WATERLOO METRO QUARTER OVER STATION DEVELOPMENT

Environmental Impact Statement
Appendix K – Noise and Vibration Impact Assessment

SSD-10438 Basement Car Park

Detailed State Significant Development
Development Application

Prepared for **Waterloo Developer Pty Ltd**

30 September 2020

Reference	Description
Applicable SSD Applications	SSD-10438 Basement Carpark
Author	Stantec (Australia) Pty Ltd Brandon Notaras
Reviewed	Waterloo Developer Pty Ltd Patrick Garland Perry Milledge Matt Rawlinson
Document Number	WMQ-BMNT-WGE-AC-RPT-SSD DA-Detailed DA
Status	For Approval
Version	3
Date of Issue	30 July 2020

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1. Glossary and abbreviations

Reference	Description
ACHAR	Aboriginal Cultural Heritage Assessment Report
ADG	Apartment Design Guide
AHD	Australian height datum
AQIA	Air Quality Impact Assessment
BC Act	Biodiversity Conservation Act 2016
BCA	Building Code of Australia
BC Reg	Biodiversity Conservation Regulation 2017
BDAR	Biodiversity Development Assessment Report
CEEC	critically endangered ecological community
CIV	capital investment value
CMP	Construction Management Plan
Concept DA	A concept DA is a staged application often referred to as a 'Stage 1' DA. The subject application constitutes a detailed subsequent stage application to an approved concept DA (SSD 9393) lodged under section 4.22 of the EP&A Act.
Council	City of Sydney Council
CPTED	Crime Prevention Through Environmental Design
CSSI approval	critical State significant infrastructure approval
CTMP	Construction Traffic Management Plan
DA	development application
DPIE	NSW Department of Planning, Industry and Environment
DRP	Design Review Panel
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPA Regulation	Environmental Planning and Assessment Regulation 2000
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	ecologically sustainable design

Reference	Description
GANSW	NSW Government Architect's Office
GFA	gross floor area
HIA	Heritage Impact Assessment
IAP	Interchange Access Plan
LGA	Local Government Area
NCC	National Construction Code
OSD	over station development
PIR	Preferred Infrastructure Report
POM	Plan of Management
PSI	Preliminary Site Investigation
RMS	Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEPP 55	State Environmental Planning Policy No 55—Remediation of Land
SEPP 65	State Environmental Planning Policy No. 65 – Design Quality of Residential Apartment Development
SRD SEPP	State Environmental Planning Policy (State and Regional Development) 2009
SREP Sydney Harbour	State Regional Environmental Plan (Sydney Harbour Catchment) 2005
SSD	State significant development
SSD DA	State significant development application
SLEP	Sydney Local Environmental Plan 2012
Transport for NSW	Transport for New South Wales
TIA	Traffic Impact Assessment
The proposal	The proposed development which is the subject of the detailed SSD DA
The site	The site which is the subject of the detailed SSD DA
VIA	Visual Impact Assessment

Reference	Description
WMQ	Waterloo Metro Quarter
WMP	Waste Management Plan
WSUD	water sensitive urban design

2. Executive summary

This noise and vibration report has been prepared by Stantec (Australia) Pty Ltd to accompany a detailed State significant development (SSD) development application (DA) for the Basement Car Park over station development (OSD) at the Waterloo Metro Quarter site.

This report has been prepared to address the relevant conditions of the concept SSD DA (SSD 9393) and the Secretary's Environmental Assessment Requirements (SEARs) issued for the detailed SSD DA (SSD 10438).

This report concludes that the proposed Basement Car Park OSD is suitable and warrants approval subject to the implementation of the following mitigation measures.

- Noise and vibration monitoring at surrounding noise and vibration sensitive receivers
- 2.4m high hoarding (Class A or Class B hoarding) to be erected from the commencement of works on site

Following the implementation of the above mitigation measures, the remaining impacts are appropriate.

3. Introduction

This report has been prepared to accompany a detailed State significant development (SSD) development application (DA) for the Basement Car Park over station development (OSD) at the Waterloo Metro Quarter site. The detailed SSD DA is consistent with the concept approval (SSD 9393) granted for the maximum building envelope on the site, as proposed to be modified.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning, Industry and Environment (DPIE) for assessment.

The detailed SSD DA seeks development consent for the design, construction and operation of:

- 2-storey shared basement car park and associated excavation
- Ground level structure
- carparking for the commercial Building 1, residential Building 2, social housing Building 4, Waterloo Congregational Church and Sydney Metro
- service vehicle spaces
- commercial end-of-trip and bicycle storage facilities
- retail end-of-trip and bicycle storage facilities
- residential storage facilities
- shared plant and services.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 9 April 2020 and issued for the detailed SSD DA. Specifically, this report has been prepared to respond to the SEARs requirements summarised below.

Item	Description of requirement	Section reference (this report)
10	Noise and Vibration Impacts (Construction). An assessment of construction noise and vibration impacts. The assessment must also outline proposed noise and vibration mitigation and monitoring procedures having particular regard for potential impacts to the adjoining heritage listed 'Waterloo Congregational Church' site.	11 and 12
General	Noise and Vibration Impact Assessment	10 and 11

Table 1 - SEARs requirements

This report has also been prepared in response to the following conditions of consent issued for the concept SSD DA (SSD 9393) for the OSD as summarised in the table below.

Item	Description of requirement	Section reference (this report)
B21(c)	Future development applications shall provide analysis and assessment of the impacts of construction works and include:	11.1 and 11.4

Item	Description of requirement	Section reference (this report)
	Noise and Vibration Impact Assessment	
B23	Future development applications shall be accompanied by a Noise and Vibration Impact Assessment that demonstrates the following requirements are met: (a) vibration from construction activities does not exceed the vibration limits established in British Standard BS7385-2:1993 Excavation and measurement for vibration in buildings. A guide to damage levels from ground borne vibration.	11.1 and 11.4
	(b) vibration testing is conducted before and during vibration generating activities that have the potential to impact on heritage items to identify minimum working distances to prevent damage. in the event the vibration testing and monitoring shows that the preferred values for vibration are likely to be exceeded, the Applicant must review the construction methodology and, if necessary, propose additional mitigation measures.	-
	(c) advice of a heritage Specialist has been incorporated on methods and locations for installed equipment used for vibration movement and noise monitoring of heritage-listed structures.	-
B24	The Noise and Vibration Assessment must provide a quantitative assessment of the main noise generating sources and activities during operation. Details are to be included outlining any mitigating measures necessary to ensure the amenity of future sensitive land uses on the site and neighbouring sites is protected during the operation of the development	10
B25	The Noise and Vibration must address the conclusions and recommendations of the Concept Acoustic Assessment Report, SLR Consulting dated 9 November 2019.	13

Table 2 - Conditions of Concept Approval

To show compliance with this SEARs requirement Table 3 outlines the appropriate mitigation measures outlined by SLR Consulting and the corresponding section within this report where the mitigation has been considered.

Section/Assessment	Measure	Section in SLR Report	Section in this report
Construction Noise – 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:	5.2.1	11.1.1 and 11.3.1

	• 7.00 am to 6.00 pm Monday to Friday • 7.00 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.		
Construction Noise	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.	5.2.8	12.1
Construction Vibration Impacts	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)	5.2.10	11.4
In-Principle Acoustic Treatment to Mechanical Equipment & Plant	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.	5.3.1.1	Not applicable to this SSD DA

Internal Road Traffic Noise Levels	Assumption of 15dB façade loss to determine internal noise levels from traffic noise levels and acoustic absorption to underside of balcony 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	5.4.2.1	Not applicable to this SSD DA
Sydney Metro Vibration Impacts	Vibration and ground-borne noise impacts from trains can be controlled at source through the use of trackforms which incorporate vibration-isolating components. 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.	5.5.2	10.2
Industrial Noise	It is anticipated that compliance with the final project trigger levels from cumulative industrial noise impacts will be achievable with standard noise mitigation measures.	5.6.2	Not applicable to this SSD DA

Table 3 – Stage 1 Mitigation Measures Compliance (by SLR Consulting)

Given there have been some changes to the design of the building form and envelope from the Concept SSD DA, and technical information regarding the trackform design has now been made available, some of the mitigation measures outlined by SLR Consulting may no longer be relevant to this project.

4. The site

The site is located within the City of Sydney Local Government Area (LGA). The site is situated about 3.3 kilometres south of Sydney CBD and eight kilometres northeast of Sydney International Airport within the suburb of Waterloo.

The Waterloo Metro Quarter site comprises land to the west of Cope Street, east of Botany Road, south of Raglan Street and north of Wellington Street (refer to Figure 1). The heritage-listed Waterloo Congregational Church at 103–105 Botany Road is within this street block but does not form a part of the Waterloo Metro Quarter site boundaries.

The Waterloo Metro Quarter site is a rectangular shaped allotment with an overall site area of approximately 1.287 hectares.

The Waterloo Metro Quarter site comprises the following allotments and legal description at the date of this report. Following consolidation by Sydney Metro (the Principal) the land will be set out in deposited plan DP1257150.

- 1368 Raglan Street (Lot 4 DP 215751)
- 59 Botany Road (Lot 5 DP 215751)
- 65 Botany Road (Lot 1 DP 814205)
- 67 Botany Road (Lot 1 DP 228641)
- 124-128 Cope Street (Lot 2 DP 228641)
- 69-83 Botany Road (Lot 1, DP 1084919)
- 130-134 Cope Street (Lot 12 DP 399757)
- 136-144 Cope Street (Lots A-E DP 108312)
- 85 Botany Road (Lot 1 DP 27454)
- 87 Botany Road (Lot 2 DP 27454)
- 89-91 Botany Road (Lot 1 DP 996765)
- 93-101 Botany Road (Lot 1 DP 433969 and Lot 1 DP 738891)
- 119 Botany Road (Lot 1 DP 205942 and Lot 1 DP 436831)
- 156-160 Cope Street (Lot 31 DP 805384)
- 107-117A Botany Road (Lot 32 DP 805384 and Lot A DP 408116)
- 170-174 Cope Street (Lot 2 DP 205942).

The detailed SSD DA applies to the Basement Car Park (the site) of the Waterloo Metro Quarter site. The site has an area of approximately 5,700sqm. The subject site comprises the following allotments and legal description at the date of this report.

- 1368 Raglan Street (Lot 4 DP 215751) (Part)
- 59 Botany Road (Lot 5 DP 215751) (Part)
- 65 Botany Road (Lot 1 DP 814205) (Part)
- 67 Botany Road (Lot 1 DP 228641) (Part)
- 124–128 Cope Street (Lot 2 DP 228641) (Part)
- 69–83 Botany Road (Lot 1, DP 1084919)

- 130–134 Cope Street (Lot 12 DP 399757) (Part)
- 136–144 Cope Street (Lots A-E DP 108312) (Part)
- 85 Botany Road (Lot 1 DP 27454)
- 87 Botany Road (Lot 2 DP 27454)
- 89–91 Botany Road (Lot 1 DP 996765)
- 93–101 Botany Road (Lot 1 DP 433969 and Lot 1 DP 738891) (Part).

The boundaries of the overall site are identified at Figure 1, and the subject site of the detailed SSD DA is identified at Figures 2 and 3. The site is reasonably flat with a slight fall to the south.

The site previously included three to five storey commercial, light industrial and shop top housing buildings. All previous structures except for an office building at the corner of Botany Road and Wellington Street have been demolished to facilitate construction of the new Sydney Metro Waterloo station. As such the existing site is predominately vacant and being used as a construction site. Construction of the Sydney metro is currently underway on site in accordance with critical State significant infrastructure approval (CSSI 7400).

Figure 1 - Aerial image of the site
Source: Urbis

The area surrounding the site consists of commercial premises to the north, light industrial and mixed-use development to the south, residential development to the east and predominantly commercial and light industry uses to the west.

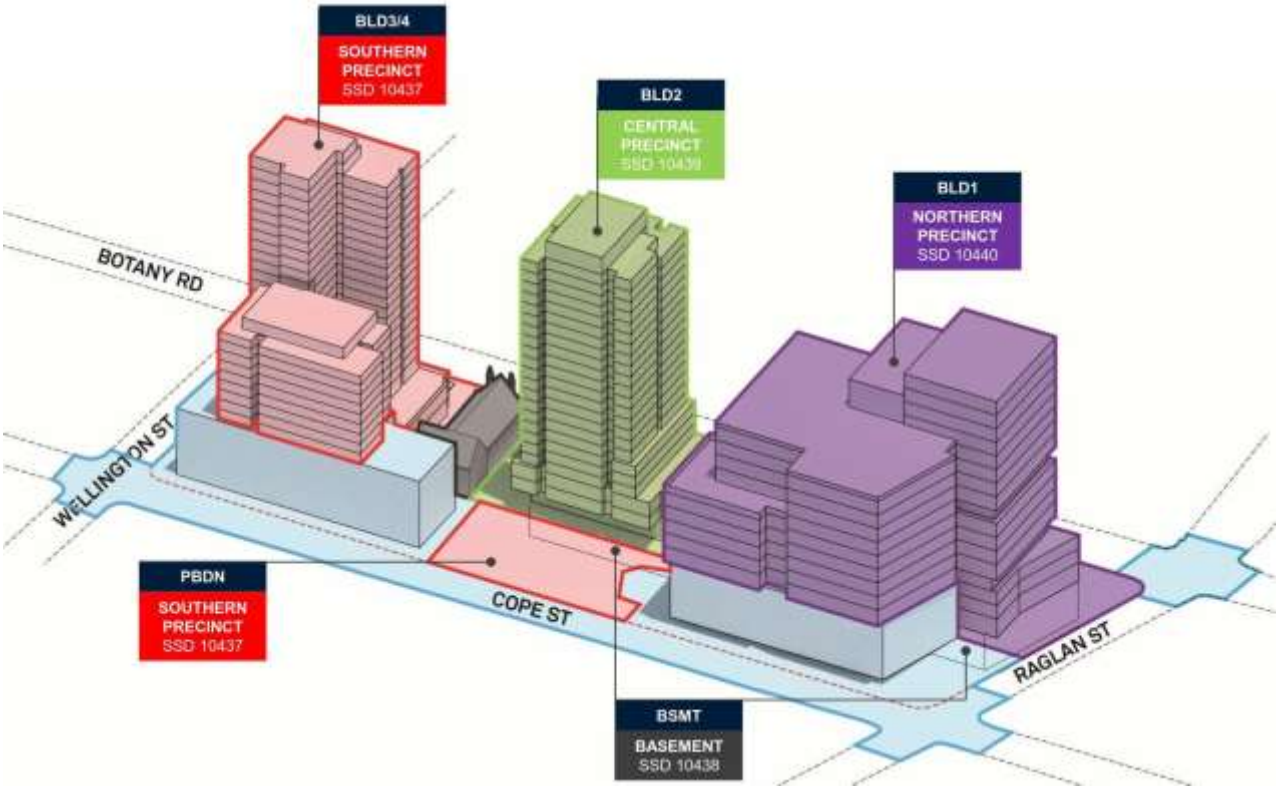


Figure 2 - Waterloo Metro Quarter site, with sub-precincts identified
Source: HASSELL

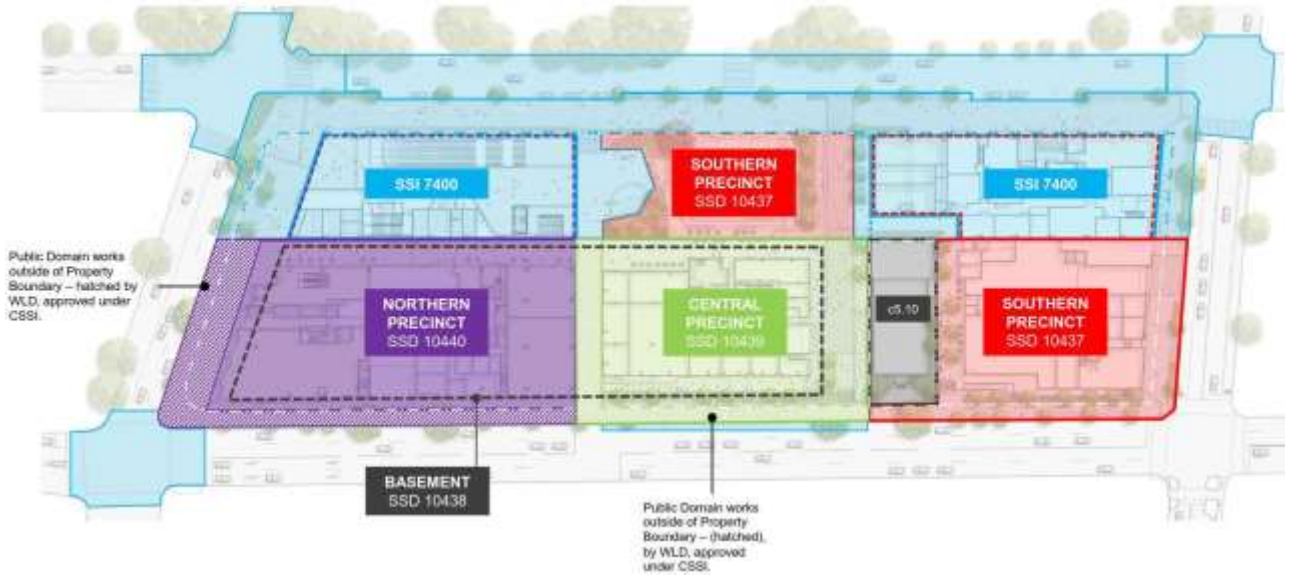


Figure 3 - Waterloo Metro Quarter site, with sub-precincts identified
Source: Waterloo Developer Pty Ltd

5. Background

5.1 About Sydney Metro

Sydney Metro is Australia's biggest public transport project. Services started in May 2019 in the city's North West with a train every four minutes in the peak. A new standalone railway, this 21st century network will revolutionise the way Sydney travels.

There are four core components:

5.1.1 Sydney Metro North West

This project is now complete and passenger services commenced in May 2019 between Rouse Hill and Chatswood, with a metro train every four minutes in the peak. The project was delivered on time and $1 billion under budget.

5.1.2 Sydney Metro City & Southwest

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

Sydney Metro City & Southwest will deliver new metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and new underground metro platforms at Central Station. In addition, it will upgrade and convert all 11 stations between Sydenham and Bankstown to metro standards.

5.1.3 Sydney Metro West

Sydney Metro West is a new underground railway connecting Greater Parramatta and the Sydney CBD. This once-in-a-century infrastructure investment will transform Sydney for generations to come, doubling rail capacity between these two areas, linking new communities to rail services and supporting employment growth and housing supply between the two CBDs.

The locations of seven proposed metro stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays.

The NSW Government is assessing an optional station at Pyrmont and further planning is underway to determine the location of a new metro station in the Sydney CBD.

5.1.4 Sydney Metro Greater West

Metro rail will also service Greater Western Sydney and the new Western Sydney International (Nancy Bird Walton) Airport. The new railway line will become the transport spine for the Western Parkland City's growth for generations to come, connecting communities and travellers with the rest of Sydney's public transport system with a fast, safe and easy metro service.

The Australian and NSW governments are equal partners in the delivery of this new railway.

The Sydney Metro project is illustrated below.

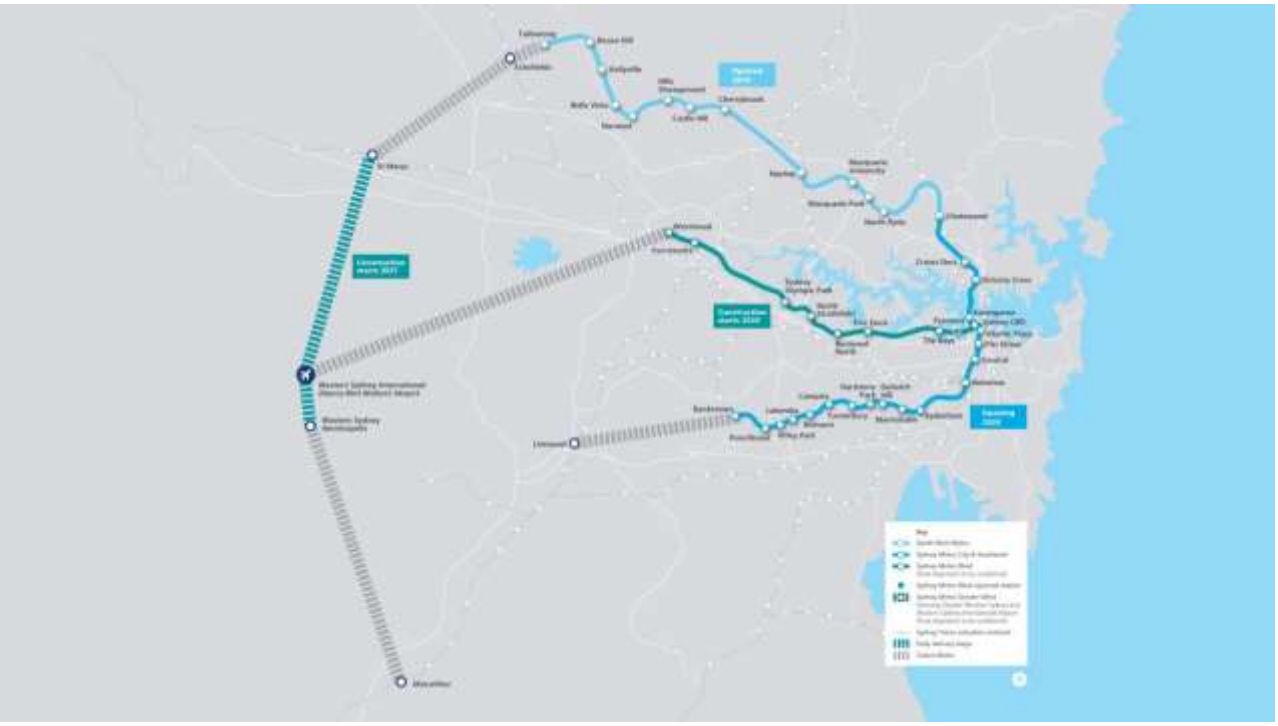


Figure 4 - Sydney Metro alignment map
Source: Sydney Metro

5.2 Sydney Metro CSSI Approval (SSI 7400)

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham project as a critical State significant infrastructure (CSSI) project (reference SSI 7400) (CSSI approval). The terms of the CSSI approval includes all works required to construct the Sydney Metro Waterloo Station. The CSSI approval also includes the construction of below and above ground works within the metro station structure for appropriate integration with the OSD.

With regards to CSSI related works, any changes to the 'metro station box' envelope and public domain will be pursued in satisfaction of the CSSI conditions of approval and do not form part of the scope of the concept SSD DA or detailed SSD DA for the OSD.

Except to the extent described in the EIS or Preferred Infrastructure Report (PIR) submitted with the CSSI application, any OSD buildings and uses do not form part of the CSSI approval and will be subject to the relevant assessment pathway prescribed by the EP&A Act.

The delineation between the approved Sydney Metro works, generally described as within the two 'metro station boxes' and surrounding public domain works, and the OSD elements are illustrated in Figure 5.

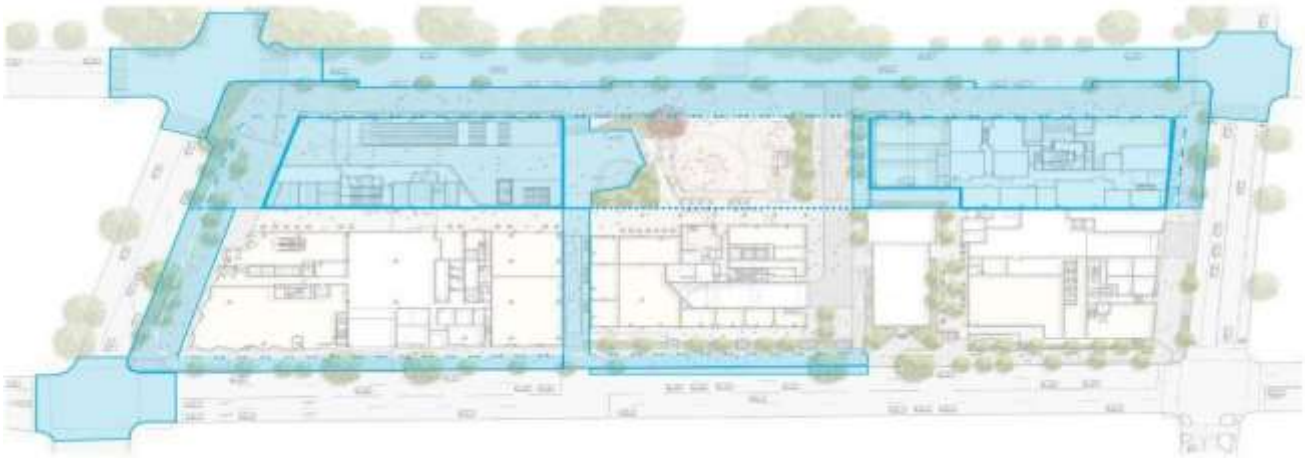


Figure 5 - CSSI Approval scope of works
Source: WL Developer Pty Ltd

5.3 Concept Approval (SSD 9393)

As per the requirements of clause 7.20 of the *Sydney Local Environmental Plan 2012* (SLEP), as the OSD exceeds a height of 25 metres above ground level (among other triggers), development consent is first required to be issued in a concept DA (formerly known as Stage 1 DA).

Development consent was granted on 10 December 2019 for the concept SSD DA (SSD 9393) for the Waterloo Metro Quarter OSD including:

- a maximum building envelope for podium, mid-rise and tower buildings
- a maximum gross floor area of 68,750sqm, excluding station floor space
- conceptual land use for non-residential and residential floor space
- minimum 12,000sqm of non-residential gross floor area including a minimum of 2,000sqm of community facilities
- minimum 5% residential gross floor area as affordable housing dwellings
- 70 social housing dwellings
- basement car parking, motorcycle parking, bicycle parking, and service vehicle spaces.

The detailed SSD DA seeks development consent for the OSD located within the Basement Car Park of the site, consistent with the parameters of this concept approval. Separate SSD DAs have been prepared and will be submitted for the Southern Precinct Central Precinct and Northern Precinct proposed across the Waterloo Metro Quarter site.

A concurrent amending concept SSD DA has been prepared and submitted to the DPIE which proposed to make modifications to the approved building envelopes at the northern precinct and central building. This amending concept SSD DA does not impact the proposed development within the southern precinct.

6. Proposed development

6.1 Waterloo Metro Quarter Development

The Waterloo Metro Quarter OSD comprises four separate buildings, a basement carpark and public domain works adjacent to the Waterloo Metro station.

Separate SSD DAs will be submitted concurrently for the design, construction and operation of each building in the precinct;

- Southern precinct SSD-10437,
- Basement Car Park SSD-10438,
- Central precinct SSD-10439, and
- Northern precinct-SSD-10440.

An overview of the Development is included below for context. This detailed SSD DA seeks development consent for the design, construction and operation of the Basement Car Park:

6.1.1 Southern Precinct

The Southern Precinct comprises:

- 25-storey residential building (Building 3) comprising student accommodation, to be delivered as a mixture of studio and twin apartments with approximate capacity of 474 students
- 9 storey residential building (Building 4) above the southern station box to accommodate 70 social housing dwellings
- ground level retail tenancies including Makerspace and gymnasium lobby, and loading facilities
- level 1 and level 2 gymnasium and student accommodation communal facilities
- landscaping and private and communal open space at podium and roof top levels to support the residential accommodation
- new public open space including the delivery of the Cope Street Plaza, including vehicle access to the site via a shared way from Cope Street, expanded footpaths on Botany and Wellington Streets and public domain upgrades
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

6.1.2 Basement Car Park

The Basement Car Park comprises:

- 2-storey shared basement car park and associated excavation comprising
- Ground level structure
- Carparking for the Commercial Building 1, Residential Building 2, social housing Building 4, Waterloo Congregational Church and Sydney Metro
- Service vehicle bays
- commercial end of trip and bicycle storage facilities

- Retail end of trip and bicycle storage facilities
- residential storage facilities
- shared plant and services.

6.1.3 Central Precinct

The Central Precinct comprises:

- 24-storey residential building (Building 2) comprising approximately 126 market residential and 24 affordable housing apartments, to be delivered as a mixture of 1 bedroom, 2 bedroom and 3 bedroom apartments
- Ground level retail tenancies, community hub, precinct retail amenities and basement car park entry
- level 1 and level 2 community facilities (as defined in the SLEP) intended to be operated as a childcare centre
- landscaping and private and communal open space at roof top levels to support the residential accommodation
- new public open space including the delivery of the Church Square, including vehicle access to the basement via a shared way from Cope Street, expanded footpaths and public domain upgrades on Botany Road
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

6.1.4 Northern Precinct

The Northern Precinct comprises:

- 17-storey commercial building (Building 1) comprising Commercial floor space, with an approximate capacity of 4000 workers
- ground level retail tenancies, loading dock facilities serving the northern and central precinct including Waterloo metro station
- landscaping and private open space at podium and roof top levels to support the commercial tenants
- new public open space including the delivery of the Raglan Street Plaza, Raglan Walk and expanded footpaths on Raglan Street and Botany Road and public domain upgrades
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

7. Methodology

To assess the noise and vibration impacts of the proposed development (Basement Car Park), the following process was carried out:

- Identify and classify the surrounding noise and vibration sensitive receivers surrounding the proposed development;
- Identify and classify the noise and vibration sources generated by the proposed development, together with external noise and vibration sources impacting on the proposed development;
- Review historical site noise investigations and carry out additional site noise investigations to quantify the background noise levels local to the proposed development;
- Determine the project noise and vibration criteria applicable to the proposed development in accordance with the requirements listed in the Secretary's Environmental Assessment Requirements (SEARs), together with the requirements in Appendix B8 of the Station Delivery Deed Schedule C1. This includes criteria for the assessment of operational noise and vibration, as well as construction noise and vibration;
- Assess the operational and construction noise and vibration impacts of the noise and vibration sources generated by the proposed development to the surrounding noise-sensitive receivers, together with any impacts on the occupants of the proposed development; and
- Provide details of mitigation measures required to alleviate noise and vibration impacts to achieve the project noise and vibration criteria.

The following operational noise and vibration assessments were conducted as part of this noise and vibration impact assessment:

- Vibration impact of the Sydney Metro rail corridor on the structure of the proposed development; and
- Noise impacts of additional traffic on surrounding local roads generated by the proposed development.

The following construction noise and vibration assessments were conducted as part of this noise and vibration impact assessment:

- Noise generated during the construction of the proposed development and associated impacts on the surrounding noise sensitive receivers; and
- Vibration generated during the construction of the proposed development and associated impacts on the surrounding vibration sensitive receivers.

The noise and vibration assessments conducted as part of this report have been assessed to the noise and vibration criteria established by NSW Environment Protection Authority (EPA) and Transport for NSW (TfNSW) outlined in Appendix B8 of the Station Delivery Deed Schedule C1.

In addition to this, the noise and vibration assessments have been conducted considering the cumulative effects of the other precincts within the Waterloo Metro Quarter Development, these being:

- Northern Precinct
- Central Precinct
- Southern Precinct
- Waterloo Integrated Station Development (ISD)
- Line-wide (trackform design)

These values have been summarised in Section 11.1 of this report.

Many of the noise and vibration sources within the OSD are shared amongst a common basement, and the equipment generating the noise and/or vibration serves many of the precincts under separate SSD DA's. The sources of noise and vibration within the OSD that have been assessed for the Basement Car Park in this SSD DA are:

- Increase in noise emissions of local roads due to traffic generated by the proposed development
- Impacts of the new Metro line and station on the basement structure
- Excavation and construction of the basement to the Ground Floor slab

8. Site Noise Investigations

Site noise investigations were conducted to obtain background noise levels at the surrounding noise sensitive receivers together with characteristic noise emissions statistics associated with vehicle movements along Botany Road.

The results of the site noise investigations were acquired from a combination of noise monitoring conducted by Stantec Australia between the 7th and 13th April 2020, and previous noise monitoring conducted by SLR Consulting and presented in their report for the Waterloo Station Development EIS (Appendix N) dated 9 November 2019 accompanying the Concept SSD DA (SSD 9393), as these results were obtained prior to the COVID-19 pandemic and are a better representation of the traffic noise and typical background levels under typical conditions.

8.1 Historical Site Noise Investigations

Forming part of the Concept SSD DA (SSD 9393), both attended and unattended site investigations were conducted by SLR Consulting in November 2019, presented in their report for the Waterloo Station Development EIS (Appendix N) dated 9 November 2019. The results of these measurements are summarised below. As discussed above, the site investigations previously conducted by SLR Consulting are important because the results of the monitoring were obtained prior to the COVID-19 pandemic. The results of the monitoring conducted will be more relevant to typical background noise and traffic noise characteristic of the area.

8.1.1 Instrumentation

It is noted in the SLR Consulting Report that the following equipment was used for the noise surveys:

- Combination of Svantek 957 and Bruel and Kjaer 2250L noise loggers with serial numbers:

  S/N:20663

  S/N:3004636

  S/N:3003632

  S/N:3005908

  S/N:3005904

  S/N:3003389

- Brüel and Kjær 2270 Precision Sound Level Meter (S/N:3008204)

SLR consulting also notes:
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

8.1.2 Locations

The locations of noise monitors installed by SLR Consulting referenced in the Waterloo Station Development EIS (Appendix N) dated 9 November 2019 are shown in Figure 6 and listed in Table 4 below:

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

Table 4 - SLR Consulting long-term noise measurement locations

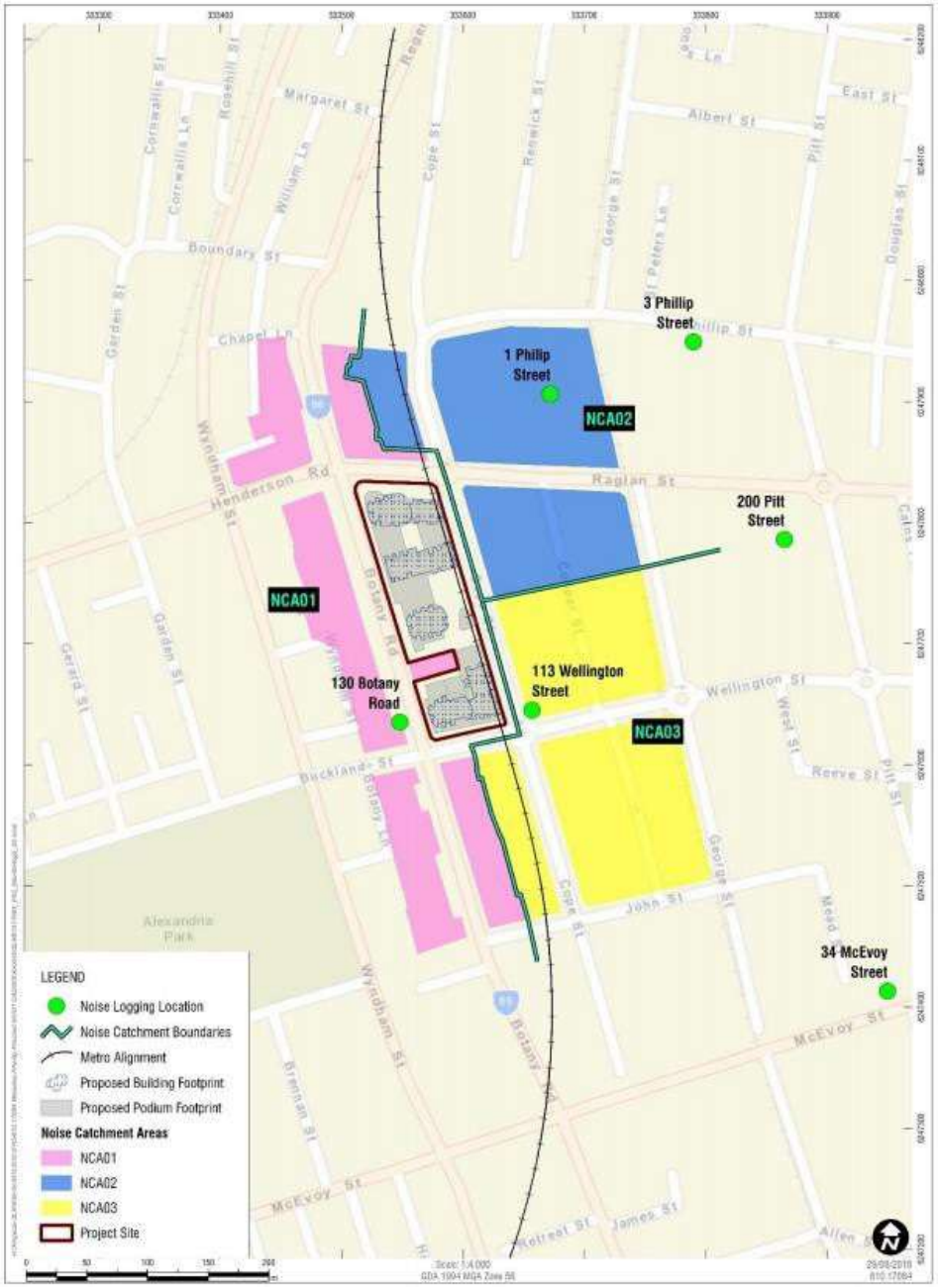


Figure 6 - Measurement locations conducted by SLR Consulting

8.1.3 Long-Term (Unattended) Noise Surveys

Outlined in SLR Consulting report, the results of the unattended ambient surveys are summarised in Table 5 as the Rating Background Level (RBL) noise levels for the Noise Policy for Industry (NPI) daytime, evening and night-time periods, and the LAeq (energy averaged) noise levels for the DoP Interim Guideline daytime and night-time periods

The 24 hour daily noise levels at each monitoring location are presented in Section 14.3.1 of this report.

Noise Monitoring Location	Measured Noise Level (dB)							
	NPI Time Periods[1]						DoP Interim Guideline Time Periods[2]	
	Daytime – RBL	Evening - RBL	Night-time – RBL	Daytime - L_{Aeq}	Evening - L_{Aeq}	Night-time - L_{Aeq}	Daytime - $L_{Aeq(15hr)}$	Night-time - $L_{Aeq(9hr)}$
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	58	46	72	70	69	72	69
L6[4]	Failed	-	-	-	-	-	-	-

Table 5 - Long-term noise measurement summary conducted by SLR Consulting

Note 1: Noise Policy for Industry (NPI) 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: DoP Interim Guideline 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 DoP 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.

8.1.4 Short-Term (Attended) Noise Surveys

Short-term (attended) noise surveys have been conducted by SLR Consulting. The results of these surveys are outlined in Table 6.

Measurement Location	Measured Noise Level (dB)[2]			Description of Ambient Noise Source during attended period
	L_{A90}	L_{Aeq}	L_{Amax}	
1 Phillip Street	48	58	75	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	52	61	85	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	62	81	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	66	80	Dominant sound source McEvoy Street traffic, with occasional pedestrian activity. Limited aircraft passbys during measurement.
113 Wellington Street	51	63	92	Constant parrot activity during measurement. Intermittent traffic noise from Wellington Road with some aircraft passby noise. Limited pedestrian activity.
130 Botany Road[1]	65	73	88	Traffic noise from Botany Road is dominant sound source, with limited aircraft passby.

Table 6 - Short-term noise measurement summary conducted by SLR Consulting

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

Note 2: Measured Noise Level is rounded to the nearest whole number

8.2 Current Site Noise Investigations

Site surveys have been conducted by Stantec Australia to obtain current background noise levels. It should be noted that the site surveys were conducted during the COVID-19 pandemic. Please refer to Section 8.2.1 for further discussion surrounding consideration given to noise monitoring results affected by COVID-19.

Short-term and long-term noise surveys were carried out on and around the proposed development site to characterise the noise generated by nearby traffic noise sources (Botany Rd, Raglan St, and Wellington St), and background and ambient noise representative of the surrounding noise-sensitive receivers.

8.2.1 COVID-19 Pandemic and Effects on Noise Surveys

These noise surveys were carried out under noise-subdued circumstances as a result of the COVID-19 pandemic. For background and ambient noise, the noise statistics obtained will be lower than that of a typical day to day operation and hence can be considered the worst-case scenario.

For the traffic noise measurements, the noise statistics obtained will not be representative of typical traffic noise on Botany Road, Raglan Street, Wellington Street. As a result, the traffic noise measured on-site has been adjusted using comparisons between COVID-19 and standard peak hour traffic volumes on these roads.

8.2.2 Instrumentation

The following equipment was used for the noise surveys:

- ARL Environmental Noise Logger, NL-42EX, S/N 873125
- ARL Environmental Noise Logger, NL-42EX, S/N 521656
- ARL Environmental Noise Logger, NL-42EX, S/N 184109
- ARL Environmental Noise Logger, NL-42EX, S/N 184111
- ARL Environmental Noise Logger, NL-42EX, S/N 885460
- Hand-held sound spectrum analyzer BandK 2250, S/N 2709742;
- Sound Calibrator BandK Type 4231, S/N 2709826;

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

8.2.3 Locations

The site location, measurement positions and surrounding noise and vibration sensitive receivers are shown in Figure 7.

Figure 7 - Overview of the site, surrounding noise-sensitive receivers and measurement locations conducted by Stantec Australia

8.2.4 Long-Term (Unattended) Noise Surveys

Background Noise

Noise monitors were placed at position L1 and L5 as shown in Figure 7 to measure the background and ambient noise that is representative of the surrounding noise-sensitive receivers. Noise monitors L1 and L5 were installed from the 7th to the 13th of April 2020. The results of the unattended background and ambient noise survey is shown in below (for the day, evening and night periods).

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
L1	61	57	50	44	42	36
L5	72	73	67	54	48	41

Table 7 - Long-term noise survey summary – Background noise (Stantec Australia Monitoring)

Note 1: Noise Policy for Industry (NPI) 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.

The local ambient noise environment is dominated by traffic noise from Botany Road throughout the majority of the day, evening and night periods. Note that any rain affected data during the period of logging has been excluded from the calculations. Refer to Figure 8 for the noise data for the total period of measurement.

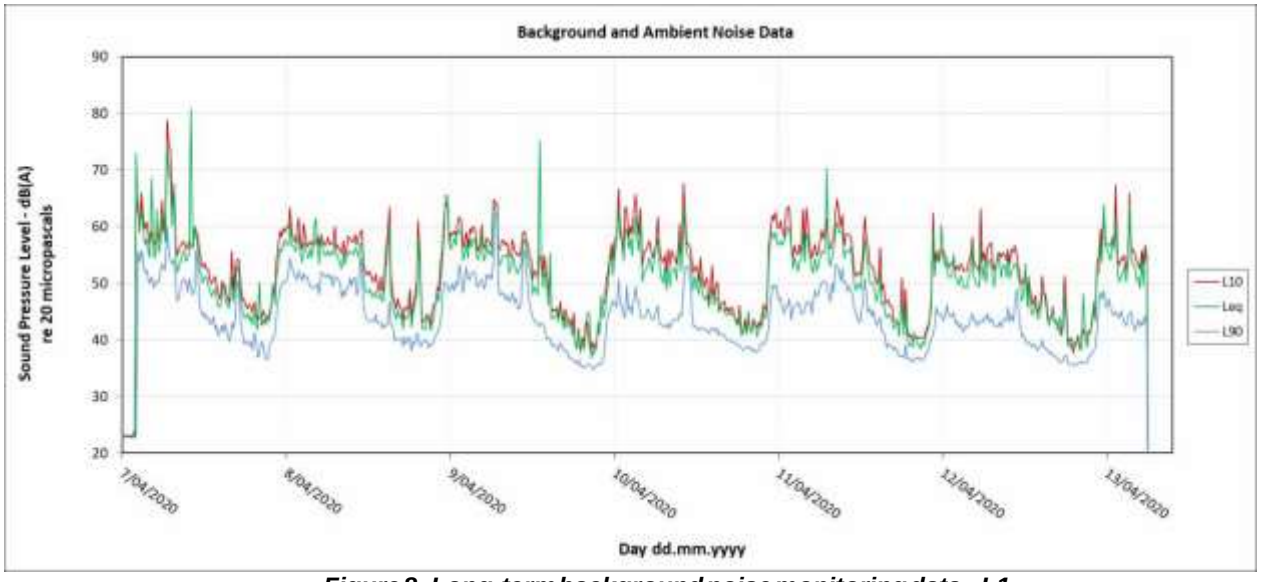


Figure 8 - Long-term background noise monitoring data – L1

Traffic Noise

Noise monitors were placed at positions L3, L4 and L5 as shown in Figure 7 to measure the noise generated by vehicle movements during the noisiest 1-hour day and the noisiest 1-hour night established in the Sydney DCP 2012, and the 15-hour day and 9-hour periods established in the DPIE's Development near Rail Corridors and Busy Roads – Interim Guideline. Noise monitors L3, L4 and L5 were installed from the 7th to the 15th of April 2019. The results for the long-term traffic noise surveys are shown in below (for the day and night periods).

Location	Equivalent Continuous Noise Level LAeq,period - dB(A)		Equivalent Continuous Noise Level LAeq,1hour - dB(A)	
	Day[1] (15hr)	Night[1] (9hr)	Day[2] (Noisiest 1h)	Night[2] (Noisiest 1h)
L3	73	59	75	61
L4	70	66	73	70
L5	73	67	76	71

Table 8 - Long-term noise survey summary – Traffic noise

Note 1: DoP Interim Guideline Assessment Time Periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am (weekly data).

Note 2: Sydney DCP 2012 Assessment Time Periods – Day: All 24 hours; Night: 10.00 pm to 7.00 am (weekly data).

Note that any rain affected data during the period of logging has been excluded from the calculations. Refer to Figure 9 (L3), Figure 10 (L4) and Figure 11 (L5) for the noise data for the total period of measurement.

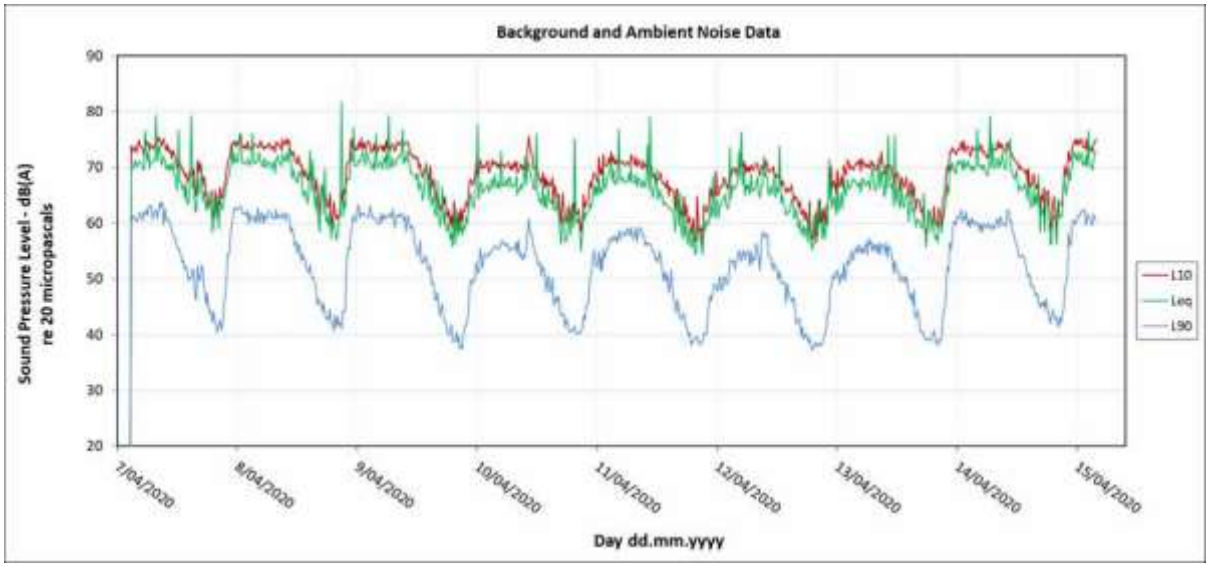


Figure 9 - Long-term traffic noise monitoring data – L3

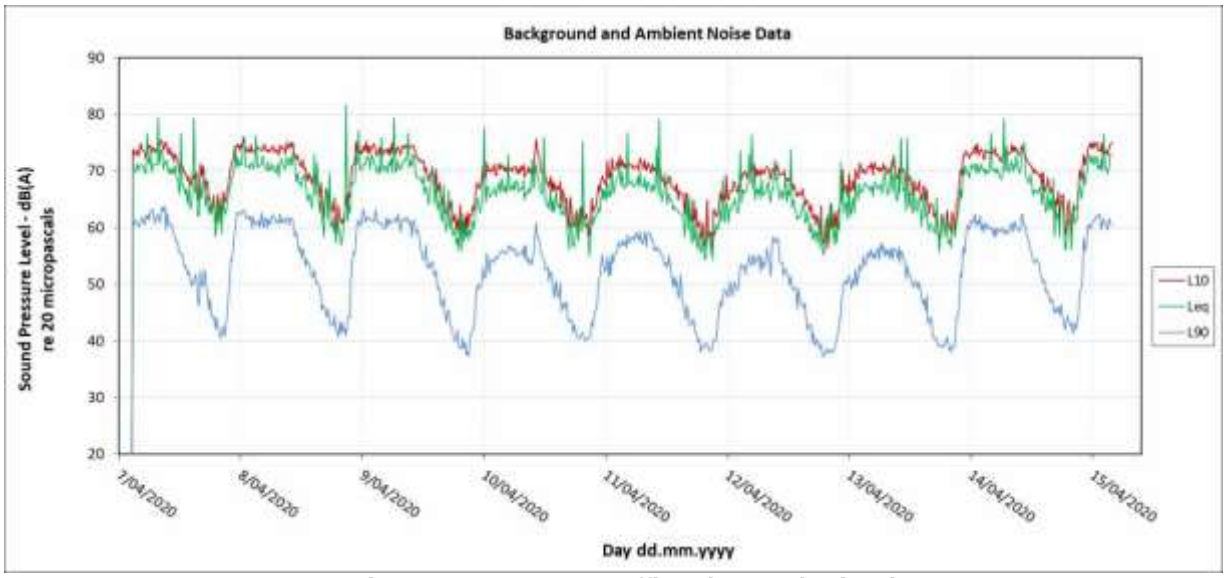


Figure 10 - Long-term traffic noise monitoring data – L4

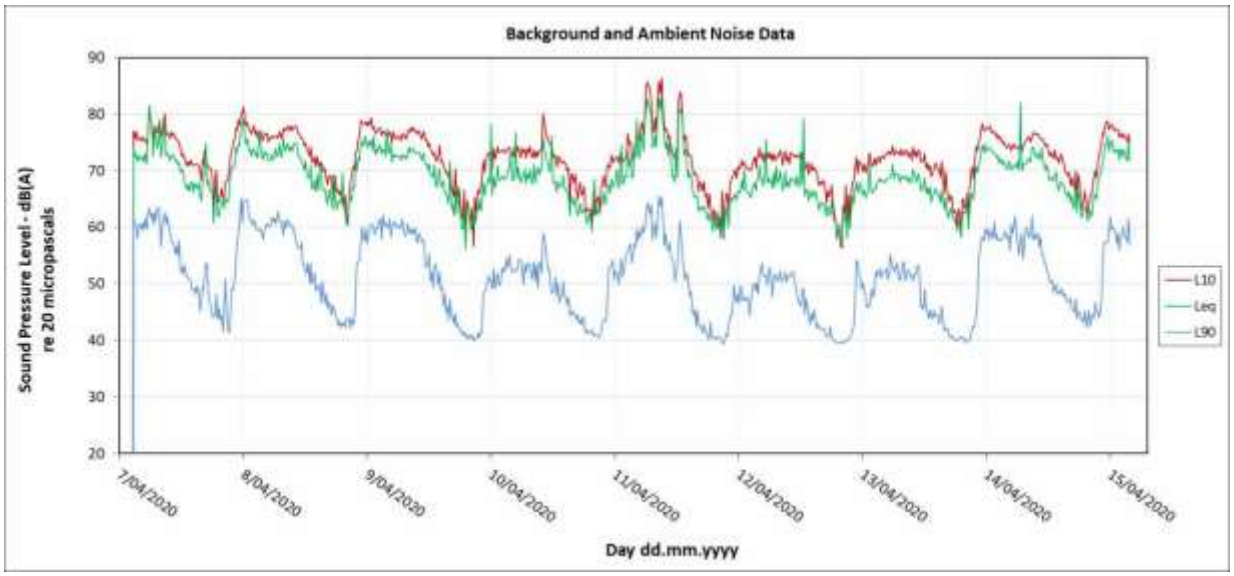


Figure 11 - Long-term traffic noise monitoring data – L5

The 24 hour daily noise levels at each monitoring location are presented in Section 14.3.2 of this report.

8.2.5 Short-Term (Attended) Noise Surveys

Background Noise

Short-term noise measurements were conducted in the vicinity of surrounding noise-sensitive receivers to characterize the background and ambient noise associated with these receivers. The results of the background noise measurements conducted at locations P1 and P2 (see Figure 7 for location) are provided in Table 9.

The measurements were conducted at times either side of 7:00am to obtain the characteristics of the background noise in the area prior to the commencement of the daytime period (daytime defined in the NPI, 7:00am – 6:00pm) and after the commencement of the daytime period.

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{A10} dB(A)	Comments
P1	27/03/2020 6:21 AM	54	46	55	Constant nature sounds with intermittent pedestrian movements. Intermittent traffic from Cope Street.
P2	27/03/2020 7:27 AM	67	58	70	Constant bird activity and chirping during measurement. Intermittent traffic noise from Wellington Road. Limited pedestrian activity.

Table 9 - Short-term noise measurement summary conducted by Stantec

Traffic Noise

Short-term noise measurements of vehicle movements were carried out on Raglan Street, Botany Road and Henderson Road. A summary of the results of the short-term noise measurements of vehicle movements on these roads conducted at locations P3 – P6 is provided in Table 10.

The measurements were conducted at times either side of 7:00am to obtain the characteristics of the traffic noise in the area prior to the commencement of the daytime period (daytime defined in the DoP Interim Guideline, 7:00am – 10:00pm) and after the commencement of the daytime period.

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{A10} dB(A)	Comments
P3	27/03/2020 7:07 AM	65	58	68	Dominant sound source is Raglan Street traffic, with occasional pedestrian activity. Limited aircraft passbys during measurement.
P4	27/03/2020 7:45 AM	72	62	74	Dominant sound source is Henderson Road traffic, with intermittent pedestrian activity.
P5	27/03/2020 8:19 AM	73	62	77	Dominant sound source is Botany Road traffic, with limited pedestrian activity. Construction works were being performed near-by.
P6	27/03/2020 6:45 AM	73	62	76	Intermittent sound source is Botany Road traffic, with limited pedestrian activity.

Table 10 - Short-term noise measurement summary conducted by Stantec

8.3 Summary of Noise Investigations

The site noise investigations are a key piece of information when understanding the existing ambient noise environment characteristic of the surrounding receivers to the proposed development. For the nominated criteria outlined in Section 9 where the measured results are required as the basis of the criteria, historical site noise investigation results, have been used because this more accurately reflects the ambient noise level for each noise catchment area (historical site noise investigation results were not affected by COVID-19 pandemic). We have delineated the various environments into Noise Catchment Areas (NCAs) together with the Integrated Station Development and the other buildings assessed in separate SSD DAs within the OSD precinct, which is outlined in Figure 12. The summary of the receivers within these catchments include:

- NCA01 - Mix of commercial and retail receivers
- NCA02 - Residential receivers
- NCA03 - Residential receivers
- SSD-10439 – Central Precinct
- SSD-10437 – Southern Precinct
- SSI-7400 – Integrated Station Development
- Waterloo Congregational Church

Figure 12 - Noise Catchment Areas (NCA)

9. Project Noise and Vibration Criteria

9.1 Relevant Noise and Vibration Assessment Documents

The project noise and vibration criteria has been established considering the following documents:

- Noise and Vibration Impact Assessment prepared by SLR Consulting dated 09 November 2018 accompanying the Concept SSD DA (SSD 9393);
- NSW EPA Noise Policy for Industry (NPI) 2017
- Waterloo Metro Quarter Design and Amenity Guidelines;
- NSW Road Noise Policy, 2011 (RNP 2011);
- NSW EPA Interim Construction Noise Guideline 2009;
- Assessing vibration: A technical guideline 2006;
- British Standard BS5228 – Part 1:1997 “Noise and Vibration Control on Construction and Open Sites.”;
- British Standard BS7358:1993 “Evaluation and Measurement for Vibration in Buildings” – Part 2: “Guide to Damage Levels from Groundborne Vibration”; and
- German Standard DIN4150 – Part 3: “Structural vibration in buildings – Effects on structures”.
- State Environmental Planning Policy No 65—Design Quality of Residential Apartment Development

9.2 Operational Noise Criteria

9.2.1 External Noise Emissions

NSW EPA Noise Policy for Industry (2017)

The *NSW Noise Policy for Industry* has been applied to address the noise emissions from the development to the surrounding noise-sensitive receivers. The NSW NPI sets out noise criteria to control the noise emission from industrial noise sources generated by the proposed development. Operational noise emissions from the development shall be addressed following the guideline in the NSW NPI.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established, the most stringent for each considered assessment period (day, evening, night) is adopted as the project noise trigger level (PNTL).

Intrusiveness Criteria

The NSW NPI states the following:

"The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the LAeq descriptor), measured over a 15minute period, does not exceed the background noise level by more than 5 dB when beyond a minimum threshold."

The intrusiveness criterion can be summarised as L_{Aeq}, 15 minute $\leq$ RBL background noise level plus 5 dB(A).

The noise surveys conducted by Stantec were taken during the COVID-19 pandemic, and hence the observed background levels (RBL) for Noise Catchment Area is noticeably lower than background levels taken by SLR Consulting. Therefore, the criteria outlined below are based on the SLR Consulting RBL's outlined in of this report, with noise monitor 'L5; corresponding to NCA01 and 'L1' corresponding to NCA03.

Due to SLR consulting's long-term (unattended) results located at L4 (within NCA02) being affected by loud bird activity, the results recorded from noise monitor 'L3' have been used instead as this is more representative of the background noise level located within the noise catchment area (NCA02).

Receiver	Period	Noise Descriptor – dB(A)	Noise Criteria – dB(A)
NCA02	Day (7:00am to 6:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	52
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	48
	Night (10:00pm to 7:00am)	$L_{Aeq,15min} \leq$ RBL + 5	42
NCA03	Day (7:00am to 6:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	55
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	51
	Night (10:00pm to 7:00am)	$L_{Aeq,15min} \leq$ RBL + 5	45
Central Precinct	Day (7:00am to 6:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	52
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	48
	Night (10:00pm to 7:00am)	$L_{Aeq,15min} \leq$ RBL + 5	42

Table 11 – NSW NPI intrusiveness criteria

Amenity Criteria

The NSW NPI states the following:

"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).

The applicable parts of Table 2.2: Amenity noise levels from Industrial Noise Sources – L_{Aeq}, dB(A) which are relevant to the project are reproduced below:

Receiver	Type of Receiver	Noise amenity area	Time of Day	L_{Aeq}, dB(A) Recommended amenity noise level	Project amenity noise level $L_{Aeq,period}$
NCA01	Commercial	All	When in use	65	60
NCA02	Residential	Urban	Day	60	55
			Evening	50	45
			Night	45	40
NCA03	Residential	Urban	Day	60	55
			Evening	50	45
			Night	45	40
Central Precinct	Residential	Urban	Day	60	55
			Evening	50	45
			Night	45	40
Waterloo Congregational Church	Place of Worship	All	Day	50	57
			Evening	50	55
			Night	50	54

Table 12 - NSW NPI amenity criteria for external noise levels

Note 1: Urban area as defined in EPA NPI 2. 2.1.6.

Note that where the resultant project amenity noise level is 10dB or more lower than the existing industrial noise level the project amenity noise levels can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

'Modifying Factor' Adjustments

The NSW NPI also states:

"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."

In order to take into account the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table C1 of Fact Sheet C of the NSW NPI (see Table 13 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Factor	Assessment / Measurement	When to Apply	Correction [1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D)*.	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.

Factor	Assessment / Measurement	When to Apply	Correction [1]	Comments
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.\	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Table 13 - Table C1 from the NSW NPI – Modifying factor corrections

Note 1: Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

Note 2: Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

Note 3: Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

Project Noise Trigger Levels

Refer to Table 14 for the NSW NPI project noise trigger levels for assessment of external noise emissions from the Metro Quarter Development. These project noise trigger levels (PNTLs) have been established in accordance with the NSW NPI and are in-line with those established in the SLR Consulting Acoustic Impact Assessment Report prepared as part of the Environmental Impact Statement accompanying the concept SSD Application for the OSD.

Receiver	Period	Descriptor	PNTL dB(A)
NCA01	Commercial Receivers		
	When in use	$L_{Aeq,15min}$	63
NCA02	Residential Receivers		
	Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	55
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	48
	Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	43
NCA03	Residential Receivers		
	Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	55
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	48
	Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	43
Central Precinct	Residential Receivers		
	Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	55
	Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	48
	Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	43
Waterloo Congregational Church	Place of Worship		
	When in use – Day	$L_{Aeq,15min}$	60
	When in use – Evening	$L_{Aeq,15min}$	58
	When in use – Night	$L_{Aeq,15min}$	57

Table 14 - Project noise trigger levels (PNTL)

9.2.1

9.2.1 Traffic Noise Generation Criteria

The L_{Aeq} noise level or the "equivalent continuous noise level" correlates best with the human perception of annoyance associated with traffic noise.

Road traffic noise impact is assessed in accordance with the introduced NSW Road Noise Policy which supersedes the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN, Department of Environment Climate Change and Water 1999). The criterion (Table 3 – Road Traffic Noise Assessment Criteria for Residential Land Uses) divides land use developments into different categories and lists the respective criteria for each case. The category that is relevant to the proposed use of the site is shown below in Table 15.

Road Category	Type of project/land use	Assessment Criteria – dB(A	
		Day (7am – 10pm)	Night (10pm – 7am)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 55 (external)	$L_{Aeq,1\ hour}$ 50 (external)

Table 15 - NSW Road Noise Policy – Traffic noise assessment criteria

If the traffic noise at the site is already in excess of the criteria noted above, the NSW RNP states that the primary objective is to reduce the existing level through feasible and reasonable measures to meet the criteria above.

If this is not achievable, Section 3.4.1 Process for applying the criteria – Step 4 states that for existing residences affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise should be limited to 2 dB above that of the corresponding 'no build option'.

9.3 Operational Vibration Criteria

9.3.1 Human Comfort

The NSW Environment Protection Authority (EPA) developed a document, "Assessing vibration: A technical Guideline" in February 2006 to assist in preventing people from exposure to excessive vibration levels within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

Continuous and Impulsive Vibration

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 16. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Impulsive vibration					
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

Table 16 - RMS values for continuous and impulsive vibration acceleration (m/s^2) 1-80Hz

9.3.2 Intermittent Vibration

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

Table 17 - Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

9.3.3 Cosmetic Damage

Table 18 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

Table 18 - Transient vibration guide values for cosmetic damage

9.3.4 Structural Damage

Ground vibration criteria is defined in terms of the levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 “Structural vibration in buildings – Effects on structures” and British Standard BS7385-Part 2: 1993 “Evaluation and Measurement for Vibration in Buildings”. Table 19 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn’t occur.

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

*For frequencies above 100Hz, at least the values specified in this column shall be applied

Table 19 - Guideline value of vibration velocity, vi, for evaluating the effects of short-term vibration

9.4 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) under the NSW Environment Protection Authority (EPA), together with the City of Sydney's Construction Hours/Noise within the Central Business District – Code of Practice 1992. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

In undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW EPA ICNG (July 2009) were specifically referenced. The construction noise limits are presented in Table 20, and are applicable to the proposed development.

Time of Day	Management Level $L_{Aeq,15min}$	How to Apply
Council's Hours: Mon – Fri (7:30am – 5:30pm) Sat (7:30am – 3:30pm) No work on Sunday and Public Holidays	Noise Affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, 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.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2. of the ICNG

Table 20: Construction Noise Criteria at Residences

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30m away from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 21 below (Section 4.1.3 of the ICNG) sets out the noise management levels for other land uses, including commercial premises. The external noise levels should be assessed at the most affected occupied point for commercial and industrial uses, and at the most affected point within 50 metres of the area boundary for parks.

Land Use	Management Level, LAeq,15min – applies when land use is being utilized
Passive recreation, parks	External noise level 60 dB(A)
Places of worship	Internal noise level 45 dB(A) / External noise level 55 dB(A)
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

Table 21 - Construction Noise Criteria for Other Land Uses

Based on the criteria in the tables above, the following noise management levels in Table 22 should be applied to the receivers within the Noise Catchment Areas outlined in Section 8.3. Construction during standard hours has been assumed.

Land Use	Receiver	Management Level, $L_{Aeq,15min}$
Commercial	NCA01	70 dB(A)
Place of worship	Waterloo Congregational Church	55 dB(A)
Residential	NCA02	50 dB(A) + 10 dB = **60 dB(A)**
	NCA03	47 dB(A) + 10 dB = **57 dB(A)**
Residential (Outside Recommended Standard Hours)	NCA02	50 dB(A) + 5 dB = **55 dB(A)**
	NCA03	47 dB(A) + 5 dB = **52 dB(A)**
Commercial	ISD (North and South)	70 dB(A)

Table 22 - Project Specific Construction Noise Management Levels

It is important to note that operation falling outside the standard hours recommended within the ICNG will be assessed under the Outside Recommended Standard Hours criteria.

9.5 Construction Vibration Criteria

It is important for vibration emissions from vibration-intensive equipment utilized during the construction works be managed to maintain appropriate levels of human comfort, and to avoid both cosmetic and structural damage. The vibration limits proposed in the ensuing sub-sections aid in achieving this outcome.

9.5.1 Human Comfort

The office of Environment and Heritage (OEH) developed a document, "Assessing vibration: A technical guideline" in February 2006 to assist in preventing people from exposure to excessive vibration levels from construction and operation of a development within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

Continuous & Impulsive Vibration

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 23. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Impulsive vibration					
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

Table 23: Preferred and maximum weighted RMS values for continuous and impulsive vibration (m/s^2)

Intermittent Vibration

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV

assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

Table 24: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

9.5.2 Cosmetic Damage

Table 25 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

Table 25: Transient vibration guide values for cosmetic damage

9.5.3 Structural Damage

Ground vibration criteria is defined in terms of the levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 “Structural vibration in buildings – Effects on structures” and British Standard BS7385-Part 2: 1993 “Evaluation and Measurement for Vibration in Buildings”. Table 26 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn’t occur.

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 26: Guideline value of vibration velocity, vi, for evaluating the effects of short-term vibration

9.5.4 Project Construction Vibration Limits

Table 27 indicates the vibration criteria for the nearest residential properties to the development.

Location	Period	Human Comfort Vibration Objectives			Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $m/s^{1.75}$ (VDV)	
		z-axis	x- and y-axis		
Residential	Daytime	10 - 20	7 - 14	0.20 - 0.40	5
	Night time	7 - 14	5 - 10	0.13 - 0.26	5

Table 27: Construction vibration criteria summary

10. Cumulative Operational Noise and Vibration Assessment

10.1 Traffic Noise Generation Impact Assessment

For the road traffic noise assessment, existing peak hour traffic count and traffic generation for the site was based on the Traffic Impact Assessment prepared by “ptc.”. This data has been used to calculate the expected noise increase due to traffic associated with the development onto Botany Rd, Wellington St, Raglan Rd and Cope St. The results are summarized in Table 28.

Location	Existing vehicles	Existing vehicles	Predicted Increase	Predicted Increase	Noise Level Increase dB	Noise Level Increase dB
	AM	PM	AM	PM	AM	PM
Botany Road	2,064	1,913	84.1	78	0.2	0.2
Wellington Street	254	342	19.3	22.9	0.3	0.3
Cope Street	122	145	42.9	22	1.3	0.6
Raglan Road	532	606	40	43.1	0.	0.3
Henderson Street	1,876	2,016	92.6	91.8	0.2	0.2

Table 28: Existing and predicted traffic noise generation (peak hour)

Based on the results of the assessment, there is predicted to be less than a 1.3dB increase in traffic noise levels. Therefore, the proposed development is expected comply with the requirements of the NSW Road Noise Policy because the predicted increase is less than 2dB.

10.2 Metro Impact Assessment

A vibration impact assessment to the Structural Damage criteria, to the nearest affected structure of the development as a result of a train pass-by within the subterranean corridor has been conducted. Source vibration levels were provided by Sydney Metro in accordance with the SWTC Appendix B8 Noise and Vibration 2.3a), which states:

"The trackform will be delivered by an Interface Contractor to ensure compliance with the requirements of the Planning Approval based on residential usage and standard forms of construction for the Station and OSD. The Contractor will be provided with a vibration spectrum at track level by the Principal's Representative."

The spectrum provided for this assessment is outlined in Table 29 below.

Velocity dB re 1nm/s – third-octave band centre frequencies (Hz)														
10	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**
65	82	86	77	76	79	81	96	84	68	54	48	46	46	51

Table 29: Metro Station Vibration Spectrum - MOTIV Prediction

Refer to Figure 13 for the results of the vibration assessment in comparison to the structural damage criteria from DIN4150 – 3.

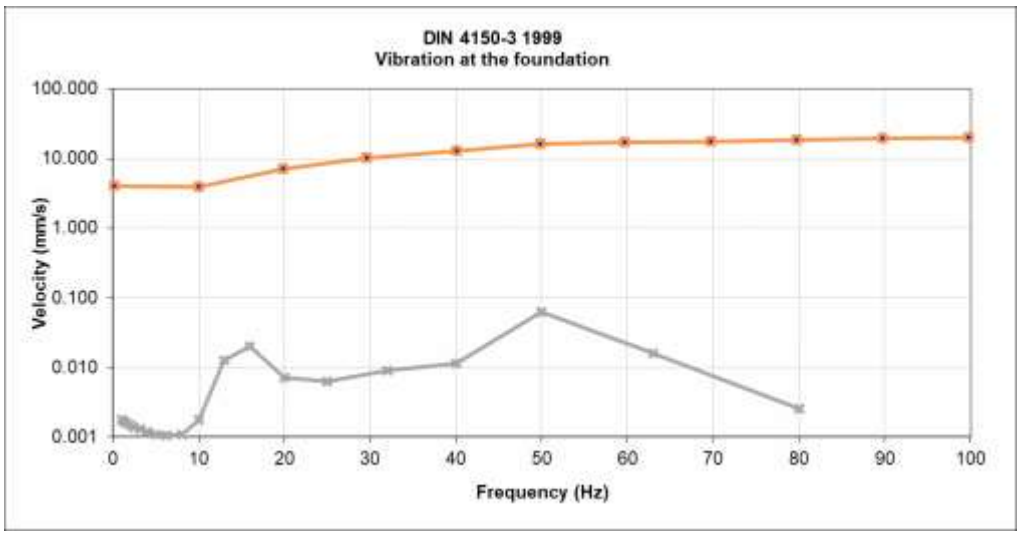


Figure 13: Spectrum of incident vibration on the nearest affected structure (DIN 4150)

Based on the predicted vibration levels at the nearest affected structure within the proposed development, it is not expected that there will be any exceedance of the criteria established for structural damage. As a consequence, the vibration impact on the structure of the proposed development is predicted to comply with the requirements of the SEPP Infrastructure 2007.

11. Construction Noise and Vibration Assessment

11.1 All Precincts - Cumulative Construction Noise Assessment

11.1.1 Proposed Construction Activities

In this assessment, the noise impact from the construction works are considered, including impacts to Waterloo Congregational Church. The proposed construction works will comprise the following stages:

- Civil Works (Basement and Southern Precinct)
- Structure – All Precincts (Ground Level to Rooftop)
- Façade – All Precincts (Ground Level to Rooftop
- Fitout, Finishes and Services

The construction works are expected to occur during the following hours:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 7:00am to 3:30pm
- Sunday and public holidays: no work
- Safety inspections are permitted from 7:00am

The construction layouts and plans have been outlined in Mirvac's Construction & Environmental Management Plan (CEMP), and the worst case scenarios for both commercial and residential receivers have been covered.

11.1.2 Expected Construction Equipment

The noise sources likely to be associated with the works listed in the previous section of this report are presented in Table 30. The equipment noise levels have been extracted from AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*.

Stages	Equipment	Sound Power Level – dB(A)	Acoustical Usage Factor (%)	Usage in 15-minute period (minutes)	Time Corrected Sound Power Level ($L_{Aeq,15min}$)
Civil Works (Excavation)	Excavator with hydraulic hammer (15t)	115	40	6	111
	Excavator (30-40t)	107	40	6	103
	Bobcat	104	40	6	100
	Bulldozer	108	40	6	104
	Mobile crane	104	16	2.5	96
	Powered hand tools	102	50	7.5	98

Stages	Equipment	Sound Power Level – dB(A)	Acoustical Usage Factor (%)	Usage in 15-minute period (minutes)	Time Corrected Sound Power Level ($L_{Aeq,15min}$)
	CFA piling rig	111	20	2.5	103
Structure & Facade	Crane (Diesel)	105	16	2.5	97
	Powered hand tools	102	50	7.5	99
	Concrete pump	108	20	3	101
	Truck	107	40	6	103

Table 30 – Cumulative Impact - Construction Equipment Noise Levels

11.1.3 Noise Modelling and Assumptions

In order to assess the noise impact from the site during the various construction stages, a noise model was prepared using commercial software SoundPLAN v8.1, which is a comprehensive software package for conducting three-dimensional complex noise propagation modelling. Using the software, a 3D model of the site and its surroundings was constructed including the nearby buildings, and the construction plant and equipment were positioned as noise sources. Within the model, the effects of the environment (built and natural) on propagation of sound were considered to reliably estimate the resulting noise effects on the surrounding noise sensitive receivers.

The noise model represents the 'reasonable' worst case periods of construction activities, meaning that all the equipment of each stage is operating simultaneously during a 15-minute observation period.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst-case scenario for each receiver;
- The mitigation measures outlined in Section 12.1 are implemented;
- Neutral weather conditions; and
- Truck and light traffic movement is conducted in accordance with the Access Plan All Precincts.

The predicted noise levels at the surrounding noise catchment areas have been based on the assumptions and aforementioned sound power levels of the equipment provided in Table 30. The results of the predicted noise levels are presented in Section 11.1.1.

The prediction modelling was conducted for each of the following construction scenarios:

- Scenario 1: Civil Works (Basement and Southern Precinct)
- Scenario 2: Structure (GF – L5):

1. Northern Precinct – Structure (GF – L5)
1. Central Precinct – Structure (GF – L5)
2. Southern Precinct (Building 3 & 4) – Structure - (GF – L5)

- Scenario 3: Structure (L6 – L10) and Façade (GF – L5):

1. Northern Precinct – Structure (L6 – L10) and Façade (GF – L5):
2. Central Precinct – Structure (L6 – L10) and Façade (GF – L5):
3. Southern Precinct (Building 3 & 4) – Structure (L6 – L10) and Façade (GF – L5)

- Scenario 4: Structure (L11 – L15) and Façade (L6 – L10)

1. Northern Precinct – Structure (L11 – L10) and Façade (L6 – L10)
2. Central Precinct – Structure (L11 – L10) and Façade (L6 – L10)
3. Southern Precinct (Building 3 & 4) – Structure (L11 – L10) and Façade (L6 – L10)

- Scenario 5: Structure (L16 – L24) and Façade (L11 – L15)

1. Northern Precinct – Structure (L16) and Façade (L11 – L15)
2. Central Precinct – Structure (L16 – L23) and Façade (GF – L5)
3. Southern Precinct (Building 3 & 4) – Structure (L16 – L24) and Façade (L11 – L15)

11.1.4 Predicted Noise Levels

The predicted noise levels during for each scenario at each receiver location have been presented in Table 31, Table 32, Table 33, Table 34, and Table 35 and have been assessed to the construction noise criteria established in Section 9.4. The noise contour maps produced by the three-dimensional noise propagation modelling are provided in Section 14.2.

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	63 - 69	59 - 65	70	-	No
NCA02	62 - 67	62 - 64	60	2 – 4	No
			55 (Outside Standard Hours)	7 – 9	No
NCA03	50 - 69	49 - 72	64	0 – 8	No
			59 (Outside Standard Hours)	0 – 13	No
Waterloo Congregational Church	74 - 76	67 - 76	55	12 – 21	Yes*

Table 31 - Predicted Noise Levels – Scenario 1: Civil Works (Basement and Southern Precinct)

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min\ dB}$	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	57 - 64	54 - 61	70	-	No
NCA02	54 – 59	53 - 57	60	-	No
			55 (Outside Standard Hours)	0 - 2	No
NCA03	46 - 54	46 - 52	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	60 - 69	58 - 66	55	3 - 11	No

Table 32 - Predicted Noise Levels – Scenario 2: Structure (GF – L5)

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	58 - 60	57 - 58	70	-	No
NCA02	50 - 57	49 - 55	60	-	No
			55 (Outside Standard Hours)	-	No
NCA03	51 - 55	50 - 55	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	61 - 65	59 - 61	55	4 - 6	No

Table 33 - Predicted Noise Levels – Scenario 3: Structure (L6 – L10) and Façade (GF – L5)

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	57 - 59	56 - 59	70	-	No
NCA02	54 -57	54 - 56	60	-	No
			55 (Outside Standard Hours)	0 - 1	No
NCA03	53 -57	52 - 57	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	57 - 60	56 - 57	55	1 - 2	No

Table 34 - Predicted Noise Levels – Scenario 4: Structure (L11 – L15) and Façade (L6 – L10)

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	55 - 58	55 - 56	70	-	No
NCA02	56 - 57	55 - 57	60	-	No
			55 (Outside Standard Hours)	0 - 2	No
NCA03	53 - 55	53 - 55	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	59 - 60	58 - 59	55	3 - 4	No

Table 35 - Predicted Noise Levels – Scenario 5: Structure (L16 – L24) and Façade (L11 – L15)

In the instance the excavation and piling for each of the precincts occurs simultaneously, the predicted noise level at nearest noise-sensitive receiver (Waterloo Congregational Church) will exceed the noise management level by 21 dB(A). This result is also conservative in the sense that the majority of the noise is generated by rock breakers in close proximity to the receiver, where this may not be the case in reality given the predominant soil type (sand).

Upon implementation of the mitigation measures outlined in Section 12.1, it is not expected there will be significant construction noise impacts on the surrounding noise-sensitive receivers within the nearby noise catchment areas.

11.2 All Precincts - Cumulative Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.

Generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the transport for NSW 'Construction Noise Strategy' document. This document presents the safe construction working limits for Cosmetic Damage to adjacent structures (in accordance with BS 7385) and Human Comfort (OH&E).

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Concrete Vibrator	<50 kN (Typically 1-2 tonnes)	5m	15m to 20m
	<100 kN (Typically 2-4 tonnes)	6m	20m
	<200 kN (Typically 4-6 tonnes)	12m	40m
	<300 kN (Typically 7-13 tonnes)	15m	100m
	>300 kN (Typically 13-18 tonnes)	20m	100m
	>300 kN (> 18 tonnes)	25m	100m
CFA Piling Rig	≤ 800mm	2m (nominal)	N/A
Excavator with hydraulic hammer (15t)	(900kg – 12 to 18t excavator)	7m	23m

Table 36: Working Distances for Vibration Intensive Plant

Concrete vibrators are expected be used in close proximity to the Waterloo Congregational Church when pouring the Ground Level slab. In addition to this, piling and excavating with a hammer attachment may be conducted in close proximity to the Waterloo Congregational Church. Mitigation measures to ensure vibration generated on the structure of the Waterloo Congregational Church does not exceed the project vibration requirements are provided in Section 9.5.4.

11.3 Basement - Construction Noise Assessment

11.3.1 Proposed Construction Activities

In this assessment, the noise impact from the construction works are considered. The proposed early construction will consist of the following stages:

- Civil Works
- Construction of basement structure

The hours of work are expected to occur during the following hours:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 7:00am to 3:30pm
- Sunday and public holidays: no work
- Safety inspections are permitted from 7:00am

The construction layouts and plans have been outlined in Mirvac's Construction & Environmental Management Plan (CEMP), and the worst case scenarios for both commercial and residential receivers have been covered.

11.3.2 Expected Construction Equipment

The noise sources likely to be associated with the works listed in the previous section of this report are presented in Table 37. The equipment noise levels have been extracted from AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*.

Stages	Equipment	Sound Power Level – dB(A)	Acoustical Usage Factor (%)	Usage in 15-minute period (minutes)	Time Corrected Sound Power Level ($L_{Aeq,15min}$)
Civil Works	Excavator with hydraulic hammer (15t)	115	40	6	111
	Excavator (30-40t)	107	40	6	103
	Bobcat	104	40	6	100
	Bulldozer	108	40	6	104
	Mobile crane	104	16	2.5	96
	Powered hand tools	102	50	7.5	98
	CFA piling rig	111	20	2.5	103
Structure	Crane (Diesel)	105	16	2.5	97

Stages	Equipment	Sound Power Level – dB(A)	Acoustical Usage Factor (%)	Usage in 15-minute period (minutes)	Time Corrected Sound Power Level ($L_{Aeq,15min}$)
	Powered hand tools	102	50	7.5	99
	Concrete pump	108	20	3	101
	Truck	107	40	6	103

Table 37: Construction Equipment Noise Levels

11.3.3 Noise Modelling & Assumptions

In order to assess the noise impact from the site during the various construction stages, a noise model was prepared using commercial software SoundPLAN v8.1, which is a comprehensive software package for conducting three-dimensional complex noise propagation modelling. Using the software, a 3D model of the site and its surroundings was constructed including the nearby buildings, and the construction plant and equipment were positioned as noise sources. Within the model, the effects of the environment (built and natural) on propagation of sound were considered to reliably estimate the resulting noise effects on the surrounding noise sensitive receivers.

The noise model represents the 'reasonable' worst case periods of construction activities, meaning that all the equipment of each stage is operating simultaneously during a 15-minute observation period.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst-case scenario for each receiver
- The mitigation measures outlined in in Section 12.1 are implemented;
- The noise levels have been assessed using neutral weather conditions
- Truck and light traffic movement is conducted in accordance with the Access Plan for the Basement.

The noise levels at the surrounding sensitive receivers have been based on the assumptions and aforementioned sound power levels of the equipment provided in Table 37. The results of the predicted noise levels are presented in Section 11.3.4.

The prediction modelling was conducted for each of the following construction scenarios:

- Scenario 1: Civil Works
- Scenario 2: Construction of Basement

11.3.4 Predicted Noise Levels

The predicted noise levels during all phases for each receiver location have been presented in Table 38 and Table 39, and have been compared with the requirements of the Interim Construction Noise Guideline (ICNG). The noise contour maps produced by the three-dimensional noise propagation modelling are provided in Section 14.2.

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	46-61	44-59	70	-	No
NCA02	47-55	42-49	60	-	No
			55 (Outside Standard Hours)	-	No
NCA03	45-53	42-49	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	46-68	46-60	55	0-5	No

Table 38: Predicted Noise Levels – Scenario 1: Civil Works

Note 1: There will be periods of time where the noise levels generated by construction works exceed the highly noise affected level. In these instances, the early works contractor is to implement the noise mitigation measures provided in Section 12.1 of this report, together with any other reasonable and feasible measures in order to reduce any potential adverse noise impact.

Receiver	Predicted Noise Level Range - Without Mitigation	Predicted Noise Level Range – With Mitigation	Noise Management Level $L_{Aeq,15min}$ dB	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
NCA01	36-42	30-33	70	-	No
NCA02	26-40	20-37	60	-	No
			55 (Outside Standard Hours)	-	No
NCA03	20-32	20-31	64	-	No
			59 (Outside Standard Hours)	-	No
Waterloo Congregational Church	30-47	25-39	55	-	No

Table 39: Predicted Noise Levels – Scenario 2: Construction of Basement

Note 1: There will be periods of time where the noise levels generated by construction works exceed the highly noise affected level. In these instances, the early works contractor is to implement the noise mitigation measures provided in Section 12.1 of this report, together with any other reasonable and feasible measures in order to reduce any potential adverse noise impact.

11.4 Basement - Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.

Generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the transport for NSW 'Construction Noise Strategy' document. This document presents the safe construction working limits for Cosmetic Damage to adjacent structures (in accordance with BS 7385) and Human Comfort (OH&E).

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Concrete Vibrator	<50 kN (Typically 1-2 tonnes)	5m	15m to 20m
	<100 kN (Typically 2-4 tonnes)	6m	20m
	<200 kN (Typically 4-6 tonnes)	12m	40m
	<300 kN (Typically 7-13 tonnes)	15m	100m
	>300 kN (Typically 13-18 tonnes)	20m	100m
	>300 kN (> 18 tonnes)	25m	100m
CFA Piling Rig	≤ 800mm	2m (nominal)	N/A
Excavator with hydraulic hammer (15t)	(900kg – 12 to 18t excavator)	7m	23m

Table 40: Working Distances for Vibration Intensive Plant

Concrete vibrators are expected be used in close proximity to the Waterloo Congregational Church when pouring the Ground Level slab. In addition to this, piling and excavating with a hammer attachment may be conducted in close proximity to the Waterloo Congregational Church. Mitigation measures to ensure vibration generated on the structure of the Waterloo Congregational Church does not exceed the project vibration requirements are provided in Section 9.5.4.

12. Construction Mitigation Measures

12.1 Construction Noise and Vibration

12.1.1 Project Specific Noise and Vibration Recommendations

Noise

A solid acoustic barrier (made from plywood or similar) 2.4 metres above Ground Level is recommended to be erected around the perimeter of the site. The acoustic barrier could be either Class A or Class B type hoarding.

Where it proves reasonable and feasible, heavy truck movements are recommended to travel along Botany Road to enter the construction site. This will not be possible for significant durations of construction on-site due to other site constraints that must be addressed by travelling along Cope St and Raglan St.

In addition, noise monitoring is recommended to be conducted at the most-affected noise-sensitive receivers in accordance with the monitoring programme proposed in Section 12.2.2 is achieved.

The flow chart presented in Figure 14 should be used to assist with noise mitigation and management measures in order to comply with the standards outlined in this report.

Vibration

As civil works begin, attended vibration measurements should be conducted on the structure of the Waterloo Congregational Church to ensure the vibration generated on the structure does not exceed the values for cosmetic damage and structural damage outlined in BS 7385 and DIN 4150 (project construction vibration limits established in Section 9.5.4). The vibration will primarily be generated by the concrete vibrators used during the concrete pour.

12.1.2 General Acoustic Recommendations for Construction

According to AS 2436 – 2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* the following techniques could be applied to minimize the spread of noise and vibrations to the potential receivers.

Noise

If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimized. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures such as screens.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. Practices that will reduce noise from the site include:

- Increasing the distance between noise sources and sensitive receivers.
- Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
- Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
- Installing purpose-built noise barriers, acoustic sheds and enclosures.

Screening

On sites where distance is limited, the screening of noise may be beneficial, and this should be taken into account during the planning stages.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, sound insulation measures may be necessary to protect workers inside the buildings.

A hoarding that includes a site office on an elevated structure offers superior noise reduction when compared with a standard (simple) hoarding. The acoustic performance is further enhanced when the hoarding is a continuous barrier.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. A noisy, stationary plant can be placed in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficiency when operating the equipment.

Where such noise barriers are not practical, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which

may effectively screen any noise-sensitive areas from the plant. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant equipment that operate on a 24-hour basis may not be an irritating source of noise during the day but may be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite an effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible, with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

In many cases it is not be practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant or to build-in at the early stages protective features required to screen traffic noise. Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any equivalent material in surface density.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the receiver, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from it.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternative warning alarms capable of providing a safe system of work that are equal to or better than the traditional ‘beeper’, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

- Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal frequency ‘beep’) are less intrusive when heard in the neighbourhood.

- Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
- Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, providing safety considerations, are not compromised.
- Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
- Spotters or observers.

The above methods should be combined, where appropriate.

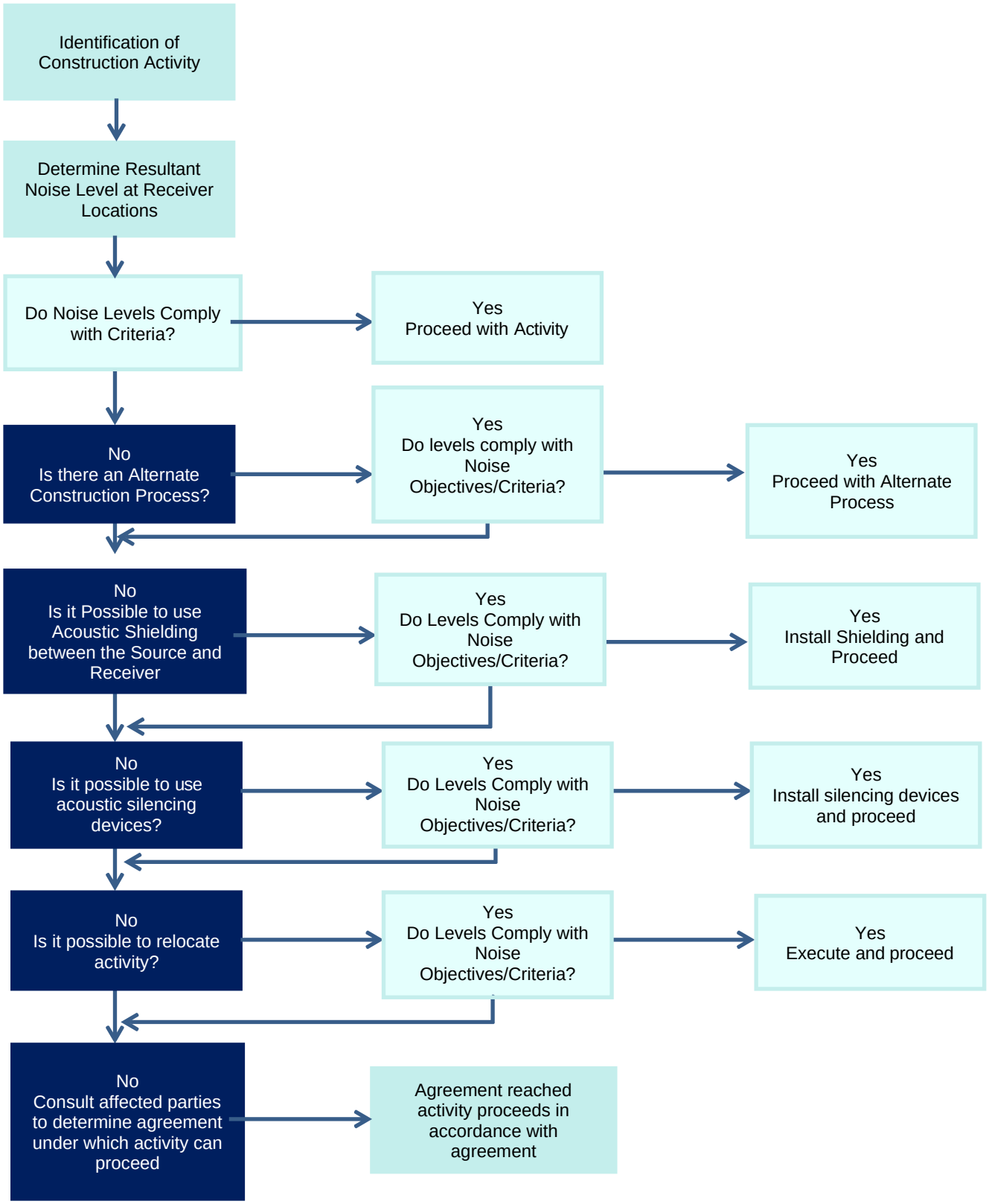


Figure 14: Noise mitigation management flow chart

12.2 Noise & Vibration Monitoring Strategy

12.2.1 General Methodology

Noise and vibration levels should be monitored from time to time to ensure that noise generated as a result of remediation and construction activities does not disturb local businesses and residents.

Monitoring may be in the form of regular checks by the builder or indirectly by an acoustic consultant engaged by the builder and in response to any noise or vibration complaints. Where noise and vibration criteria are being exceeded or in response to valid complaints, noise and / or vibration monitoring should be undertaken. This would be performed inside the premises of the affected property and on site adjacent to the affected receivers.

Monitoring is to be undertaken by an experienced noise and vibration monitoring professional or an acoustic consultant. The results of any noise or vibration monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise and vibration monitoring can take two forms:

- Short term monitoring
- Long-term monitoring

Short-term monitoring

Short-term monitoring consists of attended monitoring when critical stages of the construction are occurring. This normally provides real-time assistance and guidance to the subcontractor on site letting them know when the noise and vibration criteria are exceeded allowing the selection of alternative method on construction or equipment selection in order to minimise noise and vibration impacts.

Long-term monitoring

Similarly, long-term monitoring uses noise and vibration loggers providing real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded.

Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the DA conditions.

Both methodology are complementary and normally used simultaneously providing a significant of amount of data via the long-term monitoring but also providing information on the sources of noise and vibration generating exceedances via the short-term or attended monitoring.

12.2.2 Noise & Vibration Monitoring Programme

The proposed noise and vibration monitoring program during the civil and construction works is outlined in Table 41.

Sensitive Receiver Details	Proposed Monitoring Type and Phase
Waterloo Congregational Church	Noise – Civil and Construction
	Vibration - Civil and Construction

Table 41 - Proposed noise and vibration monitoring locations details

The monitoring programme as shown above is to be carried out during the likely noisiest stages as agreed with the Acoustic Engineer and Contractor.

13. Conclusion

A noise and vibration impact assessment for the proposed Basement and Car Park within the Waterloo Metro Quarter Over Station Development has been conducted. This document forms part of the documentation package to be submitted to relevant authorities as part of the State Significant Development Application process (SSD-10438).

This report has provided criteria, in-principle treatment and design requirements which aim to achieve the statutory criteria discussed in Section 9. In terms of noise and vibration criteria, we have provided the following:

- Operational noise criteria provided in Section 9.2;
- Operational vibration criteria for human comfort and structural damage, provided in Section 9.3;
- Construction noise criteria and construction hours provided in Section 9.4; and
- Construction vibration criteria for human comfort and structural damage, provided in Section 9.5.

Having given regard to the analysis conducted within this report, it is the finding of this noise and vibration impact assessment that the proposed development is compliant with the relevant noise and vibration criteria controls for this type of development, and it is expected to comply with the applicable regulations with regards to noise and vibration, particularly those listed above.

It is recommended the state significant development application for the proposed development is not rejected on the basis of noise and vibration, under the implementation of the mitigation measures outlined within the report.

14. Appendices

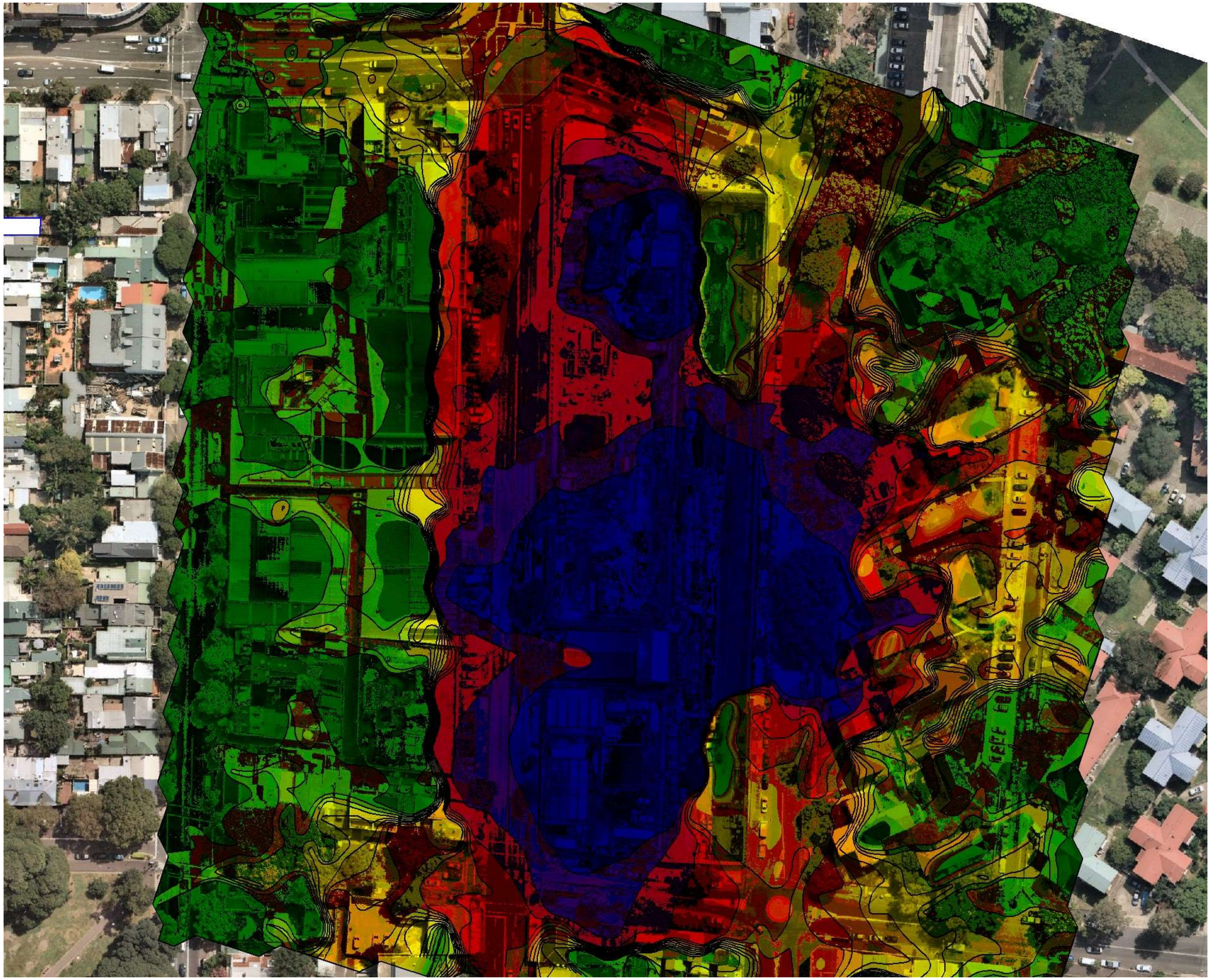
14.1 Appendix 1 – Glossary of Acoustic Terms

Acoustic Term	Definition
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the LA90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A-filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.

Acoustic Term	Definition
Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the LA90 noise level expressed in units of dB(A).
LAeq	The A-weighted “equivalent noise level” is the summation of noise events and integrated over a selected period of time.
LAeq,T	The constant A-weighted sound which has the same energy as the fluctuating sound of the measurement, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
Rw:	The Sound Insulation Rating Rw is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.

14.2 Appendix 2 – Construction Assessment Grid Noise Map

14.2.1 Cumulative Construction Noise Modelling Results



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001	DA Package	MIS	BN	10/07/20

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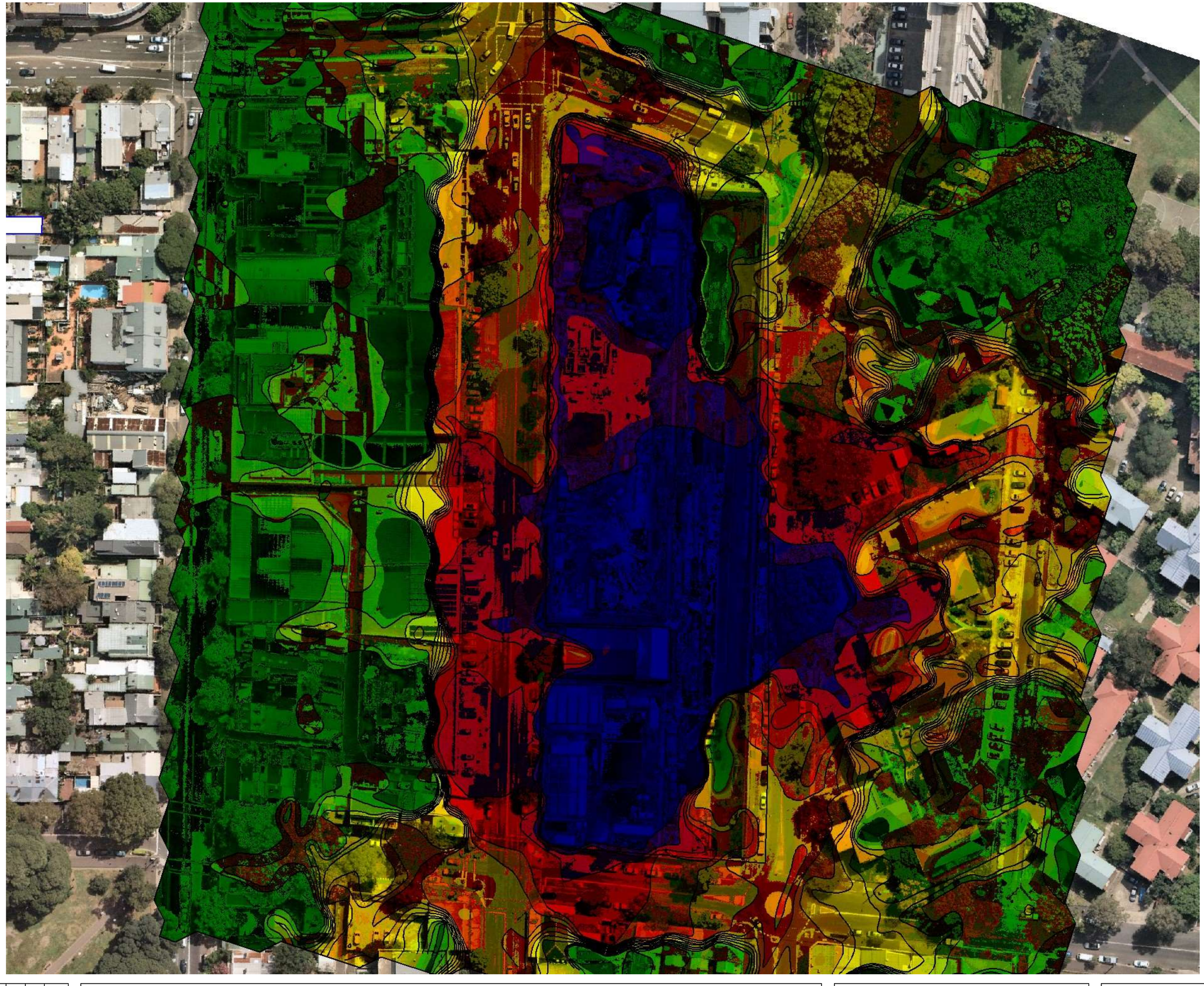

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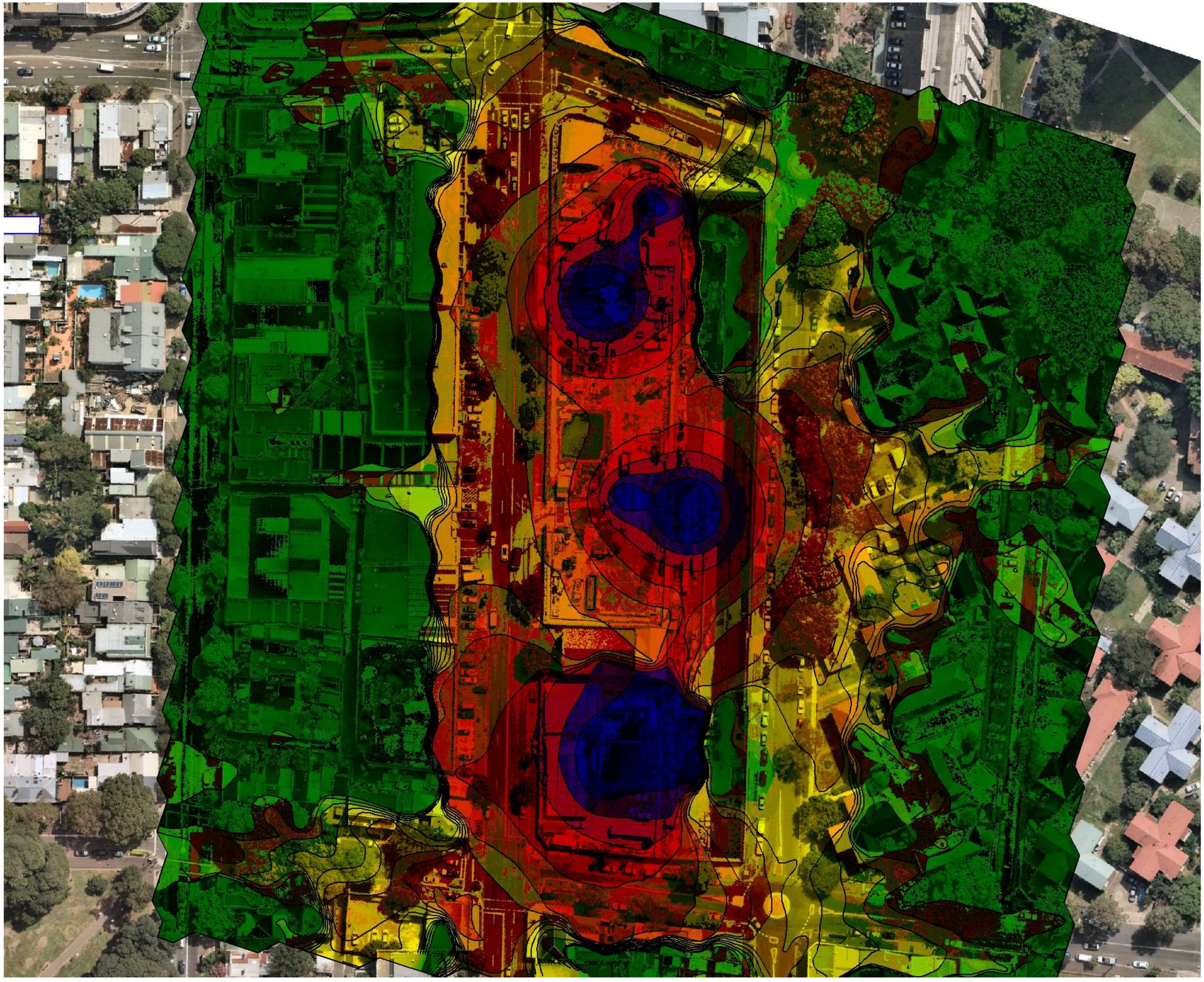

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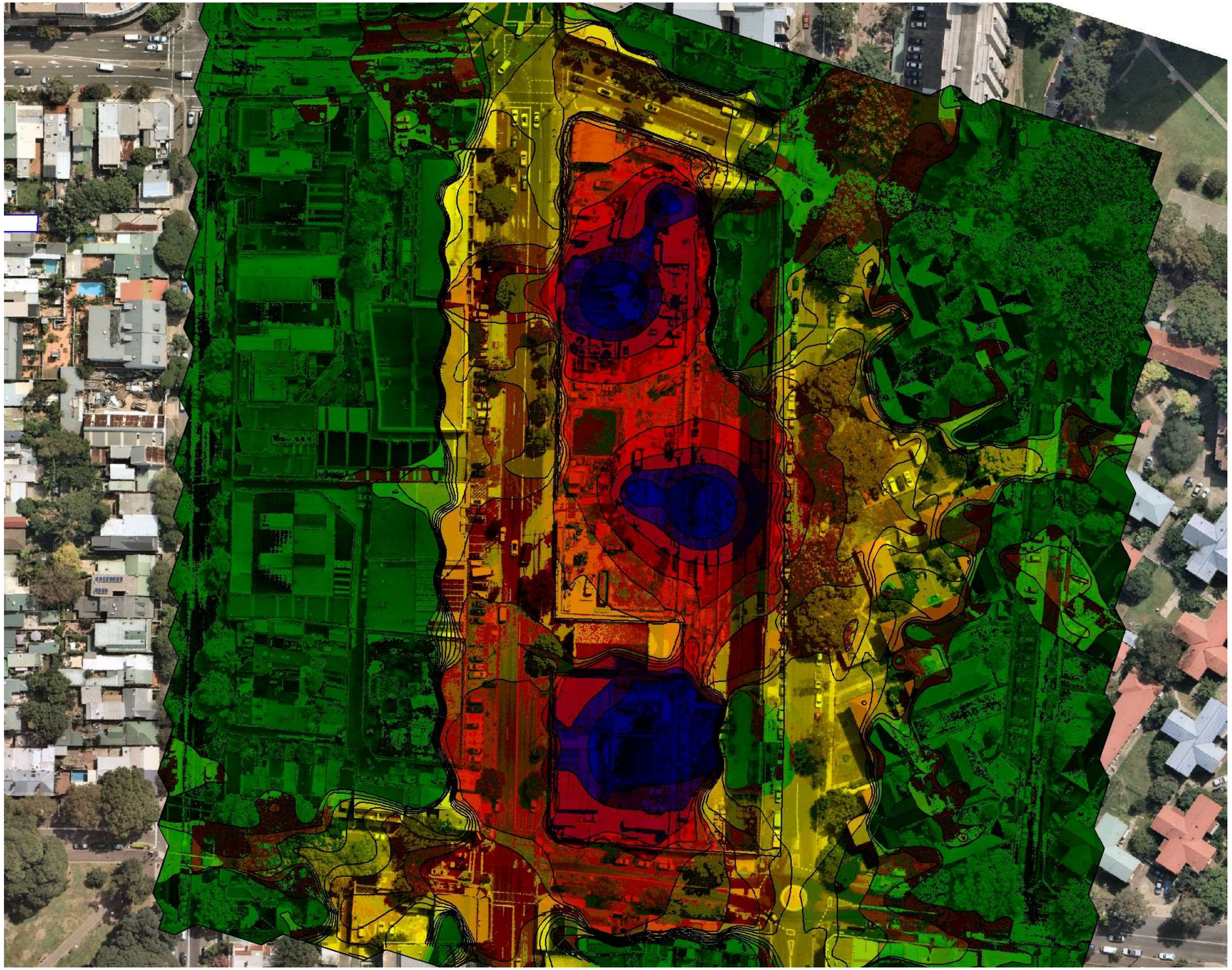

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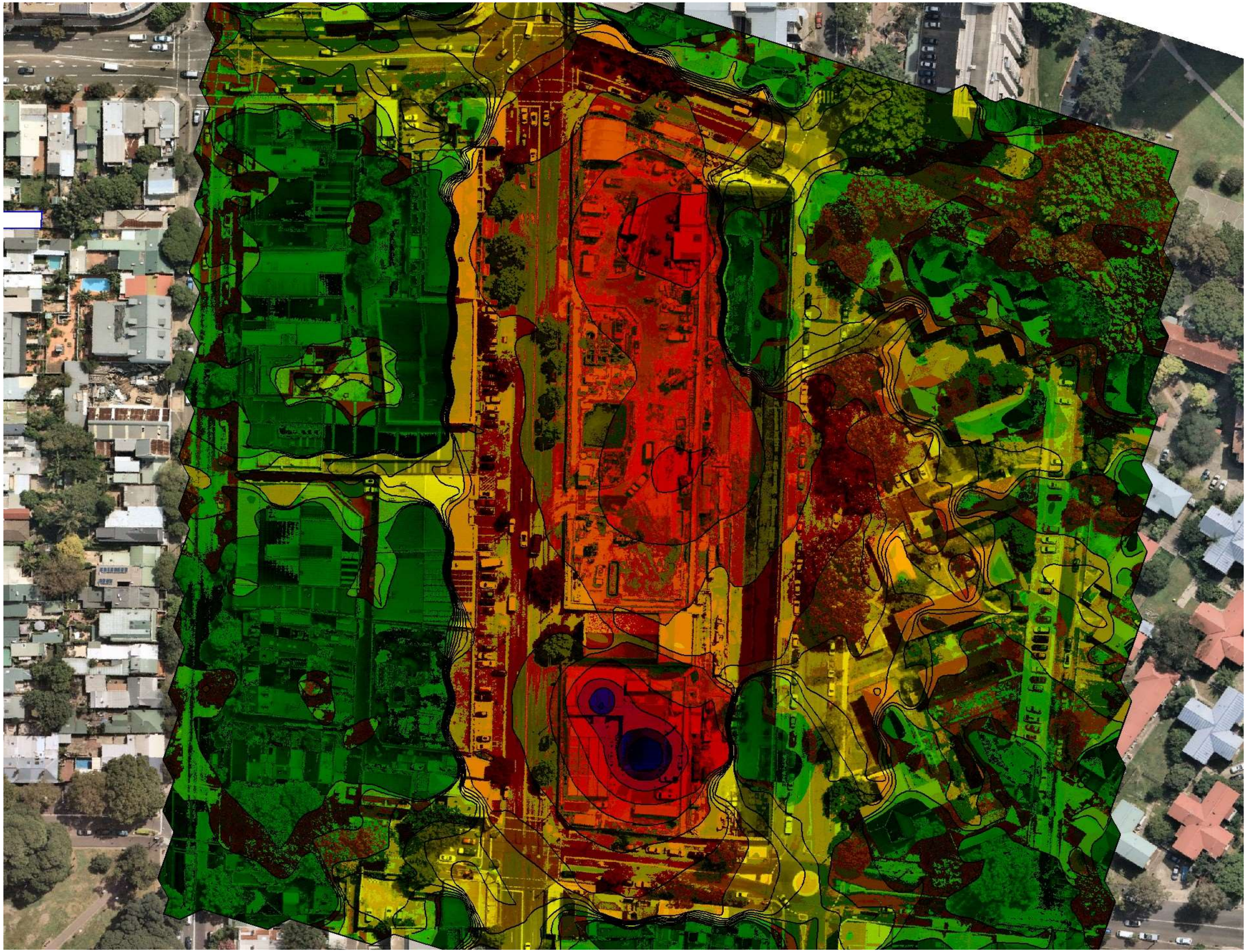

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L6 TO L10, NO MITIGATION

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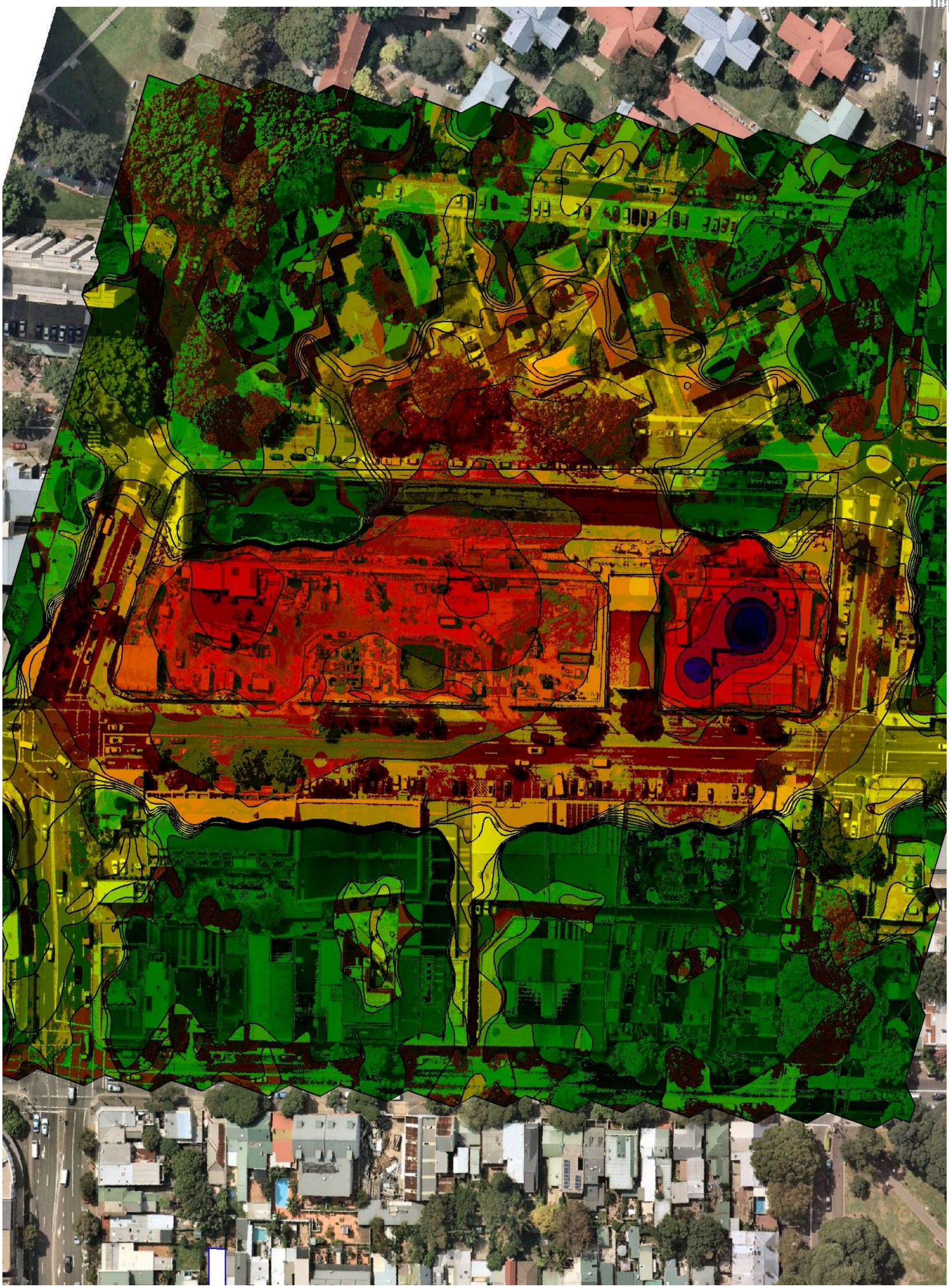

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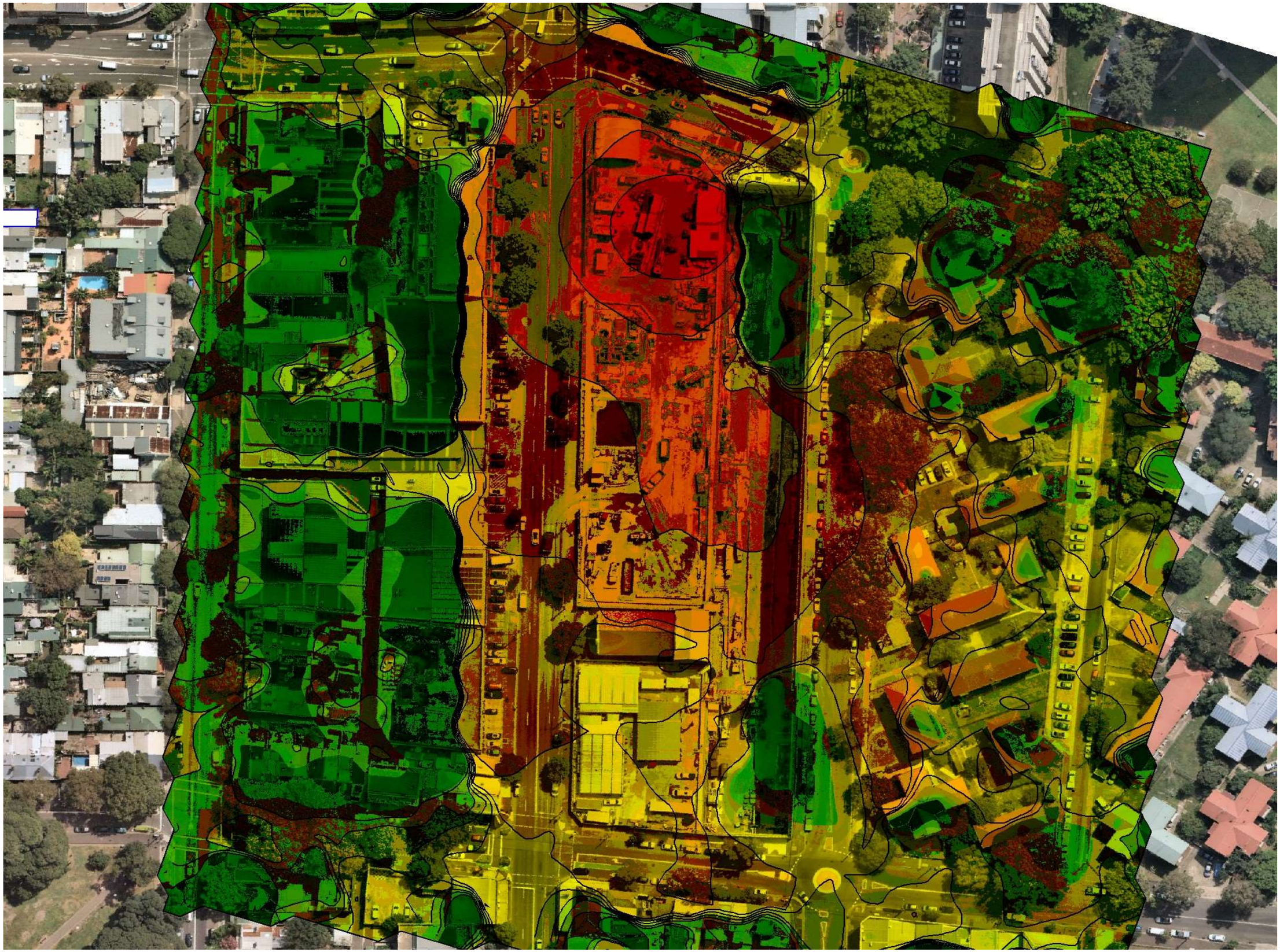

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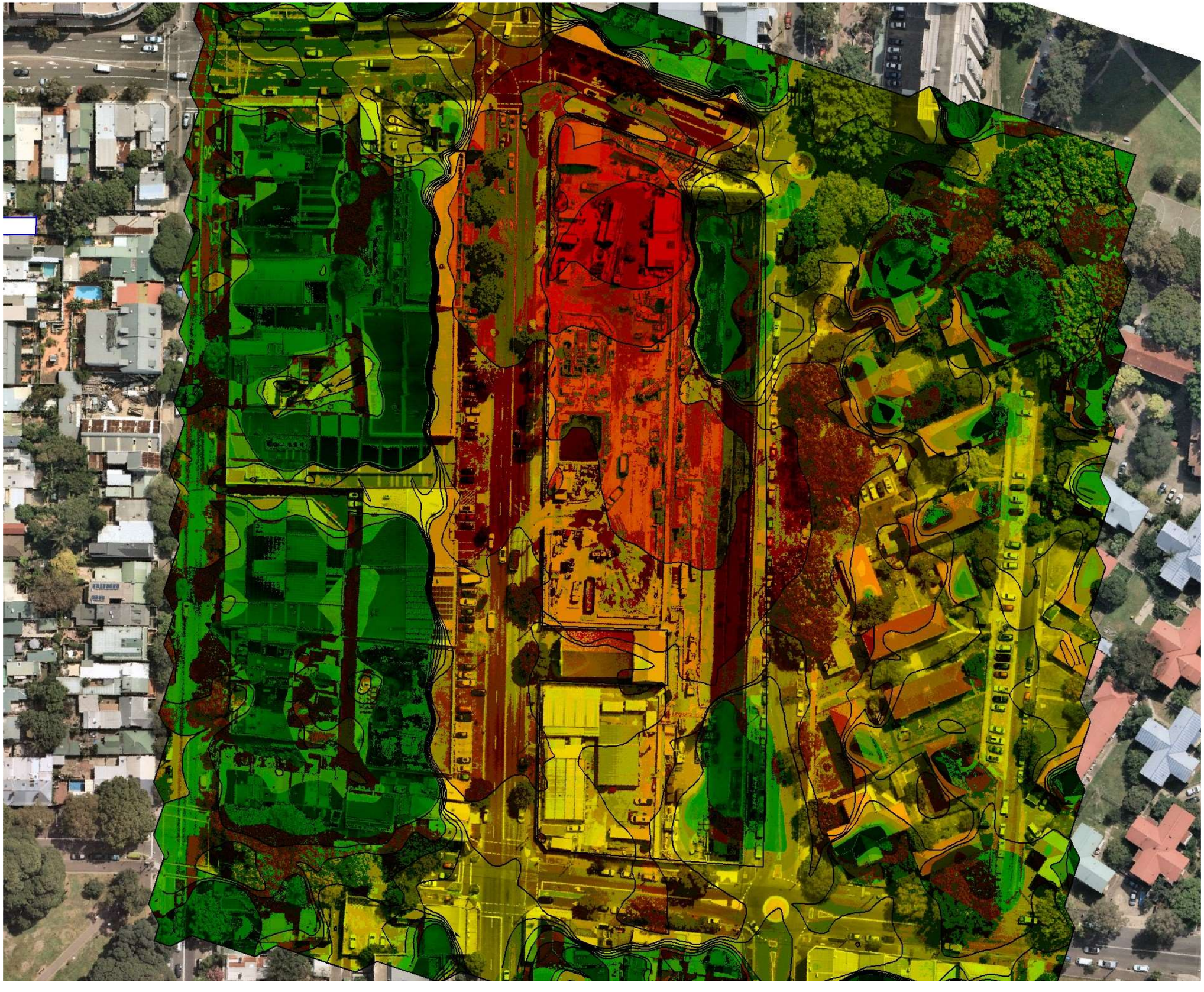

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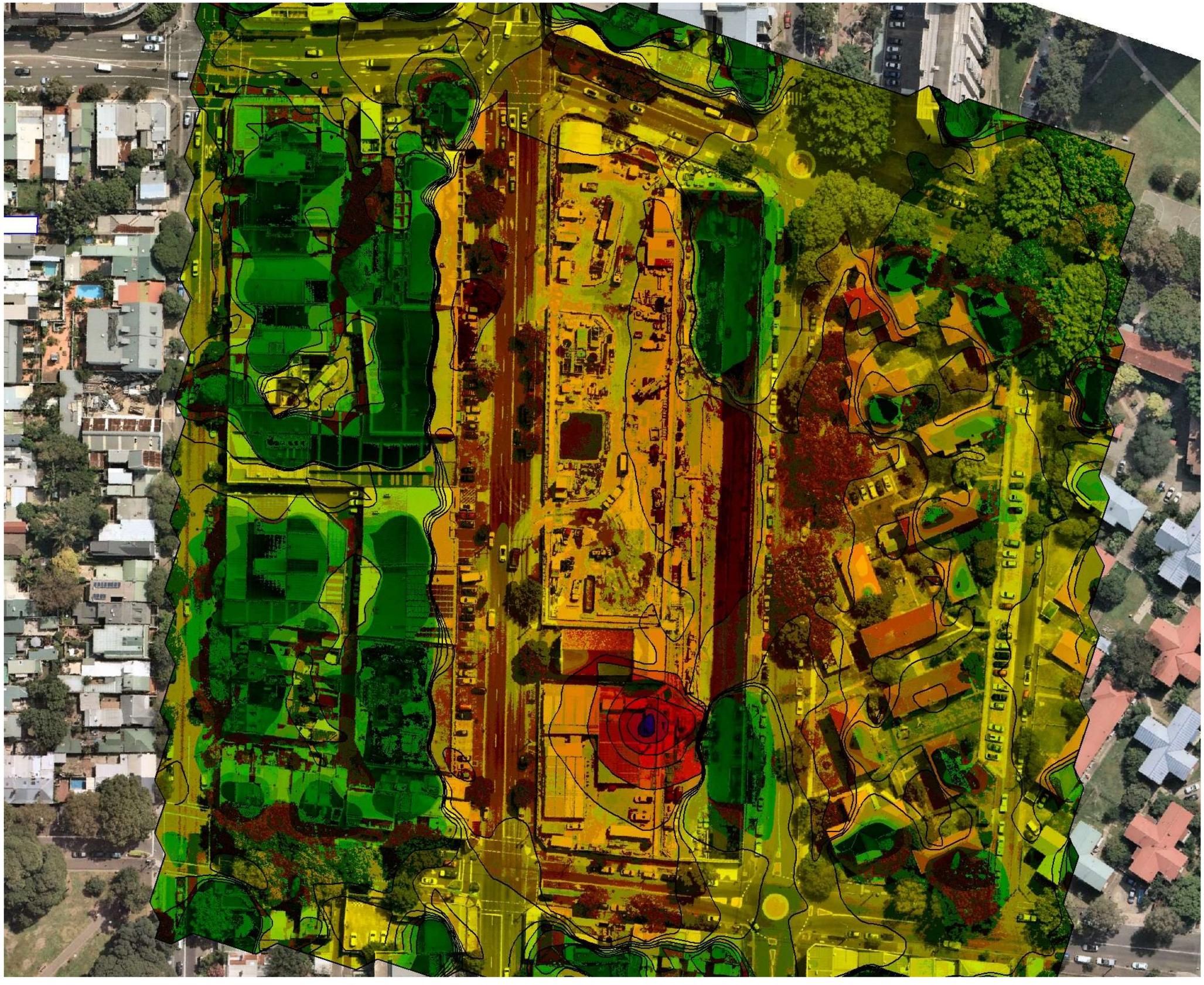

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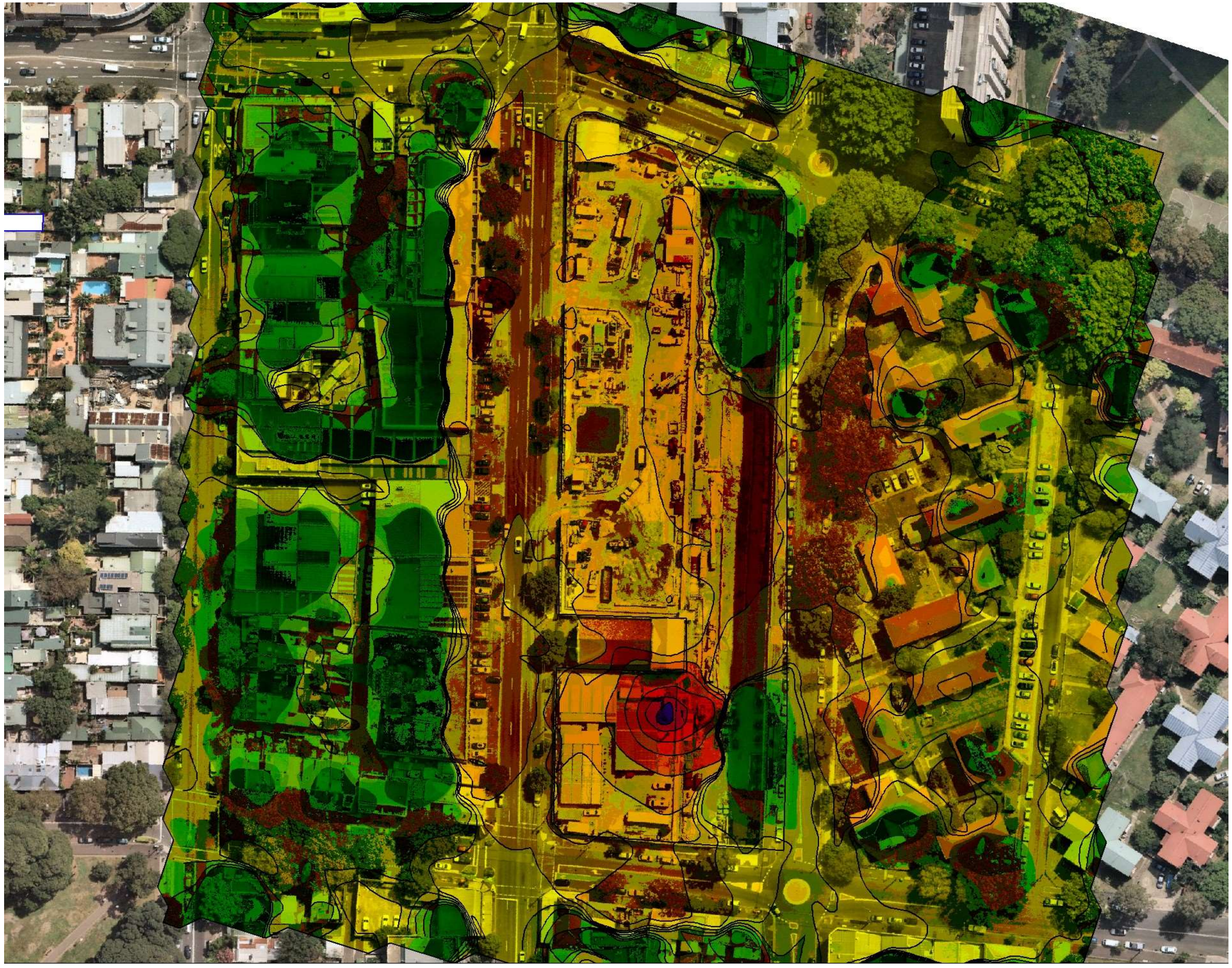

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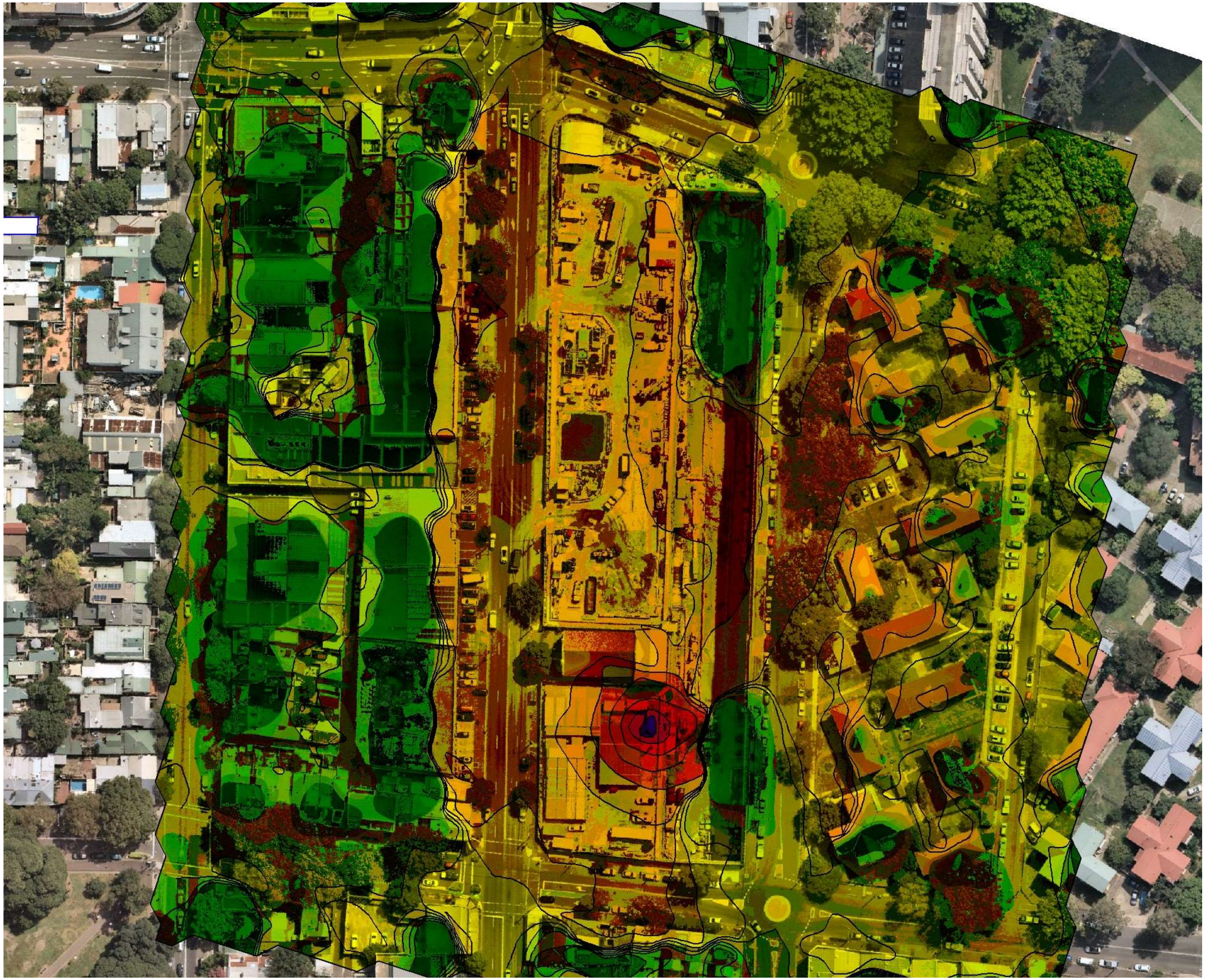

REV	DESCRIPTION	DRAWN	APPD	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

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ARCHITECT/CLIENT

WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

PROJECT

CONSTRUCTION NOISE EMISSIONS - STRUCTURE L21 TO L24, NO MITIGATION

TITLE

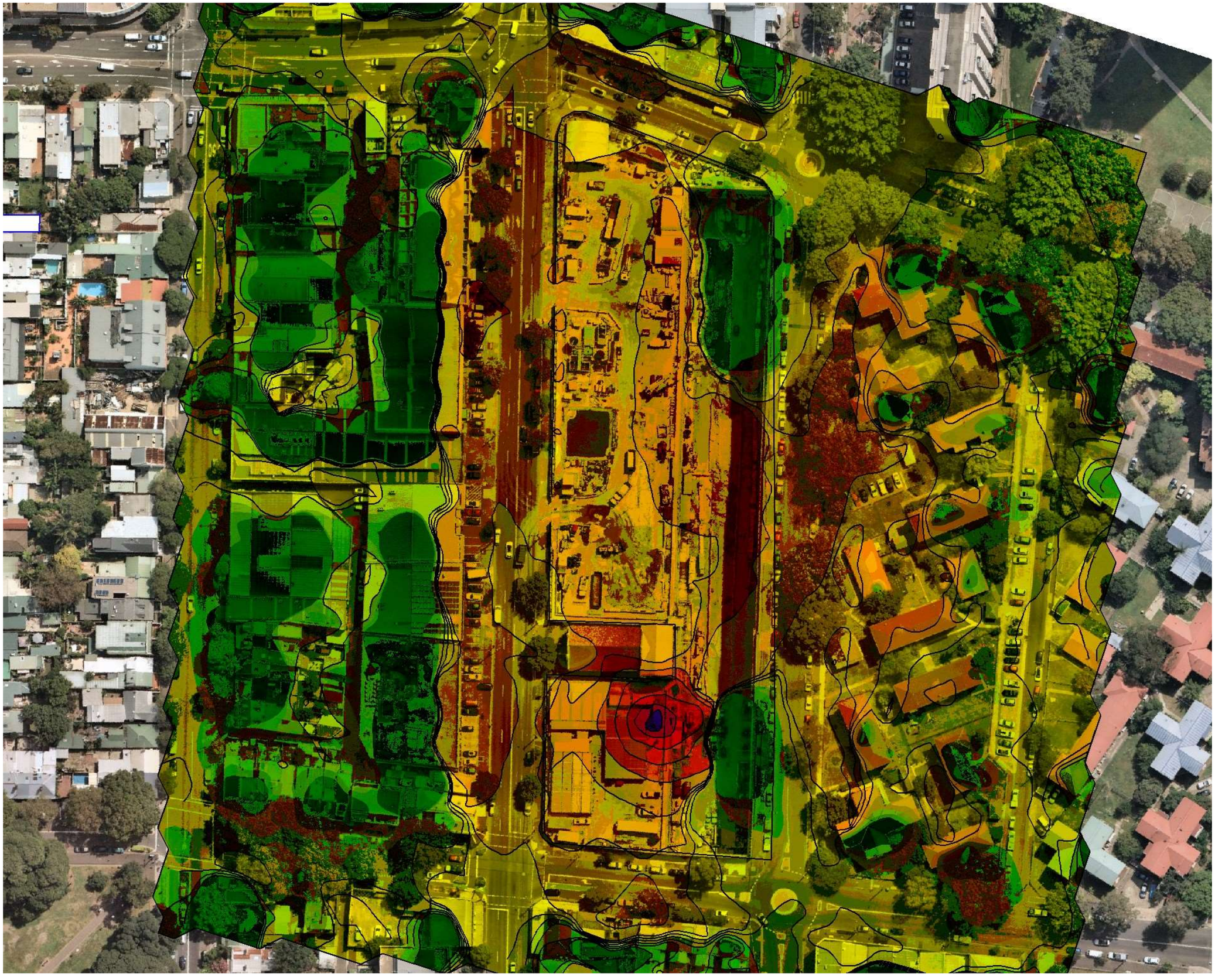
Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001



REV	DESCRIPTION	DRAWN	APPD	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

	< 45		49-51		55-57		61-63		67-69
	45-47		51-53		57-59		63-65		69-71
	47-49		53-55		59-61		65-67		> 71

ARCHITECT/CLIENT

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE L21 TO L24, WITH MITIGATION

Stantec

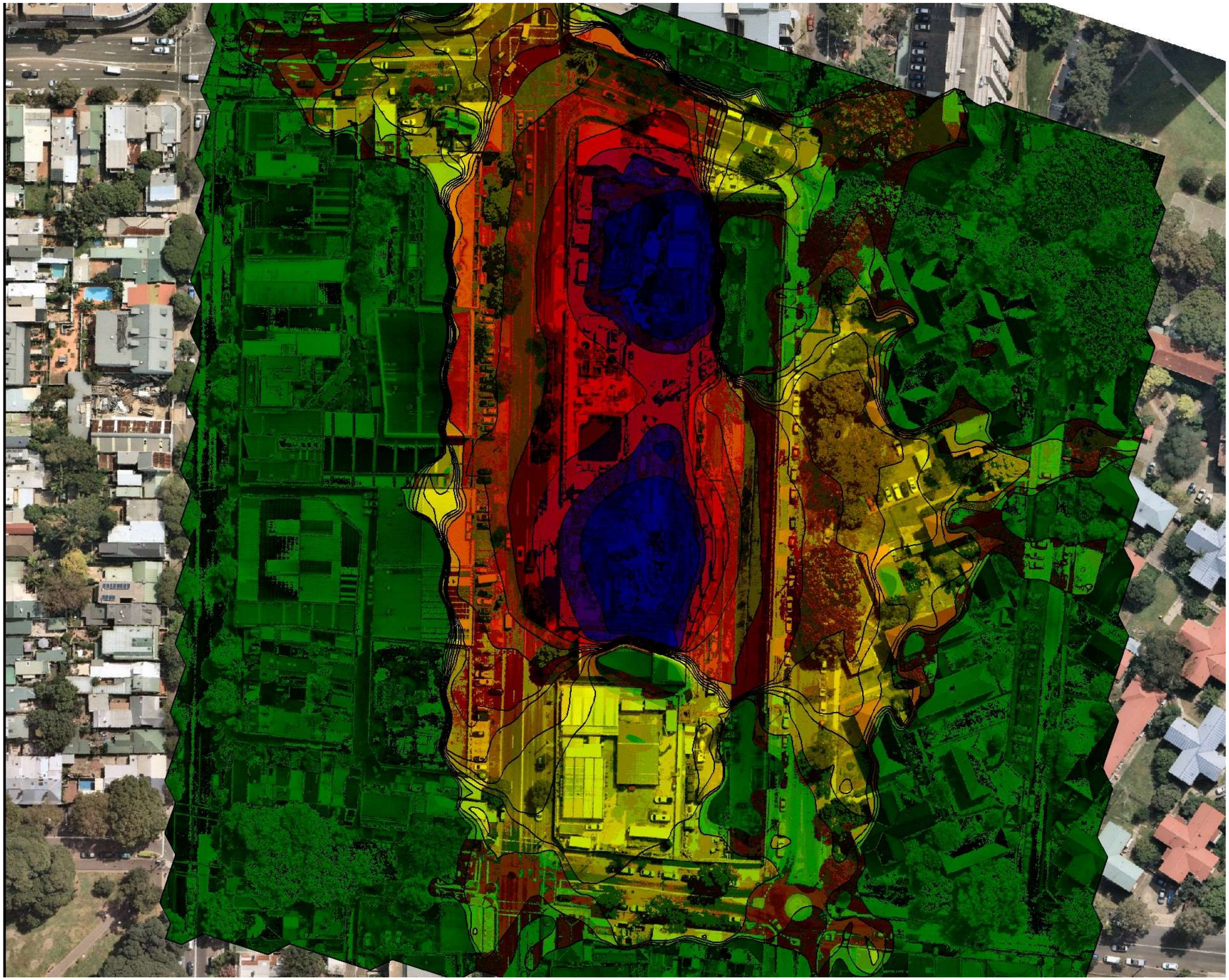
Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001

14.2.2 Basement Construction Noise Modelling Results



REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	19/06/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

ARCHITECT/CLIENT

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - BASEMENT

TITLE: CONSTRUCTION NOISE EMISSIONS -EXCAVATION, NO MITIGATION

Stantec

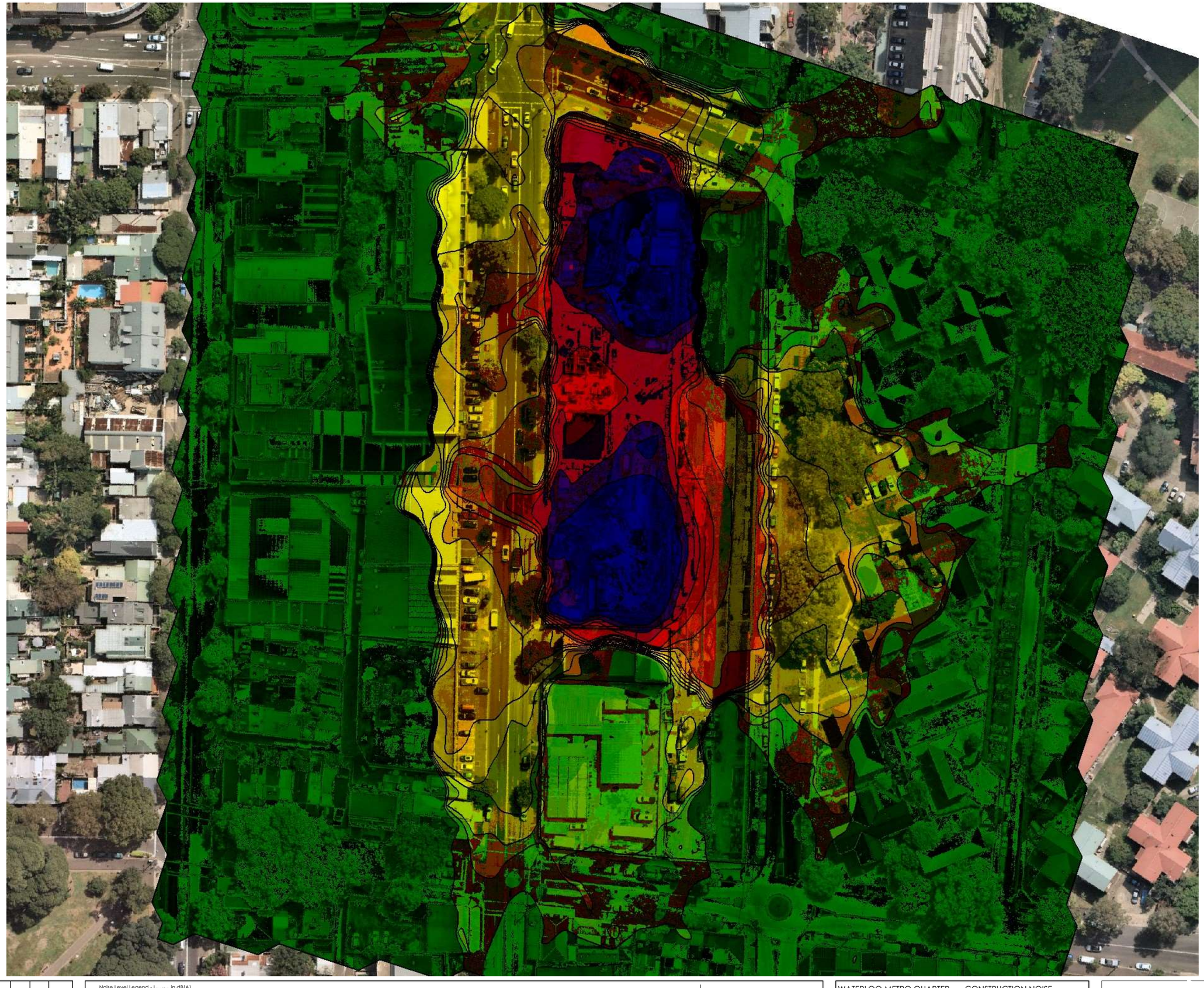
Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	BSMT-AC-GRM	001

THIS DRAWING HAS BEEN DOCUMENTED IN COLOUR
THIS DRAWING IS REQUIRED TO BE PRINTED IN COLOUR
FAILURE TO DO SO MAY RESULT IN LOSS OF INFORMATION
BLACK & WHITE PRINTING MAY BE USED IF SPECIFIC BLACK & WHITE DOCUMENTS HAVE BEEN OBTAINED FROM WGE



REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	19/06/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

	< 45		49-51		55-57		61-63		67-69
	45-47		51-53		57-59		63-65		69-71
	47-49		53-55		59-61		65-67		> 71

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WATERLOO METRO QUARTER DEVELOPMENT - BASEMENT

PROJECT

CONSTRUCTION NOISE EMISSIONS -EXCAVATION, WITH MITIGATION

TITLE

Stantec

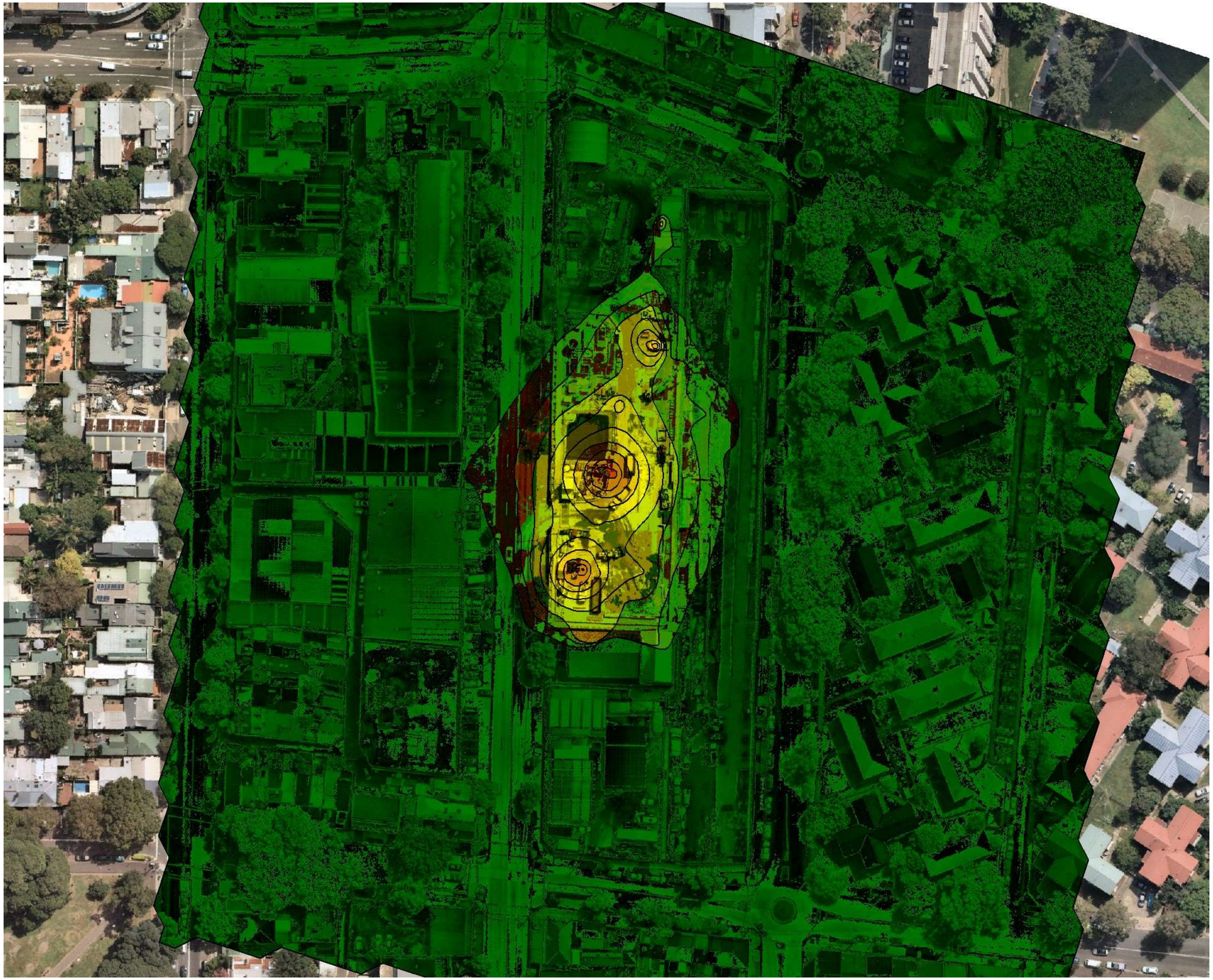
Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A3	PROJECT No	DRAWING No	REV
1:200	46198	BSMT-AC-GRM	001

THIS DRAWING HAS BEEN DOCUMENTED IN COLOUR
THIS DRAWING IS REQUIRED TO BE PRINTED IN COLOUR
FAILURE TO DO SO MAY RESULT IN LOSS OF INFORMATION
BLACK & WHITE PRINTING MAY BE USED IF SPECIFIC BLACK & WHITE DOCUMENTS HAVE BEEN OBTAINED FROM WGE



REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	19/06/20

ARCHITECT/CLIENT

PROJECT: WATERLOO METRO QUARTER DEVELOPMENT - BASEMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - CONSTRUCTION OF BASEMENT, NO MITIGATION

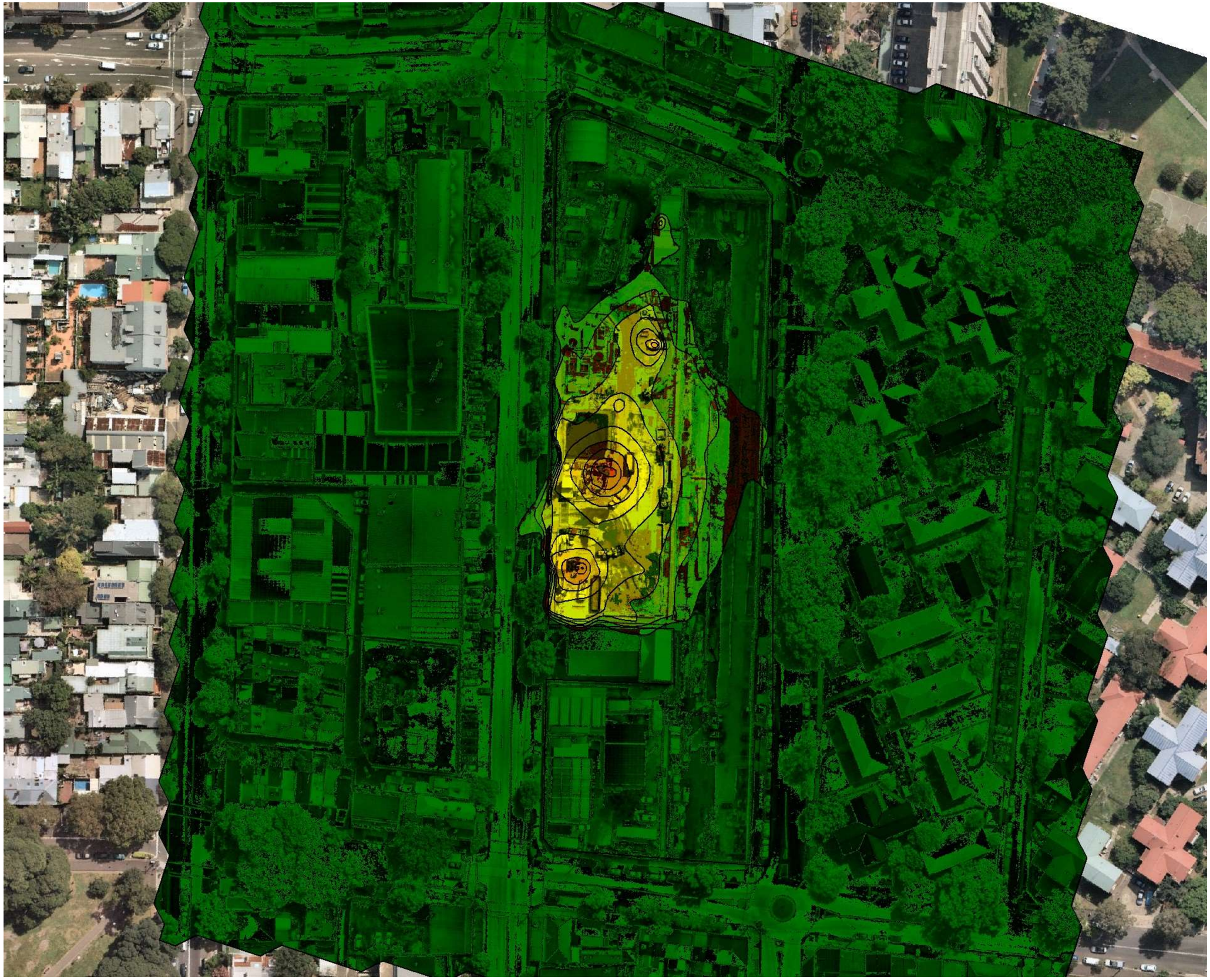
Stantec

Noise Model

Construction Noise Modeling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	BSMT-AC-GRM	001



REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	19/06/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

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WATERLOO METRO QUARTER DEVELOPMENT - BASEMENT

PROJECT

CONSTRUCTION NOISE EMISSIONS - CONSTRUCTION OF BASEMENT, WITH MITIGATION

TITLE

Stantec

Noise Model

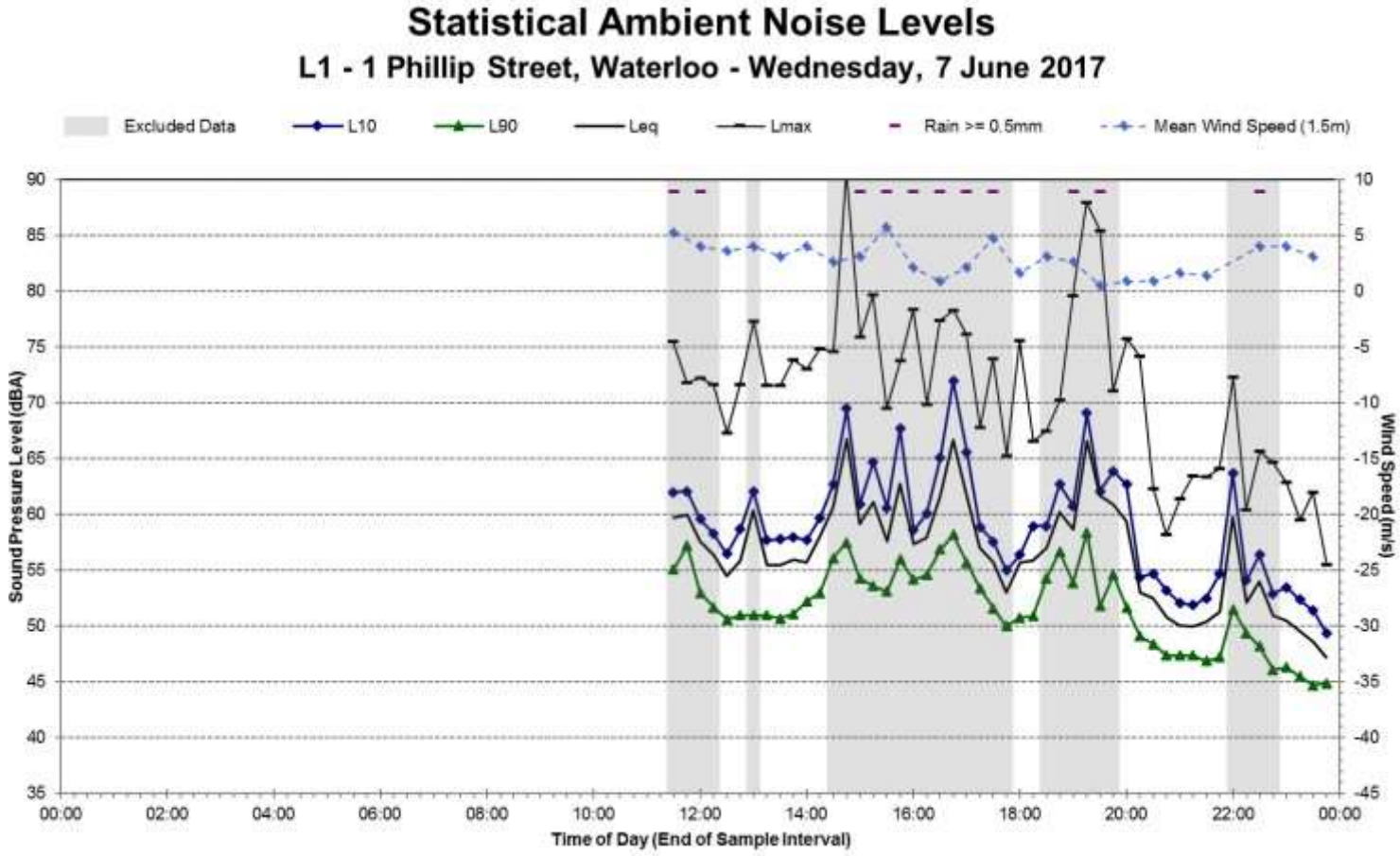
Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	BSMT-AC-GRM	001

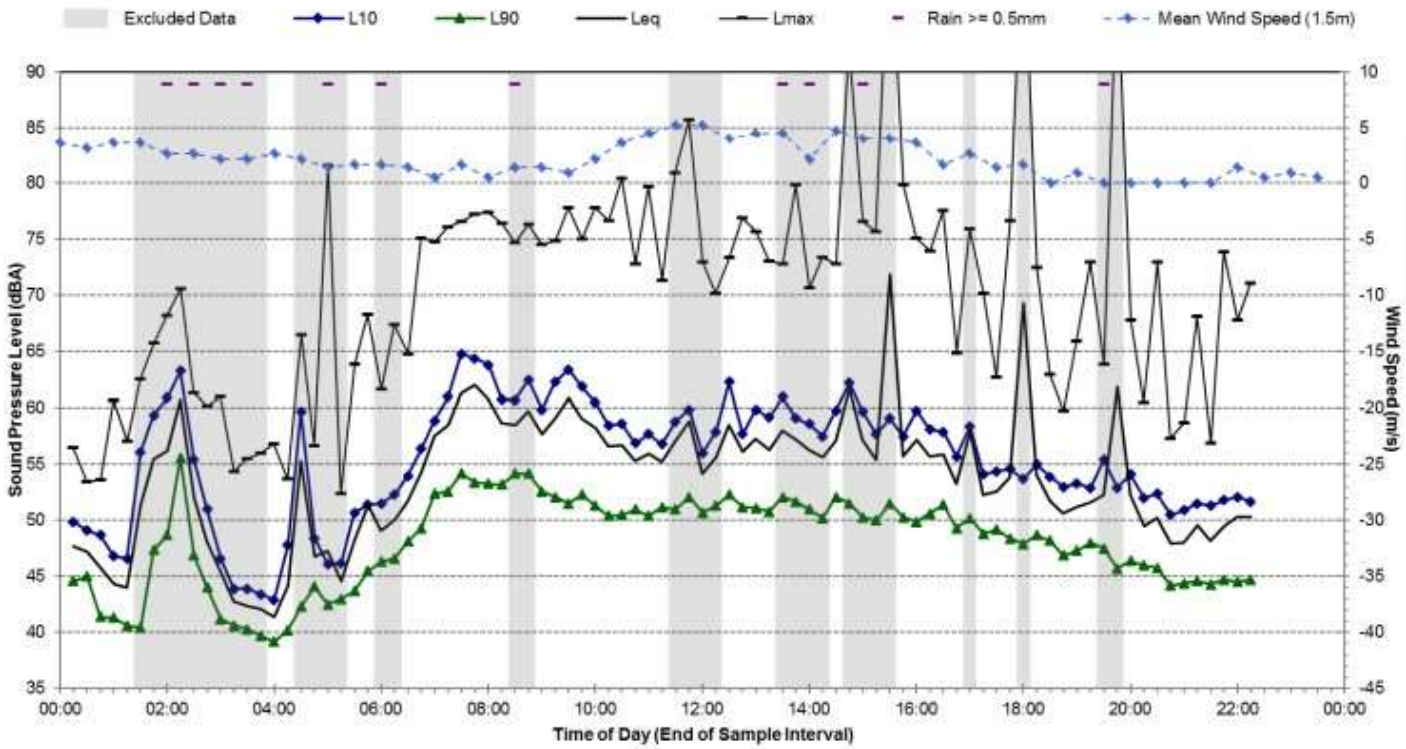
14.3 Appendix 3 – Daily Long-Term (Unattended) Noise Survey Results

14.3.1 Historical Noise Survey Results by SLR Consulting



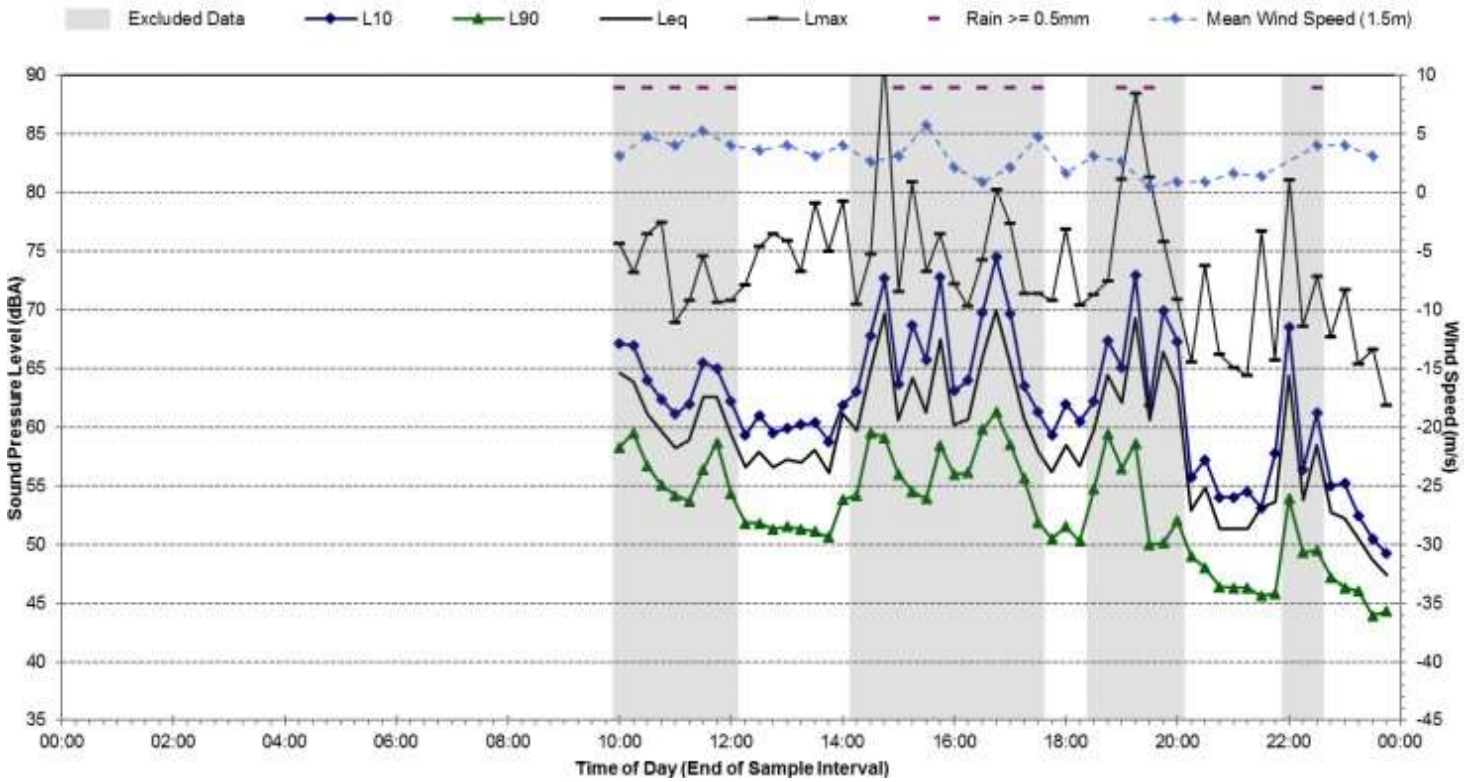
Statistical Ambient Noise Levels

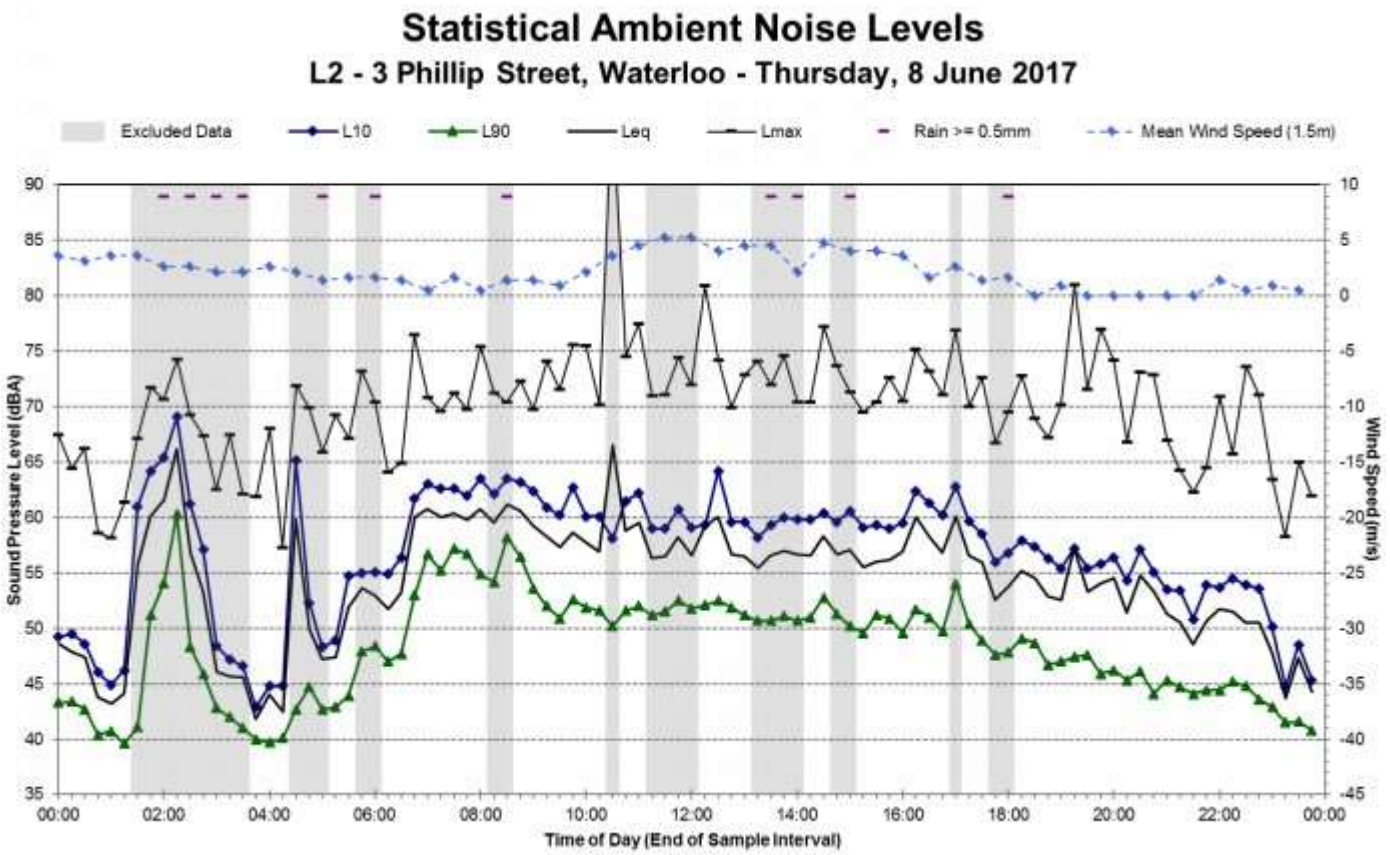
L1 - 1 Phillip Street, Waterloo - Thursday, 8 June 2017



Statistical Ambient Noise Levels

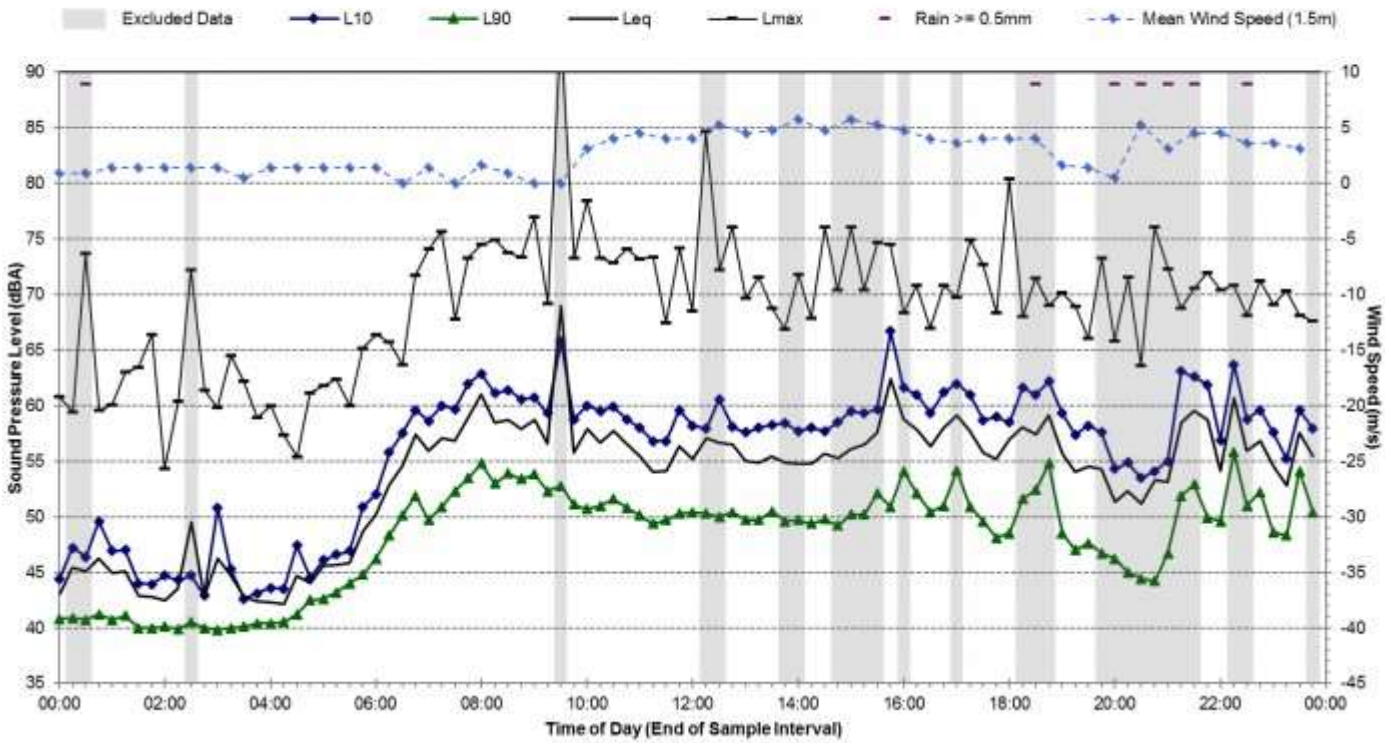
L2 - 3 Phillip Street, Waterloo - Wednesday, 7 June 2017





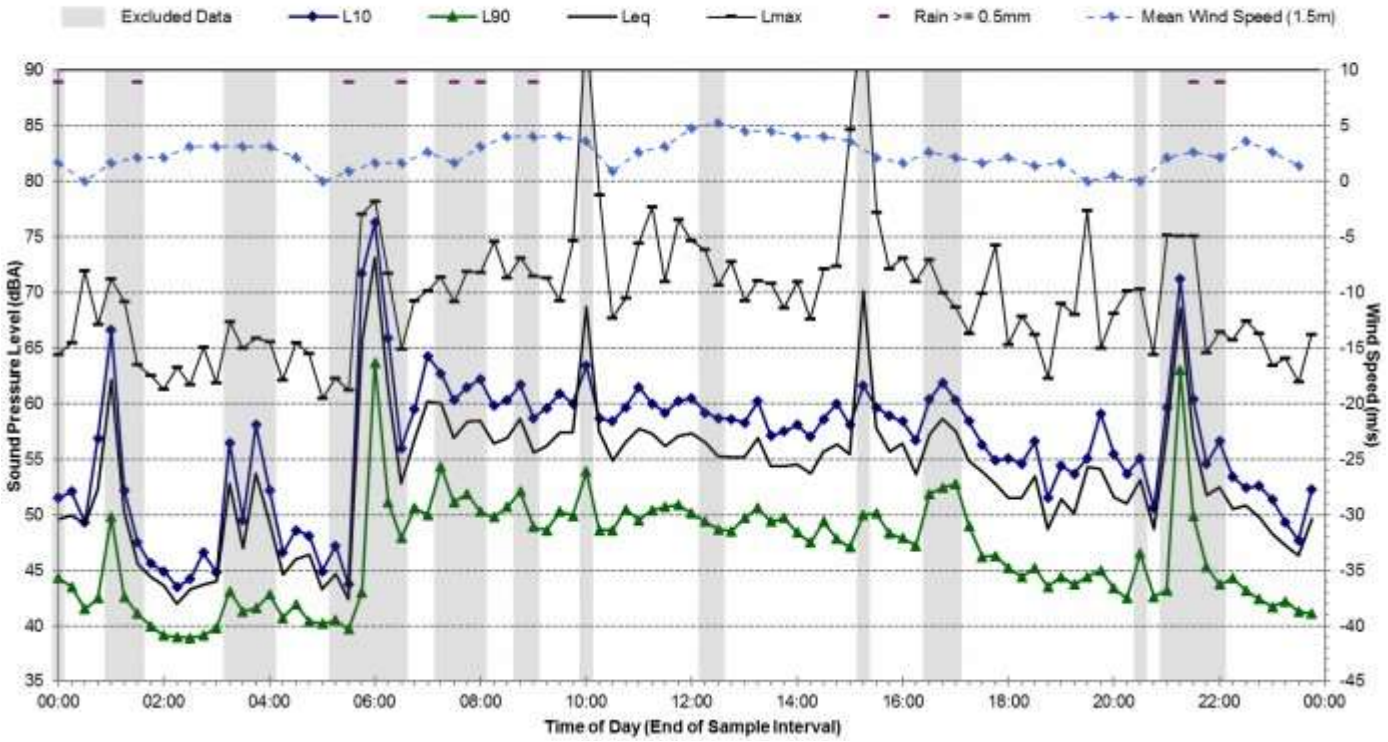
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Friday, 9 June 2017



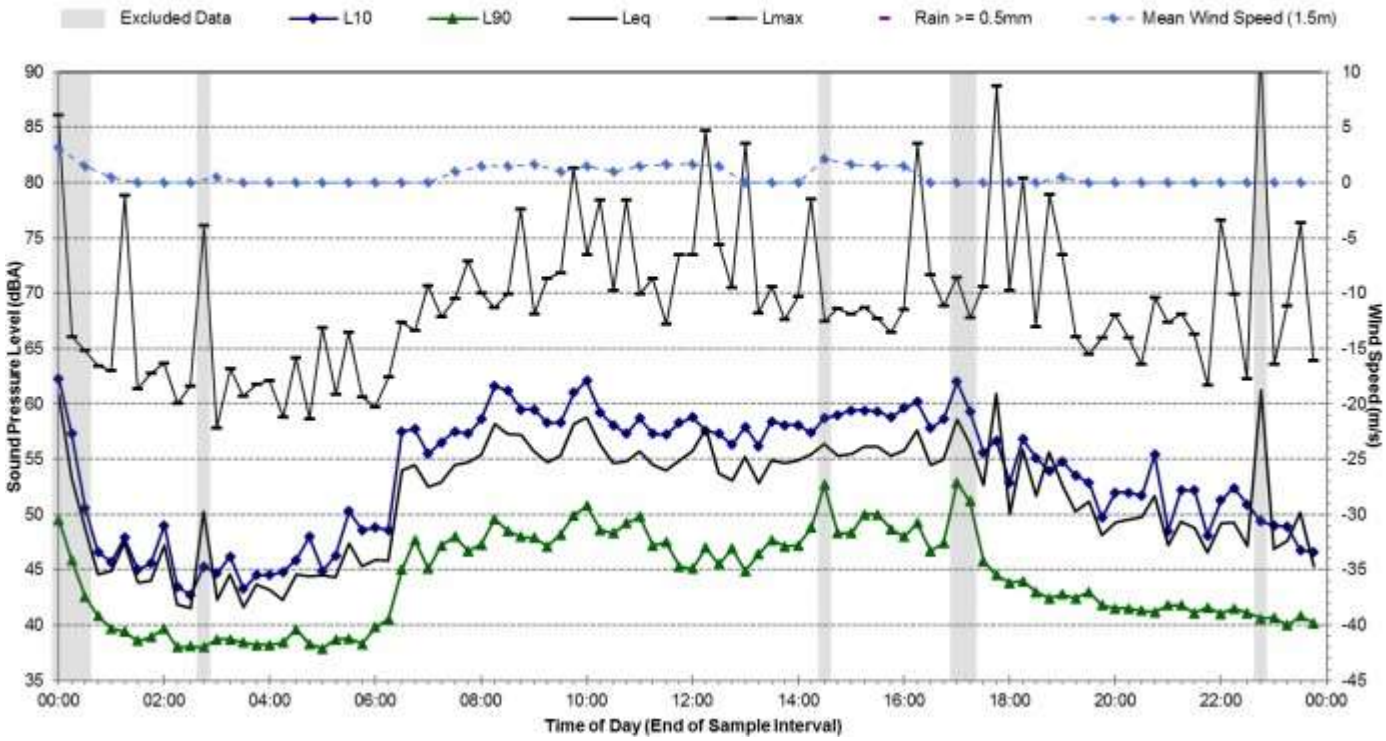
Statistical Ambient Noise Levels

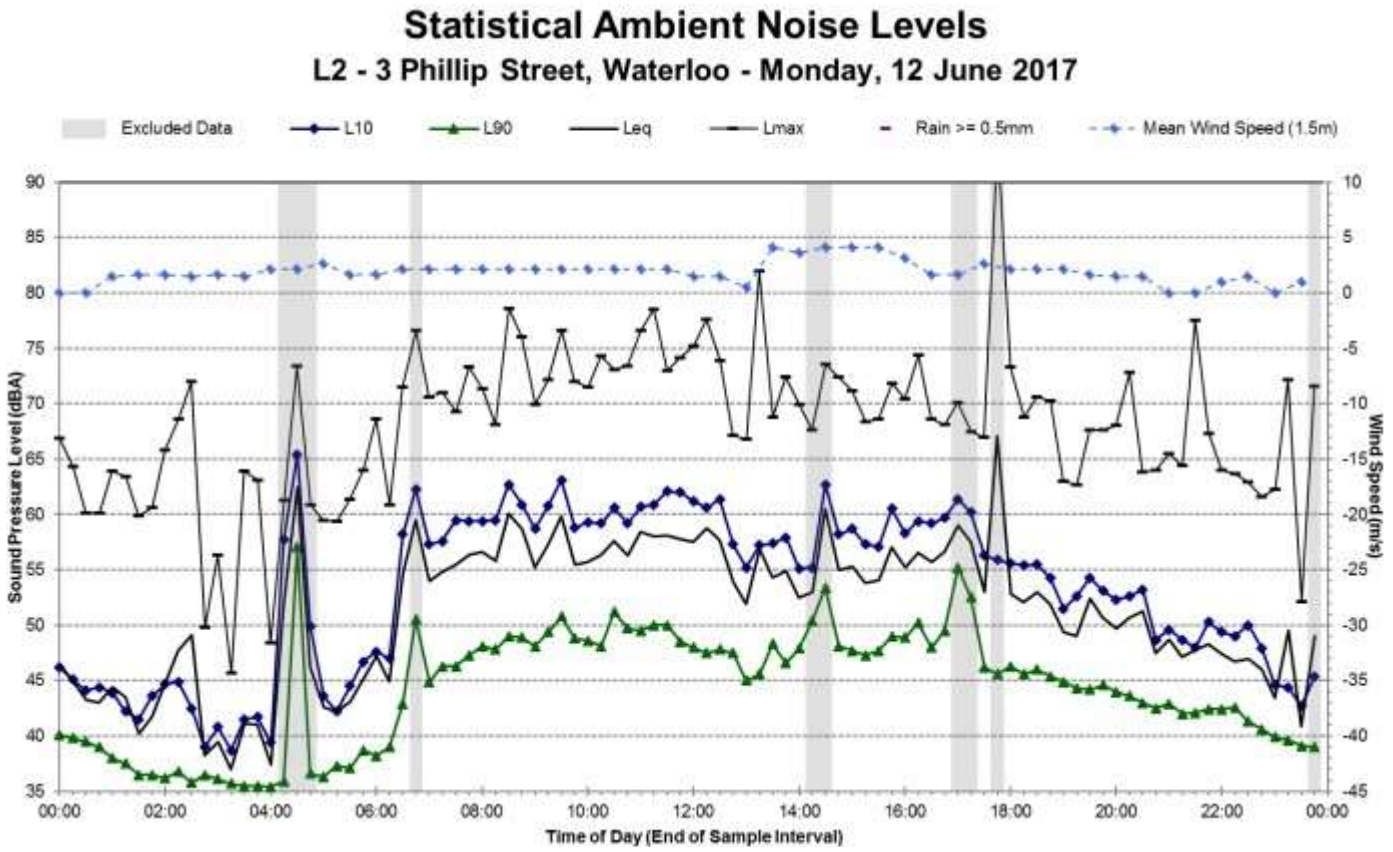
L2 - 3 Phillip Street, Waterloo - Saturday, 10 June 2017



Statistical Ambient Noise Levels

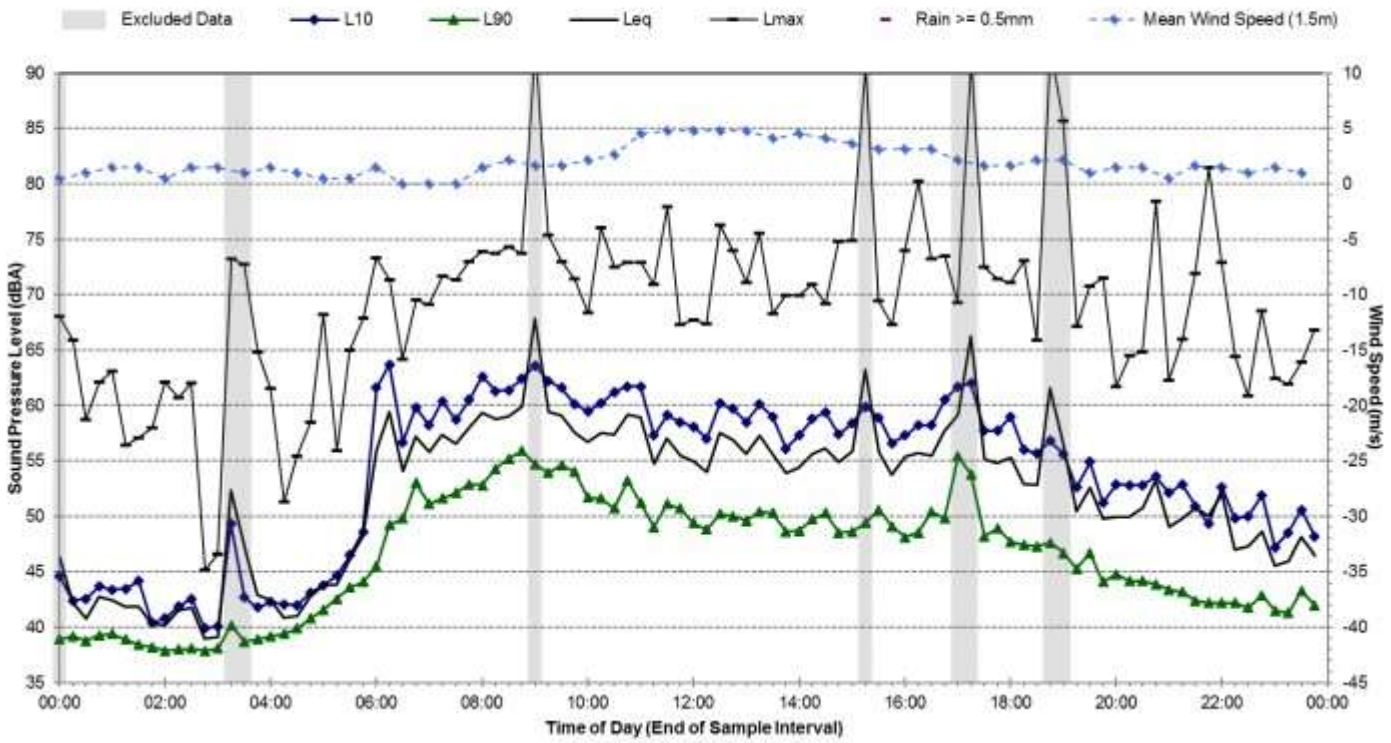
L2 - 3 Phillip Street, Waterloo - Sunday, 11 June 2017

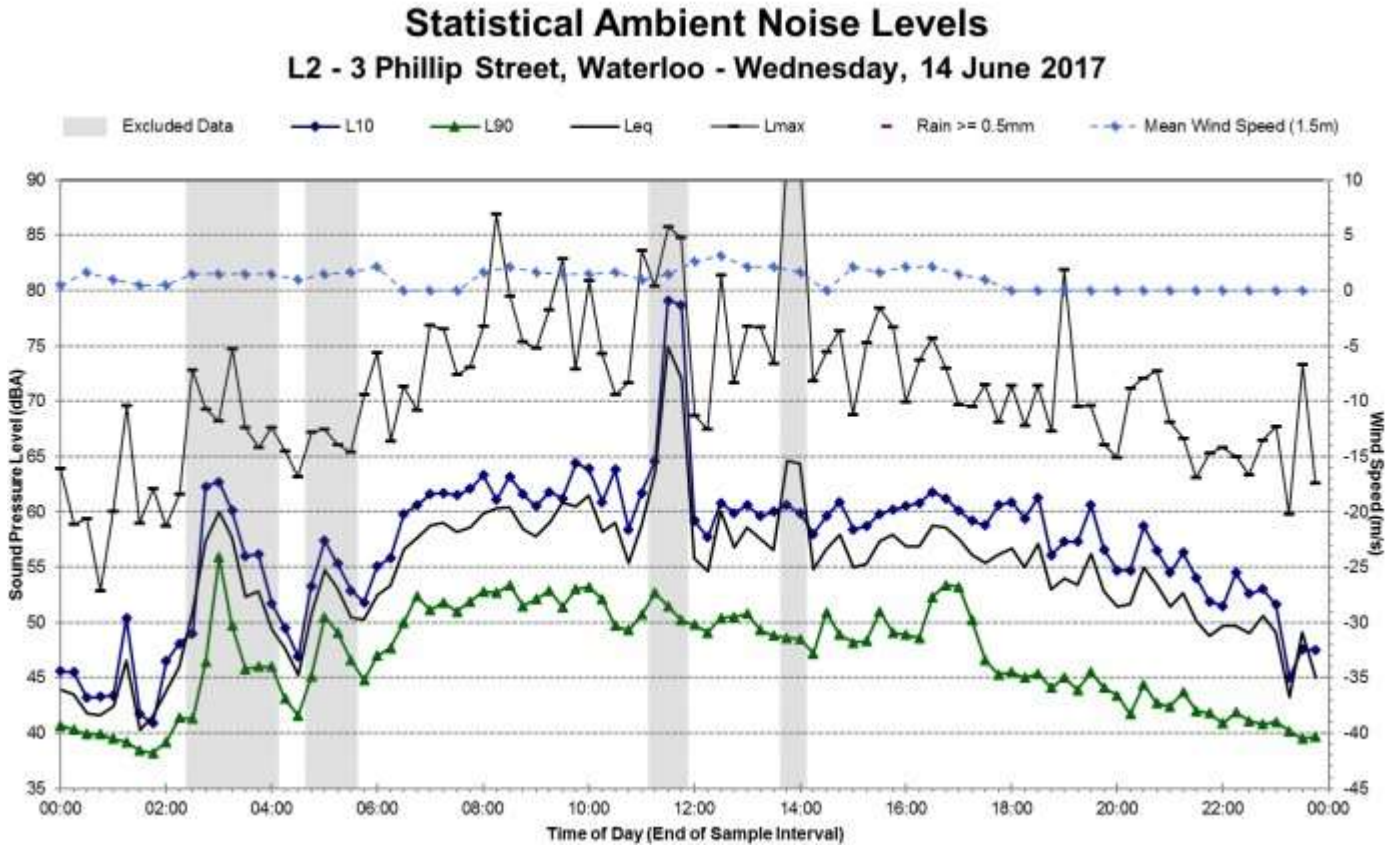


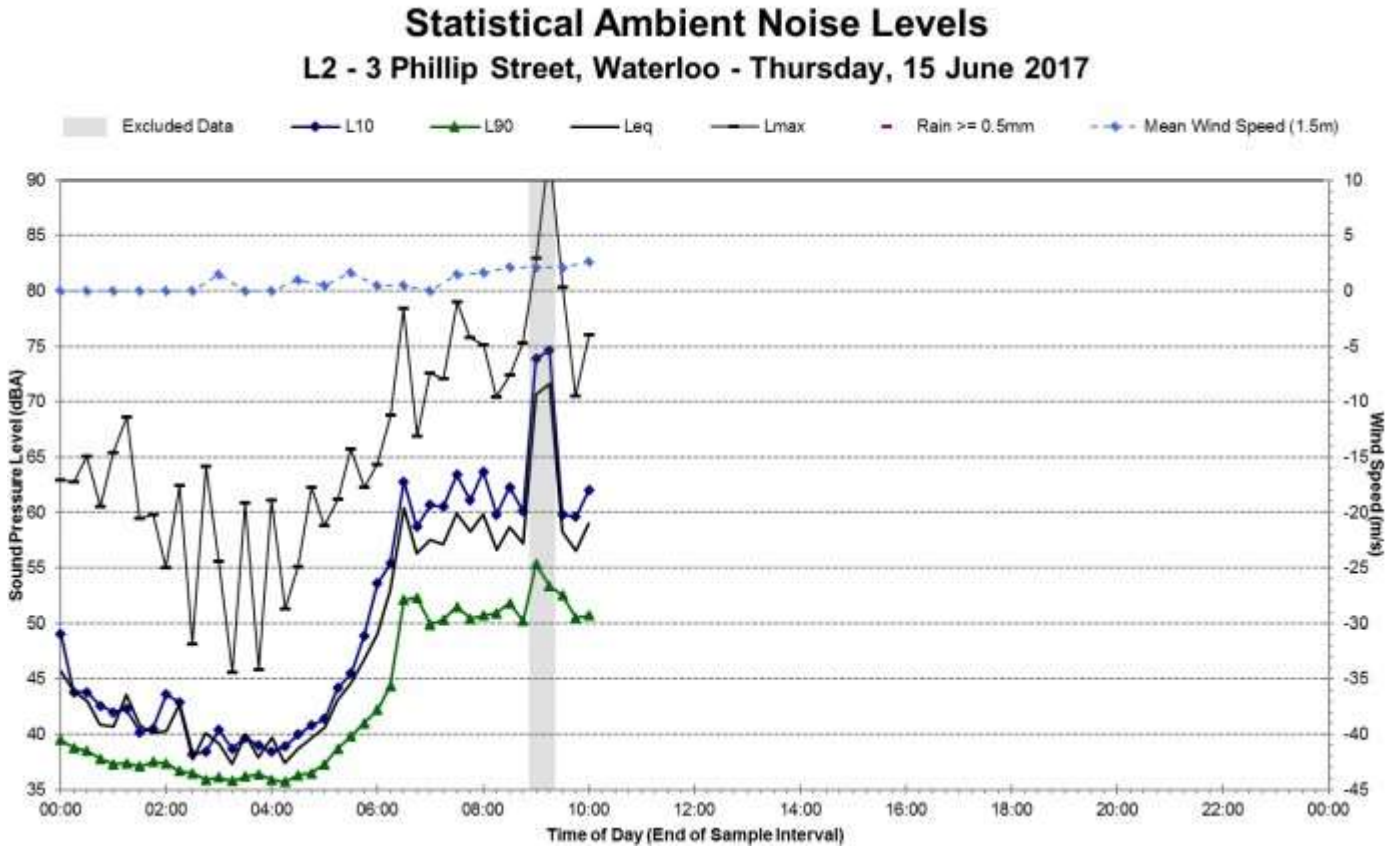


Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Tuesday, 13 June 2017

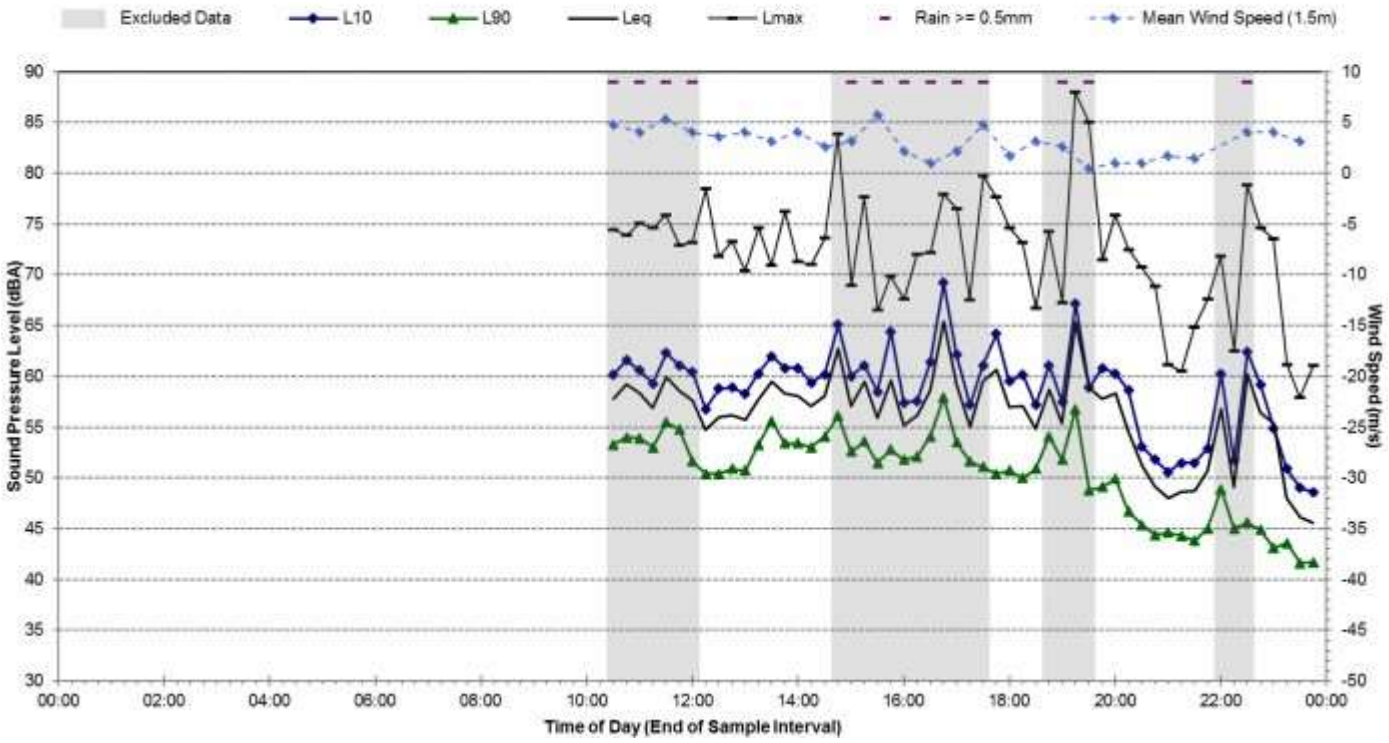






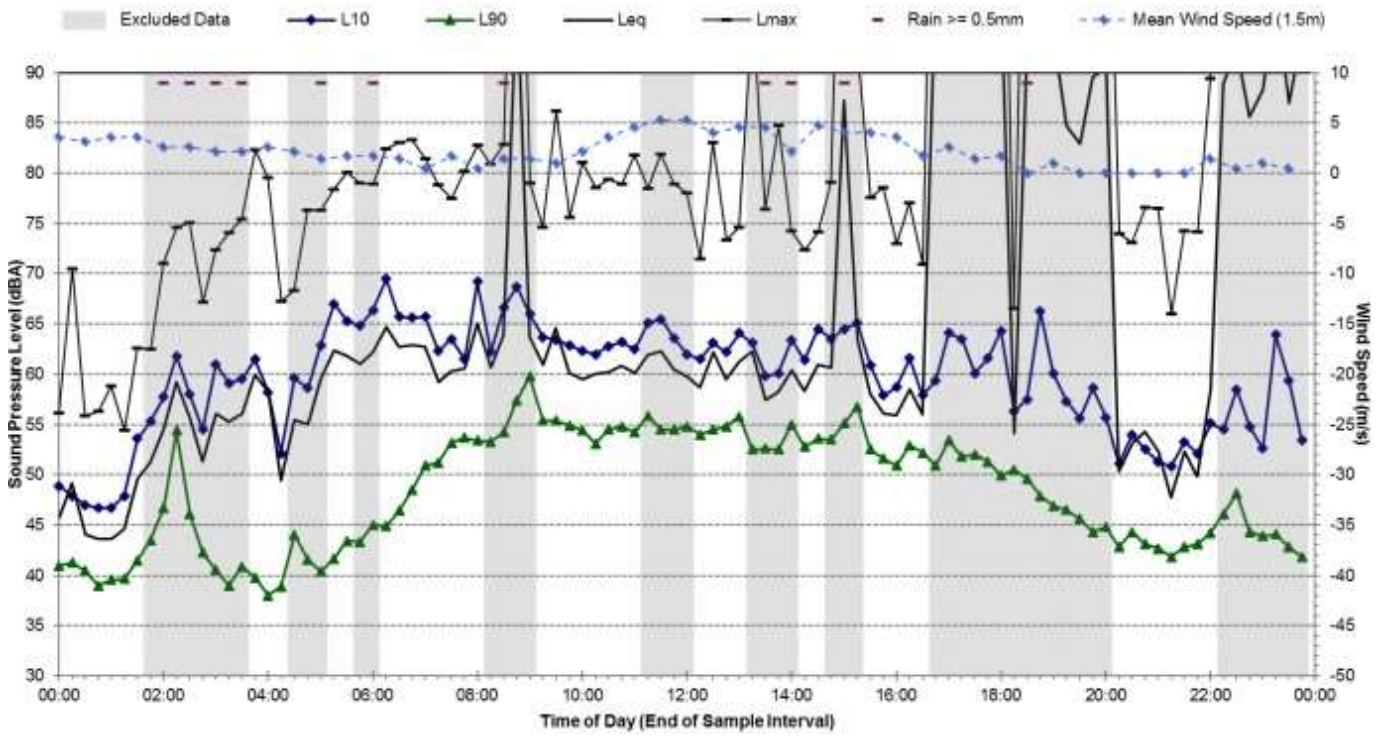
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Wednesday, 7 June 2017



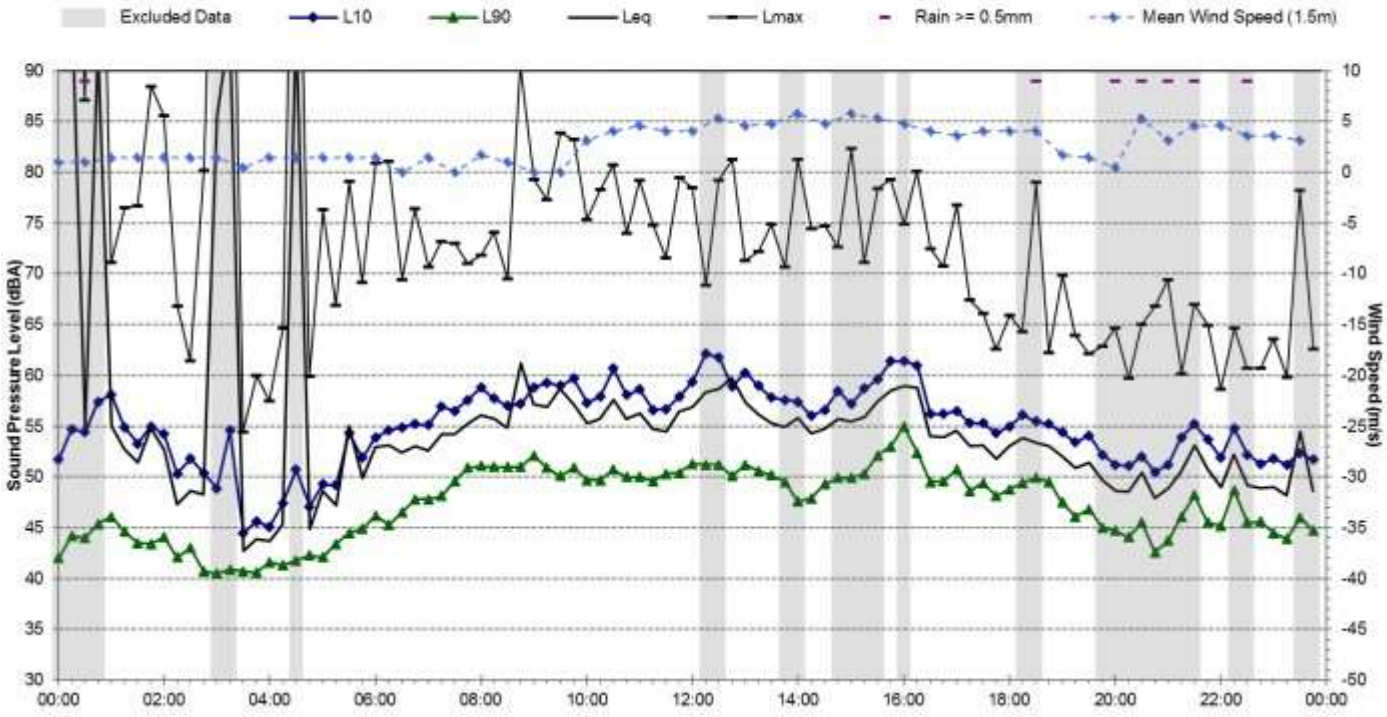
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Thursday, 8 June 2017



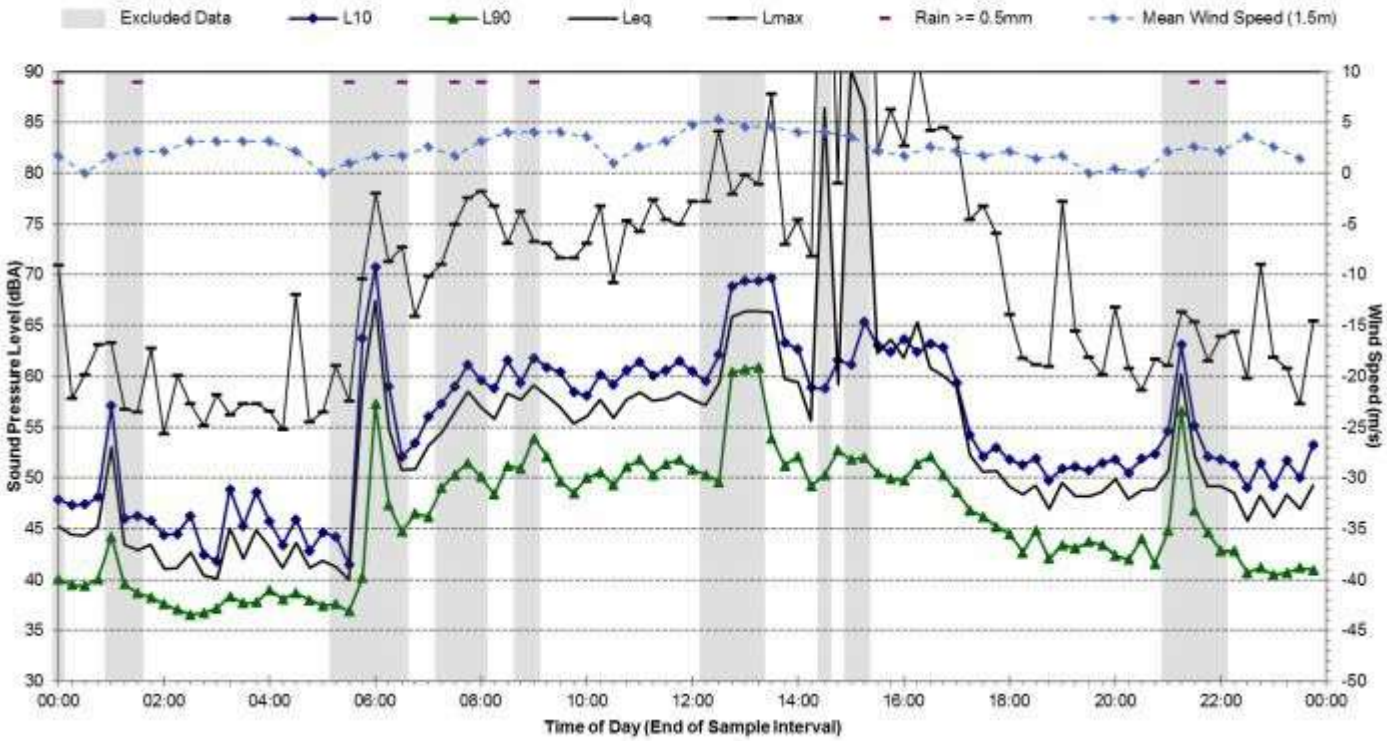
Statistical Ambient Noise Levels

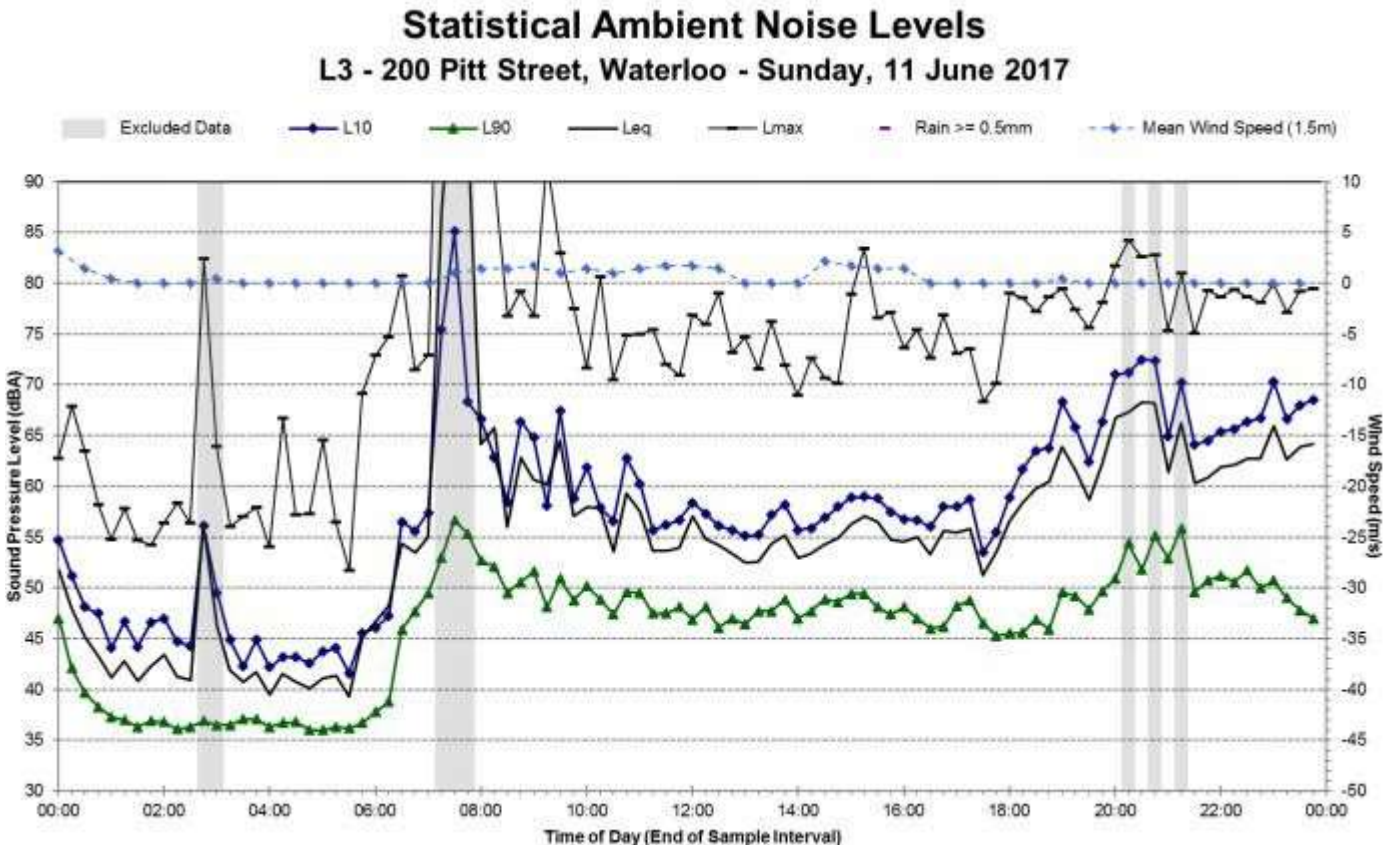
L3 - 200 Pitt Street, Waterloo - Friday, 9 June 2017



Statistical Ambient Noise Levels

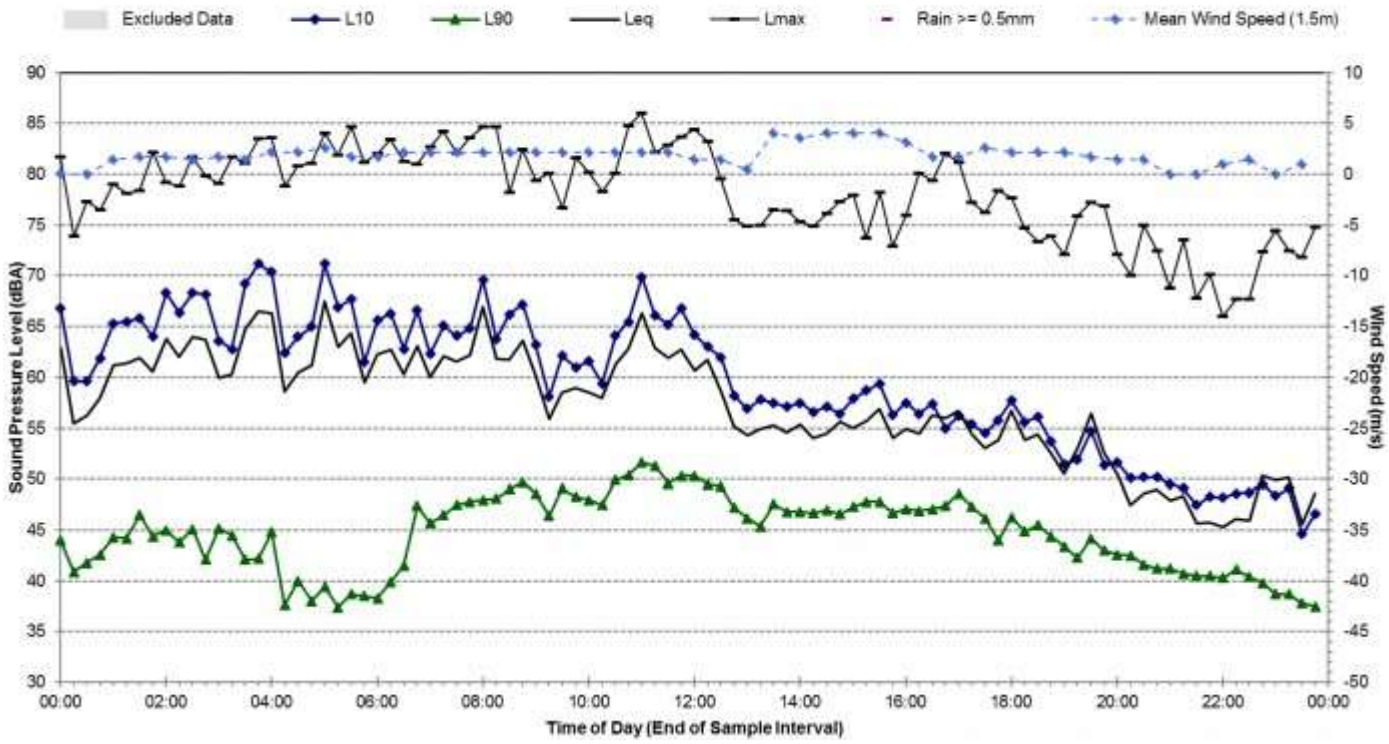
L3 - 200 Pitt Street, Waterloo - Saturday, 10 June 2017





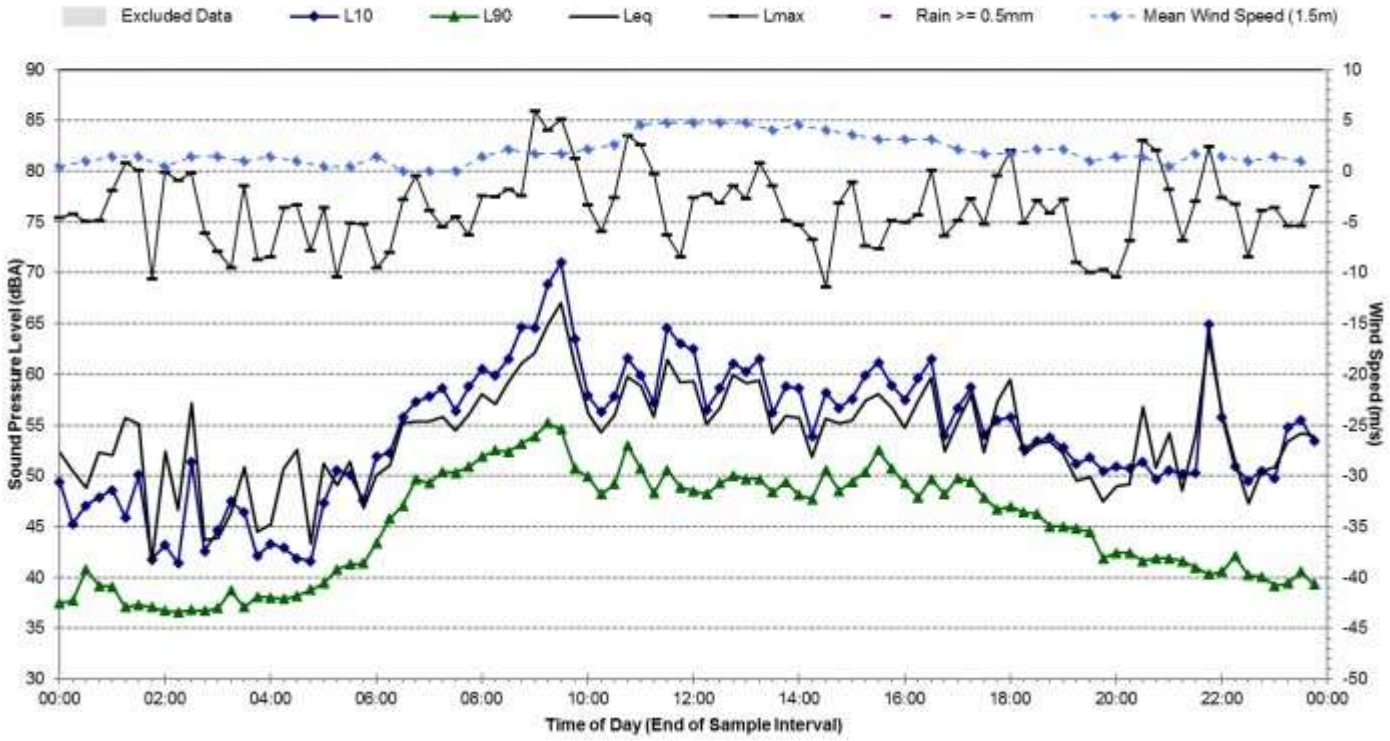
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Monday, 12 June 2017



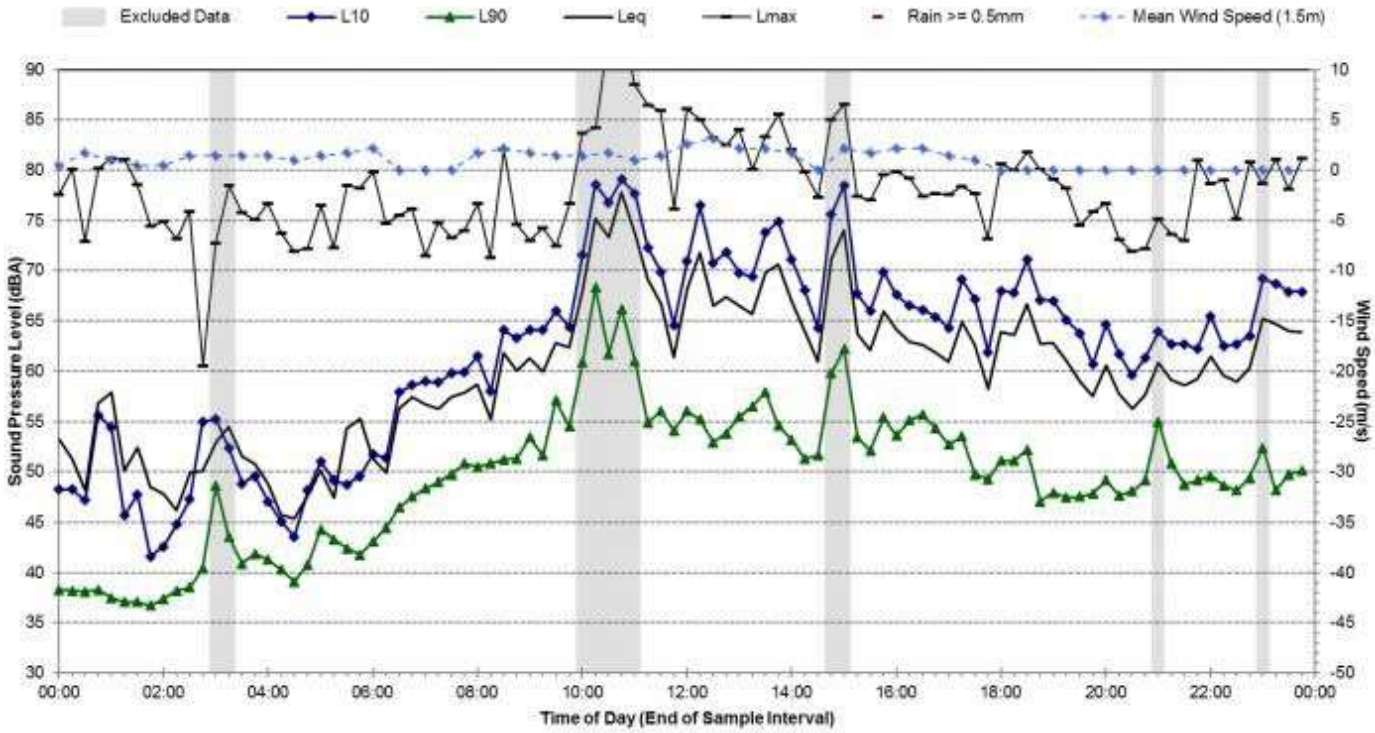
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Tuesday, 13 June 2017



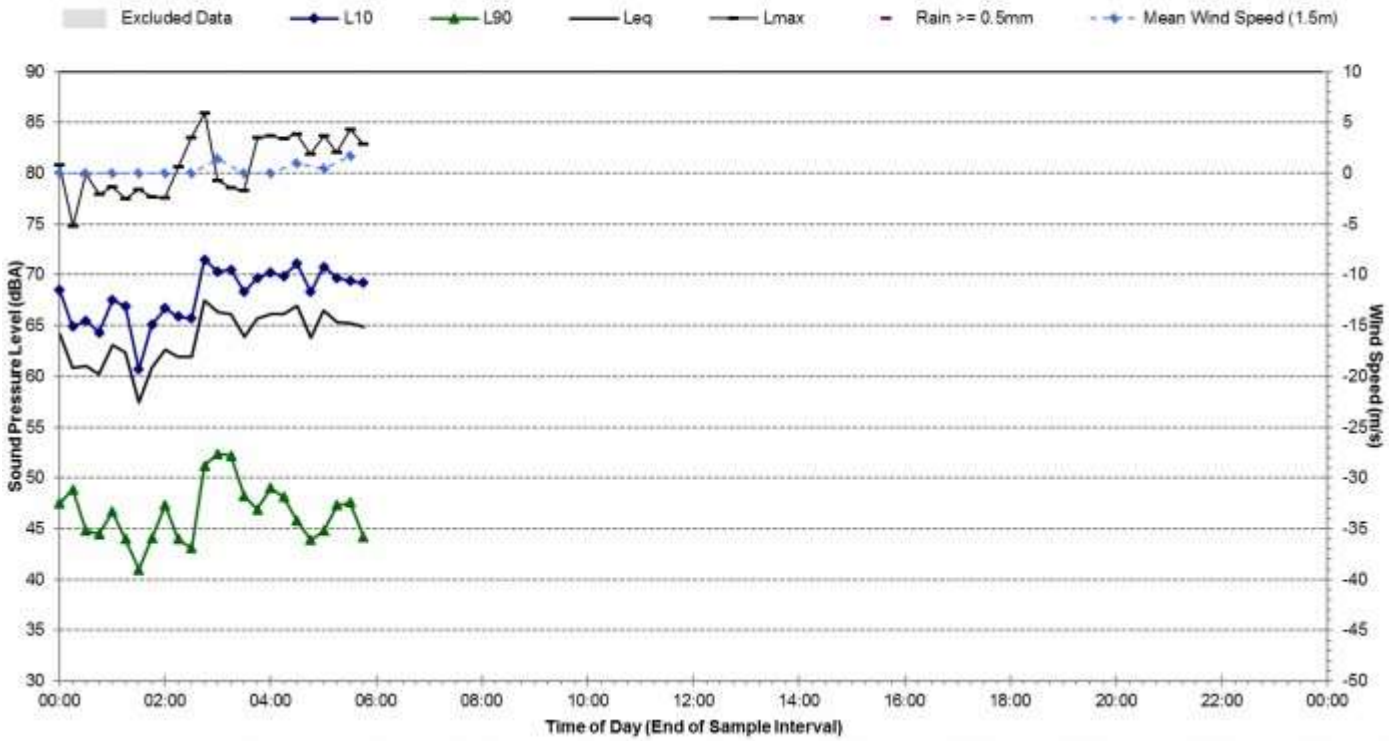
Statistical Ambient Noise Levels

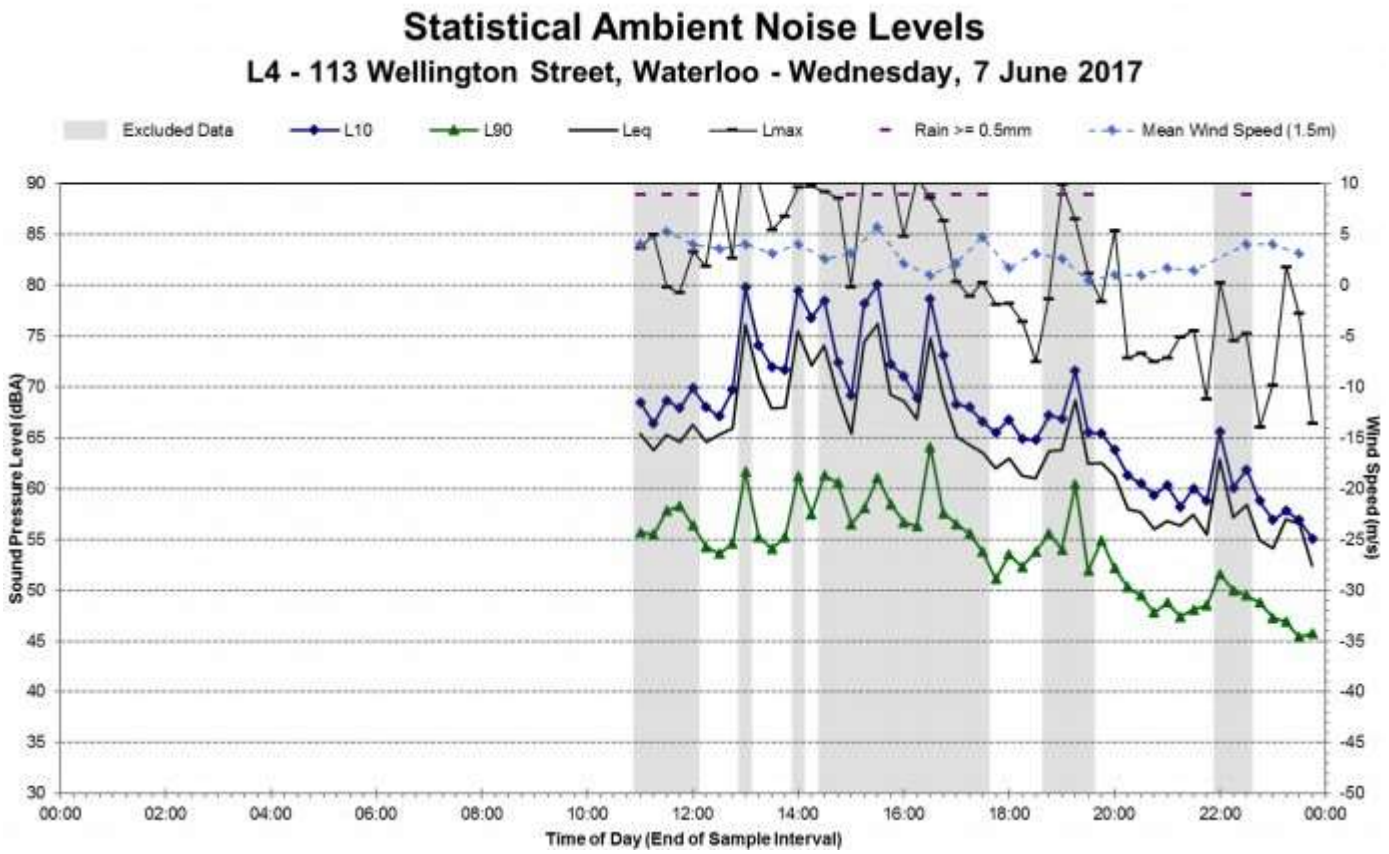
L3 - 200 Pitt Street, Waterloo - Wednesday, 14 June 2017



Statistical Ambient Noise Levels

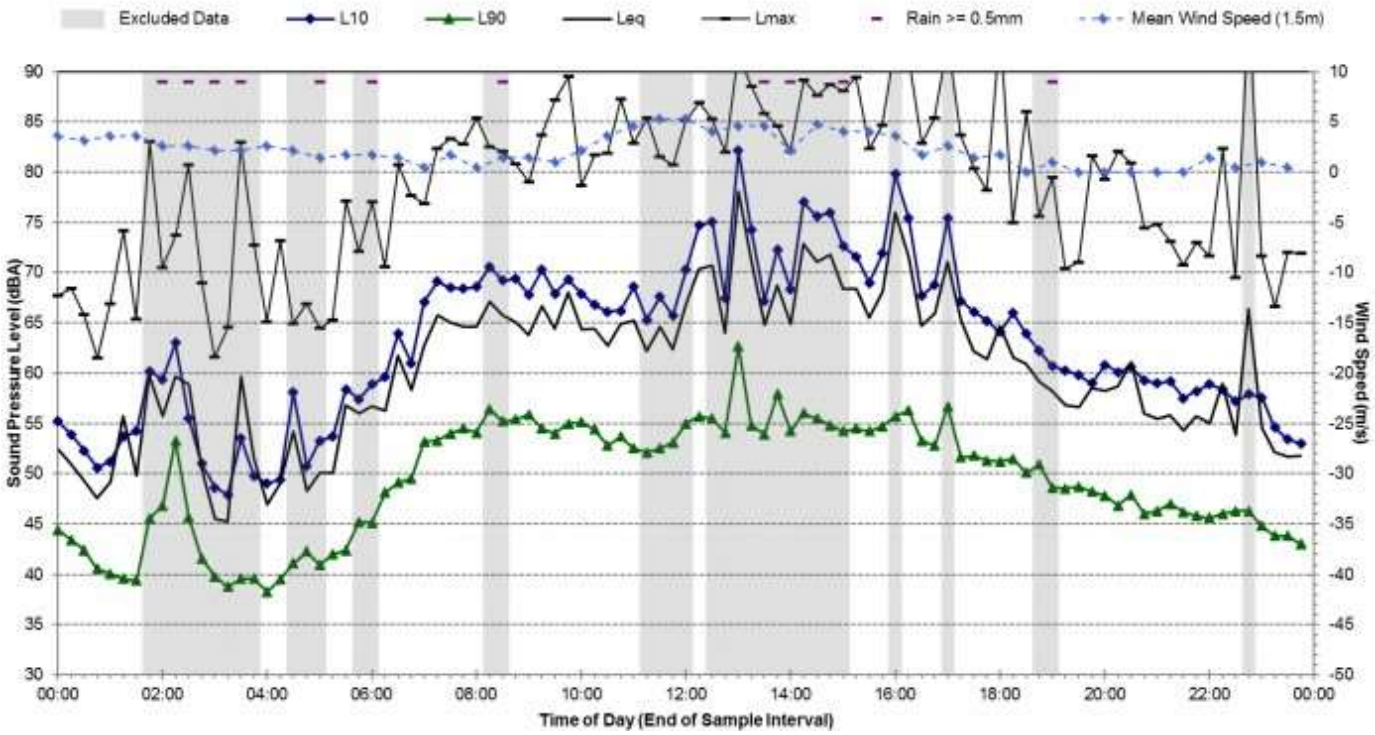
L3 - 200 Pitt Street, Waterloo - Thursday, 15 June 2017





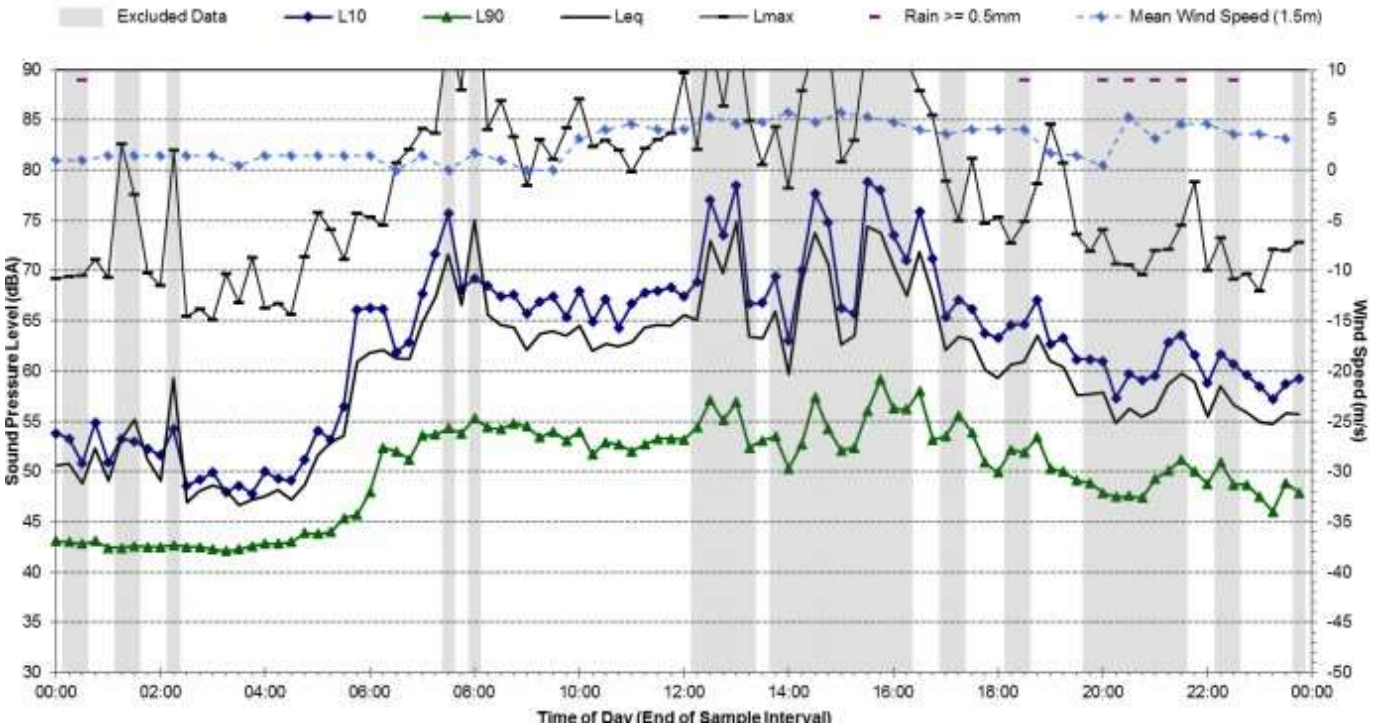
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Thursday, 8 June 2017



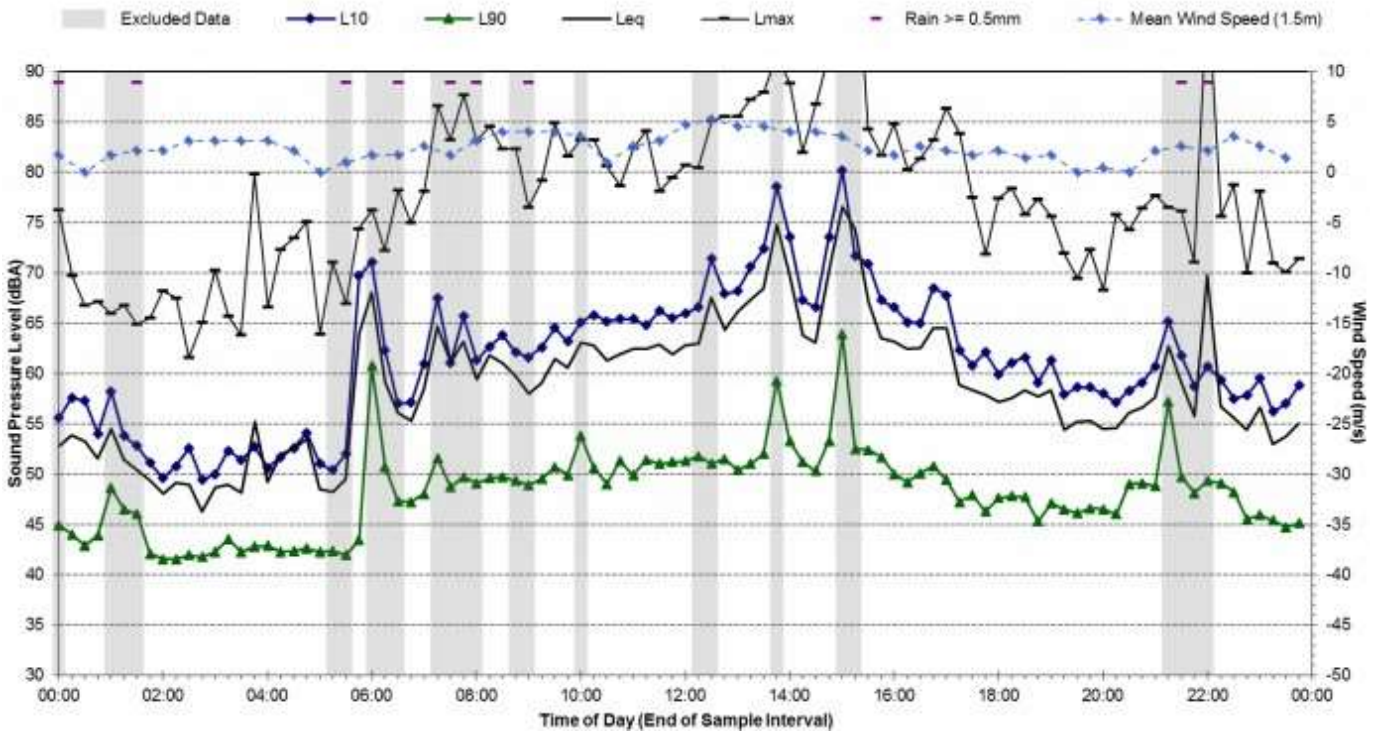
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Friday, 9 June 2017



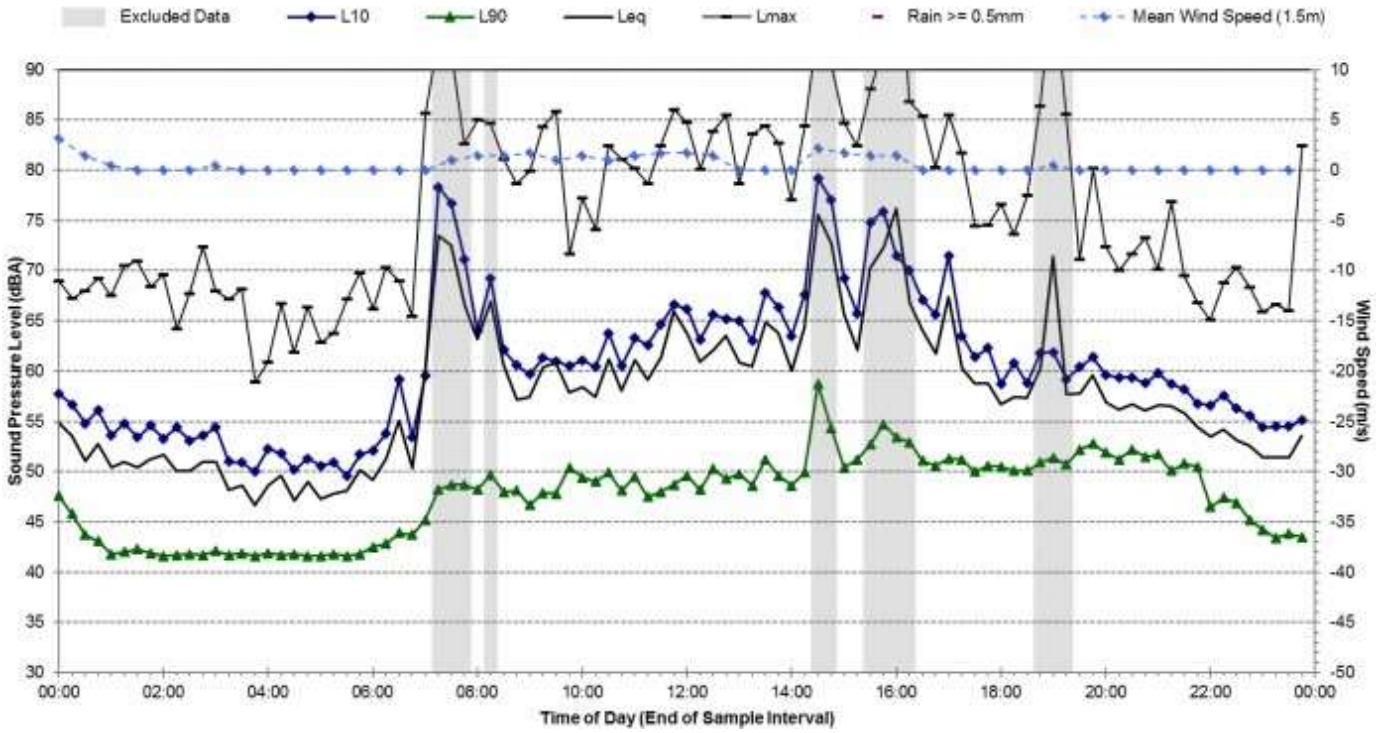
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Saturday, 10 June 2017



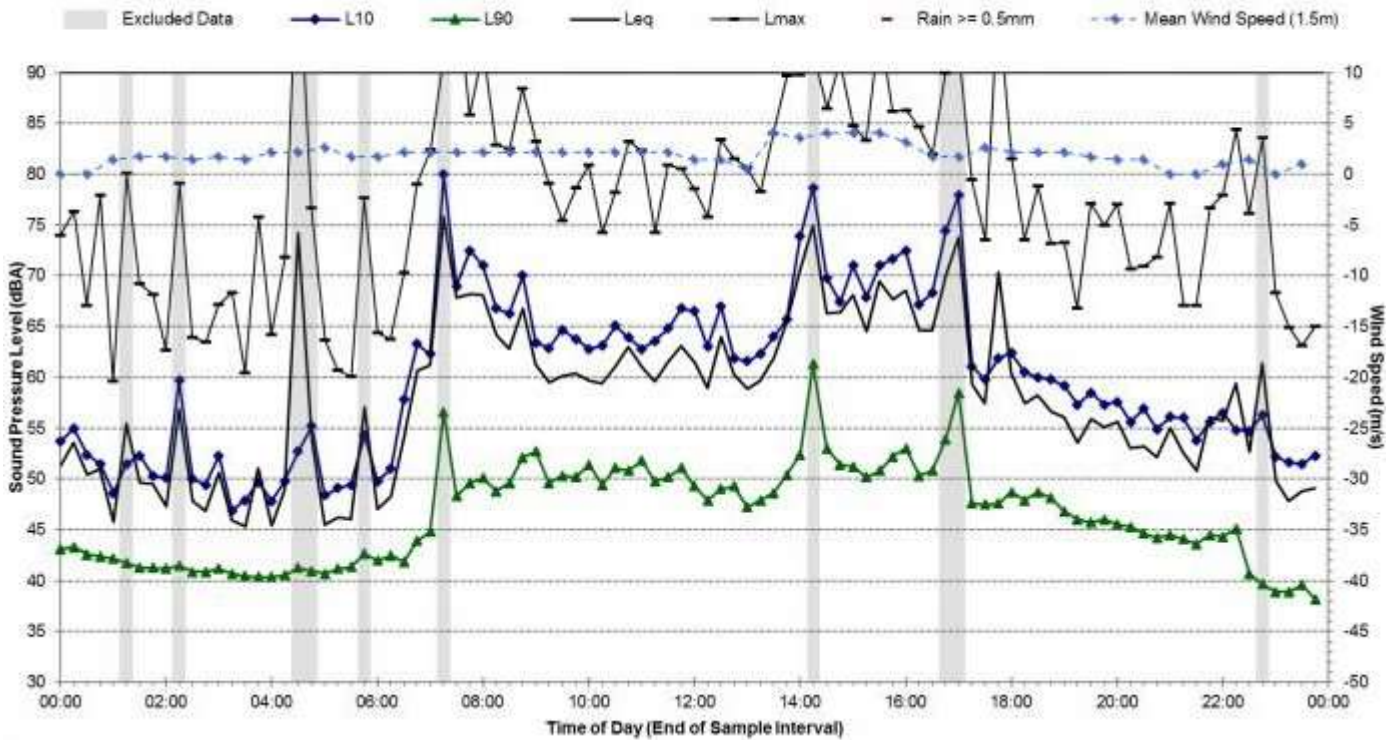
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Sunday, 11 June 2017



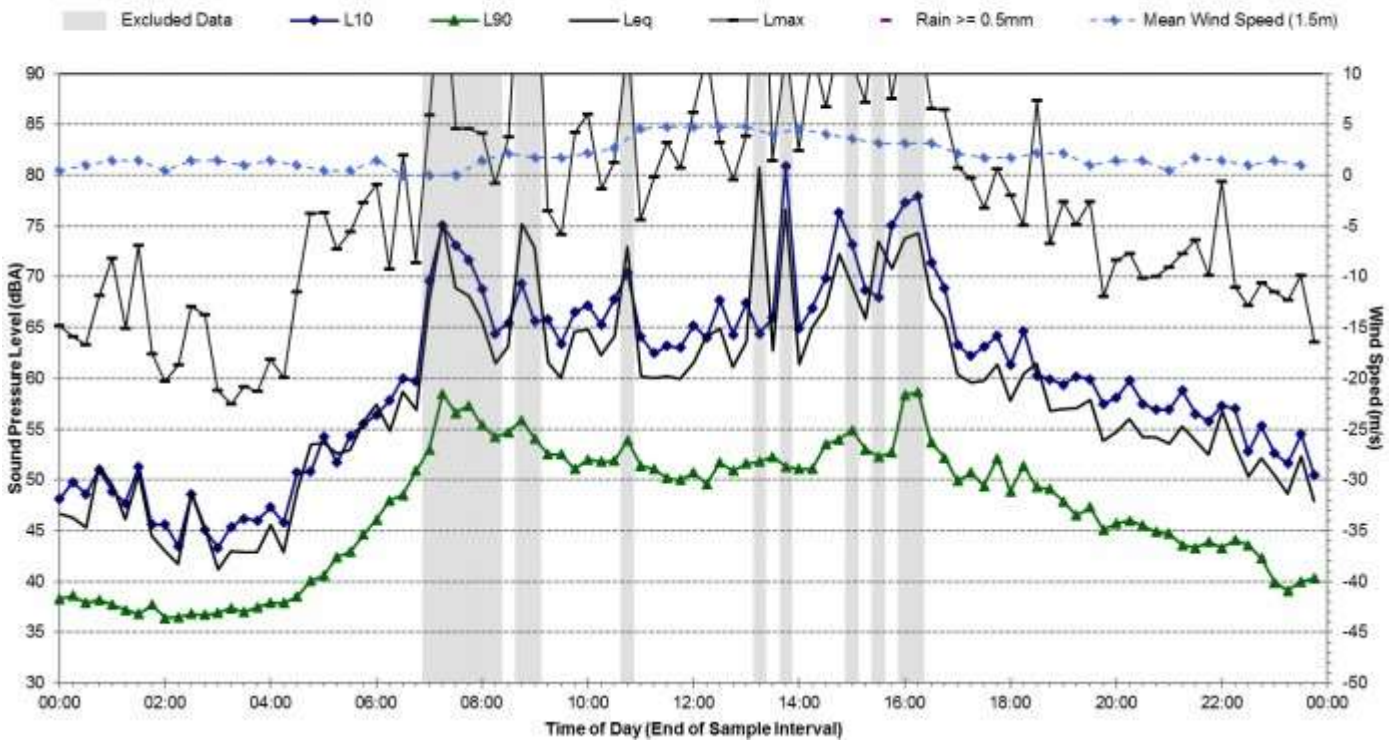
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Monday, 12 June 2017



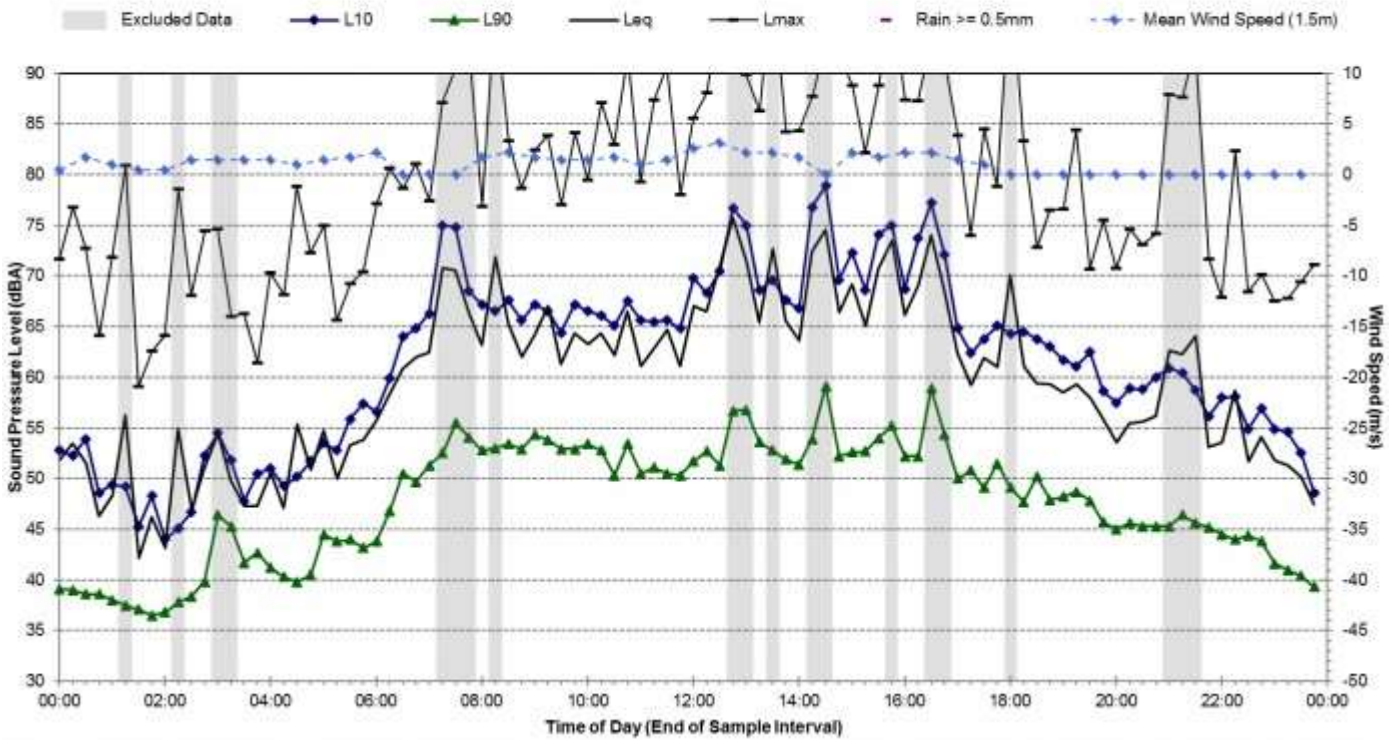
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Tuesday, 13 June 2017



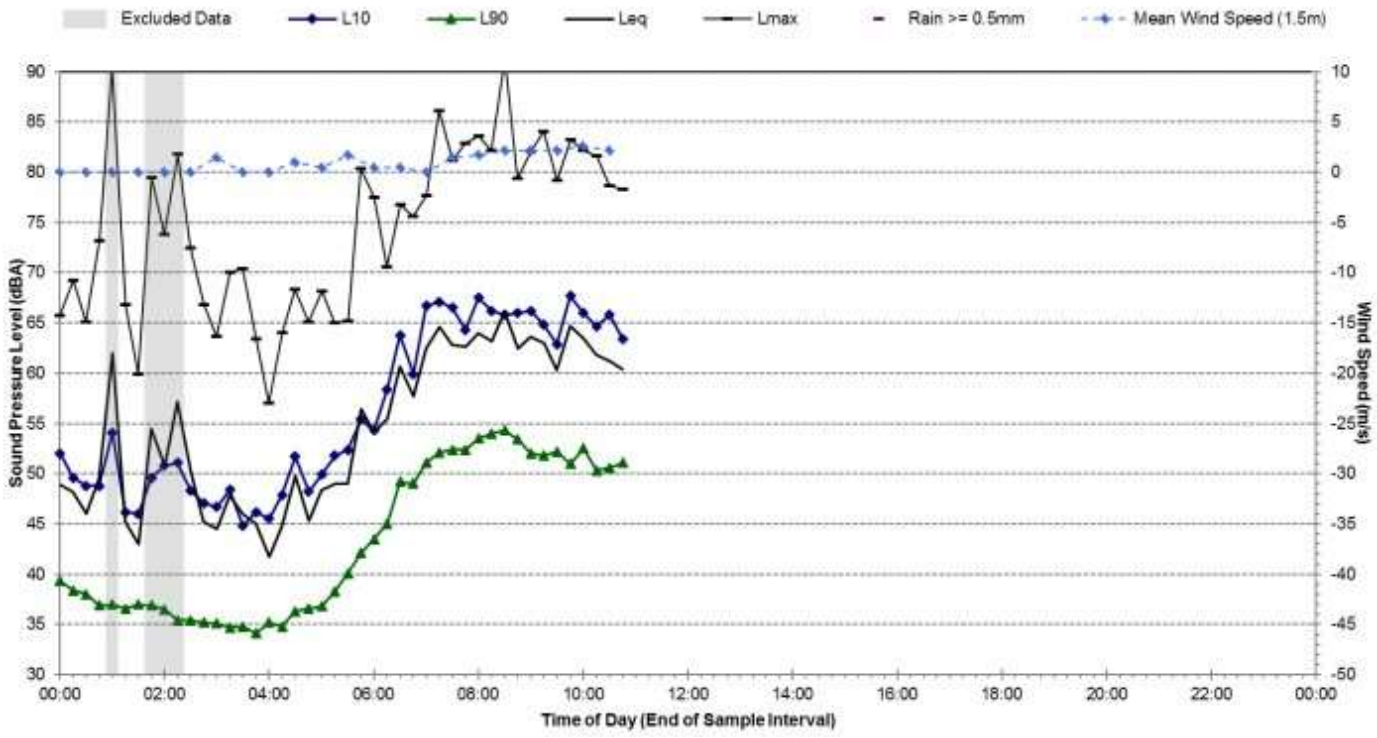
Statistical Ambient Noise Levels

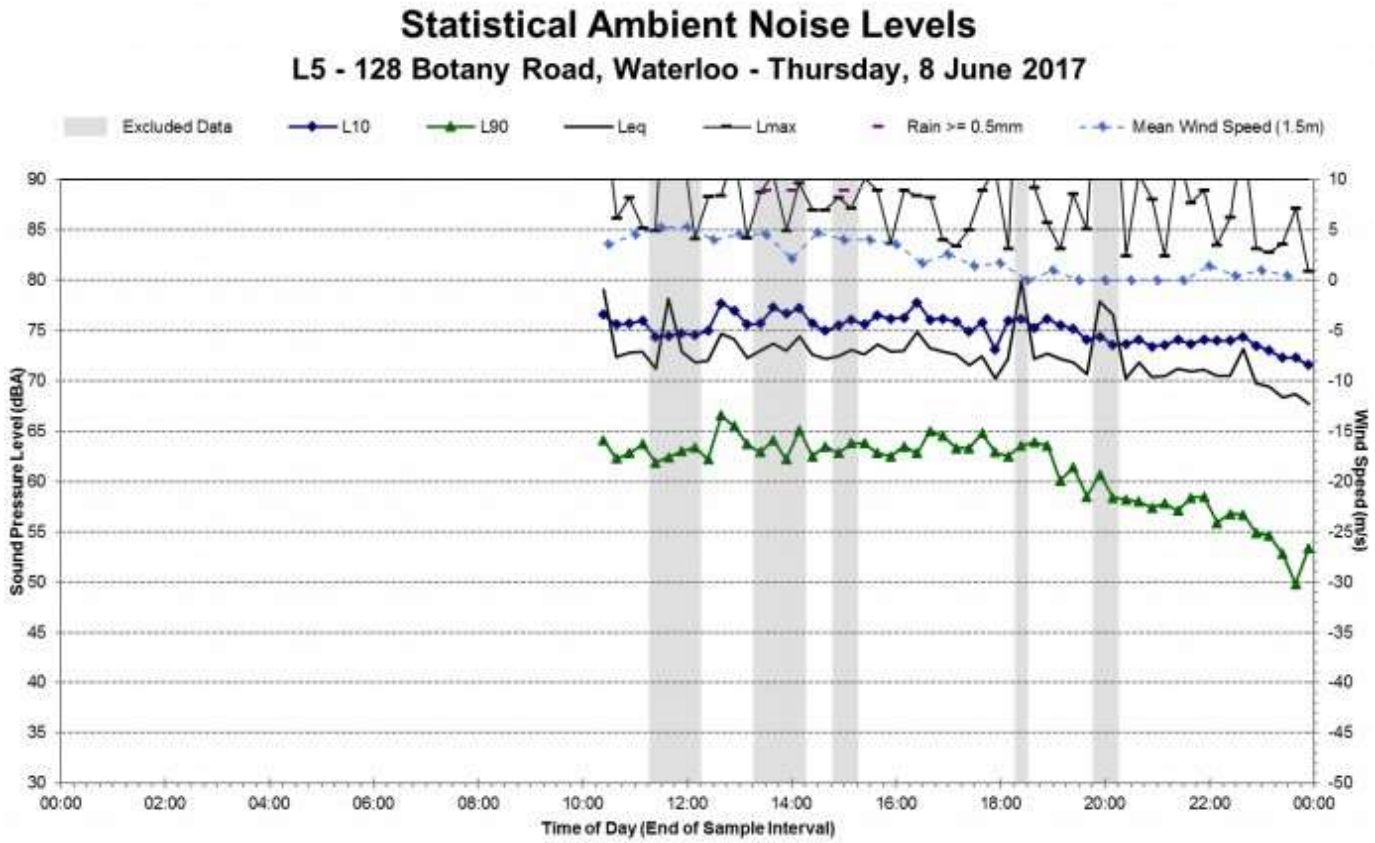
L4 - 113 Wellington Street, Waterloo - Wednesday, 14 June 2017



Statistical Ambient Noise Levels

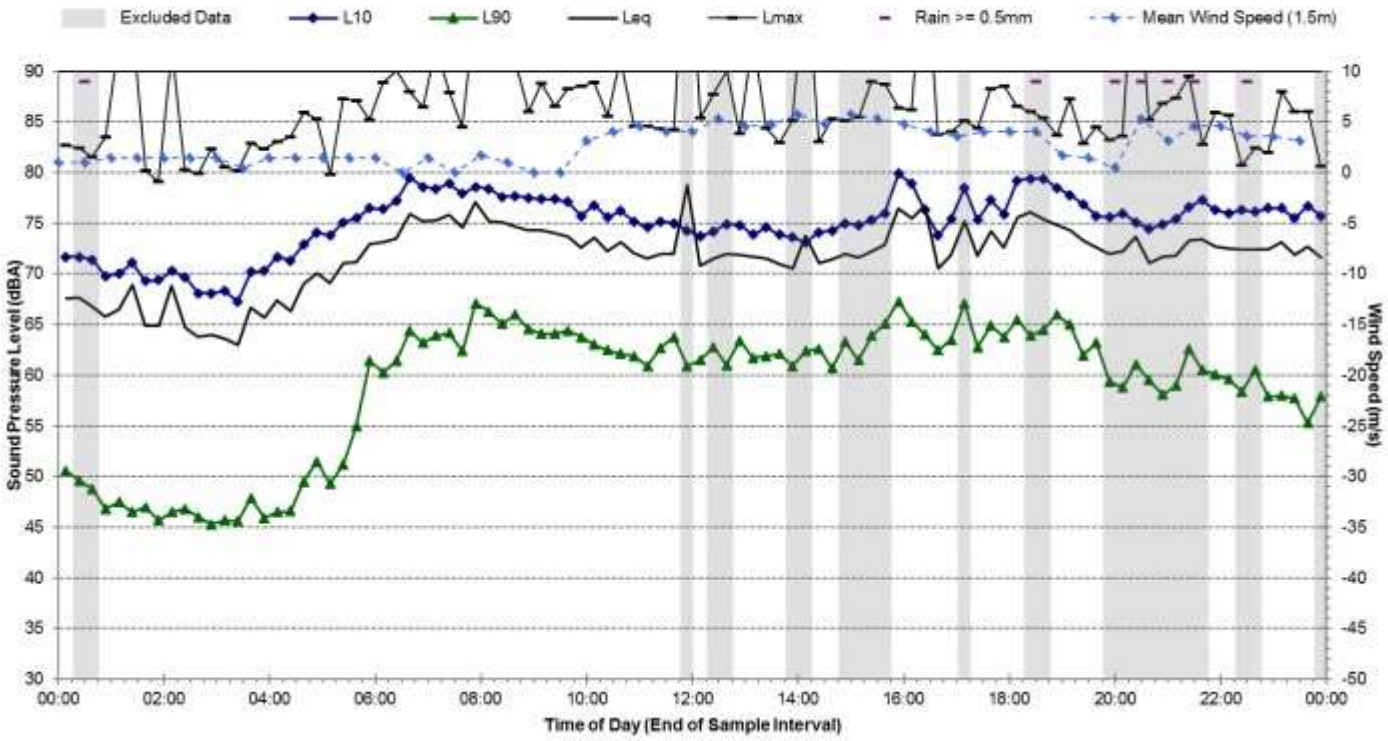
L4 - 113 Wellington Street, Waterloo - Thursday, 15 June 2017





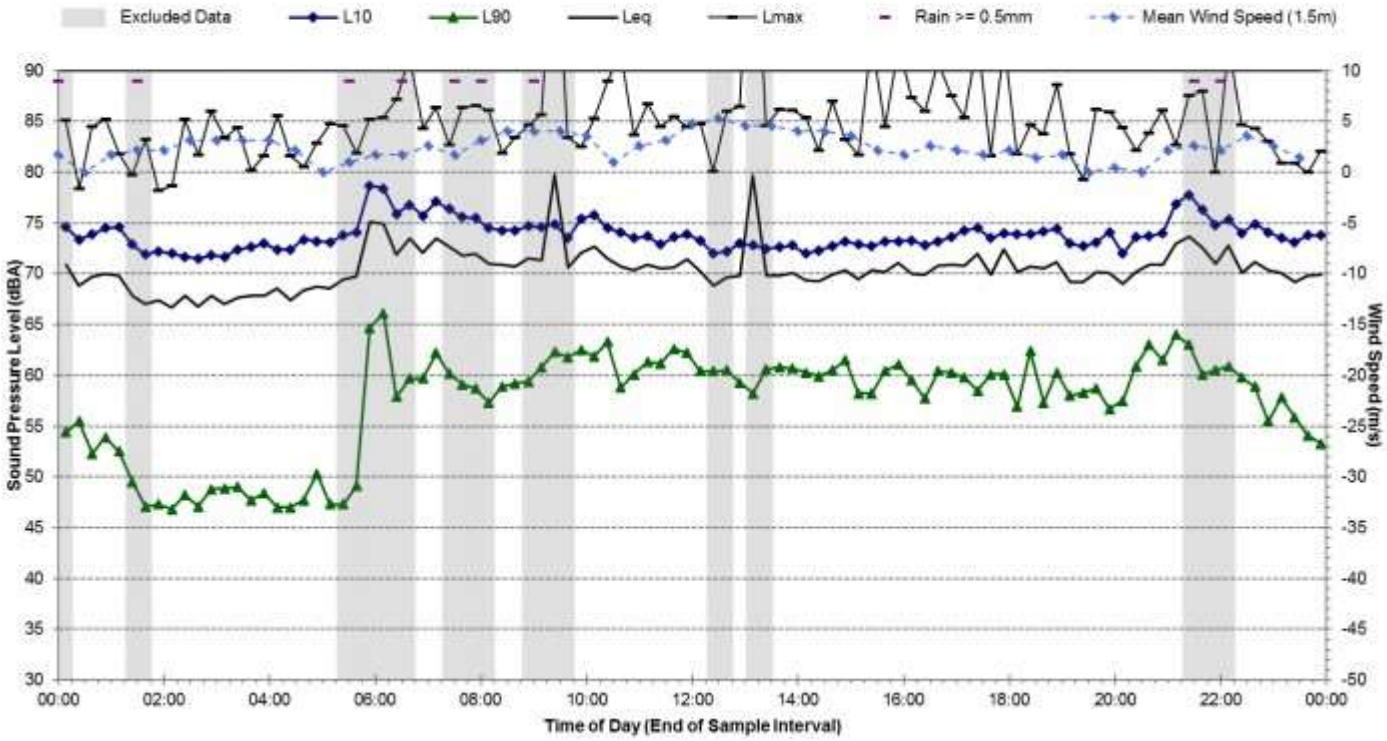
Statistical Ambient Noise Levels

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



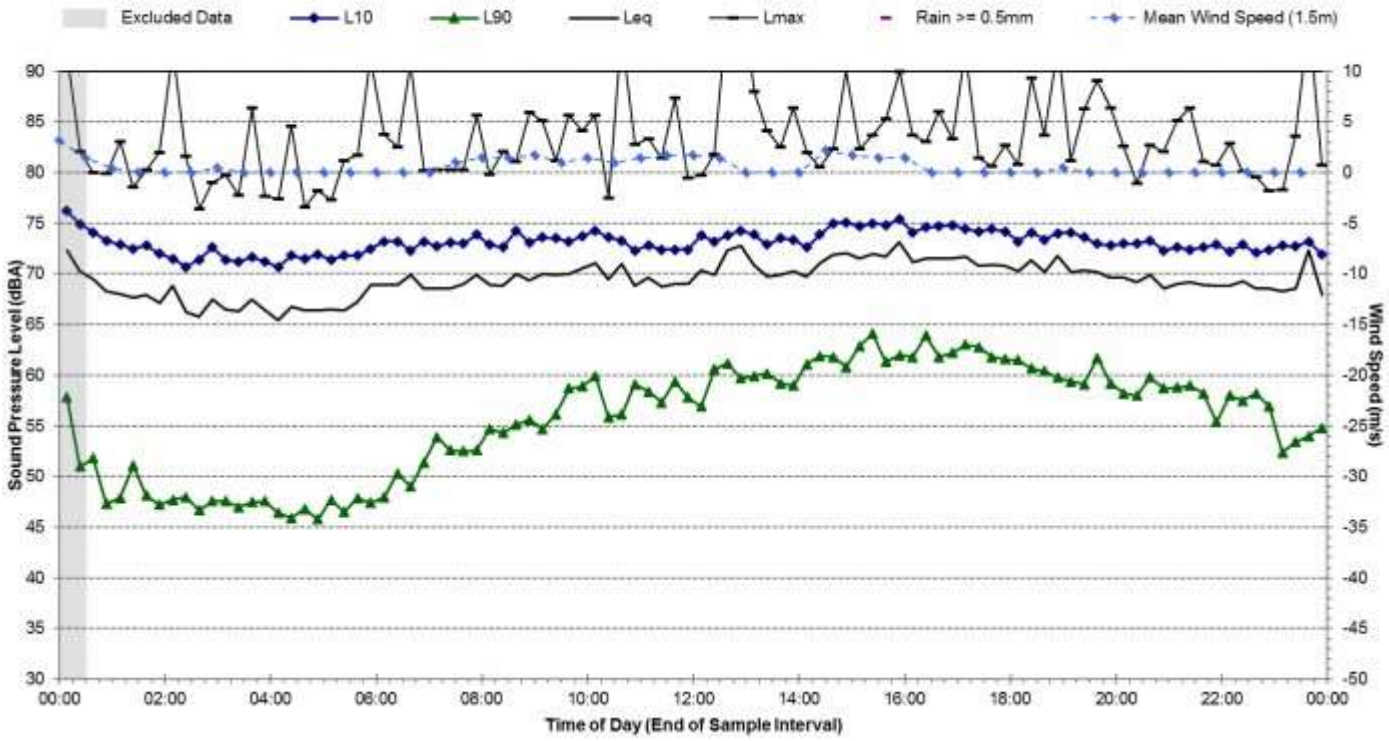
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Saturday, 10 June 2017



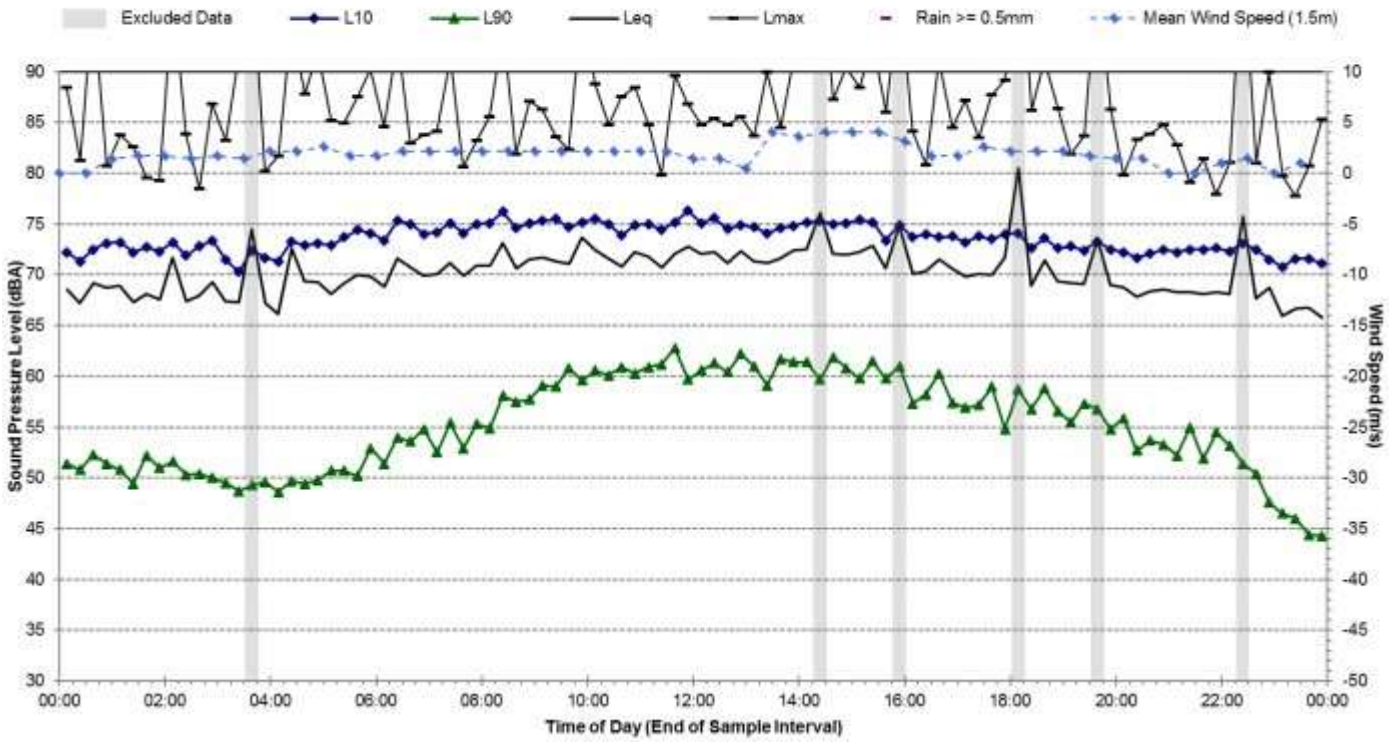
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Sunday, 11 June 2017



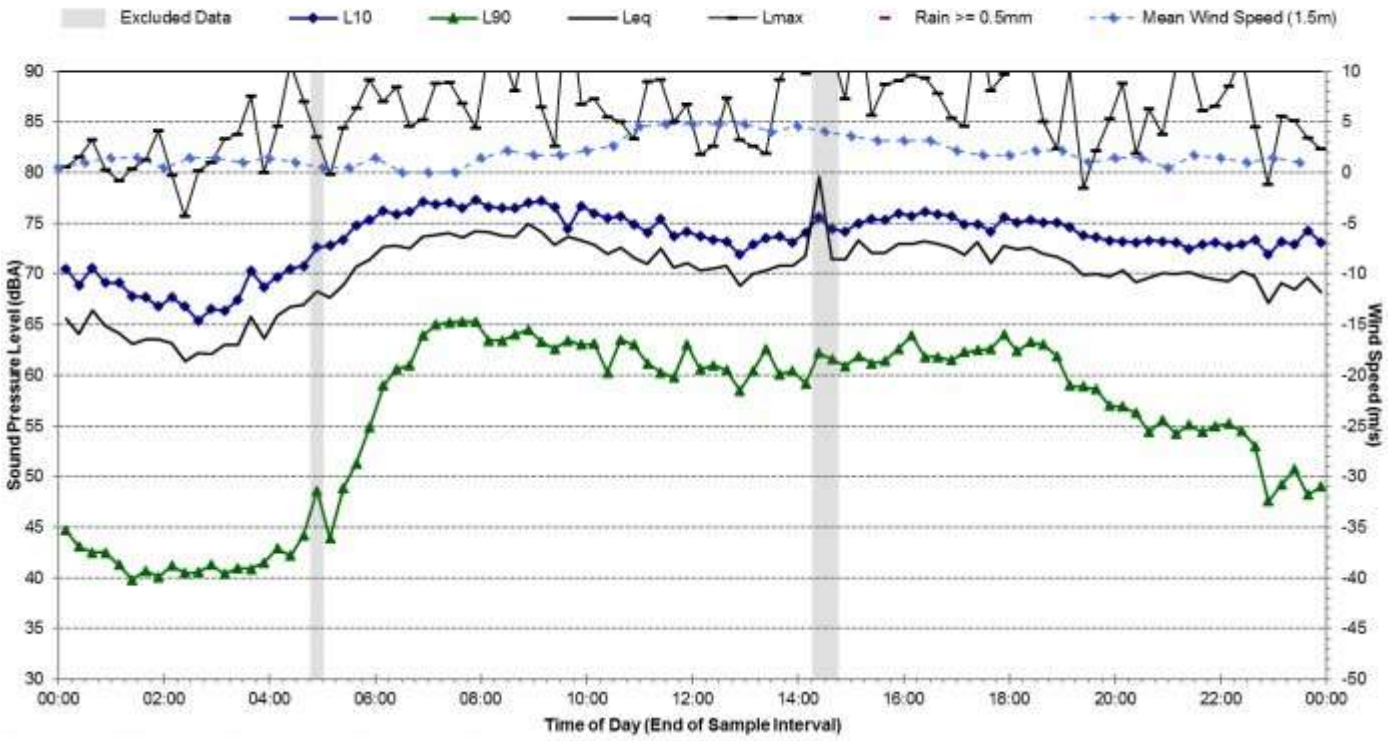
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Monday, 12 June 2017



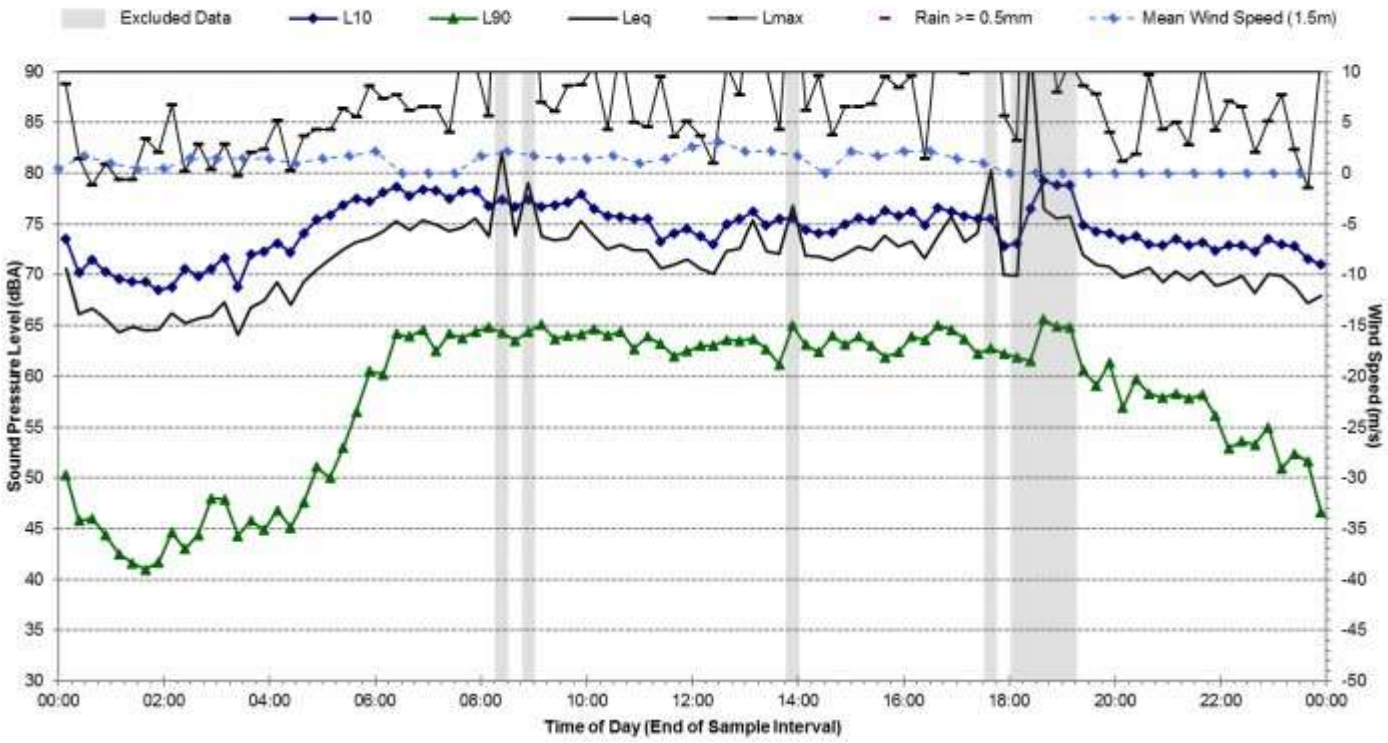
Statistical Ambient Noise Levels

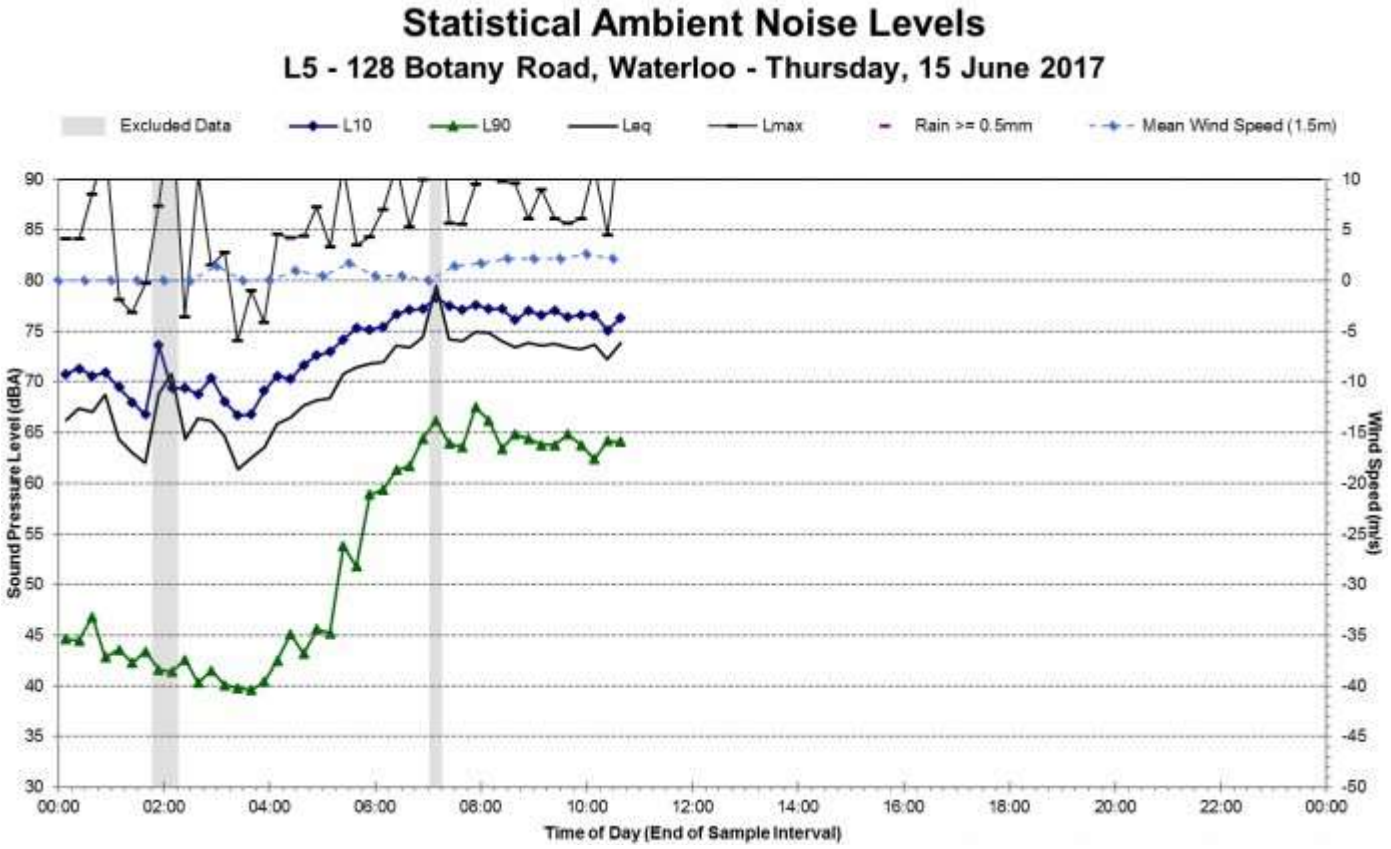
L5 - 128 Botany Road, Waterloo - Tuesday, 13 June 2017



Statistical Ambient Noise Levels

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





14.3.2 Current Noise Survey Results by Stantec Australia