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Narwee Station Upgrade

Noise and Vibration Impact Assessment

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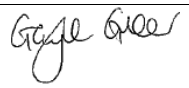
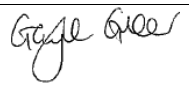
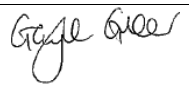
A	02-Mar-2016	Draft for Review	Gayle Greer Acoustics Team Leader – NSW	
C	29-Mar-2016	Revision to address TfNSW comments	Gayle Greer Acoustics Team Leader – NSW	
C	30-Mar-2016	Final	Gayle Greer Acoustics Team Leader – NSW	

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1.0 Introduction

1.1 Background information

AECOM Australia Pty Ltd (AECOM) has been commissioned by Transport for New South Wales (TfNSW) to undertake a Noise and Vibration Impact Assessment of the construction and operation of the proposed Narwee Station Upgrade (the 'Proposal').

Construction of the Narwee Station Upgrade is expected to commence in 2016, take up to 18 months to complete and would be undertaken during both standard construction hours and out-of-hours. Around six weekend track possessions are likely to be required over the 18 month construction period.

An alternative construction option has also been considered which may use an extended (six week) temporary station closure to allow for an accelerated construction completion which would reduce the overall program by up to six months.

The following policies and guidelines are relevant for this assessment:

- *Interim Construction Noise Guideline* (ICNG), Department of Environment and Climate Change (DECC), 2009
- *Assessing Vibration: A Technical Guideline* (AVATG), Department of Environment and Conservation (DEC), 2006
- *NSW Road Noise Policy* (RNP), Department of Environment, Climate Change and Water (DECCW), 2011
- *NSW Industrial Noise Policy* (INP), Environment Protection Authority (EPA), 2000
- *Construction Noise Strategy* (CNS), TfNSW, 2012
- DIN Standard 4150: Part 3 1999 Structural Vibration in Buildings - Effects on Structures, 1999
- British Standard 7385: Part 2 1993 Evaluation and Measurement of Vibration in Buildings, 1993
- British Standard 6472: Part 1 2008 Evaluation of Human Exposure to Vibration in Buildings, 2008
- Australian Standard AS 2436-2010, Guide to noise and vibration control on construction, demolition and maintenance sites, 2010
- Australian Standard AS 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures, 1997
- UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*, 2006.

Definitions for acoustic terminology used within this report can be found in Appendix A.

1.2 Scope

The scope of this noise and vibration impact assessment is to:

- establish the existing background noise levels in the vicinity of the Proposal
- establish construction noise management levels and vibration limits that would apply to the Proposal
- predict environmental noise and vibration levels at nearby residential and other sensitive receivers due to the Proposal
- predict noise levels from additional off-site construction traffic generated by the Proposal
- recommend mitigation measures where necessary to reduce and manage noise and vibration impacts from the Proposal to comply with established construction noise management levels and vibration limits
- consider noise from the operation of the upgraded Narwee Station.

1.3 Proposed works

The key features of the Proposal are summarised as follows:

- extension of the island platform at the eastern end to provide new stairs, a lift and waiting area
- installation of new canopies for weather protection above the new lift, stairs and waiting area providing cover up to the existing Platform Building
- refurbishment of the Platform Building with a new family accessible toilet, a Customer Information Window and staff facilities to replace existing facilities in the Ticket Office (to be demolished)
- improvements to bicycle facilities including new shelters and additional bicycle racks
- provision of a new kiss and ride area, new kerb ramps and bus zone works (including new shelter) on Hannans Road
- upgrade of the two existing accessible parking spaces in the commuter car park off Hannans Road to ensure compliance with relevant standards
- provision of an accessible parking space, upgrade of the taxi rank and kiss and ride area, and installation of Tactile Ground Surface Indicators (TGSI's) at the raised pedestrian crossing on Hurst Place and Fisher Place
- ancillary works including localised platform regrading (as necessary), improvements to lighting and seating, improvement of station communication systems (including CCTV cameras), wayfinding signage, services diversion and/or relocation, station power supply upgrade, minor road/drainage works, fencing and landscaping.

A detailed description of the Proposal is provided in Chapter 3 of the Narwee Station Upgrade Review of Environmental Factors (REF) April 2016.

1.4 Site description

Narwee Station is located within a mixed use environment comprising predominantly residential with some commercial and retail uses. The closest residential receivers are located on Fisher Place and Hannans Road. Narwee Public School is located adjacent to the station to the south west and there are other sensitive receivers in the local vicinity. The station and its surrounding environment are shown in Figure 1.

Hannans Road and Broad Arrow Road, to the north and south of the station respectively, are considered to be sub-arterial roads as per categories within the Environment Protection Authority's (EPA) NSW *Road Noise Policy*.

1.4.1 Representative receivers

In order to simplify the assessment methodology, 21 representative residential receivers have been selected to describe the noise impacts within areas with likely similar background noise levels. Residences located closest to the Proposal on their block were selected as the potentially worst affected receivers, these are listed in Table 1.

Impacts were also assessed at representative non-residential sensitive receivers, these are listed in Table 2.

The locations of the residential and non-residential receivers identified for use in the assessment are presented Figure 2. It is noted that other residential and non-residential sensitive receivers which could potentially be affected by the Proposal are scattered around the vicinity of the Proposal location.

1.4.2 Noise Catchment Areas

To assist in determining noise criteria for the receivers surrounding the Proposal, two noise catchment areas (NCA) were identified. The noise environment at each of the residential receivers within the NCA is considered to have a similar noise environment. The NCAs are shown in Figure 1.

1.4.3 Heritage items

Narwee Station is listed on RailCorp's Section 170 Heritage and Conservation Register (No. 4801924) and on the heritage schedule of the *Canterbury Local Environmental Plan 2012* (I151). In particular the Platform Building and Pedestrian Subway (pedestrian underpass) are of high significance and the platform (including brick edgings) is of moderate significance. Refer to the Narwee Station Upgrade Statement of Heritage Impact (AECOM 2016) for more information.

Table 1 Representative receiver addresses – residential

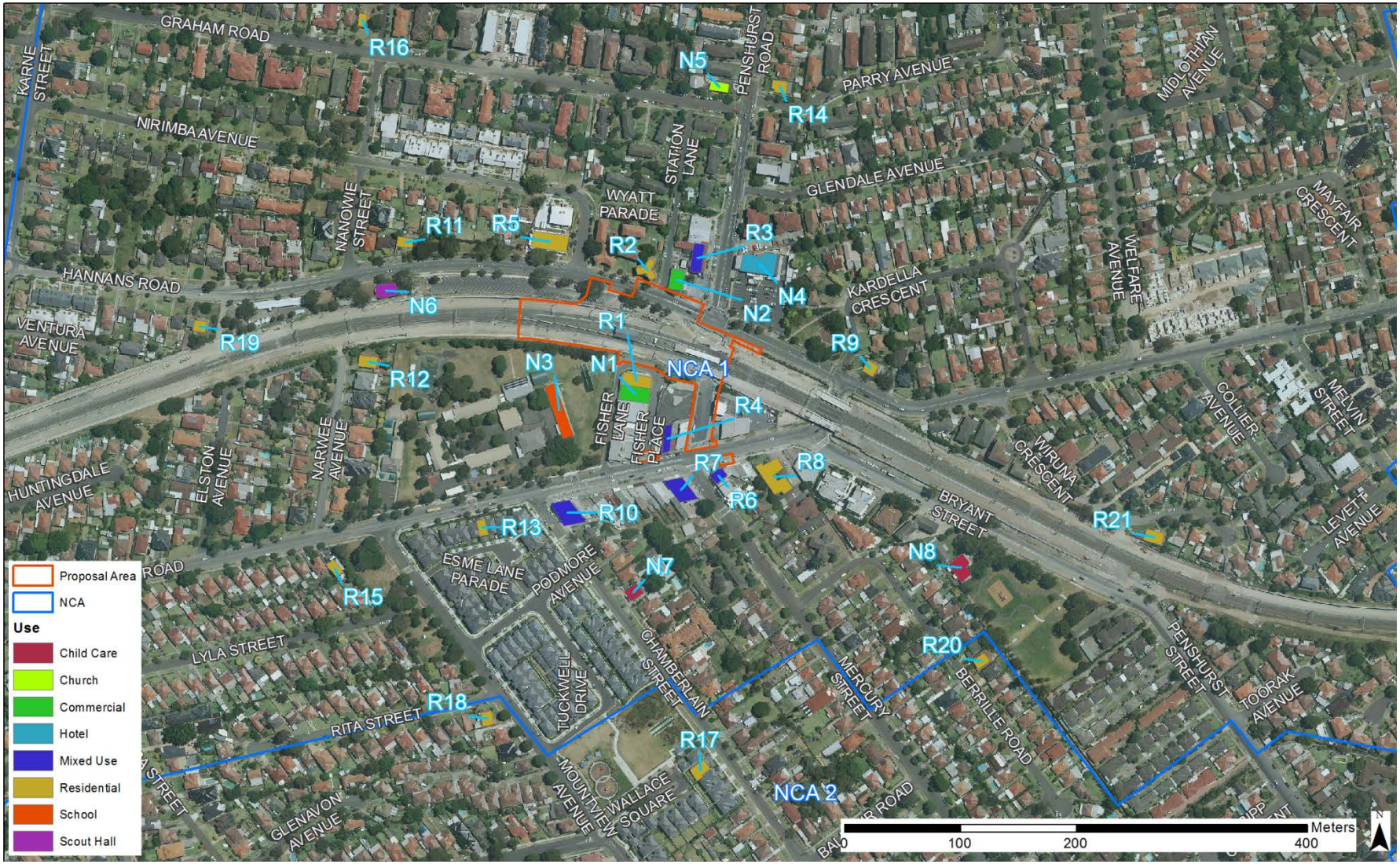
Receiver ID	Receiver address	Approximate distance to Proposal in metres
R1	18-20 Fisher Place, Narwee	7
R2	144 Hannans Road, Narwee	22
R3	153-155 Penshurst Road, Narwee (Mixed Use - Commercial / Residential)	38
R4	47 Broad Arrow Road, Narwee (Mixed Use - Commercial / Residential)	39
R5	1 Nirimba Avenue, Narwee	56
R6	52 Broad Arrow Road, Narwee (Mixed Use - Commercial / Residential)	76
R7	60 Broad Arrow Road, Narwee (Mixed Use - Commercial / Residential)	82
R8	42 Broad Arrow Road, Narwee	89
R9	20 Kardella Crescent, Narwee	125
R10	92-96 Broad Arrow Road, Narwee (Mixed Use - Commercial / Residential)	134
R11	138A Hannans Road, Narwee	162
R12	12A Narwee Avenue, Narwee	180
R13	5 Esme Lane Parade, Narwee	186
R14	106 Penshurst Road, Narwee	193
R15	98 Broad Arrow Road, Narwee	295
R16	35 Graham Road, Narwee	317
R17	17 Chamberlain Street, Narwee	325
R18	83 Mountview Avenue, Narwee	326
R19	105 Hannans Road, Narwee	326
R20	19 Berrille Road, Narwee	339
R21	3 Wiruna Crescent, Narwee	398

Table 2 Representative receiver addresses – non-residential

Receiver ID	Receiver address	Approximate minimum separation distance to nearest work location (metres)
N1	16 Fisher Place, Narwee (Commercial)	7
N2	7 Eleven	19
N3	Narwee Public School	54
N4	Narwee Hotel	67
N5	Salvation Army Church	193
N6	1st Narwee Scout Hall	105
N7	Beverly Hills Montessori Christian Preschool	100
N8	Narwee Preschool Kindergarten	210

Figure 1 Noise and vibration receivers and logger locations

Figure 2 Representative receiver locations



2.0 Existing acoustic environment

Long term unattended and short term attended measurements were undertaken to establish the existing ambient and background noise environment at potentially affected receivers.

2.1 Noise measurement methodology

Long term unattended noise monitoring was conducted at two locations between 16 and 23 February 2016. One noise logger was placed within each NCA at a representative location in the locations indicated in Table 3 and shown in Figure 1. The noise loggers were calibrated prior to and after the monitoring period with a drift in calibration not exceeding ± 0.5 dB.

All the acoustic instrumentation employed during the noise measurements comply with the requirements of "*AS IEC 61672.1-2004 Electroacoustics - Sound level meters - Specifications*" and were within their current National Association of Testing Authorities, Australia (NATA) certified in-calibration period (i.e. calibration in the last two years).

Table 3 Noise monitoring details

NCA	Logger	Location	Model	Serial number
1	1	5 Kardella Crescent, Narwee	Rion NL21	465439
2	2	4 Whitfield Avenue, Narwee	Rion NL21	865769

The noise environment at each of the residential receivers within a NCA is considered to have a similar noise environment to the unattended monitoring location with that NCA. As such each of these residential receivers is assigned the same background noise level and construction noise management level.

In accordance with the EPA's NSW *Industrial Noise Policy* (INP), noise monitoring affected by adverse weather conditions or extraneous noise events should be excluded from the monitoring data. The INP advises that data may be affected where adverse weather, such as wind speeds higher than 5 m/s or rain, occurs. Weather data was acquired from the Bureau of Meteorology's Bankstown weather station (station number 94765) located around six kilometres north-west of the Proposal.

2.2 Unattended noise measurements

The loggers measured the noise levels over the sample period and then determined L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels of the noise environment. The $L_{A1,}$ L_{A10} and L_{A90} noise levels are the levels exceeded for 1%, 10% and 90% of the measurement period respectively. The L_{A90} is taken as the background level. The L_{A1} is indicative of the maximum noise levels due to individual noise events such as the pass-by of a heavy vehicle. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The L_{A90} noise levels were analysed to determine a single assessment background level (ABL) for each day, evening and night period in accordance with the INP for each monitoring location. The ABL is established by determining the lowest ten-percentile level of the L_{A90} noise data acquired over each period of interest. Table 4 presents individual ABLs for each day's assessment periods. 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 period.

Table 4 also presents the existing L_{Aeq} ambient noise level selected for each day, evening and night-time period, in accordance with the INP. An overall representative L_{Aeq} noise level is determined by logarithmically averaging each assessment period for the entire monitoring period.

Graphical noise logging results are presented in Appendix B.

Table 4 Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels – NCA 1

	L_{A90} Background noise levels, dB(A)			L_{Aeq} Ambient noise levels, dB(A)		
Measurement date	**Day[1]**	**Evening[1]**	**Night[1]**	**Day[1]**	**Evening[1]**	**Night[1]**
Tuesday 16 February 2016	-	38	34	-	47	46
Wednesday 17 February 2016	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Thursday 18 February 2016	37	40	39	48	50	48
Friday 19 February 2016	38	41	39	48	51	47
Saturday 20 February 2016	-[2]	-[2]	39	-[2]	-[2]	48
Sunday 21 February 2016	-[2]	-[2]	36	-[2]	-[2]	49
Monday 22 February 2016	39	44	-[2]	51	54	-
Tuesday 23 February 2016	-[2]	-	-	-[2]	-	-
Rating background level	**38**	**41 (38)[3]**	**39 (38)[3]**	**-**	**-**	**-**
Log Average L_{Aeq}	**-**	**-**	**-**	**49**	**51**	**48**

Notes:
1. Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
   Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday & Public Holidays.
   Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays.
2. Indicates period affected by adverse weather conditions.
3. Level adjusted to the daytime RBL in accordance with the INP.

Table 5 Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels – NCA 2

	L_{A90} Background noise levels, dB(A)			L_{Aeq} Ambient noise levels, dB(A)		
Measurement date	**Day[1]**	**Evening[1]**	**Night[1]**	**Day[1]**	**Evening[1]**	**Night[1]**
Tuesday 16 February 2016	-	41	35	-	51	47
Wednesday 17 February 2016	-[2]	-[2]	33	-[2]	-[2]	47
Thursday 18 February 2016	38	43	37	52	54	49
Friday 19 February 2016	37	42	37	53	53	48
Saturday 20 February 2016	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Sunday 21 February 2016	38	41	37	50	50	48
Monday 22 February 2016	36	43	39	52	52	48
Tuesday 23 February 2016	-[2]	-	-	-[2]	-	-
Rating background level	**37**	**42 (37)[3]**	**37**	**-**	**-**	**-**
Log Average L_{Aeq}	**-**	**-**	**-**	**52**	**52**	**48**

Notes:
1. Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
   Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday & Public Holidays.
   Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays.
2. Indicates period affected by adverse weather conditions.
3. Level adjusted to the daytime RBL in accordance with the INP.

2.3 Attended noise measurements

The results of the attended noise monitoring are presented in Table 6.

Table 6 Attended noise measurements

Logger	Date	Time	L_{Aeq} dB(A)	L_{A90} dB(A)	Comments
1	17/02/16	14:32	52	46	Traffic noise along Broad Arrow Road is dominant
2	17/02/16	14:19	50	44	Traffic noise along perpendicular roads is dominant

Attended noise monitoring indicated that the dominant ambient noise source at both monitoring location was traffic noise from nearby roads.

2.4 Existing noise environment summary

The acoustic environment of NCA 1 is dominated by traffic on Broad Arrow Road. There is also some intermittent rail noise audible mainly during the night–time period when road traffic noise on Broad Arrow Road reduces. The acoustic environment of NCA 2 is characterised by local road traffic flows. Both NCAs have local traffic with intermittent traffic flows. These characteristics are typical of a suburban environment. For both NCAs the evening background levels are higher than the daytime background levels. This is due to a traffic peak in the evening as people travel home from work.

3.0 Construction noise and vibration criteria

3.1 Construction activity noise criteria

3.1.1 Interim Construction Noise Guideline

The EPA's *Interim Construction Noise Guideline* (ICNG) is the principal guideline for the assessment and management of construction noise in NSW. The ICNG recommends that a quantitative assessment is carried out for all *'major construction projects that are typically subject to the Environmental Impact Assessment (EIA) processes'*. Noise levels due to construction activities are predicted at nearby receivers using environmental noise modelling software and compared to the levels provided in Section 4 of the ICNG.

Where an exceedance of the management levels is predicted, the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practises to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details.

Where construction noise levels reach 75 dB(A) residential receivers can be considered as 'highly noise affected' and the proponent should, in consultation with the community, consider restricting hours 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."

The construction noise management levels (NML) for the residential and other sensitive land uses are detailed in Table 7, Table 8 and Table 9.

Table 7 ICNG Residential noise management levels

Time of day	NML, $L_{Aeq,15min}$, dB(A)[1]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	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: 1. 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 2. 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 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 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 8 presents the NMLs applicable to residential receivers nearby to this development.

Table 8 Construction noise management levels – Residential receivers

Noise catchment area	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)
1	Day	38	48	43
	Evening	38	N/A	43
	Night	38	N/A	43
2	Day	37	47	42
	Evening	37	N/A	42
	Night	37	N/A	42

Table 9 presents the NMLs applicable to other noise sensitive receivers such as educational facilities and places of worship and to commercial receivers.

Table 9 Construction noise management levels – Other receivers

Land use	Noise management levels, $L_{Aeq,15min}$ (applies when properties are in use)
Classrooms at schools and other educational institutions	55 dB(A)[1]
Places of worship	55 dB(A)[1]
Childcare centres	55 dB(A)[1]
Scout Hall (based on criteria for an indoor sports hall from AS2107)	65 dB(A)[2]
Commercial premises (including offices, retail outlets)	70 dB(A)

Notes:

1. These external management levels are based upon a 45 dB(A) internal noise management level and a 10 dB reduction from outside to inside through an open window.
2. This external management level is based upon a 55 dB(A) internal noise management level and a 10 dB reduction from outside to inside through an open window.

3.1.2 Sleep disturbance criteria

The ICNG requires a sleep disturbance analysis where construction works are planned to extend over more than two consecutive nights. On the basis of the ambient noise environment during the night-time period, the predicted L_{A1} noise levels and number of expected L_{A1} noise events should be predicted in order to determine the likelihood of potential sleep disturbance. The ICNG makes reference to the NSW *Environment Criteria for Road Traffic Noise* (ECRTN) (EPA, 1999), now superseded by the *Road Noise Policy* (RNP), for guidance in assessing the potential for 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 (10.00 pm to 7.00 am), the $L_{A1(1\ min),}$ noise level outside a bedroom window should not exceed the $L_{A90\ (15\ minute)}$ background noise level by more than 15 dB. 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 and 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 approximately 10 dB in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented in Table 10.

Table 10 Sleep disturbance criteria

Noise catchment area	Background noise level (L_{A90}), dB(A)	Sleep disturbance criteria,	$L_{A1(1\ minute)}$, dB(A)
		Screening level	Awakening reaction
1	38	53	60 – 65
2	37	52	60 – 65

3.2 Construction traffic noise criteria

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

To assess noise impacts from construction traffic or a temporary reroute due to a road closure or both an initial screening test should be undertaken by evaluating whether existing road traffic noise levels will 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 equal to or 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.

Broad Arrow Road (via Hurst Place) and Hannans Road provide the main access roads to the site. These roads are classified as sub-arterial. The external noise criteria are applied 1 metre from the external facade of an affected building.

3.3 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) [1]	*Assessing Vibration: A Technical Guideline* (AVATG)

Note 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.

3.3.1 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 DIN 4150: Structural damage safe limits for building vibration

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 (eg 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

3.3.2 Human comfort

The assessment of intermittent vibration outlined in the NSW EPA guideline A*ssessing Vibration: A Technical Guideline* (AVTG) 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$^{1.75}$) for daytime (7am – 10pm) and night time (10pm – 7am)

Location	Daytime Preferred	Daytime Max	Night time Preferred	Night time Max
Critical areas	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

4.0 Operational noise criteria

4.1 Industrial Noise Policy

The NSW *Industrial Noise Policy* (INP) provides guidance in relation to acceptable noise limits for industrial noise emissions, which includes, but is not limited to, noise emissions from mechanical plant.

The assessment procedure in the INP has two components:

- controlling **intrusive** noise impacts in the short term for residences
- maintaining noise level **amenity** for residences and other land uses.

Both components are assessed at the boundary of the noise sensitive receiver site, or if the site boundary is more than 30 metres from the noise sensitive building, a distance of 30 metres from the noise sensitive building.

Adjustments to the level of noise predicted (or measured) at the assessment location may be applied in accordance with Section 4 of the INP to account for the subjective effects of specific noise characteristics including tonality, low frequency content, intermittency, impulsiveness and duration.

4.1.1 Intrusive noise impacts

The INP states that the noise from any single noise source should not be greatly above the prevailing background noise level. Industrial noise sources are generally considered acceptable if the A-weighted equivalent continuous sound pressure level of noise from the source, measured over a 15 minute period ($L_{Aeq,15\ min}$) does not exceed the Rating Background Level (RBL) by more than 5 dB(A) for the period under consideration. This is termed the Intrusiveness Criterion.

The RBL is the background noise level to be used for assessment purposes and is determined by the methods given in the INP.

The RBL and the respective intrusive criteria for the day, evening and night periods are provided in Table 14.

Table 14 Intrusive criteria

Location	Period	RBL (L_{A90}), dB(A)	Intrusive criteria (RBL+5), dB(A)
Residential receivers – NCA 1	Day	38	43
	Evening	38	43
	Night	38	43
Residential receivers – NCA 2	Day	37	42
	Evening	37	42
	Night	37	42

4.1.2 Protecting amenity

To limit continuing increase in noise levels, the maximum ambient noise level within an area from all industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the INP. That is the noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the "background creep" or "amenity criterion".

The amenity criteria applicable to this development are provided in Table 15.

Table 15 Amenity criteria

Type of receiver	Indicative noise amenity area	Time of day	Recommended L_{Aeq} Noise level, dB(A) (Acceptable)	Recommended L_{Aeq} Noise level, dB(A) (Maximum)	Ambient noise level, dB(A)	Amenity criteria, dB(A)
Residential receivers – NCA 1	Suburban	Day	55	60	49	55
		Evening	45	50	51	45
		Night	40	45	48	40
Residential receivers – NCA 2	Suburban	Day	55	60	52	55
		Evening	45	50	52	45
		Night	40	45	48	40
School classroom - internal	All	Noisiest 1-hour period when in use	35	40	-	35
Place of Worship - internal	All	When in use	40	45	-	40
Commercial premises	All	When in use	65	70	-	65

4.1.3 Summary

A summary of the environmental noise criteria is presented in Table 16 below. This criteria applies to environmental noise emissions from any plant installed as part of the Proposal.

Table 16 Summary of environmental noise emission criteria

Location	Time of day	Intrusive Criteria L_{Aeq}, dB(A)	Amenity Criteria L_{Aeq}, dB(A)	Project Specific Noise Levels[1] Criteria L_{Aeq}, dB(A)
NCA 1	Day	43	55	43
	Evening	43	45	43
	Night	43	40	40
NCA 2	Day	42	55	42
	Evening	42	45	42
	Night	42	40	40
School classroom	Noisiest 1-hour period when in use	-	45[2]	45
Place of Worship	When in use	-	50[2]	50
Commercial premises	When in use	-	65	65

Notes:

1. Project Specific Noise Levels represent the lower of the intrusive and amenity criteria.
2. External noise level assuming windows are open for adequate ventilation

5.0 Construction noise assessment

5.1 Construction stages and scheduling

In consultation with TfNSW, four distinct work packages, each consisting of a number of construction activities, have been assumed to occur for the upgrade works. These would be confirmed by the construction contractor prior to construction commencing and further assessment would be undertaken if required. Proposed construction stages for the works are described in Table 17. The works with potentially high impact works in terms of noise levels and timing are highlighted in blue and these works are included in the construction noise assessment below.

Out-of-hours works would likely be required during around six weekend possessions over the 18 month construction period and during some evening/night-time periods to minimise traffic impacts. It should be noted that night-time construction works during possessions would not take place over longer than two consecutive nights. This would provide some respite periods during weekdays between works.

Table 17 Construction assessment scenarios and scheduling

Work package	Scenario	Timing
1 - Site establishment and enabling works	**1A – Establishment of site compound** Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas), Establishment of temporary facilities as required	Standard hours or day time possession
	1B – Removal of vegetation Removal of vegetation to allow for upgrades (if required)	Standard hours
	Services relocation	Standard hours[1]
2 - New lift and platform upgrade	**2A – Demolition of structures** Demolition of existing structures including any buildings on the platforms	Standard hours or 48 hr possession
	2B – Platform modifications Platform modifications, platform extension, lift shaft including piling and foundations for lift shaft	Standard hours or 48 hr possession
	2C – Construction of lift shaft Construction of lift shaft, stairs, fencing and new canopies	Standard hours or 48 hr possession
	Installation of lift, installation of fixtures, lighting, signage and CCTV cameras for the station areas	Standard hours or 48 hr possession
	2D – Platform resurfacing Platform resurfacing to bring gradient between 1:40 to 1:100, new platform surface drainage and communications installation	48 hr possession
3 - Station building works	**3A - Reconfiguration of internal station buildings** Reconfiguration of internal station buildings to allow for communications/equipment room, staff facilities and toilets including the family accessible toilet	Standard hours
	3B - Refresh of station building Refresh of station building including painting works	Standard hours or 48 hr possession
4 - Interchange works	**4A – Modification to the existing underpass** Modifications and making good the existing underpass including re-surfacing, lighting and painting	Standard hours
	4B – Interchange works Taxi zone, kiss and ride, bus stops, bike racks and accessible car spaces in the car park	Standard hours
	Installation of wayfinding signage, electrical and power supply upgrade works, replanting/landscaping, fencing adjustments and bollards	Standard hours

Note 1: cutover works (not noisy) during possessions

An alternative construction option has also been considered which may use an extended (six week) temporary station closure to allow for an accelerated construction completion which would reduce the overall program by up to six months. For this scenario it is likely that more works would be undertaken during the daytime rather than during weekend possessions. This would reduce the number and duration of night-time works.

5.2 Construction sources

Noise sources and their respective L_{Aeq} sound power levels for each scenario are shown in Table 18. 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 the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites* noise database and assume equipment is modern and in good working order.

Table 18 Equipment sound power levels per construction scenario

Equipment	Sound Power Level, dB(A)	Scenario
Trucks	98[1]	1A, 1B, 2A, 2B, 2C, 2D, 3A, 4A
Generator	101	1A, 1B, 2A, 2D, 4B
Bobcat	104	1A, 1B, 2A, 2D, 4B
Hand tools	94	1A, 1B, 2A, 2B, 2C, 2D, 3A, 3B, 4A, 4B
Mulcher	115	1B
Chainsaw	110	1B
Tipper	98	2A
Semi-trailers	98	2A
Demolition saw	110	2A, 2B, 2C, 3A, 4A
Jack hammer	108	2A, 2B, 2C, 2D, 3A, 4A
Excavator	98	2A, 2B, 2C, 2D, 3A, 4A
Grinder	108	2A, 2C, 2D, 3A
Manitou	92	2A, 2C
Scissor lift	100	2A
Franna crane	93	2A, 2B, 2C
Lighting tower	95	2A
Mobile crane	104	2A, 2C, 3B
Concrete pump	106	2B, 2C, 4A
Pilling rig	103	2B
Concrete truck	106	2B, 2C, 4A
Lighting tower	94	2B, 2C, 3B
Hydreama / Hirail	94	2B, 2C, 2D
Scissor lift	100	2C, 3B
Wacker packer	104	2D
Nail gun	90	3A
Mini excavator	94	4B

Note 1: Sound powers are time weighted (i.e. expected equipment levels per 15 minute period)

5.3 Modelling and conditions

In order to assess noise impacts from the site during construction, a noise model was created to represent 'reasonable' worst periods of upgrade works.

The construction of the Proposal has been modelled in SoundPLAN Version 7.3. The following features were included in the noise model:

- ground topography
- ground absorption and reflection
- buildings (residential and commercial)
- receivers (shown in Figure 1)
- construction noise sources (listed in Table 18).

Noise emissions from the construction sites have been modelled using an implementation of the ISO 9613 propagation algorithm with neutral metrological 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. The acoustic shielding calculated in the model due to fixed building structures would also vary as the construction equipment moves around the site.

5.4 Construction noise assessment

The identified residential and non-residential receivers have been assessed against the standard hours, out-of-hours daytime and evening and out-of-hours night-time NMLs. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required.

During construction not all equipment would be operating simultaneously at all times and in the one location, which would result in a slight reduction in predicted noise levels. Mitigation measures for receivers have been specified in Section 5.8 which would reasonably and feasibly reduce the impact of these exceedances.

Noise results are presented graphically in Appendix C.

5.4.1 Summary of impacts during standard hours

Results show residential exceedances during standard hours occur during all assessed stages of construction, with similar numbers of exceedances during most construction stages, as shown in Table 19. The largest numbers of exceedances occur during Stage 1B - Removal of vegetation. The largest impacts would be experienced by residences along Fisher Place and Hannans Road. Two residential receivers (R1 on Fisher Place and R2 on Hannans Road) are predicted to be 'highly affected'. It should be noted that the number of trees to be removed would be minimal and the duration would likely be around 1-2 days only.

Some non-residential receivers are predicted to exceed NMLs as shown in Table 20. These receivers include N1 (a commercial site) N3 (Narwee Public School), N4 (Narwee Hotel) and N5 (Salvation Army Church). Key noisy activities include the use of concrete saws and excavators with hammers.

5.4.2 Summary of impacts during out-of-hours

Results show exceedances of the NMLs at residential receivers during out-of-hours works occurs during all assessed stages of construction, with similar numbers of exceedances during most construction stages., as shown in Table 21. The largest numbers of exceedances occur during 'Stage 2A - demolition of existing structures'. The largest impacts would be experienced by residences along Fisher Place and Hannans Road (R1 on Fisher Place and R2 on Hannans Road). Noise levels at 18-20 Fisher Place (R1) are predicted to exceed the noise management levels by more than 25 dB(A). No receivers are predicted to be 'highly affected'.

Some non-residential receivers are predicted to exceed NMLs as shown in Table 22. These receivers include N1 (a commercial site), N3 Narwee Public School (which may have evening activities occasionally), N4 (Narwee Hotel) and N5 (Salvation Army Church).

Table 19 Predicted noise impacts at representative residential receivers – Standard hours

Receiver ID	Distance (metres)	NML	1A	1B	2A	2B	2C	3A	3B	4A	4B
R1	7	48	**74**	**82**	**72**	**68**	**69**	**74**	**68**	**69**	**60**
R2	22	48	**68**	**69**	**67**	**64**	**64**	**71**	**64**	**65**	**78**
R3	38	48	**59**	**67**	**62**	**64**	**65**	**62**	**55**	**65**	**65**
R4	39	48	**49**	**61**	**55**	**57**	**57**	**55**	**49**	**58**	**73**
R5	56	48	**58**	**64**	**61**	**58**	**58**	**64**	**57**	**59**	**63**
R6	76	48	**52**	**60**	**58**	**60**	**61**	**53**	45	**60**	**76**
R7	82	48	**54**	**58**	**58**	**63**	**63**	**51**	44	**64**	**70**
R8	89	48	**54**	**53**	**54**	**62**	**60**	**54**	**50**	**62**	**69**
R9	125	48	**51**	**63**	**58**	**60**	**60**	**57**	**49**	**62**	**51**
R10	134	48	**49**	**52**	**54**	**49**	**50**	**59**	**52**	**51**	**61**
R11	162	48	**49**	**58**	**55**	**52**	**53**	**57**	**50**	**53**	**49**
R12	180	48	47	**53**	**52**	**50**	**51**	**54**	48	**51**	**49**
R13	186	48	44	**51**	**53**	**52**	**52**	**53**	47	**53**	**53**
R14	193	48	44	**58**	**52**	**51**	**50**	45	0	**52**	46
R15	295	48	< 39	45	44	44	44	45	40	45	< 39
R16	317	48	< 39	44	< 39	< 39	< 39	< 39	< 39	< 39	< 39
R17	325	47	41	44	47	47	**49**	44	40	49	42
R18	326	47	< 39	41	39	39	39	41	< 39	40	< 39
R19	326	48	42	**52**	**49**	47	47	**51**	44	47	43
R20	339	47	< 39	41	41	41	41	42	0	42	< 39
R21	398	48	40	**52**	48	**49**	**49**	**49**	41	**51**	42

Notes: Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML. Items in **BOLD RED** indicate a 'highly affected' residential receiver with level of 75 dB(A) or greater.

Table 20 Predicted noise impacts at representative non-residential receivers – Standard hours

Receiver ID	Distance (metres)	NML	1A	1B	2A	2B	2C	3A	3B	4A	4B
N1	7	70	**73**	**72**	68	66	67	68	64	67	64
N2	19	70	47	60	51	54	54	43	0	54	47
N3	54	55	**59**	**63**	**62**	**59**	**60**	**66**	**59**	**60**	**57**
N4	67	48	**56**	**67**	**63**	**65**	**65**	**62**	**55**	**66**	**60**
N5	193	55	44	**58**	**52**	**51**	**50**	45	0	**52**	46
N6	105	65	49	58	54	51	52	56	49	52	48
N7	100	55	42	51	52	51	50	49	43	52	52
N8	210	55	44	53	54	53	52	51	45	54	54

Notes: Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML. Items in **BOLD RED** indicate a 'highly affected' residential receiver with level of 75 dB(A) or greater.

Table 21 Predicted noise impacts at representative residential receivers – outside of standard hours (day, evening and night)

Receiver ID	Distance (metres)	NML	1A	2A	2B	2C	2D	3B
R1	7	43	**74**	**72**	**68**	**69**	**71**	**68**
R2	22	43	**68**	**67**	**64**	**64**	**68**	**64**
R3	38	43	**59**	**62**	**64**	**65**	**59**	**55**
R4	39	43	**49**	**55**	**57**	**57**	**54**	**49**
R5	56	43	**58**	**61**	**58**	**58**	**64**	**57**
R6	76	43	**52**	**58**	**60**	**61**	**55**	**45**
R7	82	43	**54**	**58**	**63**	**63**	**52**	**44**
R8	89	43	**54**	**54**	**62**	**60**	**52**	**50**
R9	125	43	**51**	**58**	**60**	**60**	**56**	**49**
R10	134	43	**49**	**54**	**49**	**50**	**57**	**52**
R11	162	43	**49**	**55**	**52**	**53**	**57**	**50**
R12	180	43	**47**	**52**	**50**	**51**	**54**	**48**
R13	186	43	**44**	**53**	**52**	**52**	**52**	**47**
R14	193	43	**44**	**52**	**51**	**50**	**47**	< 39
R15	295	43	< 39	**44**	**44**	**44**	**45**	40
R16	317	43	< 39	< 39	< 39	< 39	40	< 39
R17	325	42	41	**47**	**47**	**49**	**46**	40
R18	326	42	< 39	39	39	39	39	< 39
R19	326	43	42	**49**	**47**	**47**	**50**	**44**
R20	339	42	< 39	41	41	41	41	< 39
R21	398	43	40	**48**	**49**	**49**	**47**	41

*Notes: Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML. Items in **BOLD RED** indicate a 'highly affected' residential receiver with level of 75 dB(A) or greater.*

Table 22 Predicted noise impacts at representative non-residential receivers – outside of standard hours (day, evening and night)

Receiver ID	Distance (metres)	NML	1A	2A	2B	2C	2D	3B
N1	7	70	**73**	68	66	67	66	64
N2	19	70	47	51	54	54	50	0
N3	54	55	**59**	**62**	**59**	**60**	**66**	**59**
N4	67	48	**56**	**63**	**65**	**65**	**61**	**55**
N5	193	55	**44**	**52**	**51**	**50**	**47**	**< 39**
N6	105	65	44	49	54	51	52	56

Notes: Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML. Items in **BOLD RED** indicate a 'highly affected' residential receiver with level of 75 dB(A) or greater.

N7 and N8 are preschools and so it has been assumed that these would not be impacted by out of standard hours works.

5.5 Sleep disturbance assessment

A sleep disturbance assessment was undertaken to assess works potentially required during the night-time period (e.g. during weekend track possessions). Appendix D presents the predicted maximum $L_{A1(1min)}$ noise level contours. The awakening reaction criterion of 60 – 65 dB(A) is predicted to be exceeded at residences in NCA 1 (including on Hannans Road, Fisher Place, Broad Arrow Road and Penshurst Road) for scenarios 1A – Establishment of the site compound, 2A – Demolition of structures, 2B – Platform modifications, 2C – Construction of lift shaft, 2D – Platform resurfacing and 3B – Refresh of station building.

Construction activities would be undertaken during the daytime where feasible. Should the temporary station closure construction option be used there may be greater opportunities to avoid out of hours works and reduce the occurrence of potential sleep disturbance.

The predicted construction noise levels presented in Appendix D are external noise levels. The typical outdoor to indoor noise reductions provided by most standard dwellings (i.e. without acoustical treatment) is generally accepted as being 10 dB with windows open and a minimum of 20 dB with windows closed. Therefore, by closing their windows during noisy activities residents can potentially attenuate external noise levels by 20 dB.

In addition, the predicted construction noise levels are typically the worst case noise levels, therefore the majority of the actual $L_{A1(1min)}$ noise levels are likely to be less than those predicted.

5.6 Construction traffic assessment

No traffic counts have been conducted for this assessment however numbers of construction heavy vehicles have been estimated by TfNSW as approximately 1-5 vehicles per day Monday to Friday. For weekend possession works there would be up to 10 vehicles per day.

From on-site observations during the deployment of unattended noise measurement equipment, the existing traffic flow is substantially greater than the proposed construction traffic numbers. Therefore, the construction vehicles would have a negligible impact on existing road traffic noise in the area. The traffic generated by the Proposal is considered to comply with the *Road Noise Policy* criteria.

To minimise the construction noise levels and reduce the risk of impacts occurring, construction traffic should be considered as part of the noise and vibration management plan.

5.7 Construction vibration assessment

Vibration intensive works may include the use of the following items of equipment:

- jackhammer
- bored piling rig
- wacker packer.

The safe working distances of these items of equipment from off-site receivers are shown in Table 23 which is based on recommendations of the CNS. If these safe working distances are complied with no adverse impacts from vibration intensive works are likely in terms of human response or cosmetic damage. Based on the indicative construction activities assessed for the Proposal, it is not considered likely that works would occur within the safe working distances for off-site receivers. If vibration intensive works are required within these safe working distances, mitigation measures to control excessive vibration would be implemented as outlined in Section 5.8.

The heritage items of Narwee Station have been assessed for the potential to sustain cosmetic damage from the proposed construction works. Table 23 presents indicative safe working distances for the most significant vibration generating plant.

As the Proposal would require works to two heritage structures (the Platform Building and the pedestrian underpass) it is likely that vibration intensive works would be undertaken within the safe working distances of these structures. The safe working distances for cosmetic damage are generally considered to be conservative and working within them would not necessarily result in damage to heritage fabric (above that which is required by the Proposal e.g. to create new openings in the Platform Building or pedestrian underpass) , however as factors such as work practices and intervening structures can affect vibration levels, vibration monitoring is recommended within these distances and should be undertaken at the beginning of vibration intensive works in order to refine

the safe working distances to ensure no additional impacts to heritage structures. Supplementary vibration monitoring is outlined in Section 5.8.

Table 23 Safe working distances of vibration intensive equipment to be used during the Proposal

Plant	Rating/ Description	Cosmetic damage – residential/commercial	Cosmetic damage - heritage	Human response
Jackhammer	Handheld	1 m (nominal)	1 m (nominal)	Avoid contact with structure
Wacker packer[1]	Handheld	5 m (nominal)	5 m (nominal)	15 m to 20 m
Bored piling	≤ 800 mm	2 m (nominal)	2 m (nominal)	2 m (nominal)

Note 1: No recommendations provided in the CNS for a wacker packer (assumed to be the same as a small roller)

5.8 Construction mitigation measures

5.8.1 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 reasonable and feasible safeguards to manage the noise emissions from the site and manage 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 24 presents the standard mitigation measures contained within the CNS which should be considered as mitigation measures as part of the CNVMP.

Table 24 Transport for *NSW Construction Noise 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 community consultation measures	Periodic notification (monthly letterbox drop or equivalent), website, Project Infoline, Construction Response Line, email distribution list.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.

Action required	Safeguard details
Noise Monitoring	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Maximum noise levels	The noise levels of plant and equipment must have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions should be considered as part of the selection process.
Use and siting of plant	Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Plant and vehicles to be turned off when not in use. Noise-emitting plant to be directed away from sensitive receivers.
Plan works site and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must 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 is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
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.

Action required	Safeguard details
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.

In addition to the standard mitigation measures identified in the CNS, the following specific mitigation measures have been developed as a result of the predicted impacts associated with the proposal:

- details of any necessary out-of-hours work required and processes to obtain approval from TfNSW should form part of the CNVMP
- noisy work should be scheduled to be undertaken during the standard hours as far as possible. Noisy activities that cannot be undertaken during standard construction hours should to be scheduled as early as possible during the evening and / or night-time periods. Should out-of-hours works be required, an out-of-hours works application form must be submitted to TfNSW for approval on a case-by-case basis
- alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units, and/or the use of alternative plant that perform the same function (e.g. rubber wheeled instead of steel tracked plant) should be considered and implemented where feasible and reasonable
- equipment should be regularly inspected and maintained to ensure it is in good working order
- Narwee Public School and other identified sensitive receivers would be consulted in relation to noise mitigation measures to identify any noise sensitive periods, e.g. exam periods. As much as reasonably possible noise intensive construction works in the vicinity of affected educational buildings are to be minimised
- truck drivers should 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). Construction sites should be arranged to limit the need for reversing associated with regular / repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms. Where feasible and reasonable, non-tonal reversing alarms should be used, taking into account the requirements of the Workplace Health and Safety legislation
- the noise monitoring program should be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during the construction program as the works progress. The results should be reviewed to determine if additional mitigation measures are required. All measurements should be undertaken in accordance with Australian Standard *1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures.*

For vibration intensive activities that occur within the safe working distances, as presented in Table 23, management methods to mitigate should include, as a minimum, the following:

- the use of less vibration intensive methods of construction or equipment is preferred where possible to reduce annoyance and potential for cosmetic damage (and in particular to heritage structures). All equipment should be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts
- works scheduling can often be adopted to effectively manage construction vibration impacts and in particular to limit potential impacts. Wherever possible, vibration intensive works should be limited to the least sensitive times of the day
- respite periods would be scheduled for construction activities expected to generate high levels of vibration
- if vibration intensive equipment is to be used within the safe working distances for cosmetic damage, as presented in Table 23, then it is recommended that attended vibration measurements are undertaken when work commences, to determine site specific safe working distances. Vibration intensive work should not proceed within the safe 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 dilapidation surveys of sensitive historical structures before construction works begins

- for work scheduled to occur near a building, within the safe working distance for human response but outside the safe working distance for cosmetic damage, it is considered that the additional measures highlighted in Section 5.8.3 would be sufficient to mitigate the vibration impact at nearby residential receivers. Therefore vibration monitoring would not be required at these properties.

5.8.2 Community consultation and complaints handling

All residents and sensitive receivers impacted by noise from the proposed works which are expected to exceed the NML should be consulted about the Proposal 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 residents should 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 should be detailed in a Community Liaison Plan for the construction of the Proposal and should include a 24 hour hotline and complaints management process.

5.8.3 TfNSW Construction Noise Strategy - Additional mitigation measures

TfNSW's *Construction Noise Strategy* (CNS) 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 CNS recommends the implementation of additional mitigation measures. These mitigation measures are specified within TfNSW's CNS and presented in Table 25.

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 8.

Table 25 Additional mitigation measures matrix

Time period		Action level[1] (mitigation measures)[2]			
		0 – 10 dB(A) Noticeable	10 – 20 dB(A) Clearly audible	20 – 30 dB(A) Moderately intrusive	>30 dB(A) Highly intrusive
Standard	Weekday (7am-6pm)	-	-	LB, M	LB, M
	Saturday (8am-1pm)				
	Sun/Pub Hol (Nil)				
OOHW Period 1	Weekday (6pm-10pm)	-	LB	LB, M	LB, M, IB, RO, PC, SN
	Saturday (7-8am) & (1-10pm)				
	Sun/Pub Hol (8am-6pm)				
OOHW Period 2	Weekday (10pm-7am)	LB	LB, M	LB, M, IB, PC,SN	LB, M, IB, PC,SN, AA
	Saturday (10pm-8am)				
	Sun/Pub Hol (6pm-7am)				

Notes:

1 Action level is LAeq(15 minute) noise level above background (RBL) - qualitative assessment of noise levels

2 The following abbreviations have been used (refer to Table 26 for further details):

AA: Alternative accommodation
M: Monitoring
IB: Individual briefings
LB: Letterbox drops

RO: Proposal specific respite offer
PC: Phone calls
SN: Specific notifications.

Table 26 outlines the additional mitigation measures, as outlined in the CNS.

Table 26 Description of additional mitigation measures

Abbreviation	Mitigation measure	Explanation
LB	Letter Box Drops	All residences should be notified as a minimum by letterbox drop 7 days ahead of construction activities.
M	Monitoring	Attended noise monitoring is to be undertaken as follows: At the commencement of out-of-hours works (within the first two nights), where out-of-hours works activities change; and Noise measurements shall be undertaken in accordance with the procedure documented in AS1055.1-1997 Acoustics - Description and Measurement of Environmental Noise - General Procedures.
IB	Individual Briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that would be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.
RO	Project Specific Respite Offer	Residents subjected to lengthy periods of noise or vibration may be eligible for a project specific respite offer. The purpose of such an offer is to provide residents with respite from an ongoing impact. The offer could comprise pre-purchased movie tickets or similar offer. This measure is determined on a project-by-project basis.
PC	Phone Calls	Phone calls detailing relevant information would be made to identified/affected stakeholders within seven days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.
SN	Specific Notifications	Specific notifications are letterbox dropped or hand distributed to identified stakeholders no later than seven days ahead of construction activities that are likely to exceed the noise management levels. This form of communication is used to support periodic notifications, or to advertise unscheduled works.
AA	Alternative Accommodation	Alternative accommodation options should be provided for residents living in close proximity to construction works that are likely to incur noise levels significantly above the applicable level.

6.0 Operational noise

Additional operational equipment at the station would include one new lift which would not produce significant noise emissions. As such, the operational noise environment is expected to remain largely unchanged. Standard noise controls such as appropriate selection of mechanical plant (such as lifts) would reduce any impacts. If required, operational noise emissions shall be addressed during the detailed design phase in order to comply with operational noise criteria as per the *Industrial Noise Policy.* Operational noise criteria are presented in Section 4.0.

7.0 Conclusions

A construction and operation Noise and Vibration Impact Assessment has been completed for the Narwee Station Upgrade (the 'Proposal'). Nearby noise and vibration sensitive receivers were identified, and attended and unattended noise measurements were completed to characterise the existing noise environment. The measured noise levels were used to establish operation and construction noise management levels.

The Proposal is expected to commence in 2016, take up to 18 months to complete and would be undertaken during both standard construction hours and out-of-hours. Around six weekend track possessions are likely to be required over the construction period. An alternative construction option has also been considered which may use an extended (six week) temporary station closure to allow for an accelerated construction completion which would reduce the overall program by up to six months.

7.1 Construction activity noise

Construction scenarios have been developed in consultation with TfNSW and the proposed equipment has been detailed within this report. Four distinct work packages comprising ten construction work activities were used in a computer based noise model to determine the potential changes to noise levels. Construction noise impacts were assessed at 21 representative residential receivers which were selected to describe the noise impacts within areas with likely similar background noise levels. Impacts were also assessed at representative nearby non-residential sensitive receivers, including Narwee Public School, Narwee Hotel, Salvation Army Church, 1st Narwee Scout Hall, Beverly Hills Montessori Christian Preschool, Narwee Preschool Kindergarten and commercial receivers.

The predicted construction noise levels exceed the construction noise management levels for all scenarios at residential and commercial receivers. Noise exceedances are similar to that expected for such works and are generally unavoidable within the capacity of being reasonable and feasible. The largest impacts would be experienced by residents along Fisher Place and Hannans Road, where some residents would be 'highly affected'. Implementation of mitigation measures described would aim to minimise and manage noise impacts where possible.

Mitigation measures have been recommended in line with TfNSW's *Construction Noise Strategy* in order to minimise and manage the impact of construction noise on nearby noise sensitive receivers.

7.2 Construction vibration

Safe working distances to nearby structures have been recommended for nominated plant. If the safe working distances are maintained then no adverse impact from the vibration intensive works are likely in terms of human response or cosmetic damage. Should vibration intensive activities within the safe working distances be required, the additional mitigation measures provided would be implemented.

It is unlikely that work would be undertaken within the safe working distances for commercial and residential receivers however during the lift installation and platform upgrade, work would directly impact two heritage listed structures (i.e. the Platform Building and pedestrian underpass) and vibration monitoring is recommended for these works.

7.3 Operation

During the operation of the Proposal, there may be minor changes to the existing noise levels due to the operation of the new lift however this is not considered to be significant. As such, the operational noise environment is expected to remain largely unchanged. If required, operational noise emissions shall be addressed during the detailed design phase in order to comply with operational noise criteria as per the *Industrial Noise Policy.*

Appendix A

Acoustic Terminology

Appendix A 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 [f]	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.

*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 *Industrial Noise Policy* and the EPA's *Road Noise Policy*.

Appendix B

Noise Logging

Appendix B Noise Logging

NL1 – 5 Kardella Crescent, Narwee – 16/02/16 – 23/02/16

Logger Type: Rion NL21

Serial No: 465439

Address: 5 Kardella Crescent, Narwee

Location: Front garden

Façade / Free Field: Free field

Environment: Traffic noise along Broad Arrow Road is dominant.

Table 27 Measured noise levels – NL1

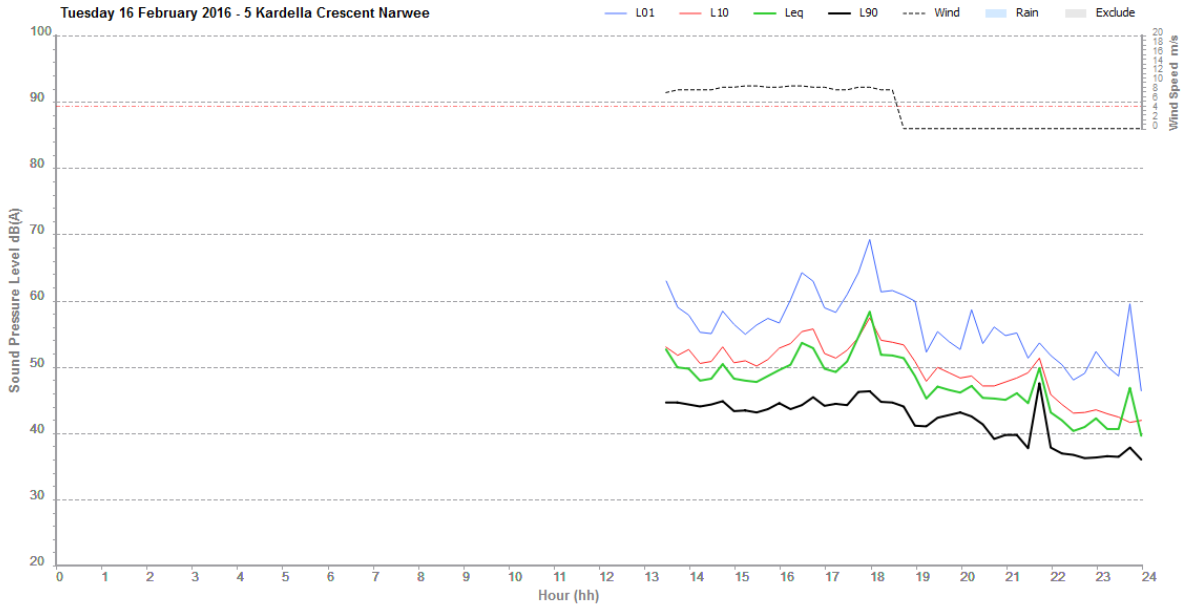
INP noise level, dB(A)		
Period	**Log average L_{Aeq}**	**Rating Background Level**
Day	49	38
Evening	51	41 (38)[1]
Night	48	39 (38)[1]

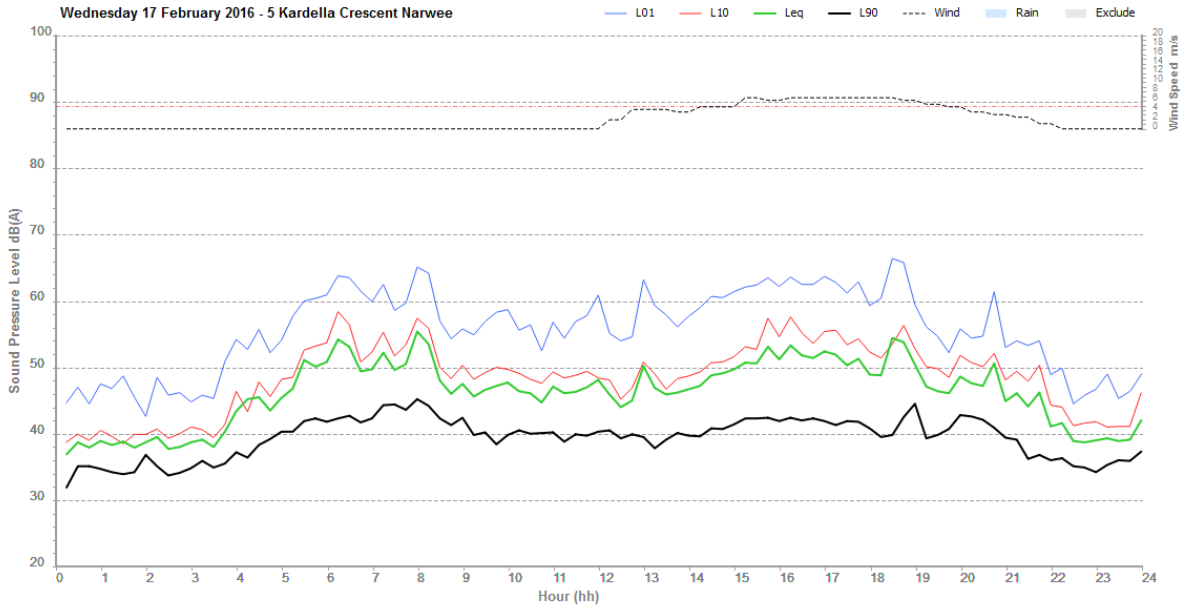
Note:

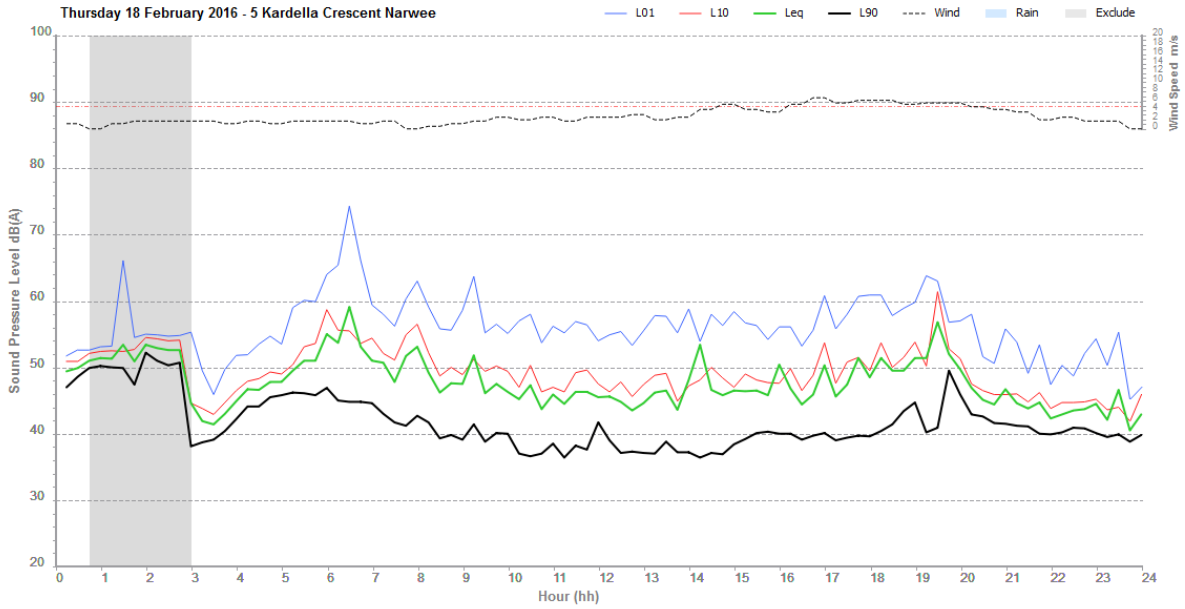
1. Level adjusted to the daytime RBL in accordance with the INP.

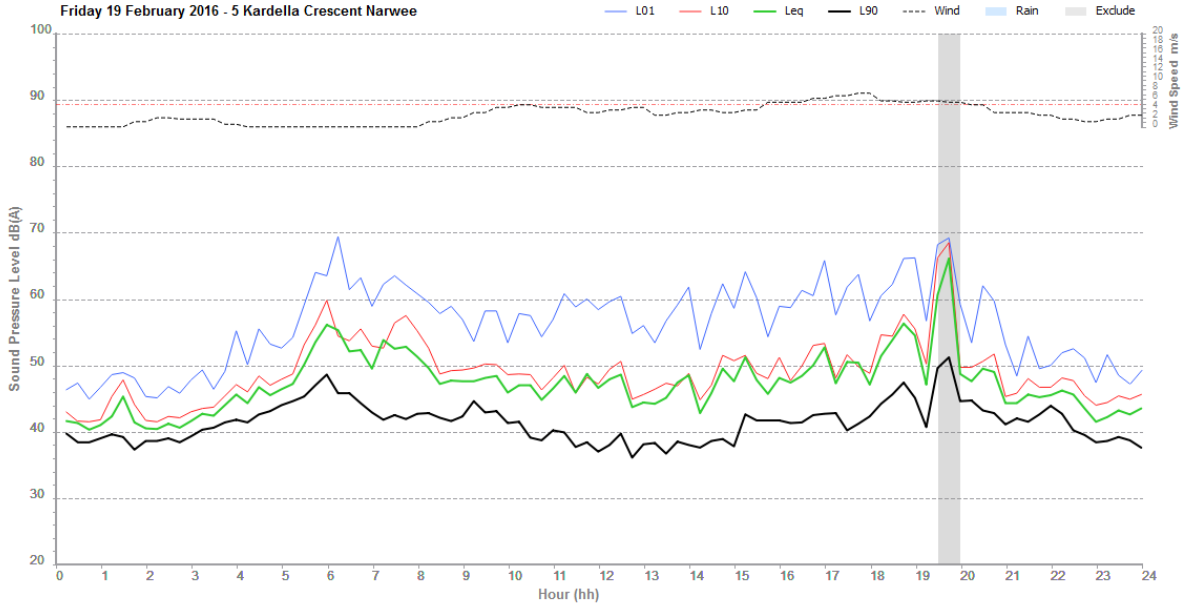
Figure 3 Logger location photo

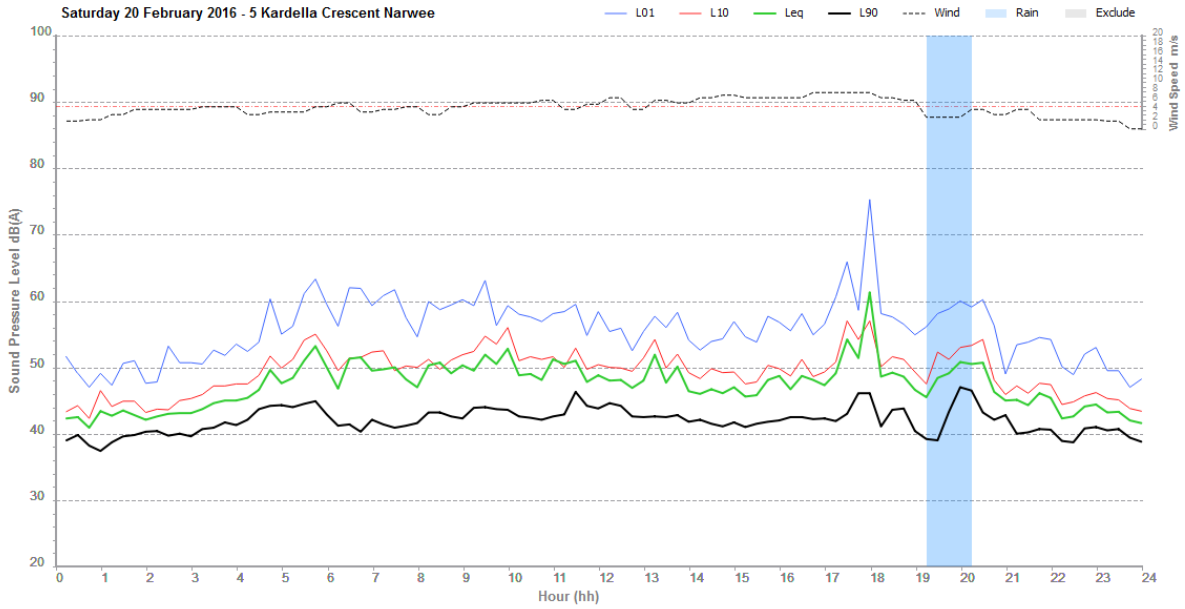
Logger graphs

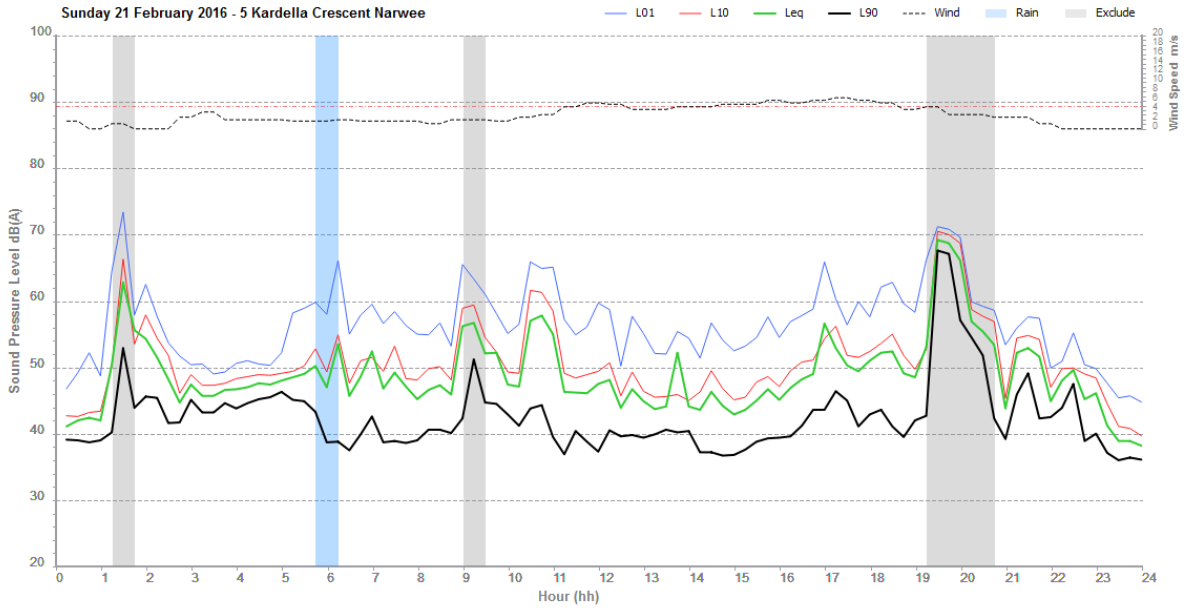


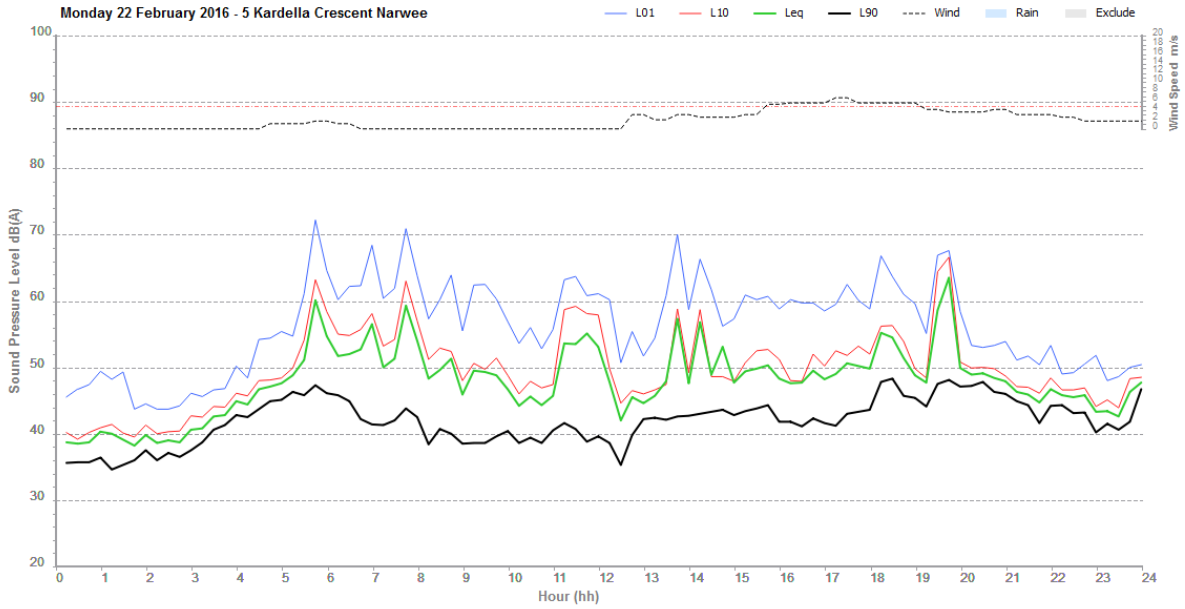


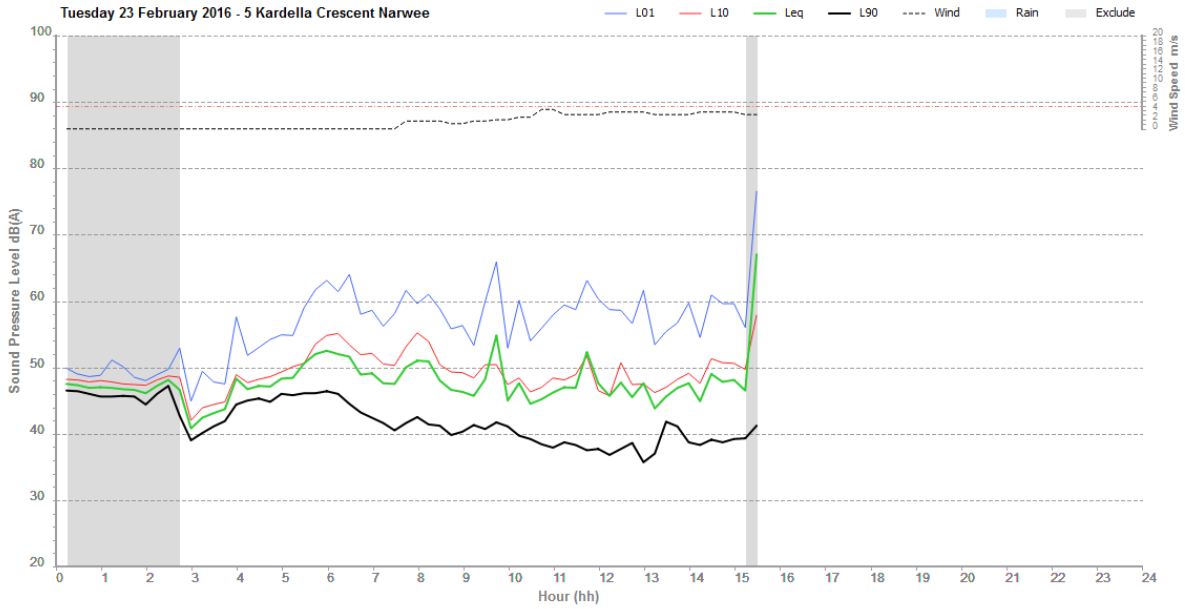

Thursday 18 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Friday 19 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Saturday 20 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Sunday 21 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Monday 22 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Tuesday 23 February 2016 - 5 Kardella Crescent Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)

NL2 – 4 Whitfield Avenue– 16/02/16 – 23/02/16

Logger Type: Rion NL21

Serial No: 865769

Address: 4 Whitfield Avenue, Narwee

Location: Front garden

Façade / Free Field: Free field

Environment: Traffic noise along perpendicular roads is dominant.

Table 28 Measured noise levels – NL2

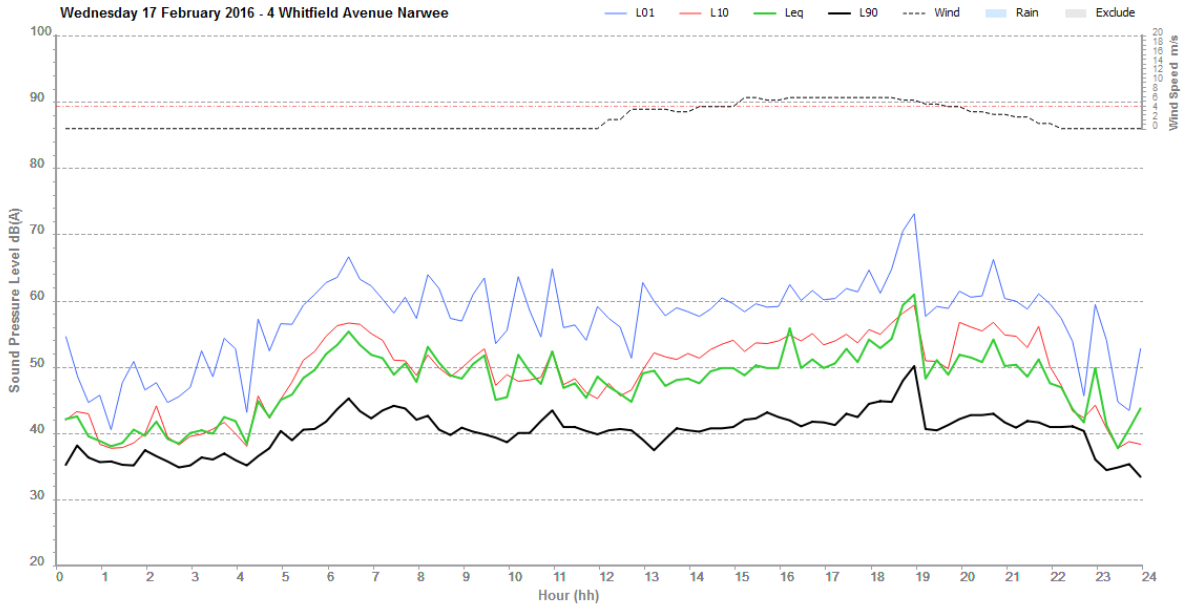
INP noise level, dB(A)		
Period	**Log average**	**Rating Background Level**
Day	52	37
Evening	52	42 (37)[1]
Night	48	37

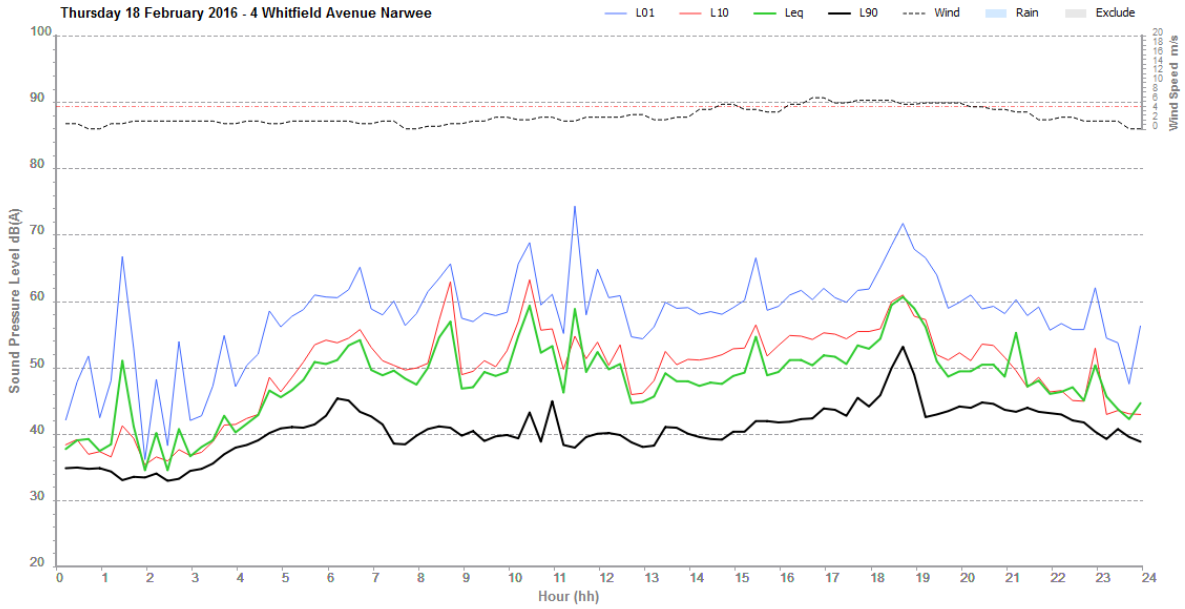
Note:

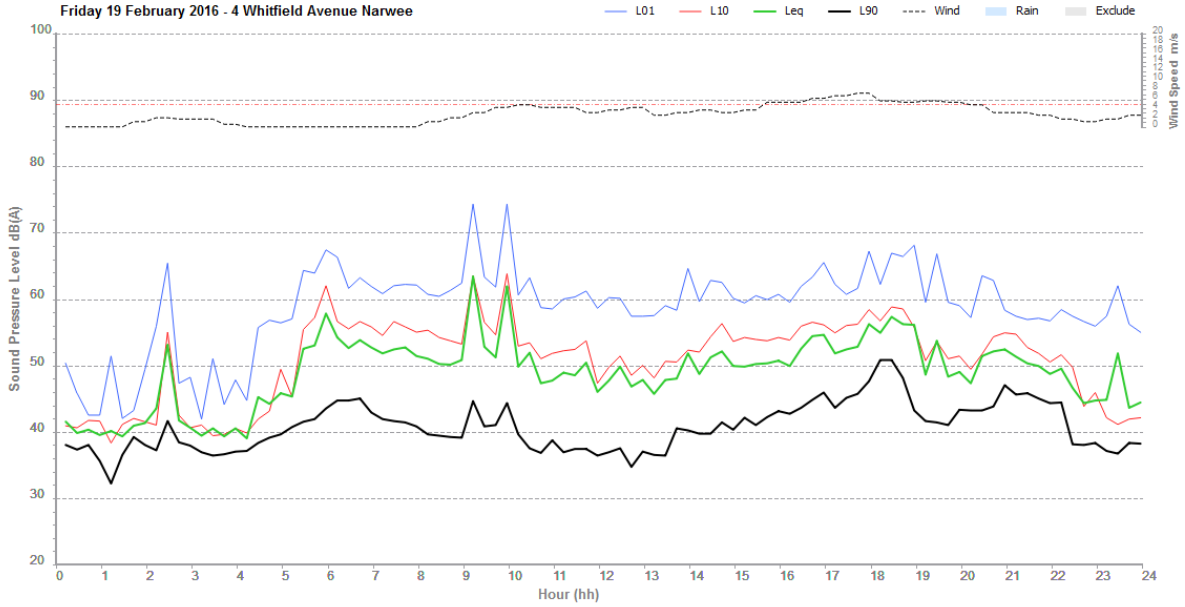
1. Level adjusted to the daytime RBL in accordance with the INP.

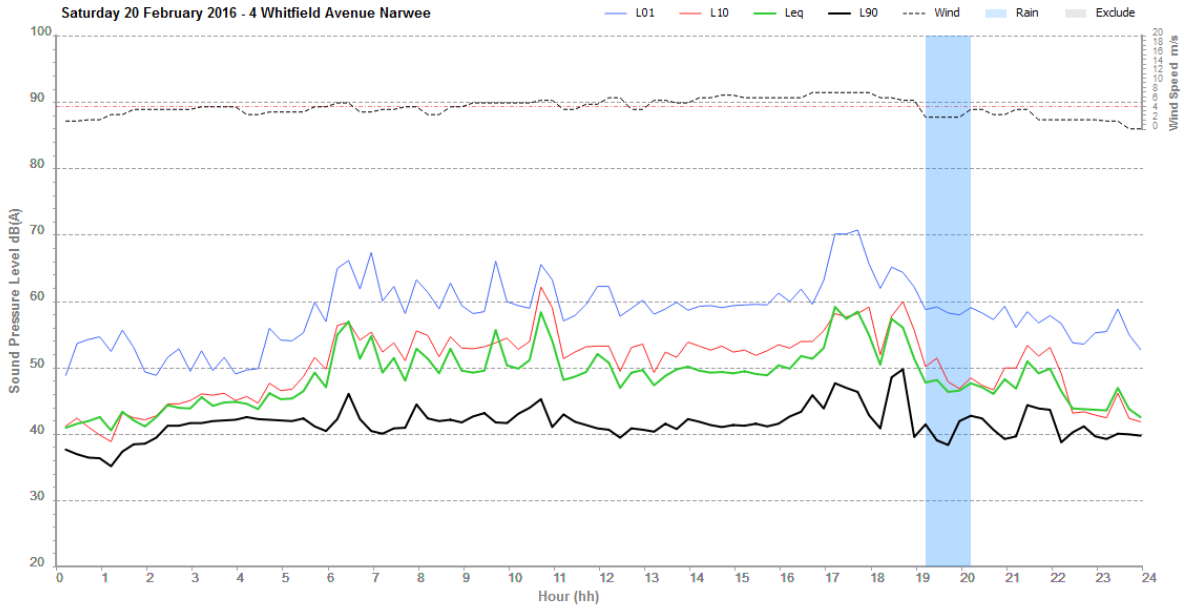
Figure 4 Logger location photo

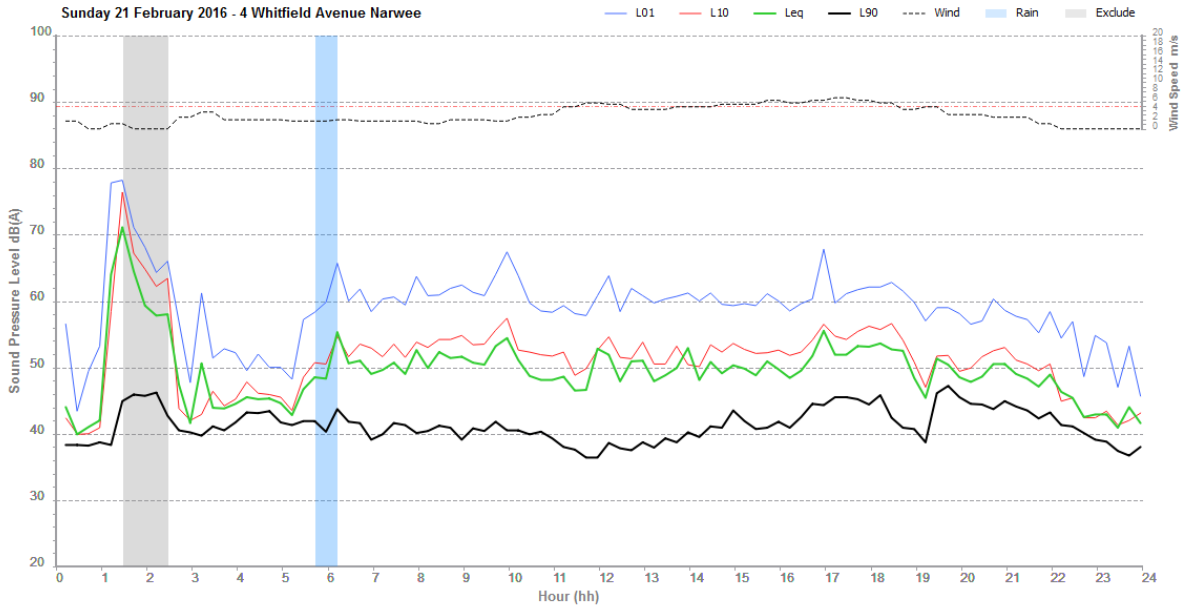
Logger graphs

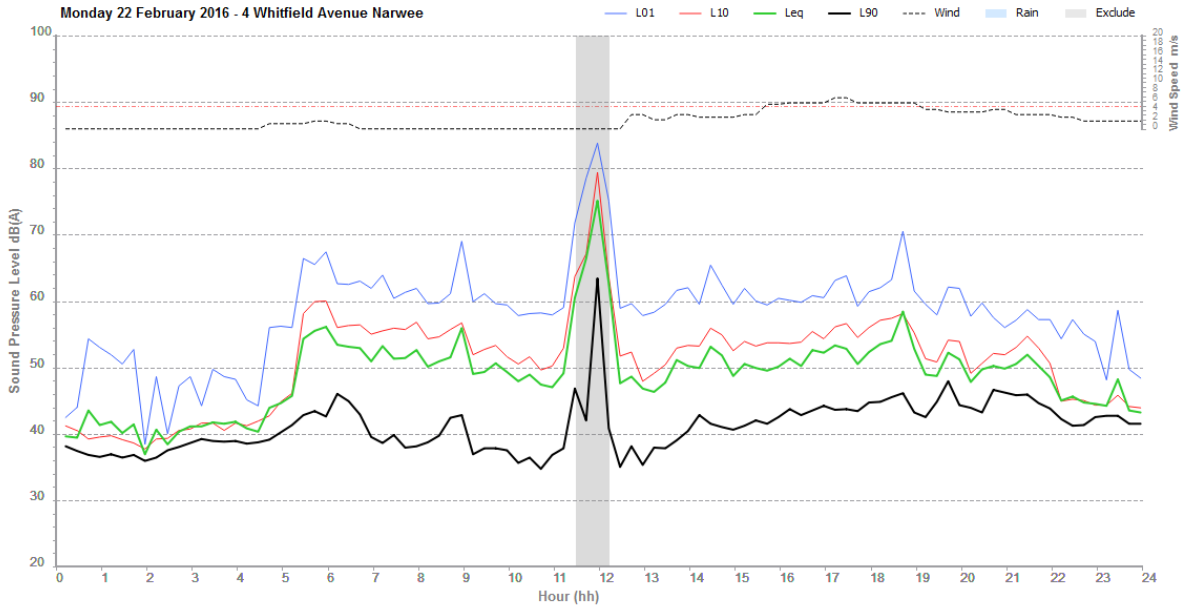


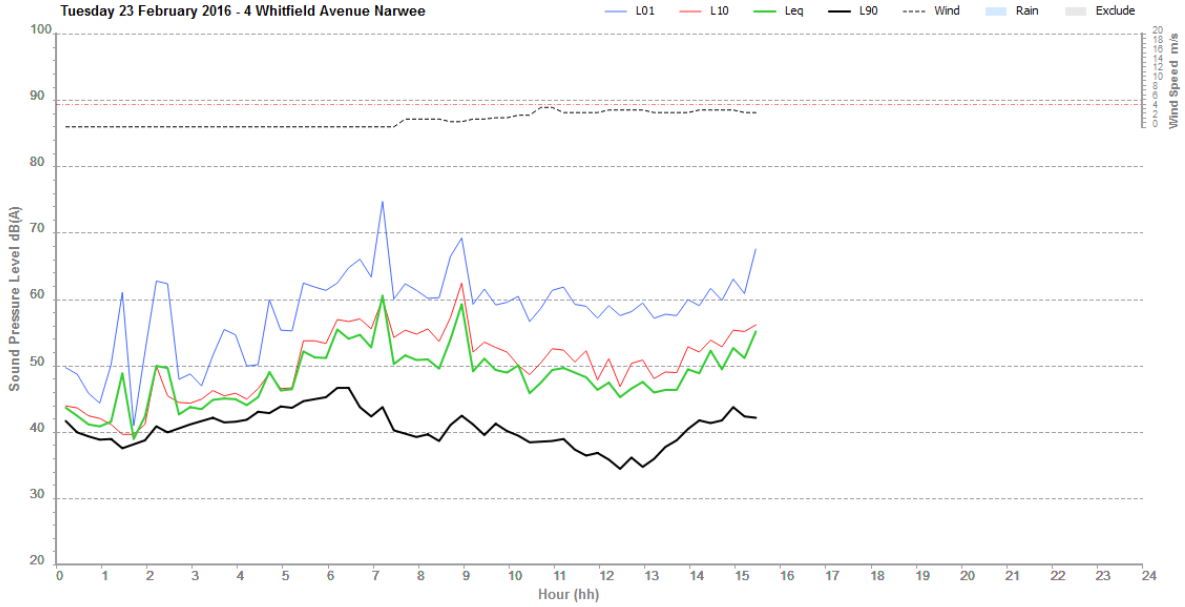

Thursday 18 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Friday 19 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Saturday 20 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Sunday 21 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Monday 22 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)


Tuesday 23 February 2016 - 4 Whitfield Avenue Narwee
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)

Appendix C

Predicted Noise Contours - Construction

Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Establishment of site compound - Sub-stage 1A

0 100 200 400 Meters

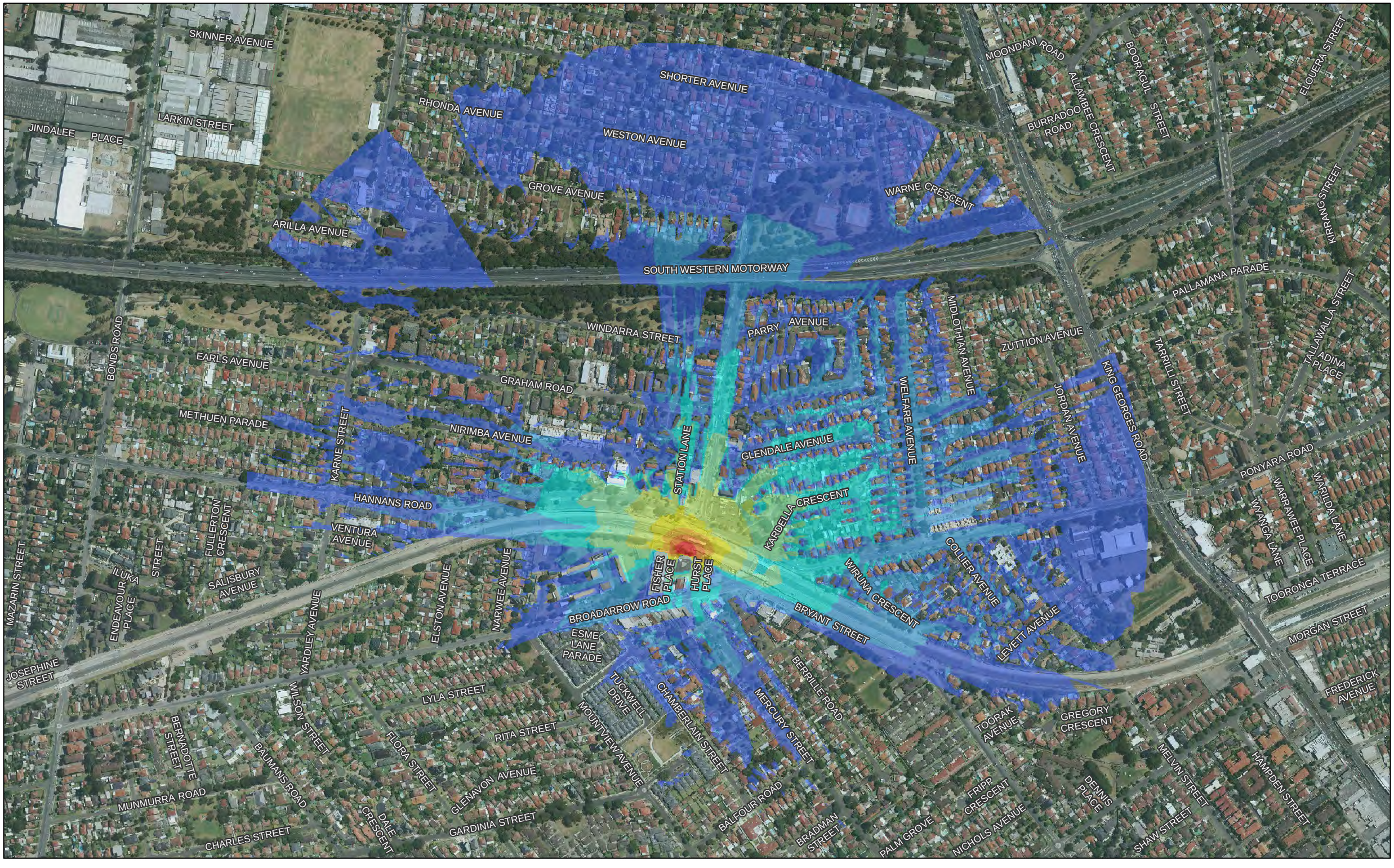
N

MAR 2016

60327214

Fig. **1**

AECOM



Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Removal of vegetation - Sub-stage 1B

MAR 2016

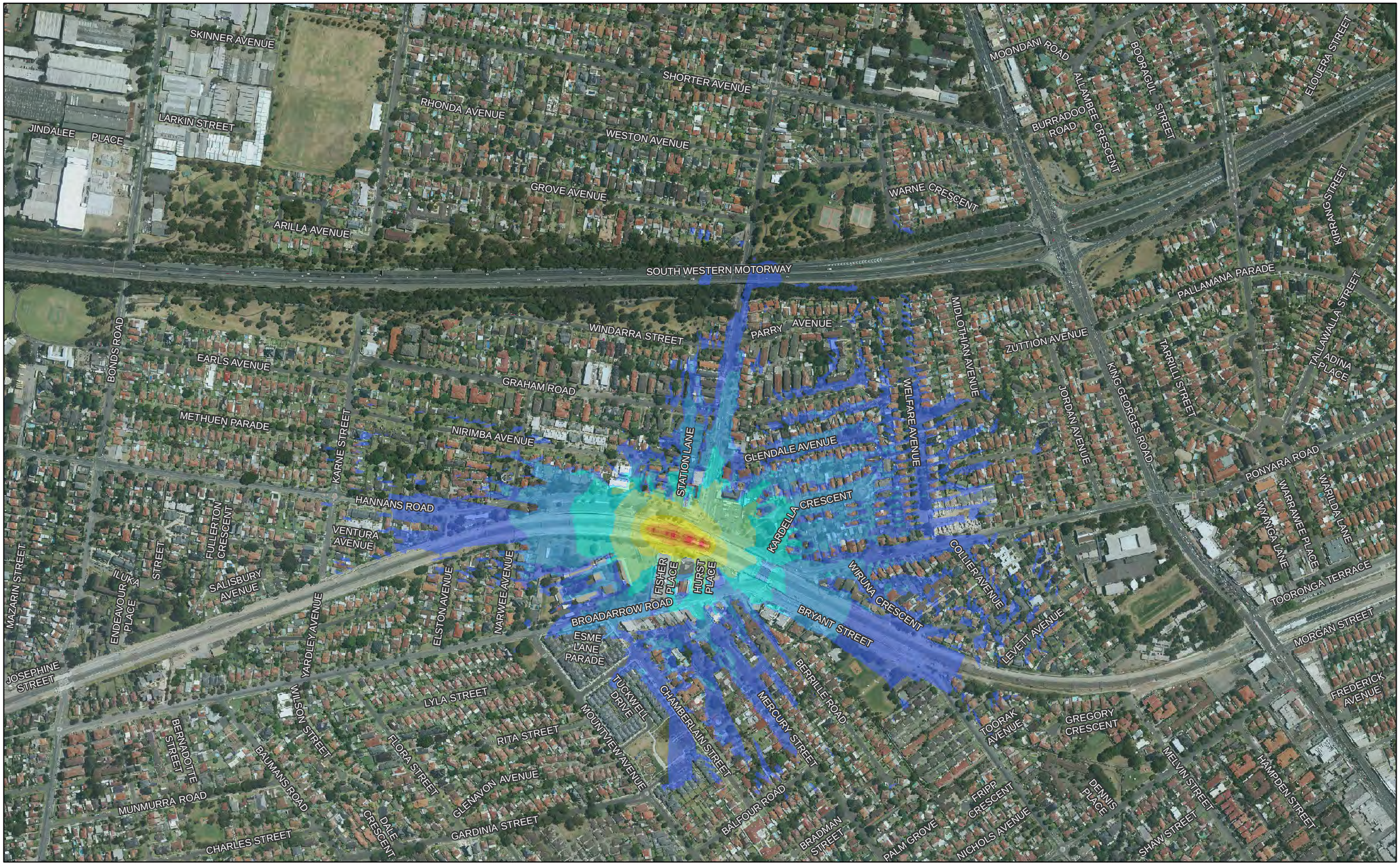
60327214

Fig **2**

N

0 100 200 400 Meters

AECOM



Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Demolition of existing structures - Sub-stage 2A

Meters

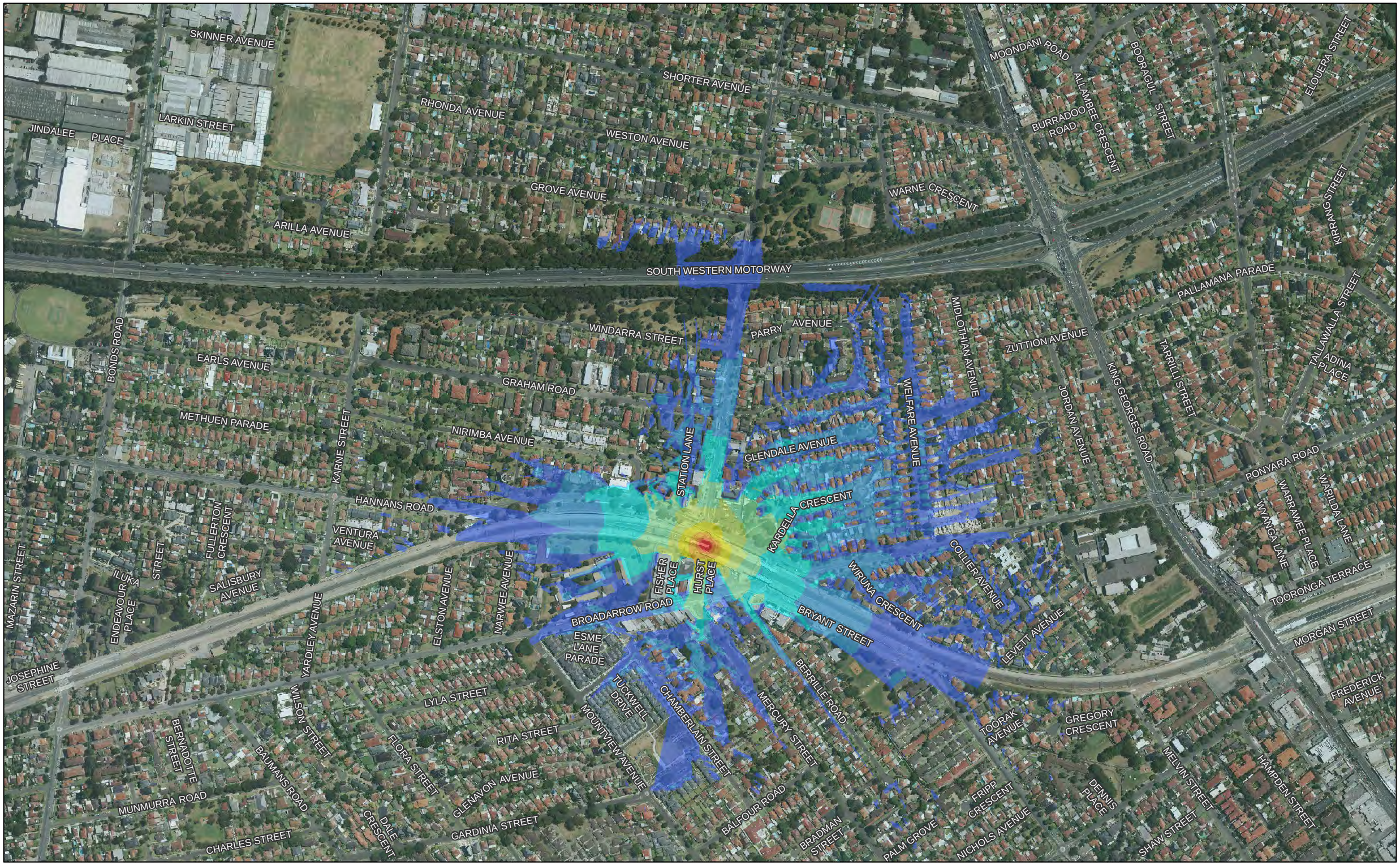
0 100 200 400

N

MAR 2016

60327214

Fig. **3**



Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Platform modifications - Sub-stage 2B

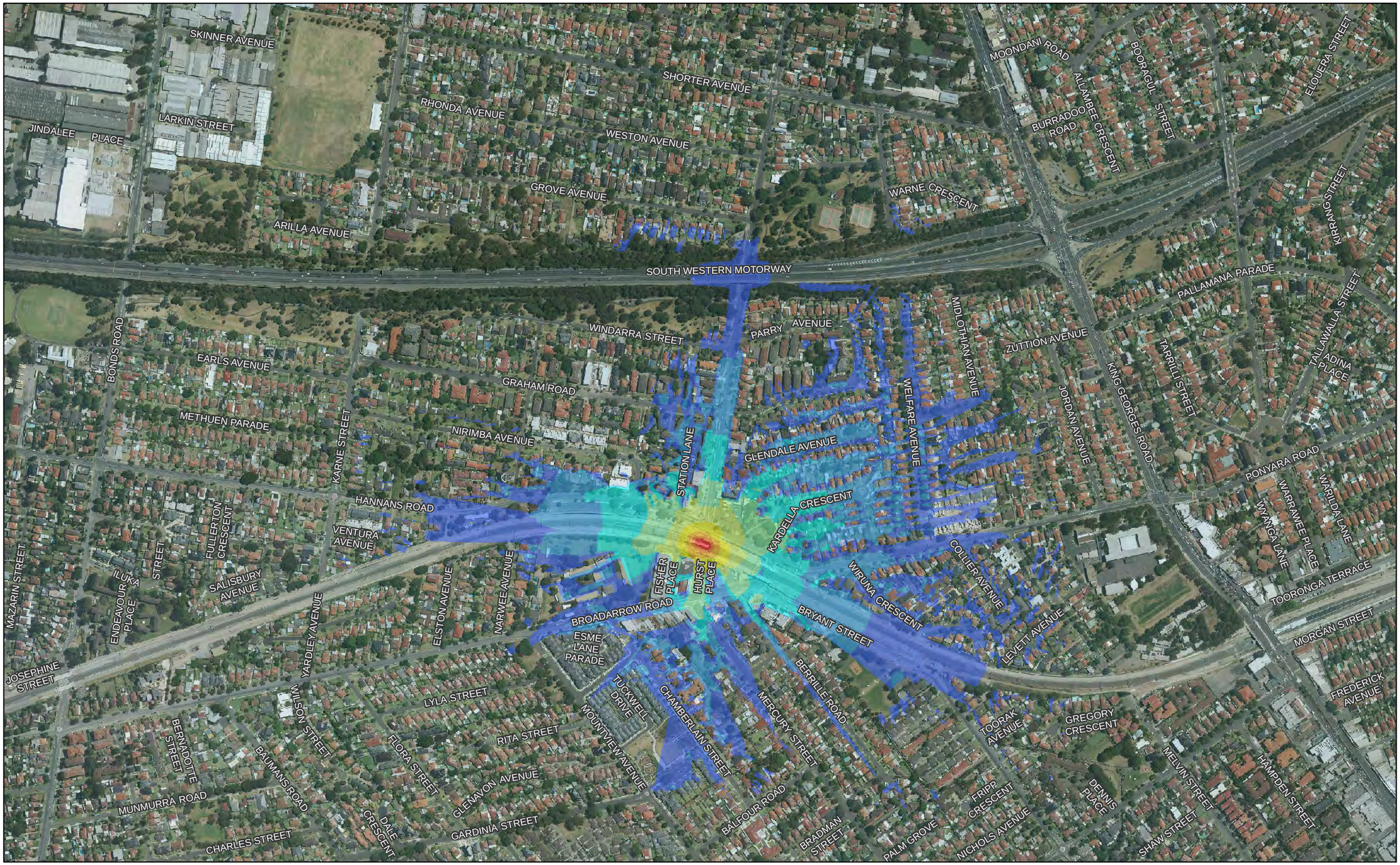
MAR 2016

60327214

Fig **4**

N

0 100 200 400 Meters



Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Construction of lift shaft - Sub-stage 2C

0 100 200 400 Meters

N

MAR 2016

60327214

Fig **5**

Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Platform resurfacing - Sub-stage 2D

MAR 2016

60327214

Fig. **6**

N

0 100 200 400 Meters

AECOM

SKINNER AVENUE
JINDALEE PLACE
LARKIN STREET
RHONDA AVENUE
SHORTER AVENUE
WESTON AVENUE
GROVE AVENUE
ARILLA AVENUE
MOONDANI ROAD
BURRADOO ROAD
ALLAMBEE CRESCENT
BOORAGUL STREET
ELOUERA STREET
WARNE CRESCENT
KIRRANG STREET
SOUTH WESTERN MOTORWAY
PALLAMANA PARADE
TALLAWALLA STREET
ADINA PLACE
BONDS ROAD
WINDARRA STREET
PARRY AVENUE
MIDLOTHIAN AVENUE
ZUTTION AVENUE
TARRILLI STREET
KING GEORGES ROAD
JORDAN AVENUE
EARLS AVENUE
GRAHAM ROAD
WELFARE AVENUE
METHUEN PARADE
KARNE STREET
NIRIMBA AVENUE
GLENDALE AVENUE
STATION LANE
PONYARA ROAD
WARRAWEE PLACE
WARILDA LANE
WIANGA LANE
HANNANS ROAD
KARDELLA CRESCENT
VENTURA AVENUE
FULLERTON CRESCENT
STREET
ILUKA PLACE
ENDEAVOUR PLACE
MAZARIN STREET
SALISBURY AVENUE
YARDLEY AVENUE
ELSTON AVENUE
NARWEE AVENUE
FISHER PLACE
HURST PLACE
COLLIER AVENUE
WIRUNA CRESCENT
TOORONGA TERRACE
BROADARROW ROAD
BRYANT STREET
LEVETT AVENUE
MORGAN STREET
ESME LANE
PARADE
JOSEPHINE STREET
TUCKWELL DRIVE
CHAMBERLAIN STREET
MERCURY STREET
BERRILLE ROAD
FREDERICK AVENUE
LYLA STREET
MOUNTVIEW AVENUE
TOORAK AVENUE
GREGORY CRESCENT
MELVIN STREET
HAMPDEN STREET
BERNADOTTE STREET
WILSON STREET
BAUMANS ROAD
FLORA STREET
RITA STREET
GLENAVON AVENUE
MUNMURRA ROAD
DALE CRESCENT
GARDINIA STREET
BALFOUR ROAD
FRIPP CRESCENT
DENNIS PLACE
PALM GROVE
BRADMAN STREET
NICHOLS AVENUE
SHAW STREET
CHARLES STREET

Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Reconfiguration of internal station buildings - Sub-stage 3A

MAR 2016

60327214

Fig. **7**

N

0 100 200 400 Meters

AECOM

Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Refresh of station building - Sub-stage 3B

MAR 2016

60327214

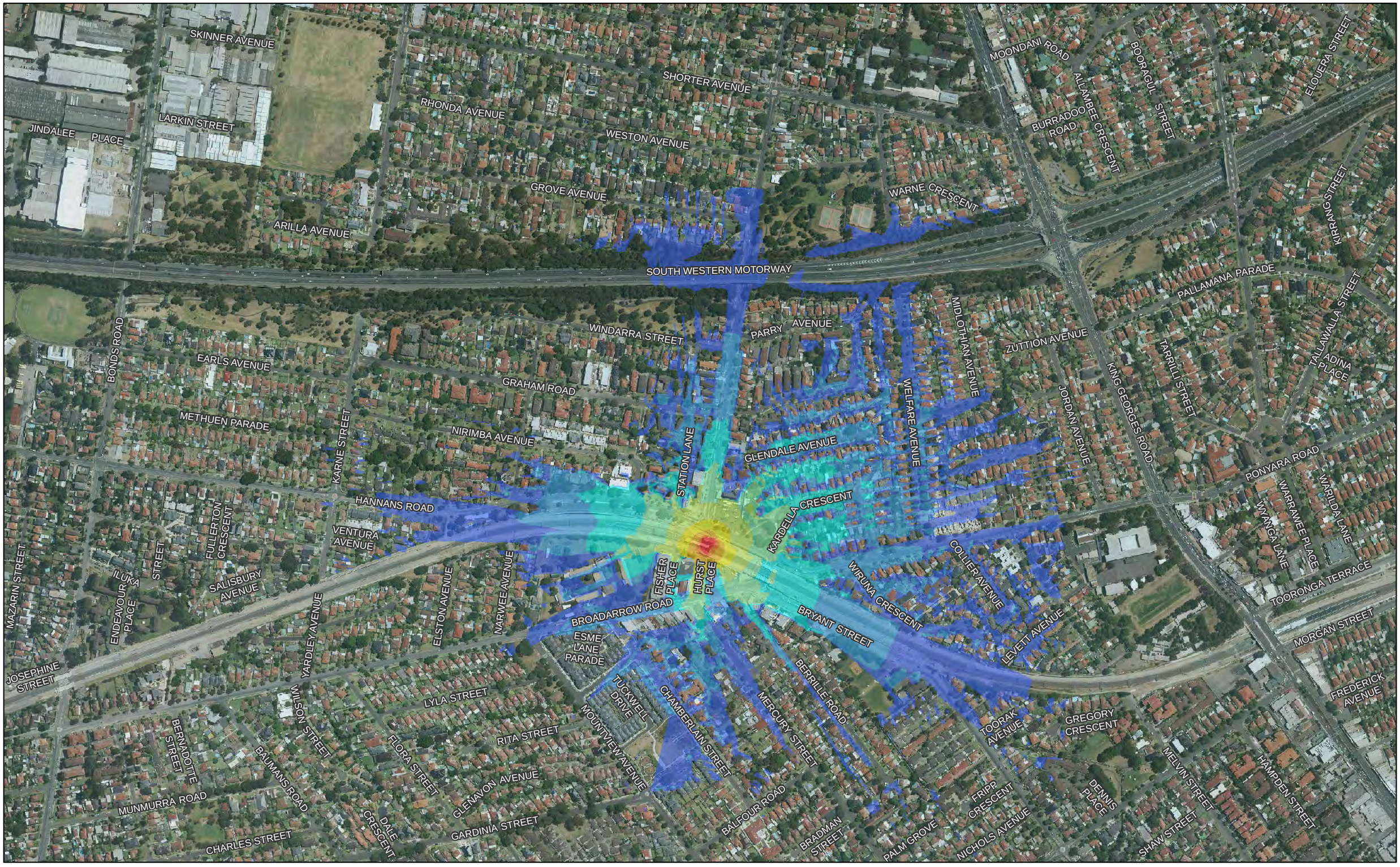
N

Meters

0 100 200 400

Fig **8**

AECOM



Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Underpass modifications - Sub-stage 4A

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Fig. **9**

N

0 100 200 400 Meters

AECOM

Sound Pressure Level, L_{Aeq} dBA

< 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | > 85

Narwee Station Upgrade

Taxi zone, kiss and ride, bus stops etc - Sub-stage 4B

0 100 200 400 Meters

N

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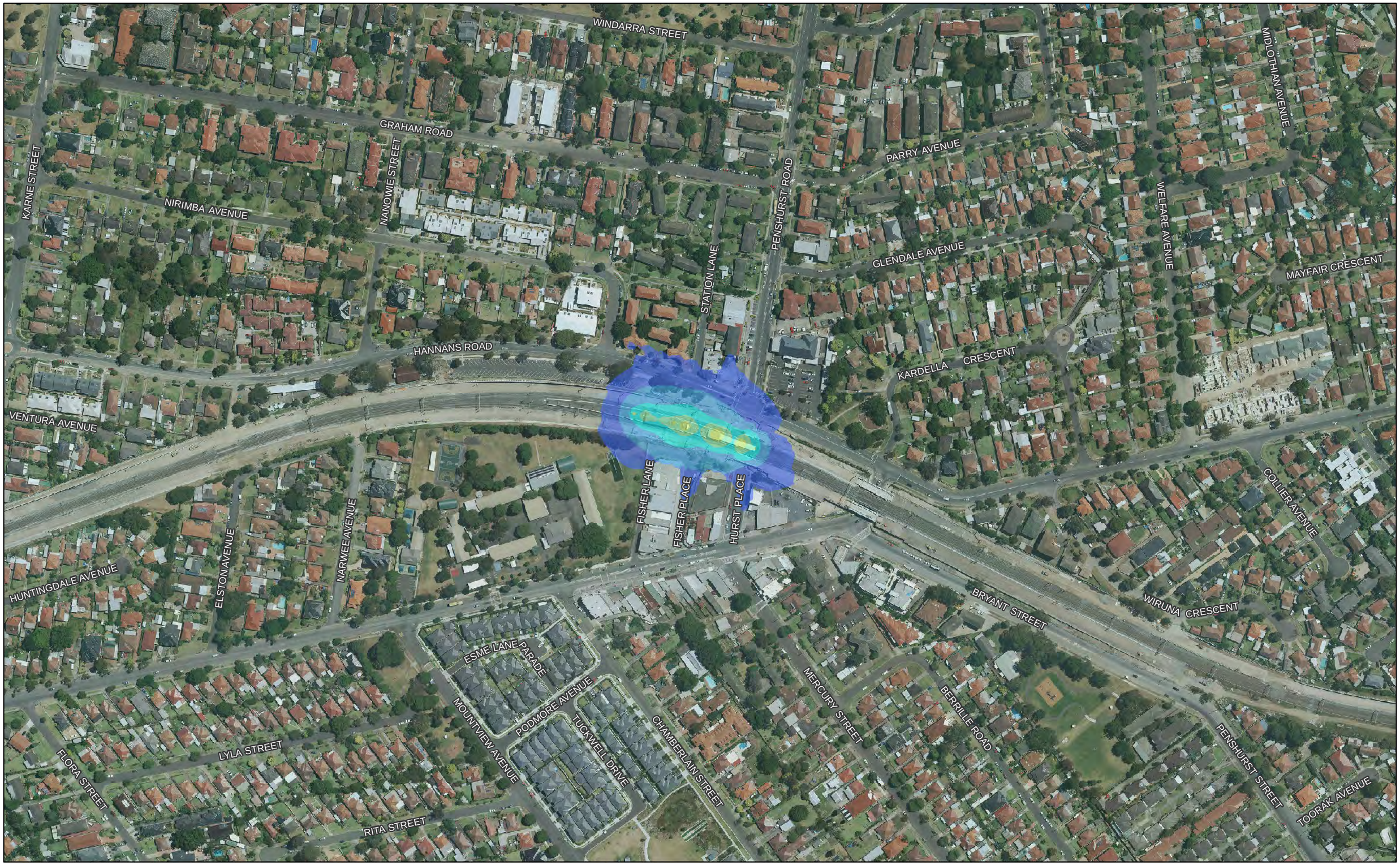
Fig **10**

Appendix D

Sleep Disturbance L_{A1} Noise Contours

AECOM



Sound Pressure Level, L_{A1} dBA

< 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | 85 - 90

Narwee Station Upgrade

Demolition of existing structures - Sub-stage 2A

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Fig. **1**

N

0 100 200 400 Meters

AECOM

WINDARRA STREET
GRAHAM ROAD
KARNE STREET
NANOWIE STREET
NIRIMBA AVENUE
PARRY AVENUE
MIDLOTHIAN AVENUE
PENSHURST ROAD
WELFARE AVENUE
STATION LANE
GLENDALE AVENUE
MAYFAIR CRESCENT
HANNANS ROAD
KARDELLA
CRESCENT
VENTURA AVENUE
FISHER LANE
FISHER PLACE
HURST PLACE
COLLIER AVENUE
HUNTINGDALE AVENUE
ELSTON AVENUE
NARWEE AVENUE
BRYANT STREET
WIRUNA CRESCENT
ESME LANE PARADE
PODMORE AVENUE
MOUNTVIEW AVENUE
TUCKWELL DRIVE
CHAMBERLAIN STREET
MERCURY STREET
BERRILLE ROAD
PENSHURST STREET
TOORAK AVENUE
LYLA STREET
FLORA STREET
RITA STREET

Sound Pressure Level, L_{A1} dBA

< 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95

Narwee Station Upgrade

Platform modifications - Sub-stage 2B

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Fig **2**

N

0 100 200 400 Meters

AECOM

WINDARRA STREET
GRAHAM ROAD
KARNE STREET
NIRIMBA AVENUE
NANOWIE STREET
PARRY AVENUE
PENSHURST ROAD
MIDLOTHIAN AVENUE
WELFARE AVENUE
GLENDALE AVENUE
MAYFAIR CRESCENT
STATION LANE
HANNANS ROAD
KARDELLA CRESCENT
VENTURA AVENUE
FISHER LANE
FISHER PLACE
HURST PLACE
COLLIER AVENUE
HUNTINGDALE AVENUE
ELSTON AVENUE
NARWEE AVENUE
BRYANT STREET
WIRUNA CRESCENT
ESME LANE PARADE
PODMORE AVENUE
MOUNTVIEW AVENUE
TUCKWELL DRIVE
CHAMBERLAIN STREET
MERCURY STREET
BERRILLE ROAD
PENSHURST STREET
TOORAK AVENUE
LYLA STREET
FLORA STREET
RITA STREET

Sound Pressure Level, L_{A1} dBA

< 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95

Narwee Station Upgrade

Construction of lift shaft - Sub-stage 2C

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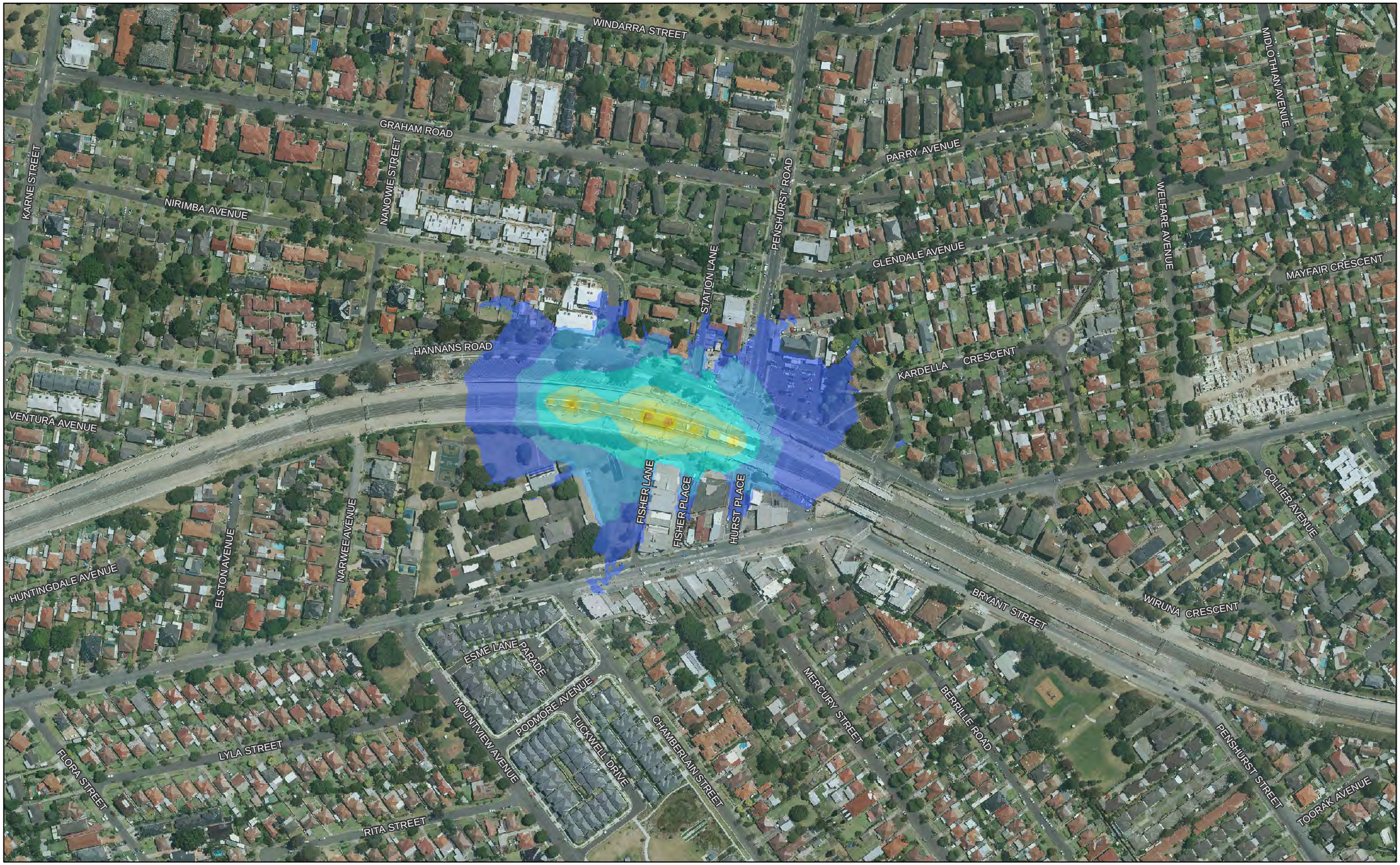
Fig **3**

N

0 100 200 400 Meters

AECOM



Sound Pressure Level, L_{A1} dBA

< 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95 | 95 - 100

Narwee Station Upgrade

Platform resurfacing - Sub-stage 2D

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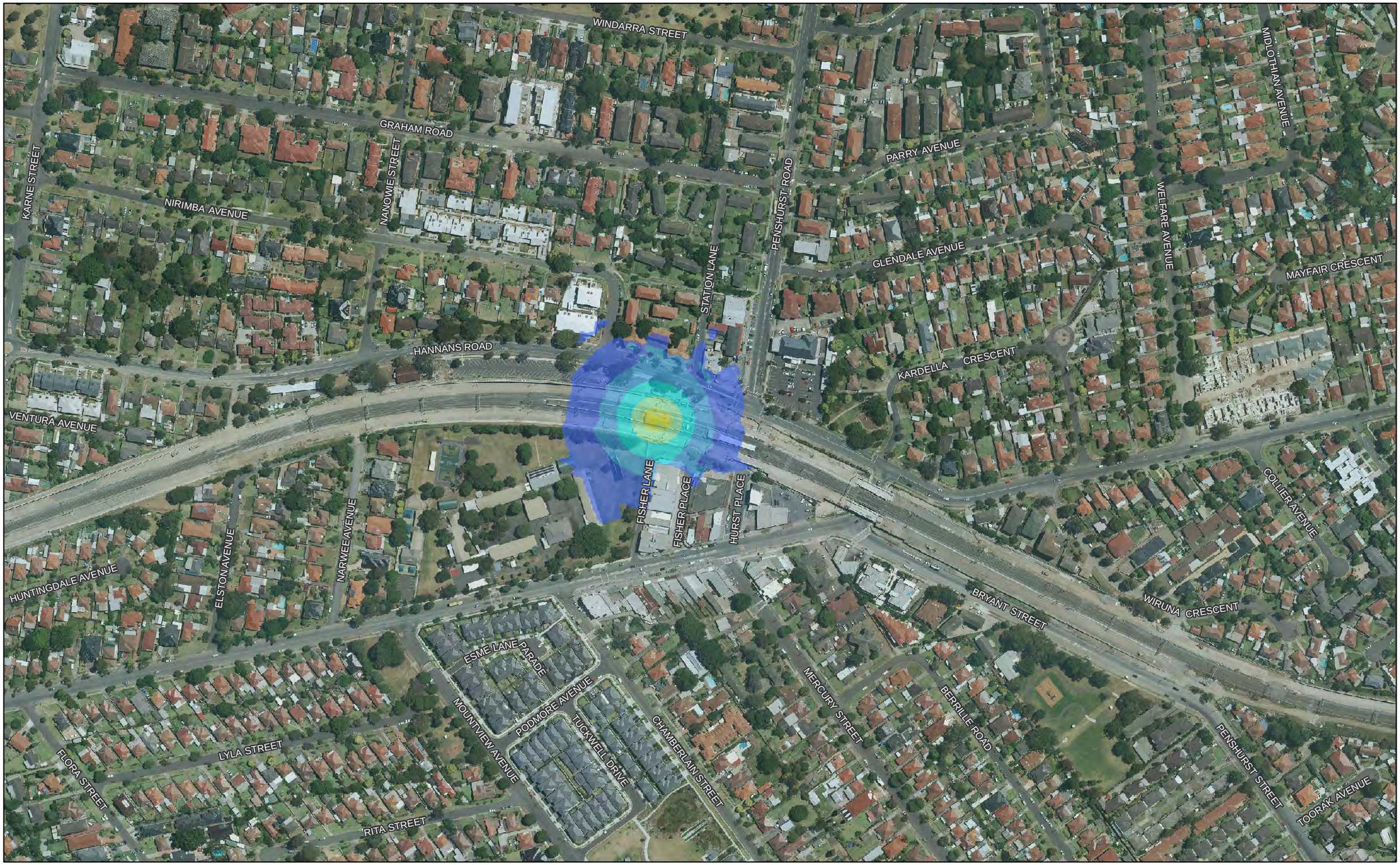
Fig **4**

N

0 100 200 400 Meters

AECOM



Sound Pressure Level, L_{A1} dBA

< 65 | 65 - 70 | 70 - 75 | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95 | 95 - 100

Narwee Station Upgrade

Refresh of station building - Sub-stage 3B

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Fig **5**

N

0 100 200 400 Meters