources were modelled using the implementation of the Nordic Rail Prediction Method, Kilde Report 67/130 *"Noise from railway traffic"*.

In accordance with the RING, noise levels were predicted at 1 metre from the façade of each building, at a height of 1.5 metres above each floor.

Predicted noise levels include a +2.5 dB façade reflection to account for noise reflecting from the building facade.

6.2 Modelled scenarios

In accordance with the RING, a comparison was made between:

- The rail noise levels if the project proceeds (termed the 'build' option), and;
- The corresponding rail noise levels, due to general rail traffic growth that would have occurred if the project had not proceeded (termed the 'no build' option).

6.3 Modelling inputs and assumptions

The following features were included in the noise model:

- Ground topography
- Ground absorption and reflection
- Receivers
- Existing terrain elevation contours
- Train movement number, lengths, speeds and rolling stock type. These movements have been taken from existing timetables for both passenger and freight movements and have assumed 30% growth for the design year of 10 years after opening. Additionally, it has been assumed that for the build and no build scenario, all passenger trains would consist of 10-car NIF sets, whilst freight traffic would increase to a length of 1600 metres, with an additional locomotive.
- Rail noise source reference levels derived from TfNSW's *Rail Noise Database* (RNDB), 2014.
- Track conditions including the following corrections:
  - Turnouts and crossing in the existing and proposed future designs (+ 6 dB(A))
  - Radii where noise from wheel squeal and flanging could occur (+3 dB(A) where R>300m<500m, and +8 where R<300m).

6.4 Predicted operational noise levels

Presented in Table 22 below is a summary of the predicted noise level against the applicable RING criteria for both the 'No build' and 'build' scenarios at the nearest residential receiver to the Proposal. It is noted that while there are some predicted exceedances of the overall L_{Amax} criteria, the change in noise levels between the 'Build' and the 'No build' option remains below the 3 dB(A) threshold outlined in the RING. Therefore, there are no predicted exceedances of the applicable RING criteria due to the operation of the Proposal. As a result, no further mitigation is considered necessary.

A graphical representation of predicted noise results is provided in Appendix D.

Table 22 Summary of predicted operational rail noise level exceedances – in accordance with *Rail Infrastructure Noise Guideline* criteria

Scenario	Maximum daytime $L_{Aeq,15hr}$ noise level	Maximum night time $L_{Aeq,9hr}$ noise level	Maximum L_{Amax} noise level
No build	58	58	85
Build	58	58	85

7.0 Mitigation measures

7.1 Construction noise and vibration mitigation

This section of the report presents construction noise and vibration mitigation measures to be considered for implementation to minimise and manage construction noise impacts.

The construction noise assessment presented in Section 4.0 of this report detailed a number of exceedances of the NMLs within the Proposal area. These were predicted as a result of various different construction activities. The following generic and receiver specific mitigation measures have been identified.

7.1.1 Construction Noise and Vibration Management Plan

A Construction Noise and Vibration Management Plan (CNVMP) should be developed for the Proposal and implemented prior to commencement of construction activities. The CNVMP should include all feasible and reasonable safeguards to manage the noise emissions from the site and any complaints which may occur due to construction noise. The CNVMP should include, as a minimum, the following:

- identification of nearby residences and other sensitive land uses
- description of approved hours of work
- description and identification of all construction activities, including work areas, equipment and duration
- description of what work practices (generic and specific) would be applied to minimise noise and vibration
- a complaints handling process
- noise and vibration monitoring procedures, including for heritage structures
- overview of community consultation required for identified high impact works.

Construction works should be planned and carried out during standard construction hours wherever possible. Table 23 presents the standard mitigation measures contained within the CNVS which should be considered as mitigation measures as part of the CNVMP.

Table 23 Transport for NSW's Construction Noise and Vibration Strategy standard mitigation measures

Action required	Safeguard details
Management measures	
Implement any project specific mitigation measures required	In addition to the measures set out in this table, any project specific mitigation measures identified in this report.
Implement stakeholder consultation measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities will be delivered to sensitive receivers at least seven days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website; • Project Infoline; • Construction Response Line; • Email Distribution List; • Web-based Surveys; • Social Media; • Community and Stakeholder Meetings; and • Community Based Forums (if required by approval conditions).

Action required	Safeguard details
Site inductions	All employees, contractors and subcontractors will receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items or slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.
Noise monitoring	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Attended vibration measurements shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction will be carried out during the standard daytime working hours. Should out-of-hours works be required an out-of-hours works application form will be submitted to TfNSW for approval on a case-by-case basis. Work generating high noise and/or vibration levels will be scheduled during less sensitive time periods as far as practicable. This will potentially include the use breakers and jackhammers.
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack hammering) will only be carried out in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work will be undertaken in the same area over any seven day period, unless otherwise approved by the relevant authority.

Action required	Safeguard details
Equipment selection	Quieter and less vibration emitting construction methods will be used where feasible and reasonable (e.g. rubber wheeled instead of steel tracked plant). Equipment will be regularly inspected and maintained to ensure it is in good working order. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits
Maximum noise levels	The noise levels of plant and equipment will have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions will be considered as part of the selection process.
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver will be avoided. The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled down or shut down. Plant and vehicles will be turned off when not in use. Noise-emitting plant will be directed away from sensitive receivers where reasonable and feasible.
Plan work site and activities to minimise noise and vibration	Traffic flow, parking and loading/unloading areas will be planned to minimise reversing movements within the site. Truck drivers will be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising the use of engine brakes, and no extended periods of engine idling).
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out-of-hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. Site access points and roads will be selected as far as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.
Silencers on mobile plant	Where possible noise from mobile plant will be reduced through additional fittings including: • residential grade mufflers • damped hammers such as “City” Model Rammer Hammers • silenced air parking brake engagement.
Construction related traffic	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.

Action required	Safeguard details
Vibration minimum working distances	If vibration intensive equipment is to be used within the minimum working distances for cosmetic damage, as presented in Table 12, then it is recommended that attended vibration measurements are undertaken when work commences, to determine “site specific minimum working distances”. The minimum working distances for cosmetic damage from Table 12 are generally considered to be conservative and working within them would not necessarily result in damage however as factors such as work practices and intervening structures can affect vibration levels. In addition, vibration intensive work should not proceed within the site specific minimum working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (e.g. via flashing light, audible alarm, SMS) when vibration levels are approaching the peak particle velocity objective. It is also advisable to carry out building condition surveys of sensitive historical structures before construction work begins.
Engine compression brakes	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans, etc.	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

7.1.2 Community consultation and complaints handling

All residents and sensitive receivers impacted by noise levels from the Proposal which are expected to exceed the NML should be consulted prior to the commencement of the particular activity, with the highest consideration given to those that are predicted to be most affected as a result of the works.

The information provided to the receivers would include:

- programmed times and locations of construction work
- the hours of proposed works
- construction noise and vibration impact predictions
- construction noise and vibration mitigation measures being implemented on site.

Community consultation regarding construction noise and vibration would be detailed in a Community Liaison Management Plan for the construction of the Proposal and would include a 24 hour hotline and complaints management process.

7.1.3 Construction road traffic

Road traffic noise levels during construction are unlikely to increase by more than 2 dB on Forest Road or The Avenue during the daytime due to the existing high volumes of traffic on these roads. Traffic noise levels may increase by more than 2 dB during the night-time, however the overall traffic noise level (including construction traffic) is expected to be less than 50 dB(A), which complies with the RNP criteria.

7.1.4 TfNSW's *Construction Noise and Vibration Strategy* - Additional Mitigation Measures

TfNSW's CNVS provides practical guidance on how to minimise, to the fullest extent practicable, the impacts on the community from airborne noise, ground-borne noise and vibration generated during the construction of TfNSW projects. This is managed through the application of all feasible and reasonable mitigation measures. Where exceedances are still expected to occur after standard mitigation measures have been applied, the CNVS recommends the implementation of additional mitigation measures. These mitigation measures are specified within the CNVS and presented in Table 24.

The provision of additional mitigation is based on the predicted exceedances above RBLs and when the exceedances occur. The RBLs can be found in Table 7.

Table 24 How to implement additional airborne noise management levels

Construction hours	Receiver perception	dB(A) above RBL	dB(A) above NML	Additional management measures
Standard hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Noticeable	5 to 10	0	-
	Clearly audible	> 10 to 20	< 10	-
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 20	PN, V
	75 dB(A) or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday-Friday (6pm-10pm) Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Noticeable	5 to 10	< 5	-
	Clearly audible	> 10 to 20	5 to 15	PN
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP#, DR#
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Noticeable	5 to 10	< 5	PN
	Clearly audible	> 10 to 20	5 to 15	PN, V
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RP, DR
	Highly intrusive	> 30	> 25	PN, V, SN, AA, RP, DR

Notes: *PN = Project notification* *SN = Specific notification, individual briefings, or phone call*
V = Verification monitoring *DR = Duration respite*
RP = Respite period *RO = Project specific respite order*
AA = Alternative accommodation

** SWLs used for the purpose of estimating noise impact shall be increased by 5 dB(A) where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics.*

[#] *Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6am)*

Table 25 outlines the additional mitigation measures, as outlined in the CNVS.

Table 25 Description of additional mitigation measures

Measure	Description	Abbreviation
Periodic Notification	For each project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN

Measure	Description	Abbreviation
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the Construction Noise and Vibration Impact Statement (CNVIS) amended. Refer to Section 8.4 for more details.	V
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all projects.	RO

Measure	Description	Abbreviation
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the Vibration Management Levels (VMLs) for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days (See Table 1).	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with Community Engagement Representatives.	DR

7.2 Operational noise mitigation – Rail noise

The results of the operational rail noise assessment in Section 6.0 show that predicted noise levels due to rail traffic from the Proposal are not expected to exceed the RING noise trigger levels at any sensitive receiver during any assessment period. As a result, no noise mitigation is proposed.

8.0 Conclusion

A Noise and Vibration Impact Assessment has been completed for the Hurstville Crossover (the Proposal). Nearby noise and vibration sensitive receivers were identified. Attended and unattended noise measurements were completed to characterise the existing noise environment. The measured noise levels were used to establish operational noise criteria and construction NMLs.

8.1 Construction noise

Construction work packages have been developed in consultation with TfNSW and the proposed equipment has been detailed within this report. Six distinct construction stages were used in a computer-based noise model to determine the predicted noise levels generated from the Proposal.

The predicted construction noise levels exceed the construction NMLs at some receivers. The magnitude of exceedances are detailed in Section 4.4.

Measures have been recommended to mitigate construction noise impacts upon nearby sensitive receivers.

The final number, degree and nature of these measures would be selected by the Contractor and be largely dependent on the construction strategy and work carried out. Specific noise management and mitigation measures would be detailed in the Contractor's CNVMP. The recommended management and mitigation measures which would be considered in the plan include:

- Effective community consultation
- Training of construction site workers
- Use of temporary noise barriers
- Monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less sensitive time periods
- Situating plant in less noise sensitive locations
- Construction traffic management
- Respite periods.

8.1.1 Construction traffic

An assessment of the likely construction traffic indicated that increases in road traffic noise levels would be considerably lower than the 2 dB(A) threshold outlined in the RNP. Therefore, no further assessment of construction traffic is required in accordance with the RNP.

8.2 Construction vibration

Minimum working distances to nearby structures have been recommended for nominated plant. If the minimum working distances are maintained, then no adverse impact from the vibration intensive works are likely in terms of human response or cosmetic damage. It is unlikely that work would be undertaken within the minimum working distances for commercial and residential receivers during the proposed vibration intensive works. Should works be required within the minimum working distances, the recommended additional mitigation measures would be implemented.

8.3 Operational noise – Rail Noise

An operational rail noise assessment was undertaken in accordance with the RING. The results of this assessment found that the predicted noise levels due to operational rail traffic within the Proposal area were below the noise trigger levels outlined in the RING. As a result, no further mitigation of operational rail traffic is currently proposed.

Appendix A

Glossary of acoustic terminology

Appendix A Glossary of acoustic terminology

The following is a brief description of acoustic terminology used in this report.

Sound power level	The total sound emitted by a source.
Sound pressure level	The amount of sound at a specified point.
Decibel, dB	The measurement unit of sound.
A Weighted decibels, dB(A)	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:

0dB(A)	Threshold of human hearing
30dB(A)	A quiet country park
40dB(A)	Whisper in a library
50dB(A)	Open office space
70dB(A)	Inside a car on a freeway
80dB(A)	Outboard motor
90dB(A)	Heavy truck pass-by
100dB(A)	Jackhammer/Subway train
110 dB(A)	Rock Concert
115dB(A)	Limit of sound permitted in industry
120dB(A)	747 take off at 250 metres

Frequency, Hz	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level, L_{eq}	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
L_{max}	The maximum sound pressure level measured over the measurement period.
L_{min}	The minimum sound pressure level measured over the measurement period.
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.

L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays.
Evening	The period from 1800 to 2200 h Monday to Sunday and Public Holidays.
Night	The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays.
Assessment background level, ABL	The overall background level for each day, evening and night period for **each day** of the noise monitoring.
Rating background level, RBL	The overall background level for each day, evening and night period for the **entire length** of noise monitoring.
Weighted sound reduction index [R_w]	A single figure representation of the air-borne sound insulation of a partition based upon the R values for each frequency measured in a laboratory environment.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*, the EPA's NSW Noise Policy for Industry and Road Noise Policy.

Appendix B

Logging results

Noise Logger Report

550 Railway Parade, Hurstville

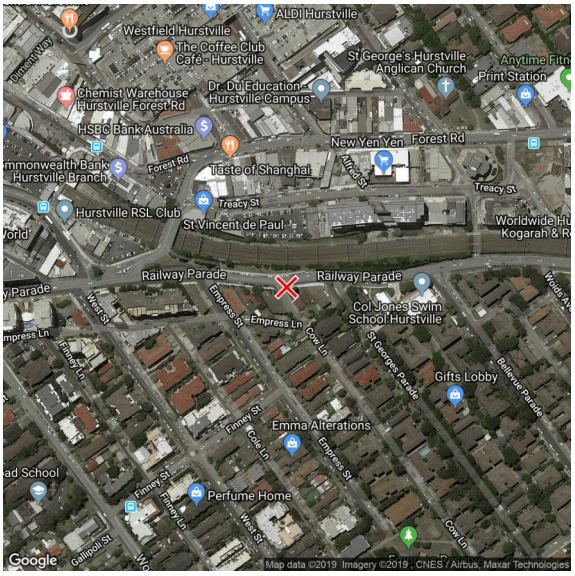
Item	Information
Logger Type	SVAN 977
Serial number	45417
Address	550 Railway Parade, Hurstville
Location	550 Railway Parade, Hurstville
Facade / Free Field	Free Field
Environment	Noise environment dominated by road traffic on Railway Parade and rail noise. Loud car radio 54 dB(A). Tangara pass by 61 dB(A).

Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Thu May 9 2019	62	59	58	-	46	-	61	58
Fri May 10 2019	60	59	56	-	-	-	60	56
Sat May 11 2019	58	58	54	-	-	36	58	54
Sun May 12 2019	59	60	55	42	46	34	59	55
Mon May 13 2019	62	59	55	47	45	35	61	55
Tue May 14 2019	60	59	56	-	44	36	60	56
Wed May 15 2019	61	59	56	46	45	35	60	56
Thu May 16 2019	60	59	56	46	46	35	60	56
Fri May 17 2019	60	-	55	-	-	-	60	55
Summary	**60**	**59**	**56**	**46**	**45**	**35**	**60**	**56**

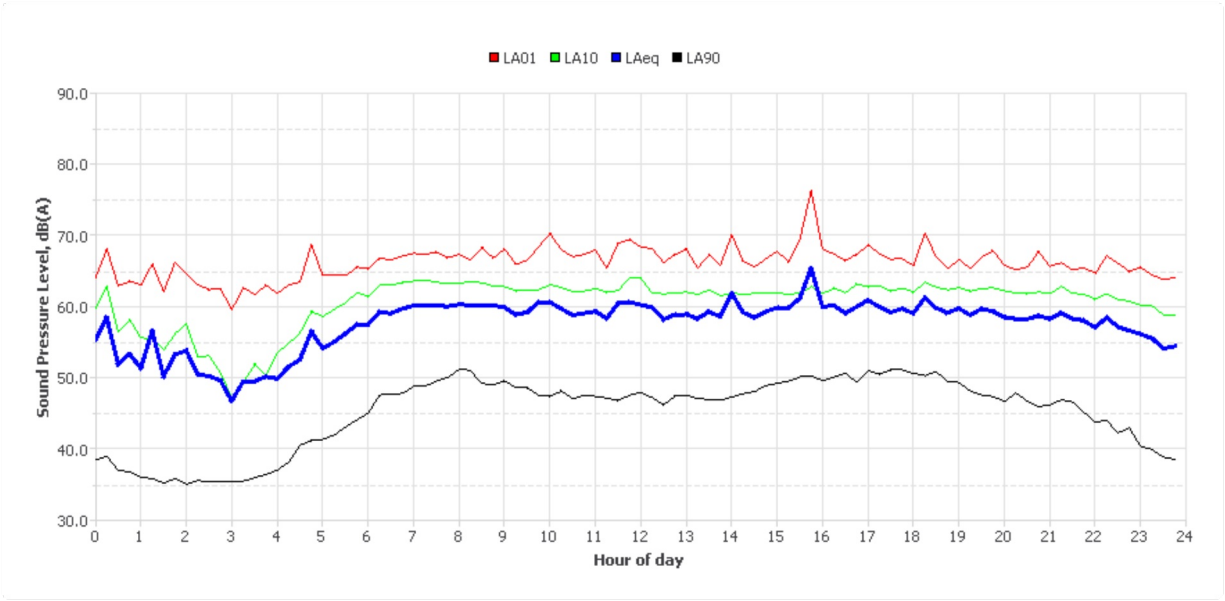
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location



Logger Deployment Photo

Typical Day



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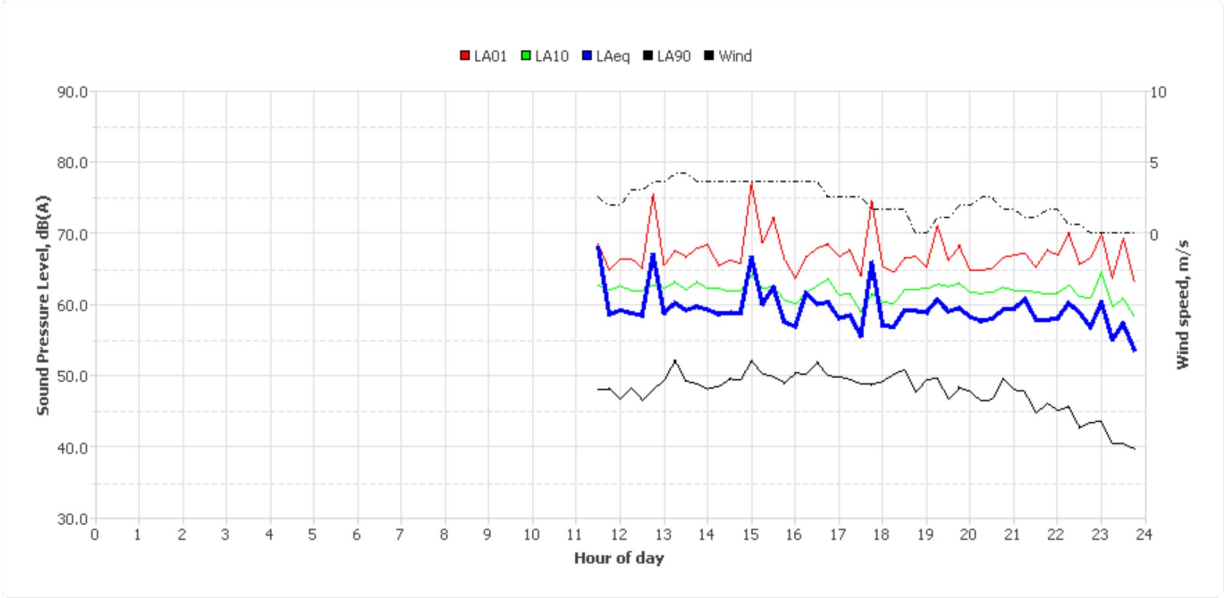

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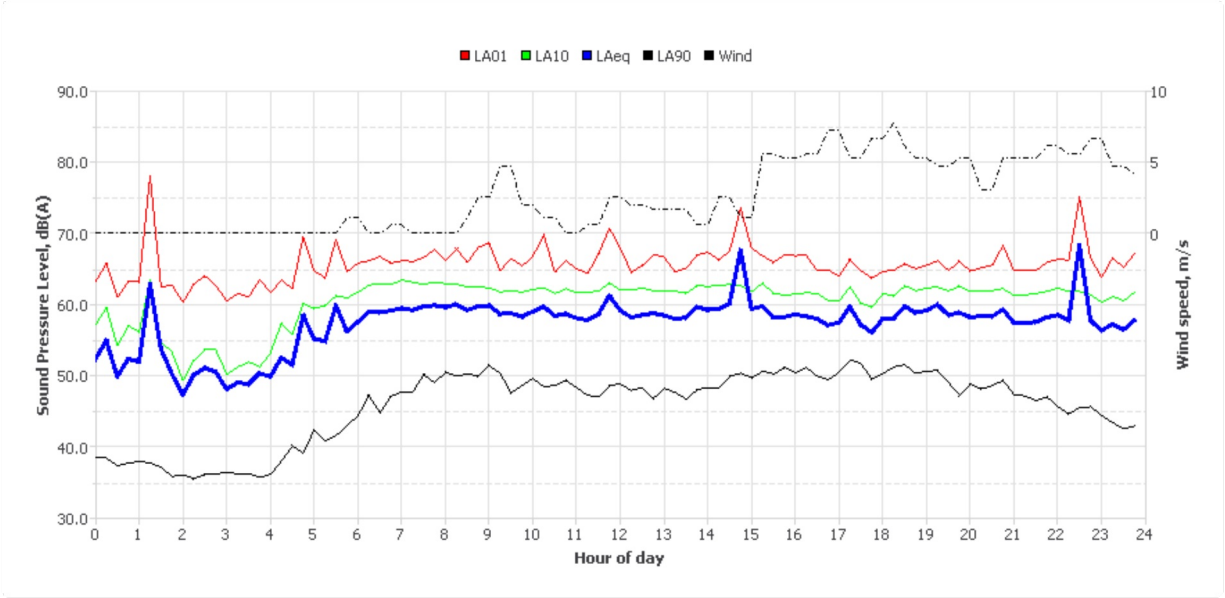

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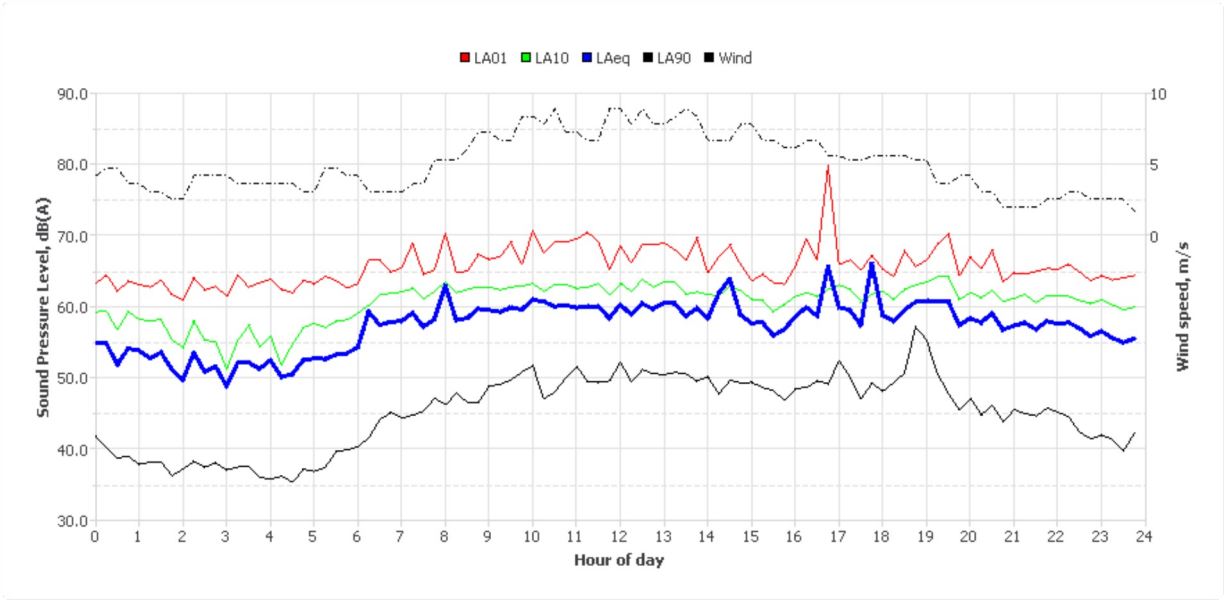

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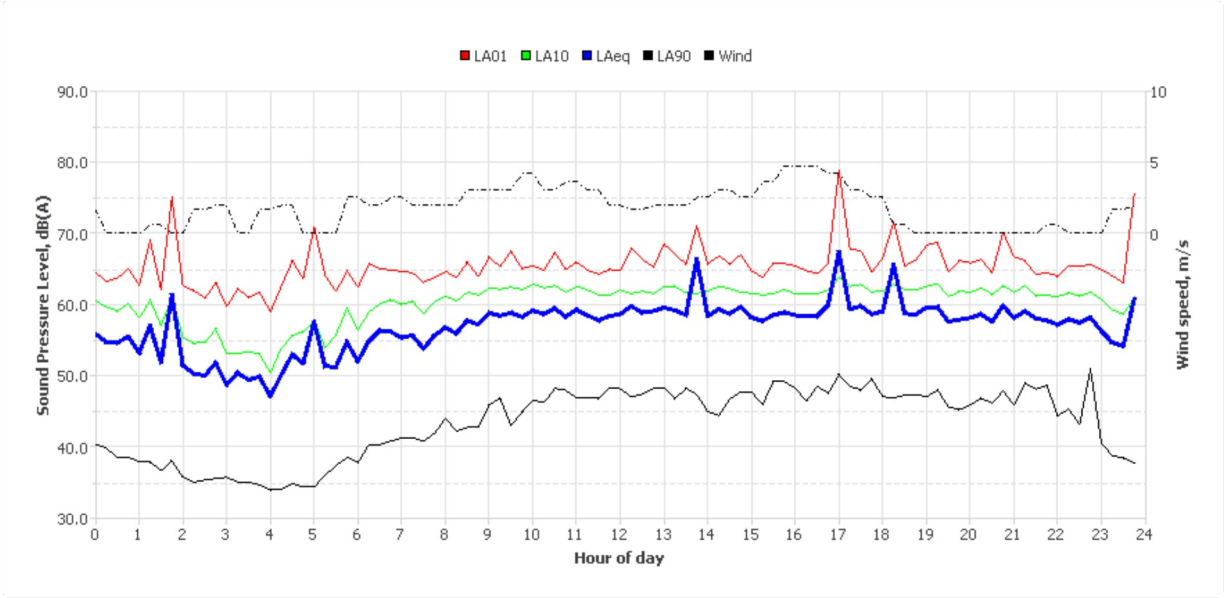
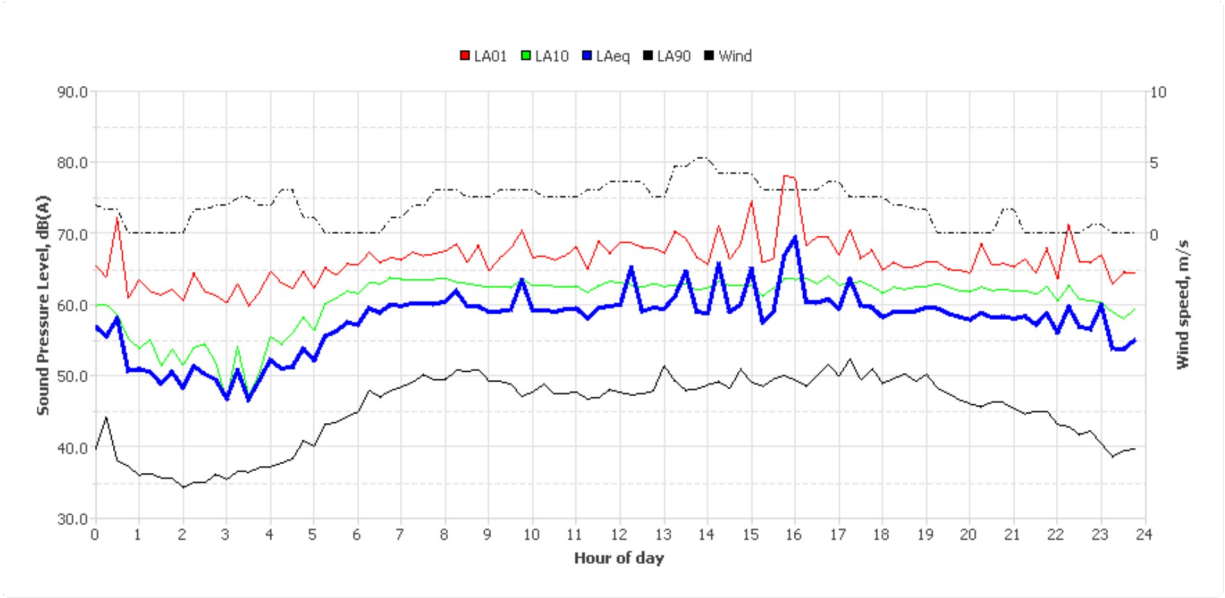


Monday, 13 May 2019



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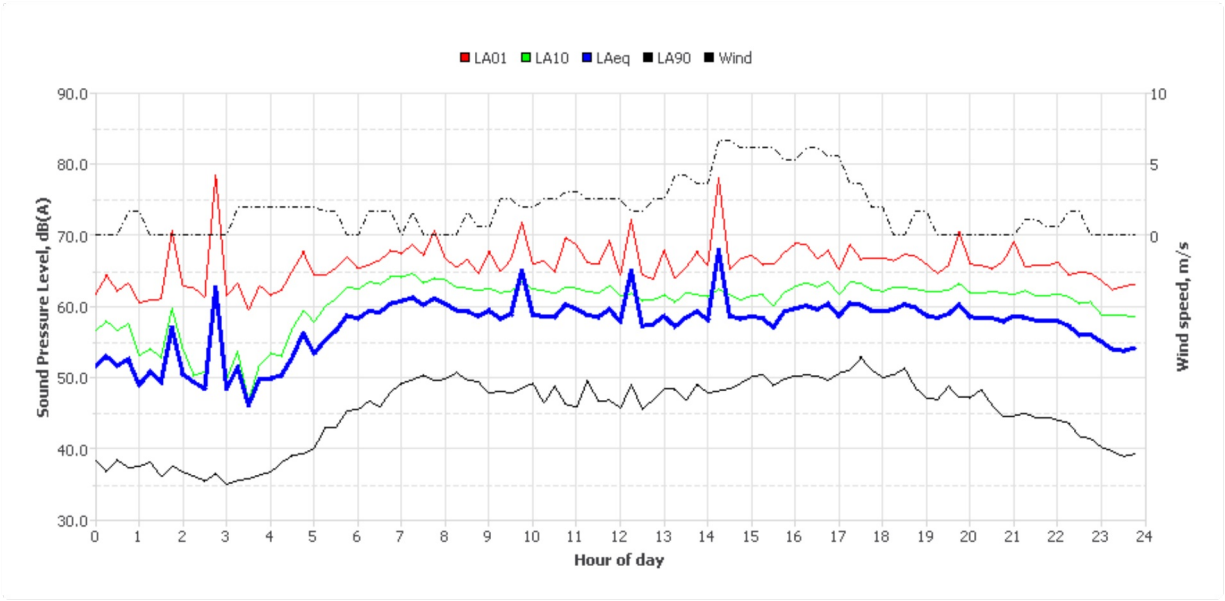

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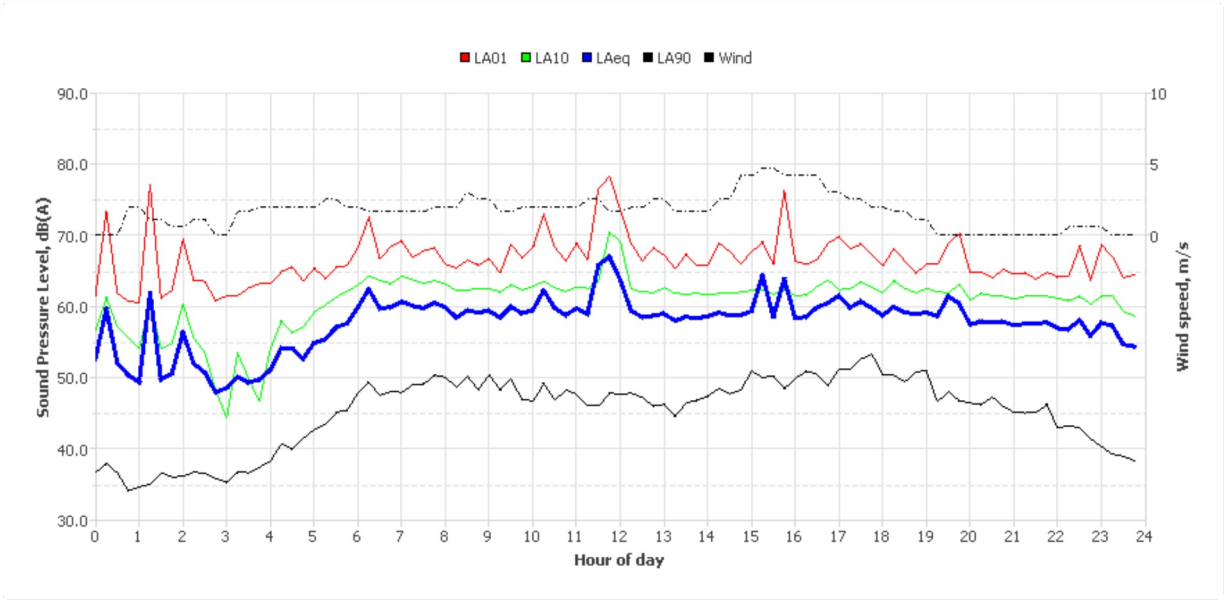

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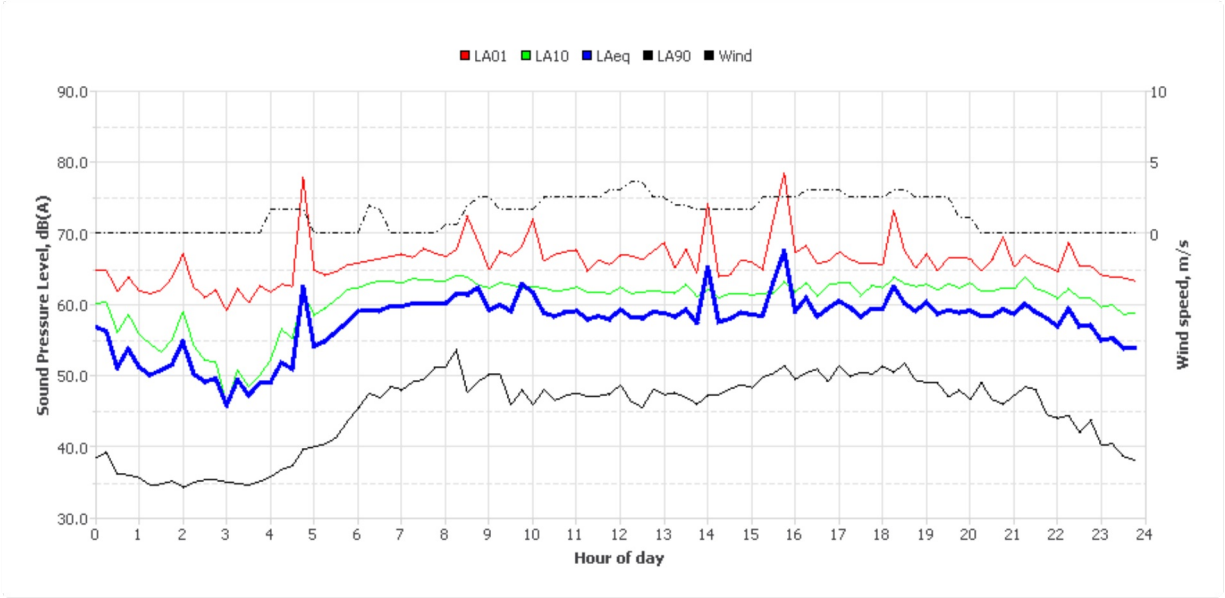

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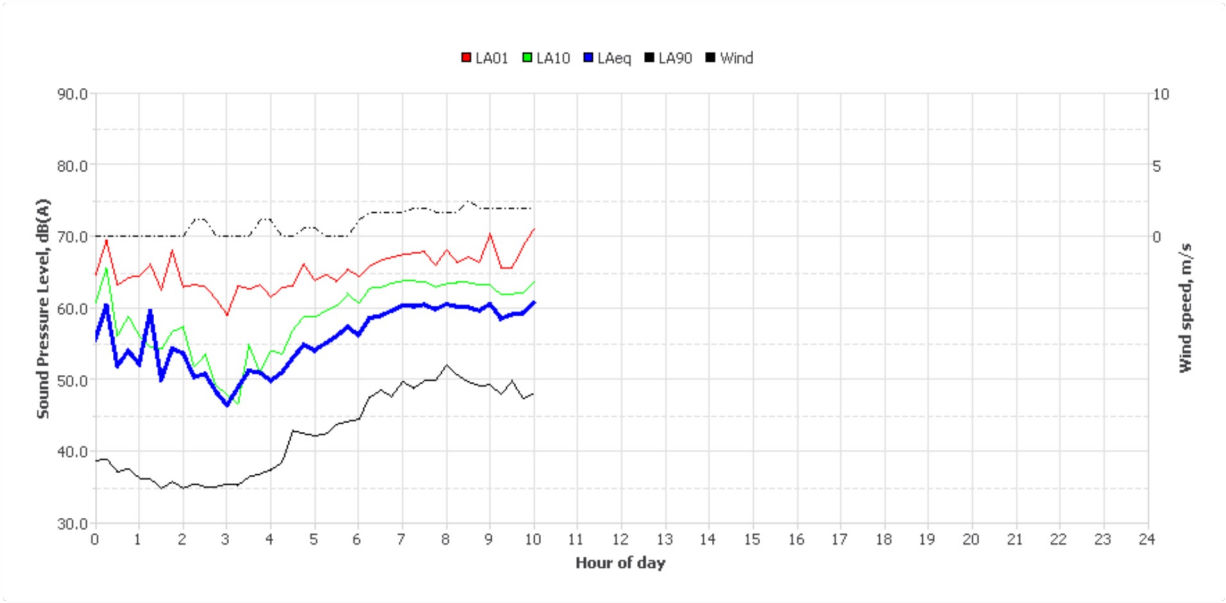
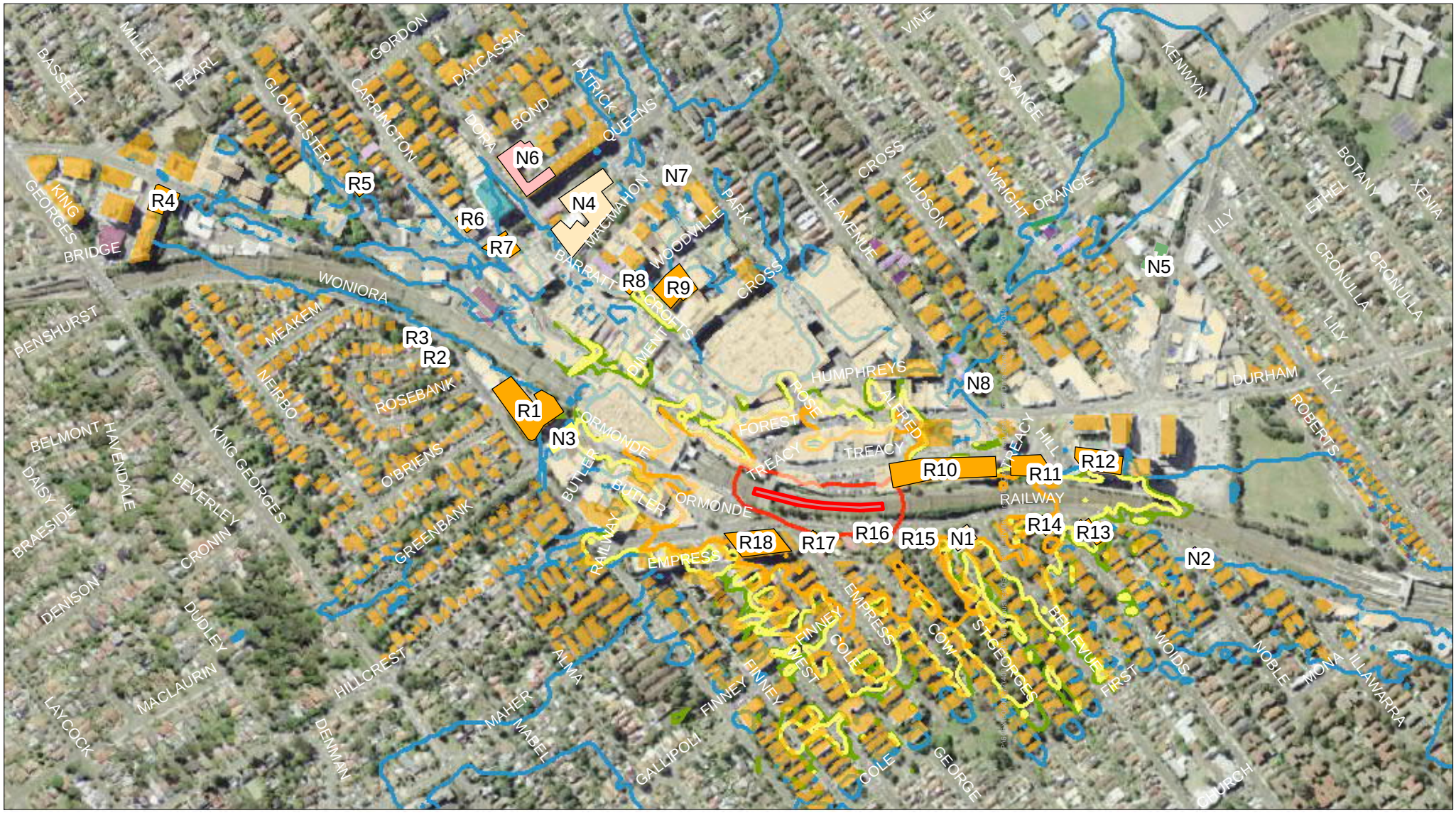


Appendix C

Construction noise contours



Crossover construction location

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

Utility work

Sound Pressure Level, L_{Aeq}, dB(A)

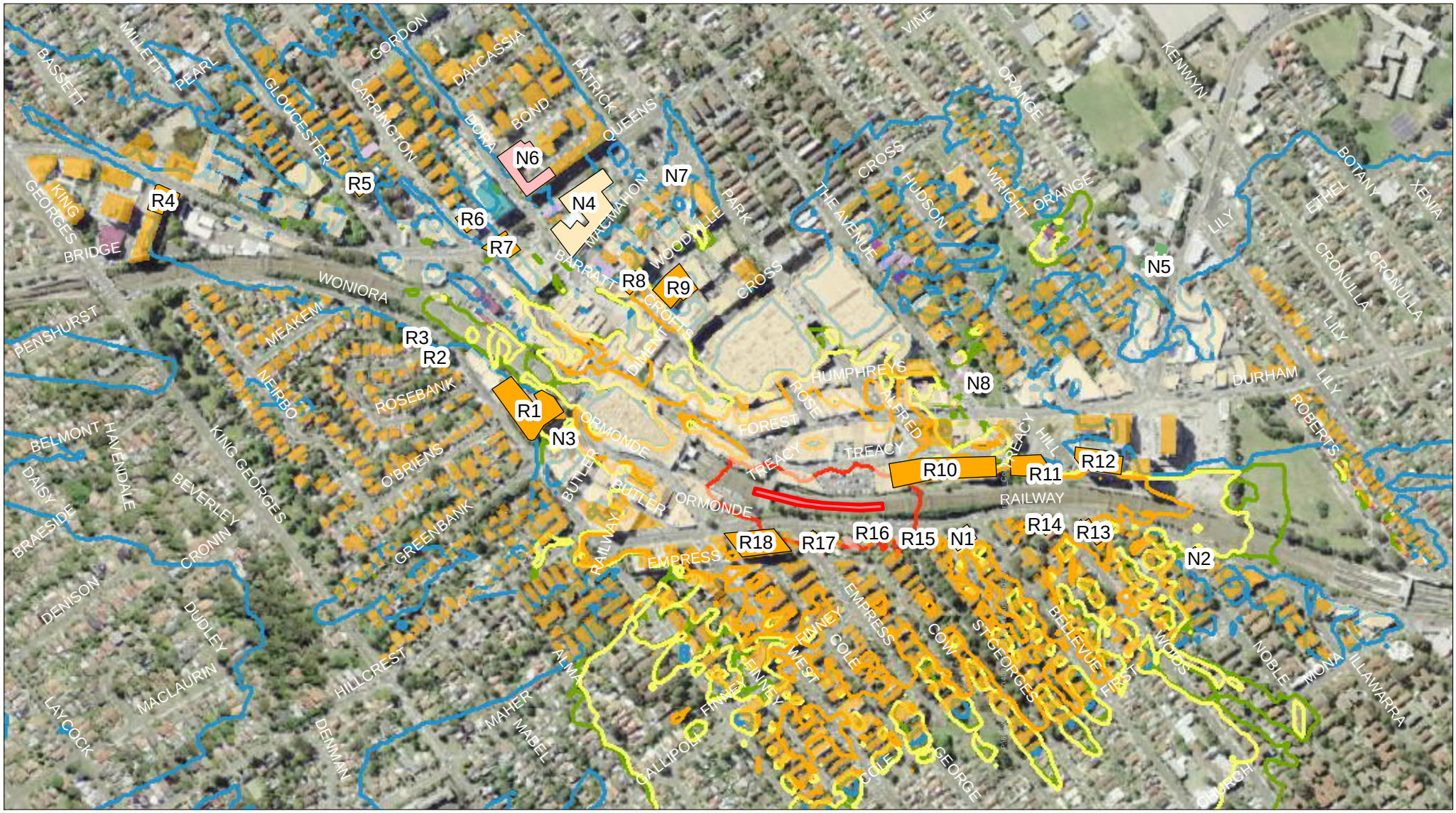
- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Hurstville Utility Work

Source:

AECOM

0 100 200 Meters



Crossover construction location

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

New Crossover

Sound Pressure Level, L_{Aeq}, dB(A)

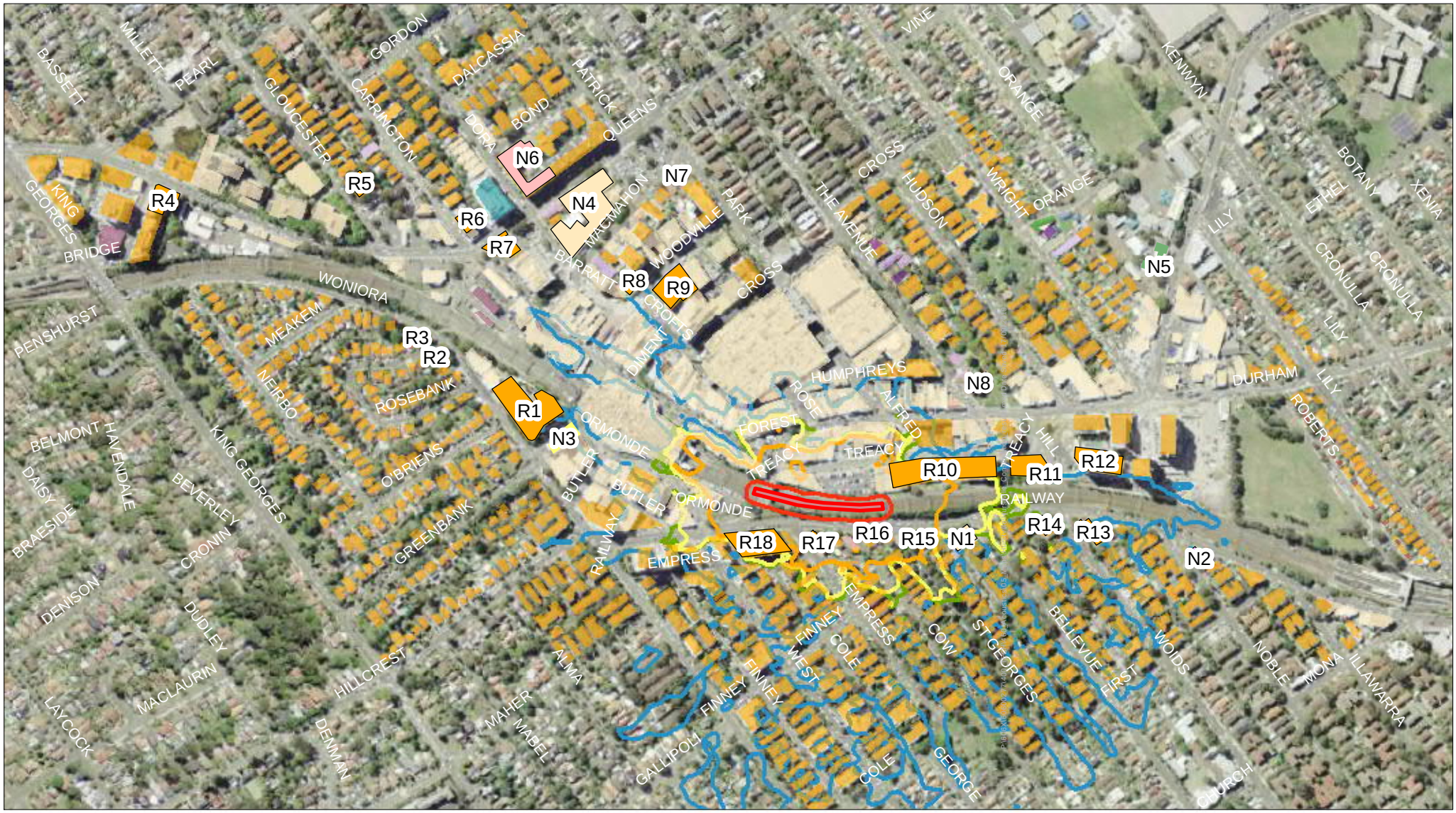
- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Hurstville New Crossover

Source:

AECOM

0 100 200 Meters



Crossover construction location

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

Signal Post

Sound Pressure Level, L_{Aeq}, dB(A)

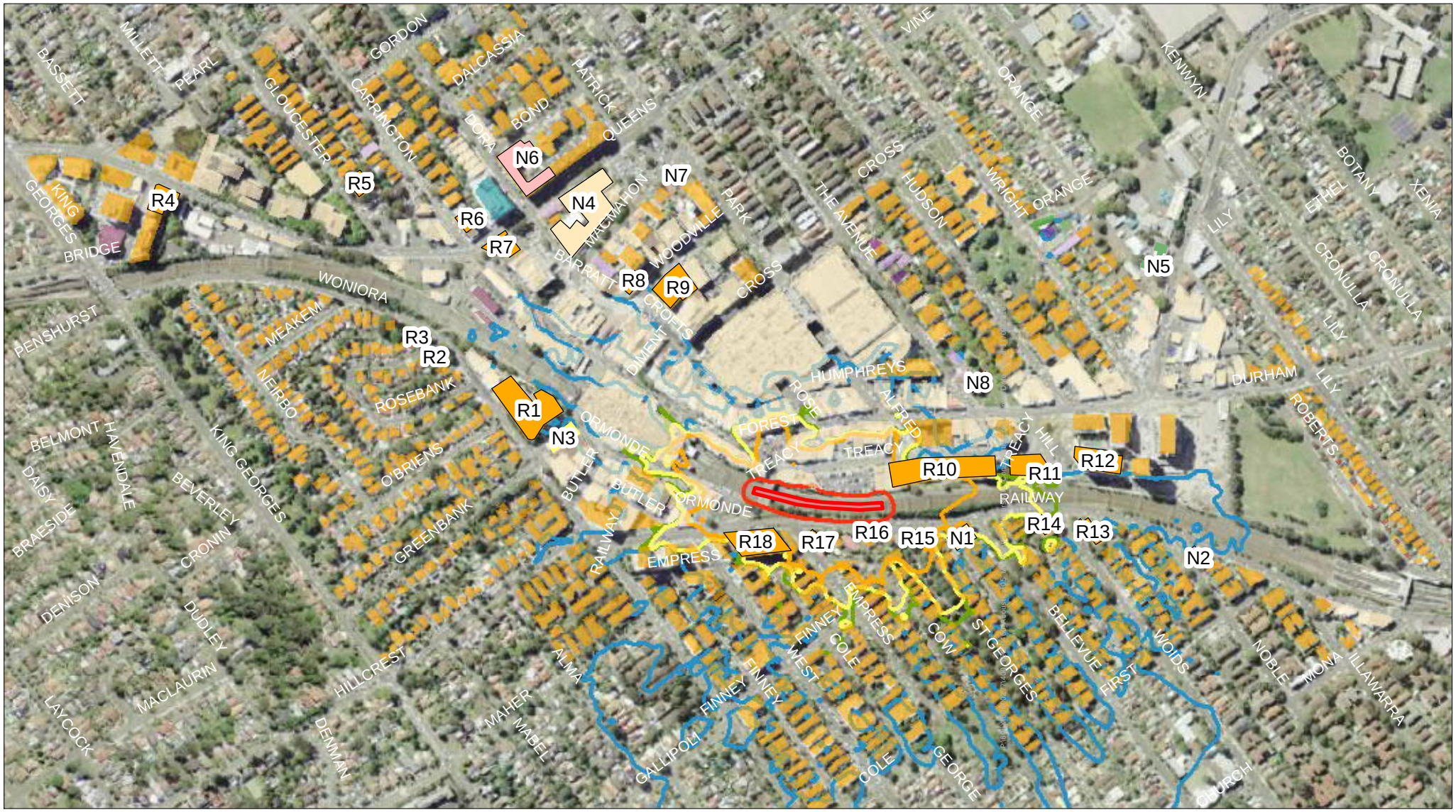
- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Hurstville Signal Post

Source:

AECOM

0 100 200 Meters



Crossover construction location

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

Demobilisation

Sound Pressure Level, L_{Aeq}, dB(A)

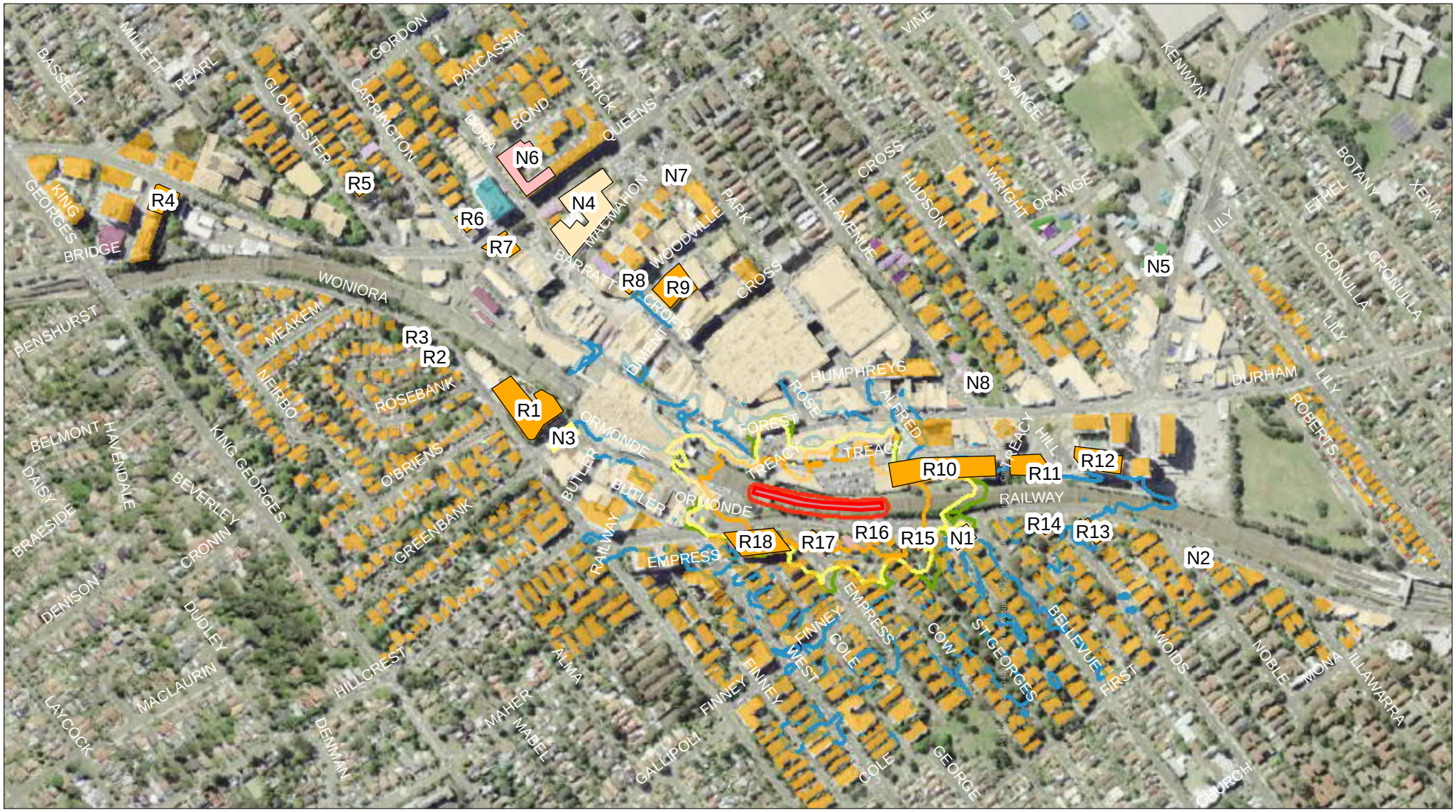
- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Hurstville Demobilisation

Source:

AECOM

0 100 200 Meters



Crossover construction location

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

Testing and Commissioning

Sound Pressure Level, L_{Aeq}, dB(A)

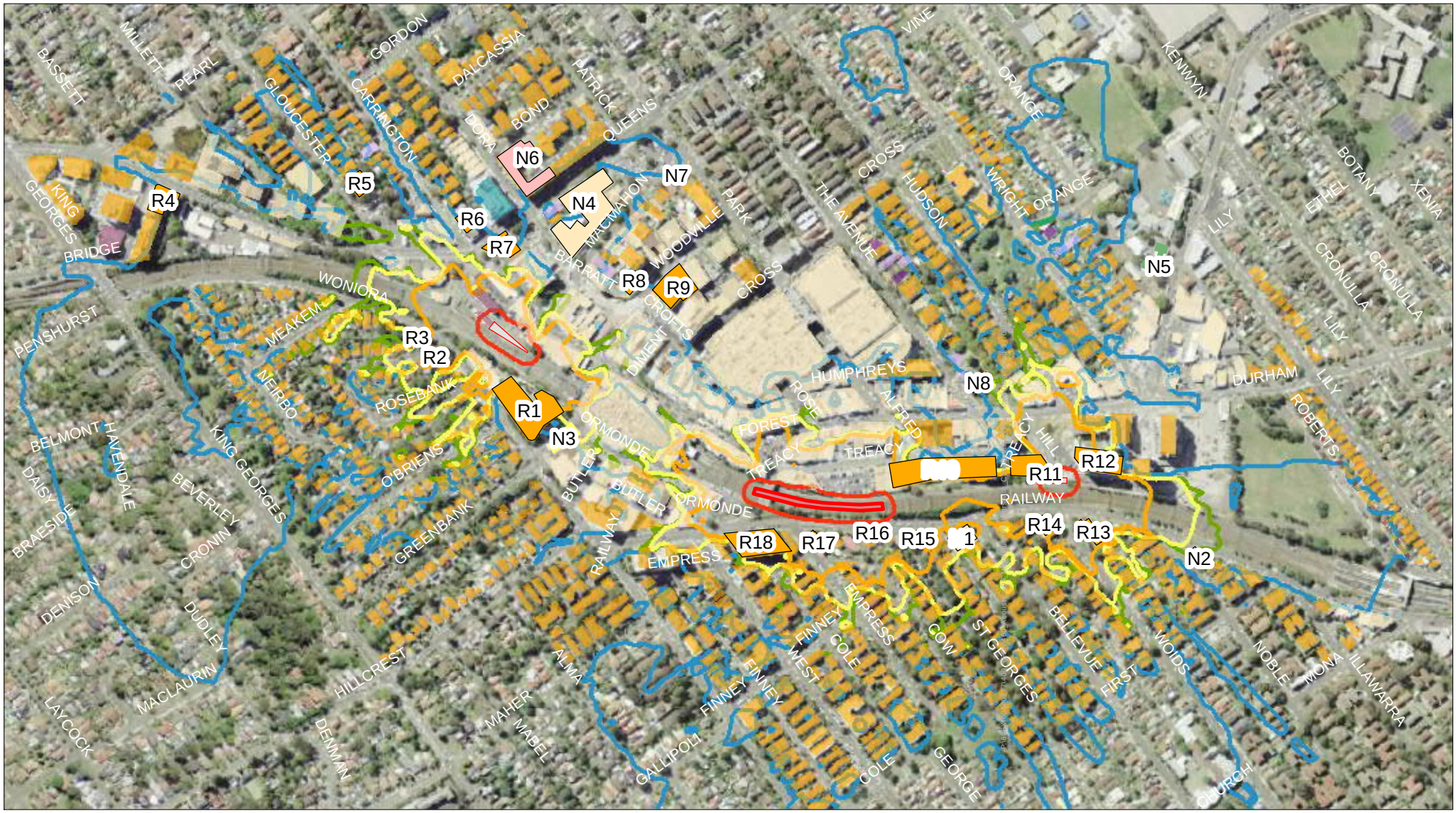
- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Source:

Hurstville Testing and Commisioning

AECOM

0 100 200 Meters



Crossover construction location
Potential Construction laydown

Receivers

Usage

- Child Care
- Commercial
- Educational
- Hospital
- Industrial
- Library
- Not Assessed
- Place of Worship
- Police Station
- Residential

Site Establishment

Sound Pressure Level, L_{Aeq}, dB(A)

- Highly Noise Affected Level - 75 dB(A)
- Standard Hours NML - 56 dB(A)
- Out-of-Hours-Daytime NML - 51 dB(A)
- Out-of-Hours Evening NML - 50 dB(A)
- Out of Hours Night NML - 40 dB(A)

Hurstville Site Establishment

Source:

N

AECOM

0 100 200 Meters

Appendix D

Operational noise contours - Rail noise

Operation Daytime - Build

Receivers

- Child Care
- Commercial
- Library
- Crossover
- Place of Worship
- Police Station
- Residential
- Rail Alignment

Sound Pressure Level, $L_{Aeq, 15\ hour}$ dB(A)

45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | > 65

0 100 200 Meters

AECOM

Operation Daytime - No Build

Receivers

- Child Care
- Commercial
- Library
- Crossover
- Place of Worship
- Police Station
- Residential
- Rail Alignment

Sound Pressure Level, $L_{Aeq, 15\ hour}$ dB(A)

45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | > 65

0 100 200 Meters

Operation Night time - Build

Receivers

- Place of Worship
- Child Care
- Police Station
- Commercial
- Residential
- Library
- Crossover
- Rail Alignment

Sound Pressure Level, $L_{Aeq,\ 9\ hour}$ dB(A)

45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | > 65

0 100 200 Meters

Operation Night time - No Build

Receivers

- Child Care
- Commercial
- Library
- Crossover
- Place of Worship
- Police Station
- Residential
- Rail Alignment

Sound Pressure Level, $L_{Aeq, 9\ hour}$ dB(A)

45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | > 65

0 100 200 Meters

AECOM

Operation - Build

Receivers

- Child Care
- Commercial
- Library
- Crossover
- Place of Worship
- Police Station
- Residential
- Rail Alignment

Build L_{Amax}

L_{Amax} = 85 dB(A)

0 100 200 Meters

Operation - No Build

Receivers

- Child Care
- Commercial
- Library
- Crossover
- Place of Worship
- Police Station
- Residential
- Rail Alignment

No Build L_{Amax}

L_{Amax} = 85 dB(A)

AECOM

0 100 200 Meters