Transport Access Program 3: Killara Station Upgrade

Noise and Vibration Impact Assessment

Transport Access Program 3: Killara Station Upgrade

Noise and Vibration Impact Assessment

Client: Transport for New South Wales

ABN: 18 804 239 602

Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com
ABN 20 093 846 925

Job No.: 60643261

Quality Information

Document Transport Access Program 3: Killara Station Upgrade

Ref 60643261

Date 25-Jun-2021

Prepared by Sharon Yung

Reviewed by Gayle Greer, Catherine Brady

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	12-May-2021	Draft for Review	Alice Thurgood	
2	9-June-2021	Updated in response to TfNSW review comments	Alice Thurgood	
2	25-June-2021	Final	Alice Thurgood	

Table of Contents

List of Figures

List of Tables

Abbreviations

Term	Meaning
AADT	Annual Average Daily Traffic
ABL	Assessment Background Level
AVATG	*Assessing Vibration: A Technical Guideline*
CNVS	*Construction Noise and Vibration Strategy*
dB	Decibel
EPA	Environment Protection Authority
ICNG	*Interim Construction Noise Guideline* (Department of Environment and Climate Change, 2009).
NATA	National Association of Testing Authorities
NCA	Noise Catchment Areas
NML	Noise Management Level
NPfI	*Noise Policy for Industry* (Environment Protection Authority, 2017)
OOHW	Out of Hours Work
RBL	Rating Background Level
RNP	*Road Noise Policy*
TfNSW	Transport for NSW
Tactiles	Tactile Ground Surface Indicator
VDV	Vibration Dose Values

1.0 Introduction

1.1 Background information

Transport for NSW is the government agency responsible for the delivery of major transport infrastructure projects in NSW and is the proponent for the Killara 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 across NSW.

AECOM Australia Pty Ltd (AECOM) has been commissioned by Transport for NSW to undertake a Noise and Vibration Impact Assessment of the construction and operation of the Proposal.

Construction of the Killara Station Upgrade is expected to commence in late-2021 and take around 18 months to complete. The construction work would primarily be undertaken during standard hours. Some work may need to occur outside standard hours and would include night work and work 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 Killara Station.

1.3 Proposed work

The key features of the Proposal are summarised as follows:

- construction of three new lifts to provide access to the station platforms and existing footbridge, including associated lift landings, canopies, throw screens and support structures
- widening of the existing footbridge to accommodate the new lift landing areas
- provision of seating and canopies at existing boarding assistance zones on the platform
- provision of a new pedestrian crossing, a kiss and ride bay with two spaces (including one accessible space), two new accessible parking spaces and new bike hoops on Culworth Avenue
- upgrade of the existing shelter on Culworth Avenue to provide accessible seating and wheelchair waiting area
- upgrade of existing footpath along Culworth Avenue to provide an accessible pathway to the station entrance from the kiss and ride bay and accessible parking spaces
- re-grading a section of the existing pedestrian footpath along Werona Avenue and provision of a ramp to the existing bus stop
- relocation of existing bike hoops and provision of new bicycle hoops on Werona Avenue

- reconfiguration of the existing toilet facilities in the station building to provide a family accessible toilet and a unisex ambulant toilet
- ancillary work including platform regrading, minor station building modifications, station power supply upgrade, protection and relocation of services and utilities, new or reinstatement of Tactile Ground Surface Indicators (tactiles) where required, upgrades to stairs, handrails and fencing, new ticketing facilities including additional Opal card readers, improvement to station communication systems (including CCTV cameras) and wayfinding signage.

Figure 1 shows the Proposal works area and Figure 2 shows the key elements of the Proposal. Further construction details are provided in Section 5.1 of this report and a detailed description of the Proposal is provided in Chapter 3 of the *Killara Station Upgrade Review of Environmental Factors* (AECOM, 2021).

Figure 1 Proposal area

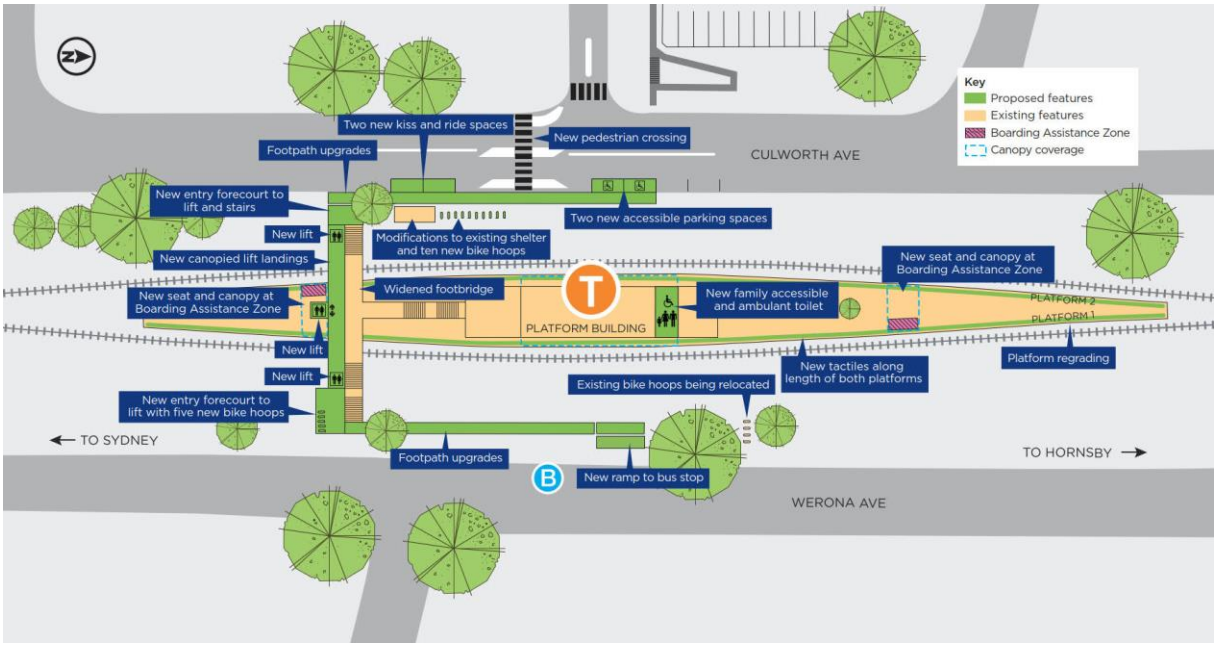


Figure 2 Proposal key elements

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 (EPA), 2017
- *Construction Noise and Vibration Strategy* (CNVS), Transport for NSW, 2019
- 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
- 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
- British Standard 5228: Part 1 2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise*
- DIN Standard 4150: Part 3 1999 *Structural Vibration in Buildings - Effects on Structures*, 1999
- International Standard ISO 9613-2:1996 - *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation.*

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

2.0 Existing acoustic environment

2.1 Site description

Killara Station is located within a residential suburban environment. Closest residential receivers are located on either side of Killara Station along Werona Avenue to the east (around 33 metres) and Culworth Avenue to the west (around 30 metres). Recreation facilities and public parks are located within the vicinity of Killara Station area. The station and its surrounding environment are shown in Figure 3.

Pacific Highway, which runs to the west of the station, is considered an arterial road and Culworth Avenue (west of the station) and Werona Avenue (east of the station) are considered sub-arterial roads as per categories within the RNP.

2.1.1 Representative receivers

To provide a comprehensive assessment, 43 representative residential receivers surrounding the Proposal, including the station and proposed compound areas) have been selected to represent the potential noise impacts associated with the Proposal. These receivers are listed in Table 1 and shown in Figure 3. Residences located closest to the Proposal within each street block were selected as representative of the potentially worst affected receivers.

Receivers within a 500 metre radius of the station are predominantly comprised of residential properties. Multi-storey apartment buildings are located to the north, west and south of Killara Station, whilst receivers to the east of the rail track are generally one and two storey buildings.

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

Table 1 Representative receiver addresses – residential

Receiver ID	Noise Catchment Area (NCA)	Receiver Address	Building Type	Approximate distance to proposal (metres)
R1	2	1/25 Werona Avenue, Killara	Detached	43
R2	2	23A Werona Avenue, Killara	Detached	47
R3	2	1/18 Culworth Avenue, Killara	Detached	57
R4	2	30 Culworth Avenue, Killara	Detached	80
R5	2	33 Werona Avenue, Killara	Detached	90
R6	2	6 Lorne Avenue, Killara	Detached	95
R7	2	3 Lynwood Avenue, Killara	Detached	146
R8	2	1/2 Arnold Street, Killara	Detached	148
R9	2	12 Culworth Avenue, Killara	Detached	175
R10	2	15/36-40 Culworth Avenue, Killara	Multi-Storey	179
R11	2	2 Lynwood Avenue, Killara	Detached	194
R12	2	1 Arnold Street, Killara	Detached	198
R13	1	14 Lorne Avenue, Killara	Detached	203
R14	1	1/18 Marian Street, Killara	Multi-Storey	207
R15	2	19 Locksley Street, Killara	Detached	217
R16	2	6-8 Culworth Avenue, Killara	Multi-Storey	250
R17	2	23 Powell Street, Killara	Detached	264

Receiver ID	Noise Catchment Area (NCA)	Receiver Address	Building Type	Approximate distance to proposal (metres)
R18	2	28 Lynwood Avenue, Killara	Detached	267
R19	2	21a Powell Street, Killara	Detached	281
R20	2	20 Karranga Avenue, Killara	Detached	284
R21	1	9/5 Wallaroo Close, Killara	Multi-Storey	298
R22	2	20 Stanhope Road, Killara	Detached	324
R23	1	3 Caithness Street, Killara	Detached	327
R24	2	22 Powell Street, Killara	Detached	329
R25	2	24 Stanhope Road, Killara	Detached	341
R26	2	20 Powell Street, Killara	Detached	344
R27	2	21 Stanhope Road, Killara	Detached	392
R28	2	40 Powell Street, Killara	Detached	399
R29	2	1/23 Stanhope Road, Killara	Detached	406
R30	1	9-19 Greengate Road, Killara	Multi-Storey	431
R31	1	18/2-6 Buckingham Road, Killara	Multi-Storey	446
R32	1	9/1-9 Buckingham Road, Killara	Multi-Storey	450
R33	2	28 Greengate Road, Killara	Detached	451
R34	2	5 Springdale Road, Killara	Detached	452
R35	1	610 Pacific Highway, Killara	Detached	454
R36	1	1/592-604 Pacific Highway, Killara	Detached	459
R37	2	42 Greengate Road, Killara	Detached	463
R38	1	544 Pacific Highway, Killara	Detached	469
R39	2	26 Greengate Road, Killara	Detached	473
R40	1	2/640 Pacific Highway, Killara	Detached	477
R41	2	2 Northcote Avenue, Killara	Detached	522
R42	1	9-23 Bruce Avenue, Killara	Multi-Storey	558
R43	2	3 Elva Avenue, Killara	Detached	623

Figure 3 Representative receiver locations

Table 2 Representative receiver addresses – non-residential

Receiver ID	Receiver address	Approximate distance to Proposal in metres
N1	Marian Street Theatre, 2 Marian Street, Killara - Theatre	126
N2	Killara Lawn Tennis Club, 6 Arnold Street, Killara - Community	180
N3	Dalcross Wellness Hospital, 28 Stanhope Road, Killara - Hospital	332
N4	Killara Uniting Church, 29A Arnold Street, Killara - Church	356

2.1.2 Noise catchment areas

To assist in determining noise criteria for the receivers surrounding the Proposal, two noise catchment areas (NCAs) were identified. The noise environment at each of the residential receivers within each NCA is considered to be similar. The NCAs are shown in Figure 4 and the applicable NCA for the representative residential receivers are identified in Table 1. NCA 1 includes receivers 250 metres west of the station adjacent to the Pacific Highway and generally has a higher background noise level associated with traffic movements on the Pacific Highway. NCA 2 includes receivers further away from the Pacific Highway directly around the station including those on the eastern side of the station spanning up to Karranga Avenue which generally have a lower background noise level being further away from the Pacific Highway.

2.1.3 Heritage items

The Killara Railway Station Group is a listed local heritage item on the Transport Asset Holding Entity of New South Wales Section 170 Heritage and Conservation Register. It is of significance at a local level as the station demonstrates the significant impact of the railway in facilitating settlement in the northern suburbs of Sydney and is an important station on the first purely suburban line in NSW. It also has one of the most important and intact railway gardens in the region. The grouping of the station building, platform and footbridge in their landscape setting, contribute to the characteristic nature of the North Shore line, with its homogenous early twentieth century station designs and garden settings.

There are 11 local heritage items located within 100 metres of Killara Station. Most are residential buildings or shops located to the immediate east and west of the station.

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 locations of the two noise loggers are shown in Figure 4.

2.2.1 Unattended noise measurement methodology

Long term unattended noise monitoring was conducted between 23 March and 1 April 2021 at 29 Marian Street (logger 1), and 31 Werona Avenue (logger 2). The noise loggers were placed at the locations indicated in Table 3 and shown in Figure 4. These locations were considered representative of the NCAs. The noise loggers were calibrated prior to and after the monitoring period with a drift in calibration not exceeding ± 0.5 dB.

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

Table 3 Noise monitoring details

NCA	Logger	Location	Model	Serial number
1	1	29 Marian Street, Killara	Svan 977	45416
2	2	31 Werona Avenue, Killara	ARL-315	15-299-444

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 NPfI, noise monitoring affected by adverse weather conditions or extraneous noise events should be excluded from the monitoring data. The NPfI advises that data may be affected where adverse weather, such as wind speeds higher than five m/s or rain, occurs. Weather data was acquired from the Bureau of Meteorology's Terrey Hills weather station (station number 066059) located around 8.5 kilometres north-west 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 NPfI 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. 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. The RBLs are presented in Table 4 below.

Copyright: Copyright in material relating to the base layers (contextual information) on this page is licensed under a Creative Commons, Attribution 3.0 Australia licence © Department of Finance, Services & Innovation 2017, (Digital Cadastral Database and/or Digital Topographic Database).

The terms of Creative Commons Attribution 3.0 Australia License are available from https://creativecommons.org/licenses/by/3.0/au/legalcode (Copyright Licence)

Neither AECOM Australia Pty Ltd (AECOM) nor the Department of Finance, Services & Innovation make any representations or warranties of any kind, about the accuracy, reliability, completeness or suitability or fitness for purpose in relation to the content (in accordance with clause 5 of the Copyright Licence). AECOM has prepared this document for the sole use of its Client based on the Client's description of its requirements having regard to the assumptions and other limitations set out in this report, including page 2.

Figure 4 Noise and vibration receivers, NCAs and logger locations

2.2.2 Attended noise measurement methodology

Attended noise measurements were conducted at logger locations 1 and 2 on 1 April 2021. The measurements were conducted over a 15 minute period for each location. Weather conditions were sunny 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 instrument 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 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 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 NPfL. 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

Location	Rating background level, L_{A90}, dB(A)			Ambient L_{Aeq} noise levels, dB(A)		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NCA 1	40	40[2]	38	57	56	52
NCA 2	42	42[2]	33	62	60	54

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. *In line with the NPfI the evening RBL is set at no higher than the daytime RBL in line with community expectations.*

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	01/04/2021	9:44	61	46	Dominated by bird calls 60 dB(A), distant road traffic noise on Pacific Highway 47 dB(A) and car pass by on Marian Street 60 dB(A).
2	01/04/2021	10:09	73	45	Dominated by road traffic noise on Werona Avenue 59 dB(A), truck pass by 53 dB(A), train pass by 65 dB(A), water feature in front yard of neighbouring property 44 dB(A) and bird calls audible occasionally 50 dB(A).

2.4 Existing noise environment summary

The acoustic environment is dominated by road traffic noise at both logging locations with natural sounds in the background. 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 ICNG is the principal guideline for the assessment and management of construction noise in NSW. As the proposed work is expected to continue for a period of more than three weeks and is within relatively close proximity to noise sensitive receivers, a quantitative assessment, based on 'reasonable' worst case work packages, has been carried out for this work.

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 ICNG (refer Table 6).

Where an exceedance of the NMLs is predicted, the ICNG recommends certain measures be implemented to minimise adverse impacts.

The construction NMLs 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 work 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 work near schools, or mid-morning or mid-afternoon for work 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	Outside recommended standard hours: • a strong justification would typically be required for work 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 ICNG 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 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

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."

Table 7 presents the NMLs applicable to residential receivers nearby to the Proposal.

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	40	50	75 (highly noise affected level)	45
	Evening	40	N/A		45
	Night	38	N/A		43
2	Day	42	52	75 (highly noise affected level)	47
	Evening	42	N/A		47
	Night	33	N/A		38

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

Table 8 Construction noise management levels – Other receivers

Land use	Noise management levels, $L_{Aeq,15min}$ (applies when properties are in use)
Place of worship	55 dB(A)[1]
Hospital wards and operating theatres	55 dB(A) [1]
Community Hall	55 dB(A)[1]
Commercial premises (including offices, retail outlets)	70 dB(A)
Active recreational area	65 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 ICNG requires a sleep disturbance analysis where construction work is 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 RNP 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	38	53	60 – 65
2	33	48	60 – 65

3.2 Construction traffic noise criteria

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

Werona Avenue and Culworth Avenue provide the main road access to Killara Station. 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]
Werona Avenue	Sub-arterial	Yes	>5,000
Culworth Avenue	Sub-arterial	Yes	>5,000

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 EPA 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 and 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 AVATG is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the daytime and night-time periods.

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

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

Location	Daytime[1] Preferred	Daytime Max	Night-time[1] Preferred	Night-time Max
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 and supporting infrastructure only and does not include changes to rail movements. As a result, operational noise is to be assessed under the NPfI.

4.1 Noise Policy for Industry

The NPfI 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 NPfI 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 NPfI 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 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 NPfI.

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	40	45
	Evening	40	45
	Night	38	43
NCA2 Residential receivers	Day	42	47
	Evening	42	47
	Night	33	38

4.1.2 Protecting amenity

To limit continuing increases in noise levels, the maximum ambient noise level within an area from all industrial noise sources should not normally exceed the recommended noise levels specified in the NPfI. 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. The project amenity level is then converted to a 15 minute period by adding 3 dB. The amenity criteria applicable to the Proposal are provided in Table 15.

Table 15 Amenity criteria

Type of receiver	Indicative noise amenity area	Time of day	Recommended amenity noise level, dB(A)	Project amenity noise level, dB(A)	
			$L_{Aeq(period)}$	$L_{Aeq(period)}$	$L_{Aeq(15\ minute)}$
NCA 1 and 2 residential receivers	Suburban	Day	55	50	53
		Evening	45	40	43
		Night	40	35	38
Hospital ward	All	Noisiest 1-hour period when in use	50	50	53
Place of worship	All	When in use	50[1]	50	53
Active recreation area	All	When in use	55	55	58
Commercial premises	All	When in use	65	65	68

4.1.3 Environmental noise emission criteria summary

A summary of the Proposal 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	45
	Evening	43
	Night	38
NCA 2	Day	47
	Evening	43
	Night	38
School classroom	Noisiest 1-hour period when in use	48
Place of worship	When in use	53
Active recreation area	When in use	58
Commercial premises	When in use	68

Notes:

1. Project noise trigger levels represent the lower of the intrusive and amenity criteria.

5.0 Construction noise assessment

5.1 Work packages and scheduling

In consultation with Transport for NSW, five distinct work packages, each consisting of a number of construction activities, have been assumed 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 5 – Demobilisation, testing and commissioning as it is expected to be a relatively low noise impact activity.

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

Out-of-hours work would likely be required during around six rail shutdowns over the 18 month construction period and during some night-time periods to minimise traffic impacts and allow for work which requires track access. Shutdowns would be required to facilitate the following:

- modification of electrical cables
- installation of piles (using piling rig) for the lifts
- foundation slab construction (concreting), delivery and craning in the new lift segments and lift cars
- platform regrading
- widening of existing footbridge
- piling, excavation of pits and installation of lift shafts
- installation of electrical containment
- services relocations.

Night-time construction work during rail shutdown periods would not take place over more than two consecutive nights. This would provide some respite periods during weekdays between work.

Table 17 Construction assessment work packages and scheduling

Work package stage	Activities	Scheduling
1. Site establishment and enabling work	• establishment of site compound (i.e. erect fencing, site offices, amenities and plant/material storage areas) • establishment of temporary facilities as required (e.g. hoarding, temporary toilets etc.) • relocation of services • survey investigations	Standard hours, out of hours and rail shutdown periods for relocation of services
2. New lifts and platform upgrades	• removal of the retail kiosk on the existing footbridge to accommodate installation of new lift • widening of the existing footbridge to accommodate the new lift landing areas • platform modifications, including piling and foundations for lift shafts • construction of lift shafts and fencing • installation of lifts • regrading of the platform • provision of seating and canopies at the existing boarding assistance zones • installation of weather protection canopies at the lift landings • installation of fixtures, tactiles, lighting, signage and CCTV cameras	Standard hours, out of hours and rail shutdown periods
3. Interchange work	• upgrade of the existing shelter on Culworth Avenue to provide accessible seating and wheelchair waiting area • installation of a kiss and ride bay with two spaces (including one accessible space) and two accessible parking spaces on Culworth Avenue, including line-marking and signage • provision of 10 new bike hoops on Culworth Avenue • upgrade of existing footpath along Culworth Avenue to provide an accessible pathway to the station entrance from the new kiss and ride bay and accessible parking spaces • re-grading a section of the existing pedestrian footpath on Werona Avenue and provision of a ramp to the bus stop, including fencing adjustments and retaining walls • provision of five new bicycle hoops at the station entrance on Werona Avenue • installation of wayfinding signage and other statutory/regulatory signage • electrical and power supply upgrade work	Standard hours, out of hours
4. Station building reconfiguration work	• reconfiguration of the existing toilets to include a family accessible toilet and a unisex ambulant toilet • conversion of the existing store room into a communications room	Standard hours

Work package stage	Activities	Scheduling
5. Demobilisation, testing and commissioning	• dismantling of existing site compound/hoarding areas • testing electrical, communications and signalling components	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 and BS5228: Part 1 2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise.* It is assumed 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[1], 2, 3, 4
Concrete saw	109[2,3]	1, 2, 3, 4
Concrete truck	106	2, 3
Crane trucks (semi-trailer and tipper)	102[2]	1[1], 5
Excavator	98	1, 2, 3
Franna crane	92[2]	2, 3
Generator	101	1, 5
Hand tools	94[2]	1, 2, 3, 4, 5
Jack hammer	110[2,3]	1, 2
Lighting tower	95[2]	1, 2, 5
Mobile crane	103[2]	2
Piling rig (bored)	102[2]	2
Power tools	94[2]	1, 4, 5
Trucks (semi-trailer and tipper)	105[2]	2, 3, 4
Welding tools	98[2]	2, 3, 4

Notes:

1. *Equipment for the operation of the northern storage and laydown compound near Powell Street was assumed to include a bobcat and truck movements only.*
2. *Sound powers are time weighted (i.e. expected utilisation percentage per 15 minute period) in accordance with the following:*
    a. *Crane trucks (semi-trailer and tipper) – 25%*
    b. *Power tools – 50%*
    c. *Trucks (semi-trailer and tipper) – 50%*
    d. *Welding tools – 50%*
    e. *Piling rig (bored) – 75%*
    f. *Mobile crane – 75%*
    g. *Franna crane – 75%*
    h. *Jackhammer – 50%*
    i. *Concrete saw – 25%*
3. *A +5 dB(A) correction has been added in accordance with the CNVS to account for noise with special audible characteristics.*

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 work.

The construction of the Proposal has been modelled in SoundPLAN Version 8.2. The following features were included in the noise model:

- ground topography
- ground absorption and reflection
- buildings (residential and commercial)
- receivers (shown in Figure 3)

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

During construction it is unlikely that all equipment would 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. However cumulative noise impacts may occur as a result of other construction work in the area. This may cause an increase of up to 3 dB(A) of the highest noise level predicted for any construction stage. This is based on the combination of the highest noise levels from this Proposal and other construction work nearby.

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 NMLs during standard hours for all assessed construction work packages at the majority of representative receivers, as shown in grey in Table 19. The largest numbers of exceedances occur during Work package 3 – Interchange work. These works also generate noise levels which exceed the highly noise affected level of 75 dB(A) or greater) at receivers (R1, R2, R3). Exceedance of the highly affected level is also predicted at R19 during Work package 1 due to the close proximity of the storage and laydown compound to the north of the station. However this compound would only be in use at the start and end of shifts therefore impacts are expected to be temporary and minimal.

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

Receiver ID[2]	NCA	Distance, metres	Standard hours NML, dB(A)	Highly affected noise level, dB(A)	Work Package[3]			
					1	2	3	4
R1	2	43	52	75	67	74	83	76
R2	2	47	52	75	66	77	75	66
R3	2	57	52	75	75	78	78	69
R4	2	80	52	75	66	67	70	69
R5	2	90	52	75	63	65	68	66
R6	2	95	52	75	72	68	71	68
R7	2	146	52	75	61	57	60	53
R8	2	148	52	75	61	67	66	61
R9	2	175	52	75	59	65	64	60
R10	2	179	52	75	67	62	62	61
R11	2	194	52	75	66	60	63	60
R12	2	198	52	75	58	63	63	58
R13	1	203	50	75	57	59	63	60
R14	1	207	50	75	57	48	52	47
R15	2	217	52	75	46	41	51	46
R16	2	250	52	75	58	66	63	59
R17	2	264	52	75	70	59	61	60
R18	2	267	52	75	53	49	52	57
R19	2	281	52	75	80	57	58	56
R20	2	284	52	75	49	51	50	42
R21	1	298	50	75	49	46	55	55
R22	2	324	52	75	46	58	58	54
R23	1	327	50	75	48	48	48	42
R24	2	329	52	75	67	51	55	51
R25	2	341	52	75	53	56	57	54
R26	2	344	52	75	69	55	57	54
R27	2	392	52	75	35	48	50	41
R28	2	399	52	75	54	52	54	53
R29	2	406	52	75	51	55	56	52
R30	1	431	50	75	43	38	40	36
R31	1	446	50	75	40	35	40	41
R32	1	450	50	75	51	45	53	47
R33	2	451	52	75	60	36	46	37
R34	2	452	52	75	52	53	54	48
R35	1	454	50	75	42	43	52	52
R36	1	459	50	75	48	39	53	49

Receiver ID[2]	NCA	Distance, metres	Standard hours NML, dB(A)	Highly affected noise level, dB(A)	Work Package[3]			
					1	2	3	4
R37	2	463	52	75	47	39	42	39
R38	1	469	50	75	32	34	32	27
R39	2	473	52	75	41	35	38	35
R40	1	477	50	75	38	39	41	32
R41	2	522	52	75	55	35	46	36
R42	1	558	50	75	46	41	42	38
R43	2	623	52	75	37	27	32	23

Notes:

1. *Items shaded in grey indicate the predicted noise levels at this receiver during this work stage exceed the daytime NMLs. Items in red indicate the receiver is highly noise affected during this work stage.*
2. *Addresses of receiver and noise catchment areas are provided in Table 1*
3. *Details of work packages provided in Table 17.*

5.4.2 Summary of impacts during night work at residential receivers

Construction noise levels are predicted to exceed the NMLs during night work for all assessed construction work packages at the majority of representative receivers as shown in grey in Table 20.

The highest noise levels are experienced during Work package 3 – Interchange Works. Noise levels at receivers R1, R2 and R3 are predicted to exceed the NMLs by more than 30 dB(A) at times during Work packages 2 and/or 3. Noise levels at receiver R4 are predicted to exceed the NML by more than 20 dB(A) during Work packages 3 and 4. Noise levels at receiver R5 are predicted to exceed the NML by more than 20 dB(A) at times during Work package 3. Noise levels at R6 are predicted to exceed the NML by more than 20 dB(A) at times during Work packages 1, 2, 3 and 4.

Noise levels at residential receivers (R17, R19 and R26) are predicted to exceed the NMLs by more than 20 dB(A) at times during Work package 1. It should be noted that these exceedances would be limited to the rail shutdown periods and some night work. In addition, night work would not be undertaken for more than two consecutive nights.

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

Receiver ID[2]	NCA	Distance metres	Night-time NML, dB(A)	Work Package[3]			
				1	2	3	4
R1	2	43	47	67	74	83	76
R2	2	47	47	66	77	75	66
R3	2	57	47	75	78	78	69
R4	2	80	47	66	67	70	69
R5	2	90	47	63	65	68	66
R6	2	95	47	72	68	71	68
R7	2	146	47	61	57	60	53
R8	2	148	47	61	67	66	61
R9	2	175	47	59	65	64	60
R10	2	179	47	67	62	62	61
R11	2	194	47	66	60	63	60
R12	2	198	47	58	63	63	58

Receiver ID[2]	NCA	Distance metres	Night-time NML, dB(A)	Work Package[3]			
				1	2	3	4
R13	1	203	45	57	59	63	60
R14	1	207	45	57	48	52	47
R15	2	217	47	46	41	51	46
R16	2	250	47	58	66	63	59
R17	2	264	47	70	59	61	60
R18	2	267	47	53	49	52	57
R19	2	281	47	80	57	58	56
R20	2	284	47	49	51	50	42
R21	1	298	45	49	46	55	55
R22	2	324	47	46	58	58	54
R23	1	327	45	48	48	48	42
R24	2	329	47	67	51	55	51
R25	2	341	47	53	56	57	54
R26	2	344	47	69	55	57	54
R27	2	392	47	35	48	50	41
R28	2	399	47	54	52	54	53
R29	2	406	47	51	55	56	52
R30	1	431	45	43	38	40	36
R31	1	446	45	40	35	40	41
R32	1	450	45	51	45	53	47
R33	2	451	47	60	36	46	37
R34	2	452	47	52	53	54	48
R35	1	454	45	42	43	52	52
R36	1	459	45	48	39	53	49
R37	2	463	47	47	39	42	39
R38	1	469	45	32	34	32	27
R39	2	473	47	41	35	38	35
R40	1	477	45	38	39	41	32
R41	2	522	47	55	35	46	36
R42	1	558	45	46	41	42	38
R43	2	623	47	37	27	32	23

Notes:

1. *Items shaded in grey indicate the predicted noise levels at this receiver during this work stage exceed the night-time NML*
2. *Addresses of receiver and noise catchment areas are provided in Table 1*
3. *Details of work packages provided in Table 17.*

5.4.3 Summary of impacts to non-residential receivers

All four non-residential receivers are predicted to be exposed to noise levels which exceed the NMLs as shaded in grey in Table 21, particularly during Work Packages 1, 2 and 3. Key noisy activities include the use of concrete saws and jack hammers. It is also noted that the predicted noise levels are based on all equipment operating at once and at the closest location to each receiver, therefore noise levels would be less for significant periods of time. Predicted exceedances of 1-2 dB(A) at the Killara Uniting Church (N4) are considered negligible.

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

Receiver ID[2]	Distance, (metres)	NML, dB(A)	Work Package[3]			
			1	2	3	4
N1	126	55	65	63	59	52
N2	180	55	55	63	58	46
N3	332	55	57	60	61	58
N4	356	55	54	55	56	45

Notes:

1. *Items shaded in grey indicate predicted noise levels at this receiver during this work stage exceed the NML*
2. *Addresses of receiver are provided in Table 2*
3. *Details of work packages provided in Table 17*

5.5 Sleep disturbance assessment

A sleep disturbance assessment was undertaken to assess work 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. Based on the predicted noise level, the awakening reaction criterion of 65 dB(A) is predicted to be exceeded at residential receivers along Werona Avenue and Culworth Avenue during all Work packages and in addition at residential receivers along Powell Street and Stanhope Road during Work package 1.

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, if residents close their windows during noisy activities, they can potentially attenuate external noise levels by 20 dB to below the sleep awakening criterion.

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 Transport for NSW as up to 30 light and five heavy vehicles per day during peak construction periods. Vehicles would access the site primarily via Culworth Avenue and Lorne Avenue for the southern construction compound and Powell Street for the northern storage and laydown construction compound.

Traffic noise levels during construction would not increase by more than 2 dB on Culworth Avenue and Powell Street, which complies with the RNP 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 work may include the use of the following items of equipment:

- jackhammer
- bored piling rig.

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

If vibration intensive work is 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 metre (nominal)	1 metre (nominal)	Avoid contact with structure
Bored piling	≤ 800 millimetres	4 metres	2 metres	N/A

It is noted that the heritage items noted in Section 2.1.3 are located well outside the minimum working distances in Table 22 above, with the exception of the Killara Railway Station Group. Vibration intensive work would likely be required within the minimum working distances of the significant heritage elements associated with the station (such as the ticket booths and station building). 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.

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 manage any complaints which may occur due to construction noise or vibration. 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 work.

Construction work should be planned and carried out during standard construction hours wherever possible. Given the relatively minor noise and vibration impacts of the Proposal, the standard and additional mitigation measures outlined in the CNVS are considered appropriate to manage potential impacts. Table 23 presents a summary of the standard mitigation measures contained within the CNVS which should be considered as mitigation measures as part of the CNVMP.

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

Action required	Safeguard details
Management measures	
Implement stakeholder consultation measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities, would be delivered to sensitive receivers at least 7 days prior to commencement of relevant work.
Site inductions	All employees, contractors and subcontractors would 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 would 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 work progress. The program would be developed in accordance with the CNVMP and any approval/licence conditions. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard *1055.2018 – Acoustics – Description and measurement of environmental noise.*
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods as far as practicable. This would 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) would only be carried out in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work would 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 would be used where feasible and reasonable (e.g. rubber wheeled instead of steel tracked plant). Equipment would be regularly inspected and maintained to ensure it is in good working order.
Maximum noise levels	The noise levels of plant and equipment would have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions would be considered as part of the selection process.

Action required	Safeguard details
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver would be avoided. The offset distance between noisy plant and adjacent sensitive receivers would be maximised. Plant used intermittently would be throttled down or shut down. Plant and vehicles would be turned off when not in use. Noise-emitting plant would be directed away from sensitive receivers where reasonable and feasible.
Plan work site and activities to minimise noise and vibration	Traffic flow, parking and loading/unloading areas would be planned to minimise reversing movements within the site. Truck drivers would 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) would be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries would occur as far as possible from sensitive receivers. Site access points and roads would be selected as far as possible away from sensitive receivers. Dedicated loading/unloading areas would be shielded if close to sensitive receivers. Delivery vehicles would be fitted with straps rather than chains for unloading, wherever possible.
Silencers on Mobile Plant	Where possible, noise from mobile plant would be reduced through additional fittings including: • Residential grade mufflers • Silencing air parking brake engagement.
Construction Related Traffic	Vehicle movements would be routed away from sensitive receivers and scheduled during less sensitive times. The speed of vehicles would be limited and the use of engine compression brakes would be minimised. On-site storage capacity would be maximised to reduce the need for truck movements during sensitive times.

Action required	Safeguard details
Vibration minimum working distances	If vibration intensive equipment is to be used within the minimum working distances for cosmetic damage, as presented in Table 22, then attended vibration measurements would be 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 would not proceed within the site specific minimum working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (e.g. via flashing light, audible alarm, SMS) when vibration levels are approaching the peak particle velocity objective. It is also advisable to carry out building condition surveys of sensitive historical structures before construction work begins. [1]Where vibration intensive works have to proceed within the site specific minimum working distances, a condition assessment would be completed and specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources would 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) would be used.

Notes:

1. Mitigation measure additional to the Construction Noise and Vibration Strategy standard mitigation measures

5.8.2 Community consultation and complaints handling

All residents and sensitive receivers impacted by noise levels from the Proposal where noise levels are expected to exceed the noise management level 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 work.

The information provided to the residents would include:

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

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

5.8.3 Transport for NSW Construction Noise and Vibration Strategy - Additional mitigation measures

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

The provision of additional mitigation is based on the predicted exceedances above RBLs and when the exceedances occur, which is related to a receiver's perception of the noise. Table 24, provides mitigation for construction noise ranges from 'noticeable' to 'highly intrusive'. The predicted noise contours in Appendix C show the location of impacted receivers and degree of noise exceedance predicted (to determine which mitigation measure should be applied to which receiver).

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	≥75 dB(A)
Standard	Weekday (7am-6pm) Saturday (8am-1pm) Sun/Pub Hol (Nil)	-	-	PN, V	PN, V	PN, V SN
Out-of-Hours Work Period 1	Weekday (6pm-10pm) Saturday (7-8am) & (1-10pm) Sun/Pub Hol (8am-6pm)	-	PN, RP[3], DR[3]	PN, V, SN, RO, RP[3], DR[3]	PN, V, SN, RO, RP[3] DR[3]	N/A
Out-of-Hours Work Period 2	Weekday (10pm-7am) Saturday (10pm-8am) Sun/Pub Hol (6pm-7am)	PN	PN, V, SN, RO[4], RP[3], DR[3]	PN, V, SN, RO[4], RP[3] DR[3]	PN, V, SN, RO[4], RP[3] DR[3], AA	N/A

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):

- *PN: Project notification*
- *V: Verification monitoring*
- *SN: Specific notification*
- *RP: Respite period*
- *DR: Duration Respite*
- *RO: Project specific respite offer*
- *AA: Alternative accommodation*

3. Respite periods and duration reduction are not applicable when work are carried out during OOHW Period 1 Day only (i.e. Saturday 6:00 am-7:00 am and 1:00 pm-6:00 pm, Sundays/Public Holidays 8:00 am-6:00 pm)

4. Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays/Public Holidays 6pm-10pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1

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

Table 25 Description of additional mitigation measures

Abbreviation	Mitigation measure	Explanation
PN	Periodic notification	A notification entitled 'Project Update', 'Construction Update' or 'Community Update' or similar is produced and distributed to stakeholders via letterbox drop and distributed to the Project postal and/or email mailing lists. The same information would be published on the Transport for NSW website. Periodic notifications provide an overview of current and upcoming work across the Project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where work may impact on them. Content and length is determined on a project-by-project basis and must be approved by Transport for NSW prior to distribution. Most projects distribute notifications on a monthly basis.
V	Verification	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver or a nominated representative location. Monitoring can be in the form of either unattended logging or operator attended surveys. Attended noise monitoring is to be undertaken as follows: • construction noise and vibration from the Project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the work. Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required.
SN	Specific notifications	Specific notifications are in the form of a personalised letter, or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Letters may be letterbox dropped or hand distributed. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that would be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the Project. Specific notifications are used to support periodic notifications, or to advertise unscheduled work and must be approved by Transport for NSW prior to implementation/distribution.

Abbreviation	Mitigation measure	Explanation
RO	Respite offers	The purpose of a respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased tickets for activities, restaurants or similar.
AA	Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction work that are likely to incur unreasonably high impacts. Alternative accommodation would be determined on a case-by-case basis and should provide a like-for-life replacement for permanent residents, including provisions for pets, where reasonable and feasible.
RP	Respite period	OOHW during evening and night periods would be restricted so that receivers are impacted for no more than three consecutive evenings and no more than two consecutive nights in the same NCA in any one week, except where this is a Duration Reduction. A minimum respite period of four evenings/five nights shall be implemented between periods of evening and/or night work. Strong justification must be provided where it is not feasible and reasonable to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by Transport for NSW through the OOHW Approval Protocol.
DR	Duration Reduction	Where Respite Periods are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through an overall Duration Reduction to minimise the duration of the activity. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with Project Community Engagement Representatives.

6.0 Operational noise

Additional operational equipment at the station would include three new lifts and new family accessible and ambulant toilet facilities which would not produce significant noise emissions. Additional car parking is not proposed as part of the Proposal. 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 NPfI. 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 Killara 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 NMLs.

The Proposal is expected to commence construction in late-2021 and take up to 18 months to complete. Construction would primarily be undertaken during standard hours. Some work may need to occur outside standard hours and would include night work and work 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.

Construction work packages and the equipment to be used have been developed in consultation with Transport for NSW. Five distinct work packages were identified and four were used in a computer-based noise model to determine the potential changes to noise levels. Construction noise impacts were assessed at 43 representative residential receivers surrounding the Proposal. Impacts were also assessed at four representative nearby non-residential sensitive receivers.

7.1 Construction noise

The predicted construction noise levels exceed the construction NMLs for all scenarios at the closest residential and non-residential receivers. Noise exceedances are generally unavoidable given the proposed work and proximity to receivers, notwithstanding the implementation of feasible and reasonable noise mitigation measures. The largest impacts would be experienced by residents along Werona Avenue and Culworth Avenue. The largest numbers of exceedances occur during Work package 3 – Interchange work.

During standard hours, three residential receivers (R1, R2 and R3) are predicted to be 'highly affected' during more than one Work package, with the interchange work (Work package 3) 'highly affecting' all three residential receivers. In addition the site establishment work (Work package 1) are expected to 'highly affect' residential receiver R19 due to the location of the storage and laydown compound to the north of the station.

During night-time work noise levels at the majority of receivers are predicted to exceed the NMLs. The highest noise levels are experienced during Work package 3 – Interchange work. Noise levels at receivers R1, R2 and R3 are predicted to exceed the NMLs by more than 30 dB(A) at times during Work packages 2 and/or 3. Noise levels at receiver R4 are predicted to exceed the NML by more than 20 dB(A) at times during Work packages 3 and 4. Noise levels at R5 are predicted to exceed the NML by more than 20 dB(A) at times during Work package 3. Noise levels at R6 are predicted to exceed the NML by more than 20 dB(A) at times during Work packages 1, 2, 3 and 4.

Noise levels at residential receivers (R17, R19 and R26) are predicted to exceed the NMLs by more than 20 dB(A) at times during Work package 1. It should be noted that these exceedances would be limited to the rail shutdown periods and some night work. In addition, night work would not be undertaken for more than two consecutive nights.

All four non-residential receivers are predicted to be exposed to noise levels which exceed the NMLs, particularly during Work packages 1, 2 and 3. Key noisy activities include the use of concrete saws and jack hammers. It is also noted that the predicted noise levels are based on all equipment operating at once and at the closest location to each receiver, therefore noise levels would be less for significant periods of time. Any impacts due to construction work would be temporary in nature and would not represent a permanent impact on the community and surrounding environment. The predicted noise levels are generally conservative and would only be experienced for limited periods during construction.

Recommendations to mitigate construction noise impacts have been provided in Section 5.8.

7.2 Sleep disturbance assessment

A sleep disturbance assessment was undertaken to assess work 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 residential receivers along Werona Avenue and Culworth Avenue during all Work packages and in addition at residential receivers along Powell Street and Stanhope Road during Work package 1.

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, if residents close their windows during noisy activities they can potentially attenuate external noise levels by 20 dB which would result in internal noise levels which are less than the sleep awakening criterion. 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.

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 the CNVS in order to minimise and manage the impact of construction noise on nearby noise sensitive receivers. Construction activities would be undertaken during the daytime where feasible.

7.3 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 work 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, commercial and residential receivers during the proposed vibration intensive work, with the exception of heritage items at the station itself. Should work be required within the minimum working distances, the recommended additional mitigation measures would be implemented.

7.4 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 NPfI.

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

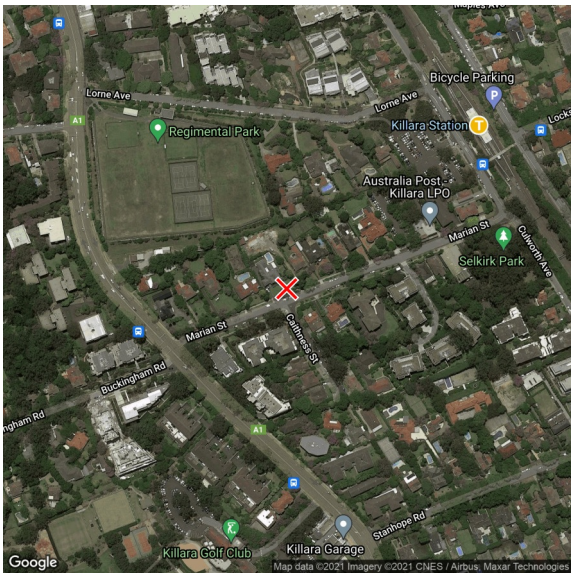
29 Marian Street, Killara

Item	Information
Logger Type	SVAN977
Serial number	45416
Address	29 Marian Street, Killara
Location	29 Marian Street, Killara
Facade / Free Field	Free Field
Environment	Dominated by bird calls and distant road traffic noise on Pacific Highway 47 dB(A). Bird calls 60 dB(A) Car pass by on Marian Street 60 dB(A)

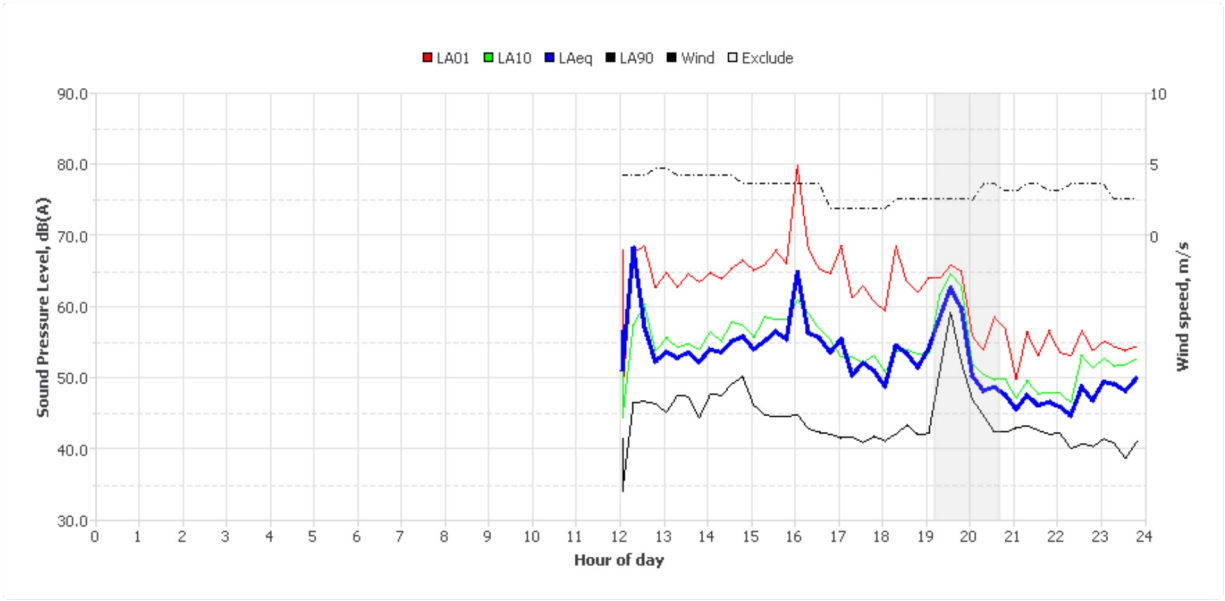
Measured noise levels

Logging Date	$L_{Aeq,day}$ 7am-6pm	$L_{Aeq,evening}$ 6pm-10pm	$L_{Aeq,night}$ 10pm-7am	ABL Day 7am-6pm	ABL Eve 6pm-10pm	ABL Night 10pm-7am	$L_{Aeq,15hr}$ 7am-10pm	$L_{Aeq,9hr}$ 10pm-7am
Tue Mar 23 2021	58	51	48	-	-	-	57	48
Wed Mar 24 2021	55	55	55	-	-	-	55	55
Thu Mar 25 2021	56	51	53	40	-	42	55	53
Fri Mar 26 2021	57	55	53	42	-	39	57	53
Sat Mar 27 2021	61	56	51	40	-	36	61	51
Sun Mar 28 2021	55	56	52	39	-	41	55	52
Mon Mar 29 2021	58	56	52	39	-	36	58	52
Tue Mar 30 2021	57	56	51	43	42	37	57	51
Wed Mar 31 2021	58	59	56	43	45	38	58	56
Thu Apr 1 2021	52	-	50	-	-	-	52	50
Summary	**57**	**56**	**52**	**40**	**43**	**38**	**57**	**52**

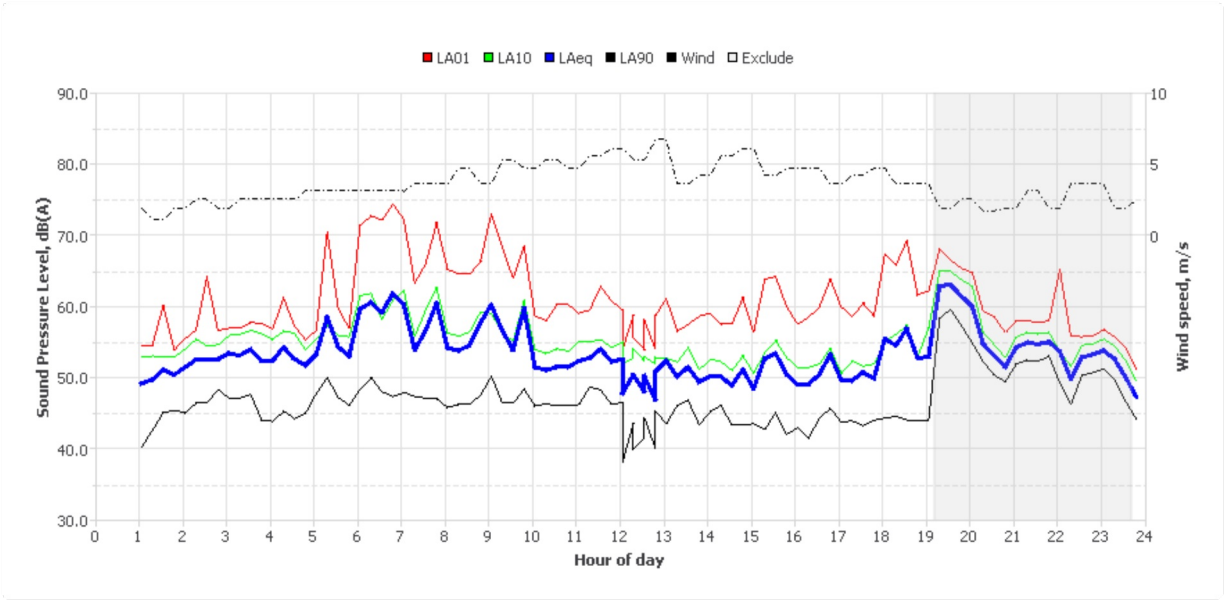
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	
29 Marian Street, Killara	

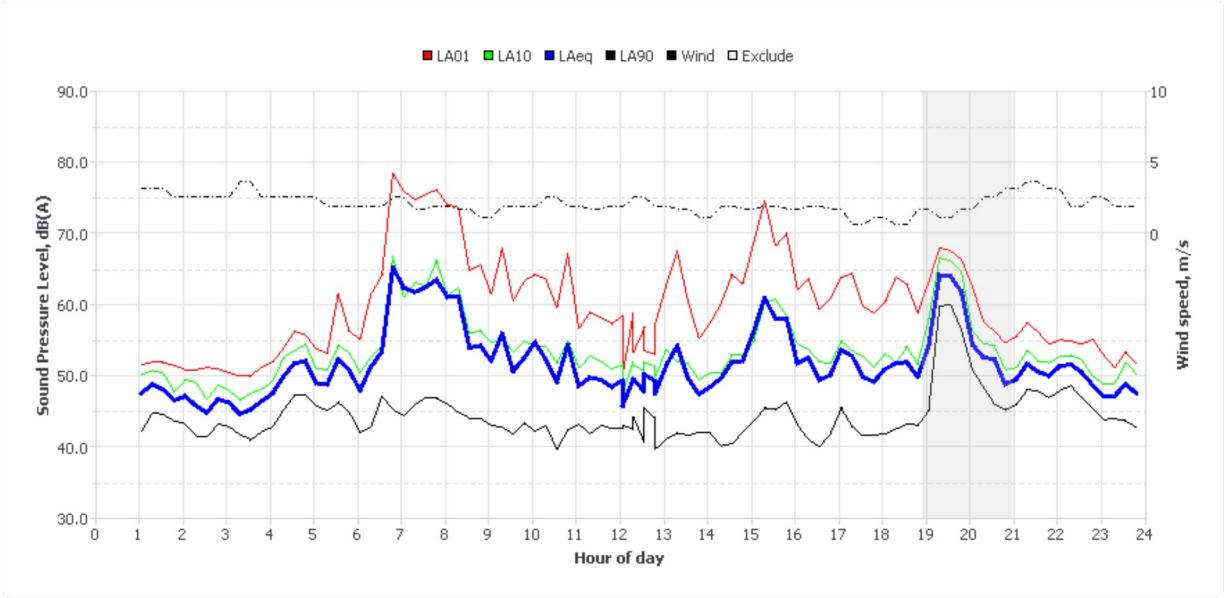
Tuesday, 23 Mar 2021



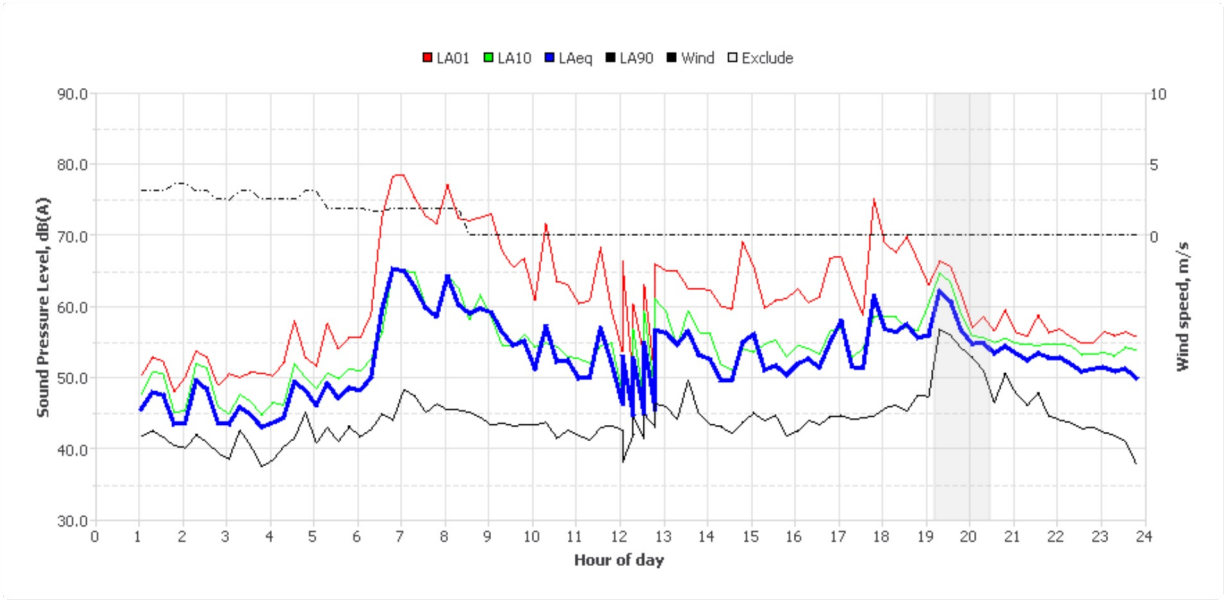
Wednesday, 24 Mar 2021



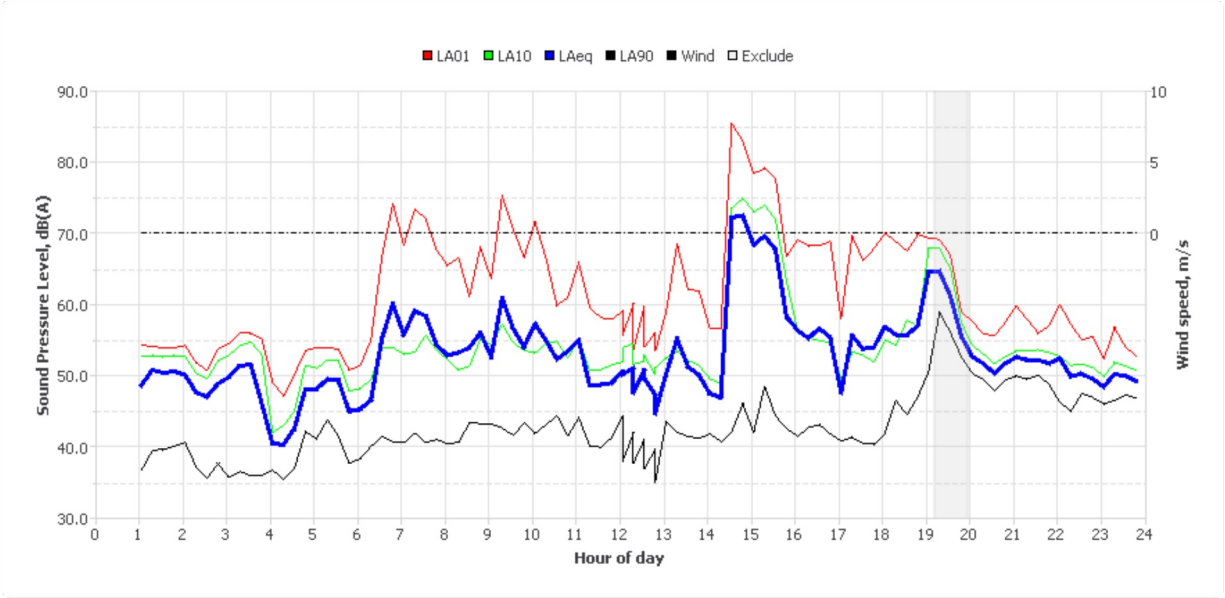
Thursday, 25 Mar 2021



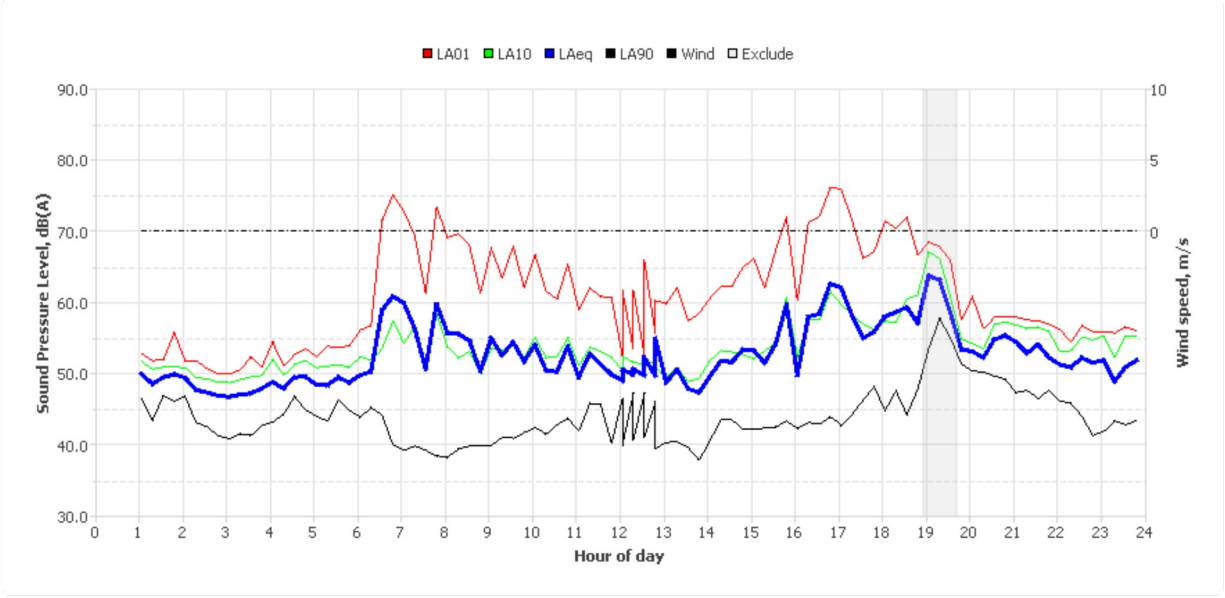
Friday, 26 Mar 2021



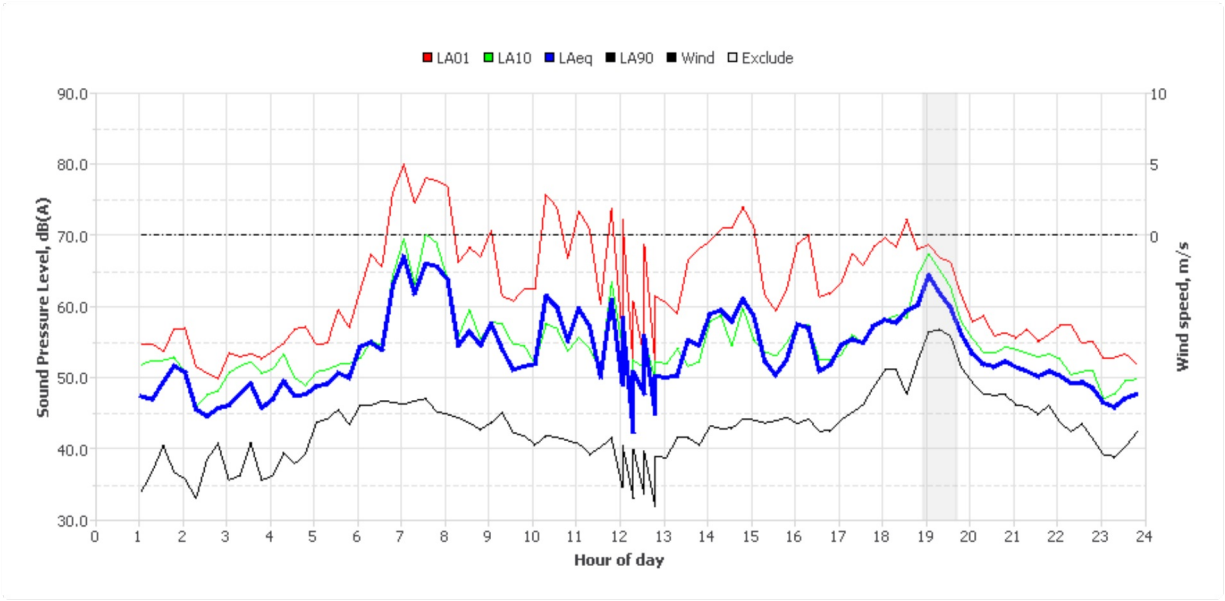
Saturday, 27 Mar 2021



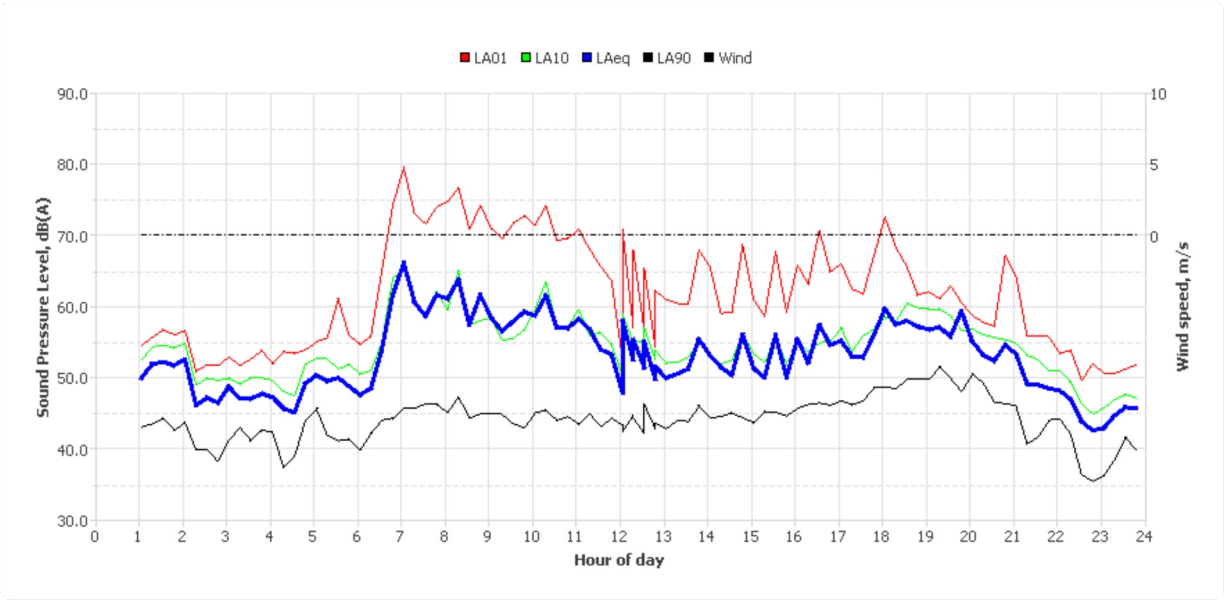
Sunday, 28 Mar 2021



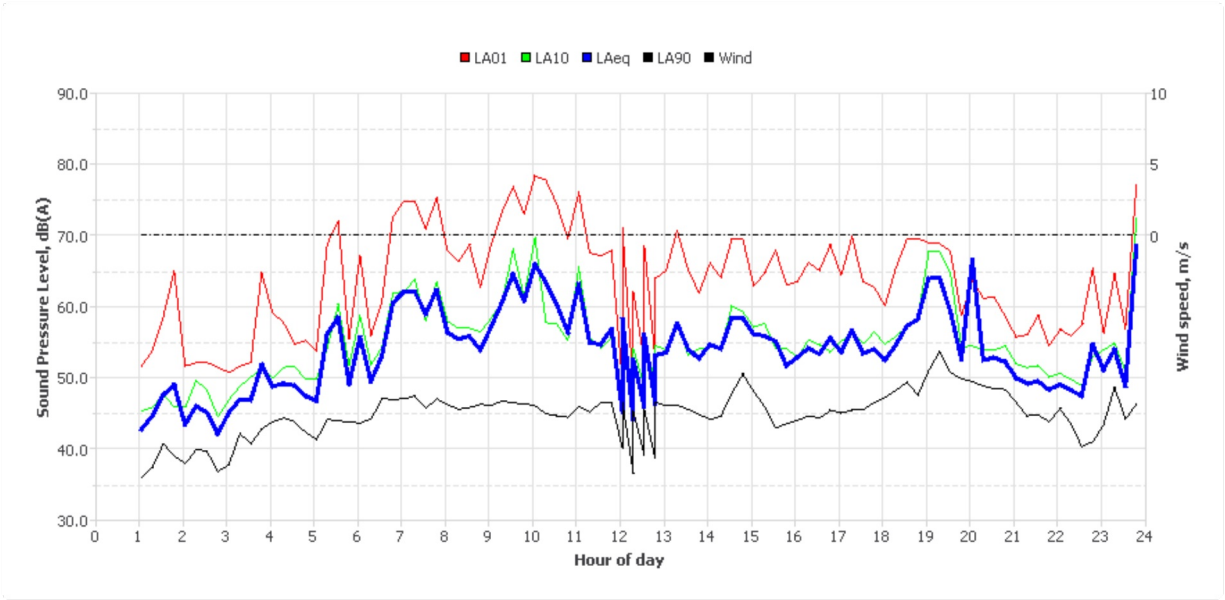
Monday, 29 Mar 2021



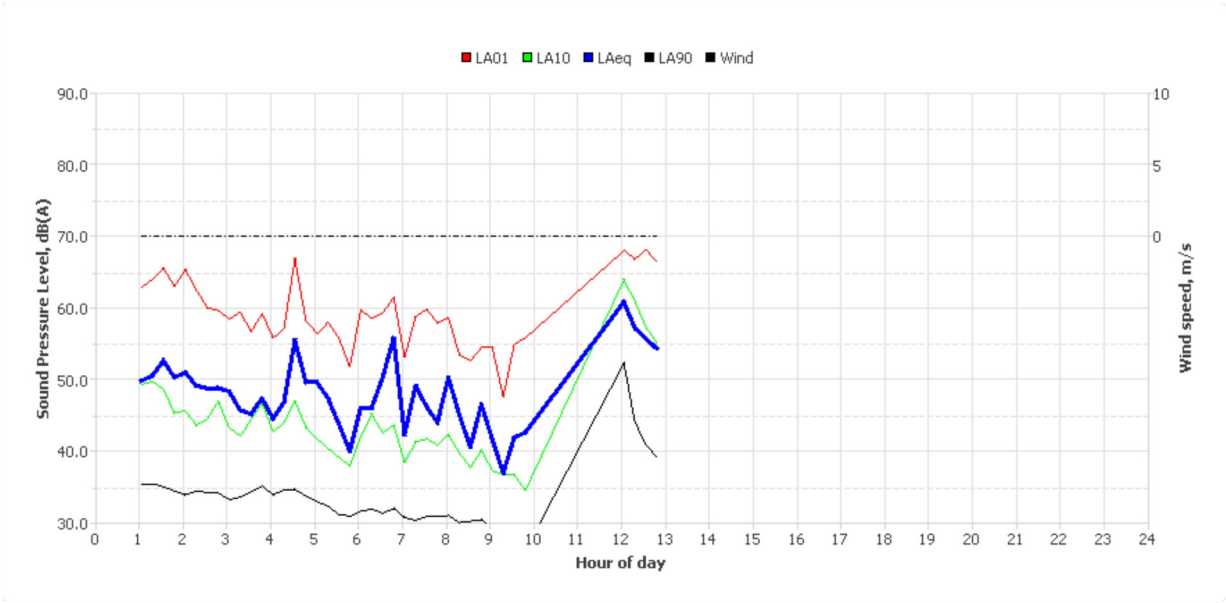
Tuesday, 30 Mar 2021



Wednesday, 31 Mar 2021



Thursday, 01 Apr 2021



Noise Logger Report

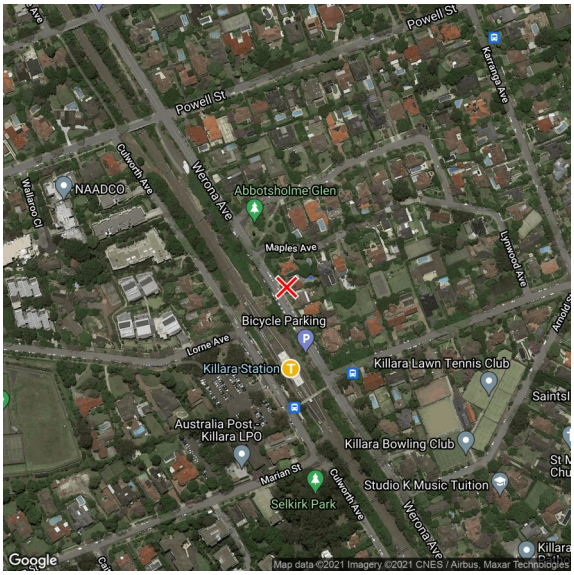
31 Werona Avenue, Killara

Item	Information
Logger Type	ARL-315
Serial number	15-299-444
Address	31 Werona Avenue, Killara
Location	31 Werona Avenue, Killara
Facade / Free Field	
Environment	Dominated by Road traffic noise on Werona Avenue 58 dB(A). Truck pass by 53 dB(A). Train pass by 65 dB(A). Water feature on front yard on neighbouring property 44 dB(A). Bird calls audible occasionally 50 dB(A).

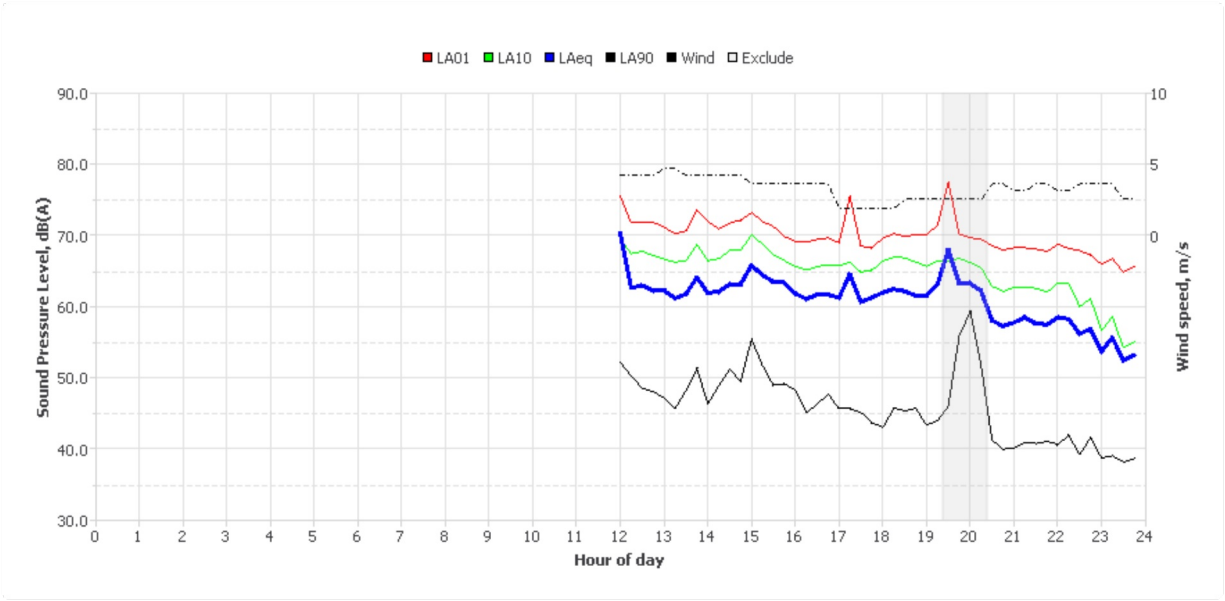
Measured noise levels

Logging Date	$L_{Aeq,day}$ 7am-6pm	$L_{Aeq,evening}$ 6pm-10pm	$L_{Aeq,night}$ 10pm-7am	ABL Day 7am-6pm	ABL Eve 6pm-10pm	ABL Night 10pm-7am	$L_{Aeq,15hr}$ 7am-10pm	$L_{Aeq,9hr}$ 10pm-7am
Tue Mar 23 2021	63	60	56	-	-	-	63	56
Wed Mar 24 2021	65	59	54	-	-	35	64	54
Thu Mar 25 2021	60	59	52	42	-	34	60	52
Fri Mar 26 2021	60	59	54	42	-	32	60	54
Sat Mar 27 2021	59	58	52	39	-	31	59	52
Sun Mar 28 2021	60	58	50	36	-	30	60	50
Mon Mar 29 2021	60	60	53	41	-	32	60	53
Tue Mar 30 2021	62	62	55	44	-	39	62	55
Wed Mar 31 2021	64	61	56	46	-	38	63	56
Thu Apr 1 2021	64	-	55	-	-	-	64	55
Summary	**62**	**60**	**54**	**42**	**-**	**33**	**62**	**54**

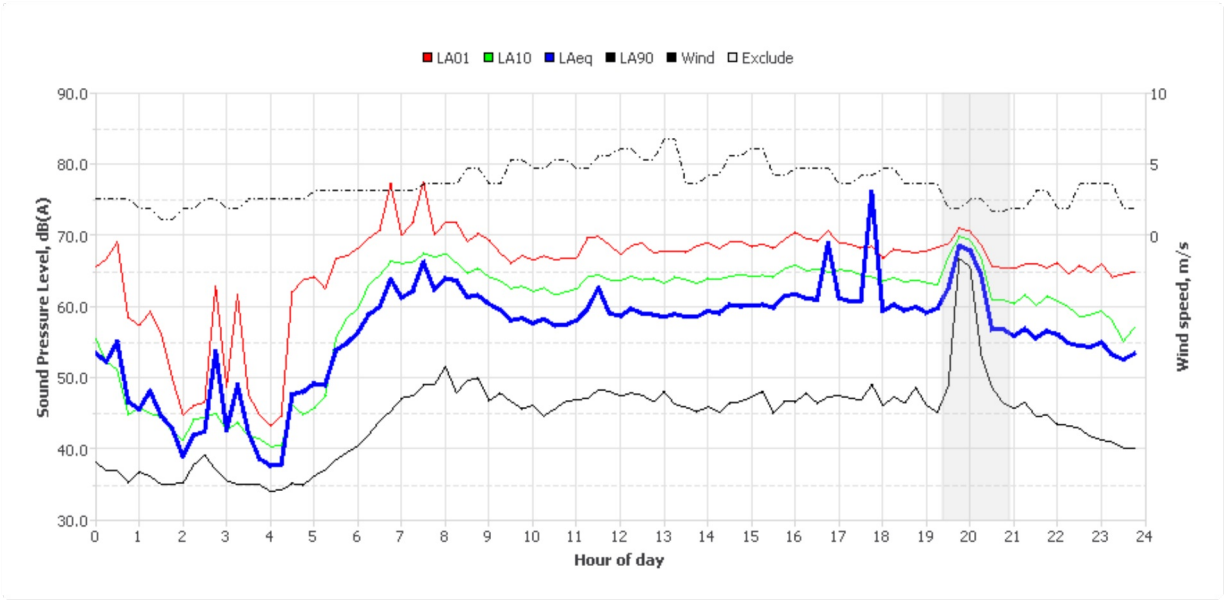
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	
31 Werona Avenue, Killara	

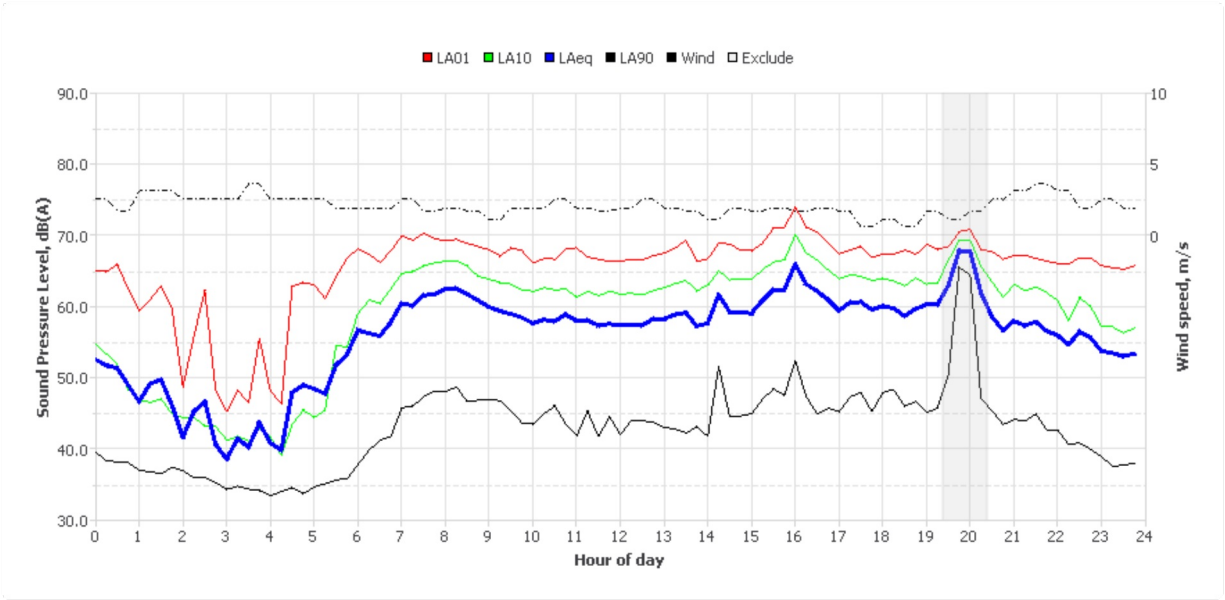
Tuesday, 23 Mar 2021



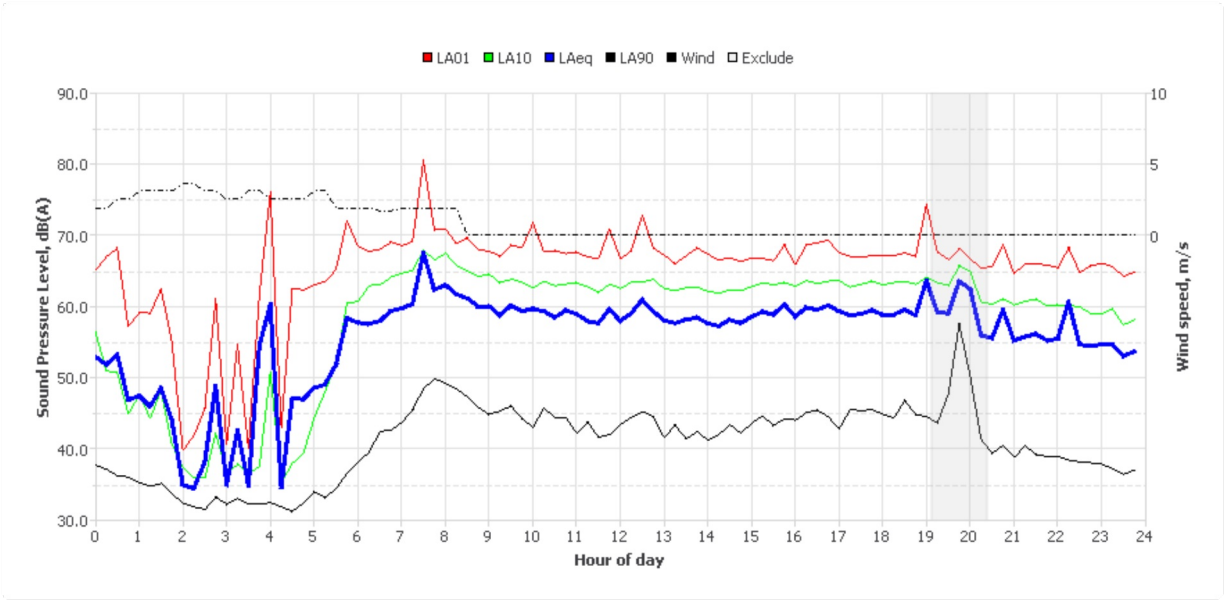
Wednesday, 24 Mar 2021



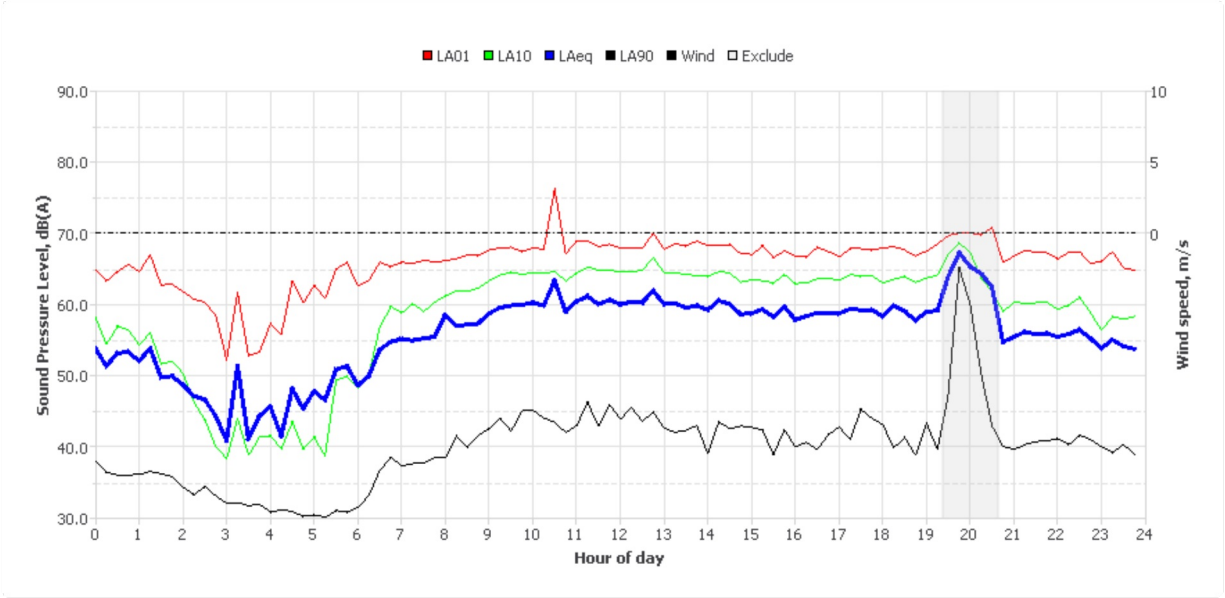
Thursday, 25 Mar 2021



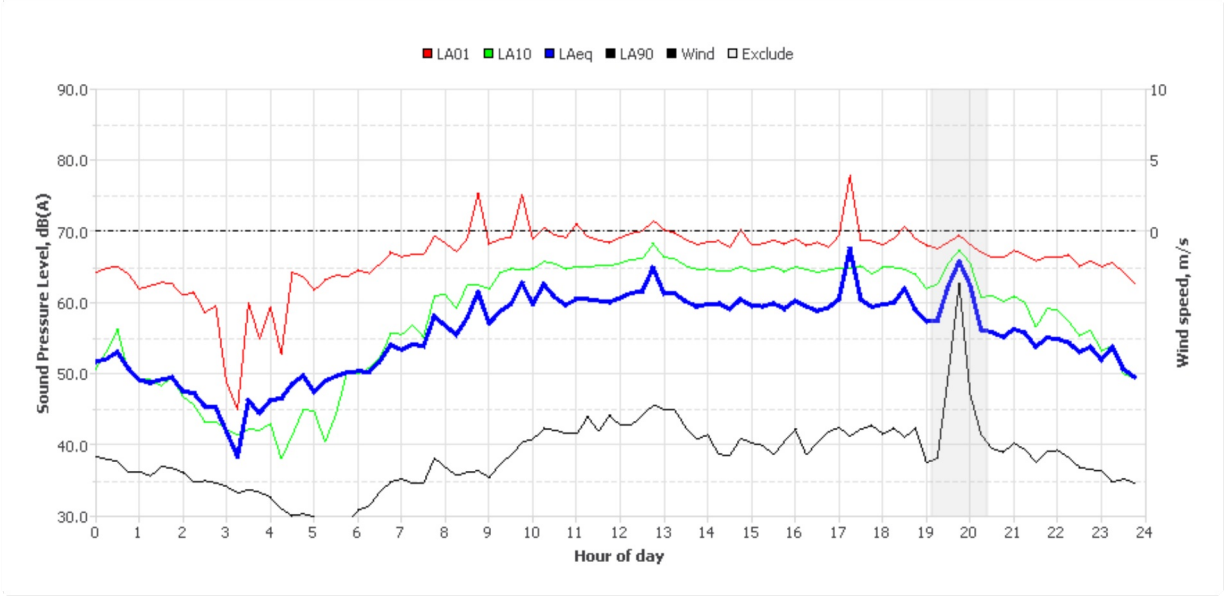
Friday, 26 Mar 2021



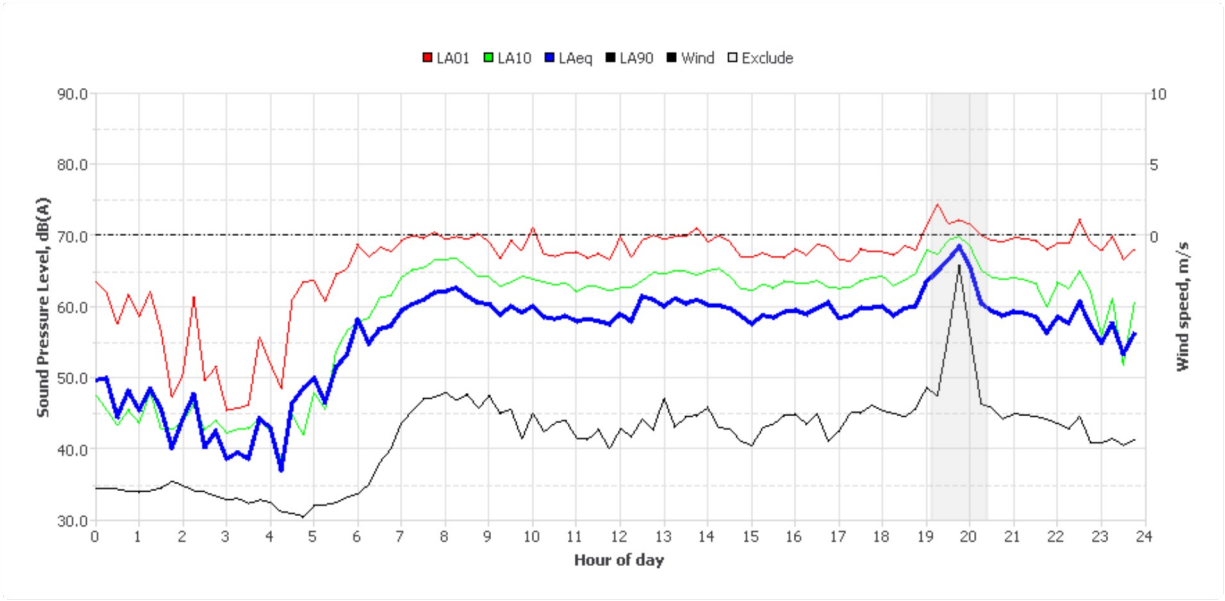
Saturday, 27 Mar 2021



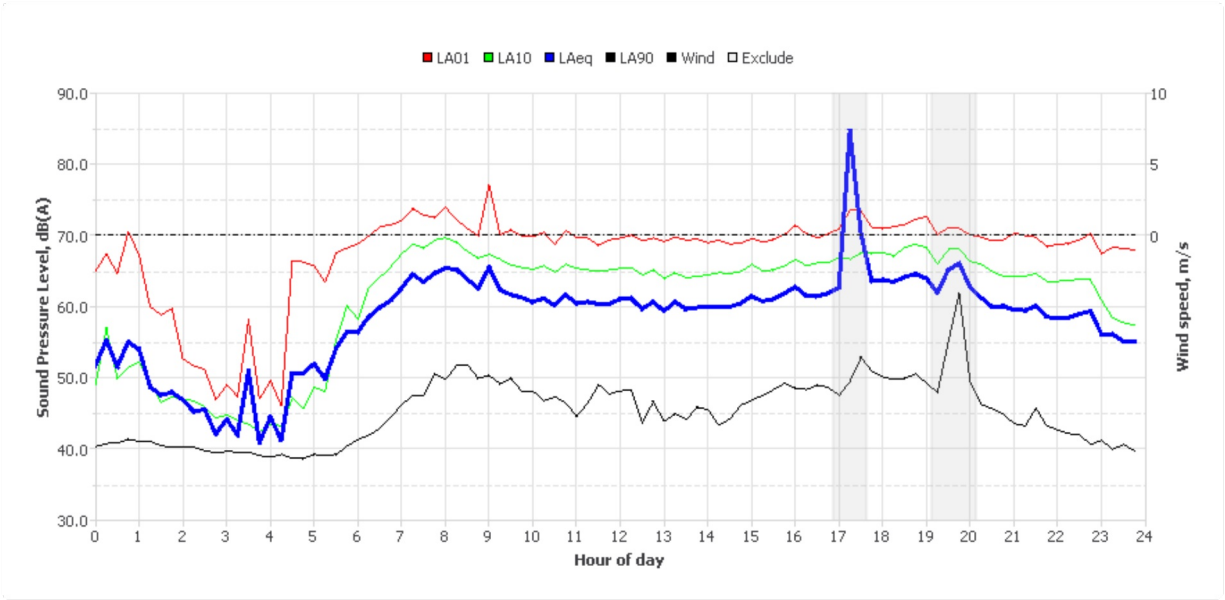
Sunday, 28 Mar 2021



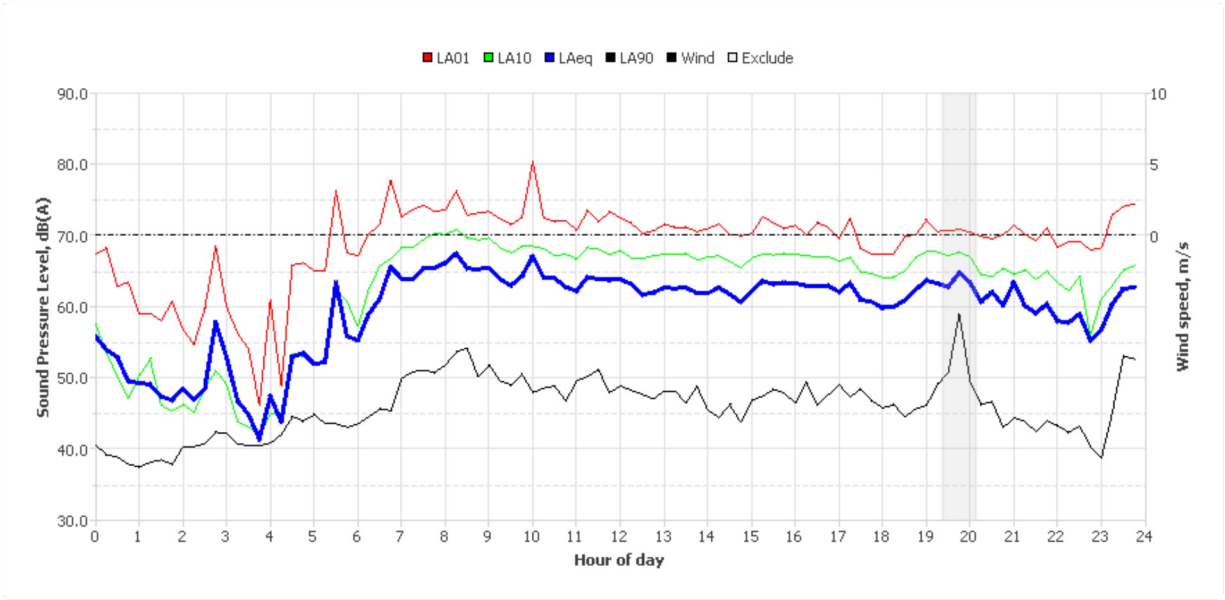
Monday, 29 Mar 2021



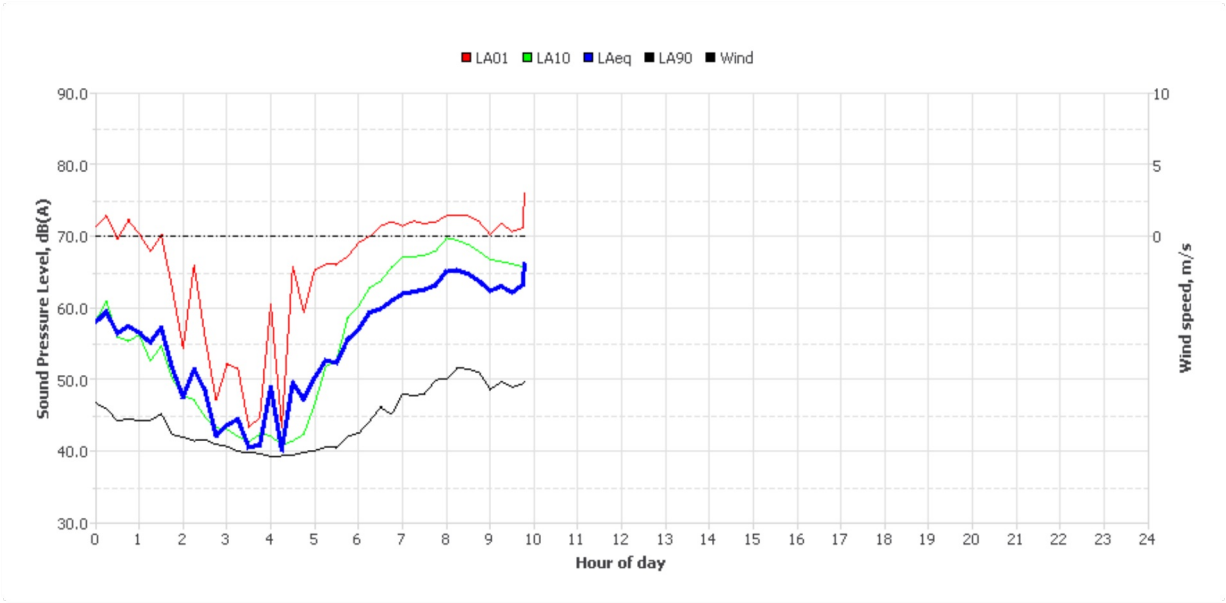
Tuesday, 30 Mar 2021



Wednesday, 31 Mar 2021

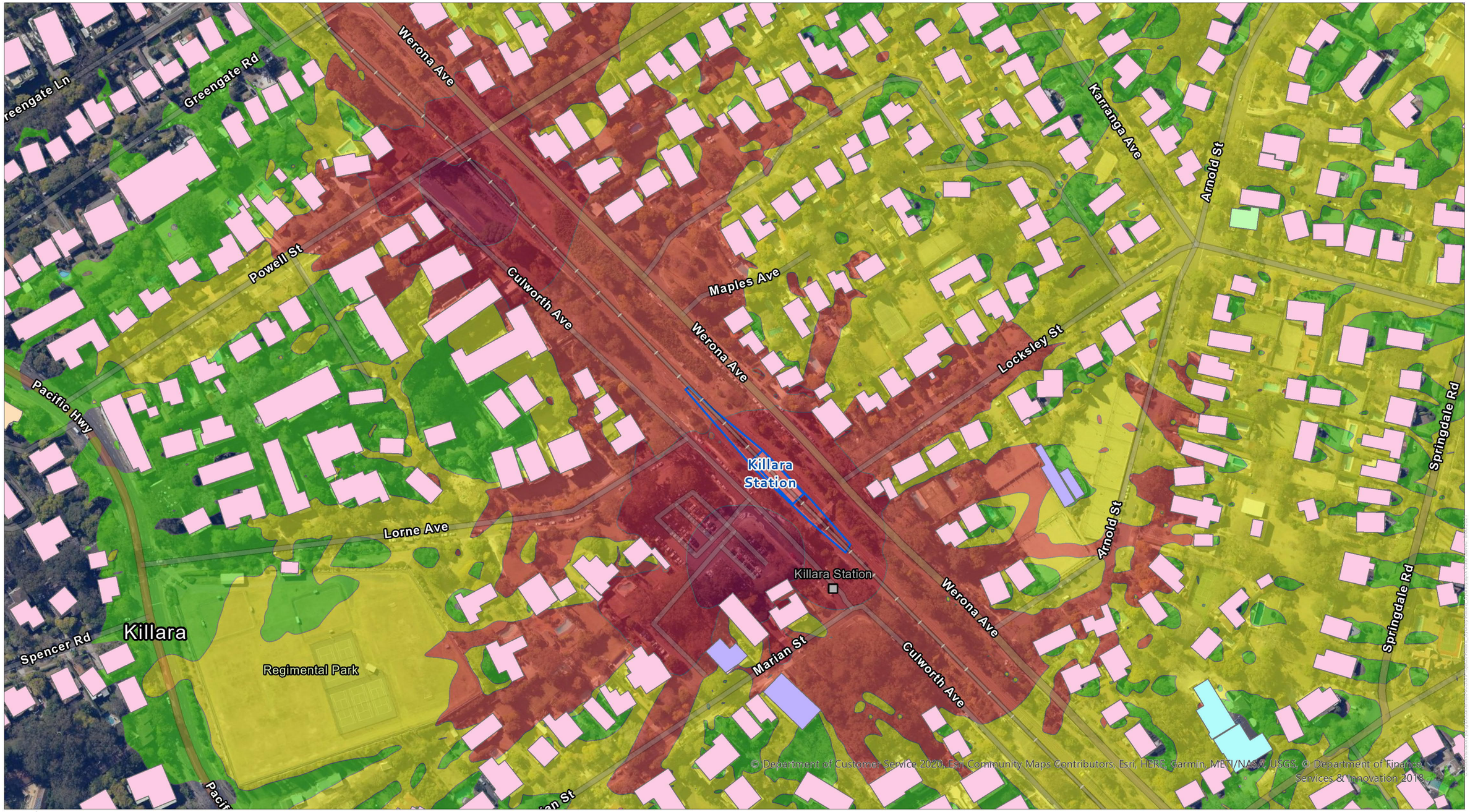


Thursday, 01 Apr 2021



Appendix C

Predicted Noise Contours - Construction



Legend

Killara Station

- Killara Station

Buildings

- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 1 - Site Establishment

LAeq (dBA)

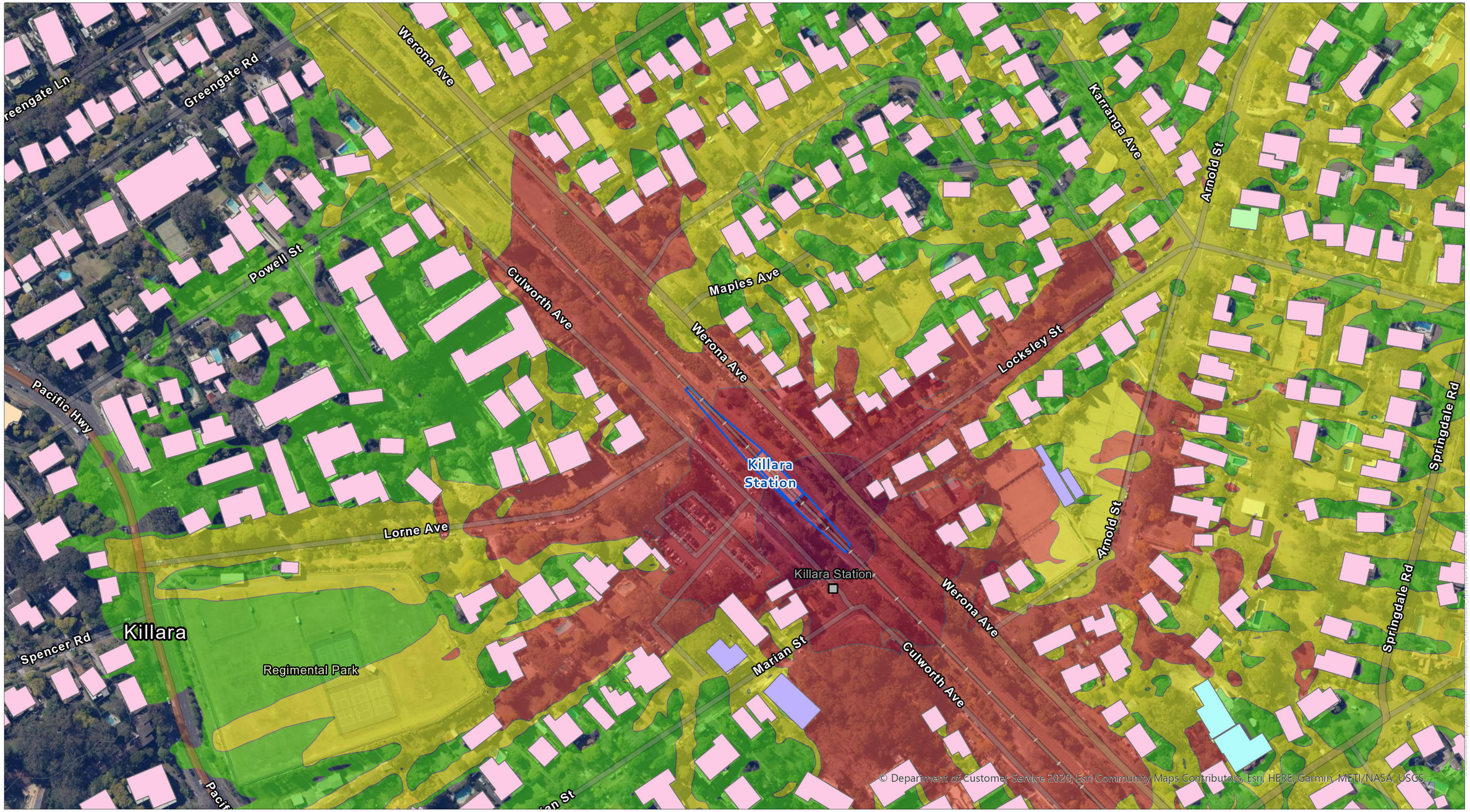
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:



Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 2 - New Lifts and Platform Upgrades

LAeq dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:

Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 3 - Interchange works

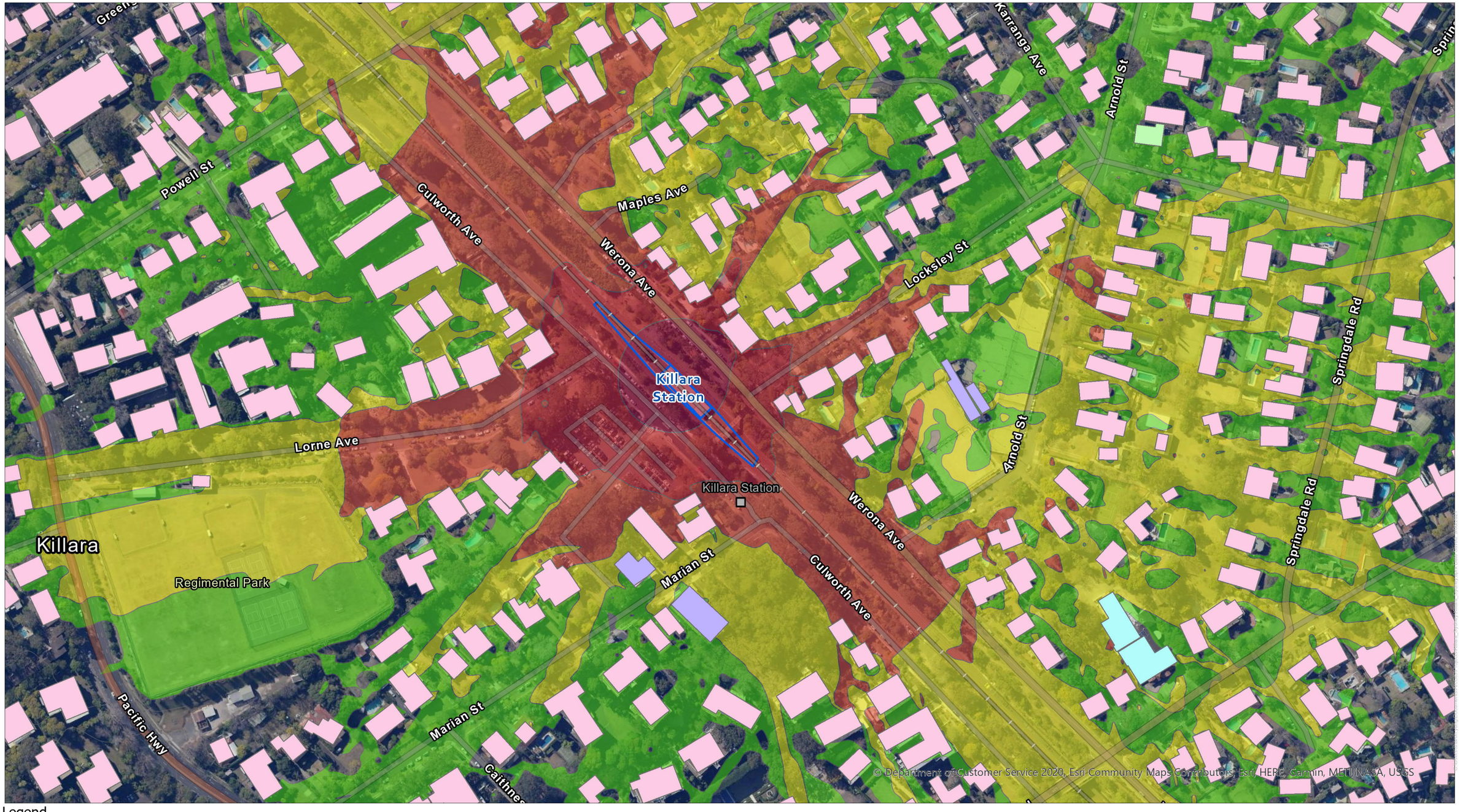
LAeq dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:



Legend

Killara Station

- Killara Station

Buildings

- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 4 - Building Reconfiguration

LAeq dB(A)

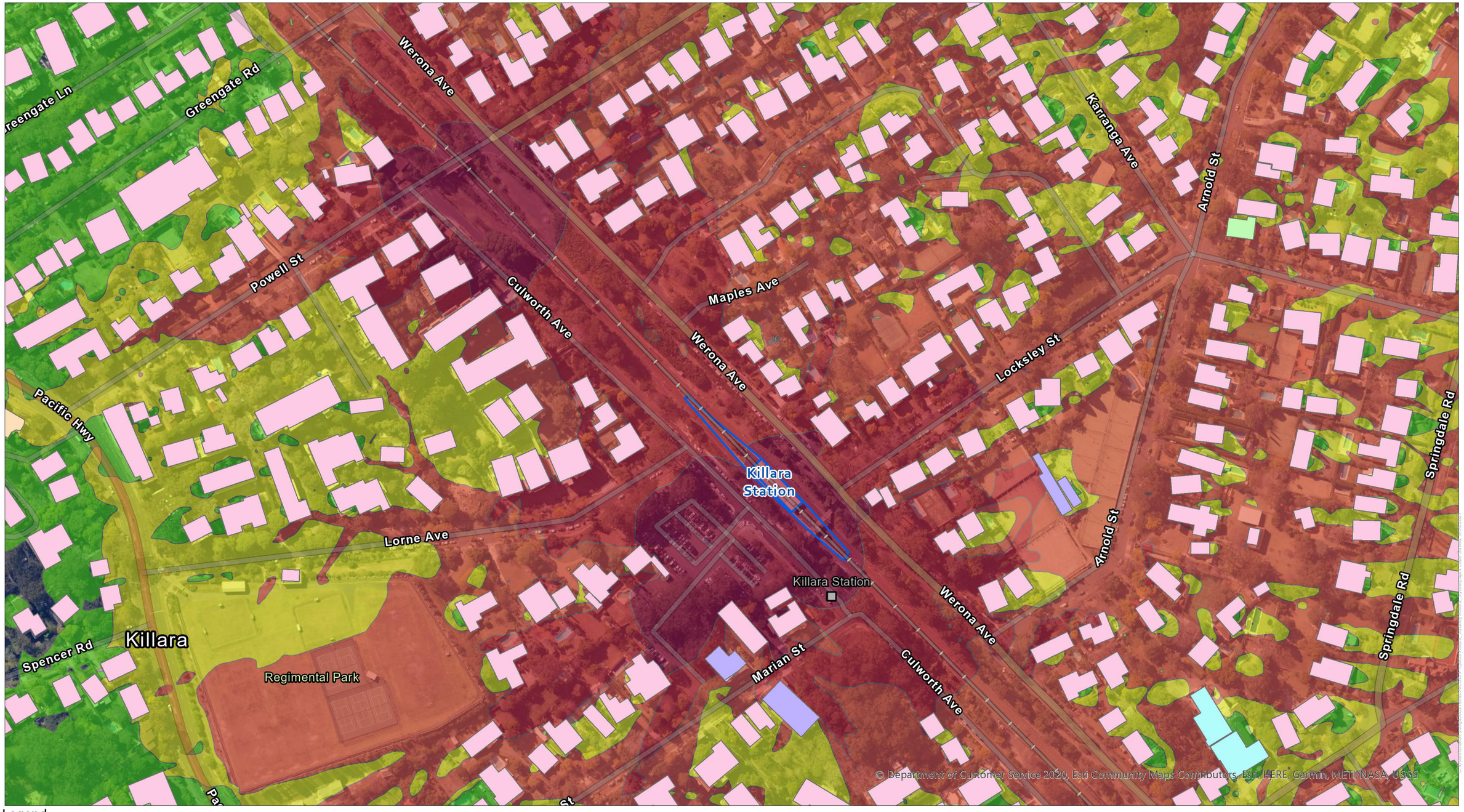
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:



Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 1 Site Establishment

L_A1 (min) dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:

Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 2 - New Lifts and Platform Upgrades

L_A1(min) dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:

Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 3 - Interchange works

L_A1(min) dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source:

Legend

Killara Station
- Killara Station

Buildings
- Commerical
- Community
- Health
- Place of Worship
- Residential

Stage 4 - Building Reconfiguration

L_A1(min) dB(A)
- ≤30
- ≤40
- ≤50
- ≤60
- ≤70
- ≤80

N

0 30 60 Meters

AECOM

Source: