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Hawkesbury River Station Upgrade

Noise and Vibration Impact Assessment

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Noise and Vibration Impact Assessment

Client: Transport for New South Wales

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Abbreviations

Term	Meaning
AADT	Annual Average Daily Traffic
CEMP	Construction Environmental Management Plan
CNVMP	Construction Noise and Vibration Management Plan
CTMP	Construction Traffic Management Plan
dB	Decibel
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EMS	Environmental Management System
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
EPI	Environmental Planning Instrument
EPL	Environment Protection Licence
ESD	Ecologically Sustainable Development (refer to Definitions)
Heritage Act	*Heritage Act 1977* (NSW)
ICNG	*Interim Construction Noise Guideline* (Department of Environment and Climate Change, 2009).
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007 (NSW)*
LEP	Local Environmental Plan
LGA	Local Government Area
NCA	Noise Catchment Areas
NML	Noise Management Level
NPfI	*Noise Policy for Industry* (Environment Protection Authority, 2017)
NSW	New South Wales
OEH	NSW Office of the Environment and Heritage
OOHW	Out of Hours Works
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
RailCorp	(former) Rail Corporation of NSW
RBL	Rating Background Level
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy
SHR	State Heritage Register
TfNSW	Transport for NSW
TMP	Traffic Management Plan
VDV	Vibration Dose Values

1.0 Introduction

1.1 Background information

Transport for NSW (TfNSW) is the government agency responsible for the delivery of major transport infrastructure projects in NSW and is the proponent for the Hawkesbury River Station Upgrade (the Proposal).

The Proposal is part of the Transport Access Program which is a NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure.

AECOM Australia Pty Ltd (AECOM) has been commissioned by TfNSW to undertake a Noise and Vibration Impact Assessment of the construction and operation of the Proposal. Construction of the Hawkesbury River Station Upgrade is expected to commence in late 2019 and take up to 18 months to complete. The construction works would primarily be undertaken during standard hours. Some works may need to occur outside standard hours and would include night works and works during routine rail shutdowns, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed, and trains are not operating.

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 Hawkesbury River Station.

1.3 Proposed works

The key features of the Proposal are summarised as follows:

- construction of two new lifts to provide access to the existing footbridge and station platforms, including associated landings and support structures
- provision of a kiss and ride space and accessible parking space within the Dangar Road carpark as well as an access path and pedestrian crossing from the carpark to the station entrance
- regrading of the footpath at the access points to the station on the Dangar Road side of the station and extending approximately 50 metres north east from the station entrance
- construction of a new family accessible toilet, a new unisex ambulant toilet, and a new staff toilet within the existing toilet facilities
- installation of a horizontal glass canopy over the entrance of the family accessible toilet
- installation of a new padmount transformer as well as ancillary electrical works to supply the station and new lifts with electricity
- ancillary works including adjustment to lighting, electrical upgrades, improvement to station communications systems (including CCTV cameras), hearing loops, wayfinding signage and installation of tactile ground surface indicators (TGSIs) as required.

A detailed description of the Proposal is provided in Chapter 3 of the *Hawkesbury River Station Upgrade Review of Environmental Factors* (AECOM, 2019).

1.4 Policies and guidelines

The following policies and guidelines are relevant for this assessment:

- *Interim Construction Noise Guideline* (ICNG), Department of Environment and Climate Change, 2009
- *Assessing Vibration: A Technical Guideline* (AVATG), Department of Environment and Conservation, 2006
- *NSW Road Noise Policy* (RNP), Department of Environment, Climate Change and Water, 2011
- *Noise Policy for Industry* (NPfI), Environment Protection Authority, 2017
- *Construction Noise and Vibration Strategy* (CNVS), Transport for NSW, 2018
- 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 1055-2018 – *Acoustics—Description and measurement of environmental noise*, 2018
- International Standard ISO 9613-2:1996 - *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*
- 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.

2.0 Existing acoustic environment

2.1 Site description

Hawkesbury River Station is located within a mainly residential suburban environment. The closest residential receivers are located on Brooklyn Road and William Street. Brooklyn Community Health Centre and Fitzies Fish and Chips are located to the south and south-east respectively of the station on the opposite side of Dangar Road. The station and its surrounding environment are shown in Figure 1.

Brooklyn Road and Dangar Road to the south-west and south-east of the station respectively, are considered to be sub-arterial roads as per categories within the *NSW Road Noise Policy*.

2.1.1 Representative receivers

To provide a comprehensive assessment, 14 representative residential receivers surrounding the Proposal, as listed in Table 1, have been selected to describe the noise impacts associated with the Proposal in accordance with the *Interim Construction Noise Guideline*. Residences located closest to the Proposal within each block were selected as the potentially worst affected receivers.

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

The locations of the residential and non-residential receivers identified for use in the assessment are presented in Figure 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 area, however as noted above, noise impacts have been assessed at representative worst-affected receivers.

Table 1 Representative receiver addresses – residential

Receiver ID	Receiver address	Approximate distance to Proposal in metres
R1	214 Brooklyn Road, Brooklyn	16
R2	139 Brooklyn Road, Brooklyn	16
R3	206 Brooklyn Road, Brooklyn	21
R4	192 Brooklyn Road, Brooklyn	26
R5	3 William Street, Brooklyn	50
R6	2 Karoola Street, Brooklyn	112
R7	21 Karoola Street, Brooklyn	130
R8	6 Bridge Street, Brooklyn	145
R9	10 George Street, Brooklyn	189
R10	Brooklyn Road, Brooklyn	160
R11	5 Government Road, Brooklyn	210
R12	168-172 Brooklyn Road, Brooklyn	301
R13	111 Brooklyn Road, Brooklyn	390
R14	16 James Road, Brooklyn	415

Table 2 Representative receiver addresses – non-residential

Receiver ID	Receiver address	Approximate distance to Proposal in metres
N1	Fitzies Fish and Chips	11
N2	Brooklyn Community Health Centre	16
N3	The Teahouse, 12 Dangar Road Brooklyn (currently closed)	17
N4	The Anglers Rest	23
N5	Brooklyn Milk Bar	36
N6	Brooklyn Marina	39

2.1.2 Noise Catchment Areas

To assist in determining noise criteria for the receivers surrounding the Proposal, a single noise catchment area (NCA) was identified as the noise environment at each of the residential receivers within the NCA is considered to have a similar noise environment. The NCA is shown in Figure 1.

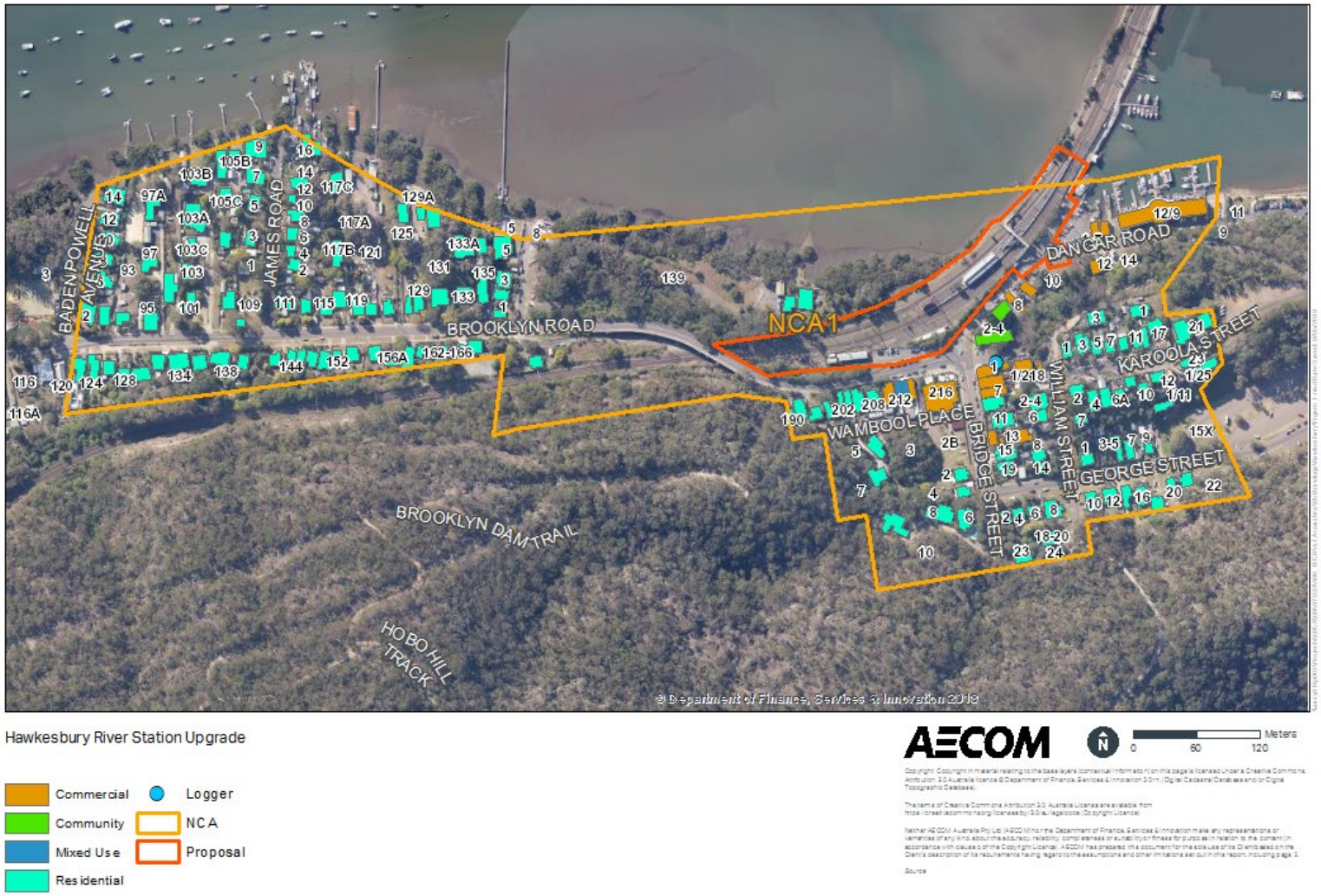

Figure 1 Noise and vibration receivers and logger locations

Figure 2 Representative receiver locations

2.1.3 Heritage items

The Hawkesbury River Railway Station group is listed as a heritage item and includes the station building and former signal box, platforms, footbridge, wharf, relay room and water spout.

In addition, the following buildings (as shown in Figure 3) are listed as heritage items:

- 206 Brooklyn Road, Brooklyn
- 208 Brooklyn Road, Brooklyn
- 212 Brooklyn Road, Brooklyn
- 6 Dangar Road, Brooklyn
- 10 Dangar Road, Brooklyn
- 1 Bridge Street, Brooklyn
- 3 Bridge Street, Brooklyn
- 5 Bridge Street, Brooklyn
- 7 Bridge Street, Brooklyn.

Figure 3 Heritage item locations

2.2 Noise measurement methodology

Long term unattended and short term attended measurements were undertaken to establish the existing ambient and background noise environment at potentially affected receivers. The location of the noise logger is shown in Figure 1.

2.2.1 Unattended noise measurement methodology

Long term unattended noise monitoring was conducted between 1 and 11 March 2019. One noise logger was placed at a representative location at the property indicated in Table 3 and shown in Figure 1. The noise logger was 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	1 Bridge Street, Brooklyn	Rion NL21	265112

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 within 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 *Noise Policy for Industry*, noise monitoring affected by adverse weather conditions or extraneous noise events should be excluded from the monitoring data. The *Noise Policy for Industry* 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 Terrey Hills weather station (station number 066059) located around ten kilometres north of the Proposal.

The logger measured 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 *Noise Policy for Industry* 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.

2.2.2 Attended noise measurement methodology

Attended noise measurements were conducted at the unattended monitoring location on 1 March 2019. The measurement was conducted over a 15 minute period. Weather conditions were overcast on the day of monitoring, with no wind.

Attended noise measurements were conducted using a Brüel & Kjær Type 2250 sound level meter. The sound level meter used is designated as a Type 1 instruments and has accuracy suitable for laboratory and field use. The sound level meter was calibrated before and after the measurements with a no drift in calibration 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).

2.3 Noise measurement results

2.3.1 Unattended noise measurement results

Table 4 also presents the existing overall representative L_{Aeq} ambient noise level and the background L_{A90} noise levels for the day, evening and night-time periods, in accordance with the *Noise Policy for Industry*. The overall representative L_{Aeq} noise levels were determined by logarithmically averaging each assessment period for the entire monitoring period.

The results for each day and the graphical noise logging results are presented in Appendix B.

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

Location	L_{A90} background Rating noise level, dB(A)			Log average noise (ambient) L_{Aeq} Levels dB(A)		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NCA 1	39	39	33	55	52	51

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.*

2.3.2 Attended noise measurements

The results of the attended noise monitoring are presented in Table 5.

Table 5 Attended noise measurements

Logger	Date	Time	L_{Aeq} dB(A)	L_{A90} dB(A)	Comments
1	1/03/2019	12:18	52	41	Freight train pass-by 55-60 dB(A). Pub voices clearly audible 43-45 dB(A). Slight bird noise and wind noise contributes to noise environment. Cicadas 40 dB(A). Local vehicle traffic 45-50 dB(A).

2.4 Existing noise environment summary

The acoustic environment is dominated by natural sounds and local vehicle traffic. Intermittent rail noise is also audible. 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 *Interim Construction Noise Guideline* is the principal guideline for the assessment and management of construction noise in NSW. As the proposed works are expected to continue for a period of more than three weeks and are within relatively close proximity to noise sensitive receivers, a quantitative assessment, based on 'reasonable' worst case construction scenarios, has been carried out for these works.

Noise levels resulting from construction activities are predicted at nearby noise sensitive receivers using environmental noise modelling software and compared to the noise management levels (NML), derived in accordance with the *Interim Construction Noise Guideline*.

Where an exceedance of the noise management levels is predicted, the *Interim Construction Noise Guideline* recommends certain measures be implemented to minimise adverse impacts.

The construction noise management levels (NML) for the residential and other sensitive land uses are detailed in Table 6, Table 7 and Table 8.

Table 6 ***Interim Construction Noise Guideline*** **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. • The *Interim Construction Noise Guideline* provides guidance on negotiating agreements.

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.*

The *Interim Construction Noise Guideline* 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."

Table 7 presents the NMLs applicable to residential receivers nearby to this development.

Table 7 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	39	49	75 (highly noise affected level)	44
	Evening	39	-		44
	Night	33	-		38

Table 8 presents the NMLs applicable to other noise sensitive receivers such as educational facilities and places of worship and to commercial receivers.

Table 8 Construction noise management levels – Other receivers

Land use	Noise management levels, $L_{Aeq,15min}$ (applies when properties are in use)
Community Hall	55 dB(A)[1]
Commercial premises (including offices, retail outlets)	70 dB(A)

Notes:

1. *This external management level is based upon a 45 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 *Interim Construction Noise Guideline* requires a sleep disturbance analysis where construction works are planned to extend over more than two consecutive nights. The 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 EPA 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. 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.

Sleep disturbance research presented in the *Road Noise Policy* concludes 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 9.

Table 9 Sleep disturbance criteria

Noise catchment area	Background noise level (L_{A90}), dB(A)	Sleep disturbance criteria, $L_{A1(1\ minute)}$, dB(A) (external)	
		Screening level	Awakening reaction
1	33	48	60 – 65

3.2 Construction traffic noise criteria

To assess noise impacts from construction traffic an initial screening test should be undertaken by evaluating whether existing road traffic noise levels will increase by more than 2 dB(A), in line with the

Road Noise Policy. Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. However, where the predicted noise level increase is greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion then noise mitigation should be considered for those receivers affected. The *Road Noise Policy* does not require assessment of noise impact to commercial or industrial receivers.

Dangar Road and Brooklyn Road provide the main road access to the site. These roads are classified as sub-arterial and are listed in Table 10. The external noise criteria are applied one metre from the external facade of an affected building.

Table 10 Roads used by construction traffic

Road	Type	Residential receivers	Estimated AADT[1]
Brooklyn Road	Sub-Arterial	Yes	500
Dangar Road	Sub-Arterial	No	500

Notes:

1. *Annual average daily traffic*

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)

Notes:

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

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

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

3.3.1 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 A*ssessing 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 13. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

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

Location	Daytime [1] Preferred	Daytime Max	Night time Preferred	Night time Max
Critical areas (examples include hospital operating theatres and precision laboratories where sensitive operations are occurring)	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions, commercial premises and places of worship	0.4	0.8	0.4	0.8
Workshops or factory environments	0.8	1.6	0.8	1.6

Notes:
1. Daytime is defined as 7:00 am to 10:00 pm. Night time is defined as 10:00 pm to 7:00 am

4.0 Operational noise criteria

The Proposal includes changes to the station only, it does not include changes to rail movements. As a result operation noise is to be assessed under the *Noise Policy for Industry*.

4.1 Noise Policy for Industry

The *Noise Policy for Industry* 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 *Noise Policy for Industry* 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.

4.1.1 Intrusive noise impacts

The *Noise Policy for Industry* 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 Noise Policy for Industry.

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)
NCA1 Residential receivers	Day	39	44
	Evening	39	44
	Night	33	38

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 *Noise Policy for Industry*. 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 project amenity level for a project is equal to the ‘recommended amenity level’ minus 5 dB. However, at this location the cumulative industrial noise is not a necessary consideration as no other industries are present or likely to be introduced. Therefore, relevant noise amenity level from Table 15 is assigned as the project amenity noise level. The project amenity level is then converted to a 15 minute period by adding 3 dB.

The amenity criteria applicable the Proposal are provided in Table 15.

Table 15 Amenity criteria

Type of receiver	Indicative noise amenity area	Time of day	Recommended Noise level, dB(A)	
			$L_{Aeq\ (period)}$	$L_{Aeq\ (15\ minute)}$
NCA 1 Residential receivers	Suburban	Day	50	53
		Evening	45	48
		Night	40	43
Commercial premises	All	When in use	65	68
Community Hall[1]	All	When in use	55	58

Notes:

1. External noise levels are based upon a 10 dB reduction from outside to inside through an open window.

4.1.3 Environmental noise emission criteria summary

A summary of the project specific noise levels is presented in Table 16 below in accordance with the NPfI. These criteria apply to environmental noise emissions from any plant installed as part of the Proposal and for residential receivers represent the lower of the intrusive and amenity criteria.

Table 16 Summary of environmental noise emission criteria

Location	Time of day	Project specific noise levels criteria[1] L_{Aeq}, dB(A)
NCA 1	Day	44
	Evening	44
	Night	38
Commercial premises	When in use	68
Community Hall	When in use	58

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5.0 Construction noise assessment

5.1 Construction stages and scheduling

In consultation with TfNSW, eight distinct work packages, each consisting of a number of construction activities, have been assumed to occur for the Proposal. These would be confirmed by the construction contractor prior to construction commencing and further assessment would be undertaken if required. These work packages are described in Table 17. All work packages have been assessed with the exception of Work package 8 – Testing and Commissioning as it is expected to be a relatively low noise impact activity. These work packages have been assessed as representative 'reasonable' worst-case construction scenarios for the Proposal.

Noise from activities within the construction compounds has been assumed to be minor in comparison to the noise generated by the worst case construction scenarios assessed.

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

Table 17 Construction assessment work packages and scheduling

Work package	Activities	Scheduling
1. Site establishment and enabling works	• establishment of construction compound (i.e. erect fencing, tree protection zones (TPZs) (if necessary), site offices, amenities and plant/material storage areas) • establishment of temporary facilities as required (e.g. hoarding, temporary toilets etc.)	Standard hours
2. Utility relocation	• re-routing of clashing utilities in corridor for impacted infrastructure • temporary diversion of low voltage line and other affected services • set up and installation of padmount transformer in the rail corridor adjacent to Dangar Road in preparation for power cutover • re-routing the remaining clashing utilities.	Standard hours
3. Earthworks and piling works	• for both lift locations, commence site preparation. The crane for both lifts would be set up in the car park off Dangar Road • mobilisation of piling rigs to access lift locations • temporary earthworks and dismantling of fencing and barriers to allow piling rigs to reach desired location.	Standard hours and rail shutdown periods
4. Lift installation works	• construction of foundation slab including excavation for lifts • removal of existing fencing and barriers • excavation of lift shaft well and establishment of foundations and formworks • insertion of piles at the both locations for new lift foundation • construction of lift shafts • installation of lifts • installation of drainage systems installation of cladding, fixtures, lighting, signage and CCTV cameras for the lift areas.	Standard hours and rail shutdown periods
5. Toilet and waiting area	• reconfiguration of the existing male toilet to create a family accessible toilet and reconfiguration of the existing female	Standard hours

Work package	Activities	Scheduling
reconfiguration works	toilet, to create a unisex toilet including a unisex ambulant toilet • regrading of existing platform within proximity to the station buildings to match the level of the buildings and amenities • reconfigure door entrance thresholds to lobby to toilet for accessibility • demolition old and installation of new anti-throw screens on station footbridge • services and fit-out works and electrical works (including any re-directed services/utilities).	
6. Station surrounds works	• line-marking of the accessible car space in the Dangar Road car park and one kiss and ride space • installation of signage, pedestrian crossings and tactiles as required • regrading of footpath at the station entrance points on the Dangar Road side of the station.	Standard hours and out of hours
7. Demobilisation	• dismantling of existing construction compounds/hoarding areas.	Standard hours
8. Testing and commissioning	• testing electrical, communications and signalling components. • commissioning of new lifts.	Standard hours

5.2 Construction sources

Noise sources and their respective L_{Aeq} sound power levels for each work package 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 work package

Equipment	Sound Power Level, dB(A)	Work package
Bobcat	104	1 ,3, 6, 7
Concrete pump	106	4, 6
Concrete truck	106	4, 6
Coring machine	110[1]	6
Demolition saw	110[1]	2, 4, 5
Excavator (with auger)	103	3
Franna crane	93	4
Generator	101	1, 4, 7, 8
Grinder	108	4, 5
Hand tools	94	1, 2 ,3, 4, 5, 6, 7, 8
Hydreama/hi-rail	94	4
Impact drill	107	5

Equipment	Sound Power Level, dB(A)	Work package
Jack hammer	108	4, 5, 6
Lighting tower	95	1, 2 ,3, 4, 6, 7, 8
Line marking truck	102	6
Manitou (forklift)	92	4
Mini excavator	94	2, 6
Mobile crane	104	4, 6
Nail gun	90	5
Piling rig (augered)	103	3
Plate compactor	105	6
Scissor lift	100	4
Trucks (semi-trailer and tipper)	98[1]	1, 2, 3, 4, 5, 6, 7
Vacuum truck	103	3
Wacker packer	104	6
250 tonne crane	100	3

Notes:

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 location of construction scenarios was based upon the PDF document titled "Hawkesbury Construction Scenarios".

The construction of the Proposal has been modelled in SoundPLAN Version 8.0. 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 and out-of-hours night-time noise management levels. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required.

During construction it is likely that all equipment would not be operating simultaneously at all times and in the one location, which would result in reduced noise levels compared with those predicted. As each construction work package would be occurring discretely, a cumulative noise impact is unlikely. Mitigation measures have been specified in Section 5.8 which may reduce the impact of these exceedances on receivers.

Noise results are presented graphically in Appendix C.

5.4.1 Summary of impacts during standard hours at residential receivers

Results show construction noise levels are predicted to exceed the noise management levels during standard hours for all assessed construction work packages at the closest representative receivers (R1 to R8 and R10), as shown in red in Table 20. It is noted that noise levels at the representative receivers shown in red also exceed the noise management levels for night works (refer Section 5.4.2 for further information).

The largest numbers of exceedances occur during Work package 4 – Lift installation works, however the highest noise levels are experienced during Work package 6 - Station surrounds works at R5. No residential receivers are predicted to be 'highly affected'.

Table 19 Predicted L_{Aeq} noise impacts at representative residential receivers for each work package during standard hours, dB(A)

Receiver ID	Distance (metres)	NML Stand-ard	Work Package						
			1	2	3	4	5	6	7
NCA 1									
R1	16	49	**59**	**61**	**61**	**67**	**52**	**55**	**60**
R2	16	49	**50**	**59**	**59**	**62**	**52**	**55**	46
R3	21	49	**55**	**64**	**58**	**63**	**52**	**54**	**59**
R4	26	49	**54**	**62**	**58**	**62**	**50**	**52**	**54**
R5	50	49	45	**52**	**62**	**61**	**58**	**70**	**50**
R6	112	49	46	49	**51**	**56**	43	47	47
R7	130	49	<38	43	**52**	**51**	**50**	**59**	<38
R8	145	49	41	48	49	**50**	47	**53**	48
R9	189	49	<38	<38	<38	43	<38	<38	<38
R10	160	49	<38	47	46	49	45	45	39
R11	210	49	<38	46	45	46	45	48	<38
R12	301	49	<38	45	44	46	42	45	<38
R13	390	49	<38	<38	<38	<38	<38	<38	<38
R14	415	49	<38	44	43	45	44	47	0

Notes:

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

5.4.2 Summary of impacts during night works at residential receivers

Results show construction noise levels exceed the NMLs at residential receivers during night works during construction work packages 3, 4 and 6, as shown in blue in Table 20. For Work package 4 construction noise levels are expected to exceed the NMLs at all representative receivers within the NCA with the exception of R13.

The largest number of exceedances occur during Work package 4 – Lift installation works, however the highest noise levels are experienced during Work package 6 - Station surrounds works at R5. Noise levels at receivers R1, R3, R4, R5 and R6 are predicted to exceed the noise management levels by more than 25 dB(A) at times. However, these exceedances would be limited to four rail possession periods and some night works for Stage 6. In addition, night works would not be undertaken for more than two consecutive nights.

Table 20 Predicted L_{Aeq} noise impacts at representative residential receivers for each work package outside standard hours, dB(A)

Receiver ID	Distance (metres)	NML Night	Work Package 3	4	6
NCA 1					
R1	16	38	**61**	**67**	**55**
R2	16	38	**59**	**62**	**55**
R3	21	38	**58**	**63**	**54**
R4	26	38	**58**	**62**	**52**
R5	50	38	**62**	**61**	**70**
R6	112	38	**51**	**56**	**47**
R7	130	38	**52**	**51**	**59**
R8	145	38	**49**	**50**	**53**
R9	189	38	<38	**43**	<38
R10	160	38	**46**	**49**	**45**
R11	210	38	**45**	**46**	**48**
R12	301	38	**44**	**46**	**45**
R13	390	38	<38	<38	<38
R14	415	38	**43**	**45**	**47**

Notes:

*1. Items in **BOLD BLUE** indicate the predicted noise levels at this receiver during this work stage exceed the night-time NML.*

5.4.3 Summary of impacts to non-residential receivers

Two non-residential receivers are predicted to be exposed to noise levels which exceed the NMLs as shown in orange in Table 21. These are the Brooklyn Community Health Centre during all the assessed work packages and the Teahouse at 12 Dangar Road during Work package 6 – Station surrounds works. Key noisy activities include the use of concrete saws, coring machines and jack hammers.

Table 21 Predicted noise impacts at representative non-residential receivers, dB(A)

Receiver ID	Distance (metres)	NML	Work Package						
			1	2	3	4	5	6	7
N1	11	70	50	58	65	64	61	67	52
N2	16	55	**56**	**57**	**60**	**65**	**56**	**61**	**59**
N3	17	70	44	54	62	62	56	**72**	48
N4	23	70	60	58	64	68	54	58	61
N5	36	70	56	54	60	64	51	59	59
N6	39	70	40	54	56	58	53	64	46

Notes:

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

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 rail shutdown periods). Appendix C presents the predicted maximum $L_{A1(1min)}$ noise level contours. The awakening reaction criterion of 65 dB(A) is predicted to be exceeded at residences along Brooklyn Road, William Street and Karoola Street (those within about 100 m of the construction site (including receivers R1 to R5) for work packages 3, 4 and 6.

The predicted construction $L_{A1(1min)}$ noise levels presented in Appendix C 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 slightly 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.

Construction activities would be undertaken during the daytime where feasible.

5.6 Construction traffic assessment

The numbers of construction vehicles have been estimated by TfNSW as up to 30 light and 5 heavy vehicles per day during peak construction periods. Vehicles would access the site via Brooklyn Road and Dangar Road.

Traffic noise levels during construction may increase by more than 2 dB on Brooklyn Road and Dangar Road however the overall traffic noise level (including construction traffic) is expected to be less than 55 dB(A) during the daytime, which complies with the *Road Noise Policy* criteria.

To minimise the construction traffic noise levels and reduce the risk of negative impacts occurring, construction traffic management 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 minimum working distances of these items of equipment from off-site receivers are shown in Table 22 which is based on recommendations of the TfNSW *Construction Noise and Vibration*

Strategy. If these minimum working distances are complied with no adverse impacts from vibration intensive works are likely in terms of human response or cosmetic damage.

As shown in section 2.1.3, there are a number of heritage items within the vicinity of the construction works including the station itself. It is unlikely that construction works will be within the minimum working distances to nearby heritage residential and commercial properties, however they may be within these distances to the station.

If vibration intensive works are required within these minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in Section 5.8.

Table 22 Minimum working distances of vibration intensive equipment to be used during the Proposal

Plant	Rating/ Description	Cosmetic	damage	Human response
		Heritage	Residential/commercial	
Jackhammer	Handheld	1 m (nominal)	1 m (nominal)	Avoid contact with structure
Wacker packer[1]	Handheld	8 m	5 m	15 m to 20 m
Bored piling	≤ 800 mm	4 m	2 m	N/A

Notes:

1. *No recommendations provided in the Construction Noise and Vibration Strategy 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 feasible and reasonable safeguards to manage the noise emissions from the site and any complaints which may occur due to construction noise. The CNVMP should include, as a minimum, the following:

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

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

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

Action required	Safeguard details
Management measures	
Implement any project specific mitigation measures required	In addition to the measures set out in this table, any project specific mitigation measures identified in this report.
Implement stakeholder consultation measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities, will be delivered to sensitive receivers at least 7 days prior to commencement of relevant works.
Site inductions	All employees, contractors and subcontractors will 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.
Noise Monitoring	A noise monitoring program will 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 program will be developed in accordance with the CNVMP and any approval/licence conditions. The results will be reviewed to determine if additional mitigation measures are required. All measurements will be undertaken in accordance with Australian Standard *1055.2018 – Acoustics – Description and measurement of environmental noise.*

Action required	Safeguard details
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction will be carried out during the standard daytime working hours. Should out-of-hours works be required an out-of-hours works application form will be submitted to TfNSW for approval on a case-by-case basis. Work generating high noise and/or vibration levels will be scheduled during less sensitive time periods as far as practicable. This will include the use of demolition saws, coring machines, grinders, impact drills and jackhammers.
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack hammering) will only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work will be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Equipment selection	Quieter and less vibration emitting construction methods will be used where feasible and reasonable (e.g. rubber wheeled instead of steel tracked plant). Equipment will be regularly inspected and maintained to ensure it is in good working order.
Maximum noise levels	The noise levels of plant and equipment will have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions will be considered as part of the selection process.
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver will be avoided. The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled down or shut down. Plant and vehicles will be turned off when not in use. Noise-emitting plant will be directed away from sensitive receivers where reasonable and feasible.
Plan works site and activities to minimise noise and vibration	Traffic flow, parking and loading/unloading areas will be planned to minimise reversing movements within the site. Truck drivers will be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising the use of engine brakes, and no extended periods of engine idling).
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.

Action required	Safeguard details
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. Site access points and roads will be selected as far as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.
Silencers on Mobile Plant	Where possible, noise from mobile plant will be reduced through additional fittings including: • Residential grade mufflers • Silencing air parking brake engagement.
Construction Related Traffic	Vehicle movements will be routed away from sensitive receivers and scheduled during less sensitive times. The speed of vehicles will be limited and the use of engine compression brakes will be minimised. On-site storage capacity will be maximised to reduce the need for truck movements during sensitive times.
Vibration minimum working distances	If vibration intensive equipment is to be used within the minimum working distances for cosmetic damage, as presented in Table 22, then it is recommended that attended vibration measurements are undertaken when work commences, to determine “site specific minimum working distances”. The minimum working distances for cosmetic damage from Table 22 are generally considered to be conservative. Working within them would not necessarily result in damage however as factors such as work practices and intervening structures can affect vibration levels. In addition, vibration intensive work should not proceed within the site specific minimum working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (e.g. via flashing light, audible alarm, SMS) when vibration levels are approaching the peak particle velocity objective. It is also advisable to carry out building condition surveys of sensitive historical structures before construction works begins.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources will be enclosed or shielded to the greatest extent possible whilst ensuring that the occupational health and safety of workers is maintained.
Shield sensitive receivers from noisy activities	Structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) will be used.

5.8.2 Community consultation and complaints handling

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

The information provided to the residents will 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 will be detailed in a Community Liaison Plan for the construction of the Proposal and will include a 24 hour hotline and complaints management process.

5.8.3 TfNSW Construction Noise and Vibration Strategy - Additional mitigation measures

TfNSW's *Construction Noise and Vibration Strategy* 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 *Construction Noise and Vibration Strategy* recommends the implementation of additional mitigation measures. These mitigation measures are specified within the *Construction Noise and Vibration Strategy* and presented in Table 24.

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

Table 24 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) Saturday (8am-1pm) Sun/Pub Hol (Nil)	-	-	LB, M	LB, M
Out of Hours Work Period 1	Weekday (6pm-10pm) Saturday (7-8am) & (1-10pm) Sun/Pub Hol (8am-6pm)	-	LB	LB, M	LB, M, IB, RO, PC, SN
Out of Hours Work Period 2	Weekday (10pm-7am) Saturday (10pm-8am) Sun/Pub Hol (6pm-7am)	LB	LB, M	LB, M, IB, PC, SN	LB, M, IB, PC, SN, AA

Notes:

1. Action level is $L_{Aeq(15\ minute)}$ noise level above background (RBL) - qualitative assessment of noise levels

2. The following abbreviations have been used (refer to Table 25 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 25 outlines the additional mitigation measures, as outlined in the *Construction Noise and Vibration Strategy*.

Table 25 Description of additional mitigation measures

Abbreviation	Mitigation measure	Explanation
LB	Letter Box Drops	All residences should be notified as a minimum by letterbox drop seven 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 two new lifts and refurbished toilet facilities (including mechanical ventilation systems) 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 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 *Noise Policy for Industry.* Operational noise criteria are presented in Section 4.0.

7.0 Conclusions

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

The Proposal is expected to commence in late 2019, take up to 18 months to complete and would be undertaken during both standard construction hours and out-of-hours. The construction works would primarily be undertaken during standard hours. Some works may need to occur outside standard hours and would include night works and works during routine rail shutdowns, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed and trains are not operating. A number of weekend rail shutdowns are likely to be required over the construction period.

Construction work packages have been developed in consultation with TfNSW and the proposed equipment has been detailed within this report. Seven distinct work packages were used in a computer-based noise model to determine the potential changes to noise levels. Construction noise impacts were assessed at 14 representative residential receivers surrounding the Proposal. Impacts were also assessed at representative nearby non-residential sensitive receivers, including Fitzies Fish and Chips, Brooklyn Community Health Centre, The Teahouse at 12 Dangar Road Brooklyn (currently closed), Hawkesbury River Marina, The Anglers Rest and the Brooklyn Milk Bar.

7.1 Construction noise

The predicted construction noise levels exceed the construction noise management levels for all scenarios at the closest residential and commercial receivers. Noise exceedances are generally unavoidable given the proposed works and proximity to receivers, notwithstanding the implementation of feasible and reasonable noise mitigation measures. The largest impacts would be experienced by residents along Brooklyn Road and Karoola Street. No residents are predicted to be 'highly affected' during any of the Work packages.

Implementation of mitigation measures outlined in Section 5.8 would aim to minimise and manage noise impacts where possible. Mitigation measures have been recommended in line with TfNSW's *Construction Noise and Vibration Strategy* in order to minimise and manage the impact of construction noise on nearby noise sensitive receivers.

7.2 Construction vibration

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

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 lifts, however these are 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 *Noise Policy for Industry.*

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.
Noise catchment area [NCA]	The noise environment at each of the sensitive receivers within a noise catchment area is considered to be similar to the unattended monitoring location within that NCA.
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 *Noise Policy for Industry* and the EPA's *Road Noise Policy*.

Appendix B

Noise Logging

Noise Logger Report

1 Bridge Street, Brooklyn

Item	Information
Logger Type	Rion NL21
Serial number	265112
Address	1 Bridge Street, Brooklyn
Location	Front Yard
Facade / Free Field	Facade
Environment	Freight train pass-by 55-60 dB(A). Pub voices clearly audible 43-45 dB(A). Slight bird noise and wind noise contributes to noise environment. Cicadas 40 dB(A). Local vehicle traffic 45-50 dB(A)

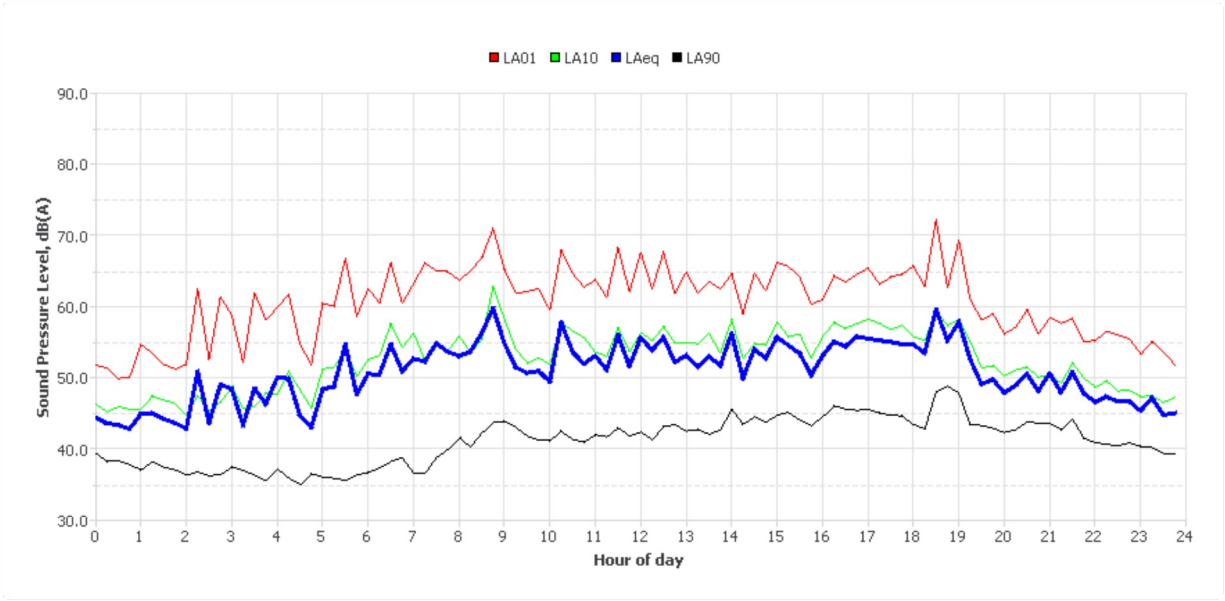
Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Fri Mar 1 2019	54	50	49	-	-	-	52	49
Sat Mar 2 2019	54	51	49	-	40	33	53	49
Sun Mar 3 2019	54	51	48	-	-	32	53	48
Mon Mar 4 2019	54	49	56	39	38	34	53	56
Tue Mar 5 2019	53	55	52	37	37	33	54	52
Wed Mar 6 2019	58	51	49	-	-	-	57	49
Thu Mar 7 2019	56	49	48	-	36	32	54	48
Fri Mar 8 2019	55	52	54	-	40	31	54	54
Sat Mar 9 2019	53	51	49	-	40	33	52	49
Sun Mar 10 2019	56	51	46	42	-	32	55	46
Mon Mar 11 2019	56	-	53	-	-	-	56	53
Summary	**55**	**51**	**51**	**39**	**39**	**33**	**54**	**51**

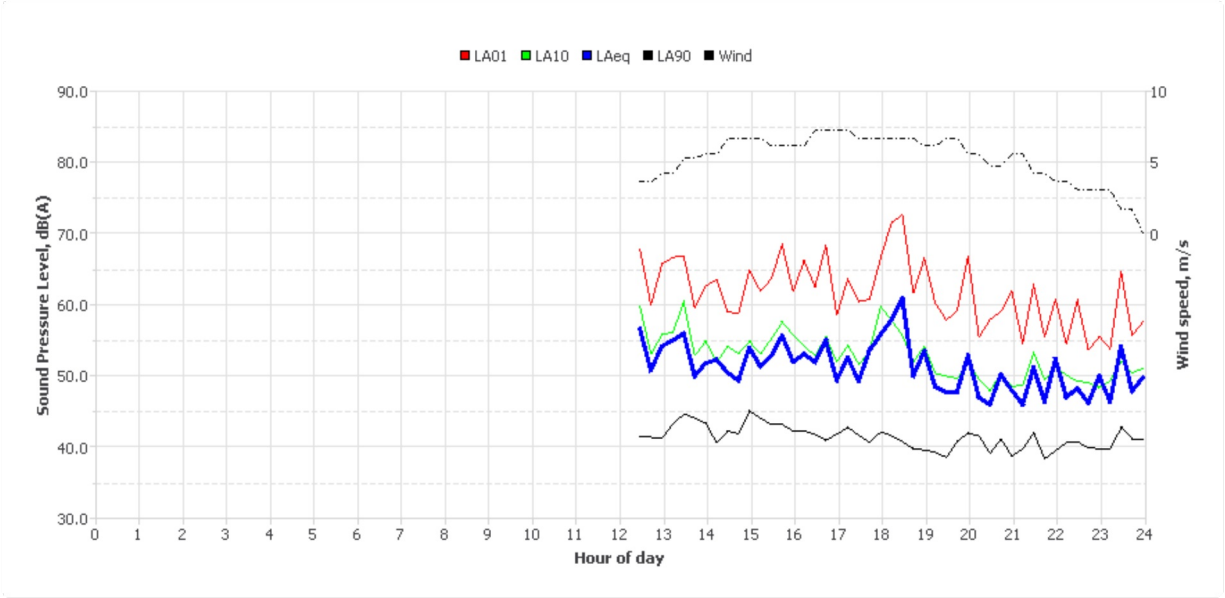
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

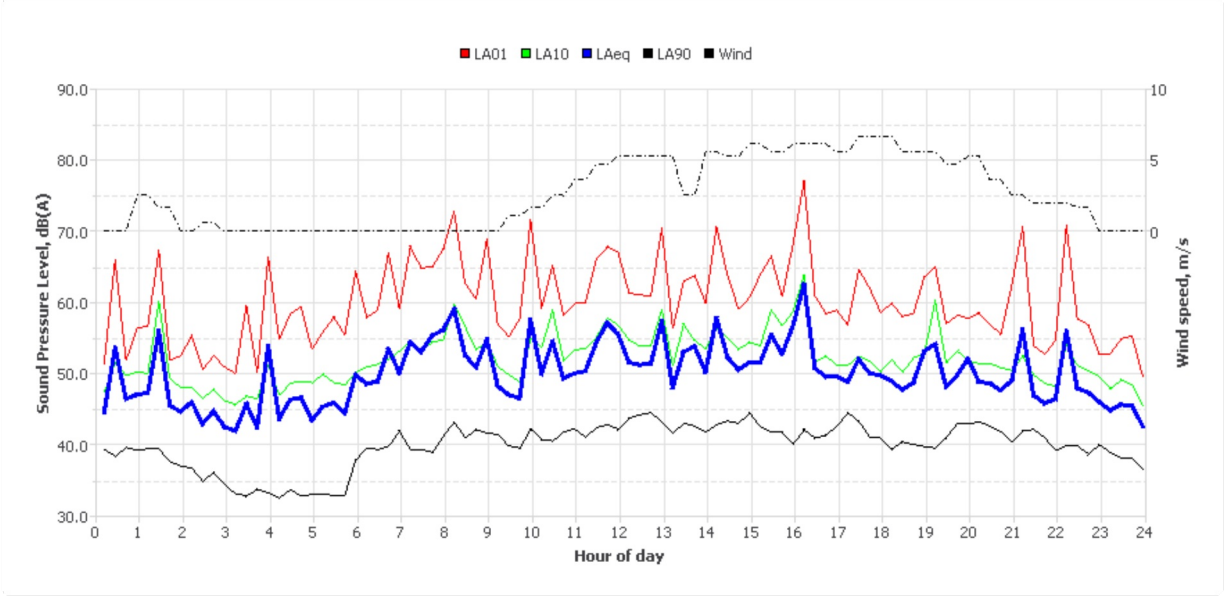
Typical Day



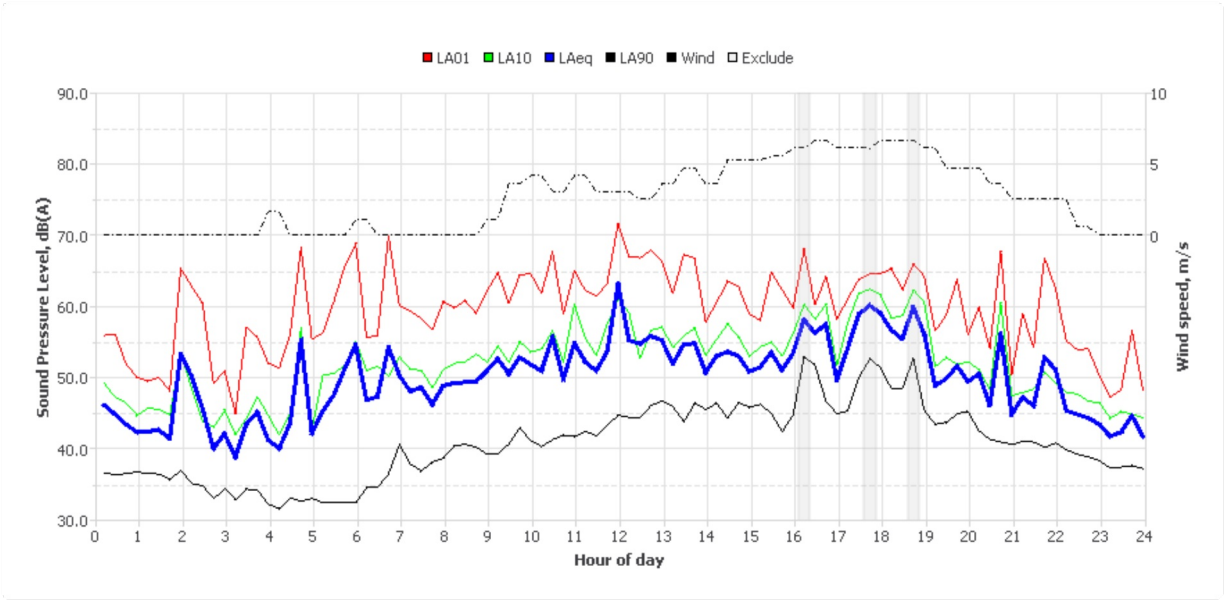
Friday, 01 Mar 2019



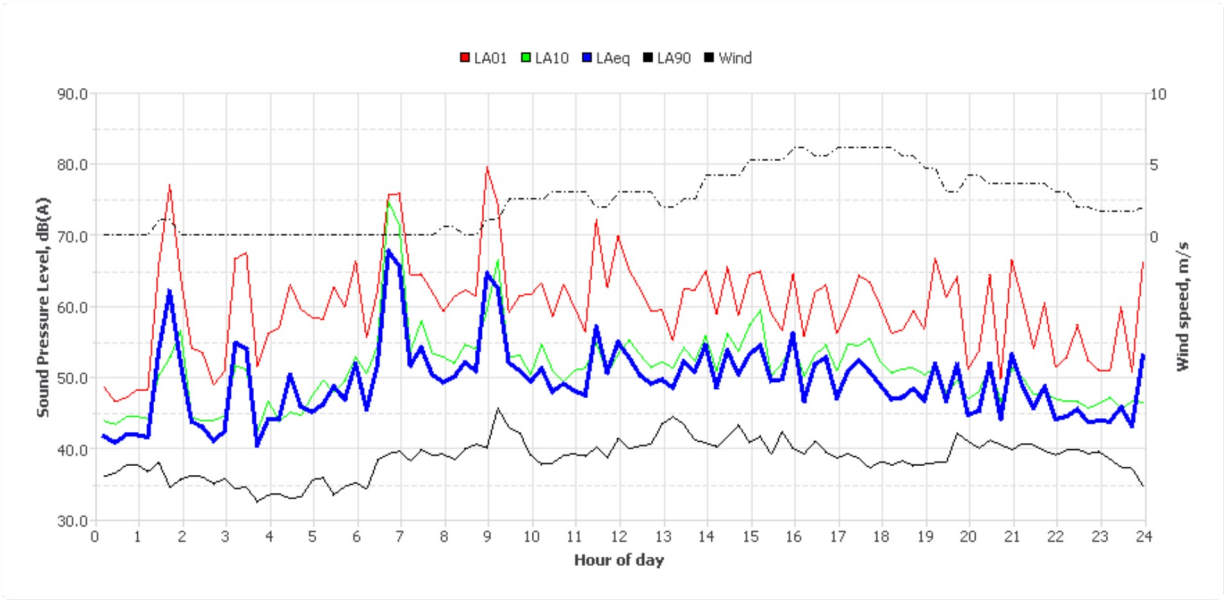
Saturday, 02 Mar 2019



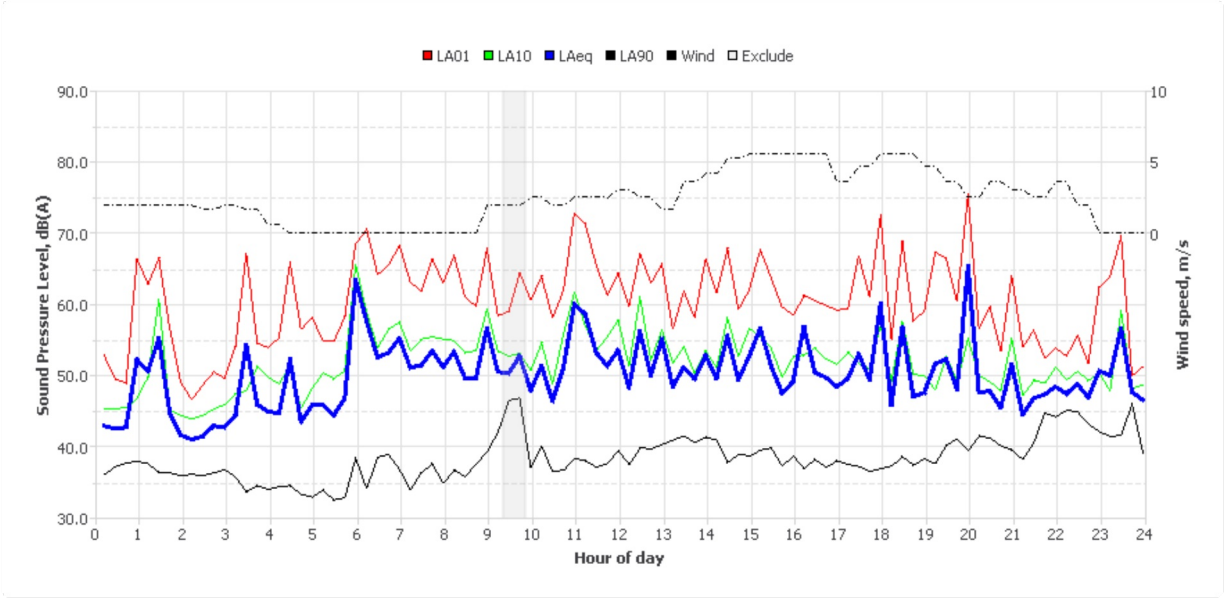
Sunday, 03 Mar 2019



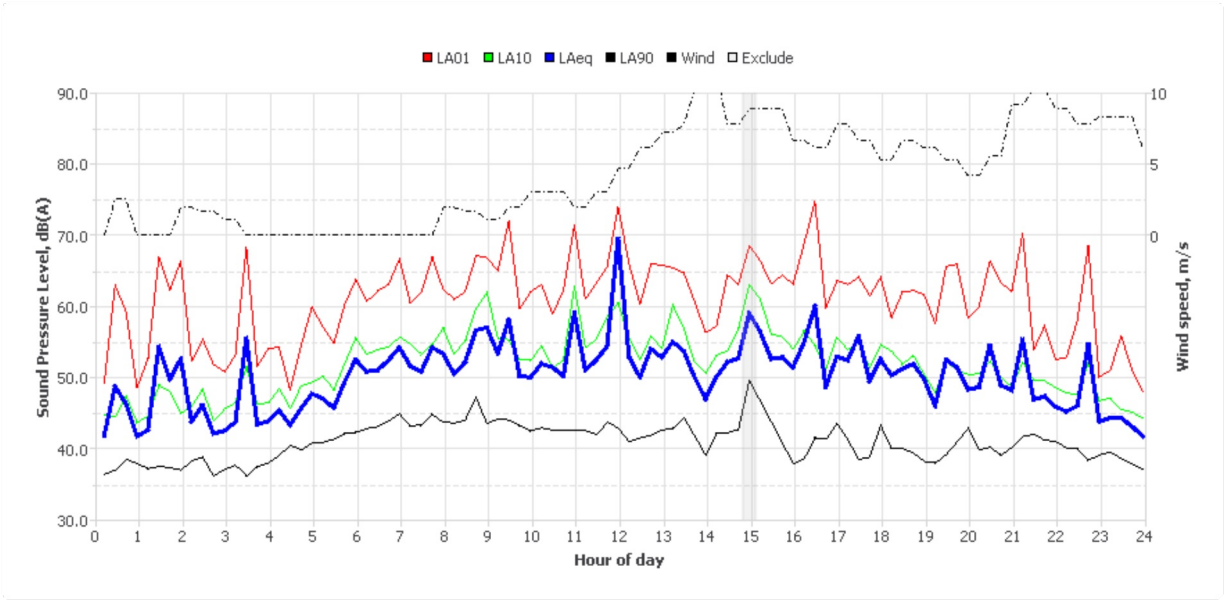
Monday, 04 Mar 2019



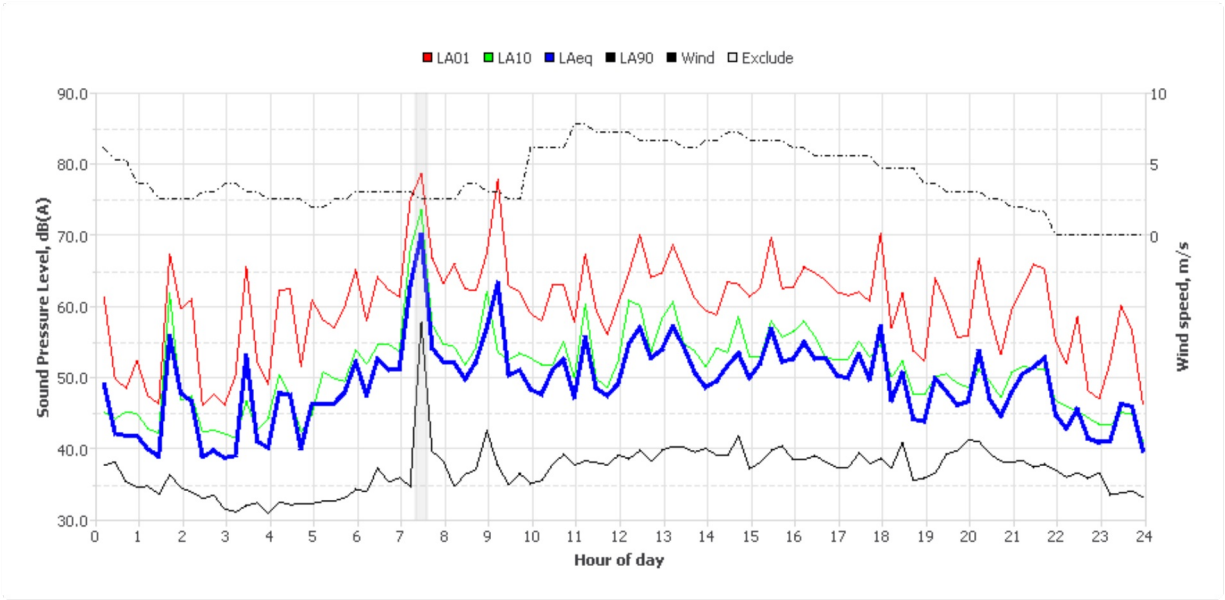
Tuesday, 05 Mar 2019



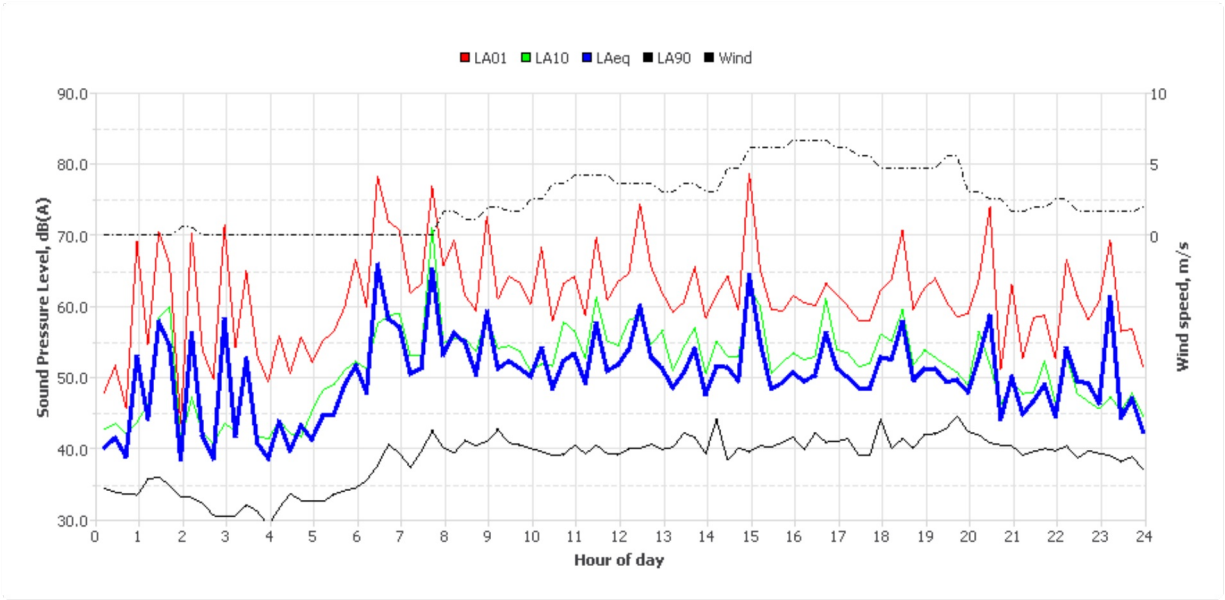
Wednesday, 06 Mar 2019



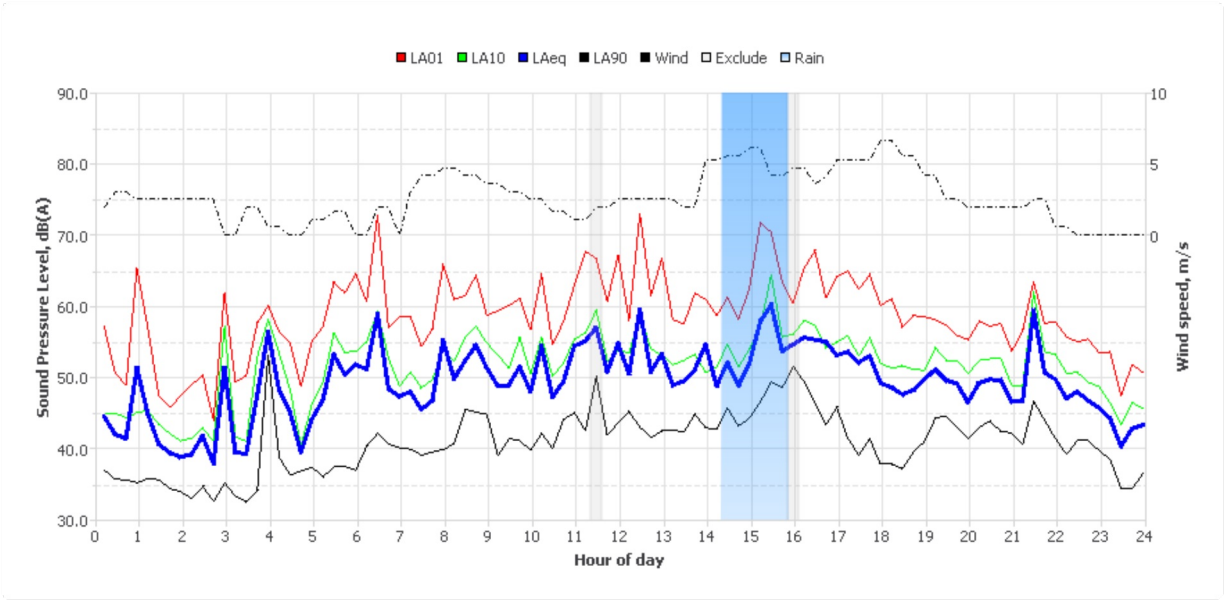
Thursday, 07 Mar 2019



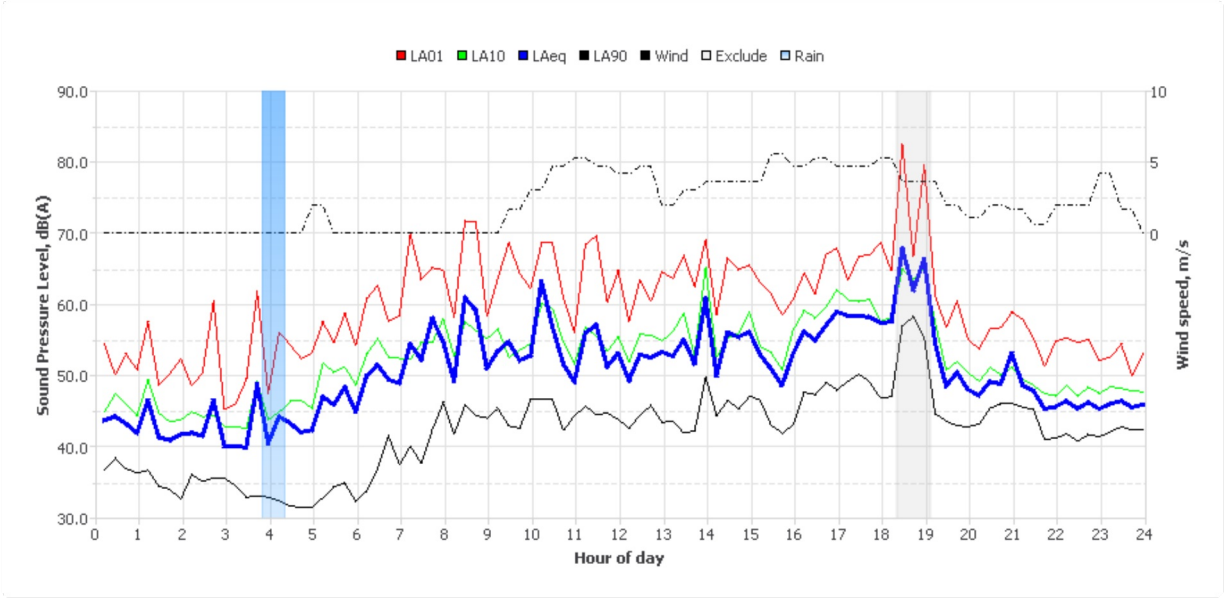
Friday, 08 Mar 2019



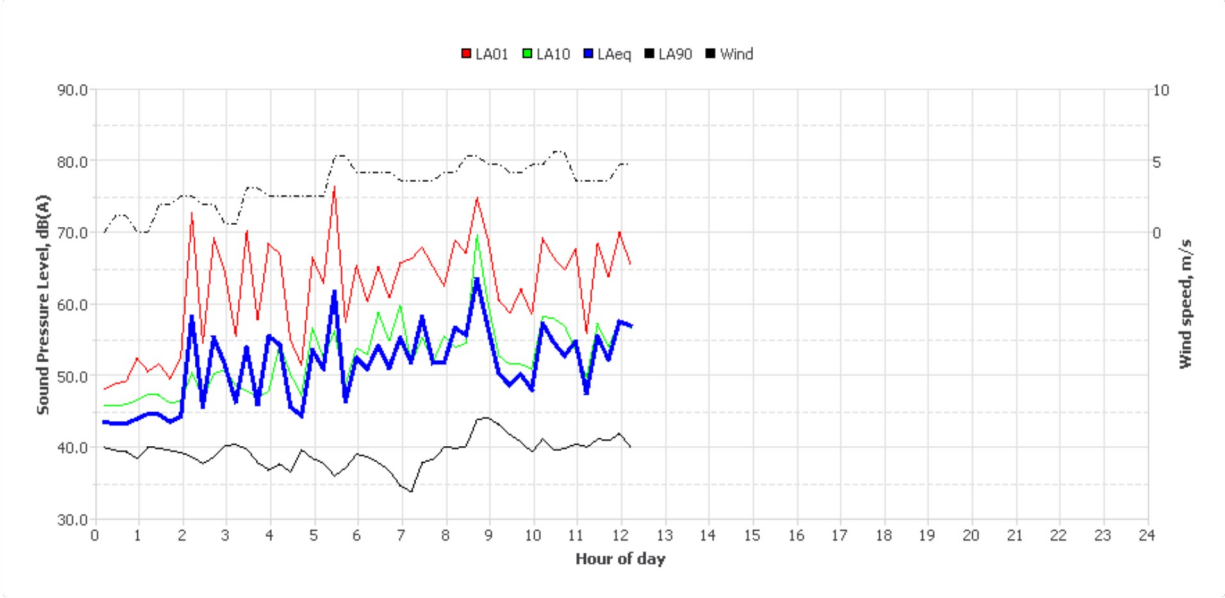
Saturday, 09 Mar 2019



Sunday, 10 Mar 2019

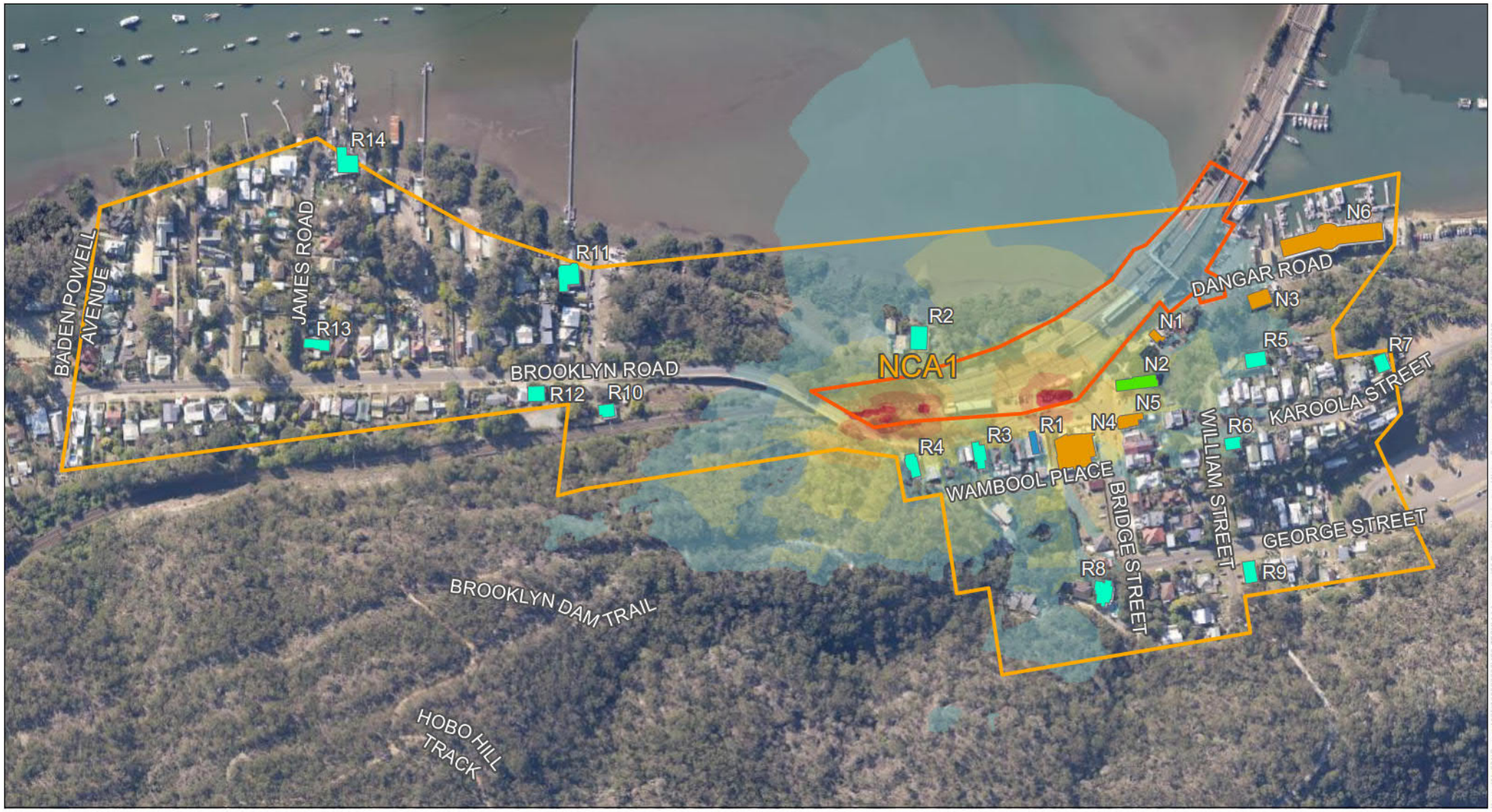


Monday, 11 Mar 2019



Appendix C

Predicted Noise Contours - Construction



Hawkesbury River Station Upgrade - Site establishment and enabling works - WP1

Commercial
Community
Mixed Use
Residential
NCA
Proposal

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

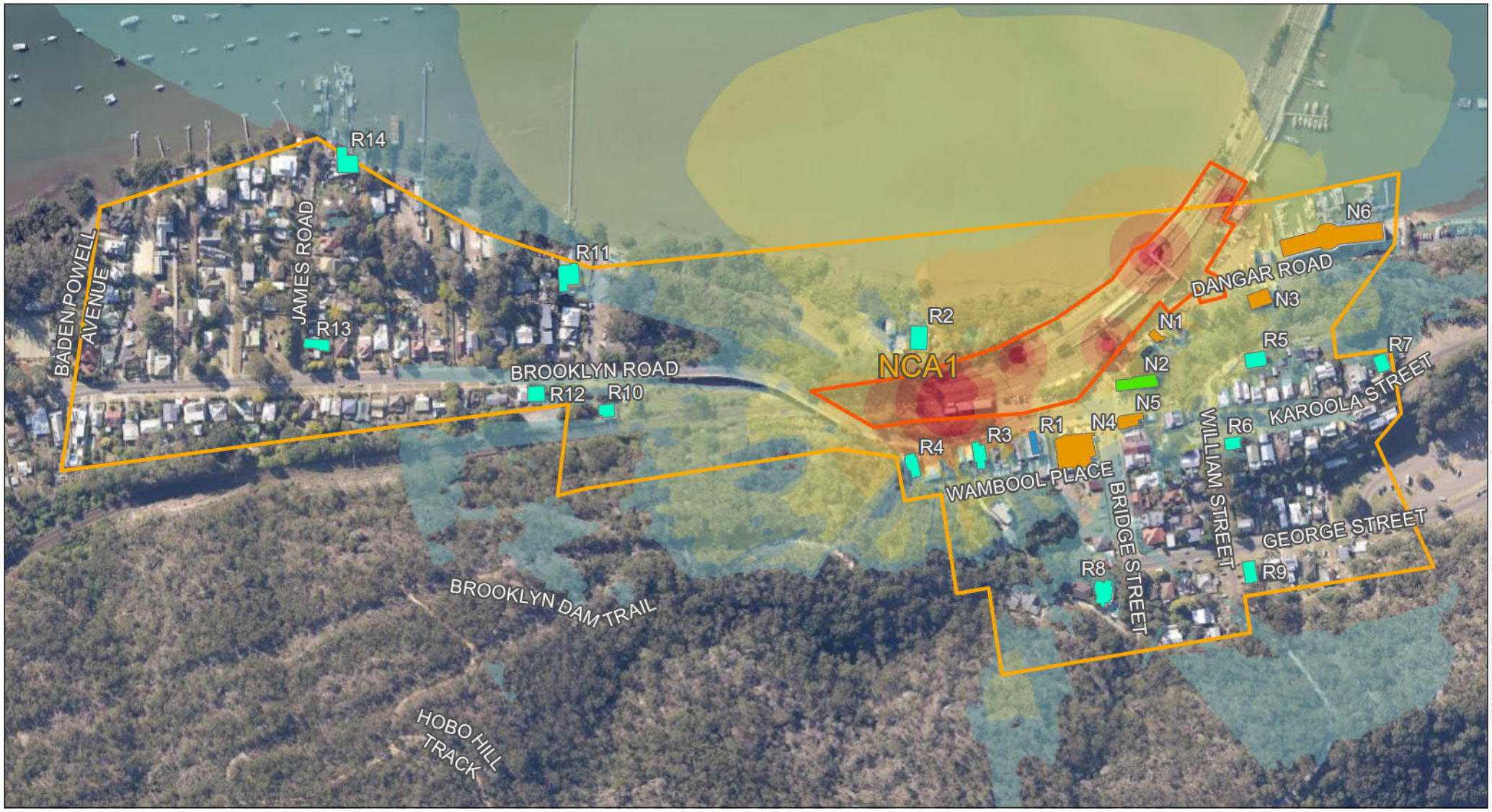
40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:



Hawkesbury River Station Upgrade - Utility relocation - WP2

Commercial
Community
Mixed Use
Residential
NCA
Proposal

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

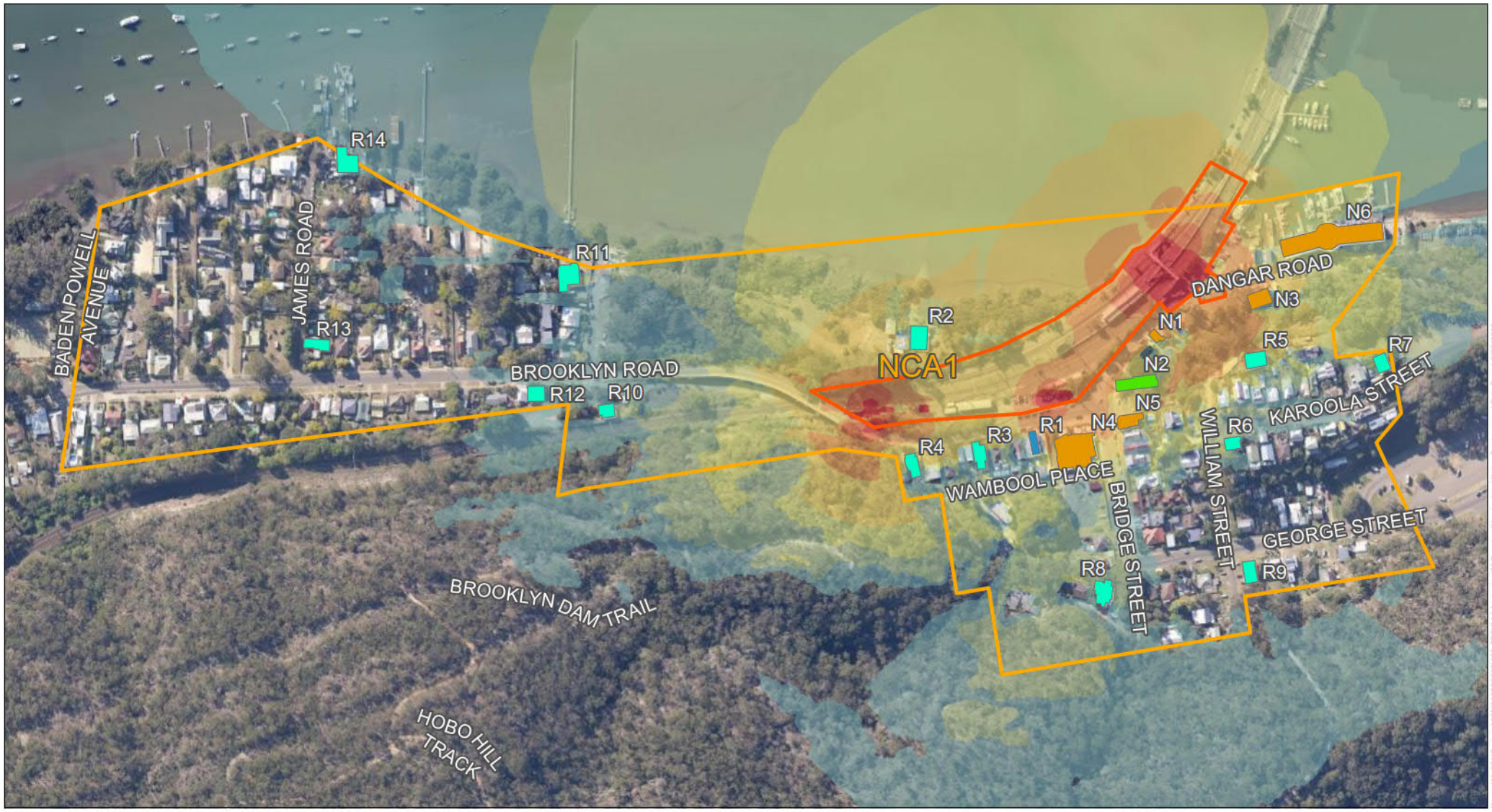
40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:



Hawkesbury River Station Upgrade - Earthworks and piling works - WP3

Commercial
Community
Mixed Use
Residential
NCA
Proposal

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

40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:

Hawkesbury River Station Upgrade - Lift installation works - WP4

Commercial
Community
Mixed Use
Residential

NCA
Proposal

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

40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:

Hawkesbury River Station Upgrade - Station, toilet and waiting area reconfiguration works - WP5

Commercial
Community
Mixed Use
Residential
NCA
Proposal

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

40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:

Hawkesbury River Station Upgrade - Station surrounds works - WP6

Commercial
Community
Mixed Use
Residential

NCA
Proposal

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

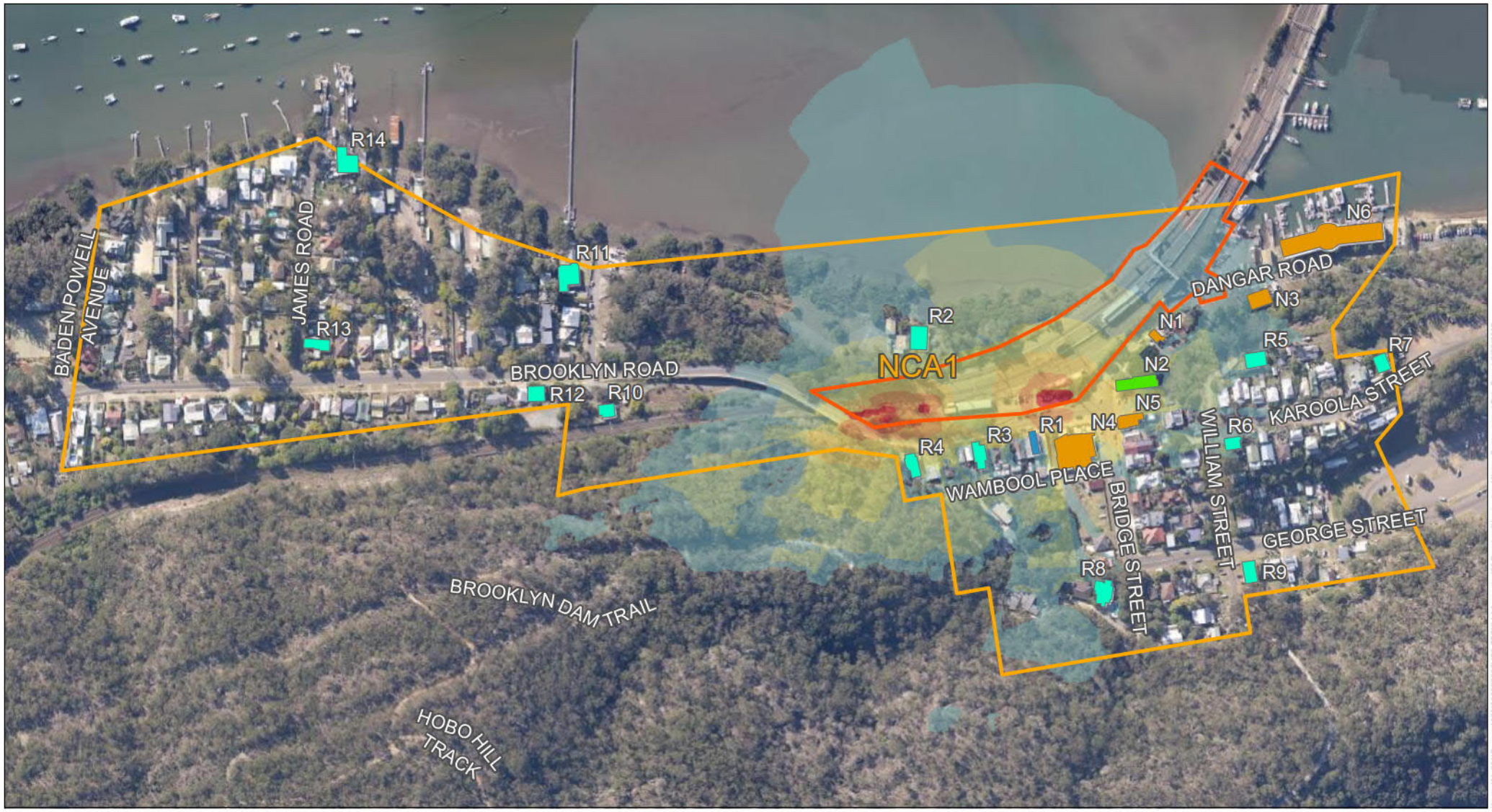
40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:



Hawkesbury River Station Upgrade - Demobilisation - WP7

Commercial
Community
Mixed Use
Residential
NCA
Proposal

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

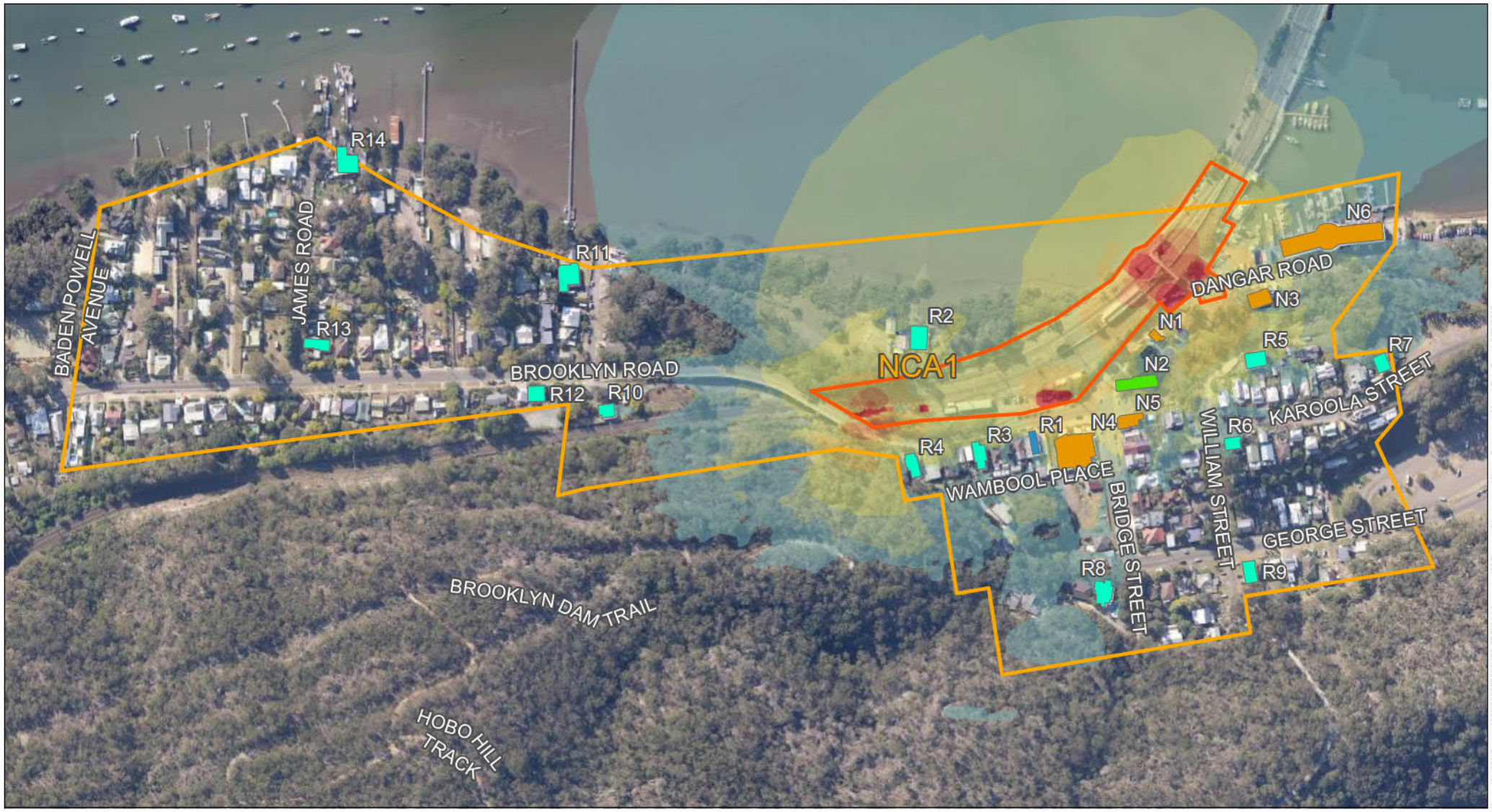
40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | 65 - 69 | > 69

AECOM

N

0 60 120 Meters

Source:



Hawkesbury River Station Upgrade - Earthworks and piling works - WP3

Commercial
Community
Mixed Use
Residential

NCA
Proposal

Sound Pressure Level, L_{A1} dB(A)

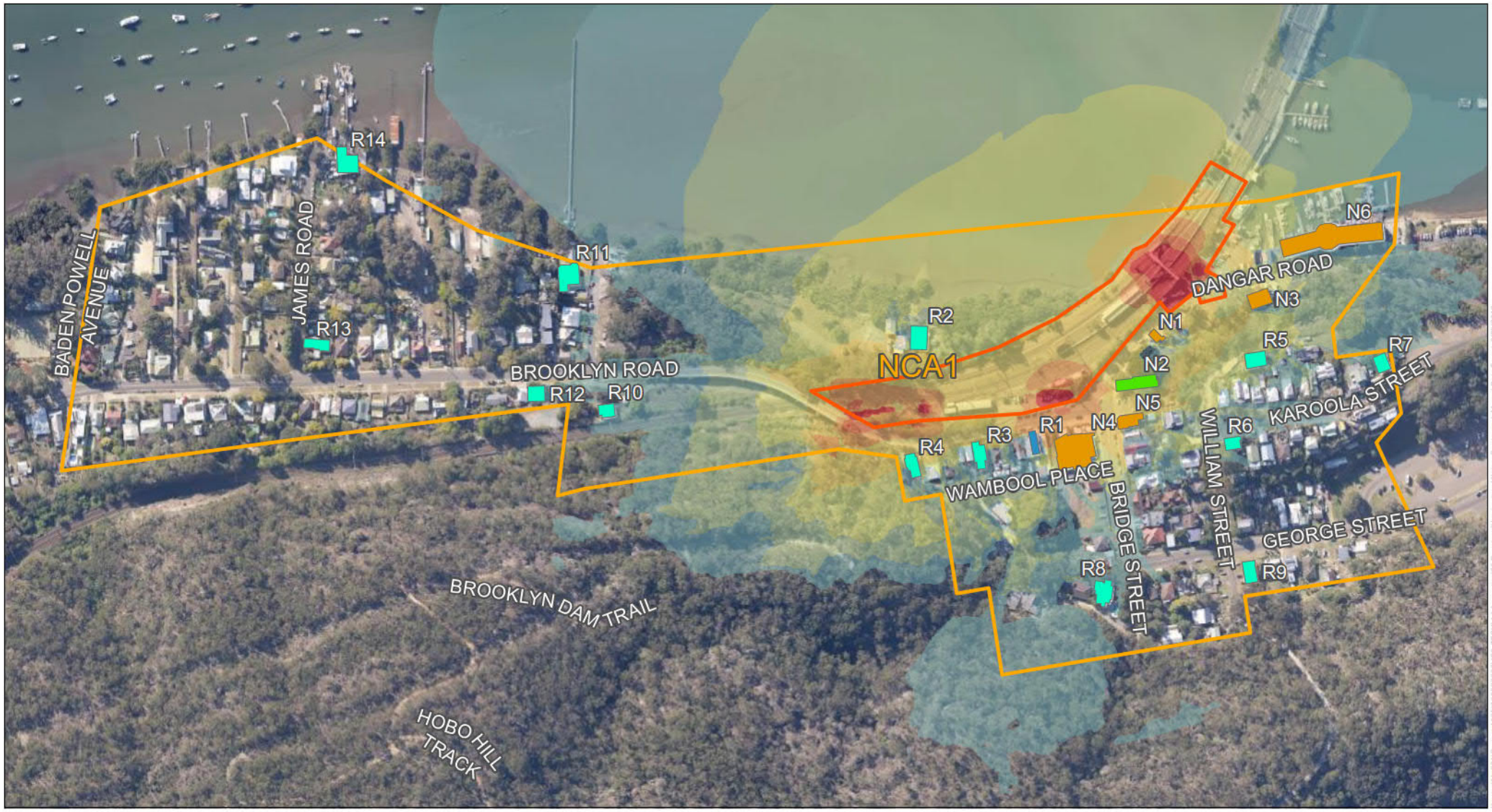
< 48 | 48 - 52 | 53 - 57 | 58 - 62 | 63 - 67 | 68 - 72 | 73 - 77 | > 77

AECOM

N

0 60 120 Meters

Source:



Hawkesbury River Station Upgrade - Lift installation works - WP4

Commercial
Community
Mixed Use
Residential
NCA
Proposal

LA1

< 48 | 48 - 52 | 53 - 57 | 58 - 62 | 63 - 67 | 68 - 72 | 73 - 77 | > 77

AECOM

N

0 60 120 Meters

Source:

Hawkesbury River Station Upgrade - Station surrounds works - WP6

Commercial
Community
Mixed Use
Residential

NCA
Proposal

LA1

< 48 | 48 - 52 | 53 - 57 | 58 - 62 | 63 - 67 | 68 - 72 | 73 - 77 | > 77

AECOM

N

0 60 120 Meters

Source: