AECOM

Transport for New South Wales
28-Jan-2016
Doc No. 60327214-RPNV-05_D

Jannali Station Upgrade

Noise and Vibration Impact Assessment

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Client: Transport for New South Wales

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28-Jan-2016

Job No.: 60327214

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Quality Information

Document Jannali Station Upgrade

Ref 60327214

Date 28-Jan-2016

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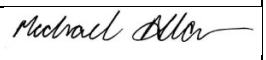
Reviewed by Gayle Greer

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	19-July-2015	Draft for Review	Michael Allan Principal Acoustic Engineer	MA
B	24-Jul-2015	First Review	Michael Allan Principal Acoustic Engineer	MA
C	25-Jan-2016	Revised results presentation	Michael Allan Principal Acoustic Engineer	MA
D	27-Jan-2016	Final report	Michael Allan Principal Acoustic Engineer	

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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 Jannali Station Upgrade.

The Jannali Station Upgrade works are expected to commence in 2016, take up to 18 months to complete and will be undertaken during both standard construction hours and weekend construction out-of-hours. Out of hours works would likely be required over five to six weekend possessions over the 18 month construction period and during some evening/night times to minimise traffic impacts.

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.

Definitions for acoustic terminology used within this report can be found within 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 Jannali Station
- establish the construction noise management levels and vibration limits that would apply to the Jannali Station upgrade works
- predict environmental noise and vibration levels at nearby residential and other sensitive receivers due to the upgrade works
- predict noise levels from additional off-site construction traffic generated by the Jannali Station works
- provide mitigation measures where necessary to reduce and manage noise and vibration impacts from the workstation upgrade works to comply with established construction noise management levels and vibration limits
- consider noise from the operation of the upgraded Jannali Station.

1.3 Proposed works

The key features of the proposed works for Jannali Station Upgrade are summarised as follows:

- new stairs, lift and upgraded entry plaza on each side of the station
- new pedestrian bridge to provide access to both platforms and across the railway
- new canopies for weather protection above the pedestrian bridge, stairs, lift landings and entry plazas
- new Family Accessible Toilet on Platform 1
- installation of undercover bicycle racks on both sides of the station
- upgraded footpaths/ramps on Jannali Avenue, Mitchell Avenue and Railway Crescent

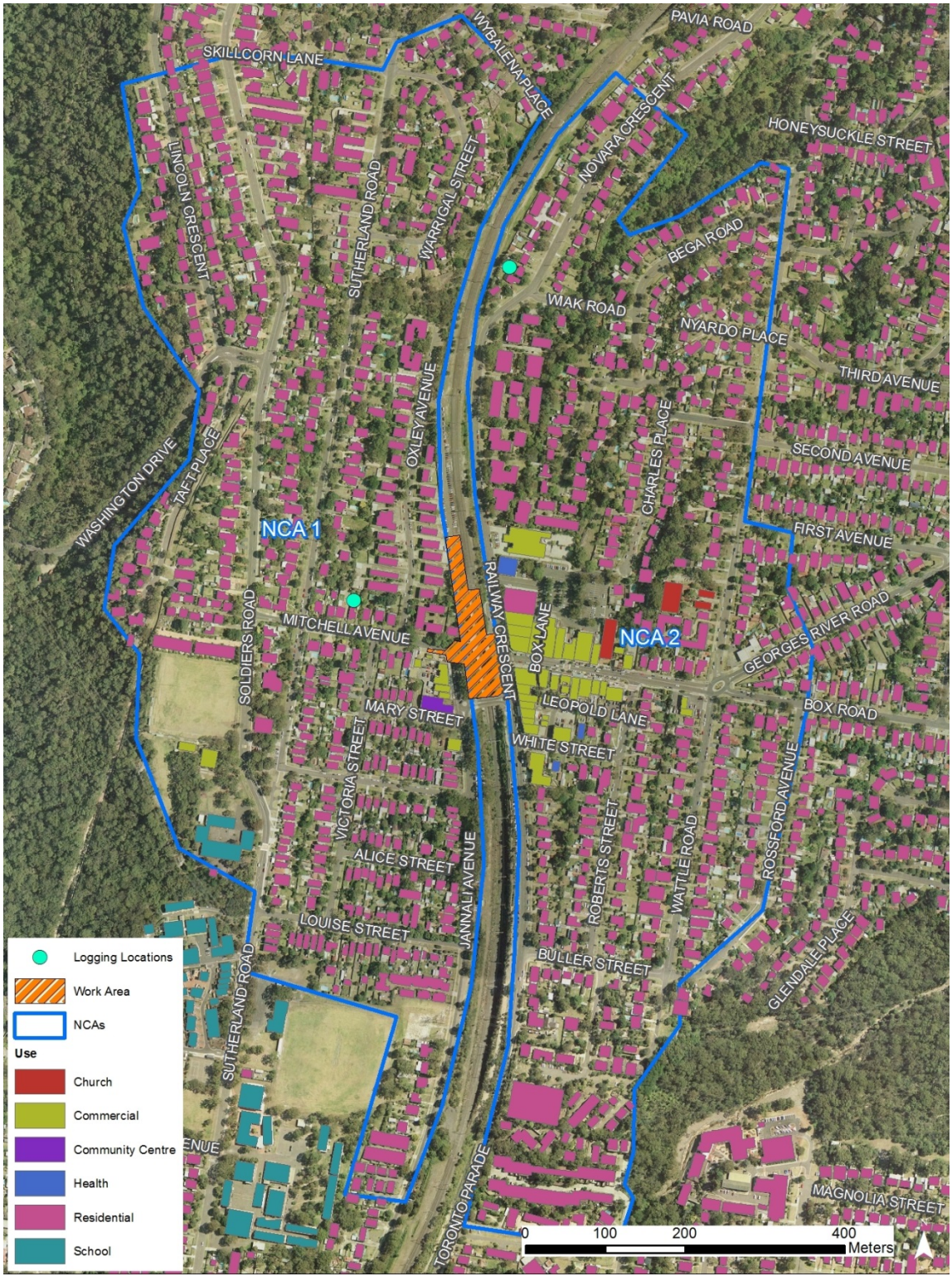
- bus zone works including construction of a shelter closer to the station entrance on Jannali Avenue and a new bus zone on Mitchell Avenue
- provision of five accessible parking spaces (three upgraded and two relocated), two kiss and ride spaces and vehicle turning area in the Oxley Avenue car park connected to the station by a widened footpath
- provision of up to three part-time kiss and ride spaces in Railway Crescent
- ancillary works, including localised platform regrading (as necessary), adjustments to lighting, improvements to station communication systems with new infrastructure (including CCTV cameras), wayfinding signage, services diversion and/or relocation, station power supply upgrade, and minor drainage works.

1.4 Site description

Figure 1 shows the location of Jannali Station and its surrounding environment. The station is located within a mixed use environment which comprises primarily residential with some commercial and retail uses. In addition a school, community centre, health centres and places of worship are located within the area.

Jannali Avenue and Mitchell Avenue to the west and Railway Crescent and Box Road to the east are considered to be sub-arterial roads as per categories within the Environment Protection Authority's (EPA) NSW Road Noise Policy (RNP).

Figure 1 Receivers and logger locations



In order to simplify the assessment methodology, 12 representative residential receivers have been selected to represent receivers on their block with likely similar background noise levels. Representative non-residential have also been selected, including all schools, community centres, health centres and places of worship plus two nearest commercial premises to the study area. Residences located closest to the worksite on their block were selected as the potentially worst affected receivers and are listed in Table 1.

Table 1 Representative receiver addresses

Receiver ID	Receiver address	Approx. distance to study area, m
	Residential	
R1	1 Mitchell Avenue, Jannali NSW 2226, Australia	10
R2	12 Oxley Avenue, Jannali NSW 2226, Australia	10
R3	48-54 Railway Crescent, Jannali NSW 2226, Australia	30
R4	28-32 Railway Crescent, Jannali NSW 2226, Australia	50
R5	12-14 Mitchell Avenue, Jannali NSW 2226, Australia	80
R6	8 White Street, Jannali NSW 2226, Australia	120
R7	33 Jannali Avenue, Jannali NSW 2226, Australia	140
R8	2 Roberts Street, Jannali NSW 2226, Australia	170
R9	93 Sutherland Road, Jannali NSW 2226, Australia	180
R10	1-9 Oxley Avenue, Jannali NSW 2226, Australia	210
R11	54 Wattle Road, Jannali NSW 2226, Australia	280
R12	169 Novara Crescent, Jannali NSW 2226, Australia	320
	Non-residential	
N1	Commercial premise, 74 Railway Crescent, Jannali NSW 2226, Australia	20
N2	Community centre, 15 Jannali Avenue, Jannali NSW 2226, Australia	20
N3	Health centre, 40-42 Railway Crescent, Jannali NSW 2226, Australia	30
N4	Health centre, 572 Box Road, Jannali NSW 2226, Australia,	40
N5	Health centre, 5 White Street, Jannali NSW 2226, Australia	100
N6	Health centre, 10 White Street, Jannali NSW 2226, Australia	110
N7	Place of worship, 527 Box Road, Jannali NSW 2226, Australia	120
N8	Health centre, 1 White Street, Jannali NSW 2226, Australia	140
N9	Place of worship, 83 Wattle Road, Jannali NSW 2226, Australia	210
N10	School, 121 Sutherland Road, Jannali NSW 2226, Australia	310

Representative receiver locations are shown in Figure 2.

Figure 2 Representative receiver locations

2.0 Existing acoustic environment

2.1 Noise sensitive receivers

Figure 2 shows the receivers which were assessed within this report. Residential and other sensitive receivers which could potentially be affected by the project works are scattered around the work area. Unattended and attended noise monitoring was completed to quantify and qualify the existing noise environment in the vicinity of the works. The noise logger locations are described in Table 3 and shown in Figure 1. Two noise catchment areas (NCA) were identified as representing the residential receivers. One logger was placed within each NCA at a representative location. A description of the receivers within each NCA is described in Table 2.

Table 2 Noise catchment area descriptions

NCA	Description
1	Residential receivers – Mixture of single storey and multi-storey residential houses Small cluster of commercial receivers to the west of the station Community centre located to the south west of the station. School located south-west of the station.
2	Residential receivers – Mixture of single storey and multi-storey residential houses Large group of commercial receivers to the east of the station Churches located to the east and north east of the station. Medical centres and other health facilities are located east and south-east of the station.

2.2 Instrumentation

The noise loggers used for long term monitoring are shown in Table 3. The noise loggers were calibrated prior and after the monitoring session 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 2 years).

Table 3 Noise monitoring details

NCA	Location	Model	Serial number
1	17 Mitchell Avenue, Jannali	Cirrus 171	G061710
2	169 Novara Crescent, Jannali	ARL 315	15-299-444

2.3 Unattended noise measurements

Noise monitoring was conducted to determine existing background noise levels at sensitive receivers. Noise loggers were placed at the locations indicated in Table 3. The noise loggers monitored noise levels continuously from 9 to 17 July 2015.

The loggers measured the noise levels over the sample period and then determined L_{A10}, L_{A90}, L_{A1}, 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 EPA's NSW Industrial Noise Policy (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.

In accordance with the INP, any noise monitoring conducted during periods of extraneous weather conditions should be excluded from the data set. The INP advises that data may be affected where adverse weather, such as wind speeds higher than 5 m/s or rain, occurs. During the measurement period for this assessment, periods of adverse weather occurred during three daytime periods. Weather data was acquired from the Bureau of Meteorology's (BOM) Holsworthy weather station.

Graphical noise logging results are presented in Appendix B and periods where data has been omitted are indicated.

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

Measurement date	L_{A90} Background noise levels, dB(A)			L_{Aeq} Ambient noise levels, dB(A)		
	Day	Evening	Night	Day	Evening	Night
17 Mitchell Avenue – NCA 1						
Thursday 09 July 2015	-	39	32	-	46	44
Friday 10 July 2015	40	36	29	53	45	40
Saturday 11 July 2015	40	-[2]	-[2]	53	-[2]	-[2]
Sunday 12 July 2015	40	37	-[2]	52	46	-[2]
Monday 13 July 2015	-[2]	-[2]	29	-[2]	-[2]	45
Tuesday 14 July 2015	-[2]	34	29	-[2]	45	44
Wednesday 15 July 2015	35	37	29	51	47	43
Thursday 16 July 2015	40	37	-[2]	52	46	-[2]
Friday 17 July 2015	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Rating background level	**40**	**37**	**30**	**-**	**-**	**-**
Log Average L_{Aeq}	**-**	**-**	**-**	**52**	**46**	**44**
169 Novara Crescent – NCA 2						
Thursday 09 July 2015	-	37	29	-	61	59
Friday 10 July 2015	39	34	28	60	57	56
Saturday 11 July 2015	40	-[2]	-[2]	59	-[2]	-[2]
Sunday 12 July 2015	38	34	-[2]	58	55	-[2]
Monday 13 July 2015	-[2]	-[2]	29	-[2]	-[2]	60
Tuesday 14 July 2015	-[2]	32	27	-[2]	62	63
Wednesday 15 July 2015	36	35	28	57	57	60
Thursday 16 July 2015	-[2]	36	-[2]	-[2]	57	-[2]
Friday 17 July 2015	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Rating background level	**39**	**35**	**30**	**-**	**-**	**-**
Log Average L_{Aeq}	**-**	**-**	**-**	**59**	**59**	**60**

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

2.4 Existing noise environment summary

The acoustic environment of NCA 1 is characterised by local traffic, trains passing on the southern line and natural sounds such as birds. The acoustic environment of NCA 2 is characterised by local traffic flows with some commercial premises. Both NCAs exhibit low evening and lower night-time ambient noise levels. These characteristics are typical of a suburban environment.

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 guidance for the assessment and management of construction noise in NSW. This document replaces the previous publication the Environmental Noise Control Manual and is used as the basis for establishing construction noise management levels.

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 for the residential and other sensitive land uses are detailed in Table 5, Table 6 and Table 7.

Table 5 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 6 presents the NMLs applicable to residential receivers nearby to this development.

Table 6 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	40	50	45
	Evening	37	N/A	42
	Night	30	N/A	35
2	Day	39	49	44
	Evening	35	N/A	40
	Night	30	N/A	35

Table 7 presents the NMLs applicable to other noise sensitive receivers such as educational facilities and places of worship and to commercial receivers

Table 7 Construction noise management levels – Other sensitive 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]
Community centre	55 dB(A)[1]
Commercial premises (including offices, retail outlets)	70 dB(A)

Notes:

1. These management levels are based upon a 45 dB(A) internal noise management level and a 10 dB reduction 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 8.

Table 8 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	30	45	60 – 65
2	30	45	60 – 65

3.2 Construction traffic noise criteria

Noise from construction traffic on public roads is not covered by the *Interim Construction Noise Guideline*. However the *Interim Construction Noise Guideline* does refer to the ECRTN, now superseded by the NSW *Road Noise Policy*, for the assessment of noise arising from construction traffic on public roads.

In assessing feasible and reasonable mitigation measures under the *NSW Road Noise Policy*, an increase of up to 2 dB(A) represents a minor impact that is considered barely perceptible to the average person.

Therefore, the noise goal applied to traffic movements on public roads generated during the construction phase of the project is an increase in existing road traffic noise levels of no more than 2 dB(A).

The RNP does not require assessment of noise impact to commercial or industrial receivers.

Jannali Avenue/Mitchell Avenue and Railway Crescent will provide the main access roads to the site. These roads would be classified as sub-arterial. The external noise criteria are applied 1 m from the external facade of the affected building.

3.3 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in Table 9.

Table 9 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 for example, a tunnel boring machine.
- 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.

DIN 4150 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 10. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

Table 10 DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	Vibration velocity in mm/s			
		At foundation	at a frequency of		Vibration at the horizontal plane of the highest floor
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
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)	3	3 to 8	8 to 10	8

3.3.2 Human comfort

The assessment of intermittent vibration outlined in the NSW EPA guideline Assessing Vibration: A Technical Guideline 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 11. 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 11 Preferred and maximum vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Daytime (7 am – 10 pm)		Night-time (10 pm – 7 am)	
	Preferred	Max	Preferred	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* 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 *Industrial Noise Policy* 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 *Industrial Noise Policy* 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 *Industrial Noise Policy* 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 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the *Industrial Noise Policy*.

The RBLs and the respective intrusive criteria for the day, evening and night periods are provided in Table 12.

Table 12 Intrusive criteria

Location	Period	RBL (L_{A90}), dB(A)	Intrusive Criteria (RBL+5), dB(A)
Residential receivers – NCA 1	Day	40	45
	Evening	37	42
	Night	30	35
Residential receivers – NCA 2	Day	39	44
	Evening	35	40
	Night	30	35

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 *Industrial Noise Policy*. 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 13.

Table 13 Amenity criteria

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq}	Noise Level, dB(A)	Ambient Noise Level, dB(A)	Amenity Criteria, dB(A)
			Acceptable	Maximum		
Residential receivers – NCA 1 & 2	Suburban	Day	55	60	54	55
		Evening	45	50	52	45
		Night	40	45	47	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 14 below.

Table 14 Summary of environmental noise emission criteria

Location	Time of Day	Criteria L_{Aeq}, dB(A)		
		Intrusive	Amenity	Project Specific Noise Levels[1]
NCA 1	Day	45	55	45
	Evening	42	45	42
	Night	35	40	35
NCA 2	Day	44	55	44
	Evening	40	45	40
	Night	35	40	35
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 remain closed

The above criteria apply to environmental noise emission from plant installed as part of the upgrade.

5.0 Construction noise assessment

5.1 Construction stages and scheduling

In consultation with TfNSW, six distinct work packages of construction have been assumed to occur for the upgrade works. These would be confirmed by TfNSW and 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 15. The works with potentially high impact works in terms of noise levels and timing are highlighted in blue. These works are included in the construction noise assessment below.

Table 15 Construction stages and scheduling

Work package	Description	Timing
1- Site establishment and enabling works	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas etc.)	Standard or day time possession
	Removal of vegetation on western and eastern sides to allow for new lift and entry plaza	Standard
	Services relocation	Mostly in standard, with cutover works (not noisy) during possessions
2 - Bridge, lift and stairs construction	Demolition of existing structures as required	Standard or day time possession
	Construction of footings for bridge columns and lift shaft Construction of retaining wall and stormwater drainage works Construction of bridge columns/lift shafts	Standard or day time possession
	Lifting of bridge span into position	Possession day and night
	Construction of stairs, canopies and anti-throw screens	Possession day and night
	Installation of lifts Installation of fixtures, lighting and CCTV cameras for affected areas	Standard or day time possession
3 - Platform/ building works	Platform resurfacing and raising/regrading	Day time possession
	Platform resurfacing and raising/regrading	Standard
4 - Interchange works	Upgrade of existing footpath from station to car park. Conversion of parking spaces to accessible parking spaces and kiss and ride	Standard
	Construction of new bus stop on Mitchell Avenue and associated footpath, kerb alignment works.	Standard or day time possession (potential for evening works)
	Construction of new pedestrian crossing at junction of Mitchell Avenue and Jannali Avenue	Overnight
5 - Finalisation	Installation of new bicycle racks on both sides of the station. Installation of wayfinding signage Electrical and power supply upgrade works Replanting/landscaping and fencing adjustments and bollards	Standard And/or day time possession (potential for evening works) for last three items.

Work package	Description	Timing
6 - Testing and commissioning	No significant noise intensive works	-

Notes:

1. High noise impact work stages which have been assessed are highlighted in blue.

Testing and commissioning is not considered to be significantly noise intensive and as such has not been considered further in this assessment.

Out of hours works would likely be required over five to six weekend possessions over the 18 month construction period and during some evening/night times 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, and would be separated by one or more weeks. This would provide some respite periods during weekdays between works.

5.2 Construction sources

Noise sources and their respective L_{Aeq} sound power levels for each work package of works are shown in Table 16. 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. These levels generally correlate with maximum noise levels (L_{Amax}) levels presented in the TfNSW's CNS, as construction equipment L_{Amax} levels are generally considered to be 8 dB higher than L_{Aeq} levels as a rule of thumb, and differences between TfNSW's CNS L_{Amax} levels and indicative L_{Aeq} levels varying from approximately 5 to 10 dB.

Table 16 Indicative construction activities, noise sources and

Work package	Sub-stage	Activities	Construction period assessed	Equipment	Sound power level per unit, dB(A)
1- Site establishment and enabling works	1A	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas etc.)	Standard or daytime possession	Trucks	98
				Generator	93
				Bobcat	104
				Hand tools	94
	1B	Removal of vegetation on western and eastern sides to allow for new lift and entry plaza	Standard hours	Mulcher	113
				Chainsaw	110
				Bobcat	104
				Trucks	98
				Hand tools	94

Work package	Sub-stage	Activities	Construction period assessed	Equipment	Sound power level per unit, dB(A)
2 - Bridge, lift and stairs construction	2A	Demolition of existing structures as required	Standard or daytime possession	Demolition saw	110
				Generator	93
				Jackhammer	108
				Excavator (with auger)	103
				Grinder	108
				Bobcat	104
				Trucks – (tipper and semi-trailers)	108
				Hand tools	94
	2B	Lifting of bridge span into position	Day, evening or night time possession	200 tonne crane	106
				Concrete pump	106
				Concrete truck	106
				Trucks	98
				Scissor lift	100
				Manitou	92
				Franna crane	93
				Balloon wheel dump truck	98
				Hi rail	90
				Hand tools	94
				Lighting towers	95
3 - Platform/building works	3A	Platform resurfacing and raising/regrading	Daytime possession	Trucks	98
				Bob cat	104
				Jackhammer	108
				Excavator	98
				Grinder	108
				Generator	93
				Balloon wheel dump truck	98
				Hi rail	90
				Wacker packer	104
				Vibratory roller	104

Work package	Sub-stage	Activities	Construction period assessed	Equipment	Sound power level per unit, dB(A)
				Hand tools	94
4 - Interchange works	4A	Construction of new bus stop on Mitchell Avenue and associated footpath, kerb alignment works	Daytime and evening possession	Trucks	98
				Excavator	98
				Concrete pump	106
				Vibratory roller	104
				Helicopter (for smoothing concrete)	100
				Hand tools	94
				Lighting towers	95
				Concrete truck	106
	4B	Construction of new pedestrian crossing at junction of Mitchell Avenue and Jannali Avenue	Daytime, evening or night time possession	Paving machine	104
				Jackhammer	108
				Excavator	98
				Vibratory roller	104
				Wacker packer	104
				Trucks	98
				Hand tools	94
				Lighting towers	95
5 - Finalisation	5A	Installation of new bicycle racks on both sides of the station. Installation of wayfinding signage Electrical and power supply upgrade works Replanting/landscaping and fencing adjustments and bollards	Daytime and evening possession	Trucks	98
				Coring machine	108
				Hand tools	94

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 upgrade works have 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 2)
- construction noise sources (listed in Table 16).

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 will also vary as the construction equipment moves around the site.

5.4 Construction noise assessment

A summary of the construction noise results is shown in Table 17, Table 18, Table 19 and Table 20 for the day, evening and night-time period, respectively. Results are presented graphically in Appendix C.

It has been assumed that sensitive receivers such as commercial, community centres, schools and health centres will not be operating during the evening or night-time periods, therefore no NMLs apply to these premises during these periods. It is noted that both places of worship assessed do operate during the evening and have been assessed to the evening period, but not the night-time period.

Numbers of residences exceeding NMLs and those predicted to exceed the highly noise affected level of 75 dB(A) are presented. The highly affected noise level only applies to residential receivers. Residential receivers have been assessed against the standard hours, out of hours daytime and evening and out of hours night-time criteria. Also presented are numbers of non-residential receivers exceeding NMLs for each construction stage. The level of impact may changes depending on the final construction methodology and further assessment would be undertaken if required. During construction not all equipment will be operating simultaneously at all times which will result in a slight reduction in predicted noise levels. Mitigation measures for receivers have been specified in Section 5.7 which reasonably and feasibly reduces the impact of these exceedances.

Table 17 shows predicted noise impacts at selected representative receivers during standard hours.

Table 17 Predicted noise impacts at representative receivers – Standard hours

	Representative receiver address	Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)							
				1A - Establishment of site compound	1B - Removal of vegetation	2A - Demolition of existing structures	2B - Lifting of bridge span into position	3A - Platform resurfacing	4A - Construction of new bus stop	4B – Construction of new pedestrian crossing	5A - Installation of new bicycle racks
	Residential										
R1	1 Mitchell Avenue, Jannali	10	50	**65**	**73**	**75**	**64**	**67**	**74**	**74**	**67**
R2	12 Oxley Avenue, Jannali	10	50	**66**	49	**59**	**58**	**61**	38	40	**54**
R3	48-54 Railway Crescent, Jannali	30	49	**61**	**64**	**74**	**70**	**67**	**61**	**61**	**65**
R4	28-32 Railway Crescent, Jannali	50	49	**57**	**57**	**58**	**56**	**58**	**55**	**54**	**51**
R5	12-14 Mitchell Avenue, Jannali	80	50	44	**57**	**57**	**56**	**53**	**60**	**56**	50
R6	8 White Street, Jannali	120	49	37	48	49	44	46	47	46	41
R7	33 Jannali Avenue, Jannali	140	50	40	**56**	**56**	**54**	**53**	40	44	**53**
R8	2 Roberts Street, Jannali	170	49	44	**53**	**53**	**52**	**51**	**52**	**51**	**52**
R9	93 Sutherland Road, Jannali	180	50	44	**56**	**55**	**52**	**53**	**55**	**54**	50
R10	1-9 Oxley Avenue, Jannali	210	50	46	**52**	**52**	50	**52**	44	45	46
R11	54 Wattle Road, Jannali	280	49	39	47	48	47	47	48	46	48
R12	169 Novara Crescent, Jannali	320	49	42	43	45	44	44	42	43	40

	Representative receiver address	Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)							
				1A - Establishment of site compound	1B - Removal of vegetation	2A - Demolition of existing structures	2B - Lifting of bridge span into position	3A - Platform resurface-ing	4A - Construction of new bus stop	4B – Construct-ion of new pedestrian crossing	5A - Installation of new bicycle racks
	Non-residential receivers										
N1	Commercial premise, 74 Railway Crescent, Jannali	20	70	55	67	68	68	65	60	62	**71**
N2	Community centre, 15 Jannali Avenue, Jannali	20	55	55	**68**	**67**	**63**	**63**	**63**	**63**	**61**
N3	Health centre, 34-38 Railway Crescent, Jannali	30	55	**62**	**61**	**65**	**63**	**63**	**57**	**59**	**59**
N4	Health centre, 572 Box Road, Jannali	40	55	34	42	43	42	42	43	41	43
N5	Health centre, 5 White Street, Jannali	100	55	39	50	50	46	48	48	47	42
N6	Health centre, 10 White Street, Jannali	110	55	40	49	53	47	47	52	48	43
N7	Place of worship, 527 Box Road, Jannali	120	55	45	50	51	48	48	47	46	45
N8	Health centre, 1 White Street, Jannali	140	55	39	50	50	46	48	48	47	42
N9	Place of worship, 83 Wattle Road, Jannali	210	55	49	55	53	53	53	52	51	49
N10	School, 121 Sutherland Road, Jannali	310	55	37	47	49	48	46	48	45	44

Notes:

1. 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

Results show residential exceedances during standard hours occurs during all assessed stages of construction, with similar numbers of exceedances during most construction stages. The largest numbers of exceedances occur during Stage 1B - Removal of vegetation, 2A - Demolition of existing structures and 3A - Platform resurfacing. The largest impacts will be experienced by residences along Oxley Avenue, Railway Crescent and Mitchell Avenue facing the study area, with one representative residence predicted to be 'highly affected' at 1 Mitchell Avenue.

Residences exceeding NMLs are located generally up to two streets west from the study area, and several streets east of the study area, extending to Wattle Road. NML exceedances extend north to Nyardo Place and south to Louise Street.

Some non-residential receivers are predicted to exceed NMLs. Of these receivers, one is a community centre located at 15 Jannali Avenue and one is a health centre located at 34-38 Railway Crescent, Jannali.

Table 18 shows predicted noise impacts at selected representative receivers during the daytime out of standard hours.

Table 18 Predicted noise impacts at representative receivers – Daytime outside of standard hours

	Representative receiver address	Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)						
				1A – Establish-ment of site compound	2A - Demolition of existing structures	2B - Lifting of bridge span into position	3A - Platform resurfacing	4A – Construct-ion of new bus stop	4B – Construct-ion of new pedestrian crossing	5A - Installation of new bicycle racks
	Residential									
R1	1 Mitchell Avenue, Jannali	10	45	**65**	**75**	**64**	**67**	**74**	**74**	**67**
R2	12 Oxley Avenue, Jannali	10	45	**66**	**59**	**58**	**61**	38	40	**54**
R3	48-54 Railway Crescent, Jannali	30	44	**61**	**74**	**70**	**67**	**61**	**61**	**65**
R4	28-32 Railway Crescent, Jannali	50	44	**57**	**58**	**56**	**58**	**55**	**54**	**51**
R5	12-14 Mitchell Avenue, Jannali	80	45	44	**57**	**56**	**53**	**60**	**56**	**50**
R6	8 White Street, Jannali	120	44	37	**49**	44	**46**	**47**	**46**	41
R7	33 Jannali Avenue, Jannali	140	45	40	**56**	**54**	**53**	40	44	**53**
R8	2 Roberts Street, Jannali	170	44	44	**53**	**52**	**51**	**52**	**51**	**52**
R9	93 Sutherland Road, Jannali	180	45	44	**55**	**52**	**53**	**55**	**54**	**50**
R10	1-9 Oxley Avenue, Jannali	210	45	**46**	**52**	**50**	**52**	44	45	**46**
R11	54 Wattle Road, Jannali	280	44	39	**48**	**47**	**47**	**48**	**46**	**48**
R12	169 Novara Crescent, Jannali	320	44	42	**45**	44	44	42	43	40

	Representative receiver address	Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)						
				1A – Establish-ment of site compound	2A - Demolition of existing structures	2B - Lifting of bridge span into position	3A - Platform resurfacing	4A – Construct-ion of new bus stop	4B – Construct-ion of new pedestrian crossing	5A - Installation of new bicycle racks
	Non-residential receivers									
N1	Commercial premise, 74 Railway Crescent, Jannali	20	70	55	68	68	65	60	62	**71**
N2	Community centre, 15 Jannali Avenue, Jannali	20	55	55	**67**	**63**	**63**	**63**	**63**	**61**
N3	Health centre, 34-38 Railway Crescent, Jannali	30	55	**62**	**65**	**63**	**63**	**57**	**59**	**59**
N4	Health centre, 572 Box Road, Jannali	40	55	34	43	42	42	43	41	43
N5	Health centre, 5 White Street, Jannali	100	55	39	50	46	48	48	47	42
N6	Health centre, 10 White Street, Jannali	110	55	40	53	47	47	52	48	43
N7	Place of worship, 527 Box Road, Jannali	120	55	45	51	48	48	47	46	45
N8	Health centre, 1 White Street, Jannali	140	55	39	50	46	48	48	47	42
N9	Place of worship, 83 Wattle Road, Jannali	210	55	49	53	53	53	52	51	49
N10	School, 121 Sutherland Road, Jannali	310	55	37	49	48	46	48	45	44

Notes:

1. 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

Several receivers are predicted to exceed daytime out of hours NMLs, with the largest number of exceedances predicted during Stage 2A – Demolition of existing structures. One highly affected receiver is located at 1 Mitchell Avenue, Jannali, directly facing the study area.

Residences exceeding daytime out of hours NMLs are located generally up to four streets west from the study area to Taft Place, and several streets east of the study area extending to Wattle Road. NML exceedances extend north to Bindea Street and south past Louise Street.

Some non-residential receivers are predicted to exceed NMLs. Of these receivers, one is a community centre located at 15 Jannali Avenue and one is a health centre located at 34-38 Railway Crescent, Jannali.

Table 19 shows predicted noise impacts at selected representative receivers during evening out of hours.

Table 19 Predicted noise impacts at representative receivers –Evening outside of standard hours

Representative receiver address		Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)			
				2B - Lifting of bridge span into position	4A - Construction of new bus stop	4B - Construction of new pedest. crossing	5A - Install new bicycle racks
	Residential						
R1	1 Mitchell Avenue, Jannali	10	42	**64**	**74**	**74**	**67**
R2	12 Oxley Avenue, Jannali	10	42	**58**	38	40	**54**
R3	48-54 Railway Crescent, Jannali	30	40	**70**	**61**	**61**	**65**
R4	28-32 Railway Crescent, Jannali	50	40	**56**	**55**	**54**	**51**
R5	12-14 Mitchell Avenue, Jannali	80	42	**56**	**60**	**56**	**50**
R6	8 White Street, Jannali	120	40	**44**	**47**	**46**	**41**
R7	33 Jannali Avenue, Jannali	140	42	**54**	40	**44**	**53**
R8	2 Roberts Street, Jannali	170	40	**52**	**52**	**51**	**52**
R9	93 Sutherland Road, Jannali	180	42	**52**	**55**	**54**	**50**
R10	1-9 Oxley Avenue, Jannali	210	42	**50**	**44**	**45**	**46**
R11	54 Wattle Road, Jannali	280	40	**47**	**48**	**46**	**48**
R12	169 Novara Crescent, Jannali	320	40	**44**	**42**	**43**	40
	Non-residential receivers						
N1	Commercial premise, 74 Railway Crescent, Jannali	20	-[2]	68	60	62	71
N2	Community centre, 15 Jannali Avenue, Jannali	20	-[2]	63	63	63	61
N3	Health centre, 34-38 Railway Crescent, Jannali	30	-[2]	63	57	59	59
N4	Health centre, 572 Box Road, Jannali	40	-[2]	42	43	41	43
N5	Health centre, 5 White Street, Jannali	100	-[2]	46	48	47	42
N6	Health centre, 10 White Street, Jannali	110	-[2]	47	52	48	43
N7	Place of worship, 527 Box Road, Jannali	120	55	48	47	46	45
N8	Health centre, 1 White Street, Jannali	140	-[2]	46	48	47	42
N9	Place of worship, 83 Wattle Road, Jannali	210	55	53	52	51	49
N10	School, 121 Sutherland Road, Jannali	310	-[2]	48	48	45	44

Notes:

1. Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML.
2. Some non-residential premises have been assumed to not operate during the evening period, therefore NMLs do not apply.

Several receivers are predicted to exceed evening out of hours NMLs, with a similar number of exceedances across all four stages. No receivers are predicted to be 'highly affected'.

Residences exceeding evening out of hours NMLs are located generally up to four streets west from the study area to Taft Place, and several streets east of the study area extending past Wattle Road. NML exceedances extend north to Bindea Street and south past Louise Street. Two churches operate during evening hours, and have been assessed, however comply with evening NMLs.

Table 20 shows predicted noise impacts at selected representative receivers during night-time out of hours.

Table 20 Predicted noise impacts at representative receivers –Night outside of standard hours

	Representative receiver address	Approx. dist. to worksite, m	NML, dB(A)	Predicted noise impact during sub-stage[1], dB(A)	
				2B - Lifting of bridge span into position	4B - Construction of new pedestrian crossing
	Residential				
R1	1 Mitchell Avenue, Jannali	10	35	**64**	**74**
R2	12 Oxley Avenue, Jannali	10	35	**58**	**40**
R3	48-54 Railway Crescent, Jannali	30	35	**70**	**61**
R4	28-32 Railway Crescent, Jannali	50	35	**56**	**54**
R5	12-14 Mitchell Avenue, Jannali	80	35	**56**	**56**
R6	8 White Street, Jannali	120	35	**44**	**46**
R7	33 Jannali Avenue, Jannali	140	35	**54**	**44**
R8	2 Roberts Street, Jannali	170	35	**52**	**51**
R9	93 Sutherland Road, Jannali	180	35	**52**	**54**
R10	1-9 Oxley Avenue, Jannali	210	35	**50**	**45**
R11	54 Wattle Road, Jannali	280	35	**47**	**46**
R12	169 Novara Crescent, Jannali	320	35	**44**	**43**
	Non-residential receivers				
N1	Commercial premise, 74 Railway Crescent, Jannali	20	-[2]	68	62
N2	Community centre, 15 Jannali Avenue, Jannali	20	-[2]	63	63
N3	Health centre, 34-38 Railway Crescent, Jannali	30	-[2]	63	59
N4	Health centre, 572 Box Road, Jannali	40	-[2]	42	41
N5	Health centre, 5 White Street, Jannali	100	-[2]	46	47
N6	Health centre, 10 White Street, Jannali	110	-[2]	47	48
N7	Place of worship, 527 Box Road, Jannali	120	-[2]	48	46
N8	Health centre, 1 White Street, Jannali	140	-[2]	46	47
N9	Place of worship, 83 Wattle Road, Jannali	210	-[2]	53	51
N10	School, 121 Sutherland Road, Jannali	310	-[2]	48	45

Notes:

1. Items in **BOLD BLACK** indicate predicted noise impact at this receiver during this work stage is above NML.

2. Non-residential premises have been assumed to not operate during the night-time period, therefore NMLs do not apply.

All representative residential receivers are predicted to exceed night-time out of hours NMLs during both construction stages, with impacts from both stages similar at most receivers. No receivers are predicted to be 'highly affected'.

A large number of residences are predicted to exceeding night-time out of hours NMLs and extend to Taft Place to the west, past Wattle Road to the east, past Wollun Street to the north and past Gailes Street to the south, as shown in Figure 4 of Appendix C. NML exceedances extend north to Bindea Street and south past Louise Street.

It should be noted that night-time construction works during possessions would not take place over longer than two consecutive nights, and would be separated by one or more weeks. This would provide some respite periods during weekdays between works. Construction works would likely take place over five to six weekend possessions.

5.5 Sleep disturbance assessment

As works will be undertaken during the night-time period sleep disturbance is required to be assessed.

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 and NCA 2 for lifting of bridge span into position, and construction of the new pedestrian crossing.

As noted above the predicted $L_{A1(1min)}$ noise level contours indicate that in some instances the awakening reaction criterion may be exceeded at some locations during both construction stages occurring at night. 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} noise levels are likely to be less than those predicted.

5.6 Construction traffic assessment

No traffic counts have been conducted for this project; however the proposed construction vehicles have been estimated by TfNSW as approximately 1-3 vehicles per day Monday to Friday. For weekend possession works there would be approximately 8-16 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 will have an insignificant impact on existing road traffic noise in the area. The traffic generated by these works is therefore deemed to comply with the RNP criteria.

5.7 Construction noise mitigation measures

5.7.1 Construction Noise and Vibration Management Plan (CNVMP)

Due to the exceedances presented in Section 5.4, AECOM recommends that a Construction Noise and Vibration Management Plan (CNVMP) is devised and implemented prior to commencement of construction activities.

The CNVMP should include all reasonable and feasible mitigation options to manage the noise emissions from the site and also any complaints which may occur due to the construction activity noise. The CNVMP should include, but not limited to, 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
- overview of community consultation required for identified high impact works.

5.7.2 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 project 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 the Community Involvement Plan for the construction of the project and should include a 24 hour hotline and complaints management process.

5.7.3 Work practices

Induction and training should be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise.

5.7.4 Construction hours and work scheduling

Details of any necessary out-of-hours work required 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 should be submitted to TfNSW for approval on a case-by-case basis.

Particularly noisy activities such as the use of concrete saws and excavators with hammers should be scheduled where feasible and reasonable around times of high background noise to provide masking.

5.7.5 Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant should be selected for each task to minimise the noise contributions.

Alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units should be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function (such as rubber wheeler plant) should be considered in place of steel tracked plant.

Equipment should be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment should be orientated away from residential receivers where feasible and reasonable.

5.7.6 Construction traffic

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). Site access and egress points should be located away from residences and other sensitive land uses, where feasible and reasonable. 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.

5.7.7 Noise monitoring

A noise monitoring program should be presented in the CNVMP.

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.

5.7.8 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 done 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 19 below.

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 6.

Table 21 Additional mitigation measures matrix

Time period		**Mitigation measures**	**$L_{Aeq,15min}$ noise level above background noise level (RBL)**		**Quantitative assessment of noise levels**
		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)				

Table 22 outlines the additional mitigation measures.

Table 22 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 will 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.

5.8 Construction vibration assessment

Vibration intensive works are proposed to occur as part of the Jannali Station upgrade works.

The works may include the use of the following items of equipment:

- vibratory roller
- jackhammer
- auger bored piling.

The safe working distances of these items of equipment from residential buildings are shown in Table 23.

If the safe working distances are complied with no adverse impact from the vibration intensive works are likely in terms of human response or cosmetic damage.

Mitigation measures to control excessive vibration are discussed within section 5.9.

Table 23 Safe working distances of vibration intensive equipment to be used during the footbridge and concourse upgrade works

Plant	Rating/Description	Safe working distance, m	
		Cosmetic damage - residential	Human response
Vibratory roller	< 50 kN (Typically 1-2 T)	5	15-20
	< 100 kN (typically 2-4t)	6	20
	< 200 kN (typically 4-6t)	12	40
	< 300 kN (typically 7-13t)	15	100
Jackhammer	Handheld	1 m nominal	Avoid contact with structure
Auger bored piling	≤ 800 mm	2	2

5.9 Construction vibration mitigation measures

For vibration intensive activities that occur within the safe working distances, as presented in Table 23, management methods to mitigate should include, but not limited, the following:

5.9.1 Equipment selection and maintenance

The use of less vibration intensive methods of construction or equipment is preferred where possible to reduce annoyance and potential for cosmetic damage. 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.

5.9.2 Works scheduling and respite periods

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 should be negotiated with the community for construction activities expected to generate high levels of vibration.

5.9.3 Supplementary vibration monitoring

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 a metre

from the building footprint, to warn operators (via flashing light, audible alarm, SMS etc.) 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 5.7 will be sufficient to mitigate the vibration impact at nearby residential receivers. Therefore vibration monitoring will not be required at these properties.

6.0 Operational noise

Additional operational equipment at the station would include new lifts and potentially a new substation (to replace the existing) which would not produce significant noise emissions. The operational noise environment is expected to remain largely unchanged however standard noise controls such as appropriate selection of mechanical plant (such as lifts) and adjustments to the PA system should be undertaken during the detailed design phase to comply with Sydney Trains speech intelligibility requirements and operational noise criteria as per the *Industrial Noise Policy*. Operational noise criteria are presented in Section 4.0.

7.0 Conclusions

A noise and vibration impact assessment has been completed for the Jannali Station Upgrade. 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 construction noise management levels.

7.1 Construction activity noise

Construction scenarios have been developed in in consultation with TfNSW and the proposed equipment has been detailed within this assessment. Five construction work packages were assessed. Construction noise impacts were assessed to 12 residential receivers which were chosen to be representative of receivers on their residential block. Impacts were also assessed to representative nearby sensitive non-residential receivers, including all schools, places of worship, community centres and health centres.

The Jannali Station Upgrade works are expected to commence in 2016, take up to 18 months to complete and will be undertaken during both standard construction hours and weekend construction out-of-hours. Out of hours works would likely be required over five to six weekend possessions over the 18 month construction period and during some evening/night times to minimise traffic impacts.

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. However, implementation of mitigation measures should aim to minimise and manage noise impacts where possible.

Mitigation measures have been recommended in line with TfNSW's CNS 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. If the safe working distances are maintained then no adverse impact from the vibration intensive works is likely in terms of human response or cosmetic damage. Should vibration intensive activities within these distances be unavoidable, the additional mitigation measures provided should be implemented.

7.3 Operation

The operational noise environment due to new mechanical plant is expected to remain largely unchanged; however, if required operational noise emissions shall be addressed during the detailed design phase in order to comply with Sydney Trains speech intelligibility requirements and 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 – 169 Novara Crescent Jannali – 09/07/15 – 17/07/15

Logger Type: ARL 315

Serial No: 15-299-444

Address: 169 Novara Crescent, Jannali

Location: Back garden

Façade / Free Field: Free field

Environment: The acoustic environment is characterised by local traffic, trains passing on the southern line and natural sounds such as birds.

Table 24 Measured noise levels – 169 Novara Crescent

INP Noise Level, dB(A)		
Period	**Log Average**	**RBL**
Day	59	39
Evening	59	35
Night	60	28

Figure 3 Logger location map – 169 Novara Crescent

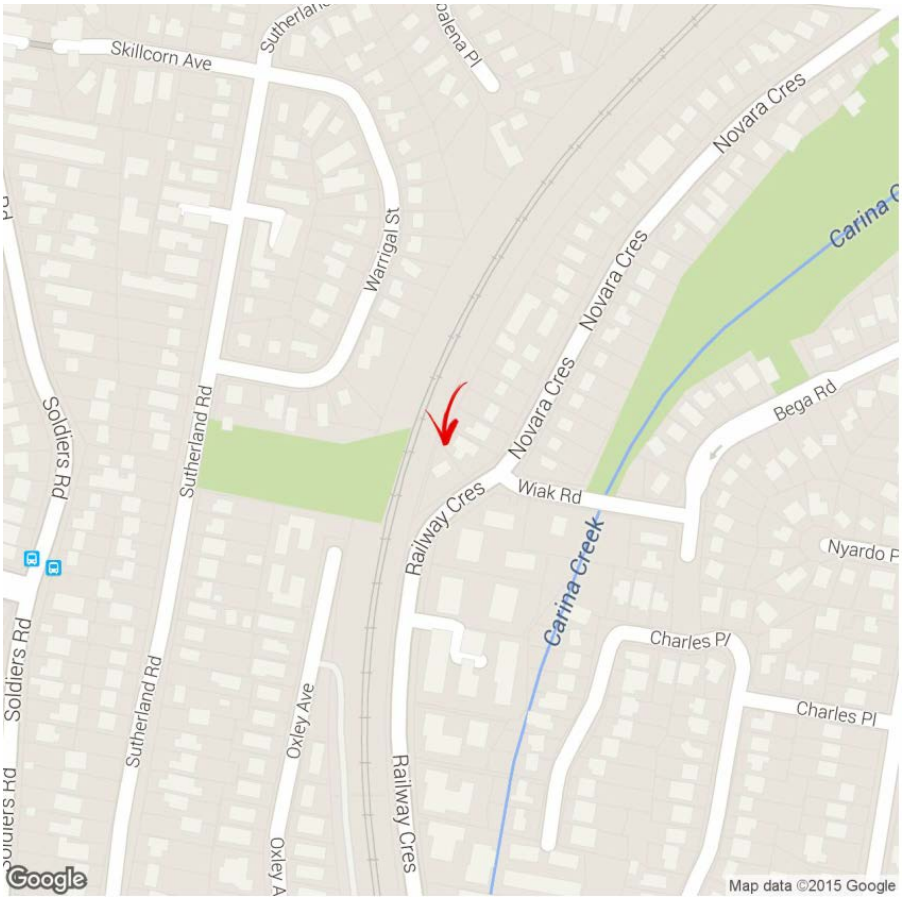
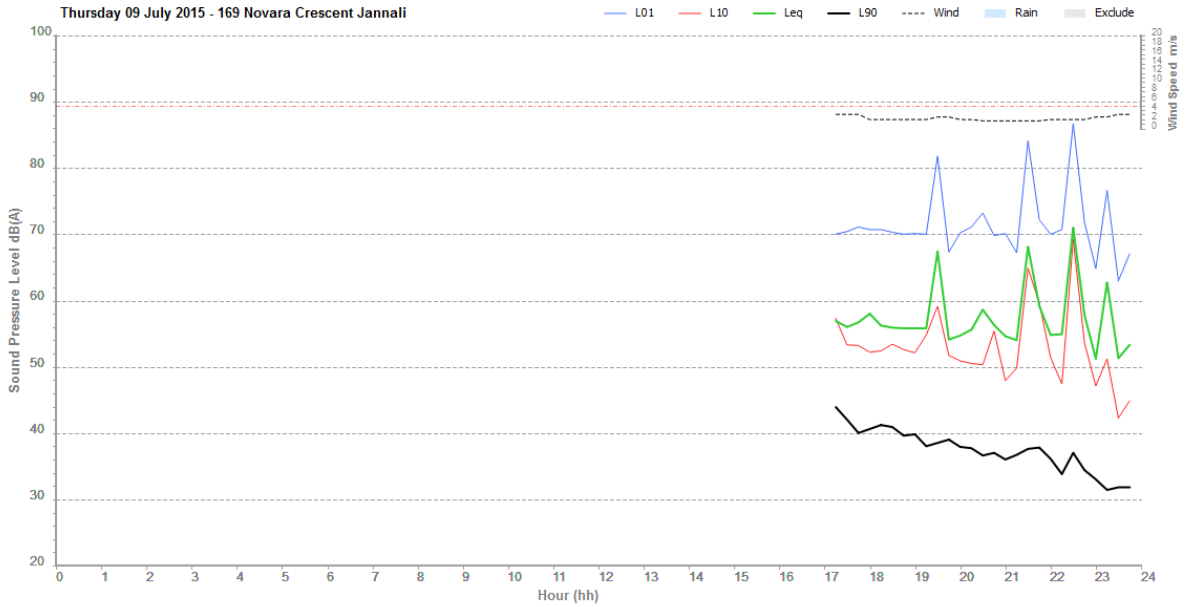
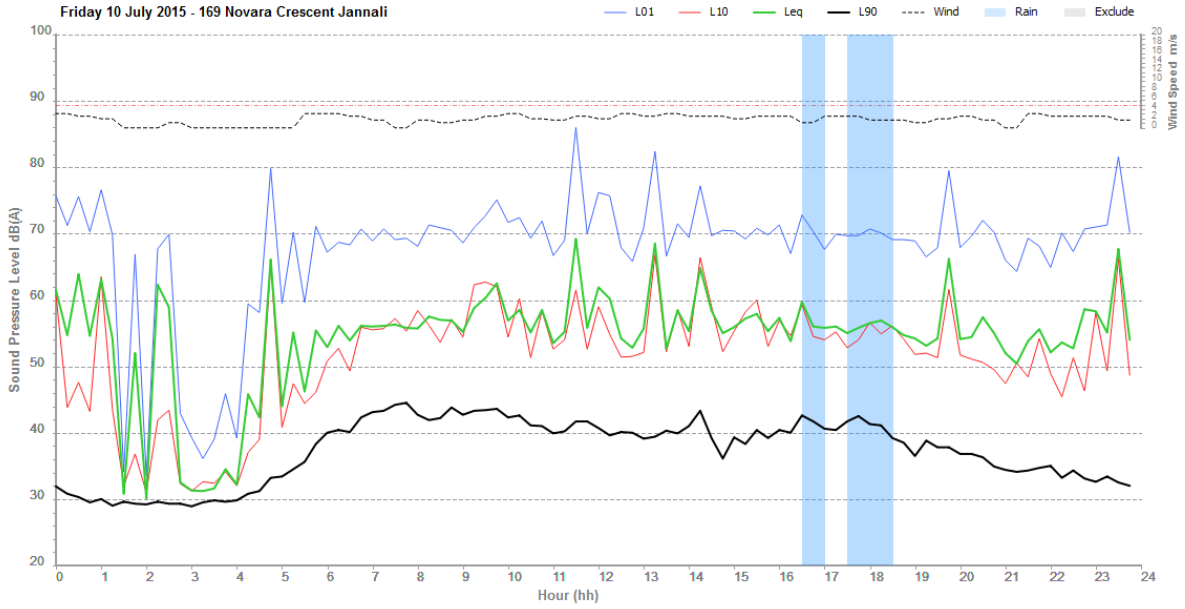
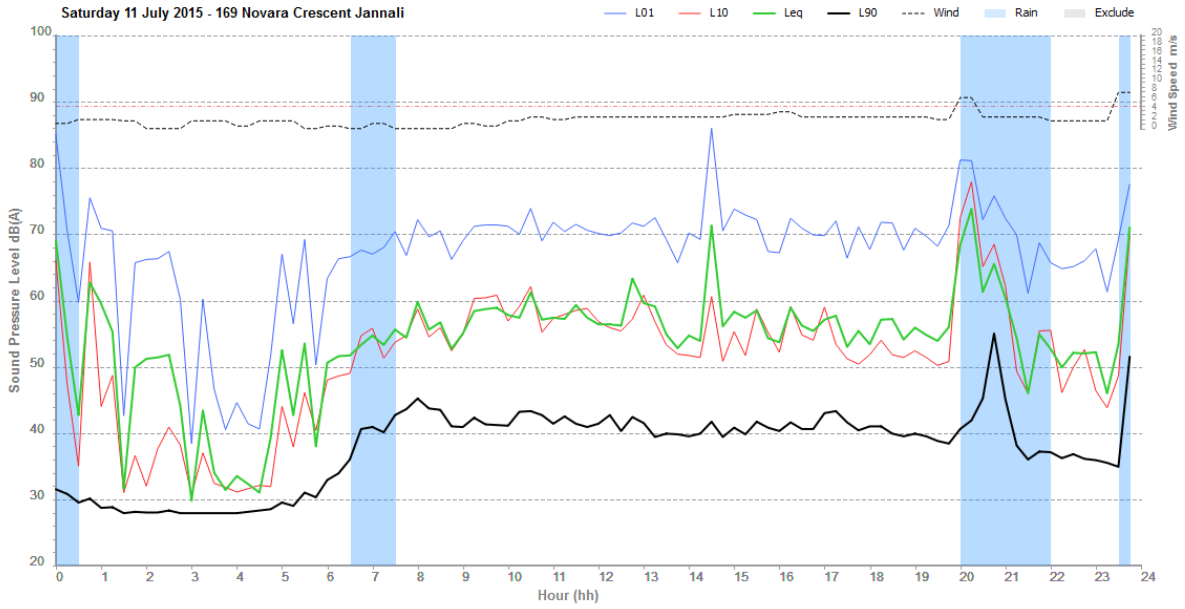


Figure 4 Logger location photo – 169 Novara Crescent

Logger graphs – 169 Novara Crescent



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Wind
Rain
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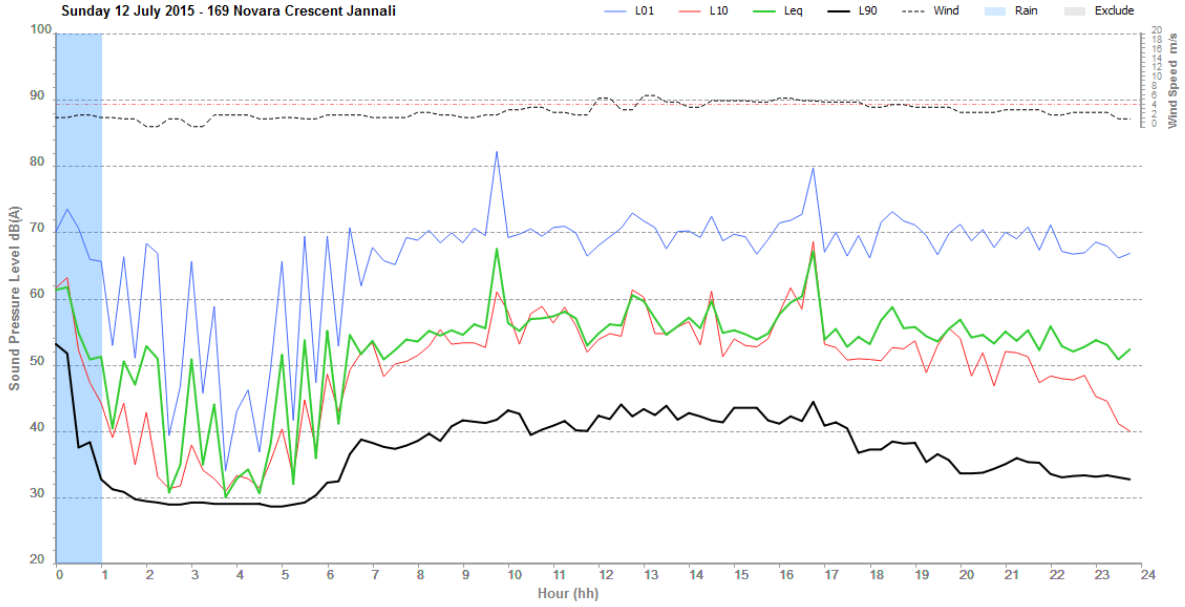
Wind Speed m/s
Hour (hh)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Rain
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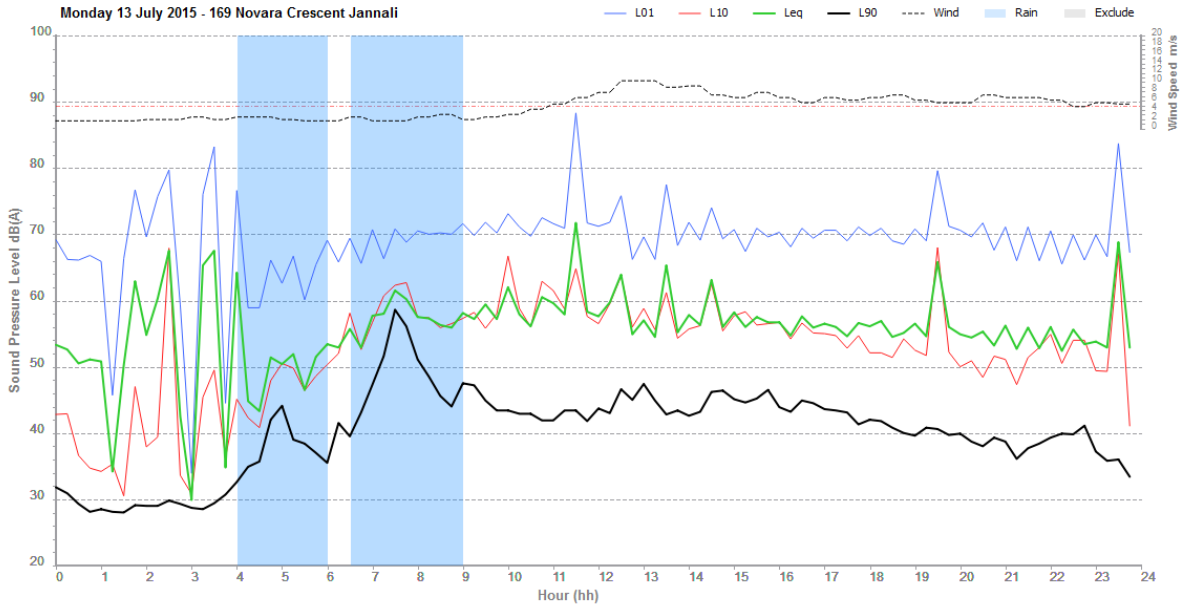
Wind Speed m/s
Hour (hh)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Rain
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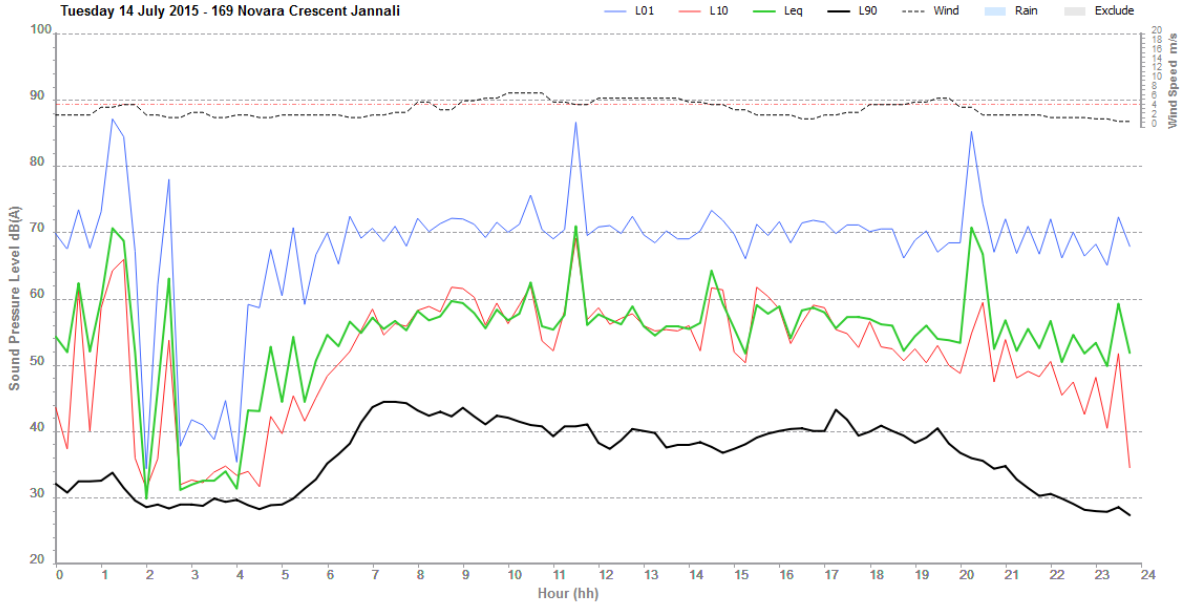
Wind Speed m/s
Hour (hh)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Rain
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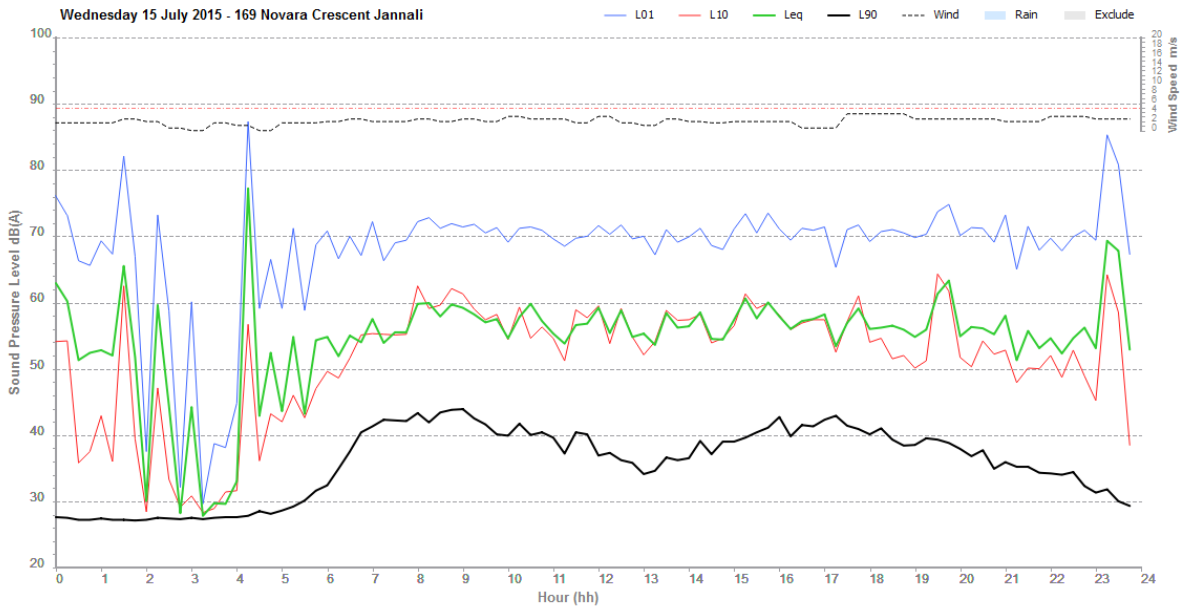
Wind Speed m/s
Hour (hh)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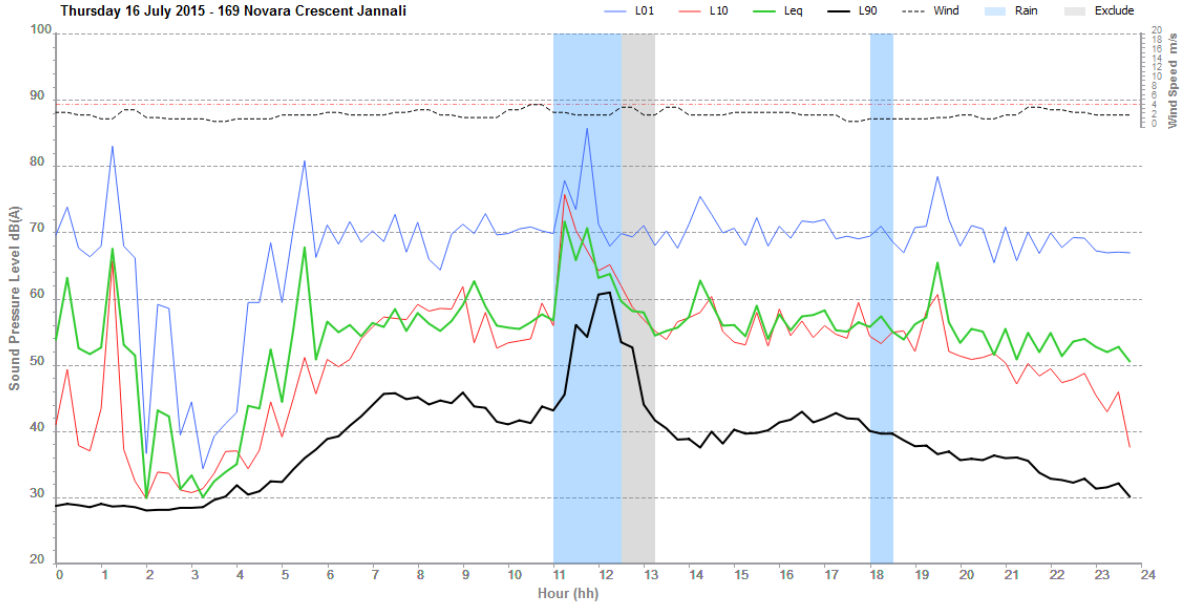
Wind Speed m/s
Hour (hh)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Rain
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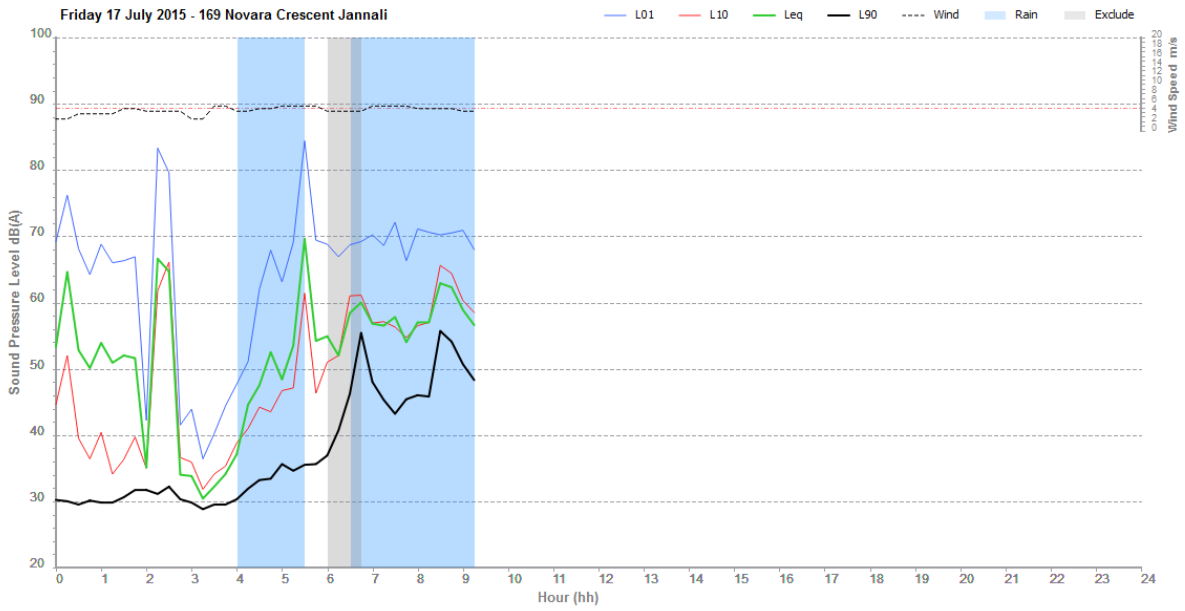
Wind Speed m/s
Hour (hh)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L01
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Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)

NL2 – 17 Mitchell Avenue Jannali – 09/07/15 – 17/07/15

Logger Type: Cirus 171

Serial No: G061710

Address: 17 Mitchell Avenue, Jannali

Location: Back garden

Façade / Free Field: Free field

Environment: The acoustic environment is characterised by local traffic with some limited commerce.

Table 25 Measured noise levels – 17 Mitchell Avenue

INP Noise Level, dB(A)		
Period	**Log Average**	**RBL**
Day	52	40
Evening	46	37
Night	44	29

Figure 5 Logger location map – 17 Mitchell Avenue

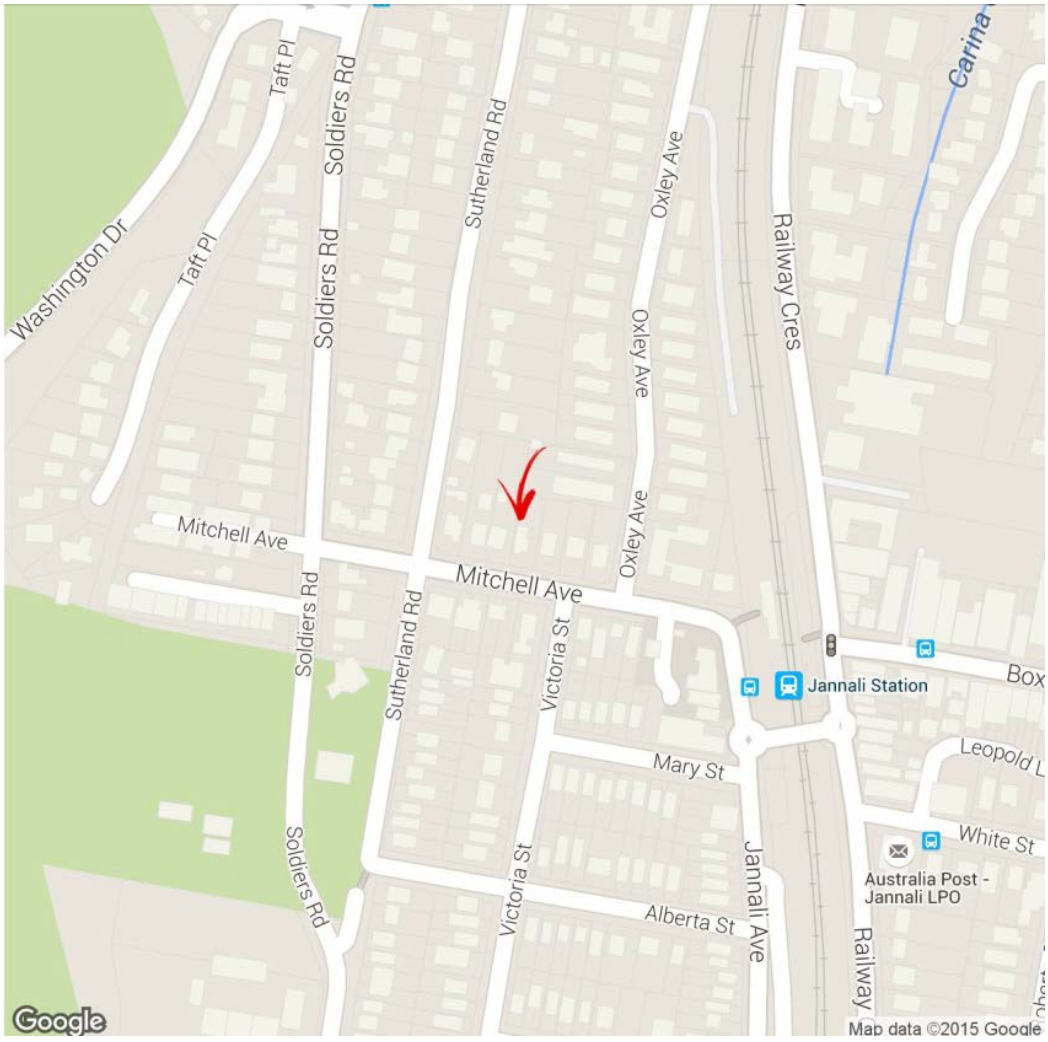
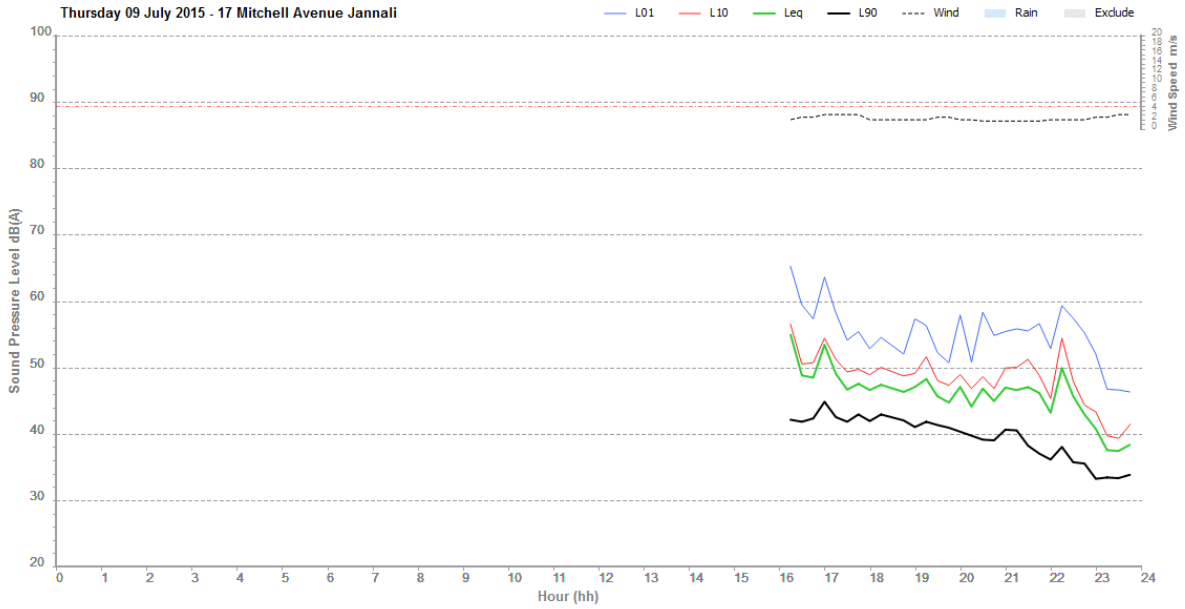
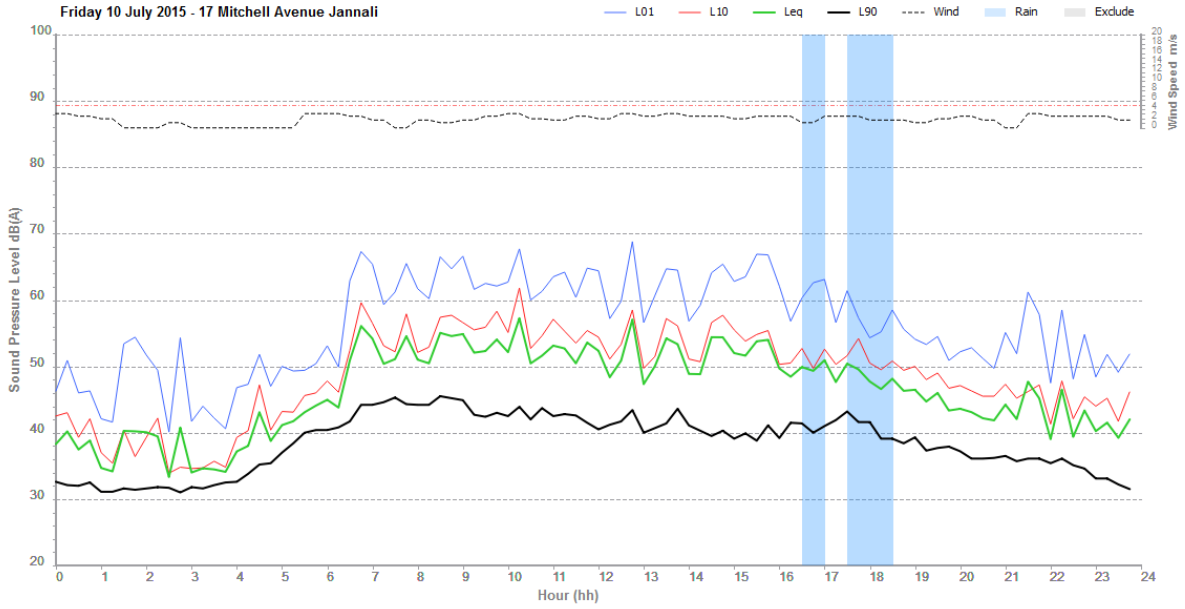
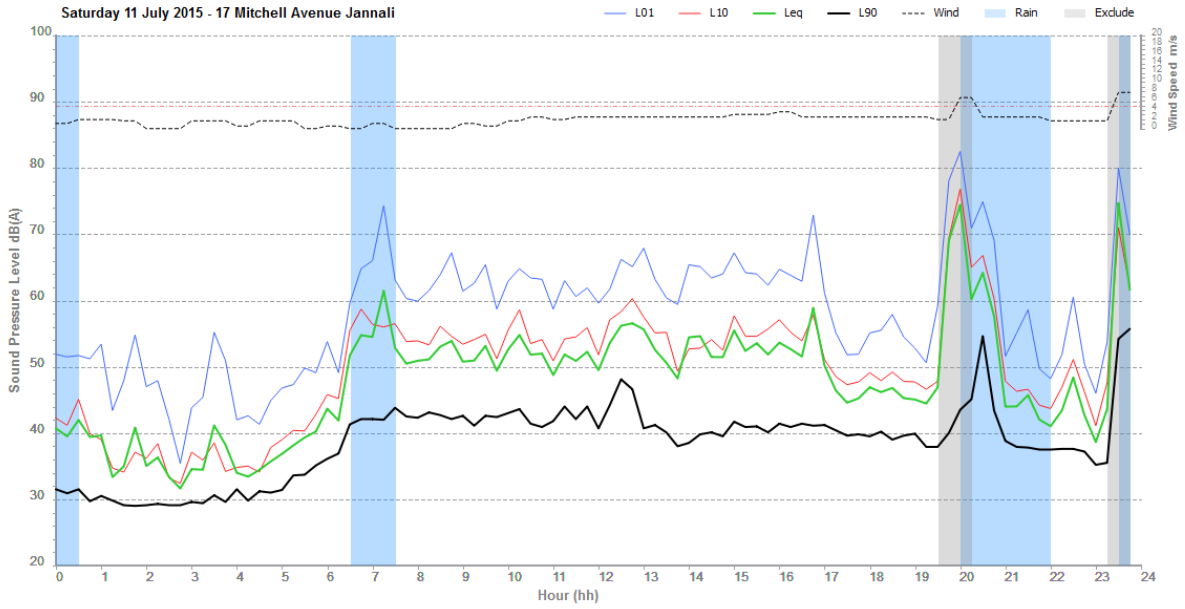


Figure 6 Logger location photo – 17 Mitchell Avenue

Logger graphs – 17 Mitchell Avenue



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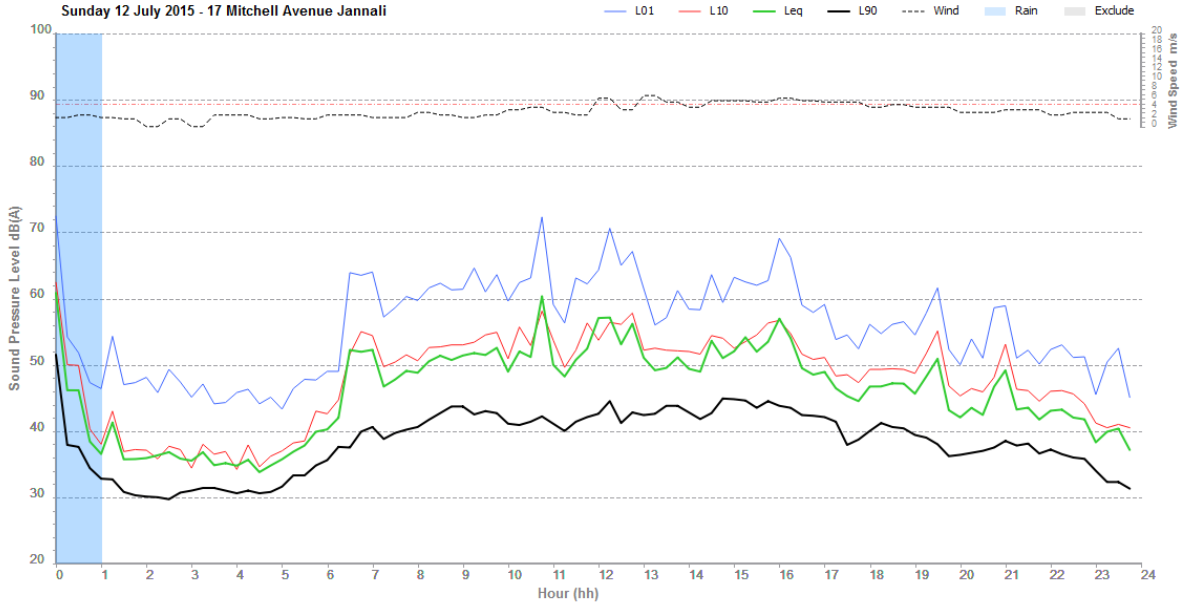
Wind Speed m/s
Hour (hh)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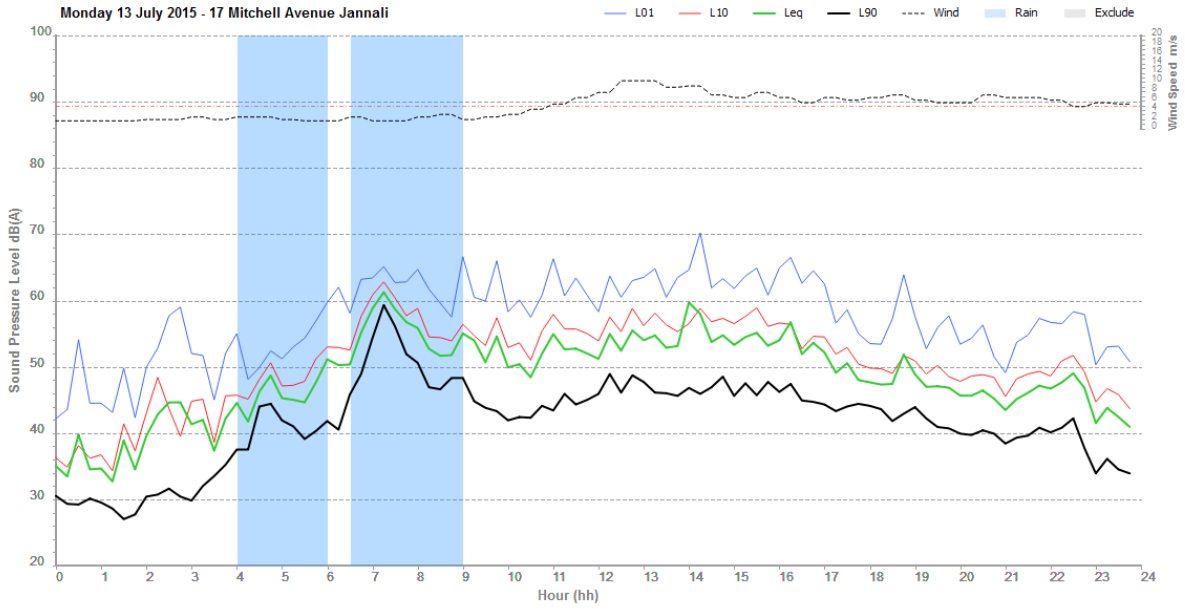
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Wind Speed m/s
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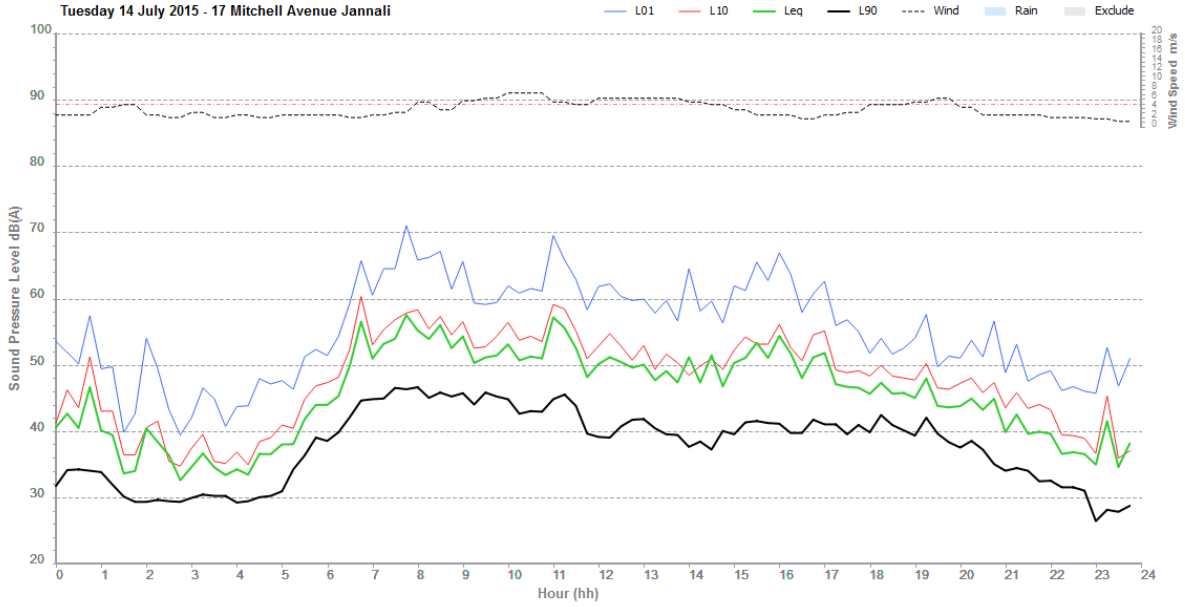
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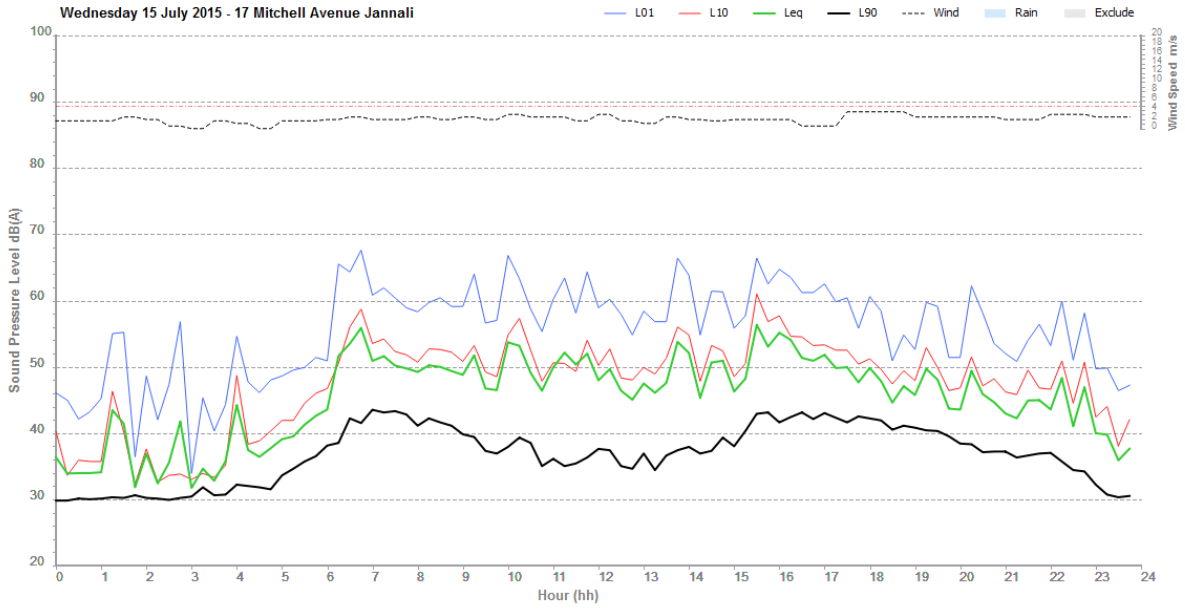
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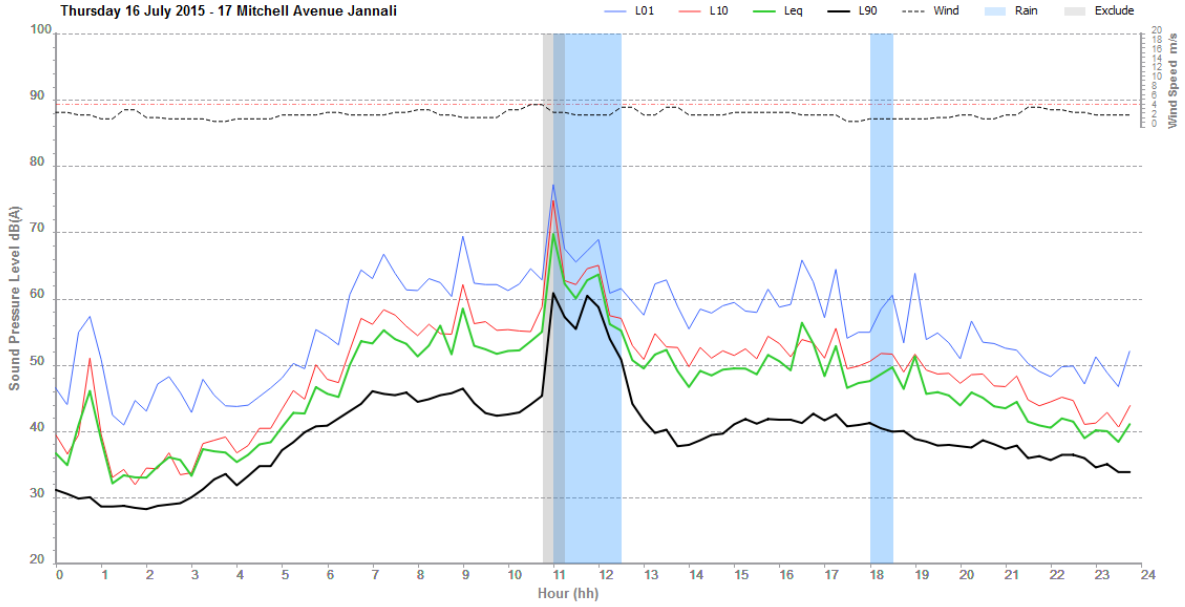
Wind Speed m/s
Hour (hh)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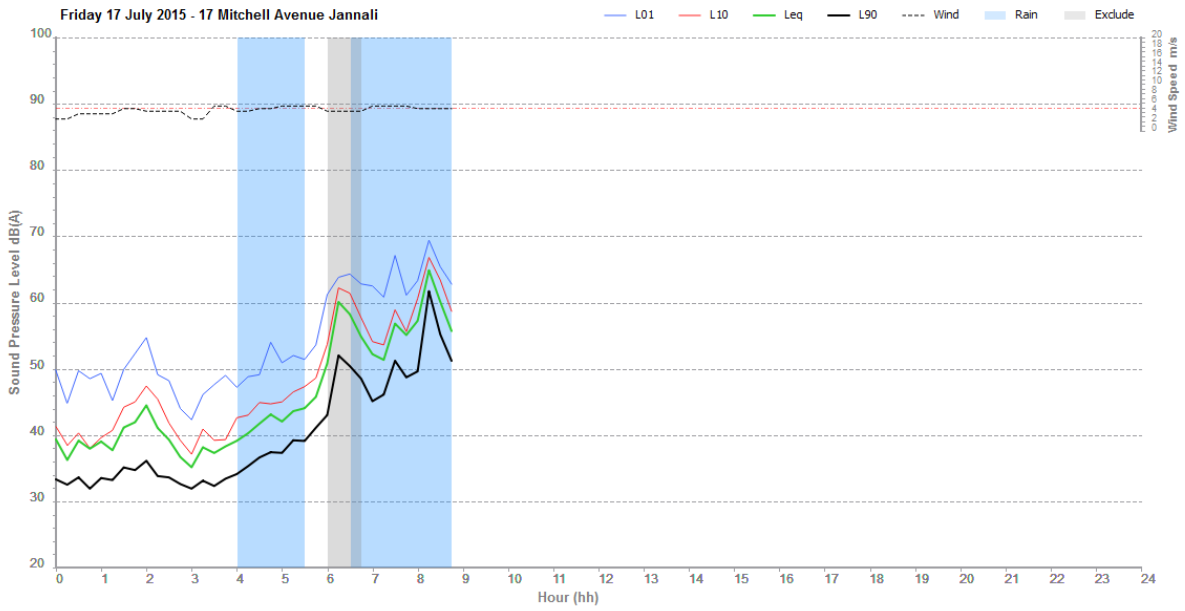
Wind Speed m/s
Hour (hh)


Friday 17 July 2015 - 17 Mitchell Avenue Jannali
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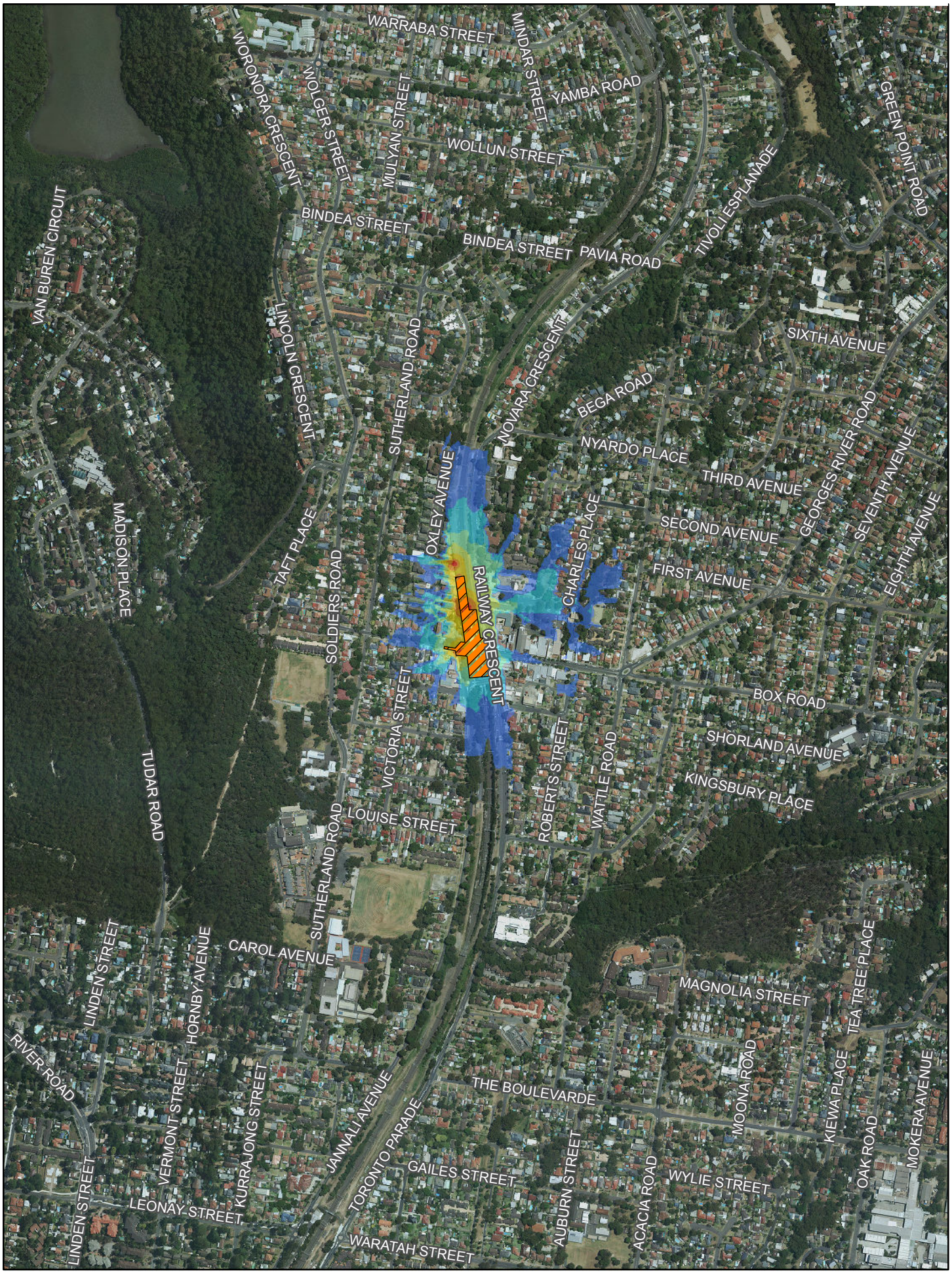
Hour (hh)

Appendix C

Predicted Noise Contours - Construction



Work Area

Sound Pressure Level, L_{Aeq}

< 44 | 44 - 49 | 49 - 54 | 54 - 59 | 59 - 64 | 64 - 69 | 69 - 74 | > 74

Jannali Station Upgrade Works - Daytime possession

Establishment of site compound

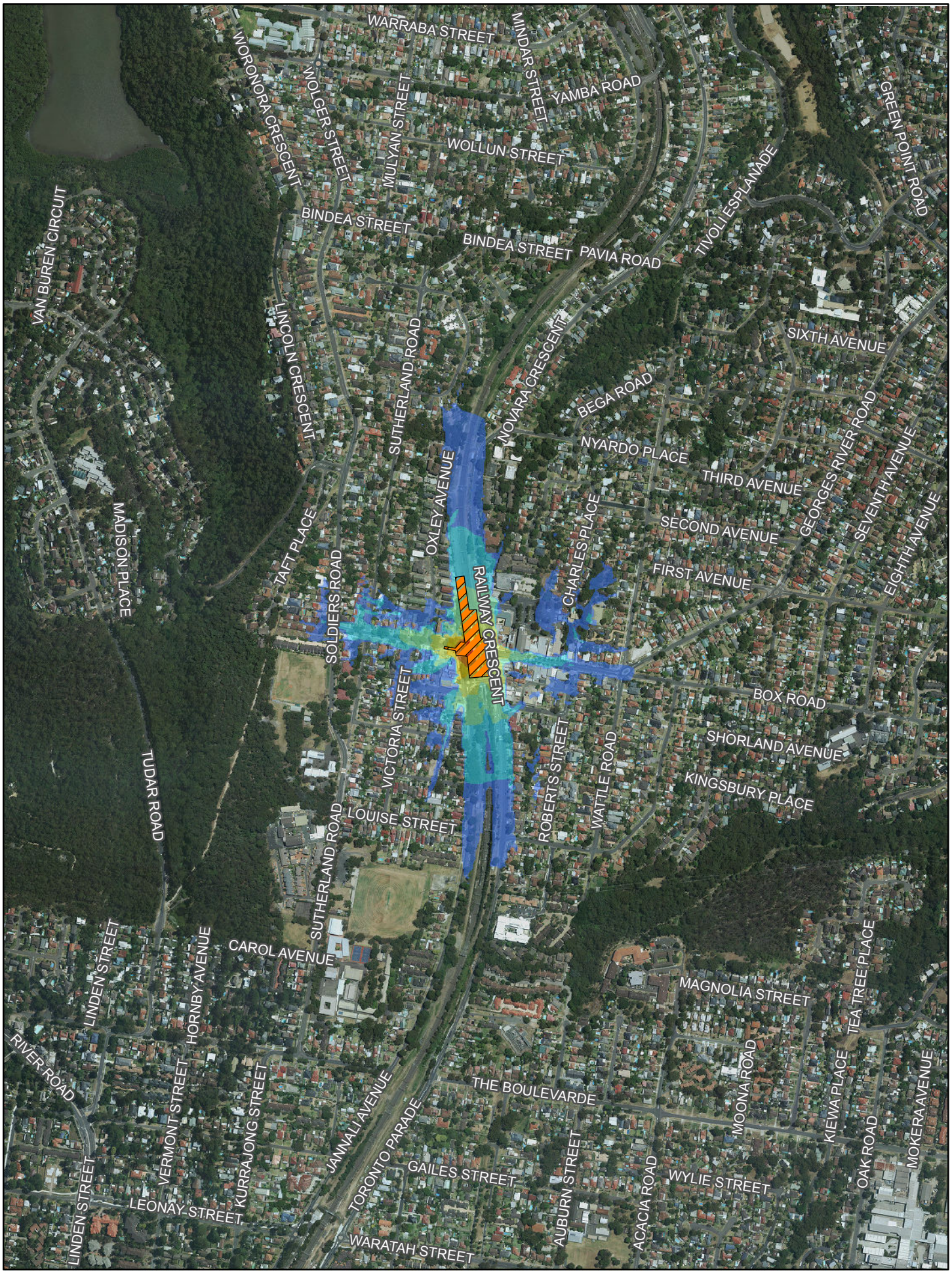
0 100 200 400 Meters

N

Nov 2015

60327214

Fig. 1



Jannali Station Upgrade Works - Standard hours daytime

Removal of vegetation

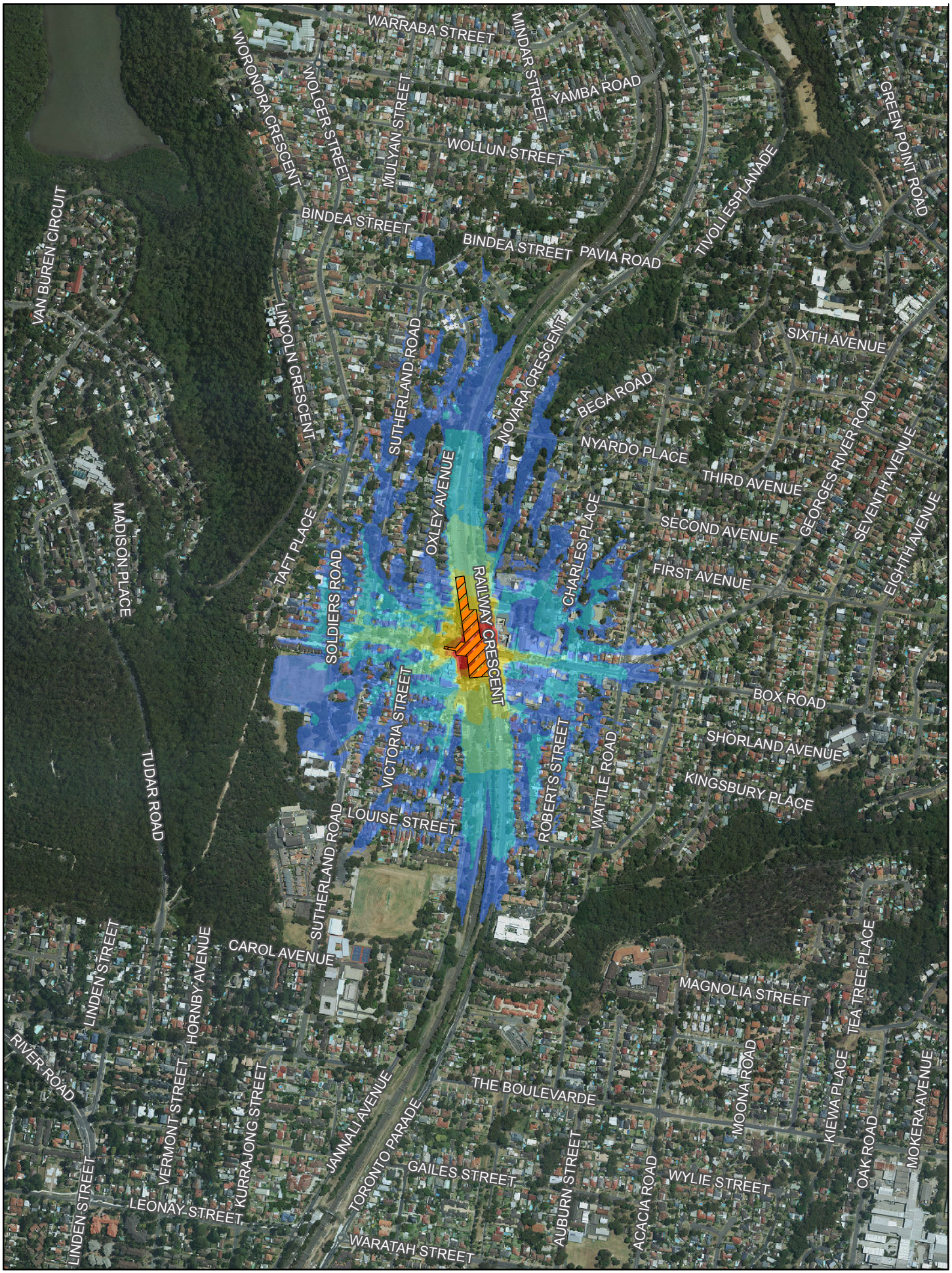
Nov 2015

60327214

0 100 200 400 Meters

N

Fig. 2



Work Area

Sound Pressure Level, L_{Aeq}

< 44 | 44 - 49 | 49 - 54 | 54 - 59 | 59 - 64 | 64 - 69 | 69 - 74 | > 74

Jannali Station Upgrade Works - Daytime possession

Demolition of existing structures

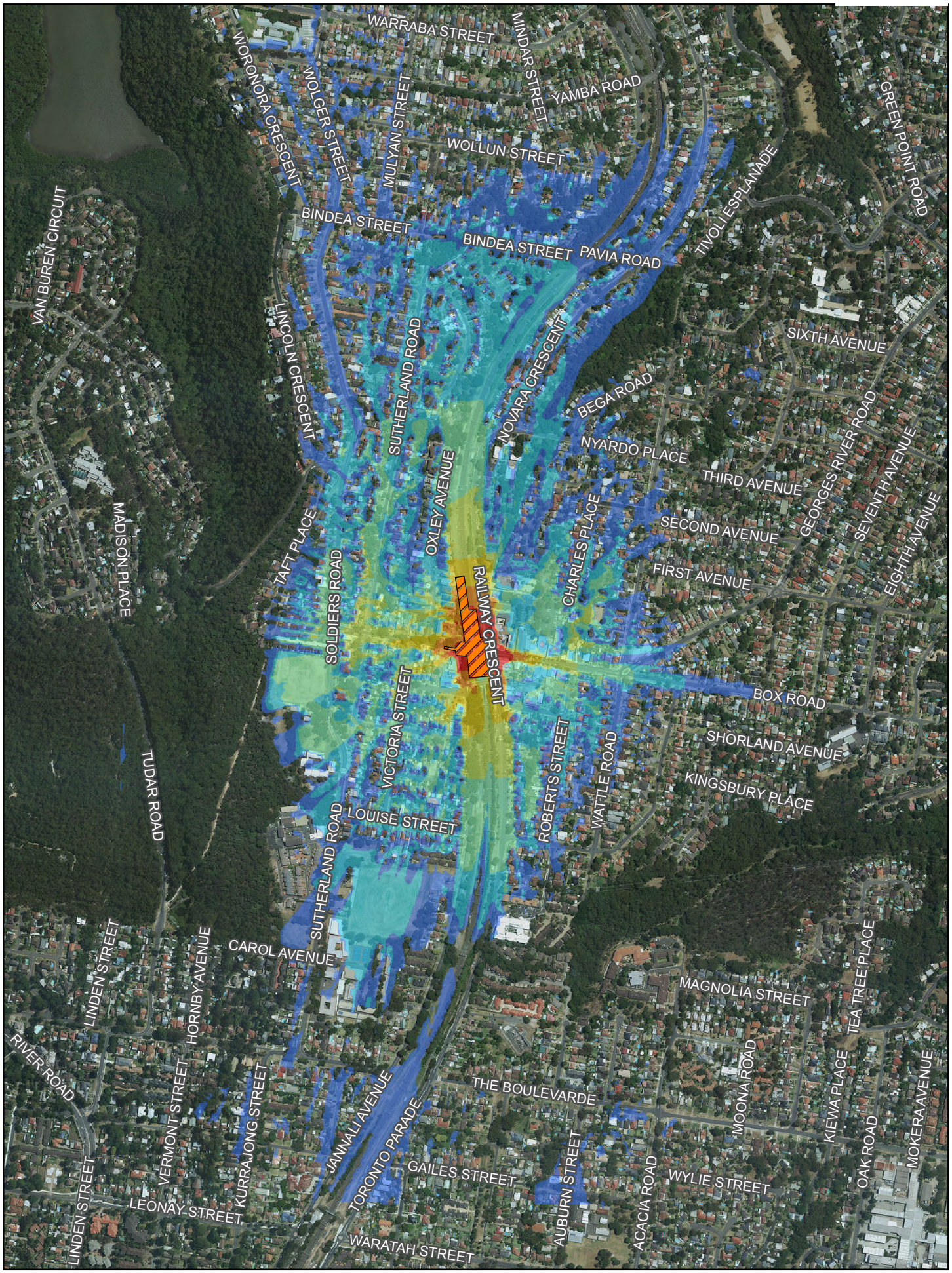
0 100 200 400 Meters

N

Nov 2015

60327214

Fig. **3**



Work Area

Sound Pressure Level, L_{Aeq}

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

Jannali Station Upgrade Works - Night-time possession

Lifting of bridge span into position

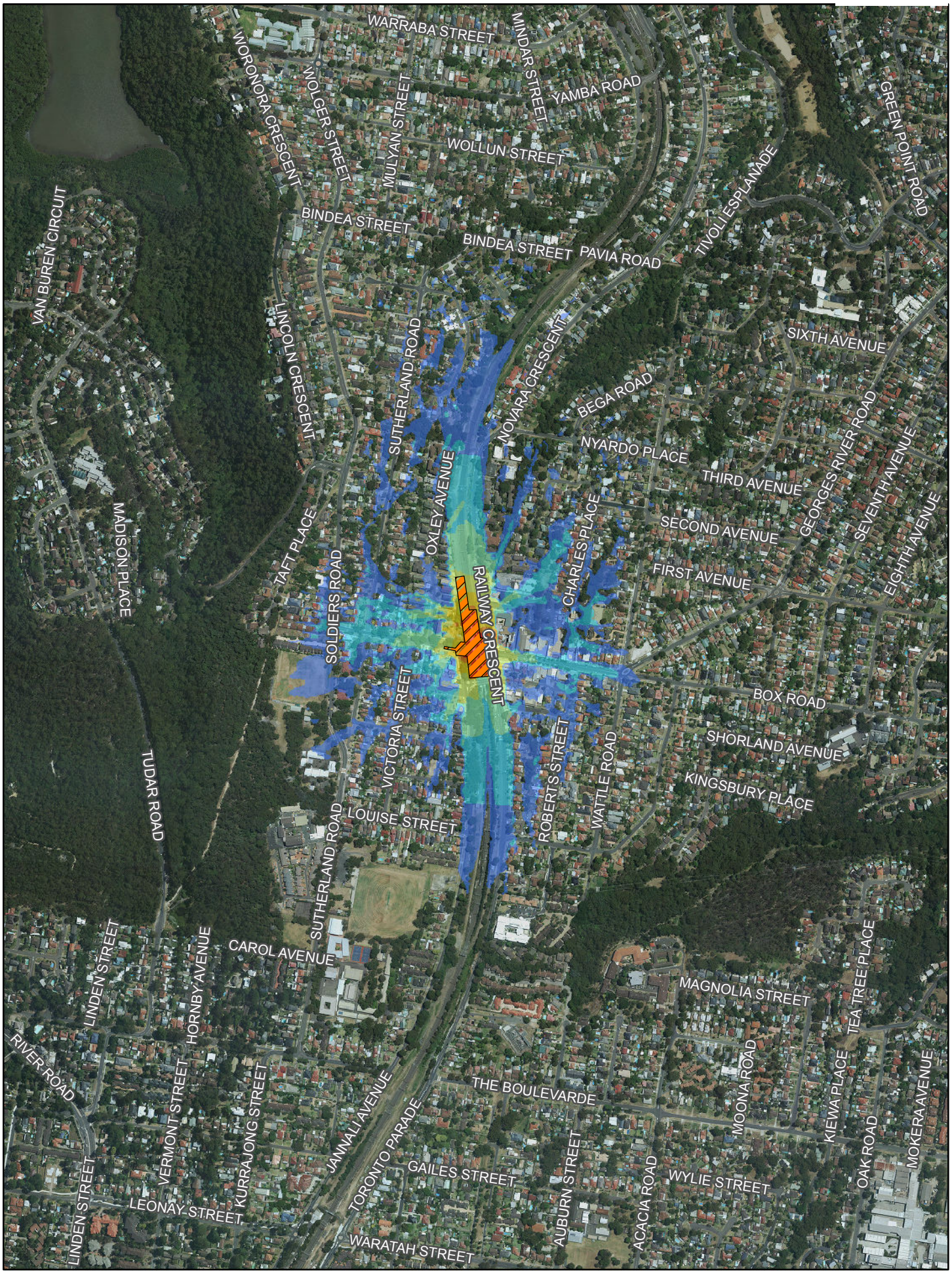
0 100 200 400 Meters

N

Nov 2015

60327214

Fig. **4**



Work Area

Sound Pressure Level, L_{Aeq}

< 44 | 44 - 49 | 49 - 54 | 54 - 59 | 59 - 64 | 64 - 69 | 69 - 74 | > 74

Jannali Station Upgrade Works - Daytime possession

Platform resurfacing

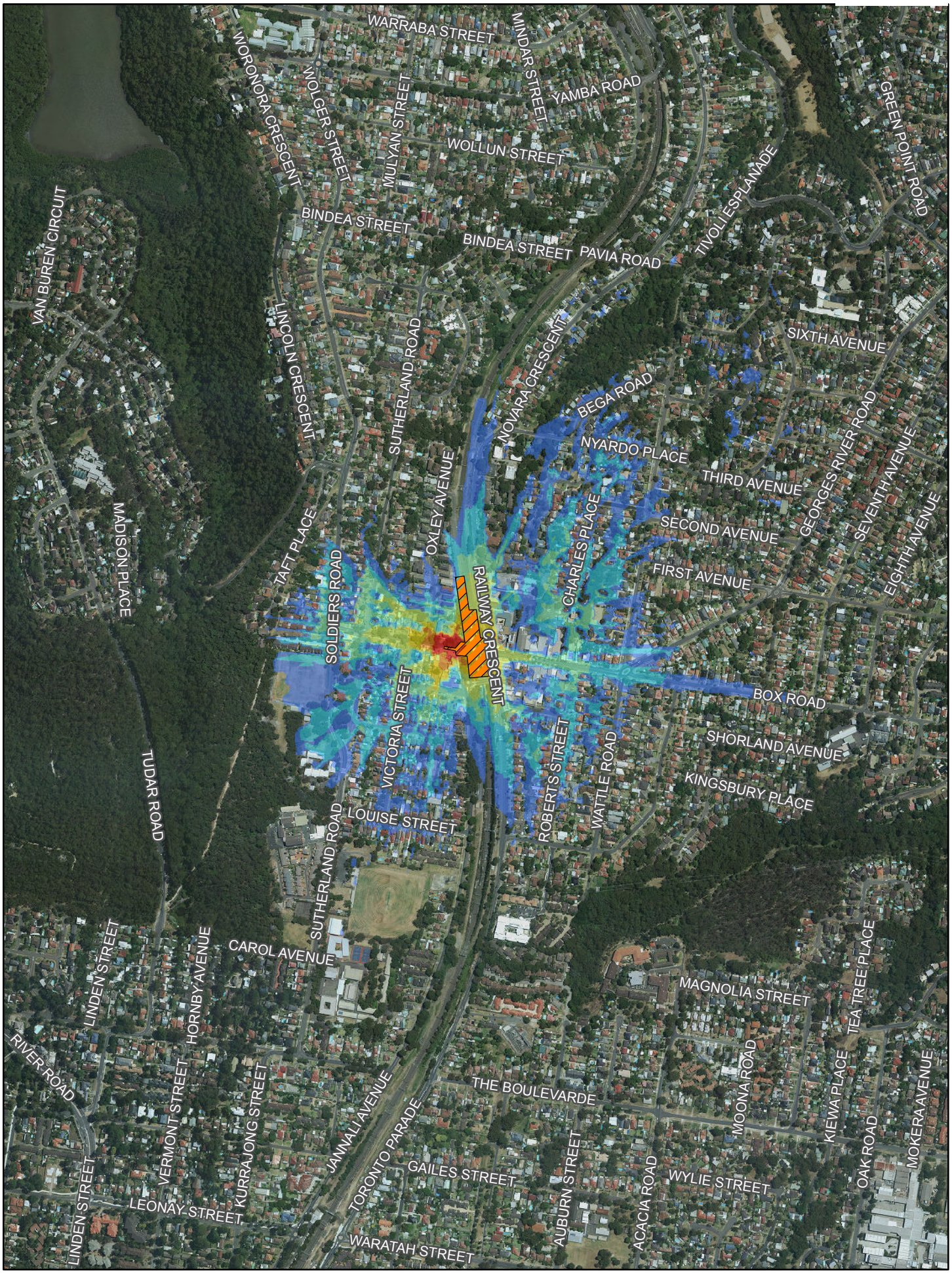
0 100 200 400 Meters

N

Nov 2015

60327214

Fig. **5**



Work Area

Sound Pressure Level, L_{Aeq}

< 40 | 40 - 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | > 70

Jannali Station Upgrade Works - Evening possession

Construction of new bus stop

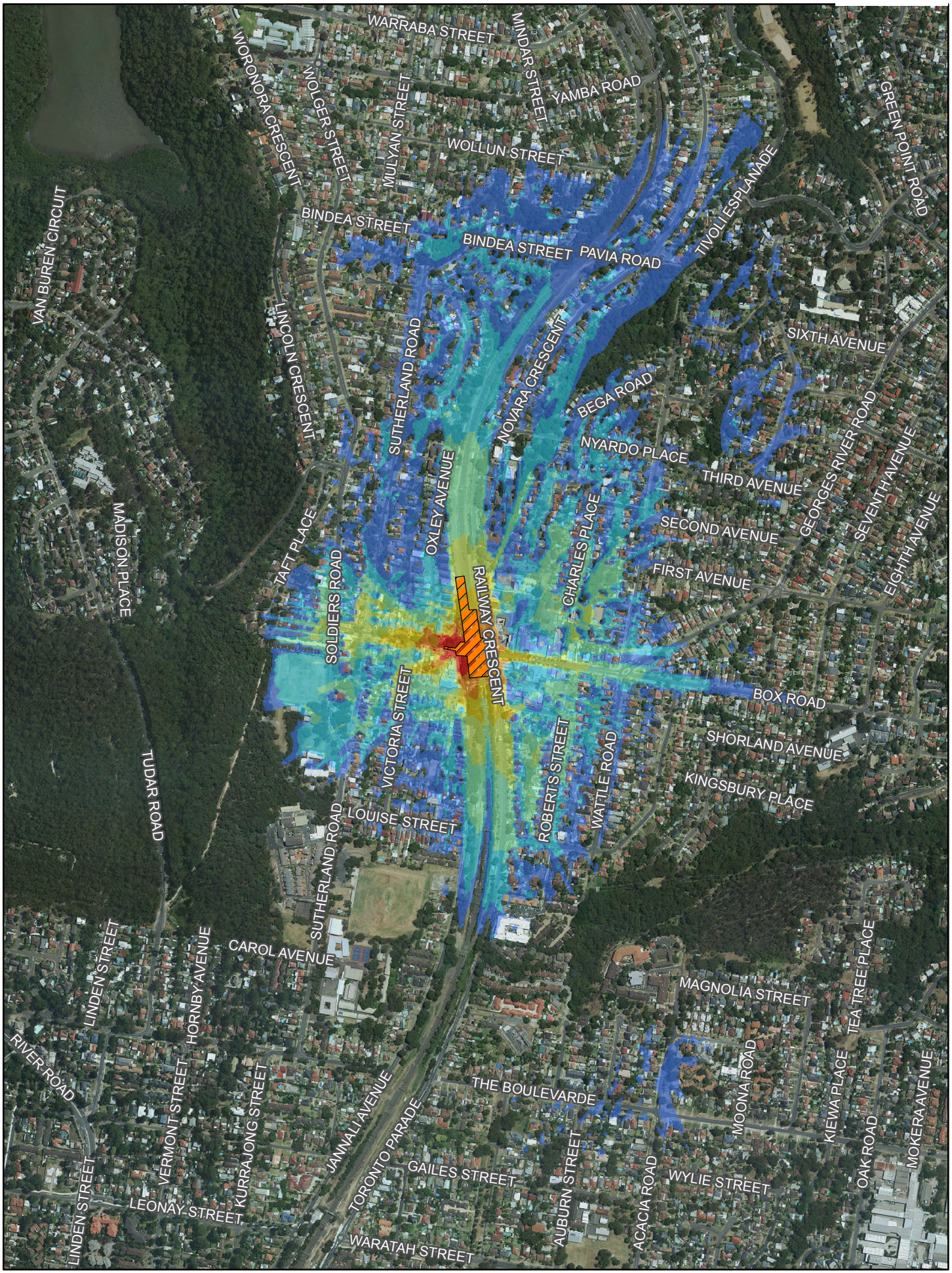
0 100 200 400 Meters

N

Nov 2015

60327214

Fig. **6**



Work Area

Sound Pressure Level, L_{Aeq}

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

Jannali Station Upgrade Works - Night-time possession

Construction of new pedestrian crossing

0 100 200 400 Meters

N

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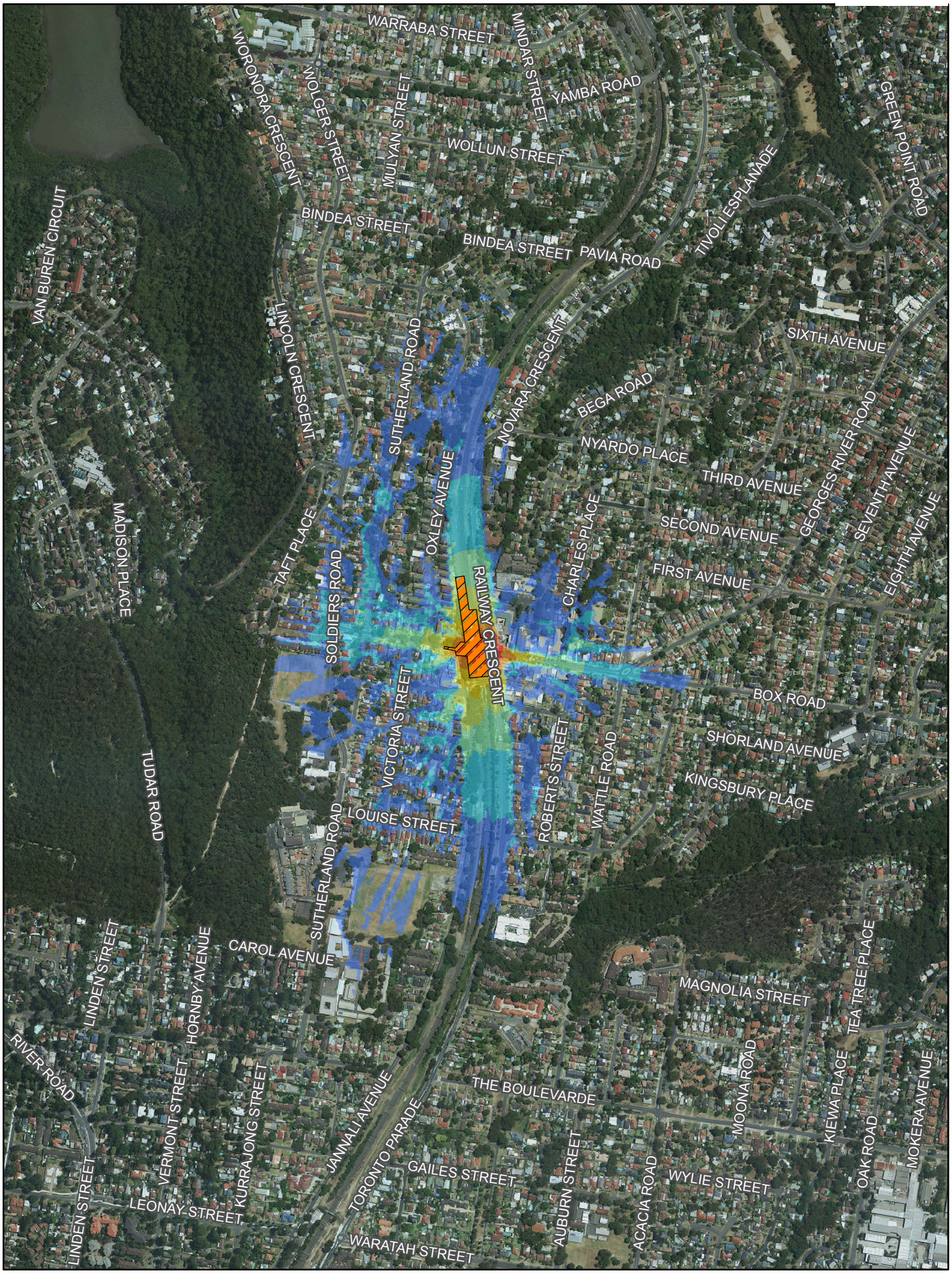
Fig. **7**



Work Area

Sound Pressure Level, L_{Aeq}

< 40 | 40 - 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70 | > 70

Jannali Station Upgrade Works - Evening possession

Installation of new bicycle racks

0 100 200 400 Meters

N

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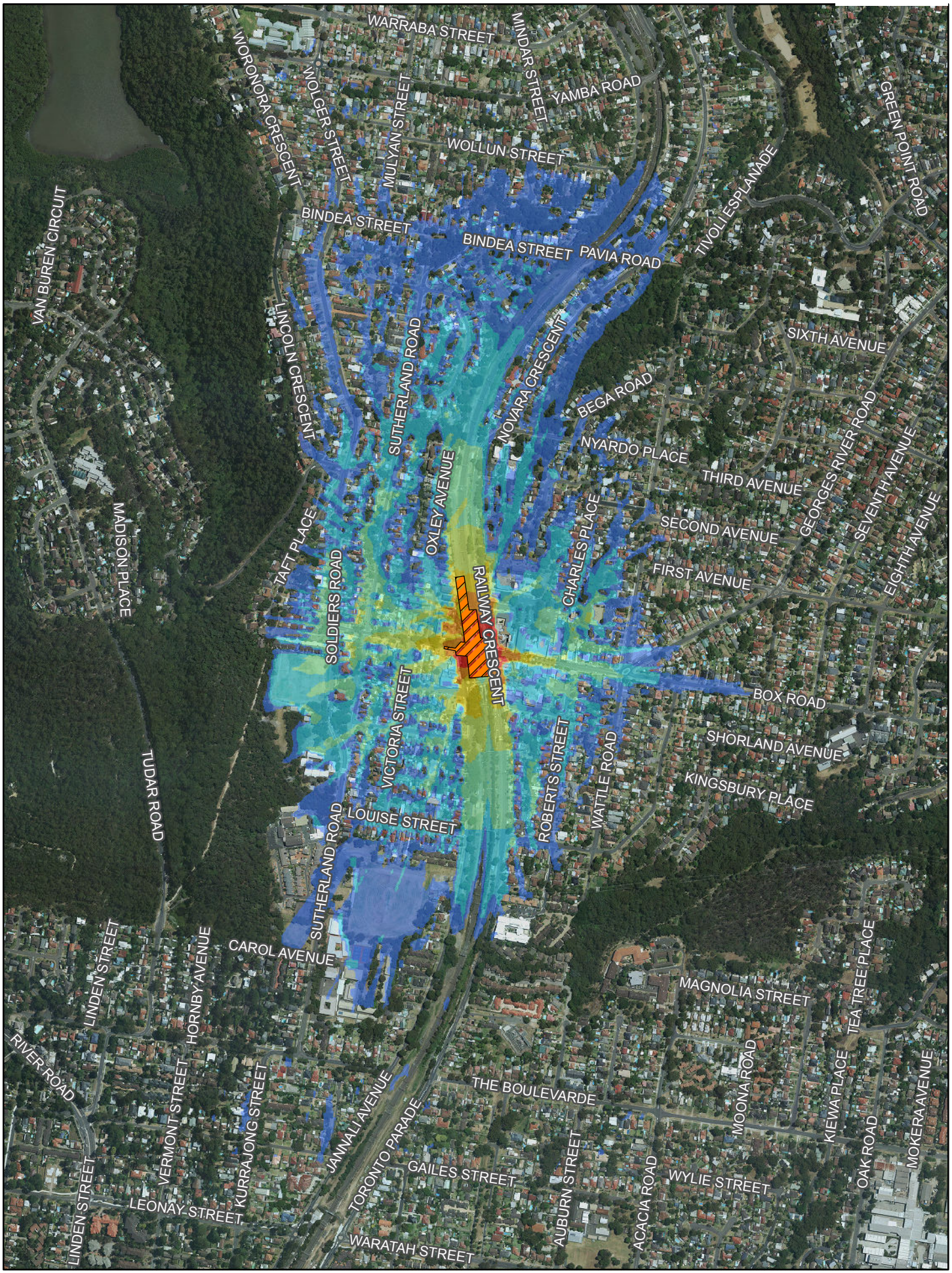
Fig. **8**

Appendix D

Sleep Disturbance L_{A1} Noise Contours



Work Area

Sound Pressure Level, L_{A1}

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

Jannali Station Upgrade Works - Night-time possession

Lifting of bridge span into position

0 100 200 400 Meters

N

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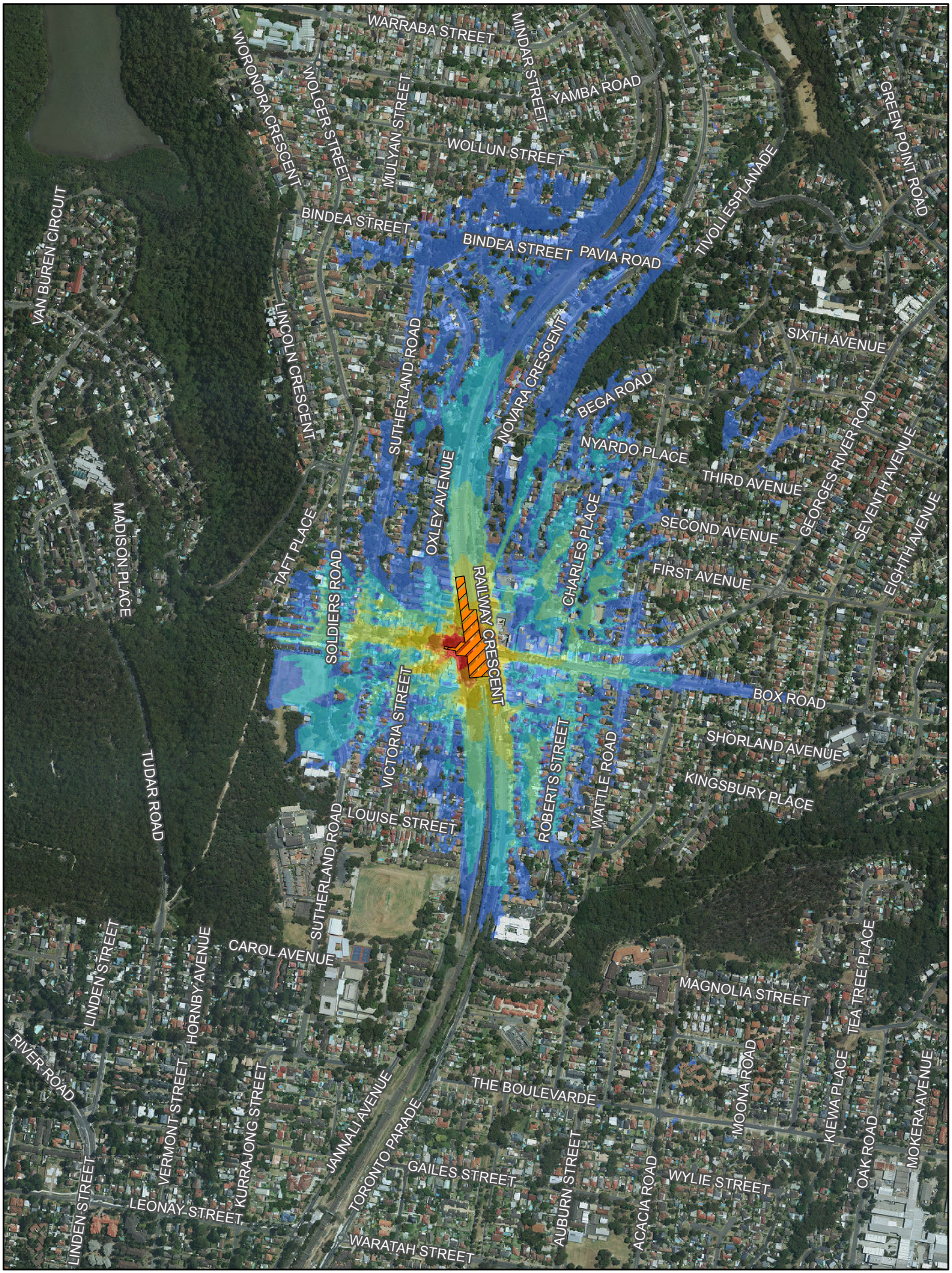
Fig. 1



Work Area

Sound Pressure Level, L_{A1}

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

Jannali Station Upgrade Works - Night-time possession

Construction of new pedestrian crossing

0 100 200 400 Meters

N

Nov 2015

60327214

Fig. **2**