Sydney Metro City & Southwest:

Waterloo Over Station Development

Acoustic Impact Assessment Report

Applicable to:	Sydney Metro City & Southwest
Author:	SLR Consulting Australia
Owner	Sydney Metro
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1.0 Introduction

1.1 Purpose of this report

This report accompanies a concept State Significant Development Application (concept SSD Application) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act.

This report should be read in conjunction with the Nominated State Significant Precinct (SSP) Study – Waterloo Metro Quarter, submitted to the Minister for Planning (the Minister) in July 2018. That study proposes new planning controls to facilitate the development proposed.

Sydney Metro is seeking to secure concept approval for over station development (OSD) above and adjacent to Waterloo Station including a podium and three taller buildings which include commercial, residential, and community land uses. A total of six buildings are proposed on the site. The concept SSD Application seeks consent for a building envelope and use for residential, retail, commercial, entertainment, community and recreational purposes, maximum building height, maximum gross floor area, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of development.

Sydney Metro proposes to procure the construction of the OSD as part of an integrated station development package, which would result in the combined delivery of the station, OSD and public domain improvements. The station and its public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by DP&E on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for “commercial premises or residential accommodation” with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

This report has been prepared to address the acoustic requirements and specifically respond to the Secretary’s Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 29th June 2018 which states that the Environmental Impact Statement (EIS) is to address the following requirements:

Table 1 SEARs Addressed

Reference	SEARs Requirement	Where Addressed in Report
8	The EIS shall: • address solar access, acoustic impacts, visual privacy, views and visual impacts, reflectivity, overshadowing and noise and vibration impacts to the surrounding area, including neighbouring properties and the public domain	**Section 4.0** and **Section 5.0** *(noise aspects only)*
9	The EIS shall include a noise impact assessment identifying: • measures to minimise and mitigate potential noise and vibration impacts of the proposal on surrounding developments. • the impacts of likely noise and vibration from surrounding land uses, such as noise from the operation of the rail line and surrounding road networks and mitigation measures to protect the amenity of residents/ visitors/ employees.	**Section 5.0**

1.2 Overview of the Sydney Metro in its context

Sydney Metro is Australia's biggest public transport project. A new standalone metro railway system, this 21st century network will deliver 31 metro stations and 66km of new metro rail for Australia's biggest city — revolutionising the way Sydney travels. Services start in the first half of 2019 on Australia's first fully-automated railway.

Sydney Metro was identified in *Sydney's Rail Future*, as an integral component of the *NSW Long Term Transport Master Plan*, a plan to transform and modernise Sydney's rail network so it can grow with the city's population and meet the future needs of customers. In early 2018, *the Future Transport Strategy 2056* was released as an update to *the NSW Long Term Transport Master Plan* and *Sydney's Rail Future*. Sydney Metro City & Southwest is identified as a committed initiative in the *Future Transport Strategy 2056*.

Sydney Metro is comprised of three projects:

Sydney Metro Northwest — formerly the 36km North West Rail Link. This $8.3 billion project is now under construction and will open in the first half of 2019 with a metro train every four minutes in the peak.

Sydney Metro City & Southwest — a new 30km metro line extending the new metro network from the end of Sydney Metro Northwest at Chatswood, under Sydney Harbour, through the CBD and south west to Bankstown. It is due to open in 2024 with an ultimate capacity to run a metro train every two minutes each way through the centre of Sydney.

Sydney Metro West – a new underground railway connecting the Parramatta and Sydney central business districts. This once-in-a-century infrastructure investment will double the rail capacity of the Parramatta to Sydney CBD corridor and will establish future capacity for Sydney's fast growing west. Sydney Metro West will serve five key precincts at Westmead, Parramatta, Sydney Olympic Park, The Bays and the Sydney CBD. The project will also provide an interchange with the T1 Northern Line to allow faster connections for customers from the Central Coast and Sydney's north to Parramatta and the Sydney CBD.

Sydney's new metro, together with signalling and infrastructure upgrades across the existing Sydney suburban rail network, will increase the capacity of train services entering the Sydney CBD – from about 120 an hour currently to up to 200 services beyond 2024. That's an increase of up to 60 per cent capacity across the network to meet demand.

Figure 1 Sydney Metro alignment map

Sydney Metro City & Southwest includes the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and on to Bankstown through the conversion of the existing line to metro standards.

The project also involves the delivery of six (6) new metro stations, including at Waterloo, together with new underground platforms at Central. Once completed, Sydney Metro will have the ultimate capacity for a train every two minutes through the CBD in each direction - a level of service never seen before in Sydney.

On 9 January 2017, the Minister approved the Sydney Metro City & Southwest - Chatswood to Sydenham application lodged by TfNSW as a Critical State Significant Infrastructure project (reference SSI 15_7400), hereafter referred to as the CSSI Approval.

The CSSI Approval includes all physical work required to construct the CSSI, including the demolition of existing buildings and structures on each site. Importantly, the CSSI Approval also includes provision for the construction of below and above ground structures and other components of future OSD (including building infrastructure and space for future lift cores, plant rooms, access, parking and building services, as relevant to each site). The rationale for this delivery approach, as identified within the CSSI application is to enable the OSDs to be more efficiently built and appropriately integrated into the metro station structures.

The EIS for the Chatswood to Sydenham alignment of the City & Southwest project identified that the OSD would be subject to a separate assessment process.

Since the CSSI Approval was issued, Sydney Metro has lodged four modification applications to amend the CSSI Approval as outlined below:

- Modification 1 - Victoria Cross and Artarmon Substation which involves relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with inclusion of a new station entrance at this location referred to as Victoria Cross North. The modification also involves the relocation of the substation at Artarmon from Butchers Lane to 98 – 104 Reserve Road. This modification application was approved on 18 October 2017.
- Modification 2 - Central Walk which involves additional works at Central Railway Station including construction of a new eastern concourse, a new eastern entry, and upgrades to suburban platforms. This modification application was approved on 21 December 2017.
- Modification 3 - Martin Place Station which involves changes to the Sydney Metro Martin Place Station to align with the Unsolicited Proposal by Macquarie Group Limited (Macquarie) for the development of the station precinct. The proposed modification involves a larger reconfigured station layout, provision of a new unpaid concourse link and retention of the existing MLC pedestrian link and works to connect into the Sydney Metro Martin Place Station. It is noted that if the Macquarie proposal does not proceed, the original station design remains approved. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporated Sydenham Station and precinct works, the Sydney Metro Trains Facility South, works to Sydney Water's Sydenham Pit and Drainage Pumping Station and ancillary infrastructure and track and signalling works into the approved project. This modification application was approved on 13 December 2017.

The CSSI Approval as modified allows for all works to deliver Sydney Metro between Chatswood and Sydenham Stations and also includes upgrade of Sydenham Station.

The remainder of the City & Southwest alignment (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line from west of Sydenham Station to Bankstown to metro standards. This part of the project, referred to as the Sydenham to Bankstown upgrade, is the subject of a separate CSSI Application (Application No. SSI 17_8256) for which an EIS was exhibited between September and November 2017. A Response to

Submissions and Preferred Infrastructure Report was submitted to DPE in June 2018 for further exhibition and assessment. This application is subject to assessment and determination by DPE, taking into consideration a further Response to Submissions Report which was submitted to DPE in September 2018.

1.3 Nominated State Significant Precinct - Waterloo

Following the decision to locate a metro station in Waterloo, the Minister determined that parts of Waterloo are of State planning significance which should be investigated for urban renewal through the SSP process. Study requirements for such investigations were issued by the Minister on 19 May 2017.

Investigation of the Precinct is being undertaken by UrbanGrowth NSW Development Corporation (UrbanGrowth NSW), in partnership with Sydney Metro and the Land and Housing Corporation (LAHC). The outcome of the SSP process will be new planning controls that will enable future development applications for renewal of the Precinct. The Precinct includes two separate but contiguous and inter-related parts:

- The Waterloo Metro Quarter (the Metro Quarter)
- The Waterloo Estate (the Estate)

A separate SSP Study for the Metro Quarter was lodged in July 2018 in advance of the SSP Study for the Estate to provide a planning framework for the construction of OSD within the Metro Quarter. The staged submission of the Metro Quarter SSP Study also facilitates the proposed development to be delivered concurrently with the metro station, as an integrated station development.

As this concept SSD Application relies upon the planning framework proposed in the Metro Quarter SSP Study, it is anticipated that the SSP Study and the EIS for the SSD Application will be exhibited concurrently.

1.4 Planning relationship between Waterloo Station and the OSD

While Waterloo Station and the OSD will form an integrated station development, the planning pathways defined under the EP&A Act require separate approval for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

For clarity, the approved station works under the CSSI Approval included the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This includes but is not limited to:

- demolition of existing development
- excavation
- integrated station and OSD structure (including concourse and platforms)

- lobbies
- retail spaces within the station building
- public domain improvements associated with the station
- access arrangements including vertical transport such as escalators and lifts
- space provisioning and service elements necessary to enable the future development of the OSD, such as lift cores, plant rooms, access, parking, retail, utilities connections and building services.

The vertical extent of the approved station works above ground level is defined by the 'transfer level' level (which for Waterloo is defined by approximately RL 33.1 over the northern station box and RL 35.1 over the southern station box), above which would sit the OSD. An example of this delineation is illustrated in **Figure 2**.

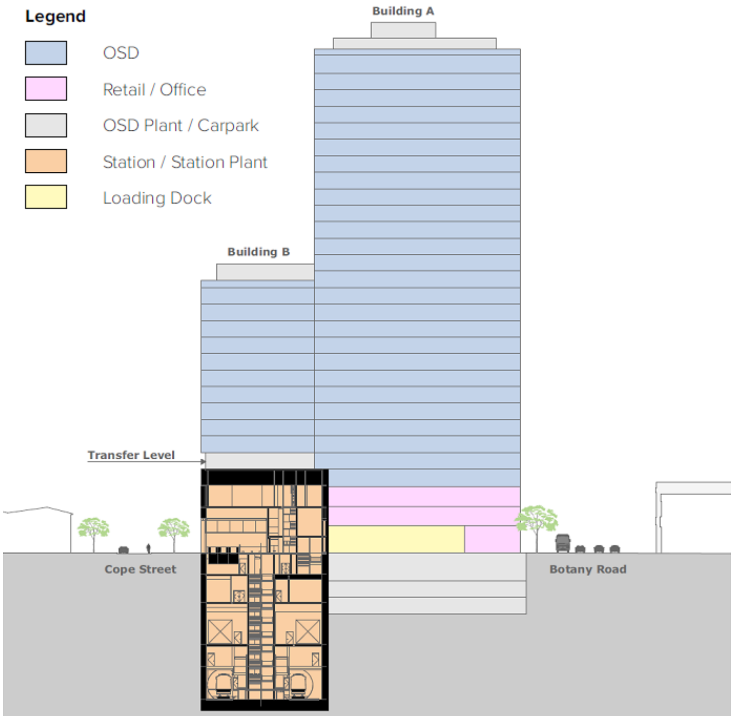

Figure 2 Delineation between the Metro station and OSD

It is noted that the structural and service requirements and space provisioning to support OSD vary from station to station. For example, based on the current level of design, Waterloo Station is not expected to provide for OSD lobbies, end of trip facilities and plant rooms. However, the detailed design may be amended to incorporate these elements as part of the integrated station development.

The CSSI Approval also establishes the general concept for the ground plane of Waterloo Station including access strategies for commuters, pedestrians and workers. In this regard, the main pedestrian access to the station would be via an entry located at the corner of Raglan and Cope Streets. The station design has continued to be developed having regard to its integration with the Metro Quarter OSD, and as a result, a second entrance to the station is to be provided from a proposed public plaza adjacent to Cope Street. Retail uses (approved under the CSSI Approval) would be located on the ground floor of the station development along the Cope Street frontage of the site.

Since the issue of the CSSI Approval, Sydney Metro has undertaken design work to determine the technical requirements for the structural integration of the OSD with the station. This level of design work, together with the planning and design undertaken for the remainder of the Metro Quarter has informed the concept proposal for the OSD. It is noted that ongoing design development of the works to be delivered under the CSSI Approval would continue with a view to developing an Interchange Access Plan (IAP) and Station Design Precinct Plan (SDPP) for Waterloo Station to satisfy Conditions E92 and E101 of the CSSI Approval. The detailed design for the Metro Quarter would continue to evolve having regard to the IAP and SDPP.

Public domain improvement works immediately adjacent to Waterloo Station would be delivered as part of the CSSI Approval to support pedestrian movements between transport modes (including to new and relocated bus stops, bike parking on Cope Street, and taxi and kiss-and-ride bays on Cope Street), while other public domain works within the Metro Quarter are proposed as part of the OSD. Final details of public domain works for the OSD will be provided with the detailed SSD Application(s) following finalisation of the SDPP and IAP for the CSSI Approval.

1.5 The site

The site is located within the City of Sydney (CoS) Local Government Area (LGA).

1.5.1 Location

The Metro Quarter comprises land to the west of Cope Street, east of Botany Road, south of Raglan Street and north of Wellington Street. The heritage listed Waterloo Congregational Church located at 103–105 Botany Road is within this block but is not part of the site.

The site has an approximate area of 1.287 hectares (refer to **Figure 3**).

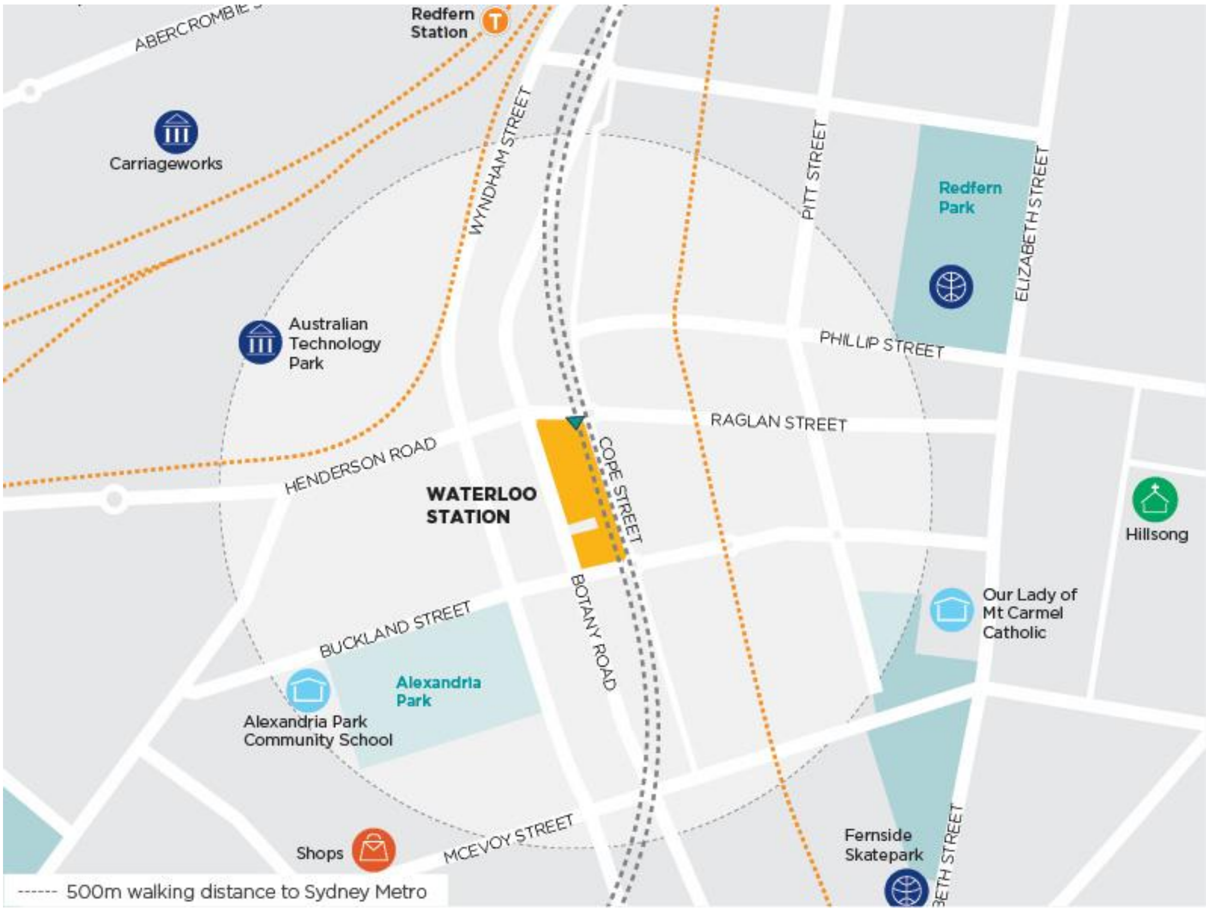

Figure 3 Waterloo Station location plan

1.5.2 Site context

The Metro Quarter is located in Redfern Street Village (see **Figure 4**) in the CoS LGA approximately 3.3 kilometres south of Sydney CBD, 1 kilometre north of Green Square and less than 1 kilometre south of Redfern Station.

Directly east is the Waterloo Estate, which is owned by the NSW Government and is under the management of NSW LAHC. The Waterloo Estate comprises 2,012 social housing dwellings and a small number of private dwellings in medium and high density forms, ranging from single storey attached dwellings to apartment buildings of up to thirty storeys.

The Metro Quarter is less than 1 kilometre south-east of the Australian Technology Park (ATP), a technology micro-cluster that currently contains around 3,000 – 3,500 workers with a range of businesses in technology and creative industries; and a start-up/business incubator hub. It is set to grow into a business park that will soon accommodate new premises currently under construction (i.e. Commonwealth Bank Australia (CBA) has committed to two major office towers).

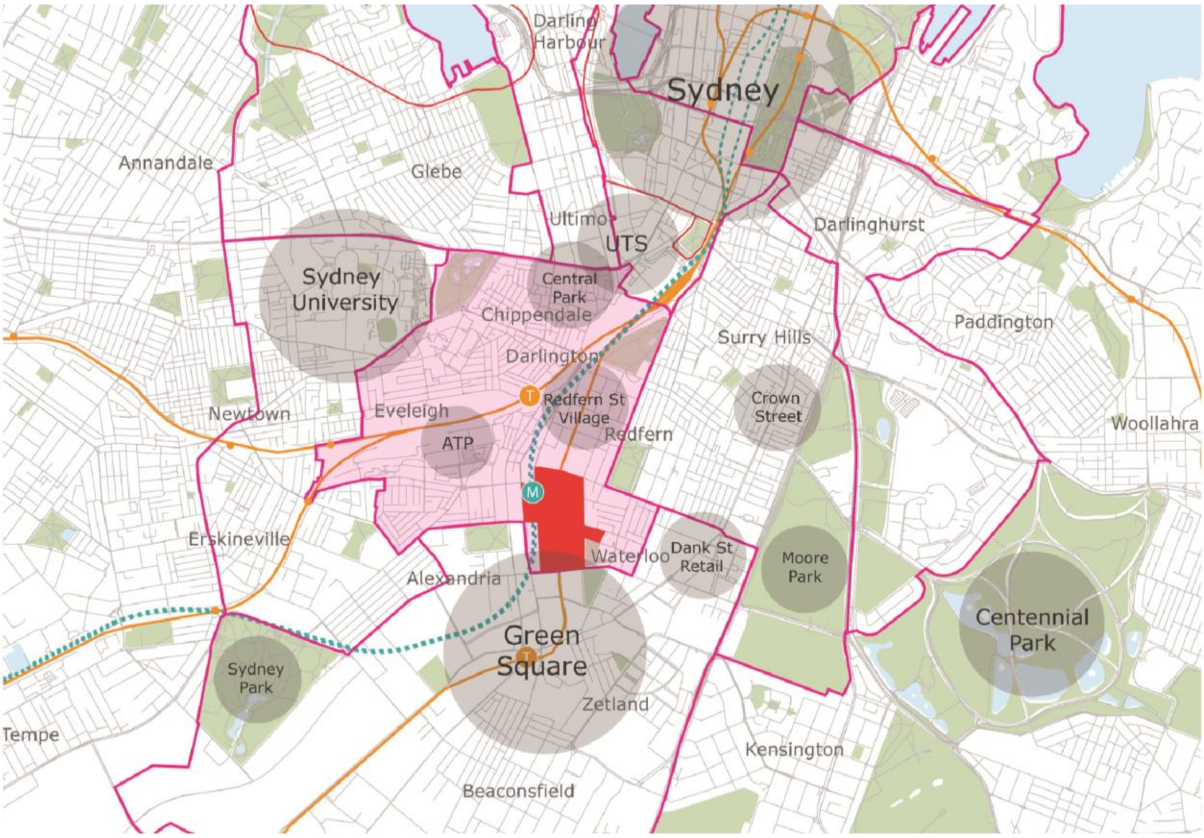

Figure 4 Location and site plan of the Waterloo State Significant Precinct (in red) and Redfern Street Village (in pink)

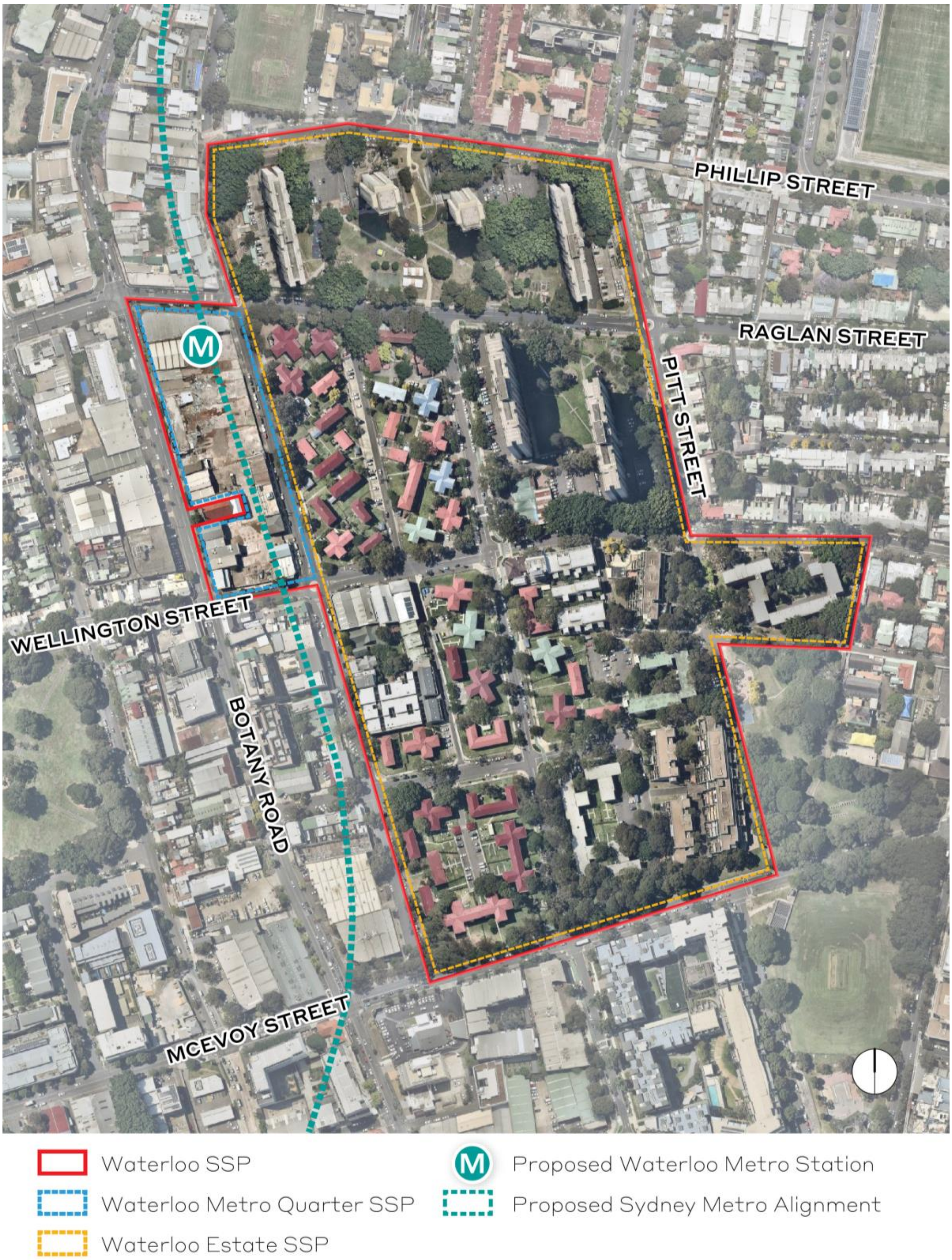

Figure 5 Nominated State Significant Precinct - Waterloo

The site comprises the following properties:

• 136B Raglan Street	Lo 4 DP 215751
• 59 Botany Road	Lot 5 DP 215751
• 65 Botany Road	Lot 1 DP814205
• 67 Botany Road	Lot 1 DP228641
• 124-128 Cope Street	Lot 2 DP228641
• 69-83 Botany Road	SP75492
• 130-134 Cope Street	Lot 12 DP399757
• 136-144 Cope Street	Lots A-E DP108312
• 85 Botany Road	Lot 1 DP27454
• 87 Botany Road	Lot 2 DP27454
• 89-91 Botany Road	Lot 1 DP996765
• 93-101 Botany Road	Lot 1 DP433969 & Lot 1 DP738891
• 156-160 Cope Street	Lot 31 DP805384
• 107-117A Botany Road	Lot 32 DP805384 & Lot A DP408116
• 119-121 Botany Road	Lot 1 DP205942 & Lot 1 DP436831
• 170-174 Cope Street	Lot 2 DP205942

The buildings and structures on the site are now demolished in accordance with the CSSI Approval with the exception of one building which is being used to support construction.

1.6 Overview of the proposed development

This concept SSD Application follows the submission of a SSP Study which supports a proposal to amend existing controls to facilitate the proposed development. The concept SSD Application will in turn comprises the first stage of seeking SSD development consent for the Waterloo OSD project. It will be followed by a future detailed SSD Application(s) for the design and construction of the OSD built form.

This concept SSD Application seeks approval for the planning and development framework and strategies to inform the future detailed design of the OSD. It specifically seeks approval for:

- maximum building envelopes, including maximum building heights, street-wall heights and ground and upper level setbacks

- a maximum gross floor area (GFA) of 68,750 square metres, comprising:
  - approximately 56,200 square metres GFA of residential accommodation, with potential to deliver approximately 700 dwellings, comprising a mix of housing including 5 to 10 percent affordable housing and 70 social housing dwellings
  - approximately 3,905 square metres GFA of retail premises and entertainment facilities
  - approximately 8,645 square metres GFA for business and commercial premises and community, health service and recreational facilities (indoor)
- a three storey podium and a free standing building located within a public plaza, accommodating non-residential land uses
- residential uses above podium level in various building forms including three taller buildings of 23, 25 and 29 storeys (Relative Level (RL) 96.9, 104.2 and 116.9 metres Australian Height Datum (AHD) respectively)
- use of OSD space provisioning within the footprint of the CSSI Approval
- public domain works, through-site links, footpaths and provision for cycle facilities and enhanced pedestrian crossings and roads
- maximum car parking rates
- loading, vehicular and pedestrian access arrangements
- strategies for utilities and services provision
- strategies for managing stormwater and drainage
- a strategy for the achievement of ecologically sustainable development
- a public art strategy
- provision for future signage zones
- a design excellence framework
- the future subdivision of parts of the OSD footprint (if required).

It is noted that the Sydney Metro comprises GFA of approximately 8,415 square metres on the site, approved under CSSI Approval. The total GFA for the integrated station development, including the station GFA is approximately 77,165 square metres, which is equivalent to an FSR of approximately 6:1.

Key parameters of the Concept proposal based on the current level of design development are indicated at **Figure 6** and **Figure 7**.

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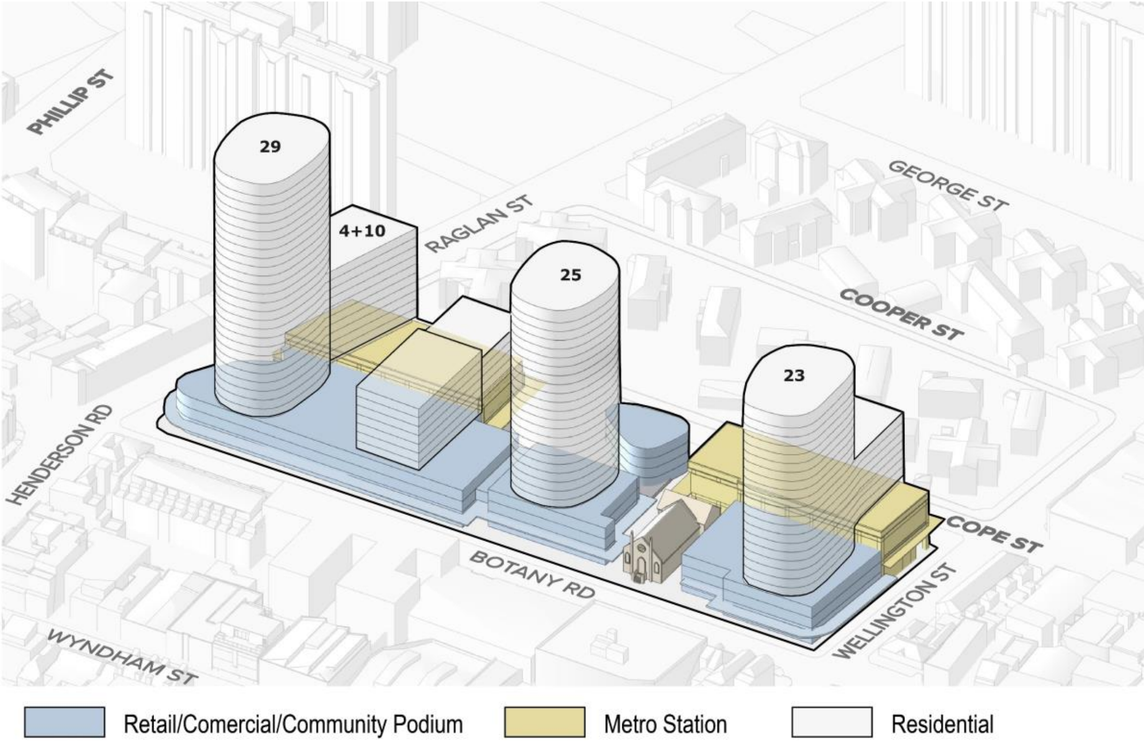

Figure 6 Proposed massing, viewed from the west

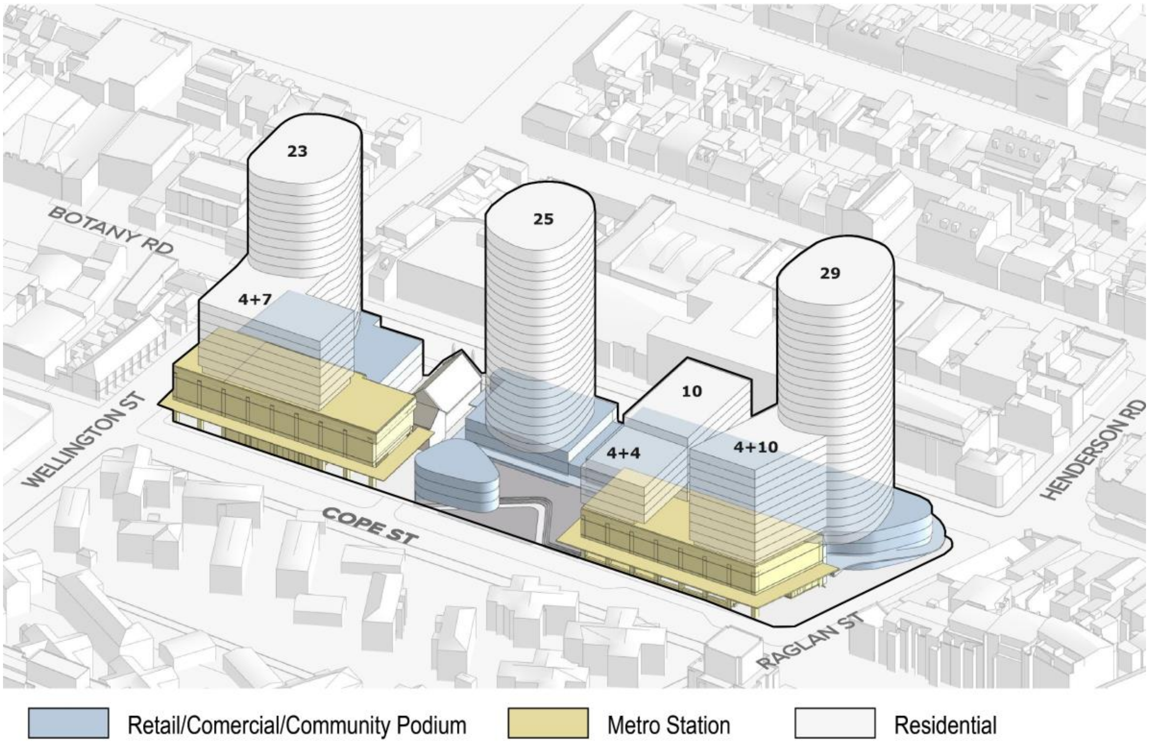

Figure 7 Proposed massing, viewed from the east

The proposal is a significant opportunity to contribute to the urban renewal process for the Waterloo SSP. The objective to deliver the Metro Quarter project as soon as reasonably possible after completion of the metro works (earmarked to open 2024) would ensure buildings within the Metro Quarter are occupied to support maximum patronage of the proposed metro station.

The Metro Quarter would contain a mix of uses including residential, commercial, retail, community facilities and services and cultural opportunities sufficient for daily life to be provided for within the wider neighbourhood and to support the activation of the precinct. This will help make Waterloo one of the most connected and attractive inner-city places to live, work and visit.

1.7 Staging and framework for managing environmental impacts

Sydney Metro proposes to procure the delivery of the Waterloo integrated station development in one single package, which would entail the following works:

- station structure fit-out, including mechanical and electrical
- OSD structure fit-out, including mechanical and electrical.

Separate delivery packages are also proposed by Sydney Metro to deliver the excavation of the station boxes/shafts ahead of the integrated station development delivery package, and linewide systems (e.g. track, power, ventilation) and operational readiness works prior to the Sydney Metro City & Southwest metro system being able to operate.

For the purposes of considering construction related impacts, three possible staging scenarios have been identified for delivery of the integrated station development:

1. Scenario 1 – the station and OSD are constructed concurrently by constructing the transfer slab first and then building in both directions. Both the station and OSD would be completed in 2024.
2. Scenario 2 – the station is constructed first and ready for operation in 2024. OSD construction may still be incomplete or soon ready to commence after station construction is completed. This means that some or all OSD construction is likely to still be underway upon opening of the station in 2024.
3. Scenario 3 – the station is constructed first and ready for operation in 2024. The OSD is built at a later stage, with timing yet to be determined. This creates two distinct construction periods for the station and OSD.

The final staging for the delivery of the OSD would be resolved as part of the detailed SSD Application(s).

For the purposes of providing a high level assessment of the potential environmental impacts associated with construction, the following have been considered:

- Impacts directly associated with the OSD, the subject of this SSD Application
- Cumulative impacts of the construction of the OSD at the same time as the station works (subject of the CSSI Approval).

Given the integration of the delivery of Waterloo Station with an OSD development, Sydney Metro proposes the framework detailed in **Figure 8** to manage the design and environmental impacts, in relation to Acoustics, consistent with the framework adopted for the CSSI Approval.

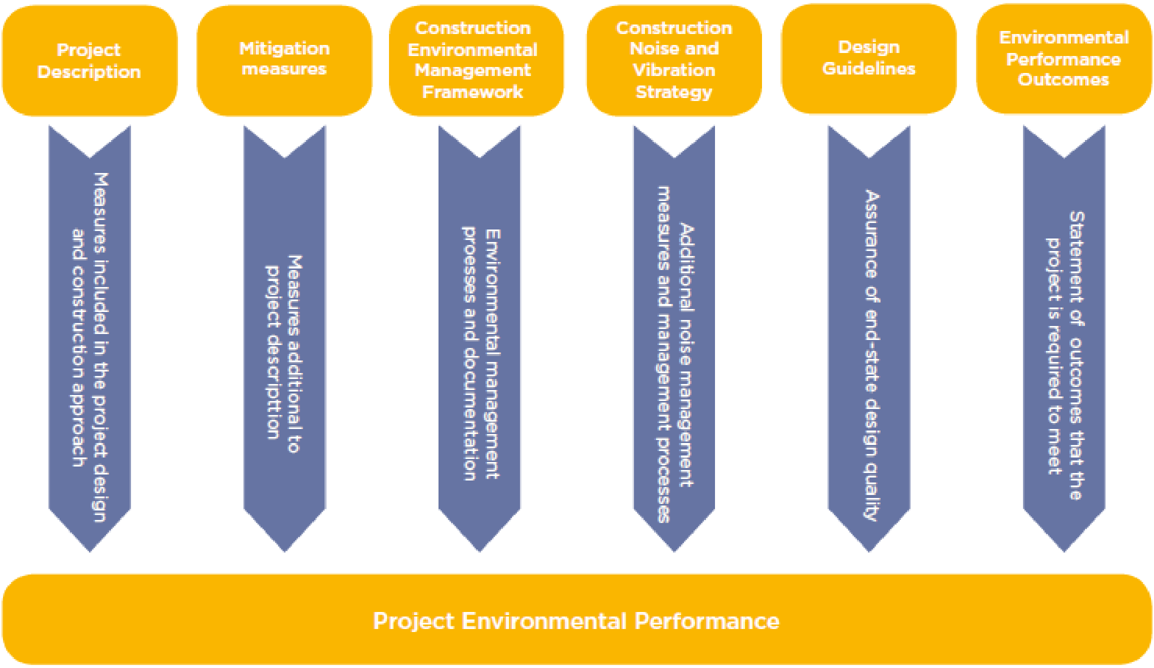

Figure 8 Project approach to environmental mitigation and management

This approach would be implemented until such time as completion of the station works (i.e. works under the CSSI Approval) is achieved. Beyond that point, standard construction environmental management practices would be implemented by the OSD developer in accordance with relevant guidelines and any conditions of approval.

2.0 Baseline Investigations

2.1 Project Overview

In accordance with the SEARs outlined in **Table 1**, baseline investigations were undertaken to identify the existing noise, vibration, air quality, and lighting environment throughout the Metro Quarter. Following this, a detailed assessment of the proposed concept design has been undertaken.

This report provides noise and vibration information relating to both the baseline investigations and the detailed assessment of the Metro Quarter development, outlining the process in detail, and providing preliminary recommendations with respect to the proposed design where required.

A glossary of acoustic terminology used throughout this report is included as **Appendix A**.

2.2 Existing Noise Environment

2.2.1 Existing Noise Sources

2.2.1.1 Road Traffic Noise

The existing noise environment throughout the project area is generally controlled by road traffic noise. The major arterial road near the project is Botany Road, which passes adjacent to the Metro Quarter, on the west side of the project. This road becomes quite congested during peak hours. Vehicle speeds are limited to 60 km/h which generally remains free-flowing outside peak hours. The surface appears to be a worn dense-graded asphalt (DGA) pavement and is likely to perform consistent with the standard DGA pavement correction.

Other collector roads include Raglan Street, Pitt Street, Cope Street and McEvoy Street. These roads are all limited to 50 km/h. Lower traffic volumes on the arterials result in generally lower noise levels. Traffic calming measures including roundabouts and speed humps reduce speeds below the posted speed limits, reducing tyre noise. Conversely, engine noise is increased as a result of these measures as the vehicles accelerate away from these measures.

McEvoy Street serves as a collector road between Botany Road, Elizabeth Street and Bourke Street which results in a higher noise generation than other collector roads.

The overall road noise environment throughout the project area sees the majority of noise emitted from Botany Road to the east of the project, with a lesser degree of noise emanated from the south.

2.2.1.2 Railway Noise

At street level, existing rail noise is generally not audible at most times in the project area due to shielding provided by the surrounding buildings. While the rail noise may be audible at times, due to the significant road network in closer proximity to these buildings, it is unlikely to be a controlling noise source.

2.2.1.3 Aircraft Noise

The Metro Quarter is not located directly under the flight path and is not directly impacted by aircraft noise.

The Australian Noise Exposure Index (ANEI) is a parameter used to describe the noise impact by airports in Australia. The ANEI is an equal energy noise index, similar to the L_{eq} from 7 pm to 7 am. The Australian Noise Exposure Forecast (ANEF) is the future predicted ANEI. Typically, the ANEF 20 contour and higher defines an area where additional noise mitigation may be required for new residential buildings.

While 364 residences exceeded the ANEI 20 contour (approximately 55 dB) in 2015 in the Waterloo-Beaconsfield area, no receivers exceeded this contour in 2016. This may be a result of changes to flight paths or operations.

Noise mitigation from aircraft noise would not be required throughout the project area.

The N70 noise contours illustrate the number of events above 70 dBA for an annual average day. These maps provide an indication of the likelihood of annoyance from aircraft noise. The N70 chart for the Sydney airport in 2016 indicates less than 10 noise events of greater than 70 dBA were experienced on an average day. This exposure is very low compared to other regions in Sydney and is not considered to be appreciably noise affected. Additionally, Sydney airport only operates between the hours of 0600 h to 2300 h and as such noise events greater than 70 dBA would generally occur during the less sensitive daytime period.

2.2.1.4 Industrial Noise Sources

While there is some light industry such as warehousing and car mechanics adjacent to the project area, there have been no noise generating industrial sources identified that would have a significant impact on the noise environment.

2.2.2 Ambient Noise Surveys and Monitoring Locations

To quantify and characterise the existing ambient noise environment across the project area, a baseline noise monitoring survey was undertaken from 8 to 15 June 2016. The measured noise levels have been used to establish existing ambient noise levels throughout the project area and to develop a detailed understanding of the existing noise environment.

Noise monitoring equipment was deployed with consideration of other noise sources that may influence the measurements, accessibility and security, and with the consent of relevant land owners. The noise monitoring locations are presented in **Table 2** and **Figure 9**.

Table 2 Ambient Noise Survey Locations

Noise Monitoring Location ID	Noise Monitoring Location Address	Equipment Serial Number
L1	1 Phillip Street, Waterloo	20663
L2	3 Phillip Street, Waterloo	3004636
L3	200 Pitt Street, Waterloo	3003632
L4	113 Wellington Street, Waterloo	3005908
L5	130 Botany Road, Waterloo	3005904
L6	34 McEvoy Street, Waterloo	3003389

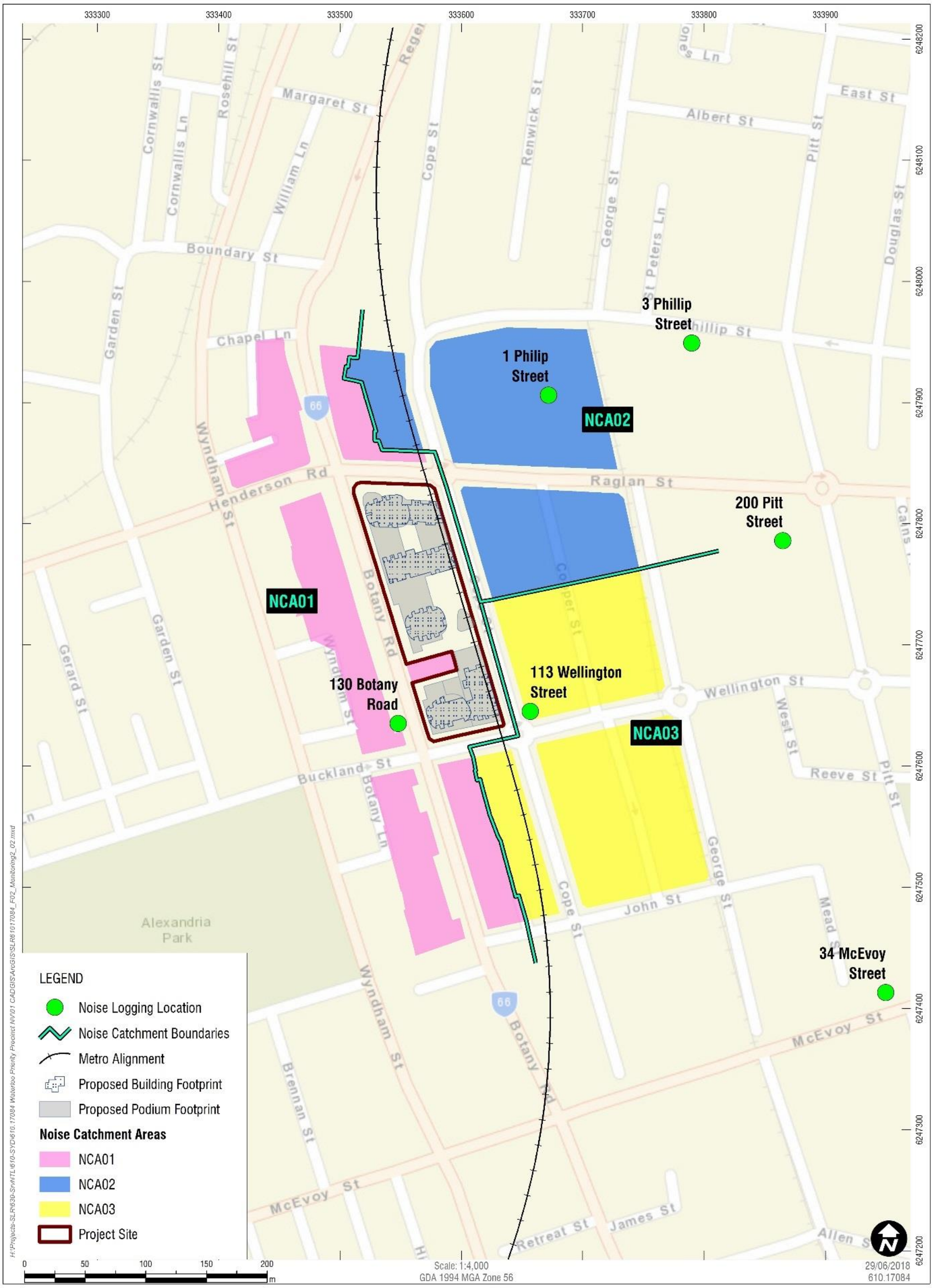

Figure 9 Waterloo State Significant Precinct, Noise Catchment Areas and Noise Logging Locations

2.2.3 Unattended Noise Monitoring

2.2.3.1 Methodology

The noise loggers continuously measured noise levels in 15 minute sampling periods to determine the existing L_{Aeq}, L_{A90} and other relevant statistical noise levels during the daytime, evening and night-time periods.

The noise measurements were carried out with a combination of Svantek 957 and Bruel and Kjaer 2250L noise loggers. The equipment was set up with microphones at 1.5 metres above the ground level. All microphones were fitted with wind shields.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of Australian Standard AS IEC 61672.1—2004 - *Electroacoustics—Sound level meters, Part 1: Specifications*[i] and carried appropriate and current National Association of Testing Authorities (NATA) calibration certificates. The calibration of the loggers was checked both before and after each measurement survey and the variation in calibration at all locations was found to be within acceptable limits at all times.

The results of the noise monitoring have been processed to exclude noise identified as extraneous and/or data affected by adverse weather conditions (such as strong wind or rain) so as to establish representative noise levels in each area.

2.2.3.2 Noise Monitoring Results

The results of the unattended ambient surveys are summarised in **Table 3** as the Rating Background Level (RBL) noise levels for the *Noise Policy for Industry* (NPfI) daytime, evening and night-time periods, and the L_{Aeq} (energy averaged) noise levels for the *NSW Road Noise Policy* RNP daytime and night-time periods. The 24 hour daily noise levels at each monitoring location are presented graphically in **Appendix B**.

Table 3 Summary of Unattended Noise Logging Results

Noise Monitoring Location	Measured Noise Level (dB)							
	NPfI Time Periods[1]						RNP Time Periods[2]	
	Daytime - RBL	Evening - RBL	Night-time - RBL	Daytime -LAeq	Evening - LAeq	Night-time - LAeq	Daytime - LAeq(15hour)	Night-time - LAeq(9hour)
L1	50	46	40	57	53	50	56	51
L2	48	42	38	57	52	50	56	50
L3	47	43	37	61	58	59	60	59
L4[3]	50	46	41	65	57	54	64	54
L5	60	57	46	72	70	69	72	69
L6[4]	Failed	-	-	-	-	-	-	-

Note 1: *Noise Policy for Industry (NPfI)* assessment periods – Daytime: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays and Public Holidays; Evening: 6:00 pm to 10:00 pm; Night: 10:00 pm to 7:00 am Monday to Saturday, 10:00 pm to 8:00 am Sundays and Public Holidays.

Note 2: Road Noise Policy (RNP) Assessment Time Periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am (weekly data).

Note 3: Attended noise measurements at this location identified a bird feeder located on the wall of the residential building. This was not identified at the time the noise logger was deployed as it was raining. At the time of the attended measurements the bird feeder attracted a large number of Rosellas which were generating noise levels over 100 dBA. This significant noise source is the reason that the RNP noise levels for L4 are higher than other comparable noise environment areas of the Waterloo project area.

Note 4: The noise logger at location L6 was damaged during the logging survey and no data was recorded.

The noise levels display a typical diurnal trend with lower noise levels during the night-time compared to the daytime and evening periods. This is characteristic of urban and suburban areas where the ambient noise environment is primarily influenced by road traffic.

2.2.4 Attended Airborne Noise

2.2.4.1 Methodology

Attended measurements of ambient noise were completed during the noise logging survey to determine the various noise sources that influence the existing noise environment. During each measurement the observer noted the various noise sources and the contributing noise level.

At each location the attended measurements were performed for 15 minutes using a calibrated Brüel and Kjær 2270 Precision Sound Level Meter (S/N:3008204). Wind speeds were less than 5 m/s at all times, and all measurements were performed at a height of 1.5 metres above ground level.

Calibration of the sound level meter was checked before and after each measurement and the variation in calibration at all locations was found to be within acceptable limits at all times.

2.2.4.2 Attended Noise Measurement Results

The noise environment at each of the attended monitoring locations is summarised in **Table 4**.

Table 4 Summary of Attended Noise Monitoring Results

Measurement Location	Measured Noise Levels (dB)			Description of Ambient Noise Source during attended period -
	LA90	LAeq	LAmax	
1 Phillip Street	48.2	58.2	74.5	Constant nature sounds with regular pedestrian movements. Intermittent traffic from Raglan Street and Phillip Street. Aircraft pass-bys are dominant sound source when present.
3 Phillip Street	51.7	60.7	84.8	Constant nature sounds with regular pedestrian movements. Intermittent traffic from Phillip Street. Dominant sound source is landscaping works in the area and aircraft pass-bys when present. It is expected that landscaping noise would not be present during night-time periods.
200 Pitt Street	55.1	61.9	80.6	Intermittent traffic noise from Raglan Street, particularly from vehicles travelling uphill. Landscaping works are dominant sound source during measurement. It is expected that landscaping noise would not be present during night-time periods.
34 McEvoy	58.2	66.4	80.0	Dominant sound source McEvoy Street traffic, with occasional pedestrian activity. Limited aircraft passbys during measurement.
113 Wellington Street	51.1	63.3	92.4	Constant parrot activity during measurement. Intermittent traffic noise from Wellington Road with some aircraft passby noise. Limited pedestrian activity.
130 Botany Road[1]	64.9	72.5	87.7	Traffic noise from Botany Road is dominant sound source, with limited aircraft passby.

Note 1: Monitoring location near to building facade. Measured noise levels considered to represent facade affected noise levels which are up to 2.5 dBA higher than the equivalent free-field condition.

2.3 Existing Vibration Environment

2.3.1 Existing Vibration Environment

There are currently no major existing vibration sources in the project area. Road traffic typically generates very low vibration levels which are well below applicable criteria. Where large discontinuities such as potholes, road plates or joins in the pavement occur, vibration levels can be perceived in close proximity to the road when heavy vehicles travel over them. Those vibration generating circumstances are a maintenance issue, rather than a design issue and are not assessed.

3.0 Proposal

3.1 Site Overview and Proposed Works

The proposed project area is located above and adjacent to Waterloo Station, between Cope Street and Botany Road, south of Raglan Street and north of Wellington Street. The project site will accommodate six new mixed-use high-rise buildings which are identified in **Figure 10**. The building numbers (B01 – B06) in **Figure 10** relate to those which have been adopted in residential noise intrusion predictions shown in **Appendix D**.

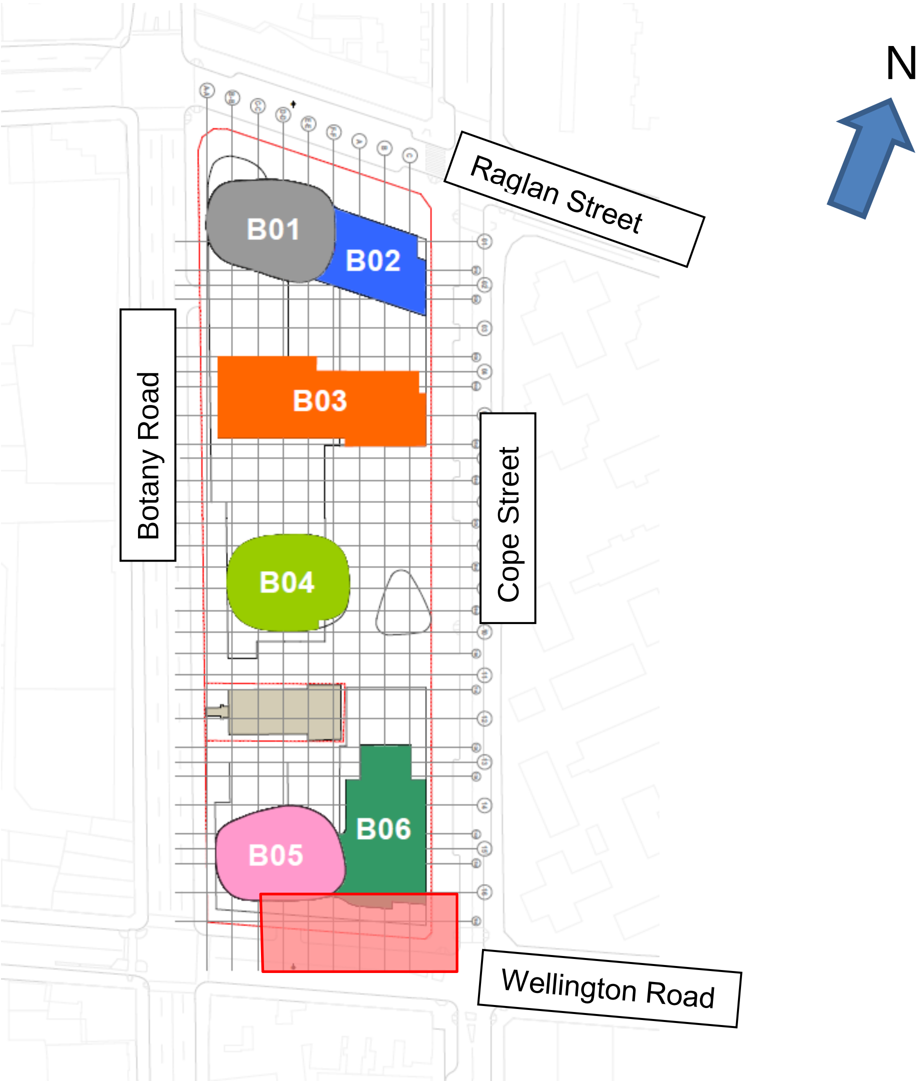

Figure 10 Project Site layout and proposed project buildings

Note 1: Development will preserve the heritage-listed Congregational Church (highlighted in red)

3.2 Potential Noise and Vibration Impacts

The following noise and vibration features with the potential to affect the surrounding environment and sensitive receivers are presented in this report:

- Noise and vibration impacts at the surrounding noise-sensitive receivers during project construction.
- Noise impacts at the surrounding noise-sensitive receivers from mechanical plant and other project related noise sources during operation.

Additionally, the following noise impacts and acoustic design requirements with respect to the proposed project buildings are outlined, with recommendations provided where appropriate.

- Potential noise intrusion impacts from external sources (ie road traffic and rail noise).
- Building facade constructions and sound insulation requirements.

Note that the scope of this report is to assess the feasibility of the potential future buildings to achieve the criteria associated with the above. Designs would be further developed as part of the detailed development application.

3.3 Noise Catchment Areas (NCAs)

Due to the urban density and colocation of different land uses surrounding the project site, in addition to the differences in the surrounding existing noise environments, Noise Catchment Areas (NCAs) have been established, containing different receiver types that may potentially be affected by noise and vibration impacts from the proposed project. Within each NCA, appropriate noise goals have been defined for each receiver type based on the following:

- The receiver's surroundings and sensitivity to noise and vibration.
- The receiver's location relative to the proposed project site.
- The results of the existing ambient noise surveys (presented in Section 2.2.3.2)
- Relevant NSW noise assessment policies and guidelines.

The defined NCAs containing different receiver types are presented in **Figure 11**.

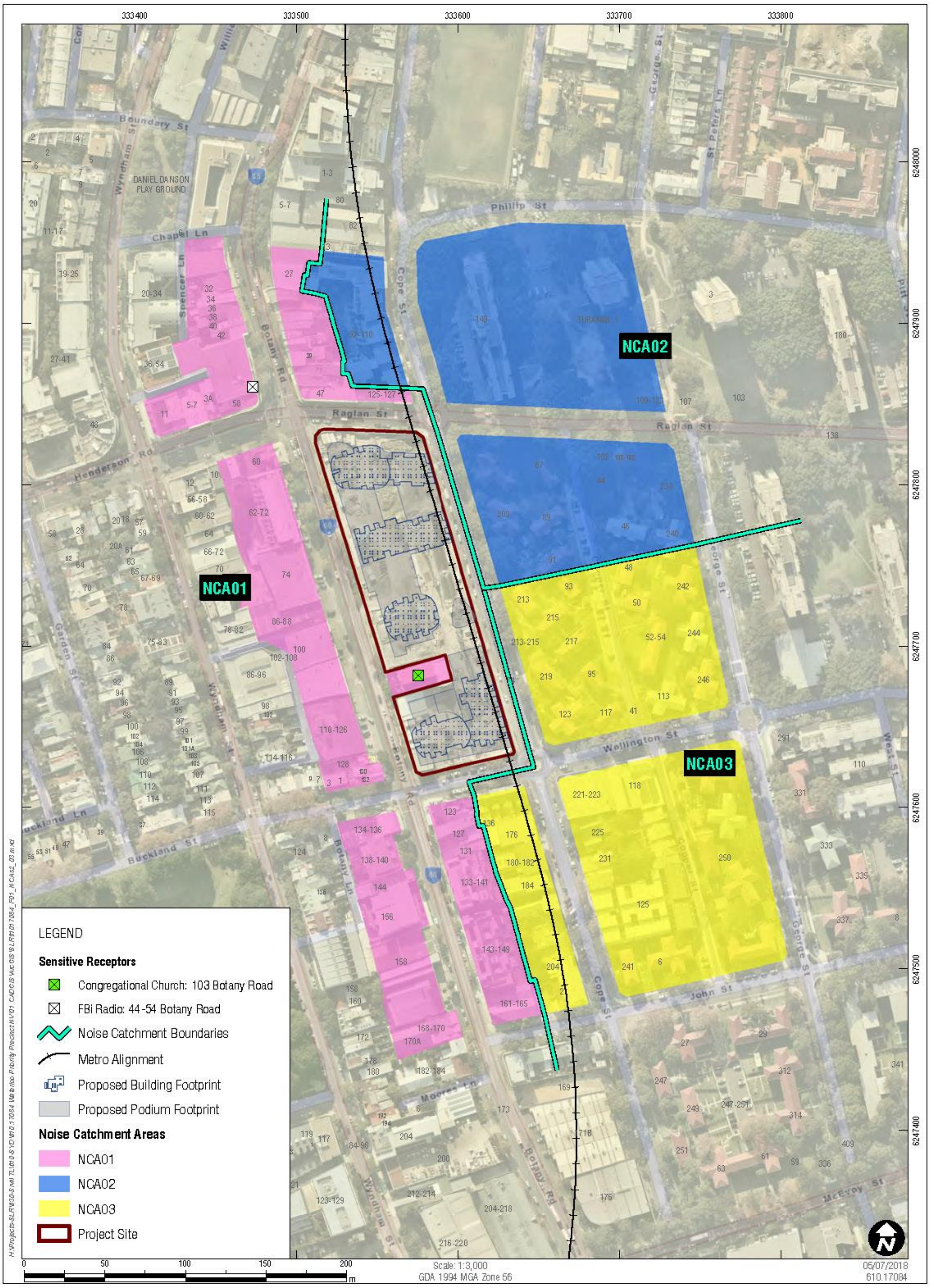

Figure 11 Project Site and Nearby Noise-Sensitive Receivers

Note 1: The heritage-listed Congregational Church which is to be preserved as part of the redevelopment is located within the project site however has been assigned to NCA01 for the purpose of this assessment.

The different land uses and receiver types within each NCA were identified through site inspection and aerial photography and are presented in **Table 5**.

Table 5 Noise Catchment Areas and Associated Land Uses

Noise Catchment Area (NCA)	Receiver Types/Land Uses identified within NCA
NCA01	Commercial premises
	Residential
	Place of worship (Congregational Church)
	Studio building (FBi Radio)
NCA02	Active recreation area
	Residential
NCA03	Commercial premises
	Residential

4.0 Implementation Plan & Strategy

4.1 Construction Noise Criteria

4.1.1 Construction Noise Guidelines

The noise guidelines and management levels for construction works are based on the publications managed by the NSW Environment Protection Authority[1] (EPA). The construction guidelines applicable to this project include:

- *Interim Construction Noise Guideline* (DECC 2009)
- *Chatswood to Sydenham, Construction Noise and Vibration Strategy* (Sydney Metro 2017)

4.1.2 Recommended Standard Construction Hours

The EPA's *Interim Construction Noise Guideline* (ICNG) recommends restricting construction works to the times outlined in **Table 6**.

Table 6 ICNG - Recommended Standard Hours of Construction

Day	Recommended Construction Hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	8.00 am to 1.00 pm
Sundays or Public Holidays	No construction

4.1.3 Construction Noise Management Levels

4.1.3.1 Residential Receivers

The ICNG recommends that the $L_{Aeq(15minute)}$ noise levels from a construction project, measured within the curtilage of an occupied noise-sensitive residence (ie at the boundary or within 30 m of the residence, whichever is the lesser) should not exceed the levels indicated in **Table 7**.

1 Noise and Vibration guidelines managed by EPA are available at the following web address http://www.environment.nsw.gov.au/noise/noise_legislation.htm.

Table 7 Recommended ICNG Noise Management Levels for Residences Affected by Construction Works

Period of Noise Exposure	$L_{Aeq(15minute)}$ Construction Noise Management Level
Recommended Standard Hours	Noise affected[1] RBL[2] + 10 dBA
	Highly Noise Affected[3] 75 dBA
Outside Recommended Standard Hours	Noise affected[1] RBL[2] + 5 dBA

Note 1: The noise affected level represents the point above which there may be some community reaction to noise.

Note 2: The RBL noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The highly noise affected level represents the point above which there may be strong community reaction to noise.

Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level during recommended standard hours, the proponent should apply all feasible and reasonable work practices to meet the NMLs. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the Highly Noise Affected, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours during which highly noisy intensive activities can occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences.
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level outside recommended standard hours, consultation with the community is required and negotiations should be considered.

The project specific residential receiver NMLs for each defined NCA (discussed in **Section 3.3** and shown in **Figure 11**) were derived from the relevant unattended noise monitoring results. The airborne construction NMLs for residences surrounding the proposed project site are shown in **Table 8**.

Table 8 Construction Noise Management Levels – Residential

Residential receivers within Noise Catchment Area (NCA)[1]	Rating Background Level (dBA)			Recommended Standard Hours		Outside Recommended Standard Hours[3]		
				Noise Affected (RBL + 10 dB)	Highly Noise Affected (75 dB)	Noise affected (RBL + 5 dB)		
	Day[2]	Evening[2]	Night[2]			Day (dBA)	Evening (dBA)	Night (dBA)
NCA01	60	57	46	70	75	65	62	51
NCA02	50	46	40	60	75	55	51	45
NCA03	50	46	41	60	75	55	51	46

Note 1: Subdivision of noise catchment areas (containing residential receivers) surrounding the project site discussed in **Section 3.3**.

Note 2: Rating Background Levels (RBL) shown with respect to the *Noise Policy for Industry (NPfI)* assessment periods – Daytime: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays and Public Holidays; Evening: 6:00 pm to 10:00 pm; Night: 10:00 pm to 8:00 am Monday to Saturday, 10:00 pm to 8:00 am Sundays and Public Holidays.

Note 3: EPA's recommended standard construction hours are 7.00 am to 6.00 pm Mon-Fri; 8.00 am to 1.00 pm Sat.

4.1.3.2 Other Sensitive Land Uses

To minimise disturbance to the characteristic activities of these other sensitive land uses, the ICNG recommends construction Noise Management Levels through a combination of internal design levels and the assessment of external noise levels. In accordance with the ICNG, the recommended airborne construction NMLs for other sensitive land uses within the defined NCAs surrounding the project site are presented in **Table 9**.

Table 9 Construction Noise Management Levels – Other Sensitive Land Uses

Noise Catchment Area	Other Sensitive Land Use within Noise Catchment Area (NCA)	$LAeq_{(15minute)}$ Construction Noise Management Level[1]
NCA01	Places of worship	Internal noise level[2] 45 dBA
NCA02	Active recreation area	External noise level[3] 65 dBA

Note 1: Applies when properties are being used.

Note 2: Internal noise levels are to be assessed at the centre of the occupied room.

Note 3: External noise levels are to be assessed at the most affected point at the property boundary or 30 m from the residence (whichever is the lesser).

4.1.3.3 Commercial and Industrial Premises

Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the ICNG outlines the process of defining management levels by separating them into the following three categories:

- Industrial premises: external LAeq 75 dBA

- Offices, retail outlets: external LAeq 70 dBA
- Other businesses that may be very sensitive to noise (e.g. theatres and child care centres): determine suitable noise levels on a project-by-project basis; consultation with the 'upper-limit' internal noise levels in AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels* (Standards Australia 2016) is recommended.

In accordance with the ICNG, the recommended airborne construction NMLs for commercial and industrial premises within the defined NCAs surrounding the project are presented in **Table 10**.

Table 10 Construction Noise Management Levels – Commercial and Industrial Premises

Noise Catchment Area	Land Use	$LAeq_{(15minute)}$ Construction Noise Management Level[1]
NCA01	Commercial	External noise level 70 dBA
	Other – Radio studio	Internal noise level 25 dBA[2]
NCA03	Commercial	External noise level 70 dBA

Note 1: As outlined in the ICNG, construction NMLs are to be assessed externally at the most-affected occupied point of the premises.

Note 2: Internal noise level derived from AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels* as recommended in the ICNG.

4.2 Construction Vibration Criteria

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

4.2.1 Human Comfort Vibration

The DECCW's *Assessing Vibration: a technical guideline* dated February 2006 (DEC, 2006) recommends the use of British Standard BS 6472-1992 for the purpose of assessing vibration in relation to human comfort.

BS 6472-1992 *Guide to evaluation of human exposure to vibration in building* nominates guideline values for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependent upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period.

The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 11**.

Table 11 Vibration Dose Value Ranges which Might Result in Various Probabilities of Adverse Comment within Residential Buildings

Place and Time	Low Probability of Adverse Comment ($m/s^{1.75}$)	Adverse Comment Possible ($m/s^{1.75}$)	Adverse Comment Probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note: For offices and workshops, multiplying factors of 2 and 4 respectively would be applied to the above vibration dose value ranges for a 16 hr day.

4.2.2 Structural Damage Vibration

Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* as they "are applicable to Australian conditions".

The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95 percent probability of no effect.

Sources of vibration that are considered in the Standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

4.2.3 Cosmetic Damage Vibration

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 12** and graphically in **Figure 12**.

Table 12 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

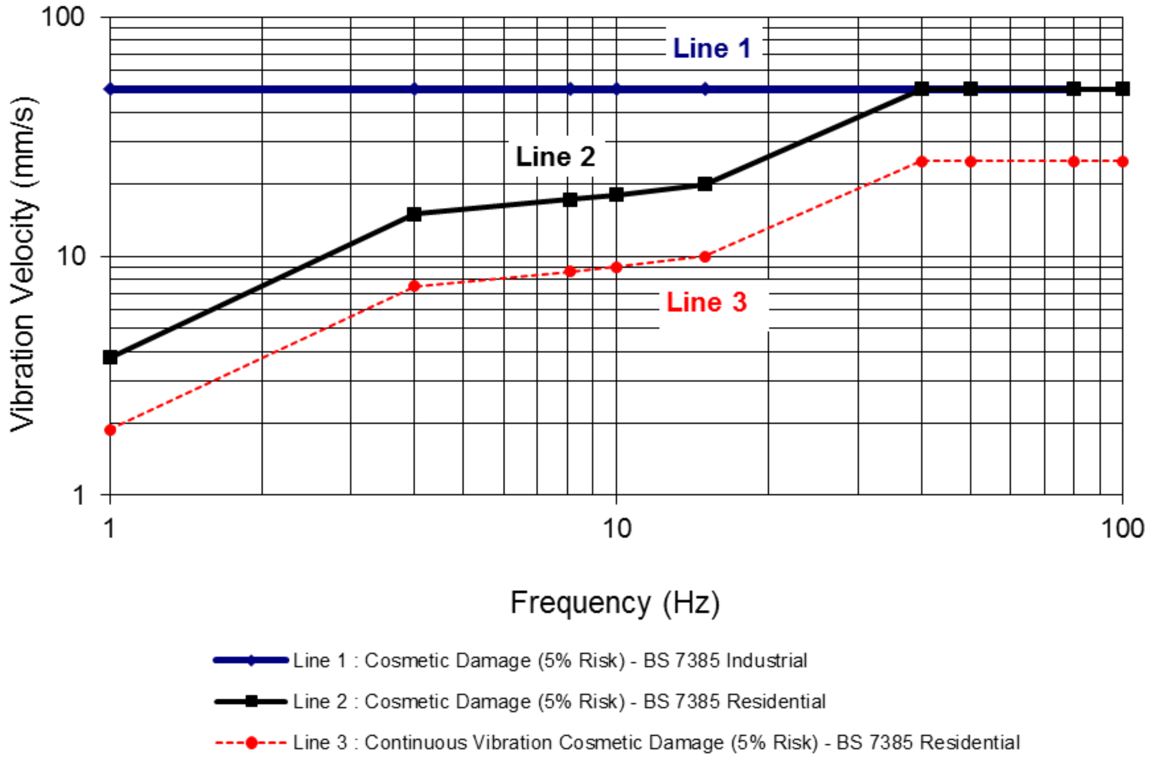

Figure 12 Graph of Transient Vibration Guide Values for Cosmetic Damage

The Standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 12**, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 12** would not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured would be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) would be compared with the guidance curves presented in **Figure 12**.

It is noteworthy that in addition to the guide values nominated in **Table 12** the Standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

4.2.4 General Vibration Screening Criterion

The Standard states that the guide values in **Table 12** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 12** may need to be reduced by up to 50 percent.

Note: rockbreaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50 percent.

Therefore for most construction activities involving intermittent vibration sources such as rockbreakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

4.2.5 Heritage

Heritage buildings and structures would be assessed as per the above screening criteria as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criteria of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered.

The Waterloo Congregational Church is a heritage structure adjoining the project area. Much of the vibration intensive work such as excavation surrounding the Church is already underway and is subject to as separate assessment by the Tunnelling, Stations and Excavation (TSE) contractor. It is recommended that the dilapidation survey and other structural information obtained by the TSE contractor is used for future works surrounding the Church in order to apply similar vibration criteria specific to this receiver.

4.3 Operational Noise Criteria

This section outlines criteria for assessing the potential impacts of noise generated by the proposed development on the surrounding noise sensitive receivers.

4.3.1 Operational Noise – Industrial Noise Emissions

The *Noise Policy for Industry* (NPfI) (EPA, 2017) outlines the procedure for assessing noise emissions from industrial noise sources, such as mechanical plant and equipment. The process involves determining project noise trigger levels at existing noise-sensitive receivers surrounding a proposed development, predicting whether emissions from the development are likely to exceed the established levels and result in potential noise impacts, and reducing the predicted levels through feasible and reasonable mitigation strategies.

The project Noise Trigger Level is the lower (ie the more stringent) value of the project intrusiveness noise level and project amenity noise level. The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative impacts from industry and maintain amenity for particular land uses.

Typically, the intrusiveness level will inform the project noise trigger level in areas with little industry (and/or ambient noise levels), whereas the amenity level will inform the project noise trigger level in areas with higher existing background noise levels.

4.3.1.1 Intrusiveness Noise Level

The intrusiveness noise level is based on the measured existing background noise levels. In accordance with the NPfI, the equivalent continuous noise level (LAeq) of the source should not exceed the measured Rating Background Level (RBL) at a residence by more than 5 dBA over any 15 minute period within any assessment period. Intrusive noise levels are only applied to residential receivers (residences). For other receiver types, only the amenity levels apply.

4.3.1.2 Amenity Noise Level

The recommended amenity noise level represents the total industrial noise at a receiver location, whereas the project amenity level represents the objective for noise from a single industrial development. The project area is considered to be urban.

4.3.1.3 Project Noise Trigger Levels

The results of the unattended noise monitoring, summarised in **Section 2.2.3.2** of this report, have been used to establish the project Noise Trigger Levels which will be used to assess the potential industrial impacts associated with the project at the surrounding receivers. The project noise trigger levels are the more stringent of the intrusiveness and amenity noise levels and are marked in bold and shaded as shown below in **Table 13**.

Table 13 Indicative project Noise Trigger Levels for Surrounding Receivers

NCA	Receiver Type	Period	Recommended Amenity Noise Level (dBA)	Measured Noise Level (dBA)		Indicative project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
				RBL	LAeq(period)	Intrusiveness	Amenity [1,2]
NC01	Residential	Day	60	60	72	65	**60**[3]
		Evening	50	57	70	62	**58**[3]
		Night	45	46	69	**51**	57[3]
	Commercial	When in use	65	n/a	72	n/a	**63**
	Place of worship – external[4]	Day	50[3]	n/a	72	n/a	**60**[3]
		Evening	50[3]	n/a	70	n/a	**58**[3]
		Night	50[3]	n/a	69	n/a	**57**[3]
NC02	Residential	Day	60	50	57	**55**	58
		Evening	50	46	53	51	**48**
		Night	45	40	50	45	**43**
	Active recreation area	When in use	55	n/a	57	n/a	**53**
NC03	Residential	Day	60	50	65	55	**58**
		Evening	50	46	57	51	**48**
		Night	45	41	54	46	**43**
	Commercial	When in use	65	n/a	65	n/a	**63**

Note 1: The project amenity noise levels have been converted to 15 minute levels by adding 3 dB.

Note 2: The recommended amenity noise levels have been reduced by 5 dB to give the project amenity noise levels due to future sources of industrial noise potentially being built in the area.

Note 3: The NPfI notes that where the existing traffic noise level is 10 dB or more above the recommended amenity noise level, then the High Traffic project amenity noise level is the existing traffic L_{Aeq} minus 15 dB.

Note 4: Internal noise levels have been converted to external noise levels using a typical 10 dB external to internal transmission loss factor.

As no other guidance is provided in the NPfI regarding recommended amenity levels for other sensitive land uses, the Radio station located directly northwest of the project site has been classified as a commercial receiver. Based on the general sound insulation requirements of such facilities and the high existing level of road traffic noise on Botany Road, noise ingress from project related industrial noise is considered to likely be negligible and a commercial receiver type classification is suitable.

At this early stage of the project, the criteria presented in **Table 13** should be regarded as indicative and will be confirmed during the next stages of the project. While the NPfI has been used to determine the above indicative trigger levels for the Metro Quarter, it is acknowledged that the CSSI Approval was approved under the now superseded *Industrial Noise Policy* and careful consideration of both guidelines will be required in the next stages of the project.

The final project trigger levels will be determined in collaboration with Sydney Metro and their future development partner, noting that the cumulative industrial noise levels from the Metro Quarter, Waterloo Station and Sydney Metro tunnel ventilation systems will be required to meet the final project triggers levels.

4.4 Internal Noise Level Criteria – Residential

This section establishes appropriate internal noise criteria for the residential areas of the proposed development in order to protect the amenity of future occupants from external noise intrusion.

4.4.1 State Environment Planning Policy

The *State Environment Planning Policy* (Infrastructure) 2007 (Infrastructure SEPP) provides guidelines to ensure that the development of new residential buildings protects the occupants adequately from noise associated with existing road and railway infrastructure. The key objectives of the provisions are to:

- Protect the safety and integrity of key transport infrastructure from adjacent development
- Ensure that adjacent development achieves an appropriate acoustic amenity by meeting the internal noise criteria specified in the Infrastructure SEPP.

The key clauses of the Infrastructure SEPP are:

Rail Corridors

Clause 86 Any development (other than development to which clause 88 of the Infrastructure SEPP applies) that involves the penetration of the ground to a depth of at least 2 m below ground level (existing) on land that is:

a. Within or above a rail corridor; or
b. Within 25 m (measure horizontally) of a rail corridor); or
c. Within 25 m (measure horizontally) of the ground directly above an underground rail corridor

Note: the consent authority must not grant consent without consulting with the rail authority and obtaining concurrence consistent with clauses 86(2)-(5)

Clause 87 Development for any of the following purposes that is on land that is in or immediately adjacent to a rail corridor and the consent authority considers development is likely to be adversely affected by rail noise or vibration:

- Building for residential use
- A place of worship
- A hospital
- An educational establishment or childcare centre

Road Corridors

Development for any of the following purposes that is on land in or adjacent to a road corridor for a freeway, a tollway, or a transit way or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data available on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:

- Building for residential use
- A place of worship
- A hospital
- An educational establishment or childcare centre

Clause 103 Any development which involves penetration of the ground to a depth of at least 3m below ground level (existing) on land that is the road corridor of roads or road projects as specified in schedule 2 of the SEPP.

For Clauses 87 (Rail) and 102 (Road)

- If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following LAeq noise levels are not exceeded:
  - In any bedroom in the building: 35 dB(A) at any time (10pm – 7am)
  - Anywhere else in the building (other than a garage, kitchen, bathroom, or hallway): 40dB(A) at any time

4.4.2 City of Sydney Development Control Plan 2012

The *City of Sydney Development Control Plan* (SDCP 2012) provides noise criteria for the development of new residential houses and units. Provided below is a summary of the requirements pertinent to the consideration of external noise.

- The repeatable maximum LAeq(1 hour) for residential buildings and serviced apartments must not exceed the following levels:

  a. for closed windows and doors:
  (i) 35 dB for bedrooms (10pm-7am); and
  (ii) 45 dB for main living areas (24 hours).

  b. for open windows and doors:
  (i) 45 dB for bedrooms (10pm-7am); and
  (ii) 55 dB for main living areas (24 hours)

- Where natural ventilation of a room cannot be achieved, the repeatable maximum LAeq (1hour) level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:
  - 38dB for bedrooms (10pm-7am); and
  - 48dB for main living areas (24 hours)
- These levels are to include the combined measured level of noise from both external sources and the ventilation system operating normally.

4.4.3 Apartment Design Guideline and City of Sydney Consultation

As part of the development of the proposal for the site, UrbanGrowth NSW Development Corporation (UGDC) and SLR have undertaken consultation with CoS and DPE. Based on this consultation, it is understood that the project should be designed to meet the requirements of DPE's *Apartment Design Guide* (ADG) Objective 4B-1 for natural ventilation.

As a result, residential areas should comply with the “windows open” (item 1 b) noise criteria of the CoS DCP as repeated in **Section 4.4.2**.

4.4.4 Ground-borne Noise – Sydney Metro

Where buildings are constructed over or adjacent to land over tunnels, ground-borne noise may be present where airborne noise does not provide a masking effect. The NSW

Development near Rail Corridors and Busy Roads – Interim Guideline specifies a night-time residential criteria of 35 dBA $L_{Amax,slow}$ which is required to be complied with by 95 percent of train passbys.

4.4.5 Vibration Criteria

Although vibration requirements aren't specified in the Infrastructure SEPP, impacts from vibration associated with transport infrastructure are commonly translated into ground-borne noise. Vibration transmission into the buildings will need to be controlled to ensure that ground-borne noise levels comply with the internal airborne noise criteria for residential buildings discussed in **Section 4.4**.

Vibration from sources internal to the Metro Quarter or from the metro station (such as plant equipment, etc) shall be designed to meet the recommended levels in Australian Standard AS2670-2 "*Evaluation of human exposure to whole-body vibration - Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)*"

4.5 Internal Noise Criteria – Non-residential uses

All internal non-residential areas shall be designed to mitigate external noise intrusion to recommended internal noise criteria based upon their use contained within AS 2107:2016 "*Acoustics - Recommended design sound levels and reverberation times for building interiors*".

5.0 Assessment

5.1 Noise Model

SoundPLAN is a software package which allows noise predictions to be made in a 3D environment and includes a digitised ground map (containing ground contours and significant structures, where appropriate), the location and acoustic power levels of significant noise sources, and the location of noise-sensitive receivers.

A SoundPLAN computer noise model was developed to predict the following:

- Potential noise impacts from construction works at the affected residential receivers (**Section 5.2**).
- Road traffic noise levels at the future project facades (**Section 5.4**).

5.1.1 Operational Noise Standard

All noise predictions within the model were calculated using ISO 9613 algorithms.

5.1.2 Model Inputs

The computer model generates noise emission levels accounting for factors such as source sound power levels, attenuation due to distance, ground and air absorption and shielding attenuation, as well as meteorological conditions.

Heights of buildings, screens and other structures were estimated based on architectural drawings provided by Sydney Metro and UGDC, as well as site inspection and aerial photography.

5.2 Construction Noise and Vibration Impacts

5.2.1 Recommended Construction Hours

Where possible, the construction works would be undertaken in accordance with the ICNG (discussed in **Section 4.1.2**) during the standard daytime working hours of:

- 7.00 am to 6.00 pm Monday to Friday
- 8.00 am to 1.00 pm on Saturdays.

On this basis, the potential noise impacts from construction works have been predicted for the daytime period only.

5.2.2 Source Location

Consistent with the requirements of the ICNG (discussed in **Section 4.1**), this construction noise assessment provides a 'realistic worst-case' assessment based on the required construction works within a 15-minute period. This is typically associated with works located nearest to a particular receiver.

In reality, the potential construction noise impacts at any particular location can vary greatly depending on the following factors:

- The location of construction works within the site relative to the nearest sensitive receiver

- The overall duration of the construction works
- The intensity of the noise levels
- The time at which the construction works are undertaken
- The character of the noise

Noise levels at sensitive receivers can also be significantly lower than the worst-case scenario when the construction works are moved further from receivers within a works area. This concept is shown in **Figure 13**.

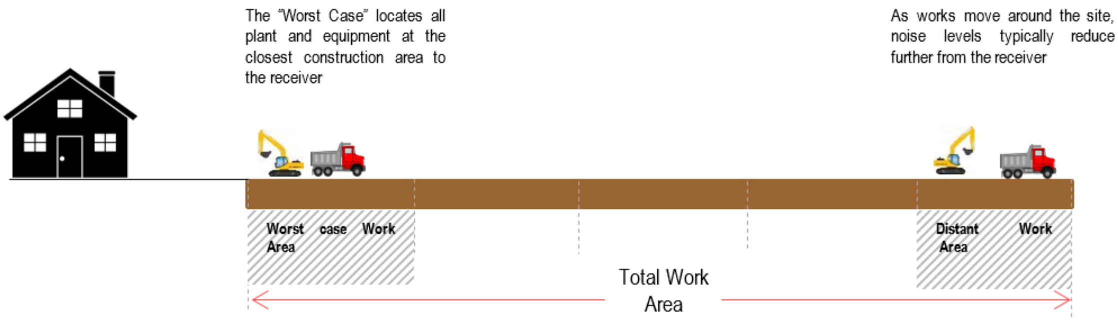

Figure 13 Illustration of Works Areas

The figure above illustrates that when the works move away from a receiver the noise levels from the operation of the construction equipment would reduce accordingly.

5.2.3 Construction Noise Model

A construction noise model was developed in SoundPLAN to predict the potential noise impacts at the surrounding residential receivers for the different proposed construction stages of the development (shown in **Figure 14**).

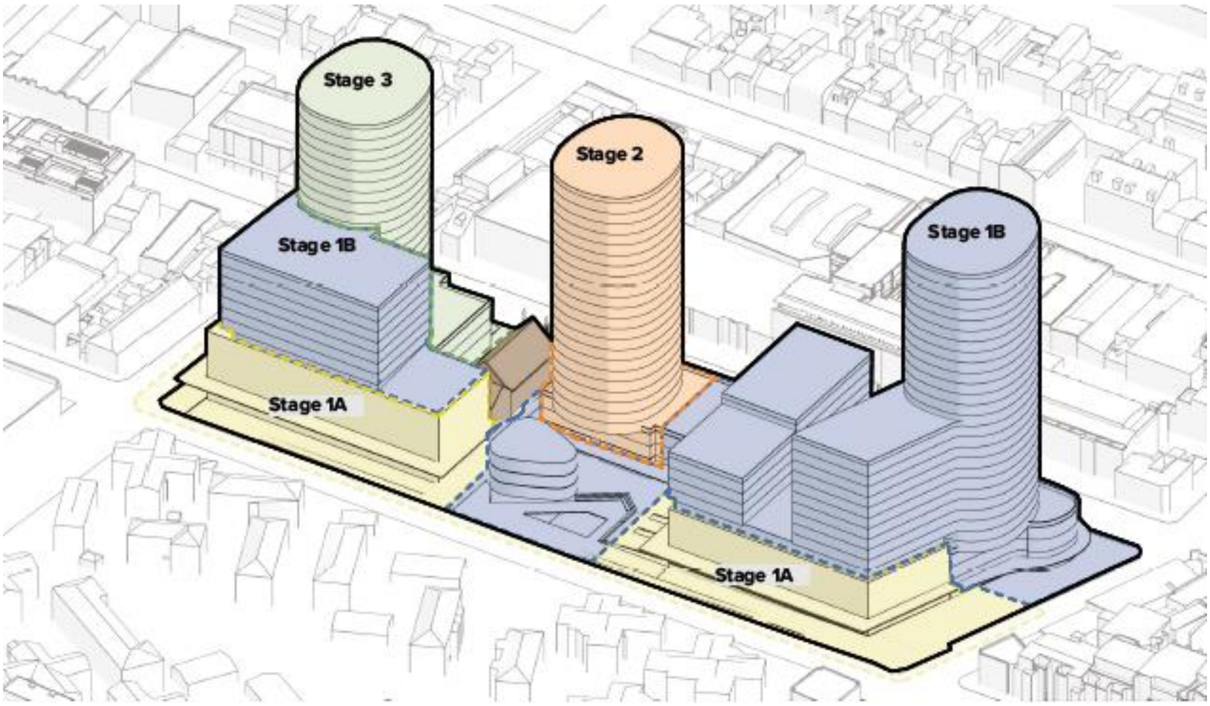

Figure 14 Proposed Construction Staging

Note 1: Image provided by UGDC.

5.2.4 Construction Noise Sources

Noise sources likely to be associated with the project construction works are based on information provided by Sydney Metro and UGDC and relate to similar development construction works in addition to SLR's experience with other construction noise assessments. Indicative sound power levels for the plant and equipment were derived from Roads and Maritime's *Construction Noise and Vibration Guideline* and the Department for Environment, Food and Rural Affairs' (UK) *Update of noise database for prediction of noise on construction and open sites.* The construction equipment and their respective sound power levels used within the model are presented in **Table 14**.

5.2.5 Construction Noise Scenarios

Two construction scenarios were modelled across the three stages (shown in **Figure 14**) based on information provided by Sydney Metro and UGDC. The scenarios were based on the construction activities that could potentially result in the highest noise impacts at the surrounding receivers. The staging and scenarios are presented alongside their associated construction plant and equipment sound power levels **Table 14**.

Table 14 Construction Works Scenarios and Noise Sources

Scenario	Stage	Associated Construction Plant and Equipment	Quantity	Sound Power Level dBA[1]	Total Sound Power Level dBA[2]
Earthworks/Basement Construction	1B	Excavator Hammer	3	122	128
		Excavator (approx. 20 tonne)	3	103	
		Vibratory Pile Driver	2	119	
		Dump Truck (approx. 15 tonne)	3	101	
		Concrete Truck	2	105	
	3	Excavator Hammer	1	122	124
		Excavator (approx. 20 tonne)	1	103	
		Vibratory Pile Driver	1	119	
		Dump Truck (approx. 15 tonne)	1	101	
		Concrete Truck	1	105	
Building Construction	1B	Mobile Crane	3	108	117
		Tower Crane	2	105	
		Concrete Placing Boom	2	93	
		Caged Material Hoist	2	91	
		Delivery Truck	3	101	
		Forklift	3	99	
		Concrete Truck	3	107	
	2	Mobile Crane		108	112
		Tower Crane		105	
		Concrete Placing Boom		93	
		Caged Material Hoist		91	
		Delivery Truck		101	
		Forklift		99	
		Concrete Truck		107	
	3	Mobile Crane		108	112
		Tower Crane		105	
		Concrete Placing Boom		93	
		Caged Material Hoist		91	
		Delivery Truck		101	
		Forklift		99	
		Concrete Truck		107	

Note 1: In each scenario, corrections were applied to the sound power levels of the plant based on an estimation of the duration of operation of each piece of construction plant within a 15-minute assessment period

Note 2: A single figure sound power level was calculated accounting for the combined plant and equipment operating concurrently in each construction scenario.

To determine the potential worst-case impacts, the construction noise sources were modelled throughout the construction areas for both the "Earthworks/Basement Construction" and "Building Construction" scenarios. As there is limited information surrounding the construction methodology and management plan, no construction noise mitigation (e.g. localized screening or site hoarding) was included in these predictions to determine the worst-case noise levels.

Due to the building base and foundations of the Stage 2 tower forming part of the construction works for Stage 1B (refer to **Figure 14**), no "Earthworks/Basement Construction" scenario was modelled for Stage 2 (shown in **Table 14**).

5.2.6 Construction Noise Predictions

For the two construction scenarios across the three stages (with the exclusion of the "Earthworks/Basement Construction" scenario in Stage 2), construction noise levels were predicted at the surrounding residential receivers within each NCA (refer to **Section 3.3**) and assessed against their respective noise management levels (NMLs) outlined in **Section 4.1.3**.

A summary of the predicted construction noise levels and NML exceedances is presented in **Table 15**. The predicted noise levels are intended to give an overview of the likely worst-case noise levels from the construction works.

Table 15 Construction Noise Impact Prediction Summary

Stage	Scenario	NCA	NML - Noise Affected (RBL + 10 dB)	Number of receivers exceeding NML	Number of receivers exceeding Highly Affected (75 dBA)	Predicted Noise Level (Worst case) L_{Aeq} dBA
1B	Earthworks/Basement Construction	NCA1	70	51	12	87
		NCA2	60	18	6	85
		NCA3	60	44	7	85
	Building Construction	NCA1	70	49	1	77
		NCA2	60	19	0	72
		NCA3	60	45	1	77
2	Building Construction	NCA1	70	10	1	81
		NCA2	60	10	0	67
		NCA3	60	7	0	68
3	Earthworks/Basement Construction	NCA1	70	54	13	88
		NCA2	60	16	0	72
		NCA3	60	41	11	84
	Building Construction	NCA1	70	22	1	77

Stage	Scenario	NCA	NML - Noise Affected (RBL + 10 dB)	Number of receivers exceeding NML	Number of receivers exceeding Highly Affected (75 dBA)	Predicted Noise Level (Worst case) LAeq dBA
	E	NCA2	60	0	0	n/a
		NCA3	60	19	0	72

Based on the scenarios that were input into the noise model, the construction noise predictions indicate that:

- The highest construction noise levels were predicted at the closest receivers surrounding the project site in all NCAs during the Stage 1B and Stage 3 Earthworks/Basement Construction works. The predicted noise levels at these receivers during 'worst case scenario' construction periods were significantly higher than the "highly noise affected" level in accordance with the ICNG criteria (outlined in **Section 4.1.3**).
- Construction noise levels exceeding the NMLs were also predicted during the Tower Construction scenarios across all three stages, with predicted exceedances above the highly affected noise level ranging from 2 dB to 6 dB.
- The highest number of impacts was predicted in NCA1 during the Stage 1B and Stage 3 Earthworks/Basement Construction scenarios with a total of 51 and 54 NML exceedance at receivers surrounding the project site respectively.
- Further exceedances of the NMLs were predicted outside of the defined NCA boundaries (refer to **Section 3.3**).
- For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted at the most exposed receivers, as the noise levels presented in this report are based on a realistic worst-case assessment.

5.2.7 Impacts on Sydney Metro Operations

In addition to the impacts on surrounding off-site sensitive receivers, should the construction of the Metro Quarter OSD occur when Waterloo Station is operational, the impacts on the staff, customers and tenants within the station should also be assessed and managed. In this event, the construction contractor should consult with Sydney Metro to determine suitable noise and vibration management levels and any implement resulting mitigation or management measures required.

5.2.8 Construction Noise Mitigation and Management

Where reasonable and feasible, the construction contractor will be required to implement best practice noise mitigation measures including:

- Judicious selection of mechanical plant and equipment (eg quieter machinery and power tools).
- Localised shielding of noisy equipment.

- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers.
- Orienting equipment away from noise-sensitive areas.
- Carrying out loading and unloading away from noise-sensitive areas.
- Minimising consecutive works in the same locality.
- Considering periods of respite.

Once more specific information regarding the proposed construction methodology, equipment and staging is known, it is recommended that the managing contractor produces a comprehensive Construction Noise and Vibration Management Plan incorporating the mitigation and management strategies recommended above, developed through consultation with the surrounding community and local authority that is also in accordance with the framework for compliance established in this report (outlined in **Section 4.1**).

When completing these assessments reference should be made to the requirements and criteria defined in the *Chatswood to Sydenham Construction Noise and Vibration Strategy* (Sydney Metro, 2017).

5.2.9 Construction Traffic Noise Impacts

5.2.9.1 Existing traffic flow on surrounding roads

In May 2017, Jacobs conducted traffic surveys around the Metro Quarter to provide data for existing traffic volumes on the surrounding road network. The findings of these surveys were provided to SLR for the purpose of this report. **Table 16** presents the afternoon peak (5 – 6 pm) traffic survey results for the surrounding roads.

The traffic surveys performed by Jacobs mainly covered the morning and afternoon peak periods, and information on the diurnal variation in traffic flows for the roads surrounding the Metro Quarter was not obtained during these surveys. Information on the diurnal variation of traffic on O'Riordan Street (Station ID: 02309 – 100 metres north of Johnson Street, Alexandria) was therefore obtained from the RMS Traffic Volume Viewer and used to estimate a 'diurnal multiplier' for the roads assessed in this study. As illustrated in **Figure 15**, the diurnal multiplier for each hour of day is the ratio of the reported traffic volume for that hour to the afternoon peak hour (4 – 5 pm) traffic volume.

Table 16 Peak Traffic Volumes – Road Network Surrounding the Metro Quarter

ID	Corridor Name	Peak Volume (vehicles/hour)
1	Botany Road - McEvoy Street to Allen Street	2,088
2	Botany Road - McEvoy Street to Buckland Street	2,075
3	Botany Road - Raglan Street to Boundary Street	1,725
4	Botany Road - Wellington Street to Raglan Street	1,841
5	Buckland Street - Wyndham Street to Gerard Street	215
6	Cope Street - Raglan Street to Phillip Street	290
7	Cope Street - Wellington Street to McEvoy Street	119
8	Cope Street - Wellington Street to Raglan Street	205
9	Elizabeth Street - Allen Street to McEvoy Street	1,710
10	Elizabeth Street - McEvoy Street to Wellington Street	2,122
11	Elizabeth Street - Phillip Street to Raglan Street	1,987
12	Elizabeth Street - Redfern Street to Phillip Street	1,820
13	Elizabeth Street - Wellington Street to Raglan Street	1,936
14	George Street - McEvoy Street to Allen Street	176
15	George Street - Phillip Street to Redfern Street	232
16	Henderson Street - Gerard Street to Wyndham Street	1,577
17	Henderson Street - Wyndham Street to Botany Road	2,160
18	McEvoy Street - Botany Road to George Street	1,190
19	McEvoy Street - Elizabeth Street to Morehead Street	882
20	McEvoy Street - George Street to Pitt Street	1,180
21	McEvoy Street - Pitt Street to Elizabeth Street	1,194
22	McEvoy Street - Wyndham Street to Botany Road	1,775
23	McEvoy Street - Wyndham Street to Brennan Street	935
24	Philip Street - Elizabeth Street to Chalmers Street	245
25	Philip Street - Elizabeth Street to Walker Street	715
26	Phillip Street - George Street to Cope Street	214
27	Phillip Street - Pitt Street to George Street	201
28	Phillip Street - Walker Street to Morehead Street	660
29	Pitt Street - McEvoy Street to Allen Street	112
30	Pitt Street - McEvoy Street to Wellington Street	74
31	Pitt Street - Phillip Street to Raglan Street	415
32	Pitt Street - Phillip Street to Redfern Street	335
33	Pitt Street - Wellington Street to Raglan Street	393
34	Raglan Street - Botany Road to Cope Street	610

ID	Corridor Name	Peak Volume (vehicles/hour)
35	Raglan Street - Cope Street to Pitt Street	451
36	Raglan Street - Elizabeth Street to Pitt Street	298
37	Wellington Street - Botany Road to Wyndham Street	137
38	Wellington Street - Cope Street to Botany Road	392
39	Wellington Street - Elizabeth Street to Morehead Street	408
40	Wellington Street - Elizabeth Street to Pitt Street	592
41	Wellington Street - Pitt Street to Cope Street	318
42	Wyndham Street - Buckland Street to Henderson Street	607
43	Wyndham Street - Henderson Street to Boundary Street	1,528
44	Wyndham Street - McEvoy Street to Buckland Street	1,555
45	Wyndham Street - McEvoy Street to Mandible Street	786

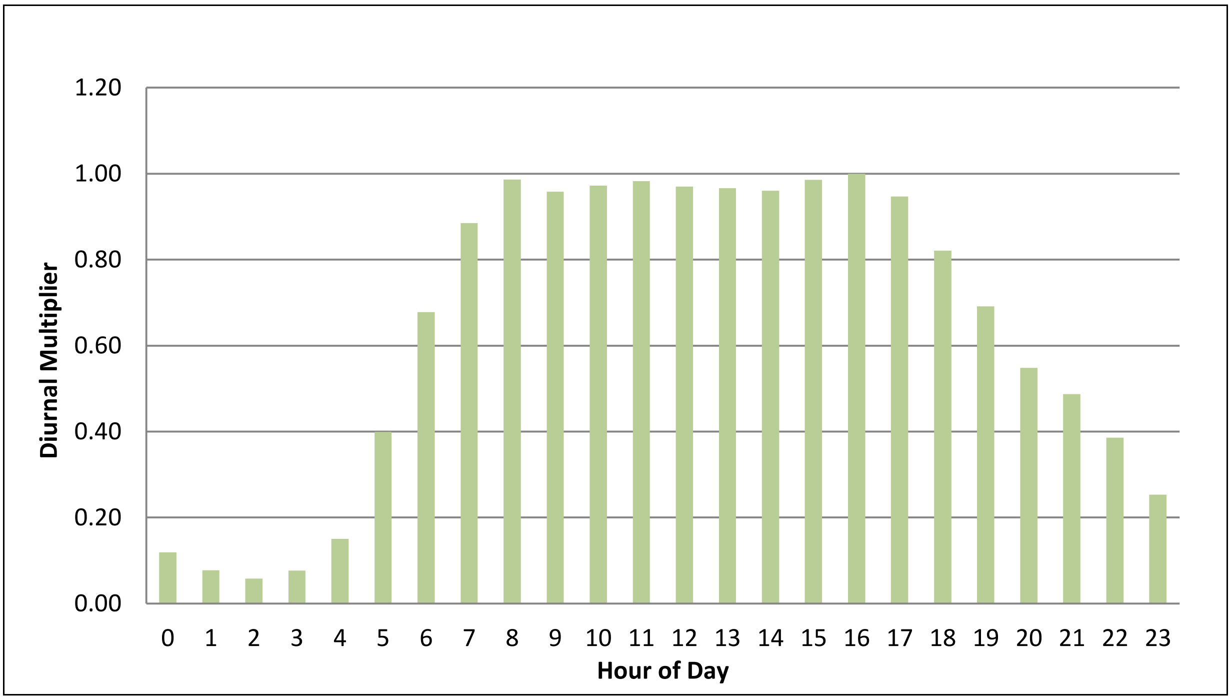

Figure 15 Diurnal Variation of Traffic on O'Riordan Street

5.2.9.2 Construction traffic volumes

Based on information provided by Sydney Metro and UGDC, the estimated number of heavy vehicle movements during peak construction period is as shown in **Table 17**.

Table 17 Peak construction vehicle movements

Period / Vehicle Type												
	Peak Hour[1]			Non Peak Hour[2]			Evening[3]			Night[4]		
	Light	HV	Total	Light	HV	Total	Light	HV	Total	Light	HV	Total
Waterloo Station[5]	2	6	8	10	23	33	2	6	8	2	6	8
OSD[6]	2	3	5	8	20	28	2	10	12	2	10	12
Total	4	9	13	18	43	61	4	16	20	4	16	20

1. AM peak hour x 1 and PM peak hour x 1 (7-8am / 5-6pm)
2. 9 hours (8-5pm)
3. 4 hours (6-10pm)
4. 9 hours (10pm-7am)
5. Sourced from Sydney Metro Chatswood to Sydenham EIS, May 2016
6. SMDO Estimates (66,800m3 = 5,350 30t trucks + other truck deliveries @ 43 truck arrivals per day on average)

5.2.9.3 Assessment

Based on the information presented in **Section 5.2.9.1** and **0**, an increase in road traffic noise due to heavy vehicles accessing the site during the construction stages is unlikely given the existing high volume of heavy vehicles on the surrounding roads. Even so, heavy vehicle access to the site during the construction stages should be assessed in further detail as the construction methodology and management plan is developed.

5.2.10 Construction Vibration Impacts

As details surrounding the proposed construction methodology, equipment and phasing are unknown, a detailed construction vibration assessment is not possible at this stage. However, it is recommended to mitigate any potential impacts using the recommended safe working distances for vibration intensive plant as indicated in **Table 18**, taken from Transport for NSW's *Infrastructure and Services Construction Noise and Vibration Strategy* (2018).

Table 18 Recommended Safe Working Distances for Vibration Intensive Plant

Equipment Item	Rating/ Description	Safe Working Distance	
		Cosmetic Damage[1]	Human Response
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (Typically > 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 18 to 34t excavator	2 m	7 m
Medium Hydraulic Hammer	1,600 kg – 5 to 12t excavator	7 m	23 m
Large Hydraulic Hammer	1,600 kg – 12 to 18t excavator	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

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

5.3 Operational Noise Impacts

5.3.1 Operational Noise – Industrial Noise Impacts

A review of the most recent architectural drawings provided by UGDC indicates that typical sources of industrial noise that may be associated with the commercial premises component of the project area may include noise from mechanical equipment including heating, ventilation and air conditioning (HVAC), carpark ventilation fans, corridor ventilation systems and carpark entry gates, substation, fire pump and fire control equipment.

At this stage, the technical specifications and layout of the proposed mechanical plant and other equipment have not been defined and potential impacts from these sources should be assessed (in accordance with the indicative project noise trigger levels outlined in **Section 4.3.1**) during the detailed design stage of the project.

Operational noise emissions from mechanical plant associated with the project should be controlled to reduce noise impacts upon neighbouring residential receivers and occupants within the proposed development. Detailed assessment and verification of mechanical noise emissions should be carried out during the detailed design stage of the project ensuring that the nominated criteria for mechanical plant emissions are met.

As noted previously, the final project trigger levels will be determined in collaboration with Sydney Metro and their future development partner during detailed design, noting that the cumulative industrial noise levels from the Metro Quarter, Waterloo Station and Sydney Metro tunnel ventilation systems will be required to meet the final project triggers levels.

Furthermore, a maximum noise level assessment for potential sleep disturbance and corrections for annoying noise characteristics should be investigated once more information regarding the project-associated industrial noise sources is known.

5.3.1.1 In-Principle Acoustic Treatment Recommendations

It is envisaged that the industrial noise sources will be able to achieve compliance with the nominated criteria through common engineering methods that may consist of:

- Selection of low-noise mechanical plant and other noise generating equipment.
- Judicious location of mechanical plant and equipment with respect to nearby noise-sensitive receivers.
- Barriers/enclosures (e.g. plant rooms).
- Silencers and acoustically lined ductwork.

The required noise mitigation measures would be reviewed during detailed design when more information regarding sources of industrial noise is available.

5.4 Noise Ingress

Due to the location of the site with respect to Botany Road, road traffic noise impacts on the proposed buildings (shown in **Figure 16**) have been predicted to confirm whether natural ventilation could be achieved while complying with the requirements of the Infrastructure SEPP and SDCP 2012 acoustic amenity requirements for residential properties outlined in **Section 4.4**.

5.4.1 Methodology

A SoundPLAN computer noise model (discussed in **Section 5.1**) was developed to predict road traffic noise levels at the proposed future Metro Quarter building facades, shown in **Figure 16**.

The road traffic noise model generates noise emission levels accounting for factors such as road traffic volume flows, attenuation due to distance, ground and air absorption and shielding attenuation, as well as meteorological conditions. Daytime (15 hour) and night-time (9 hour) two-way traffic volumes were assigned to the road traffic sources and are presented in **Appendix C**.

For each of the six proposed project buildings, single point receivers were positioned at selected facades (refer to figures in **Appendix D**). The receivers were located at three discrete heights (shown graphically in **Figure 16** and presented numerically in **Appendix D**) to predict the potential impact of road traffic noise levels at different facade heights.

SLR has worked closely with the design team in order to develop tower massing which provides localised screening to openings by way of balcony shapes. These are included within the computer model as shown in **Figure 16.**

A 2.5 dB correction was added to the predicted receiver levels to account for increased levels due to facade and balcony reflections. Additionally, a 15 dB facade loss was applied to the receiver level to predict the internal road traffic noise levels.

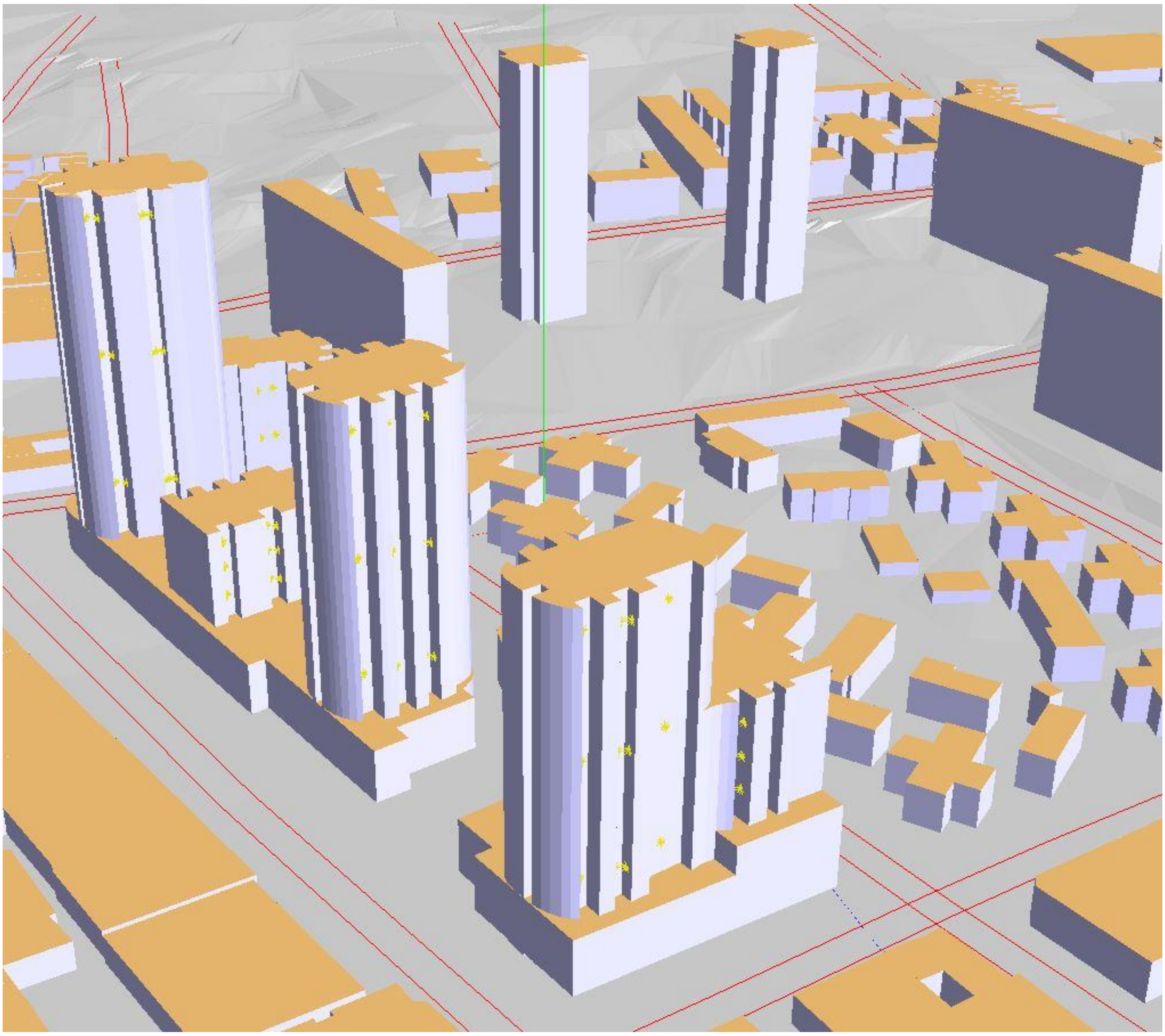

Figure 16 Metro Quarter SoundPLAN 3D Model

Note 1: Road traffic sources are shown in red.

Note 2: Single point receivers were located at each of the proposed building facades and are shown in yellow.

5.4.2 Internal Road Traffic Noise Prediction Results

The purpose of this noise and vibration assessment is to demonstrate that compliance with the nominated criteria can be achieved. This section summarises the assessment undertaken and resulting recommendations to achieve compliance.

5.4.2.1 Residential Areas

As summarised in **Section 4.4**, the driving internal noise targets for residential are the “window open” criteria of:

- 45 dBA LAeq(9hour) for bedrooms (10pm-7am)
- 55 dBA LAeq(24hour) for main living areas (24 hours)

The predicted internal road traffic noise levels are presented in **Appendix D**, and these predictions assume a 15 dBA outdoor-to-indoor loss.

Outdoor-to-Indoor Loss

- The 15 dB facade loss used to determine internal road traffic noise levels is noted as being higher than would typically be applied for a standard open window (typically taken to be 10dB), however based on previous experience and available literature, is considered reasonable when including the effect of localised screening on the balcony with low-level windows and acoustic absorption that could be applied to the balcony surfaces. The conceptual design is as shown in **Figure 17**.

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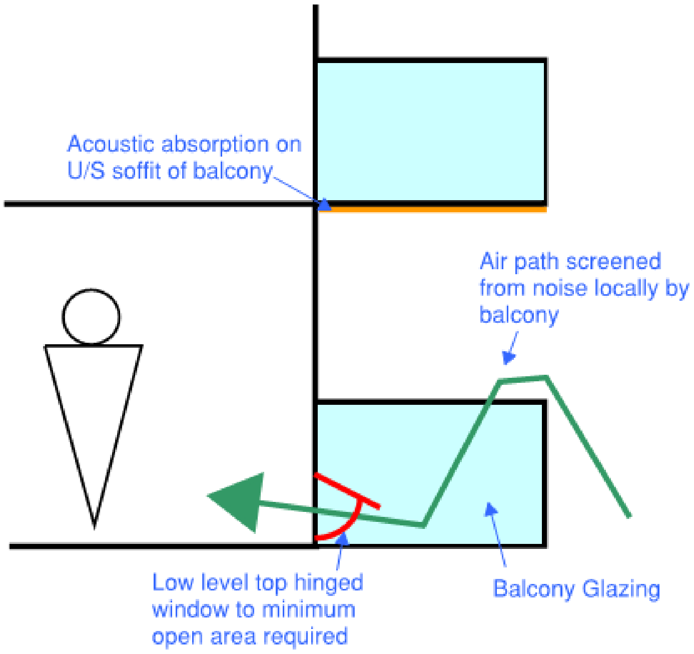


Figure 17 Concept of attenuated balcony openings (section view)

The figure of 15 dBA is considered suitable based on a review of available research into mitigating road noise intrusion through acoustically screened openings and balconies. In particular a paper authored by the Queensland University of Technology "*Investigations on road noise level spatial variability within a specially designed acoustic balcony*" (Daniel A. NAISH, Andy C. C. TAN, F. Nur DEMIRBILEK, Inter.Noise 2014) showed that at certain positions at residential windows in appropriately designed balconies, noise levels can be up to 12 dBA lower than at the facade of the building without a balcony.

This result, combined with the typical 10 dBA 'outdoor-to-indoor' loss implies that up to 22 dBA overall reduction from facade predicted noise levels may be achievable. As a result, SLR has used 15 dBA as a conservative figure and to allow design flexibility in the next stages of the project.

It will be the responsibility of the design team developing the site to demonstrate and validate any opening system to achieve a minimum of 15 dB external to internal noise reduction (for a road traffic frequency spectrum noise source).

Summary of Results for Residential Areas

With the approach outlined above, the results in **Appendix D** indicate that compliance with the internal noise goals (outlined in **Section 4.4**) for residential receivers can be achieved during the daytime period (07:00 am – 22:00 pm). Compliance with the internal noise goals for residential receivers during the night-time period (10:00 pm – 07:00 am) was also achieved in the majority of locations, however exceedances of the internal noise goals of up to 3 dB were predicted at 16 out of the sample 222 receivers. Exceedances were predicted at building B01 (facade B, D and M) and B05 (facade B, G, H, I and K). These locations face north or south respectively and are exposed to high levels of traffic noise from Botany Road.

To achieve compliance at these receivers, the internal floorplate layout should be developed such that living spaces (not bedrooms) are located at the opening locations which are found to not comply with the night-time criteria.

All glazing and solid areas of the external building fabric should also be designed such as to achieve compliance with the “windows closed” criteria in **Section 4.4.2** for periods when occupants choose to close windows. This is considered to be possible with standard (i.e. “off-the-shelf”) construction materials including acoustic laminate glazing.

Non-Residential Areas

It is considered that all non-residential (commercial) uses within the precinct will be sealed and mechanically ventilated. All glazing and solid areas of the external building fabric should be designed to achieve compliance with the AS2107:2016 criteria as referred to in **Section 4.5**. This is considered to be possible with standard (ie “off-the-shelf”) construction materials including acoustic laminate glazing.

5.5 Sydney Metro

The Metro Quarter is situated over and adjacent to Waterloo Station.

The EIS for the Sydney Metro (CSSI EIS) assessed the potential impacts in this location, however residential usages were not proposed at the Metro Quarter at that time so no specific assessment was completed.

5.5.1 Assessment of Potential Future Impacts

The potential impacts on the Metro Quarter from metro trains have been assessed for the future residential uses of the project. Reference to the cross section of the project in **Figure 18** shows the first level of residential usage is nominally around six floors above rail level (i.e. around three floors above ground level and around three levels below ground). The floors below the first residential level would be for commercial/retail, community or station services usage.

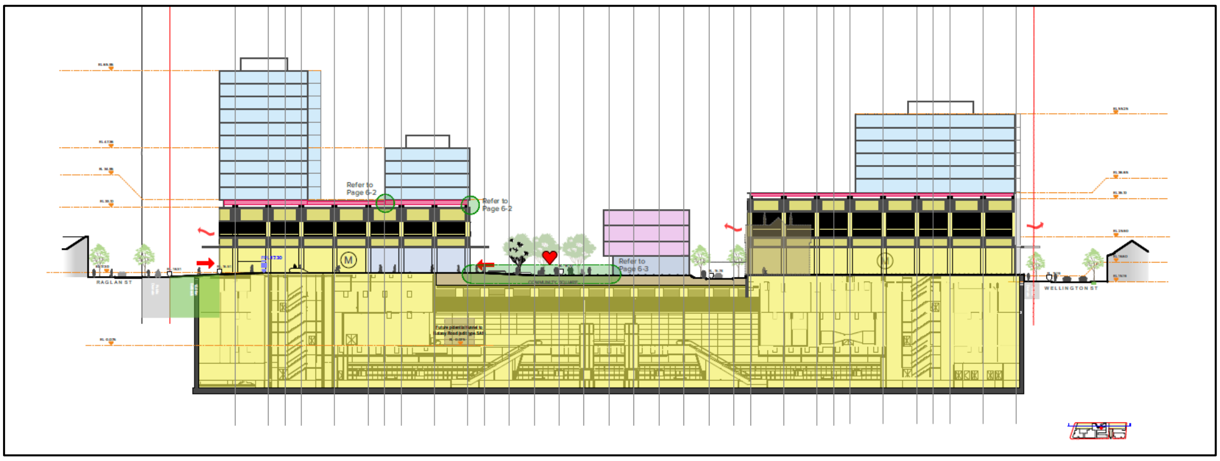


Figure 18 Metro Quarter – Waterloo Station Cross Section

A high level assessment of the potential impacts has been completed using standard trackform and high attenuation trackform (in the form of Delkor Eggs), using source spectra detailed in the CSSI EIS. No coupling loss has been included in the analysis as the station and residential structures are integrated and a conservative vibration reduction of 1 dB per level has been used. Train speeds have been assumed to be 60 km/h. A summary of the assessment is provided in **Table 19**.

Table 19 Sydney Metro – Potential Noise and Vibration Impacts

Receiver	Trackform	Vibration (RMS)		Ground-borne Noise ($L_{Amax,slow}$)	
		Criteria	Predicted	Criteria	Predicted
First level of residential	Standard	0.4 mm/s[1]	<0.1 mm/s	35 dBA (night-time)	44 to 49 dBA
	High attenuation (Delkor Eggs)		<0.1 mm/s		40 to 45 dBA

Note 1: Criteria based on continuous vibration levels detailed in *Assessing Vibration: a Technical Guideline.*

The above conservative assessment indicates:

- Tactile vibration from Sydney Metro trains is unlikely to exceed the proposed threshold levels.
- Ground-borne noise levels from trains may exceed the night-time criteria for residential receivers, with the track types assessed above.

5.5.2 Mitigation

Vibration and ground-borne noise impacts from trains can be controlled at source through the use of trackforms which incorporate vibration-isolating components. In slab or embedded track sections, this can take the form of a resilient rail fastener, booted sleeper, floating track slab or a combination of approaches. The resilience is typically in the form of elastic/resilient pads or mats, or moulded rubber elements in the resilient baseplates/fasteners.

Further investigation of the impacts from trains on the Metro Quarter would be completed as the project progresses, and Sydney Metro and their future development partner would work closely to ensure the impacts are adequately assessed and mitigated. It is anticipated that the criteria can be met through the use of resilient trackforms (potentially higher performing than those investigated in **Table 19)**, building isolation in the form of bearings at the base of the buildings, or a combination of both.

5.6 Cumulative Impacts

5.6.1 Additional Road Traffic Noise

The NSW *Road Noise Policy* (RNP) requires consideration of noise mitigation where new land use developments increase road traffic noise by more than 2 dB. For a 2 dB increase in noise to be apparent a corresponding increase in traffic volumes of approximately 60 percent is required (assuming road speeds and other factors remain unchanged).

Peak two-way traffic volume data on Botany Road has been provided by Jacobs for the existing situation together with volumes associated with the Metro Quarter and Waterloo Estate. These are shown below in **Table 20**.

Table 20 Traffic Volumes on Botany Road

Existing Traffic Flows	Metro Quarter	**Waterloo Estate**
23,175 vehicles (15 hour)	Provision for up to 427 car spaces	770 vehicles (15 hour)
6,428 (9 hour)		146 vehicles (9 hour)

The above shows that the cumulative increases in traffic from the Metro Quarter and Waterloo Estate are small in comparison to the high existing traffic volumes during the daytime and night-time. As such, potential cumulative increases in road traffic noise due to the project are expected to be significantly less than 2 dB.

5.6.2 Industrial Noise

As noise sources and locations within and surrounding the precinct area are unknown at this early stage in the project, a cumulative impact assessment of potential operational noise from future industrial sources within the precinct cannot be completed.

The potential cumulative impacts from all sources of industrial noise from the Metro Quarter, Waterloo Station and the Waterloo Estate will be undertaken for the detailed development application when more information regarding the various noise sources and locations are known.

It is anticipated that compliance with the final project trigger levels from cumulative industrial noise impacts will be achievable with standard noise mitigation measures.

6.0 Conclusion

SLR has undertaken a noise and vibration impact assessment associated with the redevelopment of the Metro Quarter which satisfies the relevant SEARs for SSD Application 18_9393. The assessment has been carried out in accordance with NSW regulatory requirements and in consultation with CoS and other relevant stakeholders.

The scope of the assessment involved deriving and establishing project specific noise goals through consultation with various NSW and Australian guidelines; undertaking a noise and vibration impact assessment for the future development with respect to the appropriate criteria; and, where required, providing recommendations for noise control measures.

A preliminary construction noise and vibration assessment has shown that under a realistic ‘worst case scenario’ a number of receivers may exceed the trigger levels established. As a result, further detailed assessment once construction methods are confirmed is required, and appropriate mitigation and management measures adopted.

With the recommendations included within this report adopted, compliance with all established operational noise and vibration criteria is expected.

APPENDIX A

Acoustic Terminology

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

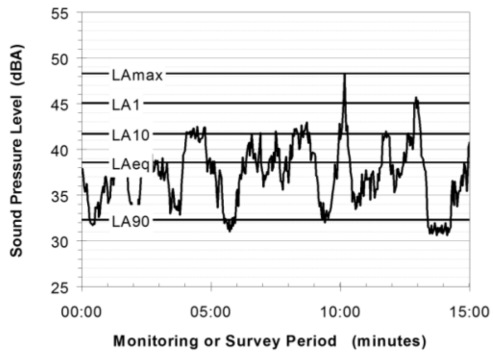
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12}W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (LAeq, LA10, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

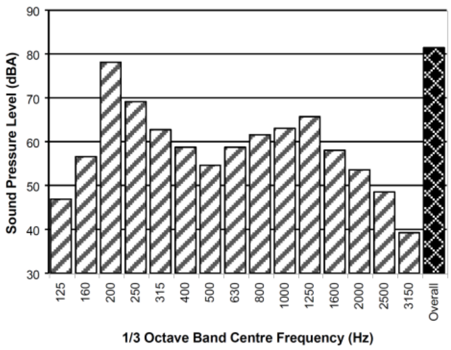
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



7 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

2 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

3 Over-Pressure

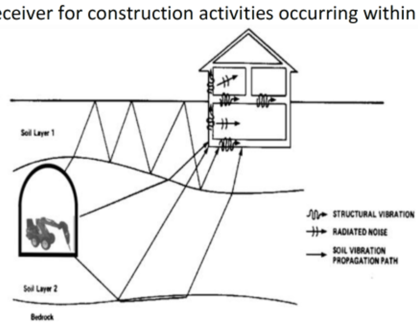
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

4 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

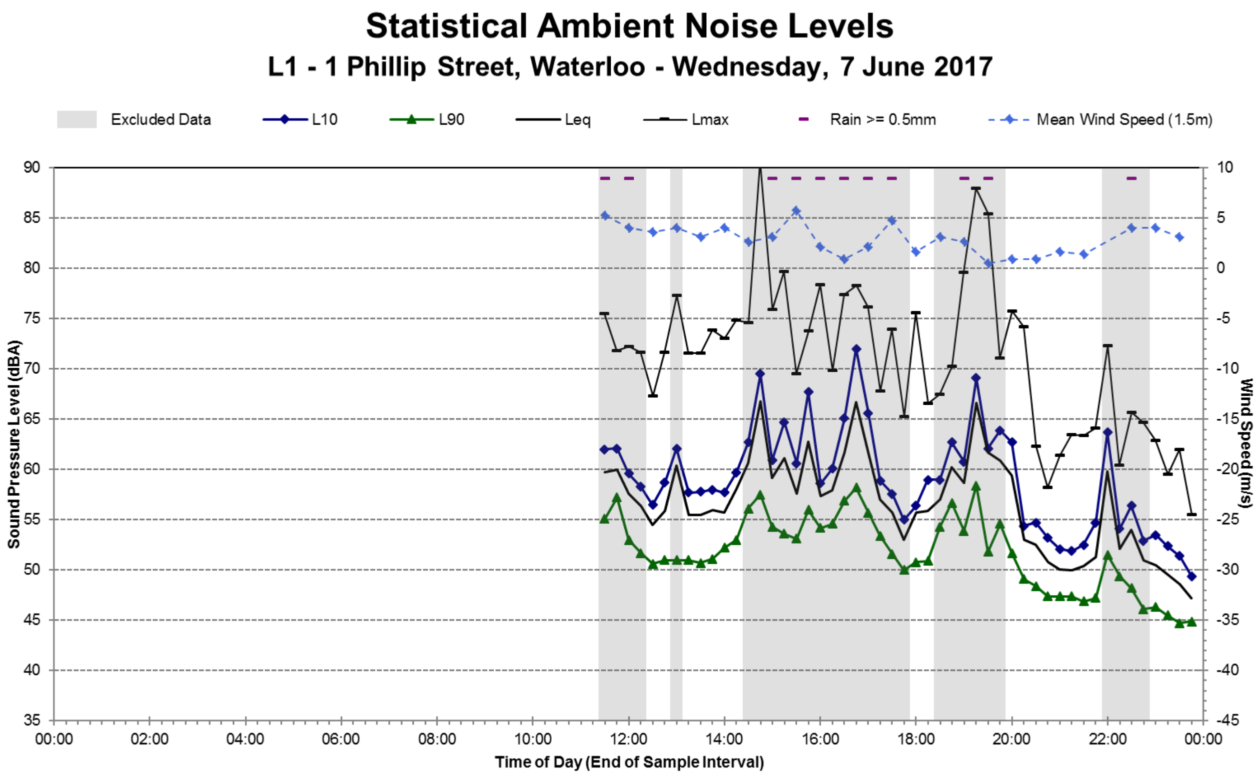
The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

APPENDIX B

Ambient Noise Monitoring Results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Excluded Data
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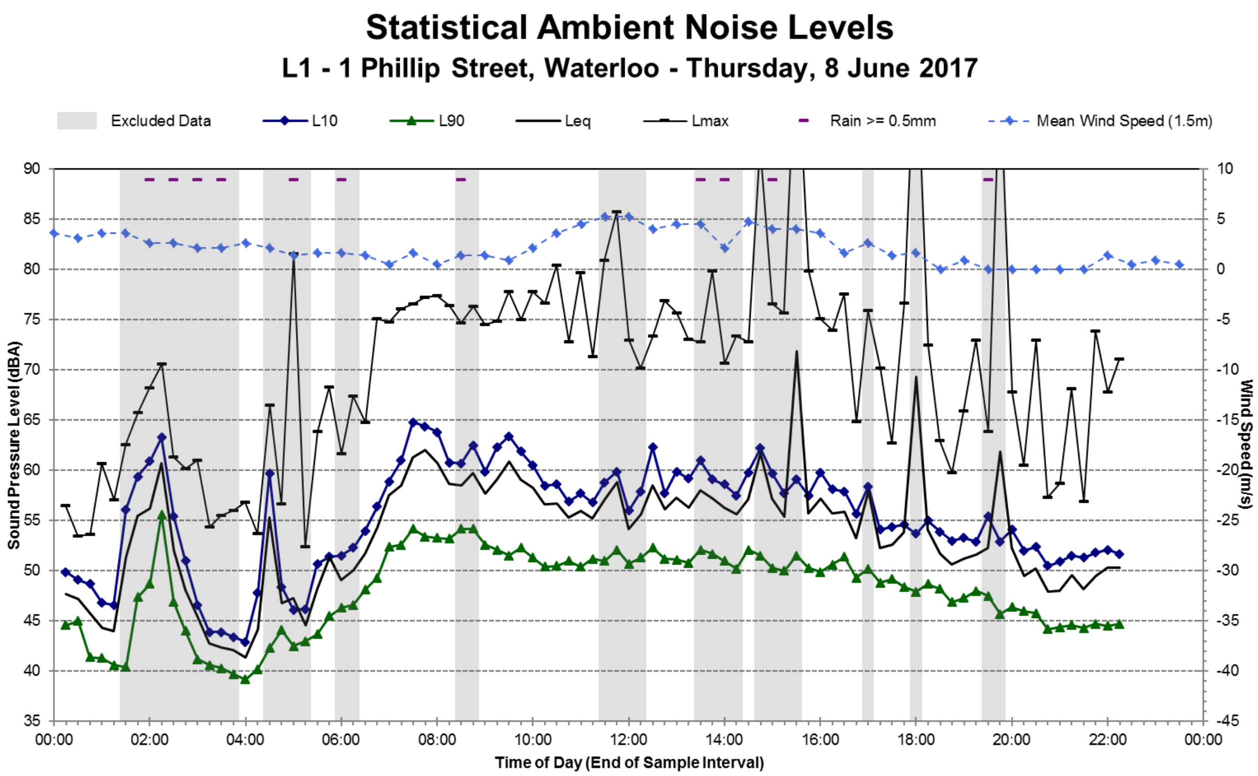
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)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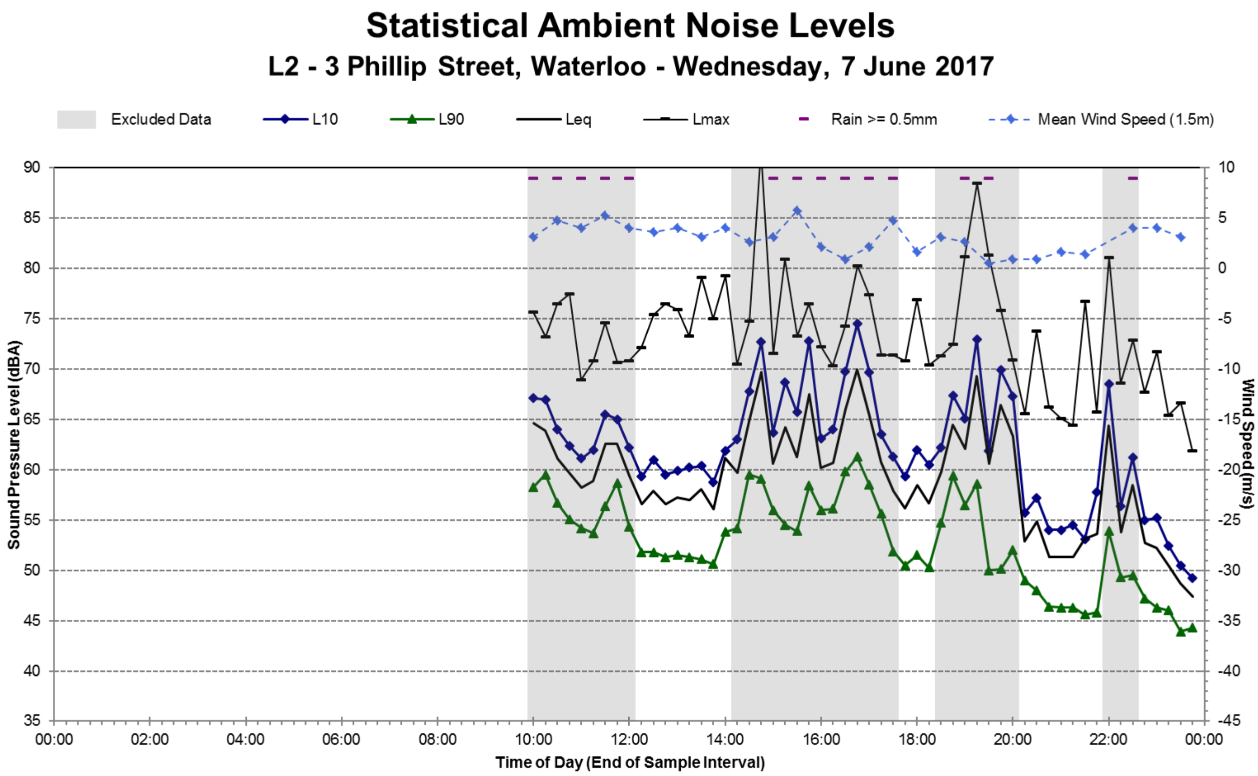
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



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Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

Statistical Ambient Noise Levels

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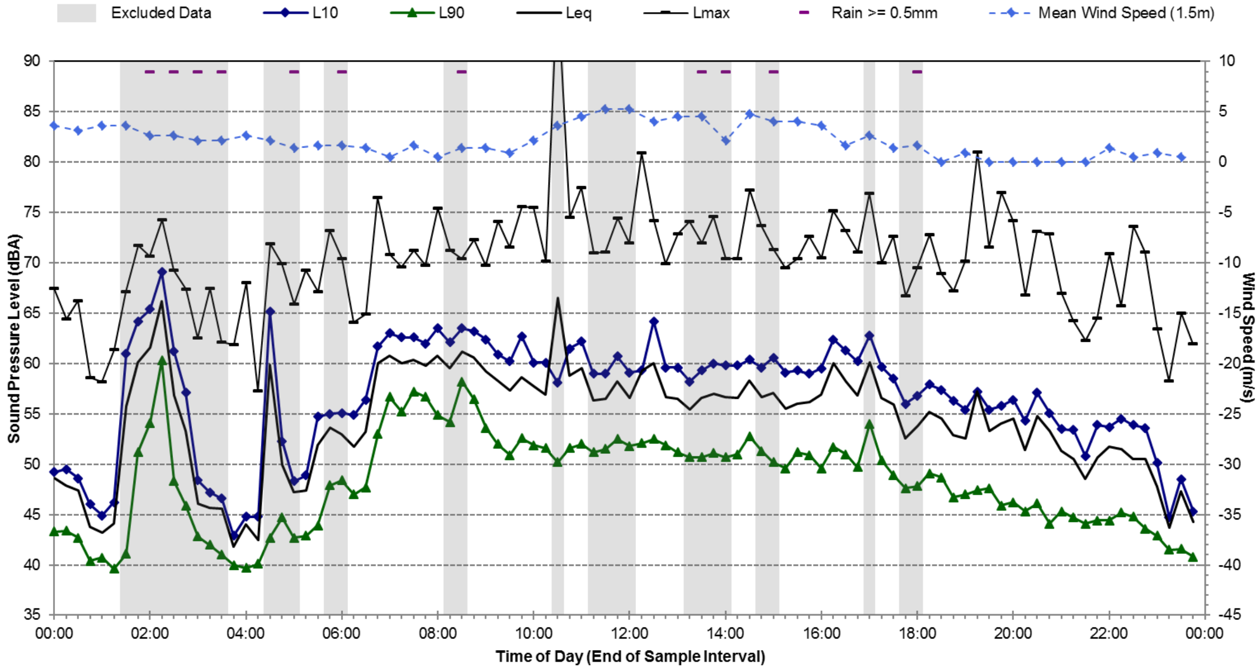

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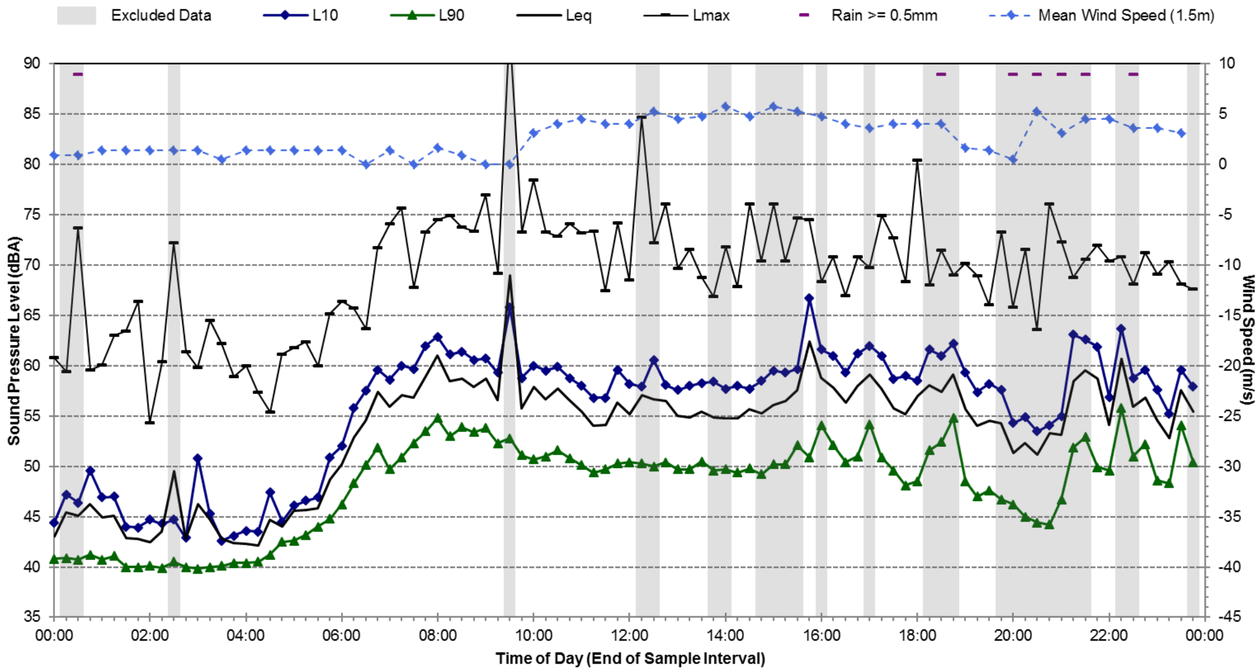

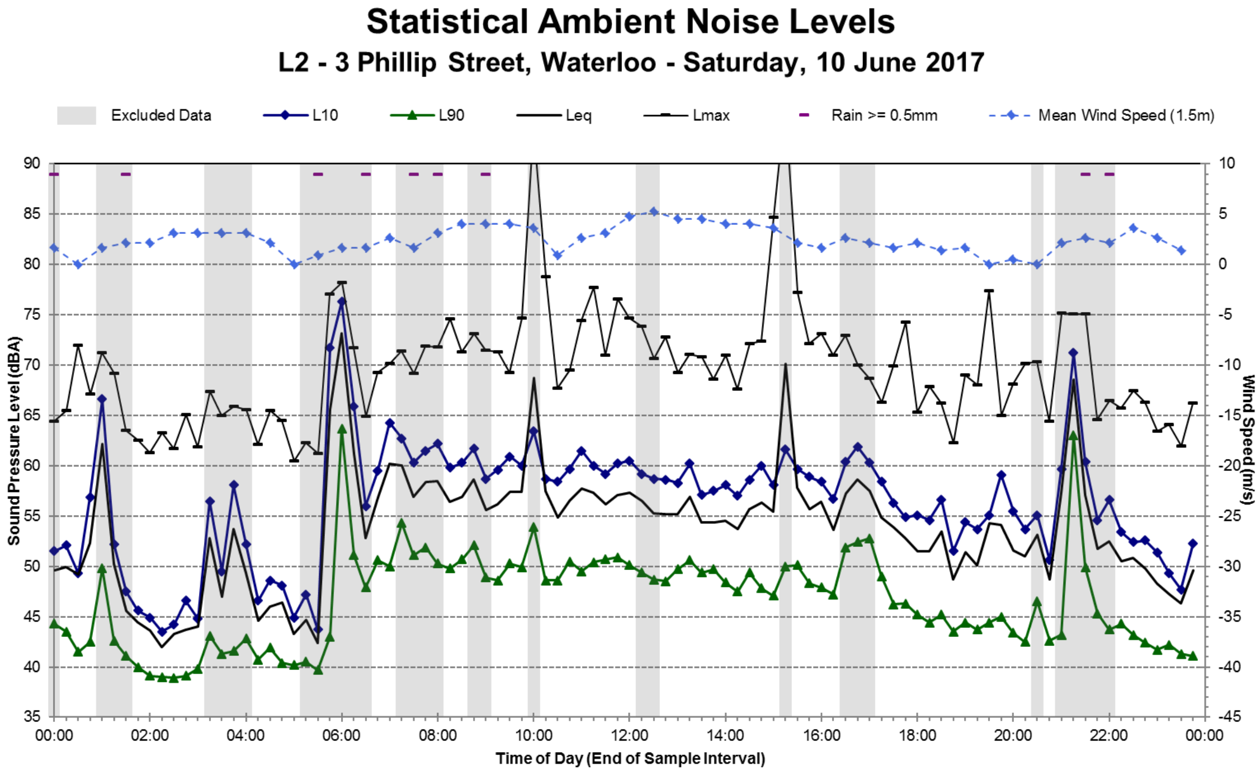
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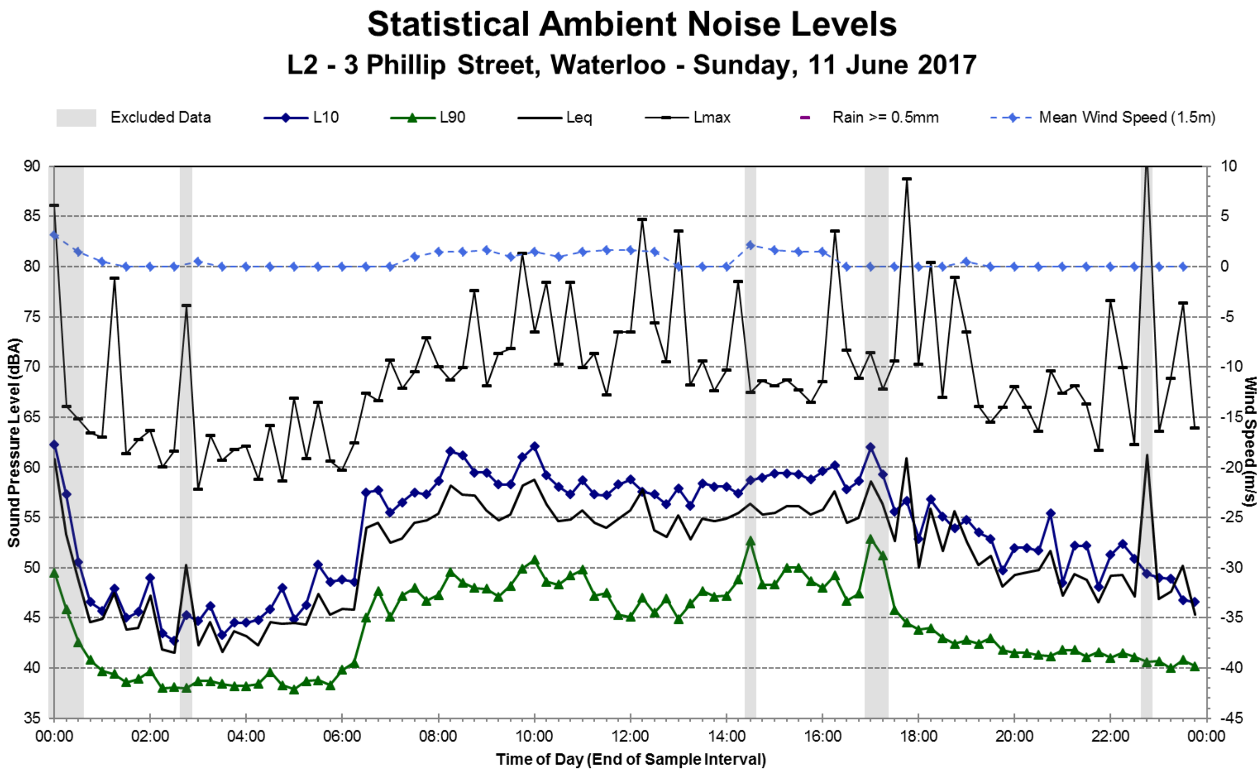
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)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Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

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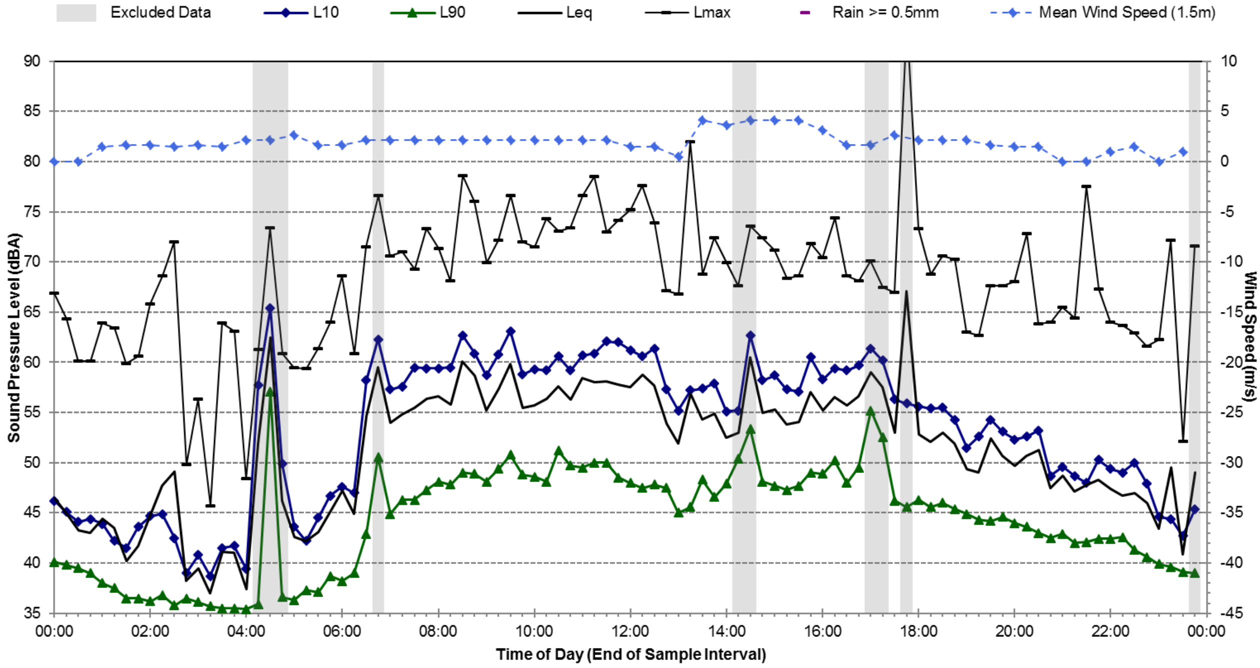

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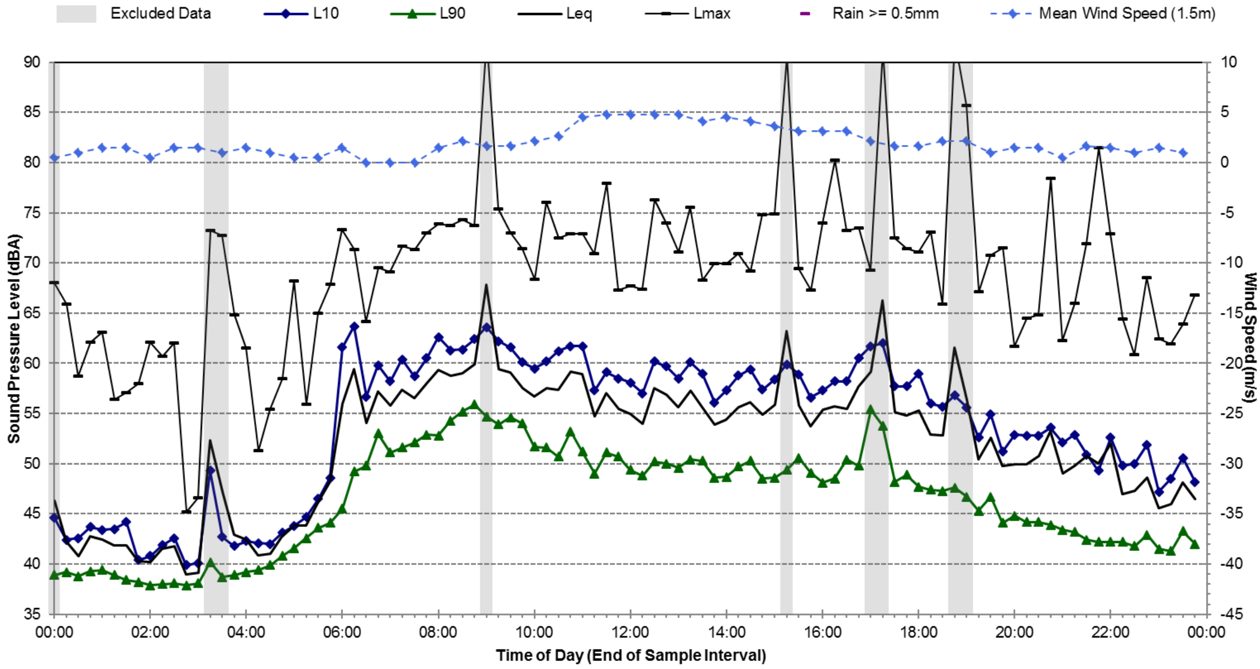

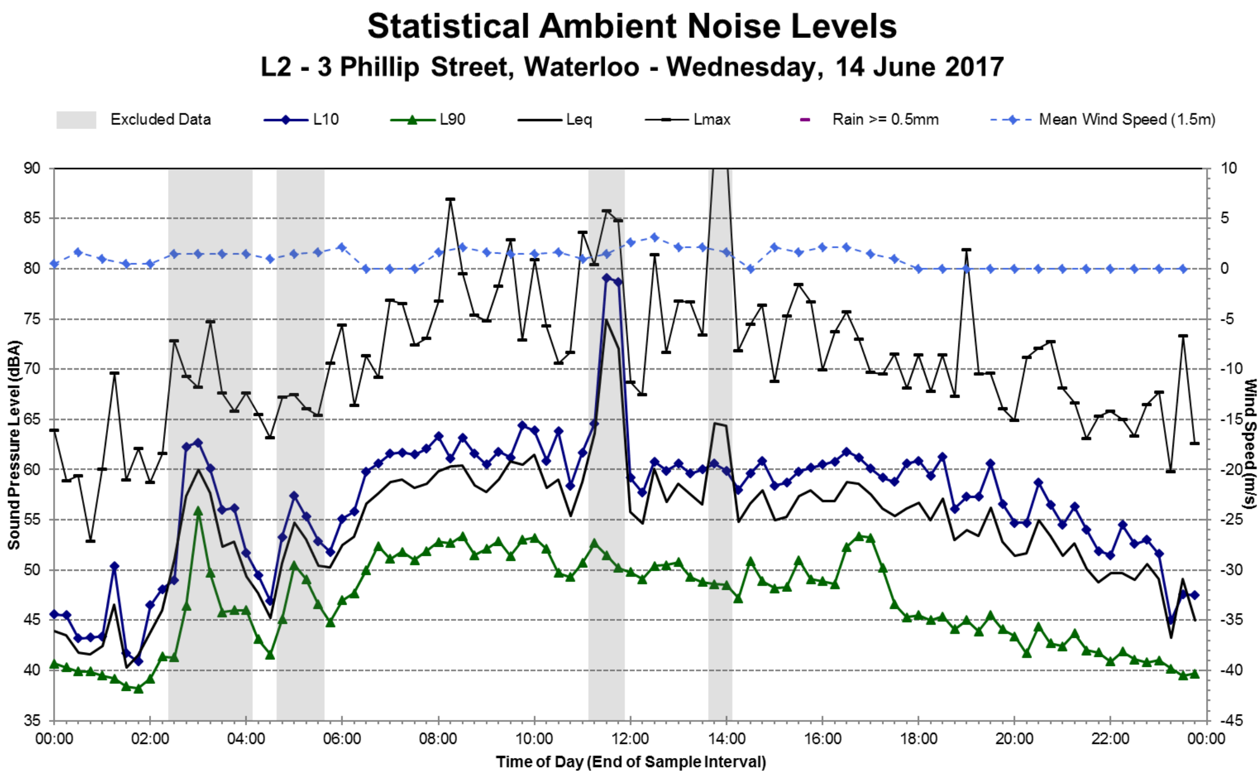
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Wind Speed (m/s)
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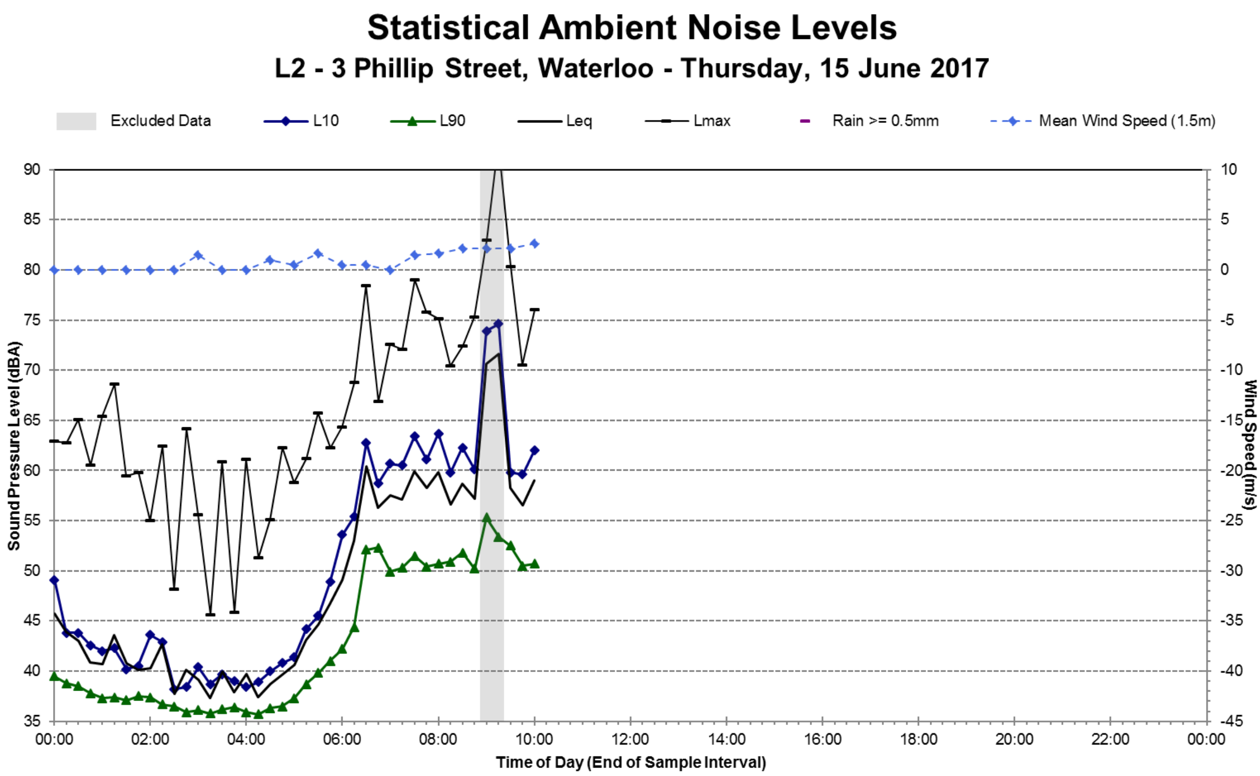
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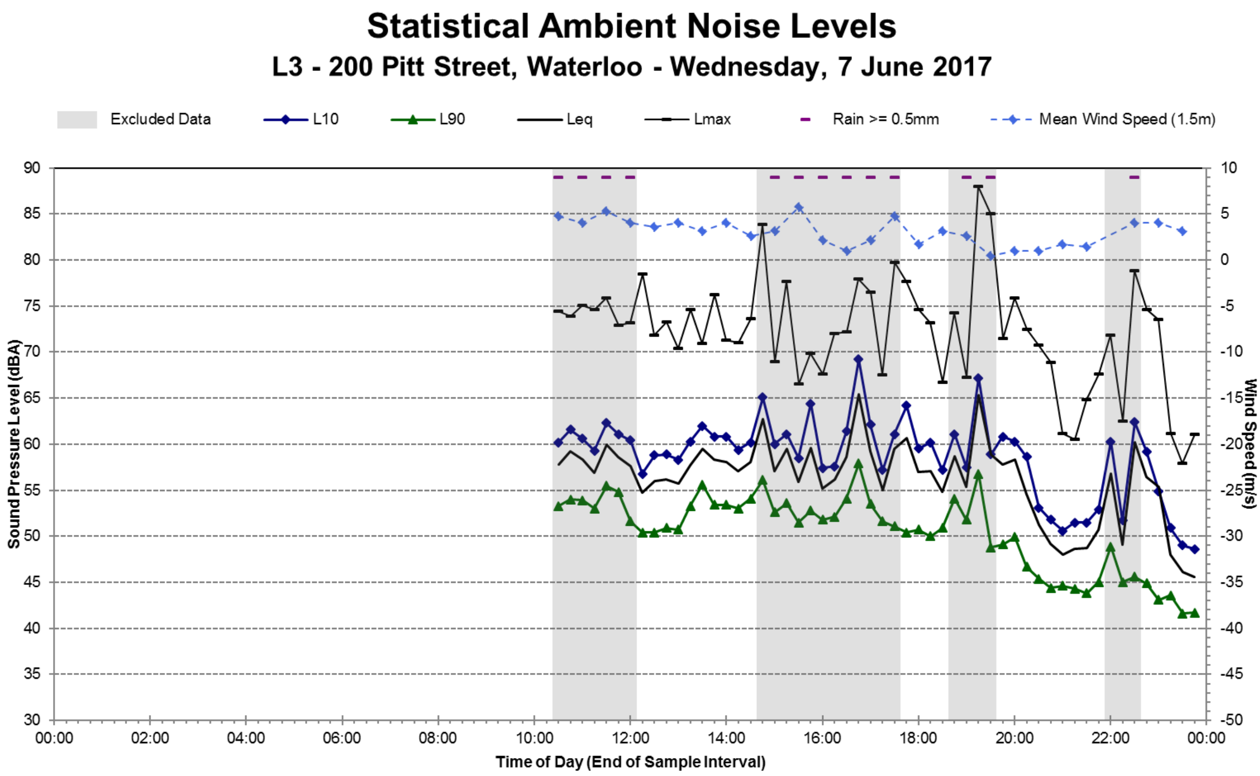
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



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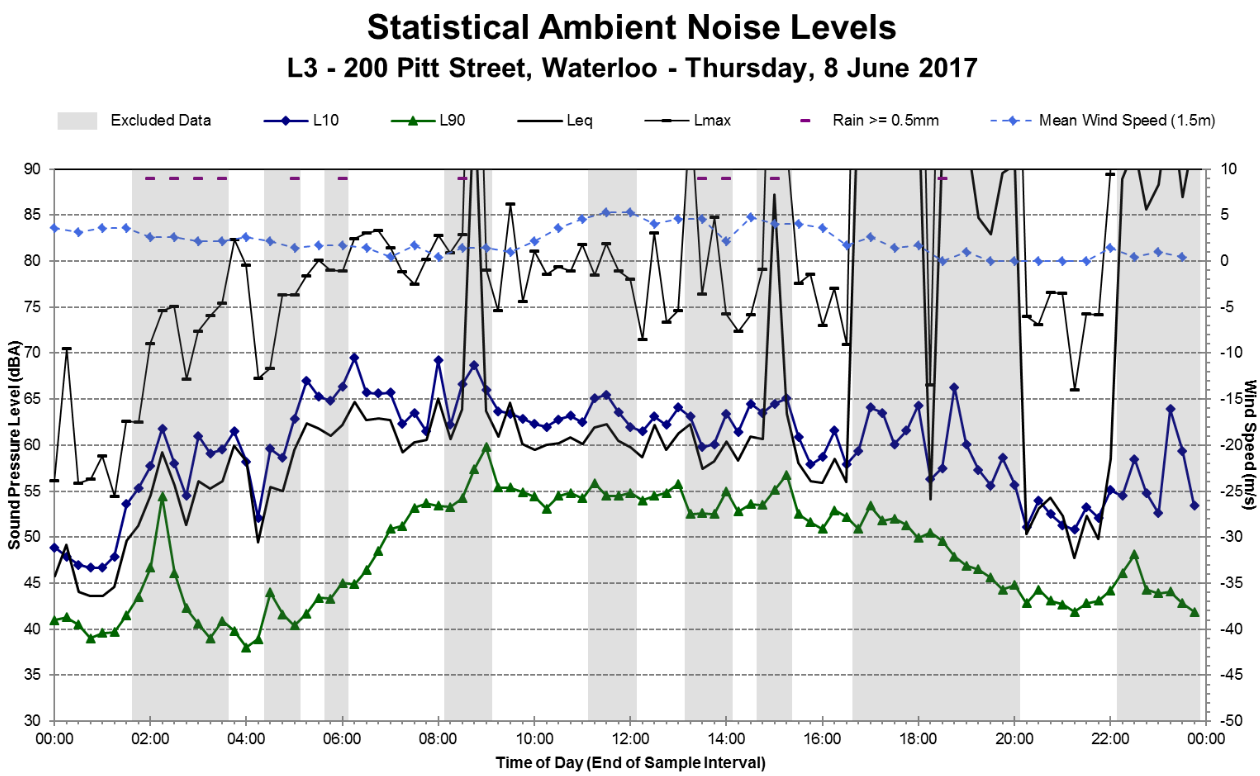
Time of Day (End of Sample Interval)



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Sound Pressure Level (dBA)
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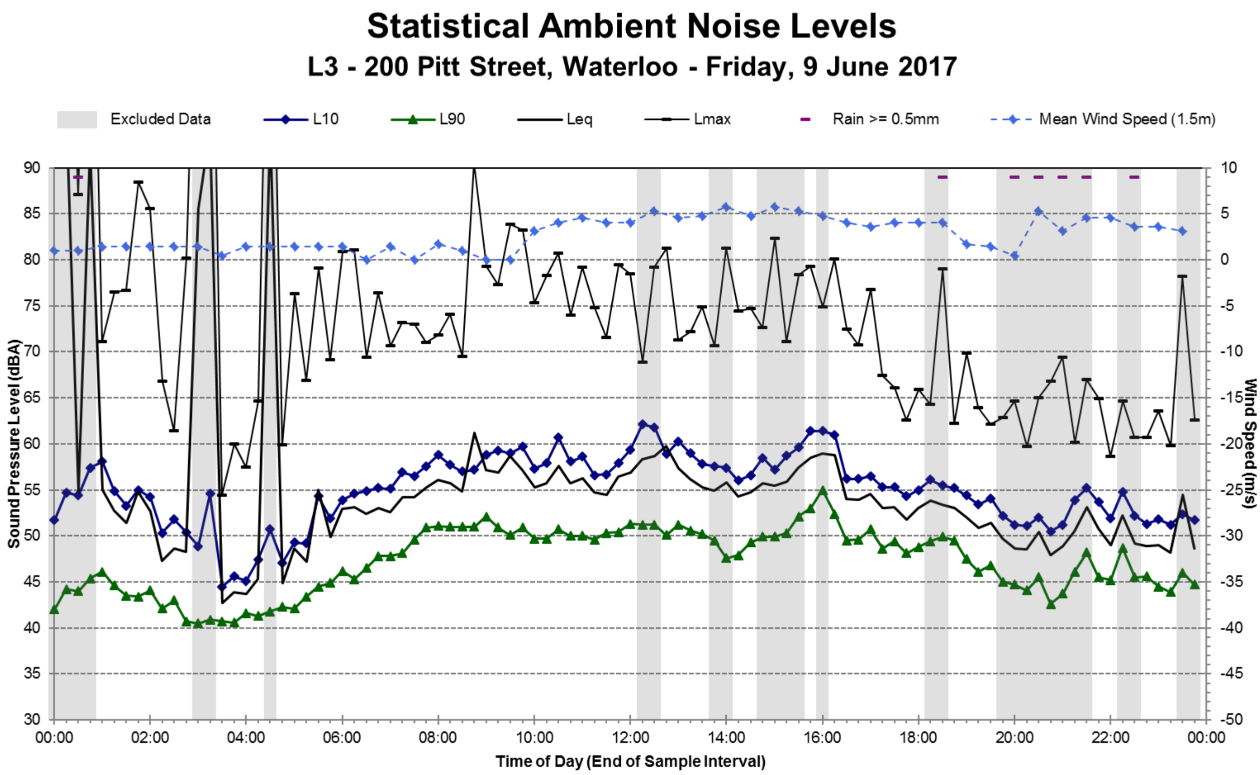
Time of Day (End of Sample Interval)



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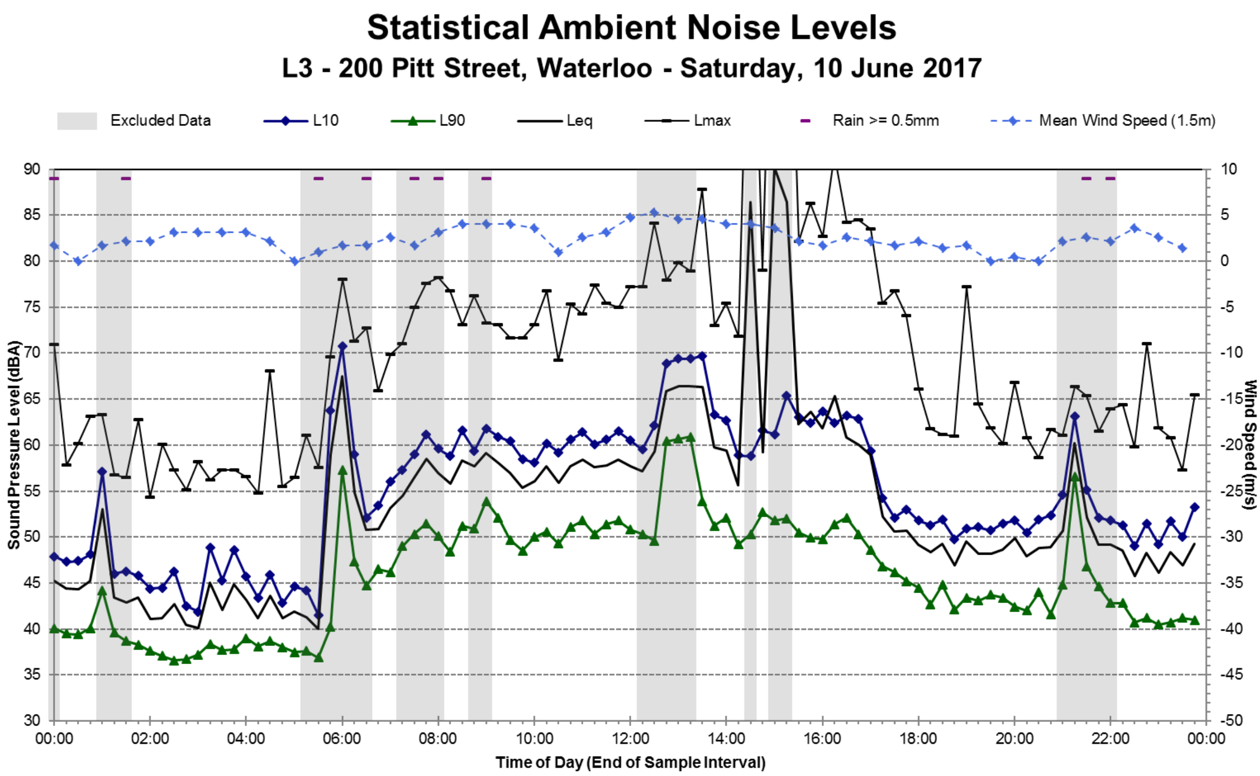
Wind Speed (m/s)
Time of Day (End of Sample Interval)



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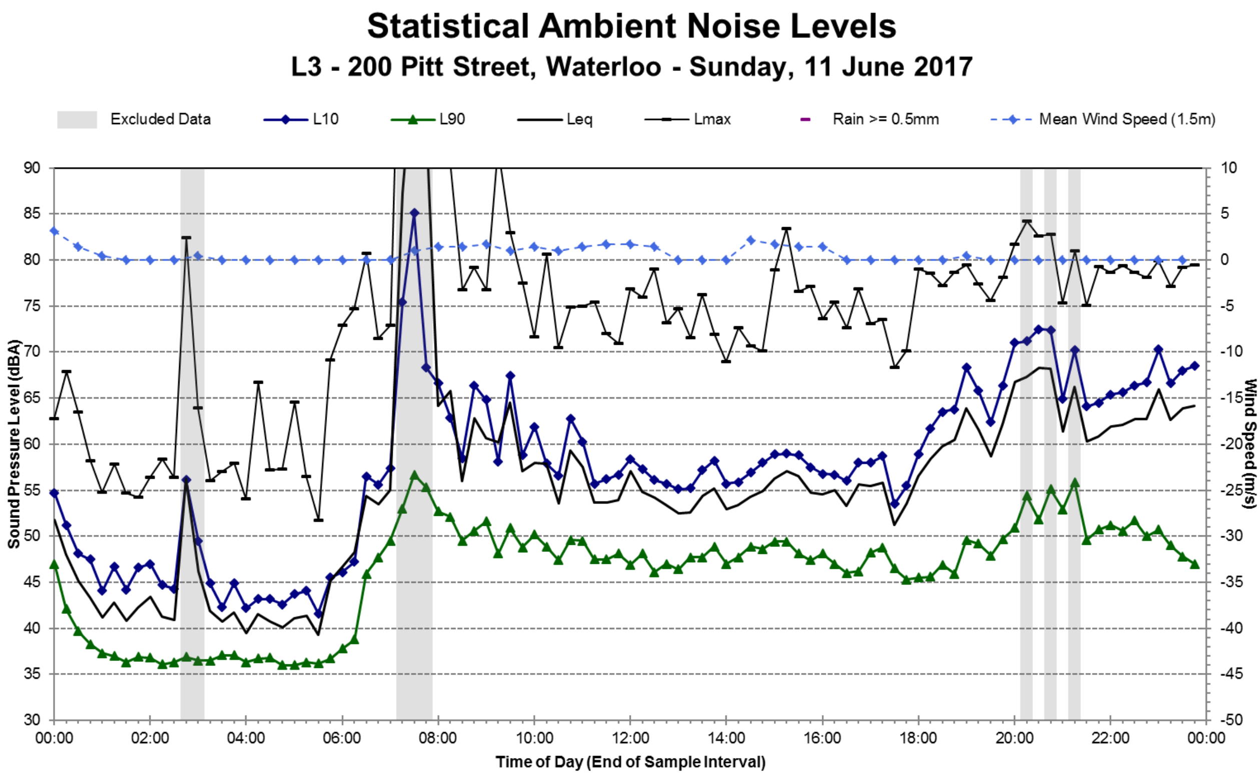
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



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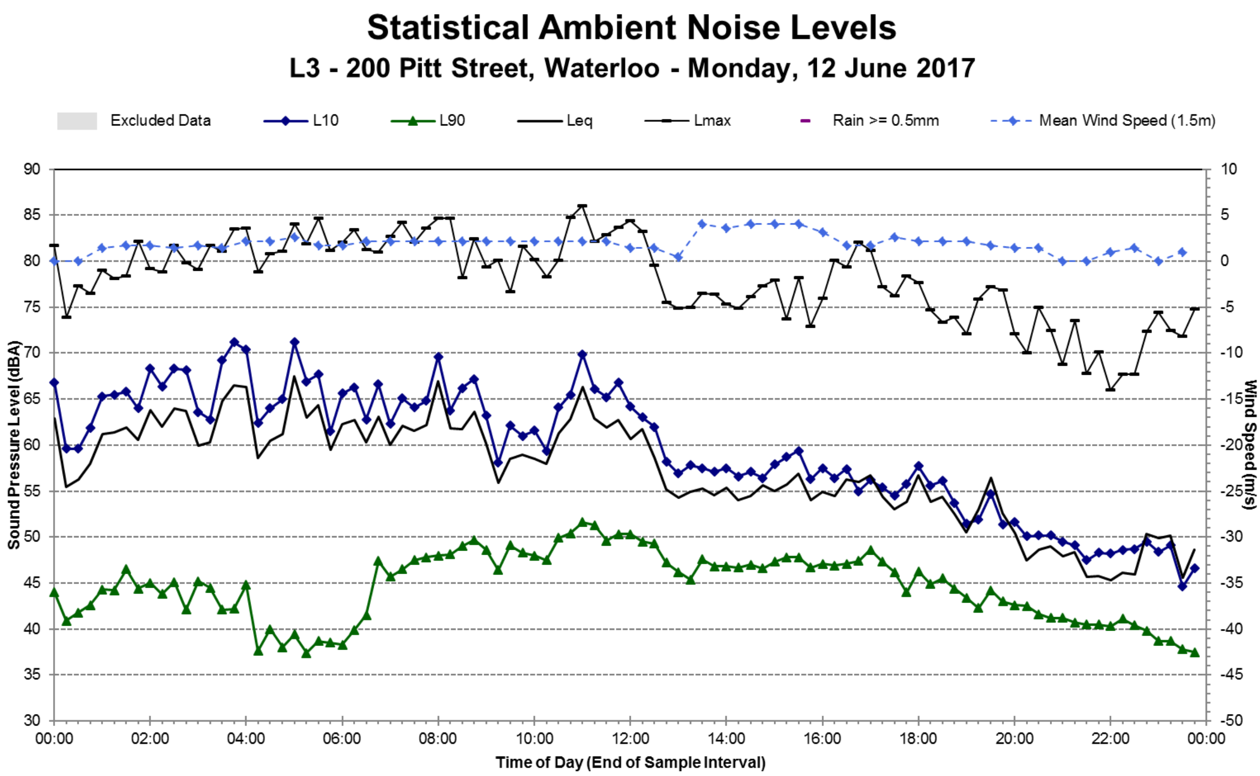

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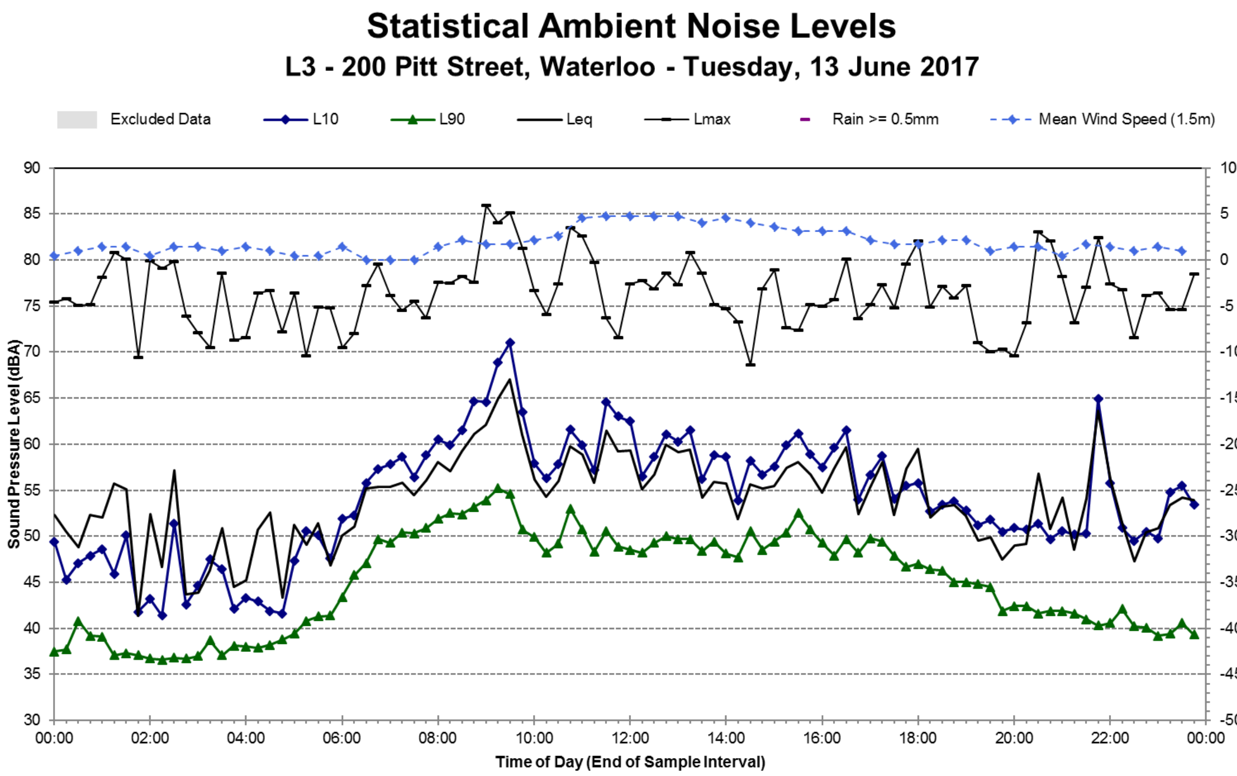
Time of Day (End of Sample Interval)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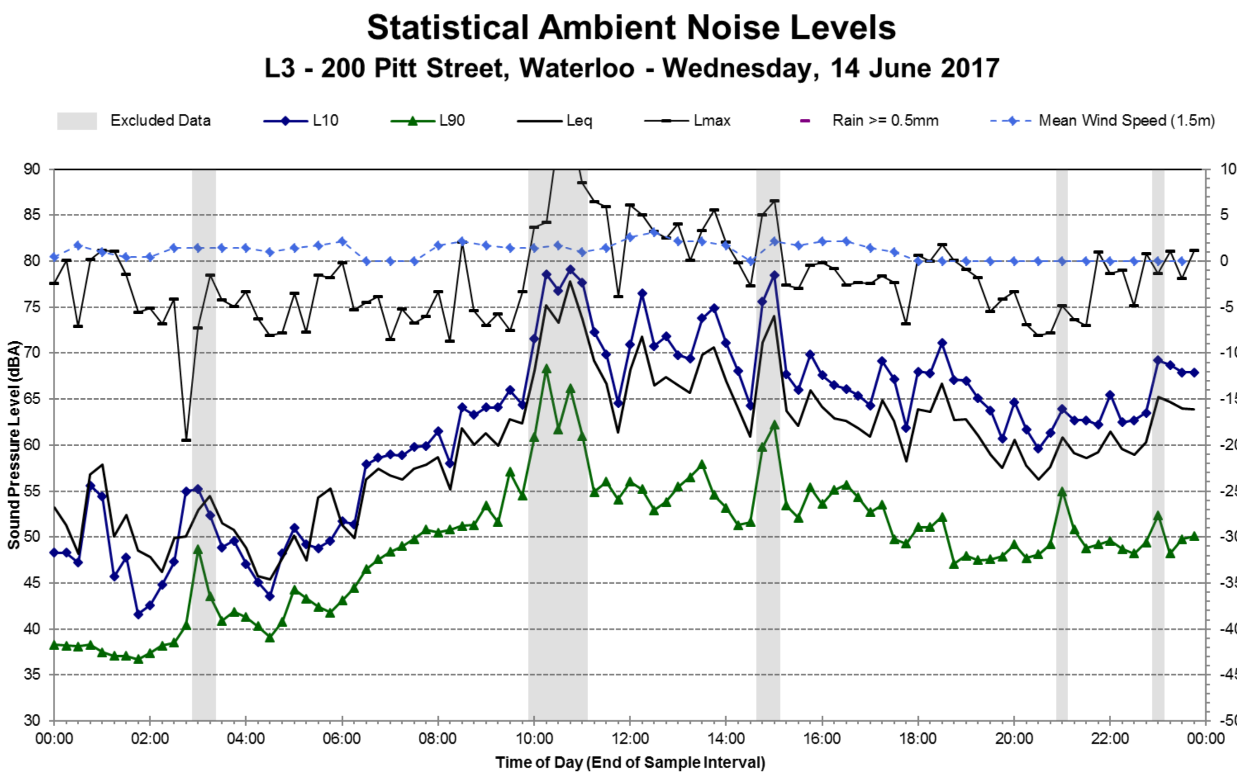
Time of Day (End of Sample Interval)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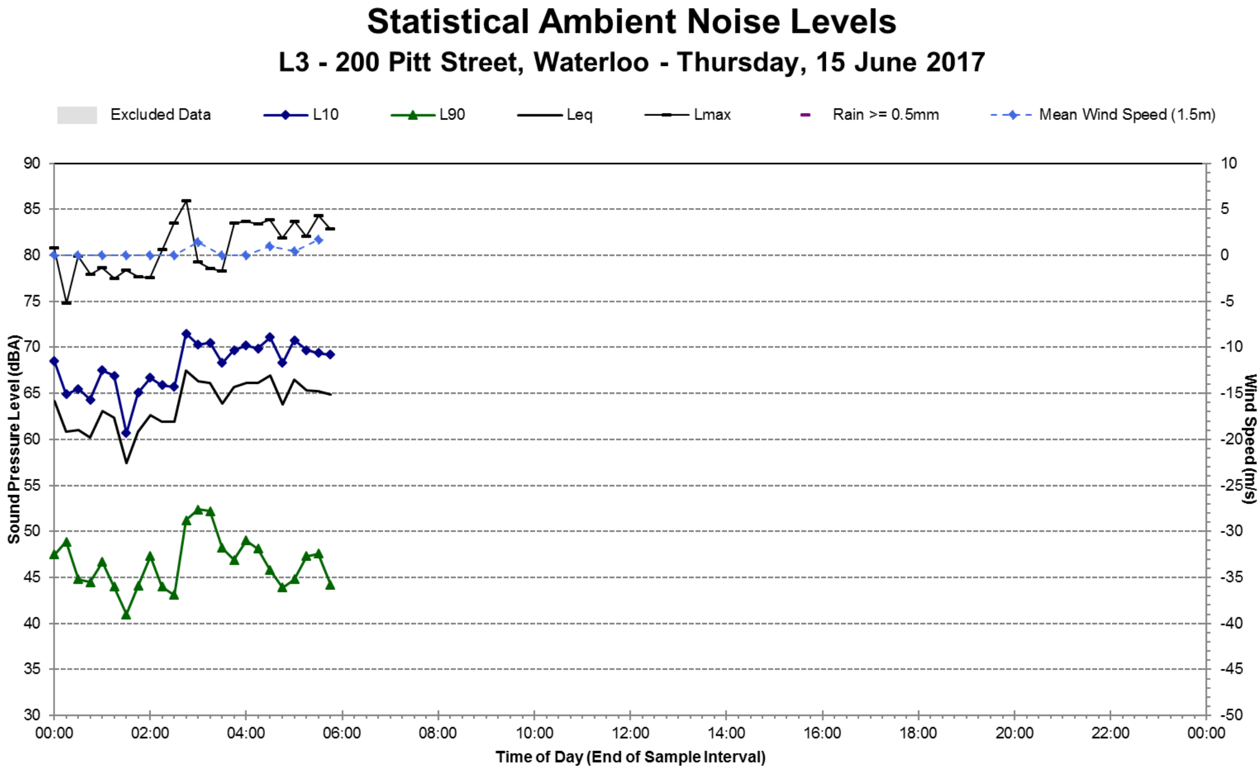
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)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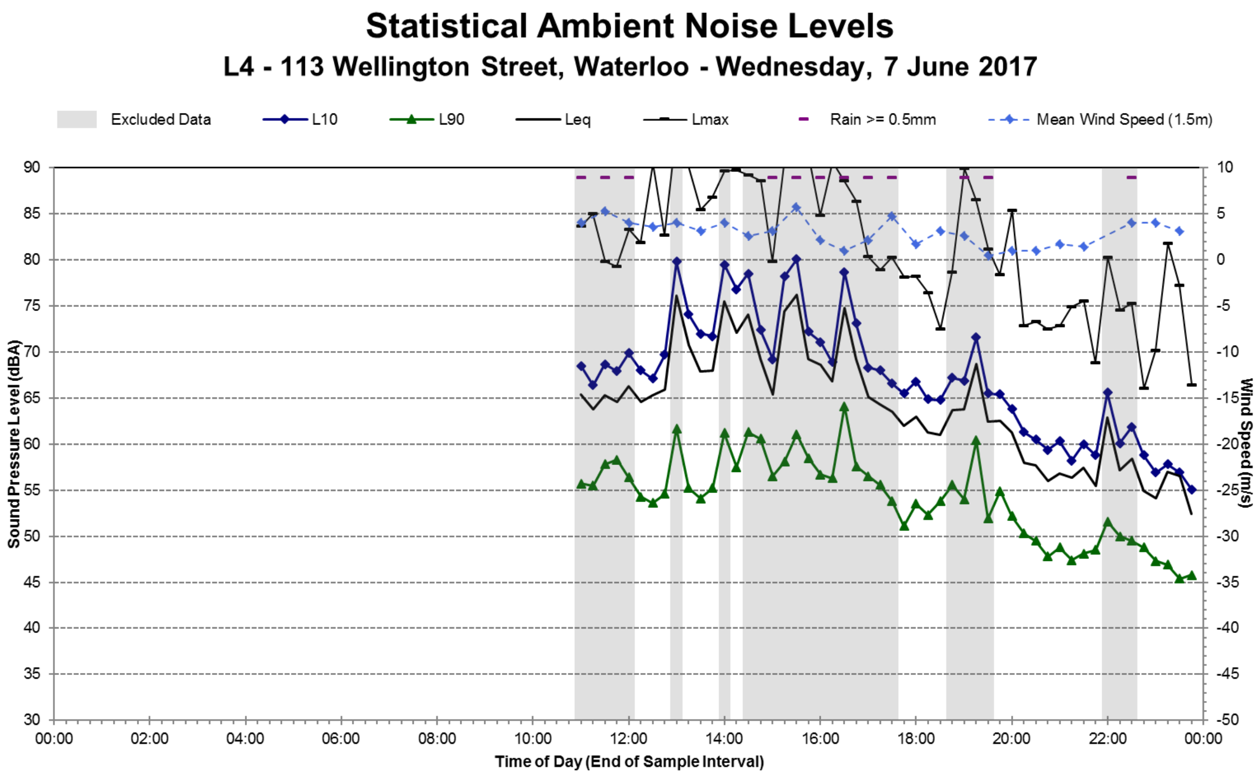
Time of Day (End of Sample Interval)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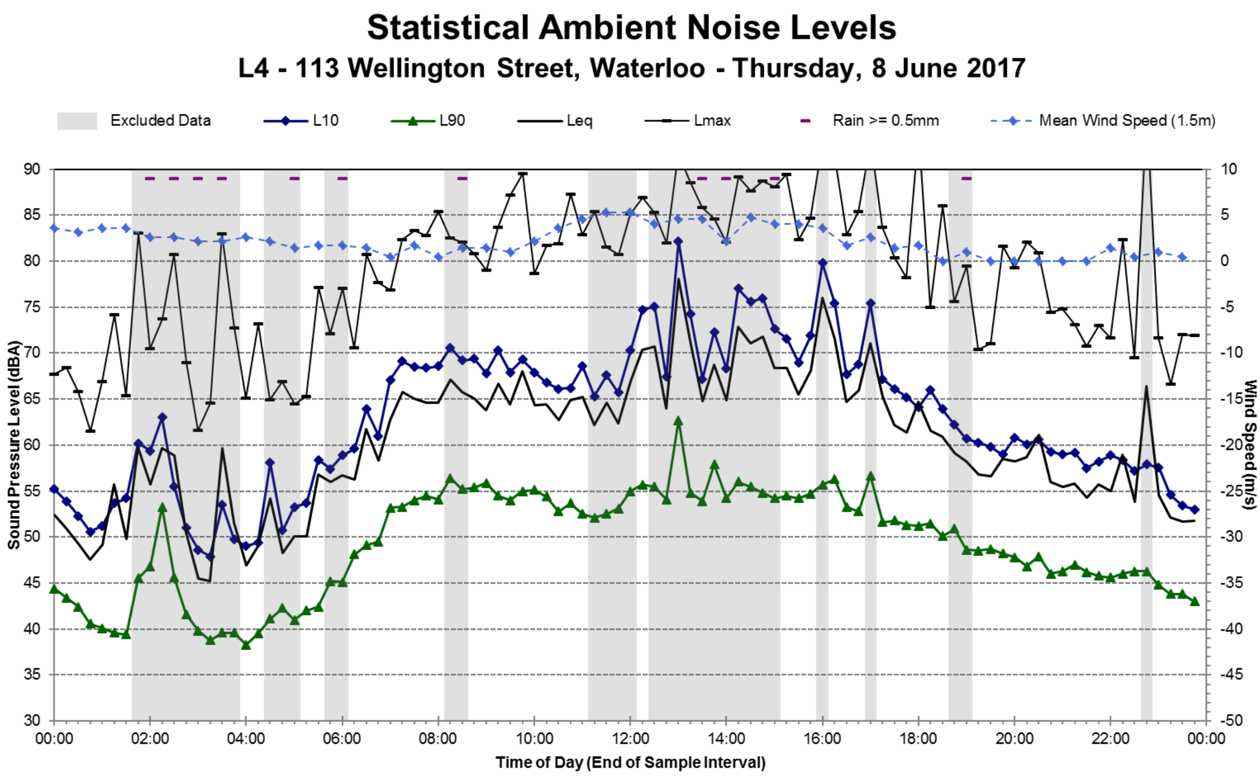
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)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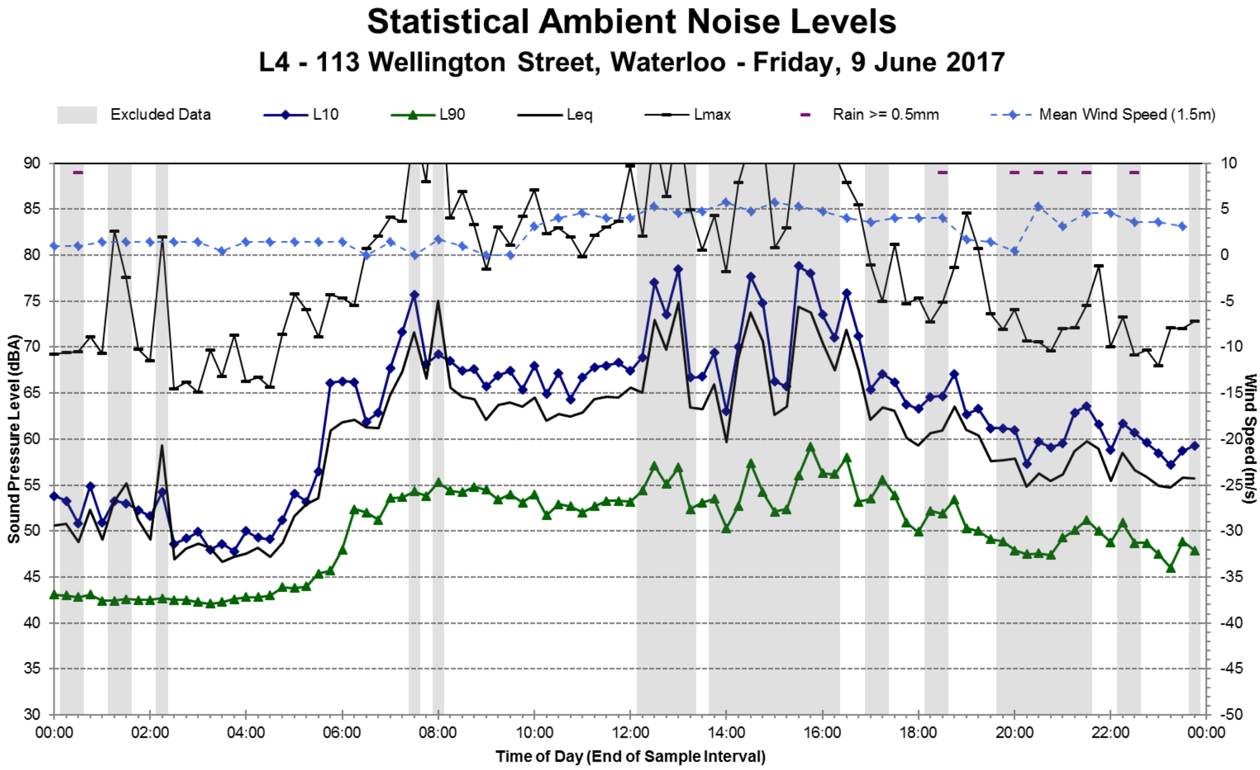
Time of Day (End of Sample Interval)



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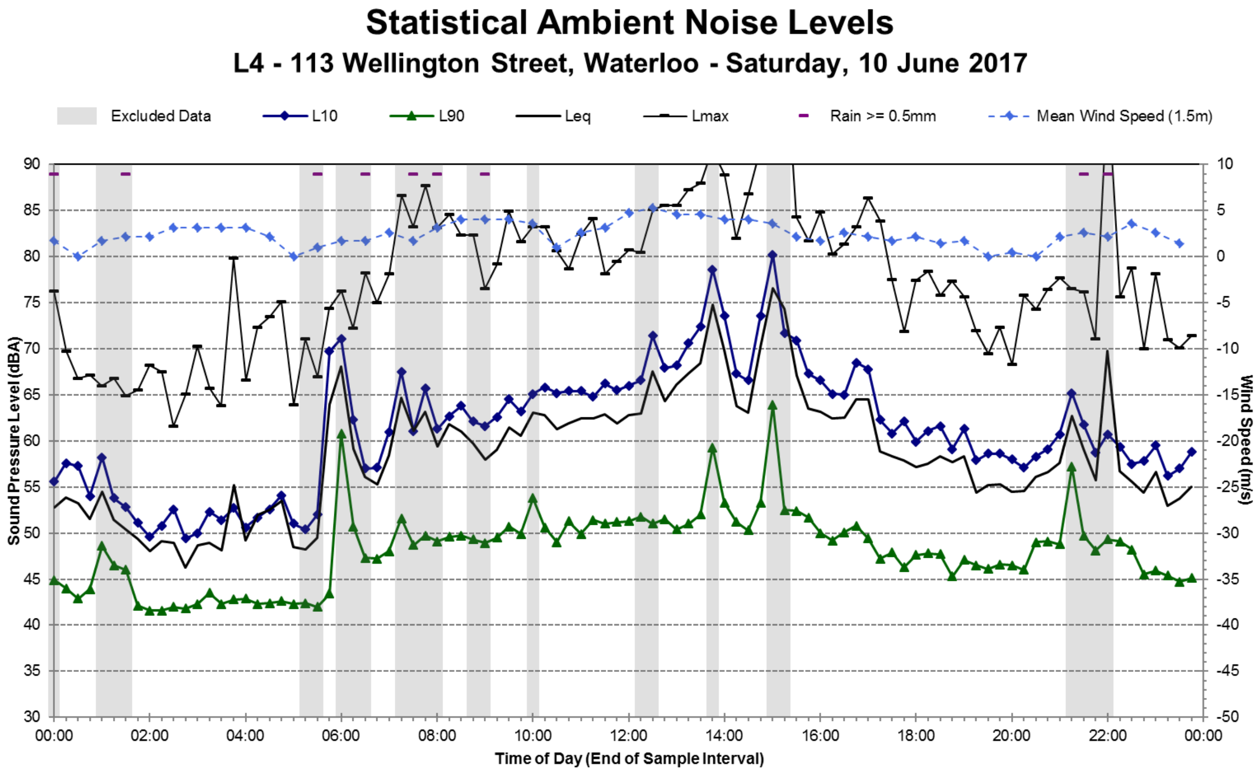
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



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Sound Pressure Level (dBA)
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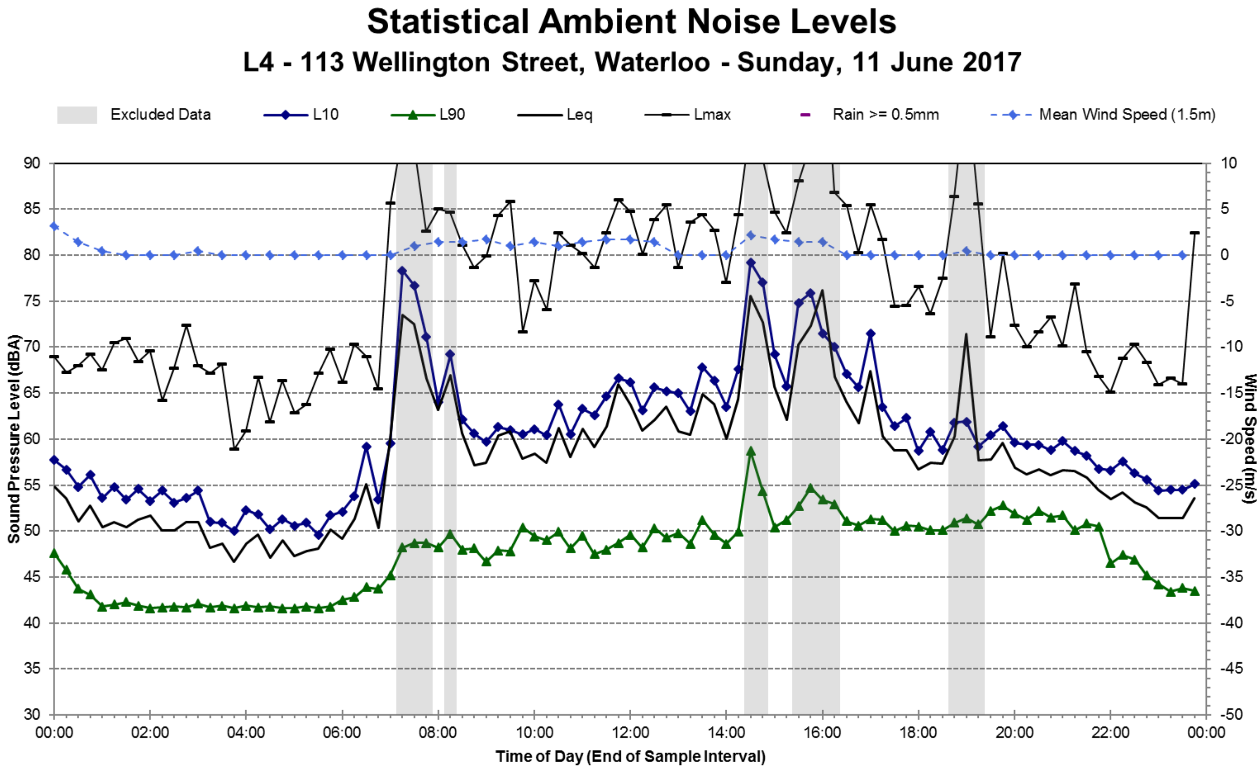
Time of Day (End of Sample Interval)



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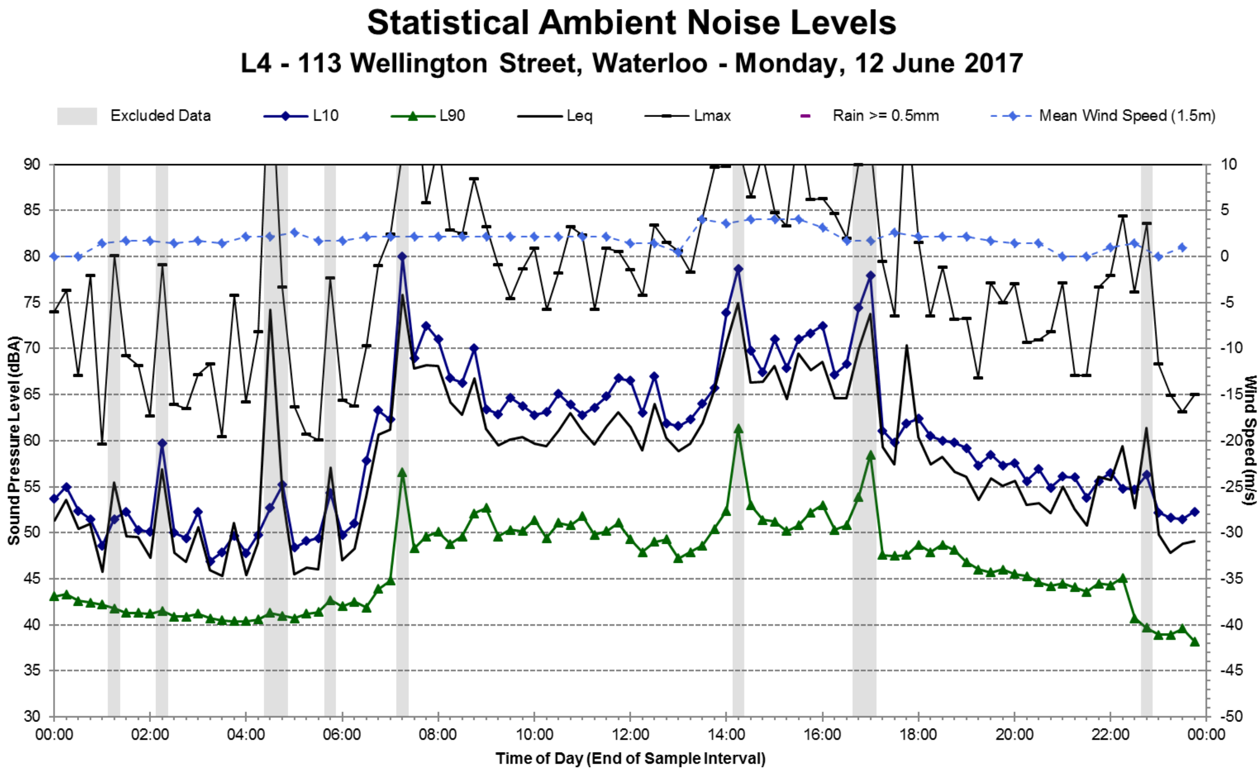
Time of Day (End of Sample Interval)



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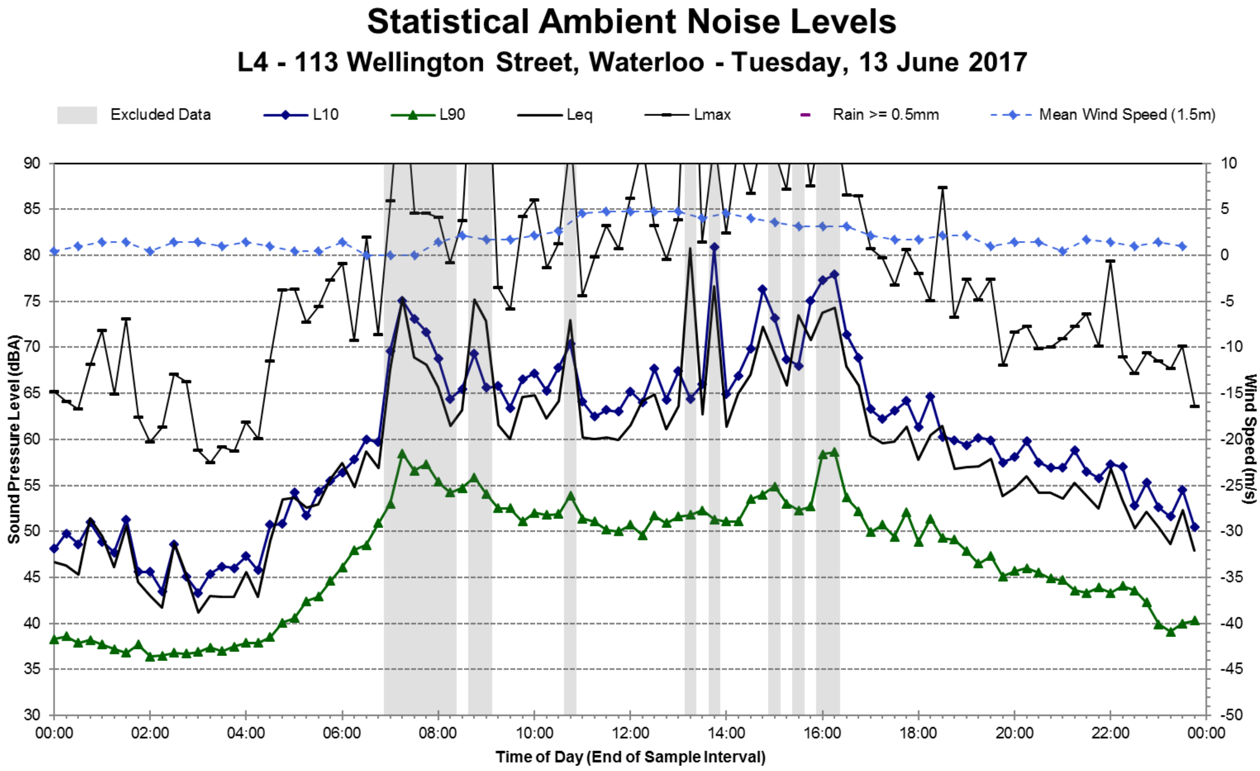
Time of Day (End of Sample Interval)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Sound Pressure Level (dBA)
Wind Speed (m/s)
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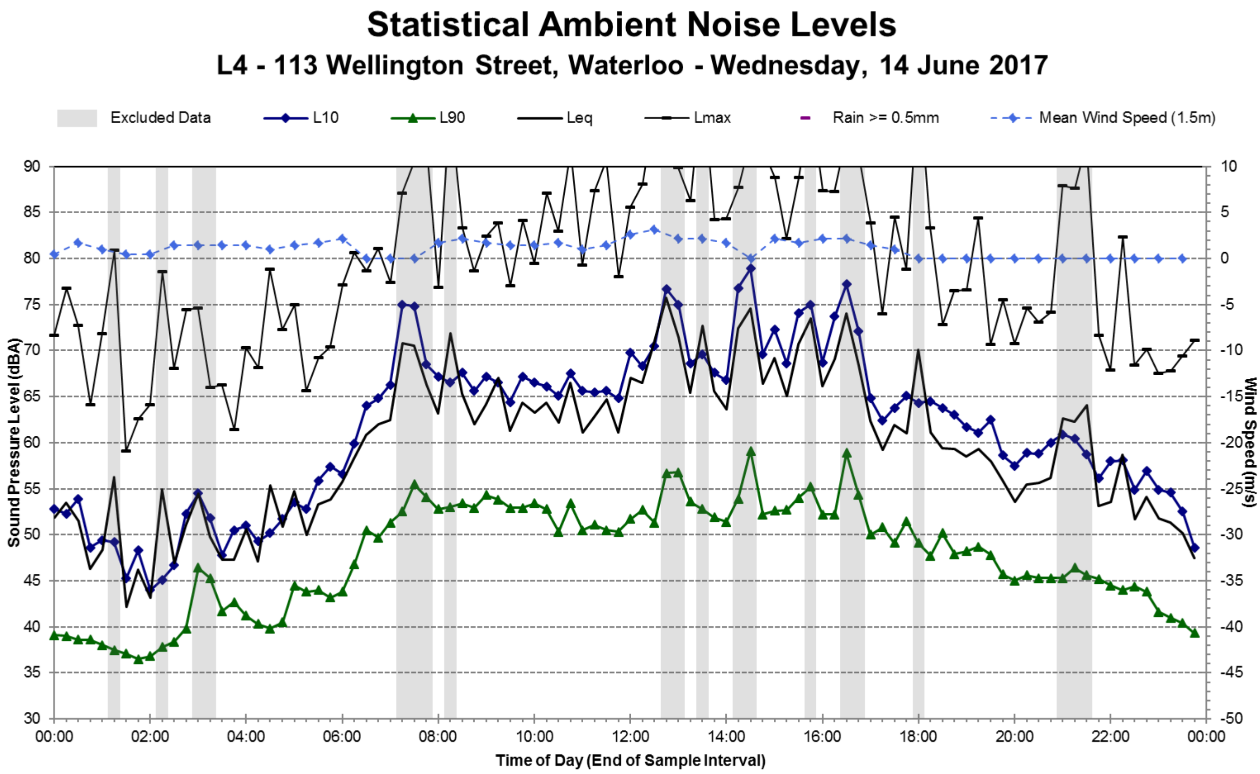
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Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
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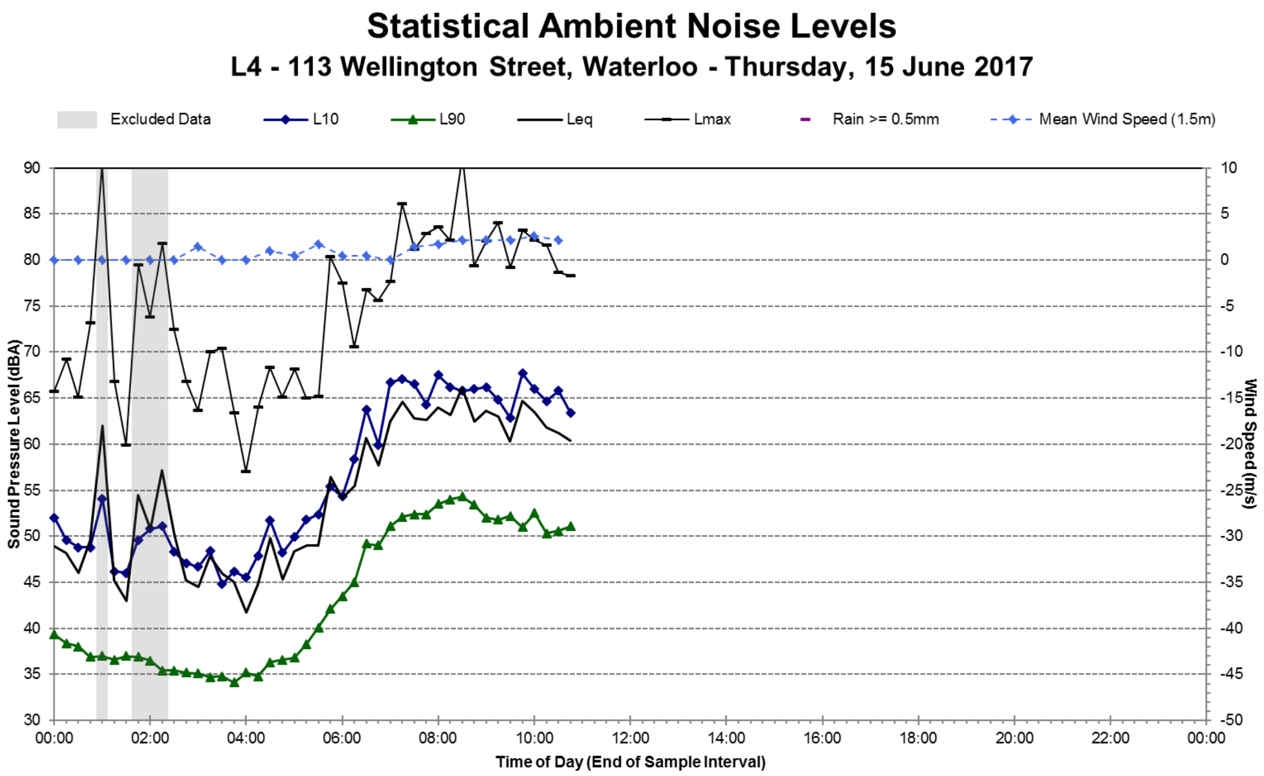
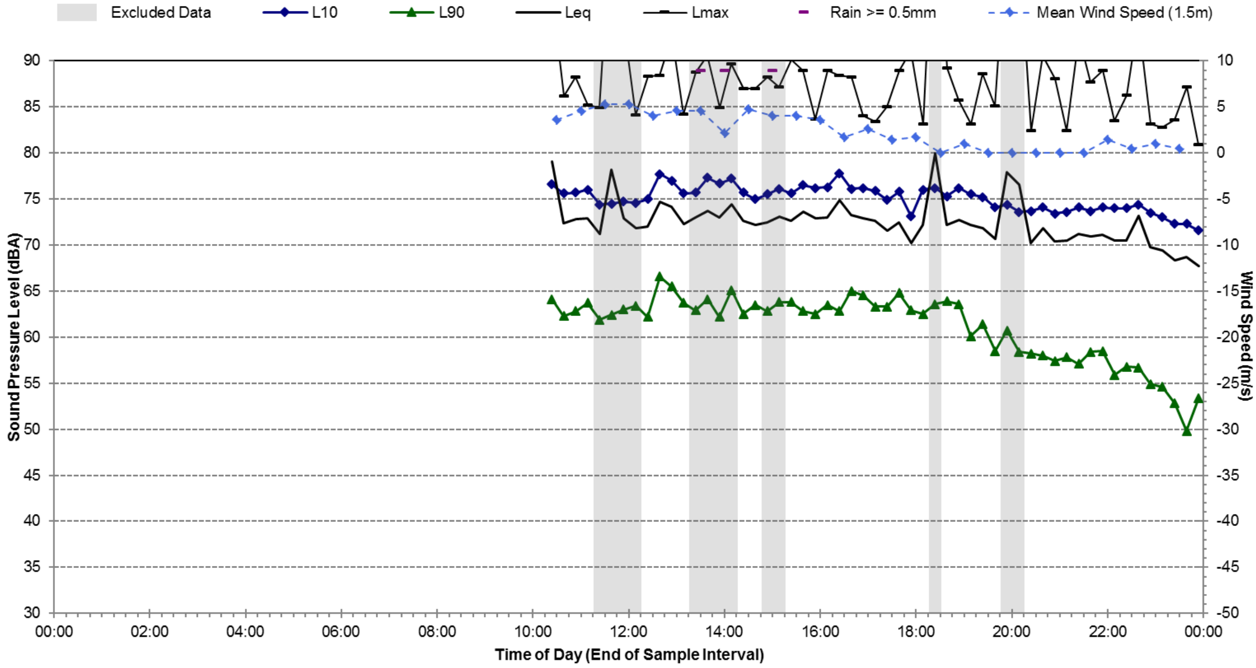
5
10



Statistical Ambient Noise Levels
L4 - 113 Wellington Street, Waterloo - Thursday, 15 June 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

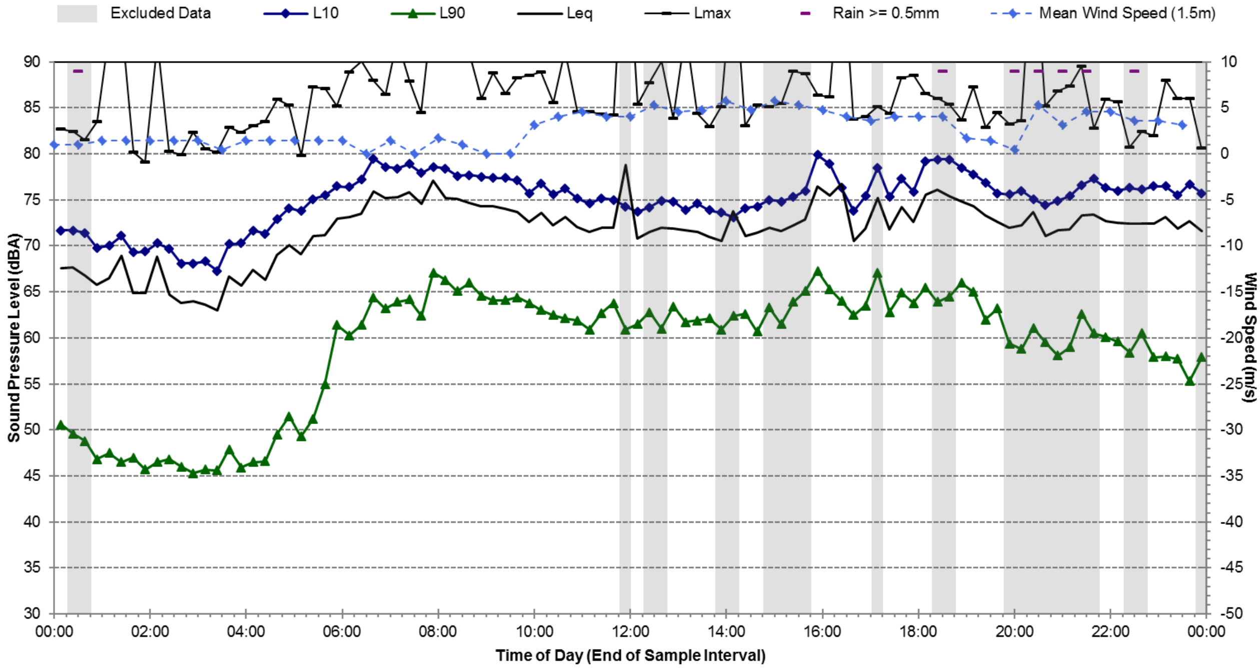
Statistical Ambient Noise Levels

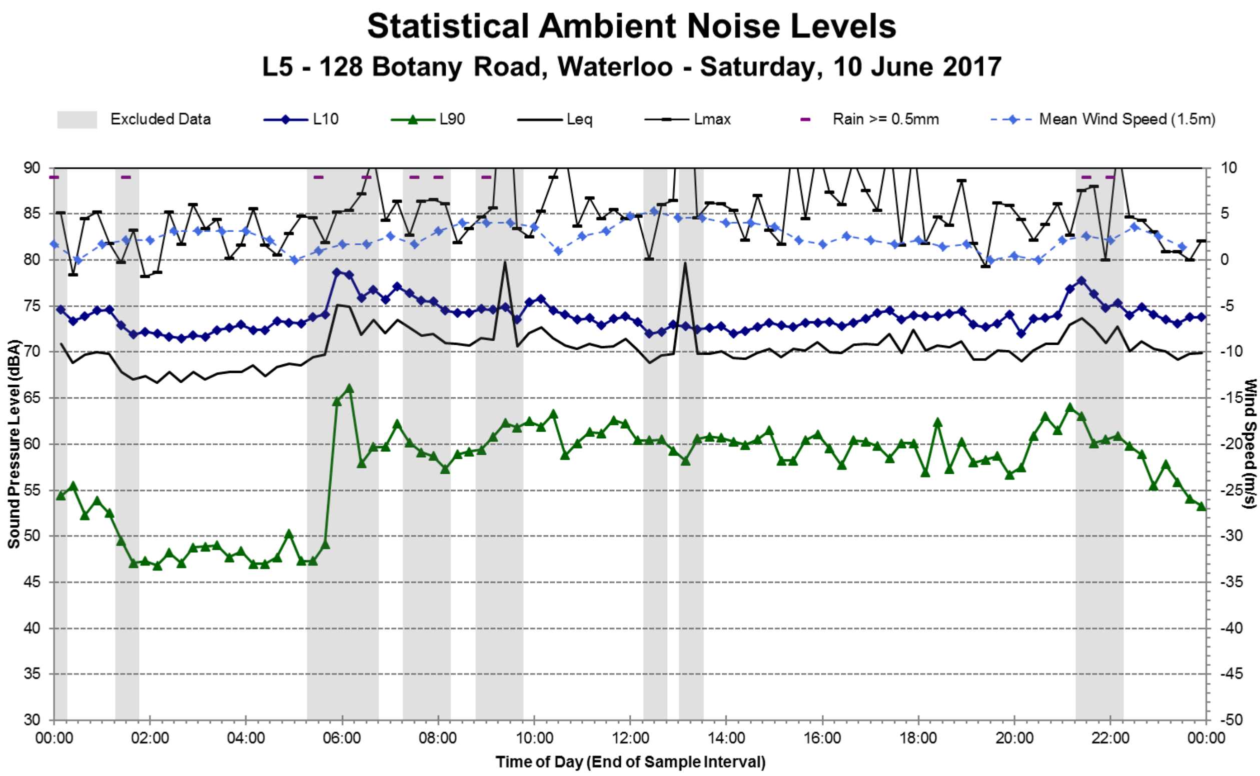
L5 - 128 Botany Road, Waterloo - Thursday, 8 June 2017

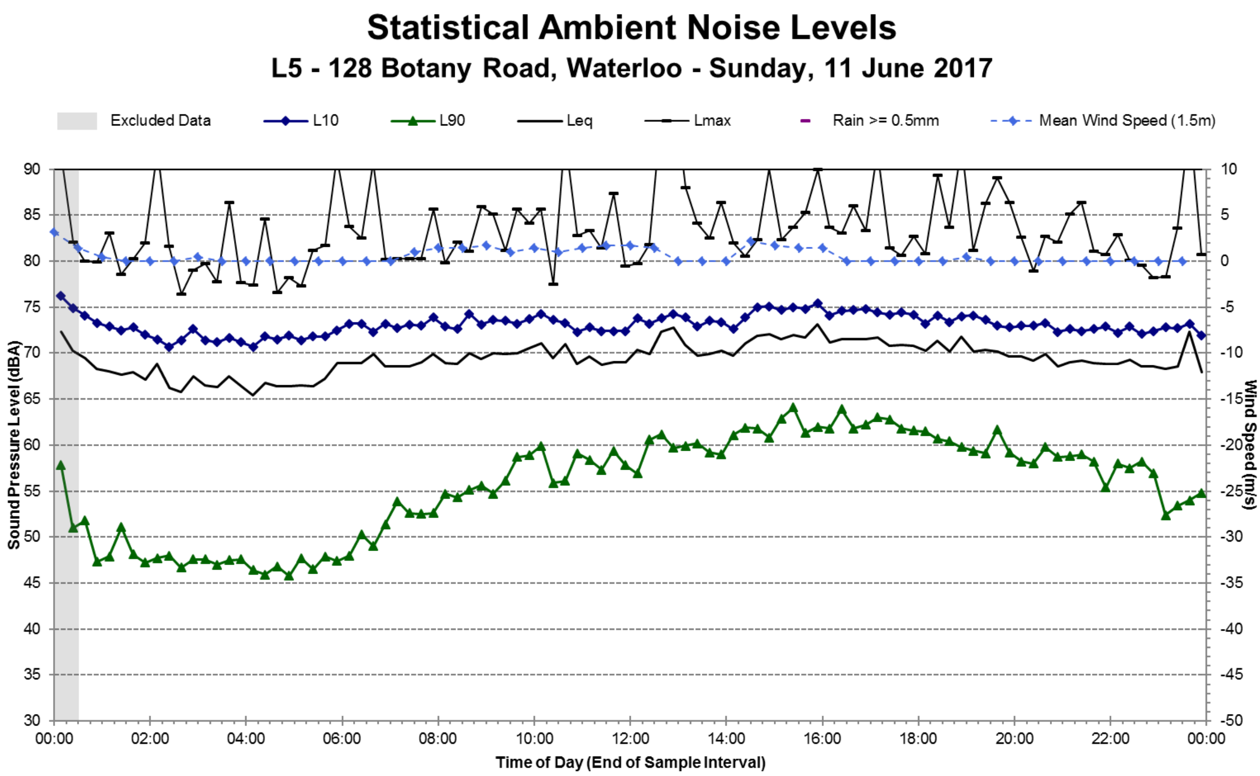


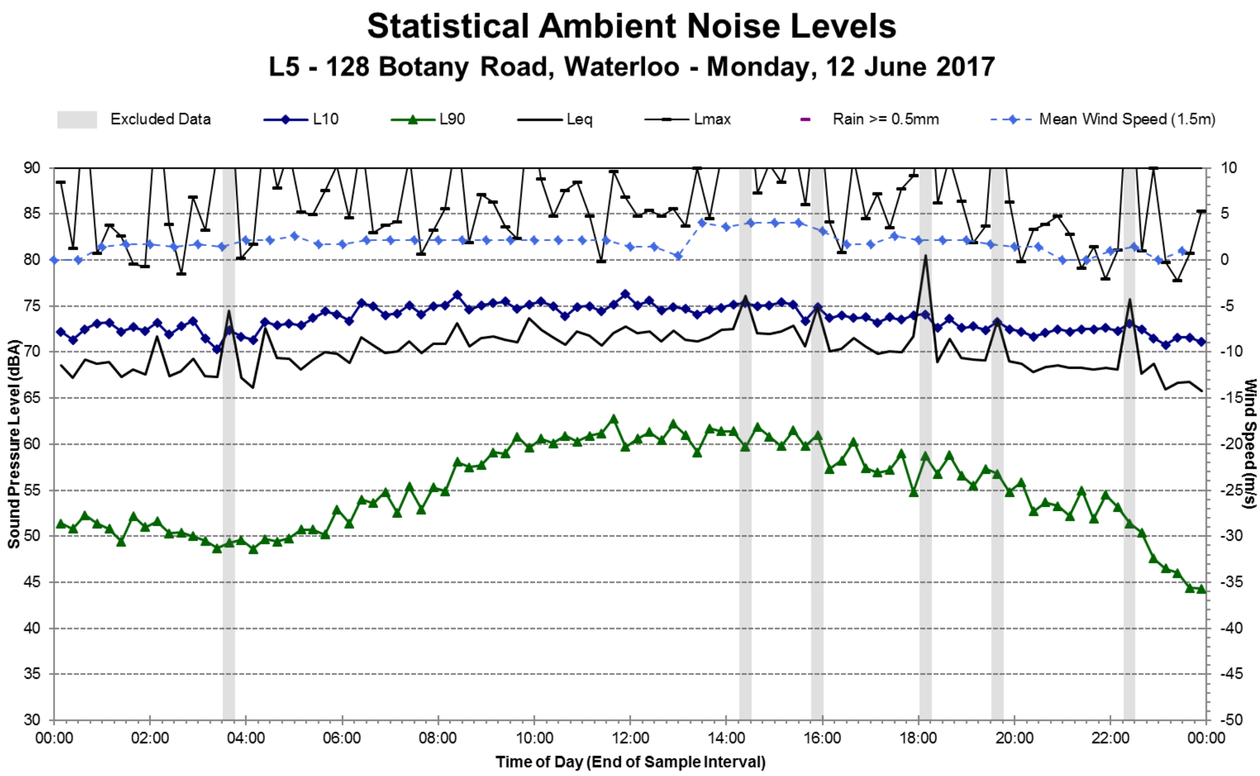
Statistical Ambient Noise Levels

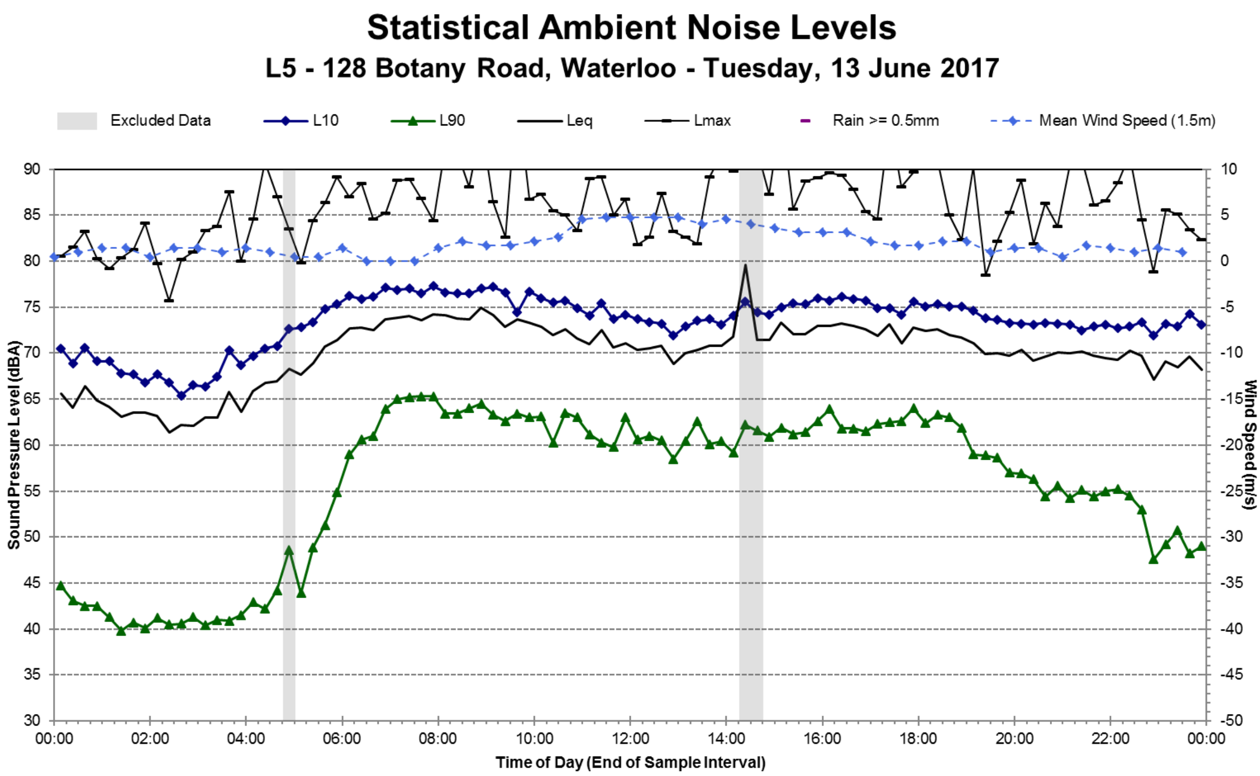
L5 - 128 Botany Road, Waterloo - Friday, 9 June 2017




Statistical Ambient Noise Levels
L5 - 128 Botany Road, Waterloo - Saturday, 10 June 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

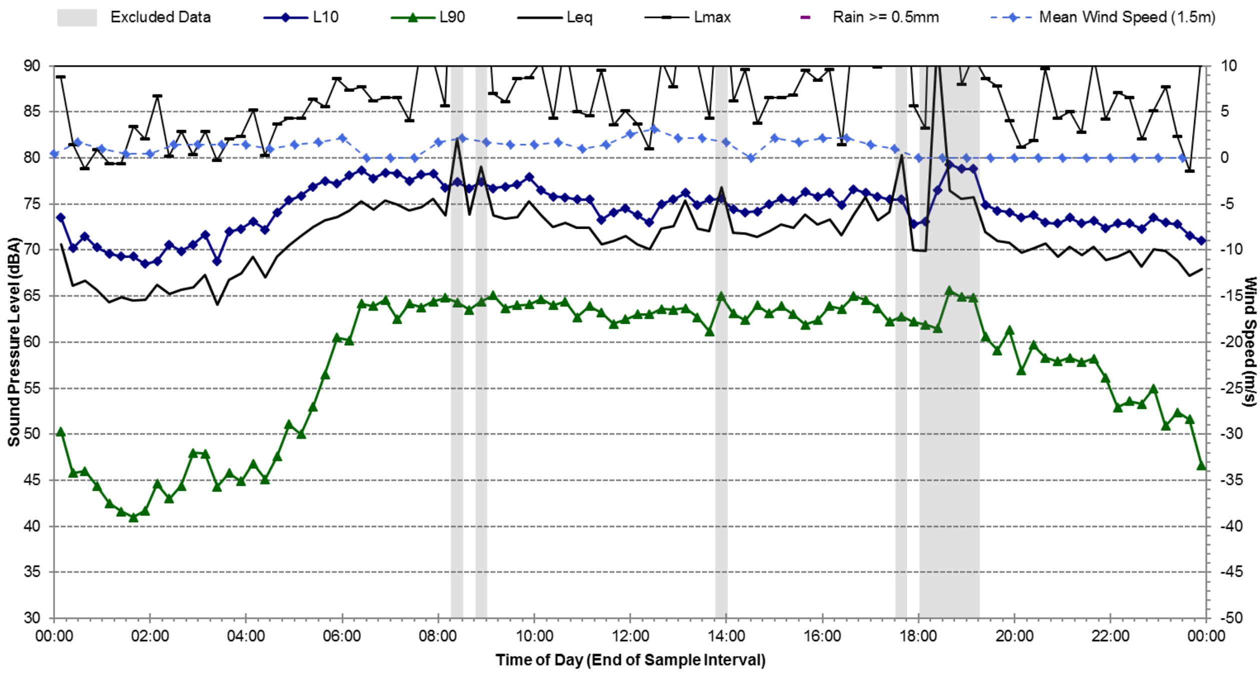

Statistical Ambient Noise Levels
L5 - 128 Botany Road, Waterloo - Sunday, 11 June 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L5 - 128 Botany Road, Waterloo - Monday, 12 June 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L5 - 128 Botany Road, Waterloo - Tuesday, 13 June 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

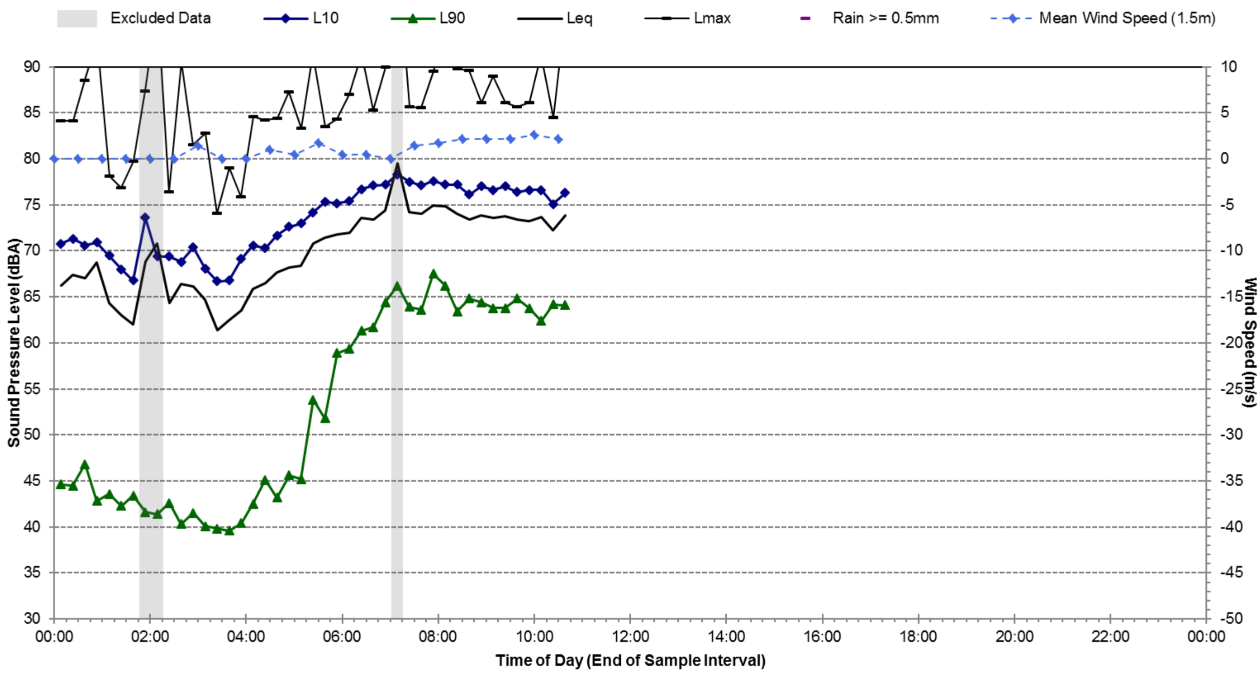
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Wednesday, 14 June 2017



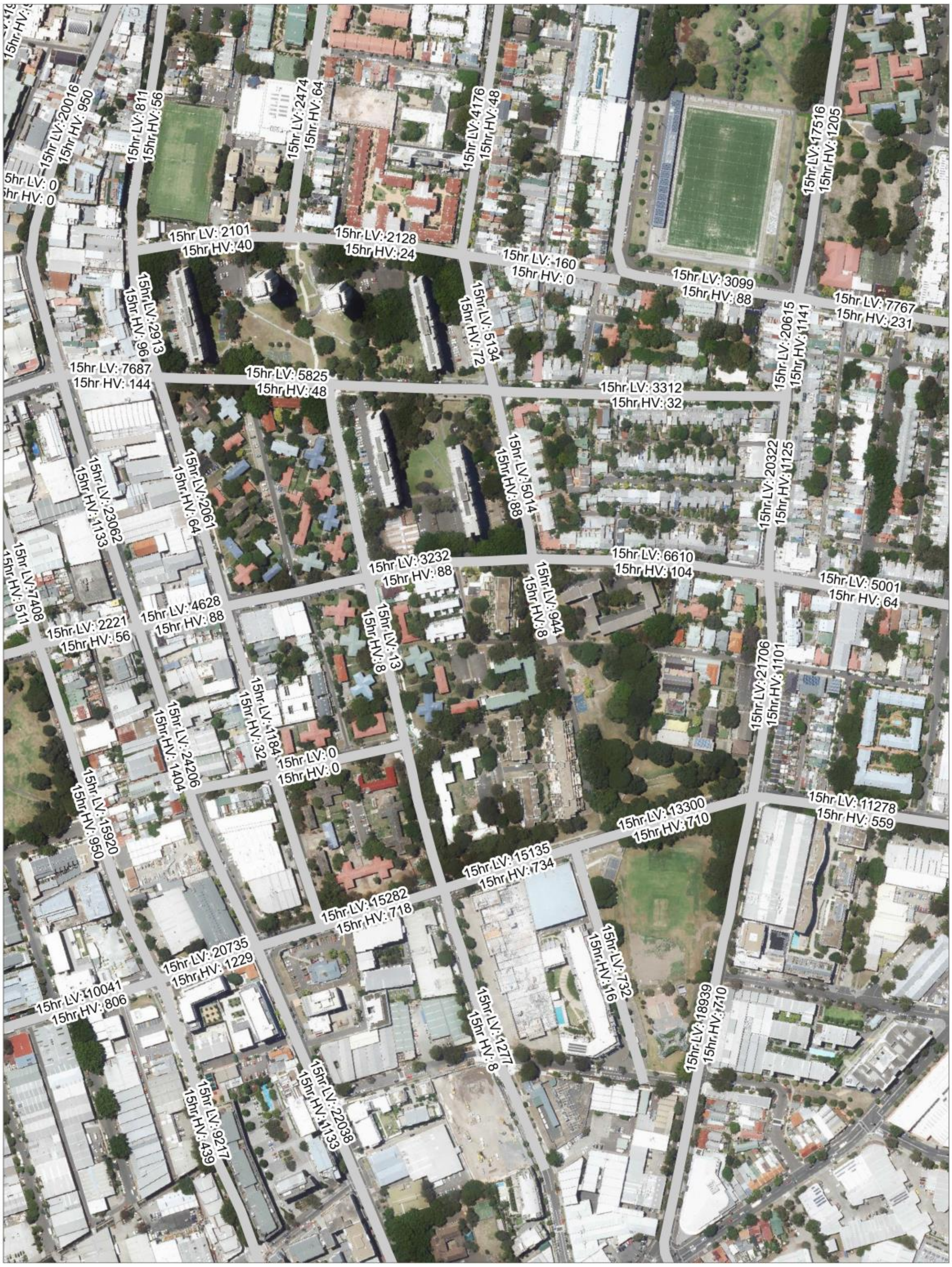
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Thursday, 15 June 2017



APPENDIX C

Existing Road Traffic Volumes



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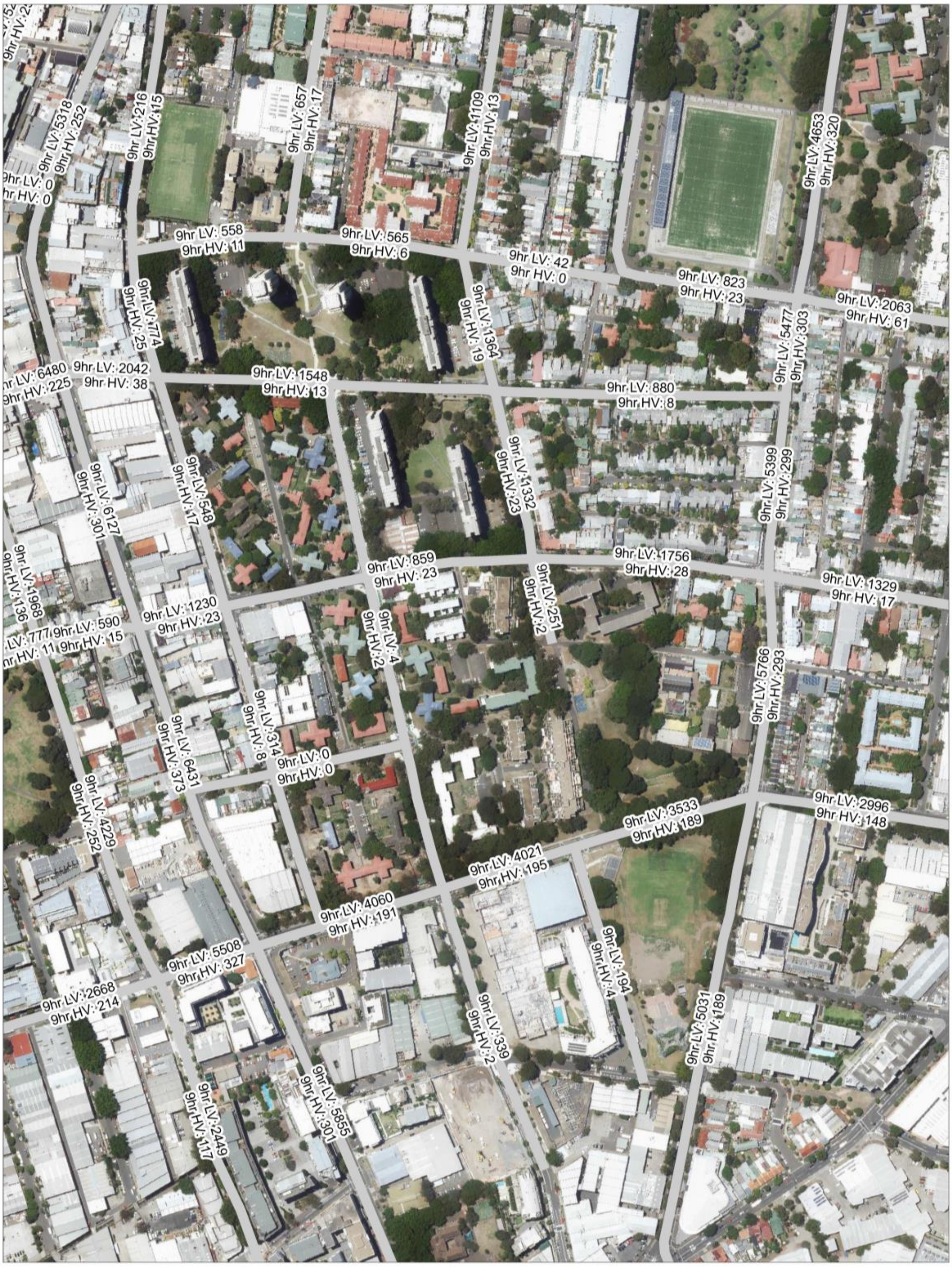
Project No.:	610.14863
Date:	28/02/2016
Drawn by:	MA
Scale:	1:4,500
Sheet Size:	@ A4
Projection:	GDA 1994 MGA Zone 56

0 40 80 120 m

UrbanGrowth NSW

Metro Quarter SSD

Daytime (7am to 10pm) traffic volumes



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Project No.:	610.14863
Date:	28/02/2016
Drawn by:	MA
Scale:	1:4,500
Sheet Size:	@ A4
Projection:	GDA 1994 MGA Zone 56

0 40 80 120 m

UrbanGrowth NSW

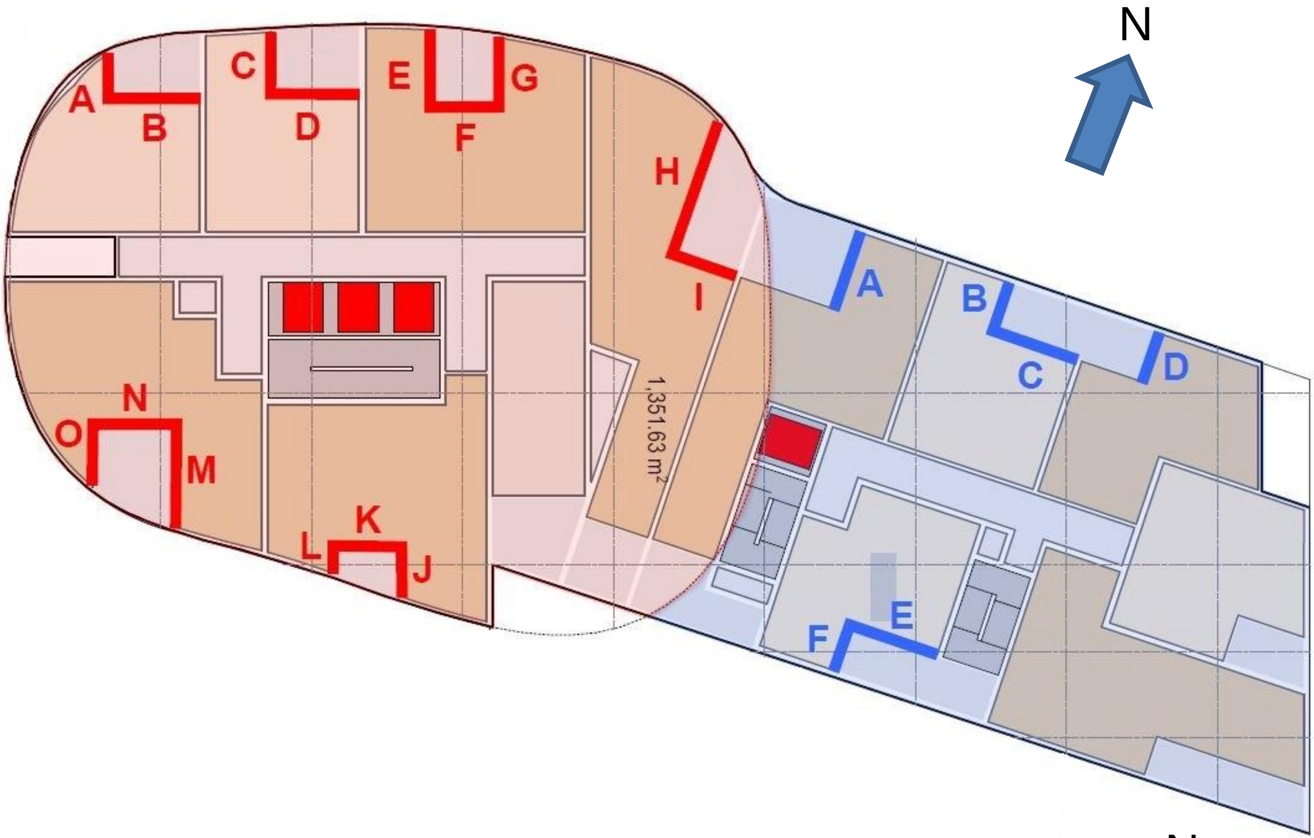
Metro Quarter SSD

Night-time (10pm to 7am) traffic volumes

APPENDIX D

Noise Ingress Predictions

Figure 19 **Facade IDs – Building 1 (B01) and Building 2 (B02)**



Note 1: Building 1 (B01) shown in red and Building 2 (B02) shown in blue.

N

Figure 20 **Facade IDs – Building 3 (B03)**

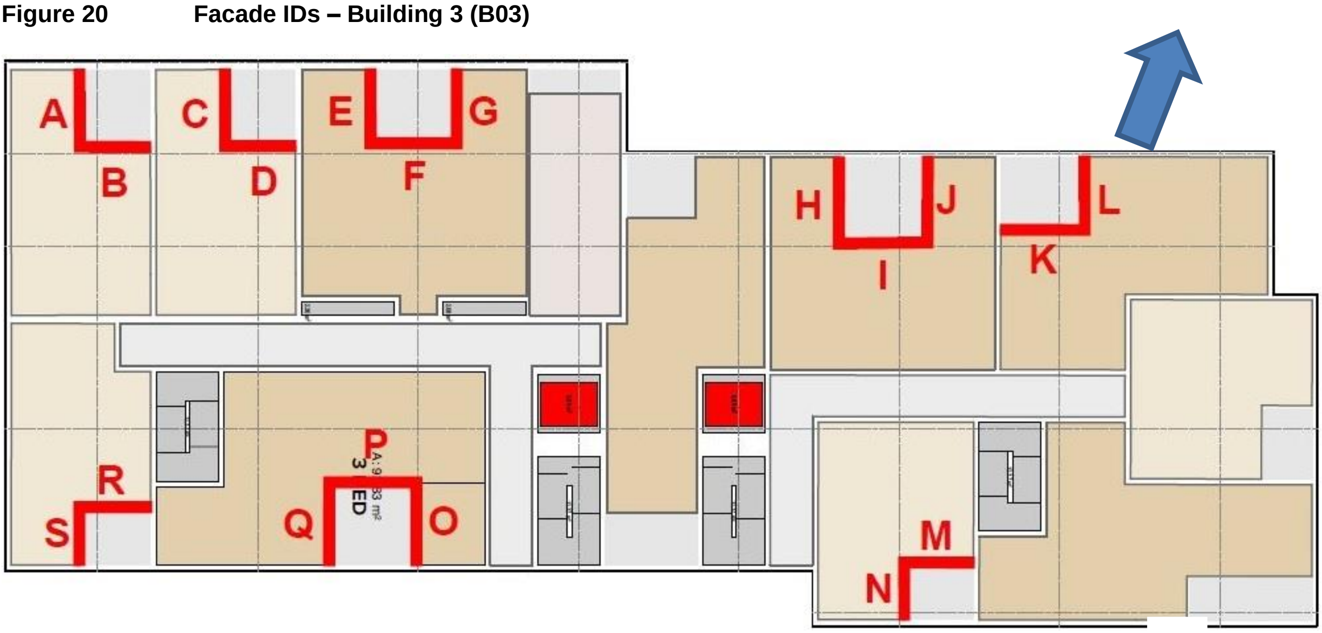


Figure 21 **Facade IDs – Building 4 (B04)**

N

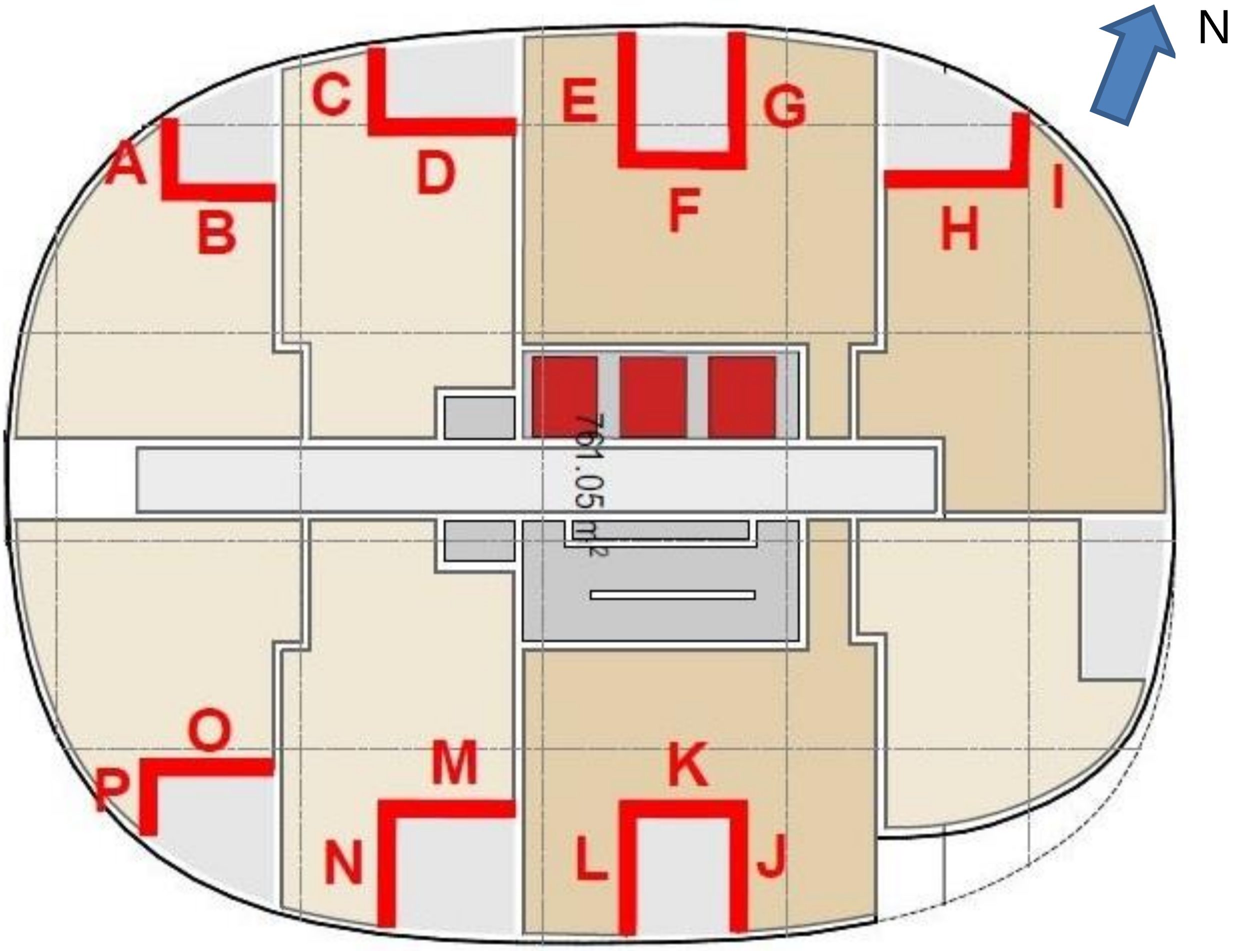
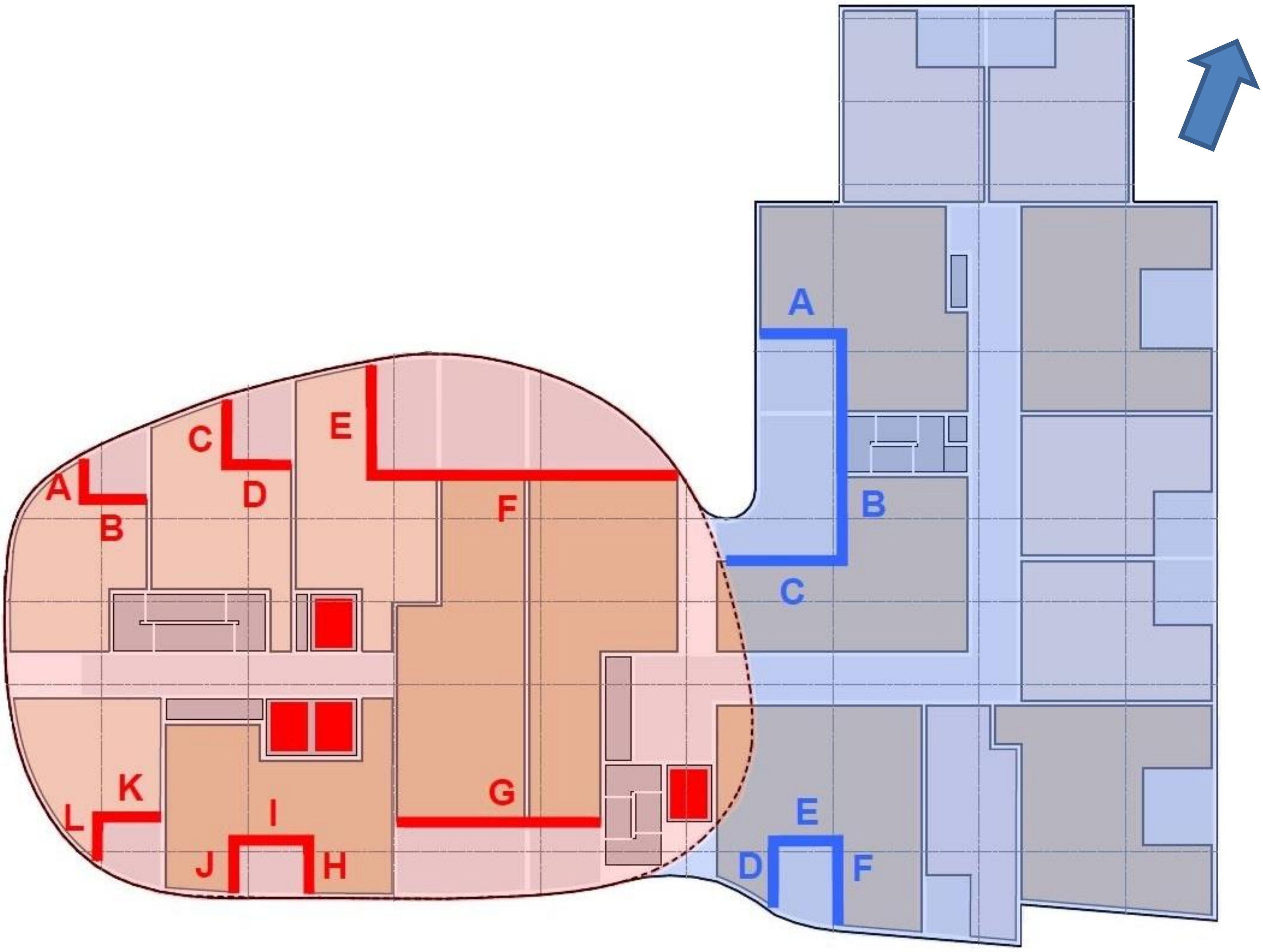


Figure 22 **Facade IDs – Building 5 (B05) and Building 6 (B06)**



Note 1: Building 5 (B05) shown in red and Building 6 (B06) shown in blue.

Table 21 Predicted Internal Road Traffic Noise Levels

ID	Receiver Height (m)(RL)	Building ID	Facade ID	Facade Direction	SP ID	Predicted Internal Noise Levels (dBA)			
1	42	B01	A	East	B01-A-LOW	46	Yes	42	Yes
2	74	B01	A	East	B01-A-MID	45	Yes	41	Yes
3	106	B01	A	East	B01-A-HIGH	45	Yes	41	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
4	42	B01	B	North	B01-B-LOW	52	Yes	48	No
5	74	B01	B	North	B01-B-MID	50	Yes	46	No
6	106	B01	B	North	B01-B-HIGH	49	Yes	45	Yes
7	42	B01	C	East	B01-C-LOW	46	Yes	42	Yes
8	74	B01	C	East	B01-C-MID	44	Yes	40	Yes
9	106	B01	C	East	B01-C-HIGH	44	Yes	40	Yes
10	42	B01	D	North	B01-D-LOW	49	Yes	45	No
11	74	B01	D	North	B01-D-MID	48	Yes	44	Yes
12	106	B01	D	North	B01-D-HIGH	48	Yes	44	Yes
13	42	B01	E	East	B01-E-LOW	45	Yes	41	Yes
14	74	B01	E	East	B01-E-MID	43	Yes	39	Yes
15	106	B01	E	East	B01-E-HIGH	43	Yes	39	Yes
16	42	B01	F	North	B01-F-LOW	45	Yes	41	Yes
17	74	B01	F	North	B01-F-MID	45	Yes	41	Yes
18	106	B01	F	North	B01-F-HIGH	45	Yes	41	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
19	42	B01	G	West	B01-G-LOW	49	Yes	45	Yes
20	74	B01	G	West	B01-G-MID	48	Yes	44	Yes
21	106	B01	G	West	B01-G-HIGH	47	Yes	43	Yes
22	42	B01	H	East	B01-H-LOW	47	Yes	43	Yes
23	74	B01	H	East	B01-H-MID	45	Yes	41	Yes
24	106	B01	H	East	B01-H-HIGH	43	Yes	40	Yes
25	42	B01	I	North	B01-I-LOW	46	Yes	42	Yes
26	74	B01	I	North	B01-I-MID	45	Yes	41	Yes
27	106	B01	I	North	B01-I-HIGH	45	Yes	41	Yes
28	42	B01	J	West	B01-J-LOW	47	Yes	44	Yes
29	74	B01	J	West	B01-J-MID	48	Yes	44	Yes
30	106	B01	J	West	B01-J-HIGH	48	Yes	44	Yes
31	42	B01	K	South	B01-K-LOW	45	Yes	41	Yes
32	74	B01	K	South	B01-K-MID	46	Yes	43	Yes
33	106	B01	K	South	B01-K-HIGH	47	Yes	43	Yes
34	42	B01	L	East	B01-L-LOW	28	Yes	24	Yes
35	74	B01	L	East	B01-L-MID	43	Yes	39	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
36	106	B01	L	East	B01-L-HIGH	44	Yes	40	Yes
37	42	B01	M	West	B01-M-LOW	51	Yes	48	No
38	74	B01	M	West	B01-M-MID	50	Yes	46	No
39	106	B01	M	West	B01-M-HIGH	48	Yes	45	Yes
40	42	B01	N	South	B01-N-LOW	48	Yes	45	Yes
41	74	B01	N	South	B01-N-MID	48	Yes	44	Yes
42	106	B01	N	South	B01-N-HIGH	47	Yes	43	Yes
43	42	B01	O	East	B01-O-LOW	40	Yes	37	Yes
44	74	B01	O	East	B01-O-MID	41	Yes	38	Yes
45	106	B01	O	East	B01-O-HIGH	42	Yes	38	Yes
46	36	B02	A	West	B02-A-LOW	46	Yes	42	Yes
47	48	B02	A	West	B02-A-MID	46	Yes	42	Yes
48	60	B02	A	West	B02-A-HIGH	46	Yes	42	Yes
49	36	B02	B	East	B02-B-LOW	47	Yes	44	Yes
50	48	B02	B	East	B02-B-MID	46	Yes	43	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
51	60	B02	B	East	B02-B-HIGH	45	Yes	42	Yes
52	36	B02	C	North	B02-C-LOW	48	Yes	45	Yes
53	48	B02	C	North	B02-C-MID	47	Yes	44	Yes
54	60	B02	C	North	B02-C-HIGH	47	Yes	43	Yes
55	36	B02	D	West	B02-D-LOW	49	Yes	45	Yes
56	48	B02	D	West	B02-D-MID	48	Yes	44	Yes
57	60	B02	D	West	B02-D-HIGH	48	Yes	44	Yes
58	36	B02	E	South	B02-E-LOW	30	Yes	27	Yes
59	48	B02	E	South	B02-E-MID	35	Yes	31	Yes
60	60	B02	E	South	B02-E-HIGH	41	Yes	38	Yes
61	36	B02	F	East	B02-F-LOW	29	Yes	25	Yes
62	48	B02	F	East	B02-F-MID	32	Yes	28	Yes
63	60	B02	F	East	B02-F-HIGH	36	Yes	32	Yes
64	34	B03	A	East	B03-A-LOW	28	Yes	24	Yes
65	41	B03	A	East	B03-A-MID	28	Yes	24	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
66	47	B03	A	East	B03-A-HIGH	32	Yes	28	Yes
67	34	B03	B	North	B03-B-LOW	45	Yes	41	Yes
68	41	B03	B	North	B03-B-MID	47	Yes	43	Yes
69	47	B03	B	North	B03-B-HIGH	47	Yes	43	Yes
70	34	B03	C	East	B03-C-LOW	27	Yes	23	Yes
71	41	B03	C	East	B03-C-MID	27	Yes	23	Yes
72	47	B03	C	East	B03-C-HIGH	31	Yes	28	Yes
73	34	B03	D	North	B03-D-LOW	36	Yes	32	Yes
74	41	B03	D	North	B03-D-MID	42	Yes	39	Yes
75	47	B03	D	North	B03-D-HIGH	43	Yes	39	Yes
76	34	B03	E	East	B03-E-LOW	27	Yes	23	Yes
77	41	B03	E	East	B03-E-MID	27	Yes	23	Yes
78	47	B03	E	East	B03-E-HIGH	31	Yes	27	Yes
79	34	B03	F	North	B03-F-LOW	26	Yes	23	Yes
80	41	B03	F	North	B03-F-MID	27	Yes	23	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
81	47	B03	F	North	B03-F-HIGH	31	Yes	27	Yes
82	34	B03	G	West	B03-G-LOW	39	Yes	35	Yes
83	41	B03	G	West	B03-G-MID	43	Yes	39	Yes
84	47	B03	G	West	B03-G-HIGH	47	Yes	43	Yes
85	34	B03	H	East	B03-H-LOW	31	Yes	27	Yes
86	41	B03	H	East	B03-H-MID	34	Yes	30	Yes
87	47	B03	H	East	B03-H-HIGH	35	Yes	31	Yes
88	34	B03	I	North	B03-I-LOW	26	Yes	23	Yes
89	41	B03	I	North	B03-I-MID	27	Yes	23	Yes
90	47	B03	I	North	B03-I-HIGH	30	Yes	26	Yes
91	34	B03	J	West	B03-J-LOW	34	Yes	29	Yes
92	41	B03	J	West	B03-J-MID	37	Yes	32	Yes
93	47	B03	J	West	B03-J-HIGH	39	Yes	34	Yes
94	34	B03	K	North	B03-K-LOW	25	Yes	22	Yes
95	41	B03	K	North	B03-K-MID	27	Yes	23	Yes
96	47	B03	K	North	B03-K-HIGH	30	Yes	26	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
97	34	B03	L	East	B03-L-LOW	33	Yes	29	Yes
98	41	B03	L	East	B03-L-MID	36	Yes	32	Yes
99	47	B03	L	East	B03-L-HIGH	38	Yes	34	Yes
100	34	B03	M	South	B03-M-LOW	34	Yes	30	Yes
101	41	B03	M	South	B03-M-MID	34	Yes	31	Yes
102	47	B03	M	South	B03-M-HIGH	35	Yes	31	Yes
103	34	B03	N	East	B03-N-LOW	39	Yes	35	Yes
104	41	B03	N	East	B03-N-MID	38	Yes	35	Yes
105	47	B03	N	East	B03-N-HIGH	39	Yes	35	Yes
106	34	B03	O	West	B03-O-LOW	38	Yes	35	Yes
107	41	B03	O	West	B03-O-MID	46	Yes	43	Yes
108	47	B03	O	West	B03-O-HIGH	48	Yes	44	Yes
109	34	B03	P	South	B03-P-LOW	34	Yes	31	Yes
110	41	B03	P	South	B03-P-MID	42	Yes	38	Yes
111	47	B03	P	South	B03-P-HIGH	42	Yes	38	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
112	34	B03	Q	East	B03-Q-LOW	32	Yes	28	Yes
113	41	B03	Q	East	B03-Q-MID	34	Yes	30	Yes
114	47	B03	Q	East	B03-Q-HIGH	35	Yes	31	Yes
115	34	B03	R	South	B03-R-LOW	48	Yes	44	Yes
116	41	B03	R	South	B03-R-MID	49	Yes	45	Yes
117	47	B03	R	South	B03-R-HIGH	48	Yes	45	Yes
118	34	B03	S	East	B03-S-LOW	44	Yes	40	Yes
119	41	B03	S	East	B03-S-MID	44	Yes	40	Yes
120	47	B03	S	East	B03-S-HIGH	44	Yes	41	Yes
121	38	B04	A	East	B04-A-LOW	27	Yes	23	Yes
122	64	B04	A	East	B04-A-MID	32	Yes	28	Yes
123	91	B04	A	East	B04-A-HIGH	37	Yes	33	Yes
124	38	B04	B	North	B04-B-LOW	46	Yes	43	Yes
125	64	B04	B	North	B04-B-MID	47	Yes	43	Yes
126	91	B04	B	North	B04-B-HIGH	48	Yes	44	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
127	38	B04	C	East	B04-C-HIGH	48	Yes	44	Yes
128	38	B04	D	North	B04-C-MID	33	Yes	29	Yes
129	64	B04	C	East	B04-C-LOW	31	Yes	27	Yes
130	91	B04	C	East	B04-C-HIGH	38	Yes	34	Yes
131	91	B04	D	North	B04-C-LOW	40	Yes	36	Yes
132	64	B04	D	North	B04-D-MID	46	Yes	42	Yes
133	38	B04	E	East	B04-E-LOW	29	Yes	25	Yes
134	64	B04	E	East	B04-E-MID	31	Yes	27	Yes
135	91	B04	E	East	B04-E-HIGH	39	Yes	35	Yes
136	38	B04	F	North	B04-F-LOW	26	Yes	22	Yes
137	64	B04	F	North	B04-F-MID	34	Yes	29	Yes
138	91	B04	F	North	B04-F-HIGH	43	Yes	39	Yes
139	38	B04	G	West	B04-G-LOW	36	Yes	32	Yes
140	64	B04	G	West	B04-G-MID	44	Yes	40	Yes
141	91	B04	G	West	B04-G-HIGH	47	Yes	42	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
142	38	B04	H	North	B04-H-LOW	29	Yes	25	Yes
143	64	B04	H	North	B04-H-MID	34	Yes	30	Yes
144	91	B04	H	North	B04-H-HIGH	43	Yes	39	Yes
145	38	B04	I	West	B04-I-LOW	31	Yes	27	Yes
146	64	B04	I	West	B04-I-MID	42	Yes	37	Yes
147	91	B04	I	West	B04-I-HIGH	45	Yes	41	Yes
148	38	B04	J	West	B04-J-LOW	47	Yes	43	Yes
149	64	B04	J	West	B04-J-MID	46	Yes	43	Yes
150	91	B04	J	West	B04-J-HIGH	45	Yes	42	Yes
151	38	B04	K	South	B04-K-LOW	29	Yes	25	Yes
152	64	B04	K	South	B04-K-MID	37	Yes	34	Yes
153	91	B04	K	South	B04-K-HIGH	37	Yes	34	Yes
154	38	B04	L	East	B04-L-LOW	27	Yes	23	Yes
155	64	B04	L	East	B04-L-MID	31	Yes	28	Yes
156	91	B04	L	East	B04-L-HIGH	36	Yes	32	Yes
157	38	B04	M	South	B04-M-LOW	44	Yes	40	Yes
158	64	B04	M	South	B04-M-MID	44	Yes	40	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
159	91	B04	M	South	B04-M-HIGH	43	Yes	40	Yes
160	38	B04	N	East	B04-N-LOW	27	Yes	23	Yes
161	64	B04	N	East	B04-N-MID	31	Yes	28	Yes
162	91	B04	N	East	B04-N-HIGH	36	Yes	33	Yes
163	38	B04	O	South	B04-O-LOW	49	Yes	45	Yes
164	64	B04	O	South	B04-O-MID	48	Yes	44	Yes
165	91	B04	O	South	B04-O-HIGH	46	Yes	43	Yes
166	38	B04	P	East	B04-P-LOW	38	Yes	34	Yes
167	64	B04	P	East	B04-P-MID	39	Yes	36	Yes
168	91	B04	P	East	B04-P-HIGH	39	Yes	36	Yes
169	36	B05	A	East	B05-A-LOW	40	Yes	36	Yes
170	60	B05	A	East	B05-A-MID	40	Yes	36	Yes
171	85	B05	A	East	B05-A-HIGH	40	Yes	37	Yes
172	36	B05	B	North	B05-B-LOW	50	Yes	46	No
173	60	B05	B	North	B05-B-MID	49	Yes	45	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
174	85	B05	B	North	B05-B-HIGH	48	Yes	44	Yes
175	36	B05	C	East	B05-C-LOW	30	Yes	27	Yes
176	60	B05	C	East	B05-C-MID	32	Yes	28	Yes
177	85	B05	C	East	B05-C-HIGH	34	Yes	31	Yes
178	36	B05	D	North	B05-D-LOW	46	Yes	43	Yes
179	60	B05	D	North	B05-D-MID	46	Yes	43	Yes
180	85	B05	D	North	B05-D-HIGH	46	Yes	42	Yes
181	36	B05	E	East	B05-E-LOW	30	Yes	26	Yes
182	60	B05	E	East	B05-E-MID	33	Yes	29	Yes
183	85	B05	E	East	B05-E-HIGH	36	Yes	32	Yes
184	36	B05	F	North	B05-F-LOW	44	Yes	41	Yes
185	60	B05	F	North	B05-F-MID	47	Yes	43	Yes
186	85	B05	F	North	B05-F-HIGH	47	Yes	43	Yes
187	36	B05	G	South	B05-G-LOW	49	Yes	45	Yes
188	60	B05	G	South	B05-G-MID	50	Yes	47	No

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
189	85	B05	G	South	B05-G-HIGH	49	Yes	46	No
190	36	B05	H	West	B05-H-LOW	52	Yes	48	No
191	60	B05	H	West	B05-H-MID	51	Yes	47	No
192	85	B05	H	West	B05-H-HIGH	49	Yes	46	No
193	36	B05	I	South	B05-I-LOW	50	Yes	46	No
194	60	B05	I	South	B05-I-MID	49	Yes	46	No
195	85	B05	I	South	B05-I-HIGH	48	Yes	45	Yes
196	36	B05	J	East	B05-J-LOW	46	Yes	42	Yes
197	60	B05	J	East	B05-J-MID	45	Yes	42	Yes
198	85	B05	J	East	B05-J-HIGH	45	Yes	42	Yes
199	36	B05	K	South	B05-K-LOW	51	Yes	47	No
200	60	B05	K	South	B05-K-MID	50	Yes	46	No
201	85	B05	K	South	B05-K-HIGH	49	Yes	45	No
202	36	B05	L	East	B05-L-LOW	46	Yes	43	Yes
203	60	B05	L	East	B05-L-MID	46	Yes	43	Yes
204	85	B05	L	East	B05-L-HIGH	46	Yes	42	Yes
205	42	B06	A	South	B06-A-LOW	30	Yes	26	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
206	49	B06	A	South	B06-A-MID	33	Yes	30	Yes
207	56	B06	A	South	B06-A-HIGH	37	Yes	33	Yes
208	42	B06	B	West	B06-B-LOW	45	Yes	41	Yes
209	49	B06	B	West	B06-B-MID	46	Yes	42	Yes
210	56	B06	B	West	B06-B-HIGH	46	Yes	43	Yes
211	42	B06	C	North	B06-C-LOW	44	Yes	40	Yes
212	49	B06	C	North	B06-C-MID	44	Yes	41	Yes
213	56	B06	C	North	B06-C-HIGH	45	Yes	41	Yes
214	42	B06	D	East	B06-D-LOW	40	Yes	36	Yes
215	49	B06	D	East	B06-D-MID	43	Yes	39	Yes
216	56	B06	D	East	B06-D-HIGH	43	Yes	40	Yes
217	42	B06	E	South	B06-E-LOW	43	Yes	39	Yes
218	49	B06	E	South	B06-E-MID	45	Yes	42	Yes
219	56	B06	E	South	B06-E-HIGH	46	Yes	42	Yes
220	42	B06	F	West	B06-F-LOW	46	Yes	43	Yes

ID	Receiver	Building	Facade	Facade	SP ID	Predicted Internal Noise Levels (dBA)			
221	49	B06	F	West	B06-F-MID	48	Yes	45	Yes
222	56	B06	F	West	B06-F-HIGH	49	Yes	45	Yes