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# ALEXANDRIA TO MOORE PARK STAGE 1

## Noise and Vibration Assessment

22 November 2019

Jacobs

TL052-01F02 (r4) Noise & Vibration Assessment.docx

35 1982-2017 ACOUSTIC ENGINEERING EXCELLENCE

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# Executive summary

## The proposal

Roads and Maritime Services (Roads and Maritime) proposes to upgrade four intersections and introduce clearways between the Euston Road and Maddox Street intersection in Alexandria and the Anzac Parade, Alison Road and Dacey Avenue intersection in Moore Park (the proposal). The proposal is located about three kilometres south of the central business district (CBD) in the suburbs of Alexandria, Waterloo and Moore Park within the City of Sydney local government area (LGA) (refer to Figure 1-1).

The proposal consists of the following:

- New clearways on both sides of Euston Road and McEvoy Street between Maddox Street and Bourke Street from 6:00am to 7:00pm Monday to Friday and 9:00am to 6:00pm on weekends
- New clearways at all times along Lachlan Street and Dacey Avenue between Bourke Street and Anzac Parade
- Right turn bans at most intersections without traffic signals and a right turn ban into Bunnings from McEvoy Street
- Improving intersection capacity at:
  - Fountain Street and McEvoy Street
  - Botany Road and McEvoy Street
  - Elizabeth Street and McEvoy Street
  - South Dowling Street, Lachlan Street and Dacey Avenue
- Minor kerb adjustments at:
  - Stokes Avenue and McEvoy Street
  - Kensington Lane and McEvoy Street
- Landscaping adjustments and replacement tree planting where works are undertaken
- Relocation of utilities and adjustments to traffic signals and street lights
- Property acquisitions, leases and adjustments
- Temporary construction facilities, including site compounds and stockpile sites at:
  - The Roads and Maritime car park on the south-west corner of the McEvoy Street and Stokes Avenue intersection, Alexandria (Site 1)
  - Road reserve at the southern end of Cope Street, Alexandria (Site 2)
  - Road reserve at the southern end of George Street, Alexandria (Site 3)

- The vacant land (Lot 2 DP800705) at the corner of the intersection of McEvoy Street and Bourke Street, Waterloo (Site 4)
- Lots 1, 2 and 3 DP 76985, Lot 4 DP 86722 and Lot 14 DP80926 on the western corner of the Lachlan Street and Amelia Street intersection, Waterloo (Site 5).

The proposal would be constructed in four construction zones centred around the four main intersections that are to be upgraded. This approach would minimise traffic impacts on residents and businesses. The duration of construction impacts within each of the four construction zones would typically be between 12 to 36 months. Construction is expected to commence in early 2020 and would take around 36 months to complete.

The proposal is Stage 1 of a larger project that would include upgrades at other major intersections located along the Euston Road, McEvoy Street, Lachlan Street and Dacey Avenue corridor. Stage 1 would improve traffic performance and can be implemented early with minimal property acquisitions.

The proposal is located about three kilometres south of the CBD in the suburbs of Alexandria, Waterloo and Moore Park within the City of Sydney local government area (LGA) and Kensington within the Randwick LGA. The proposal corridor includes east-west roads running from Euston Road at Maddox Street in Alexandria and along McEvoy Street, Lachlan Street and Dacey Avenue to the intersection of Alison Road and Anzac Parade at Moore Park. The proposal corridor's land use context is one that is a modified urban environment in a fast growing redevelopment area, which includes a mix of residential, commercial / business, recreational, industrial and transport related land uses. The main features of the proposal area and its surrounds include:

- Moore Park, Moore Park golf course and E.S. Marks athletics field
- Centennial Parklands which contain the Kensington Ponds
- Tay Street Reserve
- The Supa Centre Moore Park shopping complex
- Residential properties to the south (Tay Street) and north-east (Martin Road), apartments along the western side of South Dowling Street and new unit developments in Green Square
- Randwick Race Course is located south and the Sydney Cricket Ground, Moore Park showground and Allianz Stadium are located to north of the proposal
- The approved CBD and South East Light Rail (CSELR) corridor also runs through the study area
- The approved CSELR corridor, which is currently being constructed and runs along Anzac Parade and Alison Road
- The Green Square Urban Renewal Precinct and other urban renewal projects
- Commercial premises including retail at the western end of the road corridor

- Waterloo Oval and Waterloo Park.

## This report

This report assesses the potential noise and vibration impacts of the proposal to support the Review of Environmental Factors (REF) as required under Part 5 of *the Environmental Planning and Assessment Act 1979* (EP&A Act). This report assesses the potential for noise or vibration impacts from the proposal to acoustically sensitive receivers within the study area and presents mitigation measures to address those impacts.

The assessment of operational noise impacts was undertaken in accordance with Roads and Maritime's *Noise Criteria Guideline* (NCG) and *Noise Mitigation Guideline* (NMG). The assessment of construction noise and vibration impacts was undertaken in accordance with Roads and Maritime's *Construction Noise and Vibration Guideline* (CNVG) and the Department of Environment and Climate Change's *Interim Construction Noise Guideline* (ICNG) and other supporting standards.

## Potential impacts

The assessment has identified that 48 separate buildings (comprised of 389 receivers) qualify for consideration of noise mitigation as a result of the proposal's predicted operational noise impact.

Based on ground surveys, Roads and Maritime expects that it would not be either feasible or reasonable to provide noise mitigation to 30 of these 48 buildings, as they have been constructed in accordance with recent building approval standards, and therefore, likely to already incorporate the requisite noise mitigation. The remaining 18 buildings have been identified as eligible for noise mitigation.

Where possible the proposal would be constructed during the standard construction hours. Activities such as utility relocation, and civils works including milling and paving works would occur at night due to safety and road occupancy requirements. The assessment identifies that the proposal's construction would impact the community including causing a number of residences to be highly noise affected, likely necessitating dedicated noise management measures and the offering of periods of respite.

## Mitigation measures

Operational noise mitigation would be delivered as at-property acoustic treatments where it is feasible and reasonable to do so. The use of quieter road pavements and noise barriers were investigated; however, the use of these measures would not be feasible and reasonable due to space constraints, low future traffic speeds, visual impact, security, and state heritage considerations.

The types of at-property treatments that may be provided by Roads and Maritime include:

- The installation of courtyard screen walls
- Provision of fresh air ventilation systems (so that doors and windows may remain closed as preferred)

- Upgrading window and door seals and treatment of sub floor ventilation
- The sealing of building facade noise leakage paths such as at wall vents, eaves or below-floor spaces.
- Upgrading windows, glazing and solid core doors on the exposed facades
- The specific acoustic treatment for each of the 18 buildings would be determined following a site visit to establish the feasibility and reasonableness of applying such treatments and in consultation with the landowner. In particular, this relates to whether the existing building facade already provides a level of noise attenuation equal to that that would be provided by Roads and Maritime in response to the proposal's operational noise impacts.

For the mitigation of construction noised impacts, the assessment has outlined standard as well as additional noise mitigation measures that would be expected to be deployed in the proposal's construction program to mitigate these impacts. These include restricting some construction staging and specific noise-intensive activities to day time periods, erecting noise hoardings and deploying low-noise plant. The offering to the community of periods of respite may also be required. In all cases, the construction noise impacts reported in this assessment reflect worst-case conditions when all plant is operating concurrently and nearest to a receiver. Construction noise levels would often be lower than the reported upper noise levels as works move away from the receiver and as fewer items of plant are operated.

Vibratory rolling is expected to be undertaken within 100 metres of residences and commercial buildings for various stages of works and so may impact human comfort within those buildings. The proposal shall adopt mitigation measures to protect against these impacts including notification strategies, vibration monitoring and offering of periods of respite.

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# 1 Introduction

## 1.1 Overview of the proposal

Roads and Maritime Services (Roads and Maritime) proposes to upgrade four intersections and introduce clearways between the Euston Road and Maddox Street intersection in Alexandria and the Anzac Parade, Alison Road and Dacey Avenue intersection in Moore Park (the proposal). The proposal is located about three kilometres south of the central business district (CBD) in the suburbs of Alexandria, Waterloo and Moore Park within the City of Sydney local government area (LGA) (refer to Figure 1-1).

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The proposal as shown in Figure 1-2 would be constructed in four construction zones centred around the four main intersections that are to be upgraded. This approach would minimise traffic impacts on residents and businesses. The duration of construction impacts within each of the four construction zones would typically be between 12 to 36 months. Construction is expected to commence in early 2020 and would take around 36 months to complete.

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- Randwick Race Course is located south and the Sydney Cricket Ground, Moore Park showground and Allianz Stadium are located to north of the proposal
- The approved CBD and South East Light Rail (CSELR) corridor also runs through the study area
- The approved CSELR corridor, which is currently being constructed and runs along Anzac Parade and Alison Road
- The Green Square Urban Renewal Precinct and other urban renewal projects

- Commercial premises including retail at the western end of the road corridor
- Waterloo Oval and Waterloo Park.

## 1.2 Purpose and scope of this report

A noise and vibration assessment has been undertaken to assess the potential noise and vibration impacts of the proposal to support the Review of Environmental Factors (REF) as required under Part 5 of *the Environmental Planning and Assessment Act 1979* (EP&A Act). This report assesses the potential for noise or vibration impacts from the proposal to acoustically sensitive receivers within the study area and presents mitigation measures to address those impacts.

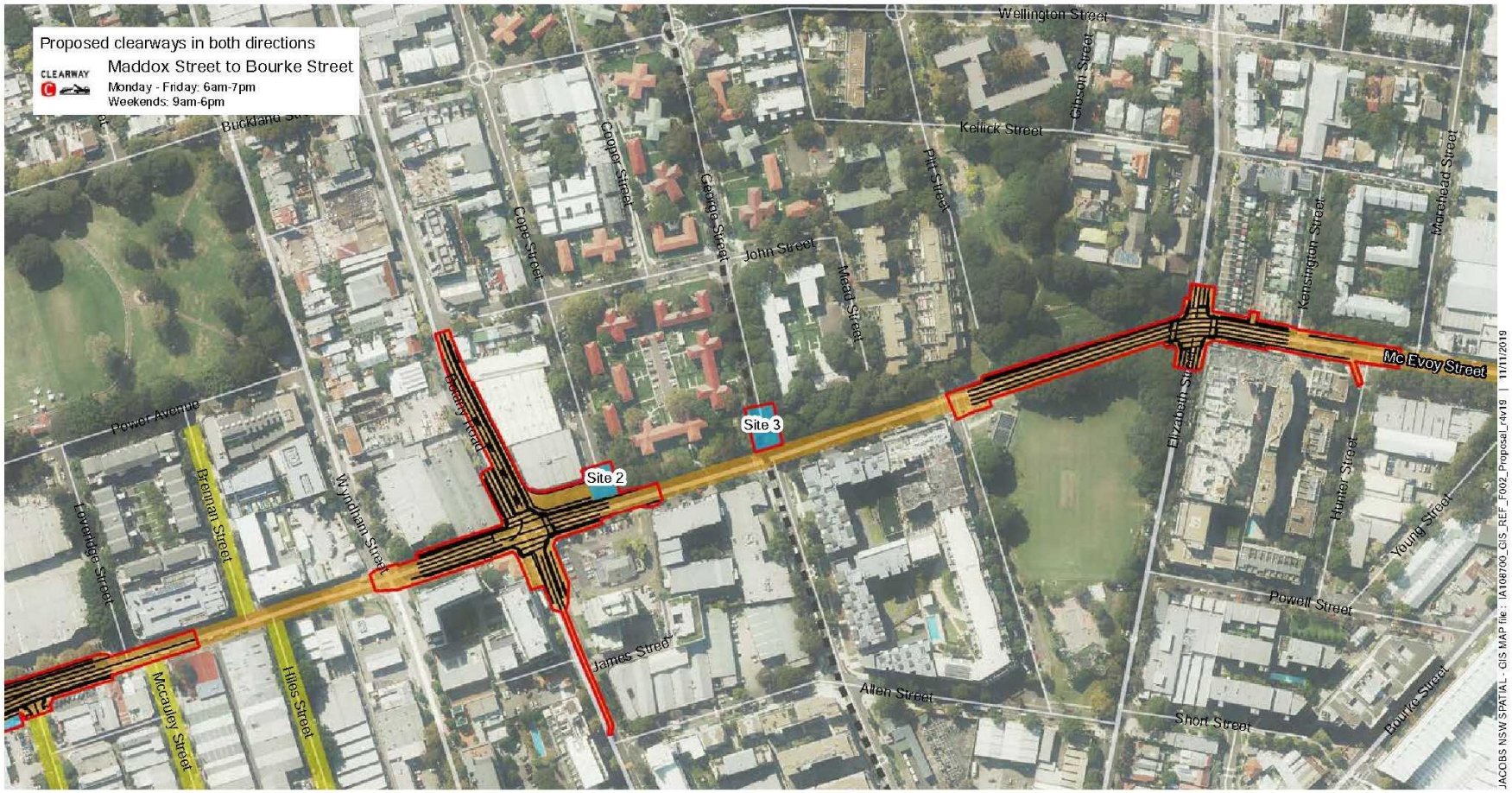
The assessment of operational noise impacts was undertaken in accordance with Roads and Maritime's *Noise Criteria Guideline* (NCG) and *Noise Mitigation Guideline* (NMG). The assessment of construction noise and vibration impacts was undertaken in accordance with Roads and Maritime's *Construction Noise and Vibration Guideline* (CNVG) and the Department of Environment and Climate Change's *Interim Construction Noise Guideline* (ICNG) and other supporting standards.

**Figure 1-1 – Locality surrounding proposal**


**Figure 1-1** | The locality
Alexandria to Moore Park Stage 1

## Figure 1-2 – Map of the proposal


**Figure 1-2a** | The proposal
Alexandria to Moore Park Stage 1




Legend

- Concept design
- Road
- Railway line
- Proposal area
- Construction impacts:
  - Construction footprint
  - Construction compounds
- Operational impacts:
  - Clearways and intersection upgrades
  - Parking changes in side streets

0 200 m
1:4,000 @ A4

N

Data sources
Jacobs 2016
LPI 2016
Roads and Maritime 2016
ARUP 2016

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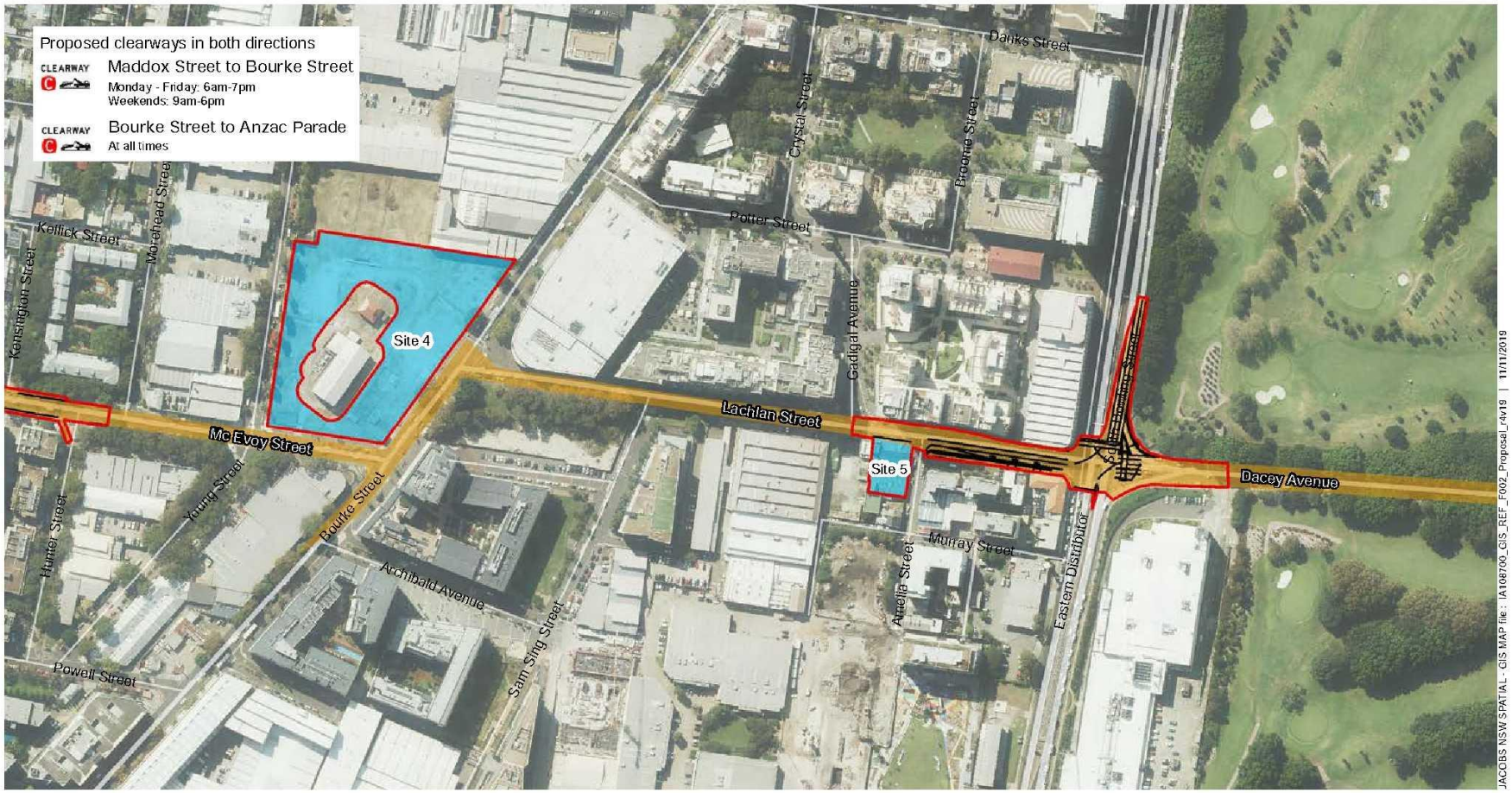
Figure 1-2b | The proposal
Alexandria to Moore Park Stage 1

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Concept design
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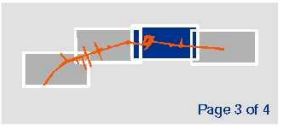


Figure 1-2c | The proposal
Alexandria to Moore Park Stage 1

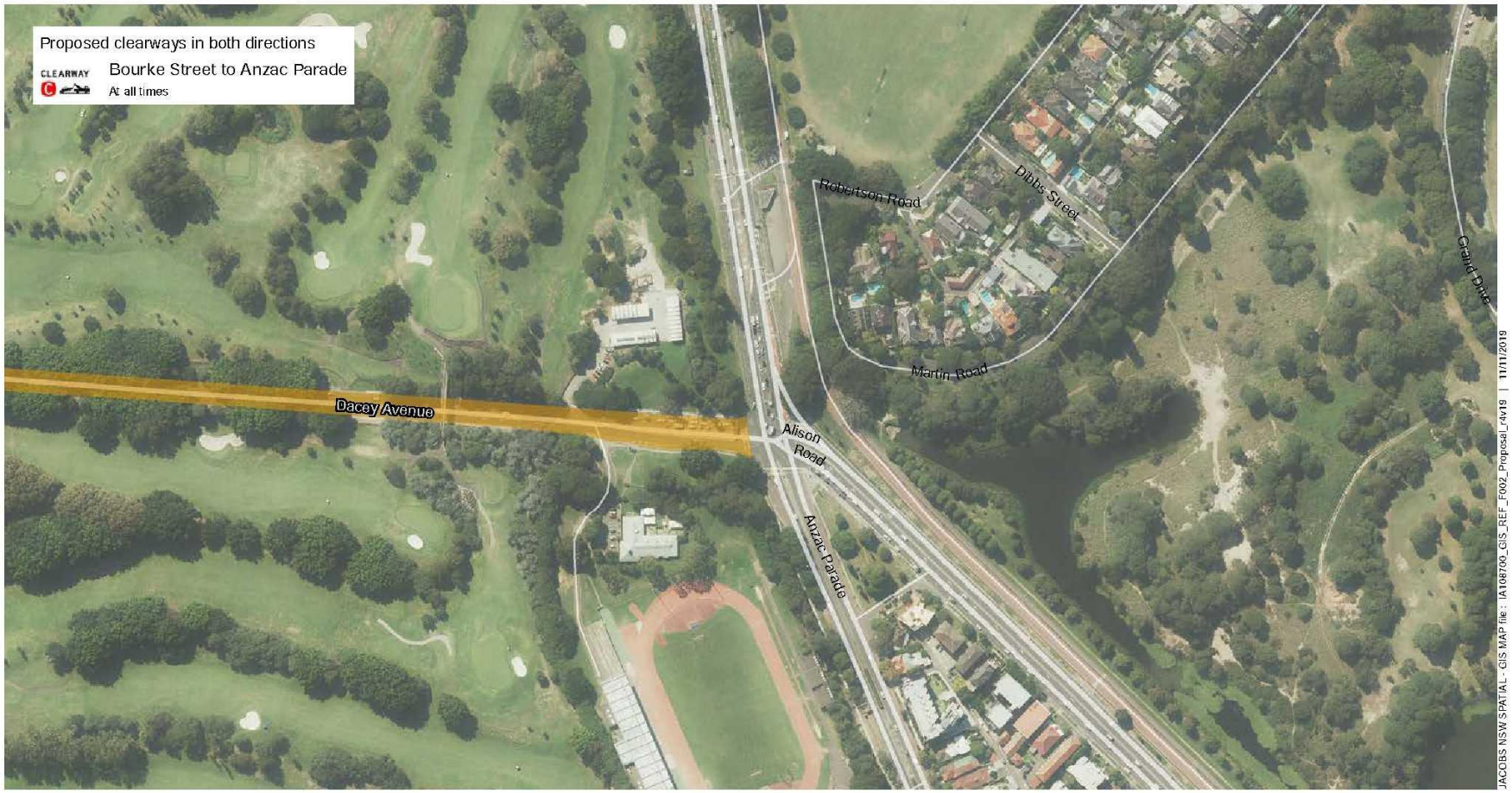


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Figure 1-2d | The proposal
Alexandria to Moore Park Stage 1

# 2 Assessment description

## 2.1 Study area

The study area surrounding the proposal consists of a mix of urban residential properties, commercial premises, industrial premises, educational facilities, places of worship and recreational areas. The study area extends 600m from the proposal corridor, which is the typical distance adopted for the operational noise assessment in accordance with the relevant policies and guidelines.

This assessment investigates operational traffic and construction noise and vibration impacts at sensitive receivers within the study area. Sensitive receivers potentially impacted by the construction and operation of the proposal are currently exposed to road traffic noise from the proposal corridor.

## 2.2 Noise catchment areas

As it is not feasible to determine background noise levels for each receiver individually, noise monitoring is undertaken for groups of receivers based on them having a common exposure to the same construction works. To facilitate the assessment of noise impacts from the proposal, noise sensitive receivers within the study area have been divided into Noise Catchment Areas (NCAs). NCAs extend as far back from the project as is required to ensure all areas of lower background noise are included and therefore, worst case construction noise impacts would be identified. This ensures that the determined mitigation measures would address impacts at all receivers.

Nine (9) NCAs were identified for the noise sensitive areas surrounding the proposal, as described in Table 2-1 and shown in Figure 2-1 and Figure 2-2.

**Table 2-1 – Description of NCAs**

| NCA | Number of Receivers within NCA | Description of NCA |
|---|---|---|
| NCA 1 | 560 | Far west side of the study area, bounded by Princes Highway, Sydney Park Road, Huntley Street, Bourke Road and Campbell Road. Predominantly consists of Sydney Park on the northside, and commercial and industrial buildings to the south. |
| NCA 2 | 5,307 | West side of the study area, bounded by Erskineville to St Peters rail line, Swanson Street, Mitchell Street, Harley Street, Euston Road and Sydney Park Road. Predominantly consists of multi-storey residential buildings to the west, single residential buildings to the north and south, and industrial buildings in the centre, with three parks in the north east. |
| NCA 3 | 8,248 | Central north west of the study area, bounded by Henderson Road, Botany Road, McEvoy Street, Harley Street, Mitchell Road and Swanson Street. Predominantly consists of single residential, commercial and industrial buildings along Botany Road and McEvoy Street and central parks. |
| NCA 4 | 570 | Central south west of the study area bounded by McEvoy Street, Botany Road, O'Riordan Street, Collins Street and Huntley Street. Predominantly consists of commercial and industrial buildings, with multi storey mixed and residential buildings along Botany Road in the east. |

| NCA | Number of Receivers within NCA | Description of NCA |
|---|---|---|
| NCA 5 | 7,069 | Central north of the study area bounded by Turner Street, Elizabeth Street, McEvoy Street and Botany Road. Predominantly consists of residential buildings in the east and north including dispersed multi storey residential towers. Government housing is located in the centre and south of this NCA, with a mix of residential, commercial and industrial along the western boundary and along Botany Road. Redfern Oval is located to the north east of the NCA. |
| NCA 6 | 7,026 | Central north of the study area bounded by Redfern Street, Young Street, Telopea Street, Bourke Street, Thurlow Street, South Dowling Street, Lachlan Street, McEvoy Street and Elizabeth Street. This NCA consists of single residential buildings in the north and west, multi storey residential and mixed use buildings in the east and south east and commercial buildings in the centre and south. |
| NCA 7 | 8,431 | Central south of the study area bounded by McEvoy Street, Lachlan Street, South Dowling Street, Defries Avenue and Botany Road. This NCA consists of a mix between multi storey residential and mixed use buildings dispersed through the NCA, single residential buildings and commercial buildings. |
| NCA 8 | 50 | North east of the study area, with boundaries along South Dowling Street (up to and including Sydney Boys High School), Anzac Parade, and Dacey Avenue. This NCA is predominantly made up of Moore Park Golf Course, with Sydney Girls High School and Sydney Boys High School in the north. |
| NCA 9 | 4187 | South east of the study area, with boundaries along Dacey Avenue, Anzac Parade, Gloucester Place, Winkurra Street and South Dowling Street. This NCA consists of single and multi-storey buildings in the southern half and Moore Park Golf Course in the northern half. E.S Marks Athletics Field is in the east of the NCA and Moore Park Supa Centre is in the west. |

**Figure 2-1 – Site, surrounds, NCAs and noise monitoring locations (eastern end)**

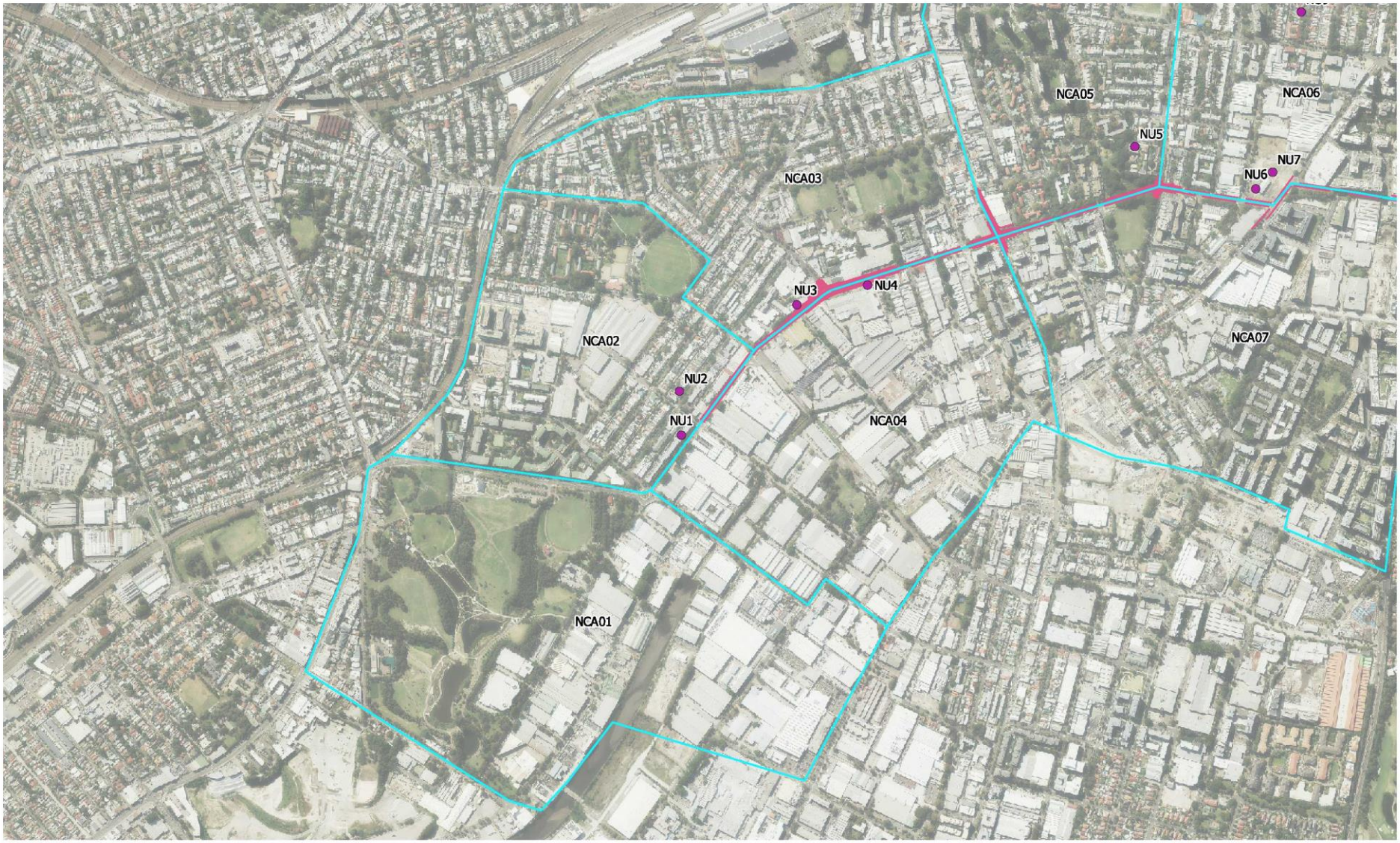


**Figure 2-2 – Site, surrounds, NCAs and noise monitoring locations (western end)**

# 3 Existing noise environment

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

As the noise environment of an area almost always varies over time, background noise levels need to be determined for the purpose of determining construction noise goals. The NSW Noise Policy for Industry (NPfI, Environment Protection Authority 2017) outlines the following standard time periods over which the background noise levels are to be determined:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays and Public Holidays.
- Evening is defined as 6:00pm to 10:00pm, Monday to Sunday and Public Holidays.
- Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays and Public Holidays.

In Roads and Maritime *Construction Noise and Vibration Guideline* (CNVG, 2016), standard construction hours are defined in the CNVG as 7:00am to 6:00pm, Monday to Friday, 8:00am to 1:00pm Saturdays and no work on Sundays or Public Holidays. Periods outside of these standard hours are referred to as "Out of Hours Works" periods. Potential Out of Hours Works periods are as follows:

- Out of Hours Works Day – 7:00am to 8:00am, Saturday and 8:00am to 6:00pm Sunday
- Out of Hours Works Evening – 6:00pm to 10:00pm, Monday to Sunday
- Out of Hours Works Night – 10:00pm to 7:00am, Monday to Friday, Saturday 10:00pm to Sunday 8:00am and 10pm to 7am Sundays.

For the assessment of operational noise, traffic noise levels are assessed separately for daytime and night time periods, defined by the NSW *Road Noise Policy* (RNP, 2011) as follows:

- **Day** is defined as 7:00am to 10:00pm.
- Night is defined as 10:00pm to 7:00am.

## 3.1 Existing background noise and traffic noise

To determine existing $L_{eq}$ traffic noise levels and background $L_{90}$ noise levels along the proposal corridor and at nearby noise sensitive areas, long-term noise monitoring was previously undertaken by Jacobs between 9 and 17 February 2017, at 12 representative locations.

The noise environment in the study area is generally influenced by traffic noise from the proposal corridor and the surrounding road network. The measured existing background noise and traffic noise levels are presented in Table 3-1, for each unattended noise monitoring location (NU).

**Table 3-1 – Measured rating background level($L_{90}$) and traffic noise ($L_{eq}$) noise levels**

| Monitoring Locations | | Measured Background Noise Level, dB(A) (Rating Background Level) | | | | Measured $L_{Aeq}$ Traffic Noise Level, dB(A) | |
|---|---|---|---|---|---|---|---|
| ID | Address | Standard Hours | Out of Hour Works | | | | |
| | | | Day | Evening | Night | Day | Night |
| NU1[3] (within NCA 2) | Unit 48, 95 Euston Rd, Alexandria (Level 3 balcony facing Euston Rd) | 61 | 54 | 54 | 40 | 69 | 63 |
| NU2[3] (within NCA 2) | 189 Lawrence St, Alexandria | 45 | 42 | 42 | 35 | 57 | 48 |
| NU3[3] (within NCA 3) | Unit M05, 147-161 McEvoy St, Alexandria (Level 2 balcony facing McEvoy St) | 60 | 53 | 53 | 44 | 67 | 63 |
| NU4[3] (within NCA 4) | 110A McEvoy St, Alexandria (Sunshade office) | 51 | 50 | 50 | 38 | 61 | 58 |
| NU5[3] (within NCA 5) | 2-6 Kellick St, Waterloo (Mount Carmel Catholic Primary School) | 43 | 40 | 40 | 36 | 55 | 45 |
| NU6[3] (within NCA 6) | 921 Bourke St, Waterloo (Sydney Water site facing McEvoy St) | 56 | 56 | 56 | 55 | 63 | 59 |
| NU7[3] (within NCA 6) | 921 Bourke St, Waterloo (Sydney Water site facing Bourke St) | 56 | 53 | 53 | 46 | 62 | 57 |
| NU8[4] (within NCA 6) | 10 Lachlan St, Waterloo (Level 12 terrace facing Lachlan St) | 58 | 56 | 56 | 53 | 63 | 58 |
| NU9[3] (within NCA 6) | 86 Mariott St, Redfern | 44 | 41 | 41 | 40 | 56 | 46 |
| NU10[4] (within NCA 7) | 879 South Dowling St, Waterloo (Sydney Water site facing South Dowling St) | 57 | 55 | 55 | 51 | 64 | 62 |
| NU11[3] (within NCA 6) | 847 South Dowling St, Waterloo (Level 15 terrace facing South Dowling St) | 64 | 63 | 63 | 51 | 67 | 64 |
| NU12[4] (within NCA 9) | Moore Park Golf (at southern boundary near residential towers in Kensington) | 46 | 44 | 44 | 39 | 55 | 46 |

Notes
1. "NU" = Unattended noise monitoring location
2. Existing $L_{Aeq}$ noise levels are reported in terms of the RNP's day (7am-10pm) and night (10pm-7am) periods.
3. Logger located At-facade (ie noise levels were monitored from a location within 1m of the building facade)
4. Logger located in free-field (ie noise levels were monitored from a location away from building facades)

# 4 Construction noise assessment

## 4.1 Construction noise objectives

Construction noise management levels are determined by the NSW *Interim Construction Noise Guideline* (ICNG, DECC 2009) in accordance with the Roads and Maritime *Construction Noise and Vibration Guideline* (CNVG, 2016).

### 4.1.1 Construction hours

Roads and Maritime would limit construction activity to Standard Hours where it is feasible and reasonable to do so to limit construction noise and vibration impacts to receivers. Standard construction hours are defined in the CNVG as:

- Monday to Friday – 7am to 6pm
- Saturday – 8am to 1pm
- No work on Sundays or Public Holidays.

Periods outside of these standard hours are referred to as "Out of Hours Works" periods. The CNVG segregates "Out of Hours Works" periods into the following two bands according to the sensitivity of receivers to noise impacts:

- Out of Hours Works 1 (OOHW1) – Monday to Friday 6pm to 10pm, Saturday 7am to 8am and 1pm to 10pm, and Sunday 8am to 6pm
- Out of Hours Works 2 (OOHW2) – Monday to Friday 10pm to 7am, Saturday 10pm to Sunday 8am, and Sunday 6pm to Monday 7am.

### 4.1.2 Residential land uses

The guideline intends to provide respite for high and/or extended noise and vibration generating activities near receivers outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 4-1 below (reproduced from Table 2 of the ICNG) sets out the noise management levels for residences and how they are to be applied. It is noted NMLs based on Table 4-1 would not be applicable for sensitive land uses and commercial receivers.

**Table 4-1 – Noise management levels at residential receivers**

| Time of Day | Management Level $L_{Aeq\ (15\ min)}$* | How to Apply |
|---|---|---|
| Recommended standard hours:<br>– Monday to Friday 7am to 6pm<br>– Saturday 8am to 1pm<br>– No work on Sundays or public holidays | Noise affected<br>RBL + 10dB(A) | The noise affected level represents the point above which there may be some community reaction to noise.<br>Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.<br>The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details. |
| | Highly noise affected<br>75dB(A) | The highly noise affected level represents the point above which there may be strong community reaction to noise.<br>Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:<br>• 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)<br>• 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<br>RBL + 5dB(A) | A strong justification should typically be required for works outside the recommended standard hours.<br>The proponent should apply all feasible and reasonable work practices to meet the noise affected level.<br>Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community.<br>For guidance on negotiating agreements see section 7.2.2 of the ICNG. |

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

Residential receivers are considered 'noise affected' where construction noise levels are greater than the noise management levels identified in Table 4-1. The noise affected level represents the point above which there may be some community reaction to noise. Where predicted and/or measured construction noise levels exceed noise management levels, all feasible and reasonable work practices would be applied to meet the management levels.

Furthermore, during standard construction hours a highly affected noise objective of $L_{Aeq(15min)}$ 75 dB(A) applies at all receivers.

Table 4-2 identifies the adopted construction noise management levels (NMLs) for the nearest affected residential receivers within the NCAs surrounding the proposal. The NMLs for each NCA are derived from the RBLs represented by the background noise levels measured at the monitoring locations and presented in Table 3-1.

**Table 4-2 – Summary of construction noise management levels for residential receivers, dB(A)**

| NCA | Background Noise Level RBL | | | Noise Management Level (NML) $L_{Aeq(15\ minute)}$ | | | |
|---|---|---|---|---|---|---|---|
| | | | | Standard Hours (RBL+10dB) | Out of Hours (OOH) (RBL+5dB) | | |
| | Standard Hours | OOWH1 | OOWH2 | Day | Day | Evening | Night |
| NCA 1[1] | 45 | 42 | 35 | 55 | 47 | 47 | 40 |
| NCA 2[2] | 45 | 42 | 35 | 55 | 47 | 47 | 40 |
| NCA 3 | 60 | 53 | 44 | 70 | 58 | 58 | 49 |
| NCA 4 | 51 | 50 | 38 | 61 | 56 | 55 | 43 |
| NCA 5 | 43 | 40 | 36 | 53 | 45 | 45 | 41 |
| NCA 6[3] | 44 | 41 | 40 | 54 | 46 | 46 | 45 |
| NCA 7 | 57 | 55 | 51 | 67 | 60 | 60 | 56 |
| NCA 8 | N/A (No residential receivers in this NCA) | | | | | | |
| NCA 9 | 46 | 44 | 39 | 56 | 49 | 49 | 44 |

Notes: 1. No noise monitoring was conducted within NCA 1, the RBL used was taken from the adjacent NCA 2
2. The RBL used for NCA 2 is the lowest RBL of the two monitoring locations within NCA 2.
3. The RBL used for NCA 6 is the lowest RBL of the five monitoring locations within NCA 6.

### 4.1.3 Sensitive land uses and commercial premises

Table 4-3 sets out the ICNG noise management levels for other noise sensitive receiver locations. As identified for residential receivers, a 'highly affected' noise objective of $L_{Aeq(15min)}$ 75dB(A) is adopted for all noise sensitive receivers, with exceedances addressed as described in Table 4-1.

**Table 4-3 – Noise management levels at sensitive land uses and commercial premises**

| Land use | Where Objective Applies | Noise Management Level, |
|---|---|---|
| Classrooms at schools and other educational institutions | Internal noise level | 45 dB(A) |
| Hospital wards and operating theatres | Internal noise level | 45 dB(A) |
| Places of worship | Internal noise level | 45 dB(A) |
| Active recreation areas | External noise level | 65 dB(A) |
| Passive recreation areas | External noise level | 60 dB(A) |
| Commercial premises | External noise level | 70 dB(A) |
| Industrial premises | External noise level | 75 dB(A) |

Notes: 1. Noise management levels apply when receiver areas are in use only.

For classrooms at schools and other educational institutions, hospital wards and operating theatres and places of worship, assuming that the building structures would typically provide a minimum of 10dB(A) reduction from external noise levels to internal noise levels, the external NML are set to 10dBA above the internal NML i.e 55dB(A).

### 4.1.4 Sleep disturbance

Given that night works are to occur, noise emanating from construction works associated with the proposal has been assessed for its potential to disturb sleep. The NSW EPA has made the following policy statement with respect to sleep disturbance:

*"Peak noise level events, such as reversing beepers, noise from heavy items being dropped or other high noise level events, have the potential to cause sleep disturbance. The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development. The Industrial Noise Policy does not specifically address sleep disturbance from high noise level events.*

*Research on sleep disturbance is reviewed in the NSW Road Noise Policy. This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*

*From the research, the EPA recognised that the current sleep disturbance criterion of an LA1, (1 minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, the EPA will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*

*The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy. Other factors that may be important in assessing the extent of impacts on sleep include:*

- *how often high noise events will occur*
- *time of day (normally between 10pm and 7am)*
- *whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

*The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. The EPA will accept analysis based on either LA1, (1 minute) or LA, (Max)."*

*Source: http://www.epa.nsw.gov.au/noise/applicnotesindustnoise.htm Downloaded: 04.12.2014*

Where the background noise levels are less than 40dB(A), some studies indicate that the above approach may result in noise limits that are unnecessarily strict.

In relation to maximum noise level events, the NSW *Road Noise Policy* (NSW EPA, 2012) identifies several investigations into the impacts of intermittent and emerging noise sources on the disturbance of sleep. Reference is made to enHealth report (2004) which notes the following in relation to maximum noise level events:

> *"As a rule in planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) LAmax more than 10 or 15 times per night."*

The NSW *Road Noise Policy* summaries the research on sleep disturbance to date as follows:

- *maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep*
- *one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly*

The above references identify that internal noise levels of 45dB(A) and up to 55dB(A), may have the potential to impact sleep but are unlikely to cause awakenings. On the assumption that there is a 10dB(A) outside-to-inside noise loss through an open window, the above references indicate that external noise levels of $L_{Amax}$ 55 to 65dB(A) are unlikely to cause awakening reactions.

To assess the likelihood of sleep disturbance, an initial screening level of ($L_{Amax}$ or $L_{A1(1min)} \leq L_{A90(15min)}$ + 15dB(A) is used. In situations where this results in an external screening level of less than 55dB(A), a minimum screening level of 55dB(A) is set. Note that this is equivalent to a maximum internal noise level of 45dB(A) with windows open.

Where there are noise events found to exceed the initial screening level, further analysis is made to identify:

- the likely number of events that might occur during the night assessment period
- Whether events exceed an 'awakening reaction' level of $L_{A1(1min))}$ 65dB(A).

Therefore, based on the above information, the sleep disturbance assessment levels for the proposal are presented in Table 4-4.

**Table 4-4 – $L_{A1,1min}$ (or $L_{Amax}$) sleep disturbance assessment levels**

| NCA | External Screening Level ($L_{A90,15min}$ + 15) | Awakening Reaction Level |
|---|---|---|
| NCA 1 | 55[1]dB(A) | 65dB(A) |
| NCA 2 | 55[1]dB(A) | 65dB(A) |
| NCA 3 | 59dB(A) | 65dB(A) |
| NCA 4 | 55[1]dB(A) | 65dB(A) |
| NCA 5 | 55[1]dB(A) | 65dB(A) |
| NCA 6 | 55[1]dB(A) | 65dB(A) |
| NCA 7 | 66dB(A) | 65dB(A) |

| NCA | External Screening Level ($L_{A90,15min}$ + 15) | Awakening Reaction Level |
|---|---|---|
| NCA 8 | N/A (No residential receivers in this NCA) | |
| NCA 9 | 55[1]dB(A) | 65dB(A) |

Notes: 1. External screening level is less than 55dB(A) so the minimum screening level of 55dB(A) is set

## 4.2 Construction noise sources

The following table lists typical construction activities and the associated major plant and equipment likely to be used by the contractor to carry out the necessary construction work for the proposal and their corresponding sound power levels.

**Table 4-5 – Proposed typical construction activities and sound power levels, dB(A) re. 1pW**

| Construction phase | Typical plant and equipment | Sound power level $L_{Aeq(15min)}$ | Total activity sound power level $L_{Aeq(15min)}$ |
|---|---|---|---|
| **Mobilisation and site establishment**<br><br>(indicative time of exposure to any one receiver: 1 week) | Truck (HIAB) | 100 | 106 |
| | Road Truck | 102 | |
| | Scissor Lift | 95 | |
| | Franna Crane | 98 | |
| | Light Vehicles | 82 | |
| | Hand Tools | 92 | |
| **Tree felling**<br><br>(To be undertaken only out of hours. Indicative time exposure of any receiver: 2-3 nights with noise respite periods) | Excavator (tracked) 35t | 110 | 119 |
| | Chainsaw 4-5hp | 114 | |
| | Tub grinder/mulcher 40-50hp | 116 | |
| | Cherry Picker | 100 | |
| | Dump Truck | 110 | |
| | City Crane | 110 | |
| **Utility relocation**<br><br>(indicative time of exposure to any one receiver: 1-10 weeks) | Excavator (tracked) 35t | 110 | 125 |
| | Dump truck /2t Tipper | 107 | |
| | Road Truck (Hiab) | 105 | |
| | Franna Crane 20t | 98 | |
| | Jackhammer* | 121 | |
| | Pneumatic Hammer* | 117 | |
| | Concrete Saw* | 117 | |
| | Vacuum Truck | 109 | |
| | Backhoe | 100 | |
| | Power Generator | 101 | |
| | Scissor Lift / EWP | 98 | |
| | Skid Steer | 110 | |
| | Plate Compactor/ Tamper Rammer | 110 | |
| **Utility relocation (minor)**<br><br>(indicative time of exposure to any one receiver: 1-10 weeks) | Excavator (tracked) 20t | 110 | 119 |
| | 2t Tipper | 107 | |
| | Concrete Saw* | 115 | |
| | Vacuum Truck | 107 | |
| | Power Generator | 101 | |
| | Skid Steer | 110 | |
| | Plate Compactor/Tamper Rammer | 110 | |

| Construction phase | Typical plant and equipment | Sound power level $L_{Aeq(15min)}$ | Total activity sound power level $L_{Aeq(15min)}$ |
|---|---|---|---|
| **Drainage infrastructure** (indicative time of exposure to any one receiver: 1-5 weeks) | Backhoe | 107 | 117 |
| | Franna Crane 20t | 102 | |
| | Excavator (tracked) 20t | 110 | |
| | Concrete Truck | 110 | |
| | Truck Compressor | 108 | |
| | Vibratory Roller | 75 | |
| | Plate Compactor/Tamper Rammer | 110 | |
| | Road Truck (Bogie) | 108 | |
| | Hiab Truck | 105 | |
| **Roadworks and tie-ins** (indicative time of exposure to any one receiver: 1-3 weeks) | Excavator | 110 | 120 |
| | Skid Steer | 110 | |
| | Dump Truck (Truck & Dog) | 107 | |
| | Spray Seal Equipment | 103 | |
| | Concrete Truck | 108 | |
| | Asphalt Paver | 104 | |
| | Concrete Saw* | 117 | |
| | Vibratory Roller 20-30t | 110 | |
| | Slip-Forming Machine | 102 | |
| | Vacuum Truck | 107 | |
| **Milling work** (indicative time of exposure to any one receiver: 1-3 weeks) | Pavement Profiler | 114 | 120 |
| | Skid Steer | 110 | |
| | Dump Truck | 104 | |
| | Asphalt Truck and Sprayer | 106 | |
| | Smooth Drum Roller | 104 | |
| | Concrete Saw* | 117 | |
| **Paving work** (indicative time of exposure to any one receiver: 1-6 weeks) | Pavement Laying Machine | 114 | 120 |
| | Dump Truck (Truck and Dog) | 104 | |
| | Asphalt Truck and Sprayer | 106 | |
| | Concrete Truck | 108 | |
| | Smooth Drum Roller | 104 | |
| | Concrete Saw* | 117 | |
| **Finishing work** (indicative time of exposure to any one receiver: 1-5 weeks) | Road Truck (Hiab) | 105 | 110 |
| | Scissor Lift | 92 | |
| | Franna Crane 20t | 98 | |
| | Line Marking Truck | 108 | |
| **Construction of compounds** | Franna Crane 20t | 95 | 114 |
| | Excavator (tracked) 35t | 110 | |
| | Concrete Truck | 108 | |
| | Dump Truck | 104 | |
| | Concrete Vibrator | 97 | |
| | Concrete Pump | 108 | |
| | Power Generator | 101 | |
| | Light Vehicles | 82 | |

| Construction phase | Typical plant and equipment | Sound power level $L_{Aeq(15min)}$ | Total activity sound power level $L_{Aeq(15min)}$ |
|---|---|---|---|
| **Site compounds (operation)** | Front End Loader | 112 | 115 |
| | Excavator 20t | 107 | |
| | Road Truck | 102 | |
| | Compressor | 109 | |
| | Welding Equipment | 105 | |
| | Light Vehicles | 82 | |
| | Power Generator | 101 | |

The sound power levels for the majority of activities presented in Table 4-5 are based on maximum levels given in Table F.1 of Roads and Maritime's CNVG, Table A1 of Australian Standard 2436 - 2010 *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, the ICNG, information from past projects and information held in the Renzo Tonin & Associates library files.

## 4.3 Construction traffic

The assessment of noise impacts from traffic associated with the construction works for the proposal is highlighted in Section 9 of the CNVG. The CNVG states the following:

> *"…an initial screening test should first be applied by evaluating whether noise levels will increase by more than 2dBA due to construction traffic or a temporary reroute due to a road closure. Where increases are 2dBA or less then no further assessment is required."*

Construction vehicles would generally access the proposal from major roadways feeding into the proposal, resulting in a temporary increase in heavy vehicle movements in the surrounding road network. Construction traffic would include vehicles, light and heavy trucks and concrete trucks. Construction traffic would be greatest during the main earthwork and civil construction, and would comprise vehicles transporting equipment, materials and spoil, and construction workers accessing the work sites.

The construction traffic volumes during work hours have been anticipated to be in the order of 40 to 60 heavy vehicle movements and 20 to 30 light vehicle movements within each active construction zone.

As a proportion of the required fill material would be sourced from outside of the proposal area, major material truck haulage routes would be required between the proposal area and the sourced material. Material being imported from the local quarries would use major roadways where possible and would access the proposal from established and designated access points.

It is assumed that traffic associated with the construction of the proposal would use Euston Road, McEvoy Street and South Dowling Street as a route to and from the construction site. From the traffic counting data (Section 6.3.3), the Annual Average Daily Traffic (AADT) volumes along these roads are in excess of 10,000. Based on the estimated construction traffic movements and the traffic volumes along the potential roads used to access the proposal, it is expected that construction traffic would increase

existing traffic volumes by less than 1%, which equates to a noise increase of less than 1dB(A). Therefore, noise from construction traffic would be well within the requirements of the CNVG.

Nevertheless, construction traffic noise impacts should be confirmed during the preparation of the Construction Noise and Vibration Management Plan as part of the detailed design stage when the final construction scheduling is determined.

## 4.4 Construction noise assessment

Construction noise impacts were predicted to the receiver locations surrounding the proposal by modelling the noise sources, receiver locations and construction activities as outlined above. Predicted noise level ranges determined for each construction activity represent the quietest plant item operating at the furthest distance to receivers and all plant items operating concurrently at the closest distance to receivers. This approach is conservative and has been adopted to ensure the full extent of possible noise impacts are assessed (what might occur in the worst-case). Therefore, the noise generated during construction works would generally be within the range of predictions presented below.

Furthermore, it is noted that the following activities are expected to occur concurrently and noise impacts from these concurrent activities have also been predicted:

- Utility relocation
- Civil works (Roadworks and tie-ins or paving work or finishing work)
- Site compounds (operation).

APPENDIX B presents the construction noise contours for the noisiest works including utility relocation, civil works and for activities expected to occur concurrently. Detailed predicted $L_{Aeq}$ construction noise levels for each individual activity and the site compounds associated with the construction phase and for activities expected to occur concurrently can be requested from Roads and Maritime Services

Based on the predicted $L_{Aeq}$ construction noise levels, the day, evening and night construction noise management levels would generally be exceeded at most residential receivers in each NCA. Residential receivers closest to the proposal corridor and directly adjacent to the construction works are also predicted to be highly noise affected [ie. >75dB(A)] during the day period.

For sensitive land uses and commercial premises, construction noise levels exceed the relevant NMLs at some receiver locations and also exceed the highly noise affected level of 75dB(A).

It is noted that in most cases the exceedances of the NMLs and highly noise affected level of 75dB(A) are based on the activity occurring at a point nearest to the receiver and with all plant and equipment operating concurrently. However, not all plant and equipment would typically operate concurrently and this is considered to be a worst case scenario.

Nevertheless, in light of the predicted noise levels presented and in accordance with the CNVG, it is recommended that a feasible and reasonable approach towards noise management measures be applied to reduce noise levels as much as possible to manage the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 4.5.

## 4.5 Construction noise mitigation measures

The following recommendations provide in-principle noise control solutions in accordance with the CNVG to reduce construction noise impacts to the affected receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required.

### 4.5.1 General noise management measures

Noise management measures in accordance with the CNVG would be implemented for the proposal. Appendix B of the CNVG presents standard noise mitigation measures, which are reproduced in Table 4-6.

**Table 4-6 – Standard noise mitigation measures**

| Action Required | Details |
|---|---|
| **Management Measures** | |
| Implementation of any project specific mitigation measures required | Implementation of any project specific mitigation measures required. |
| Implement community consultation or notification measures | Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night period, any operational noise benefits from the works (where applicable) and contact telephone number.<br>Notification should be a minimum of 7 calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required.<br>Website (if required)<br>Contact telephone number for community<br>Email distribution list (if required)<br>Community drop in session (if required by approval conditions) |
| Site inductions | All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include:<br>• all project specific and relevant standard noise and vibration mitigation measures<br>• relevant approval conditions<br>• permissible hours of work<br>• any limitations on high noise generating activities<br>• location of nearest sensitive receivers<br>• construction employee parking areas<br>• designated loading/unloading areas and procedures<br>• site opening/closing times (including deliveries)<br>• environmental incident procedures. |

| Action Required | Details |
|---|---|
| Behavioural practices | No swearing or unnecessary shouting or loud stereos/radios on site.<br>No dropping of materials from height where practicable, throwing of metal items and slamming of doors. |
| Update Construction Environmental Management Plans | The CEMP must be regularly updated to account for changes in noise management issues and strategies. |
| **Source Controls** | |
| Construction hours and scheduling | Where feasible and reasonable, construction should be carried out during the standard daytime working hours.<br>Work generating high noise levels should be scheduled during less sensitive time periods. |
| Construction respite period during normal hours and out-of-hours | The duration and respite of high noise generating activities would be undertaken in accordance with the CNVG, and consultation with the community.<br>As a guide, high noise generating activities near receivers should be carried out in blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The duration of each block of work and respite should be flexible to accommodate the usage and amenity at nearby receivers. |
| Equipment selection | Use quieter and less noise emitting construction methods where feasible and reasonable.<br>Ensure plant including the silencer is well maintained. |
| Plant noise levels | The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix F of the CNVG.<br>Implement a noise monitoring audit program to ensure equipment remains within the more stringent of the manufacturer's specifications or Appendix F of the CNVG. |
| Rental plant and equipment | The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in the CNVG. |
| Use and siting of plant | The offset distance between noisy plant and adjacent sensitive receivers is to be maximised where possible.<br>Plant used intermittently to be throttled down or shut down.<br>Noise-emitting plant to be directed away from sensitive receivers.<br>Only have necessary equipment on site. |
| Plan worksites and activities to minimise noise | Locate compounds away from sensitive receivers and discourage access from local roads, where possible.<br>Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.<br>Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible.<br>Very noisy activities should be scheduled for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11 pm, where possible.<br>If programmed night works is postponed the work should be re-programmed and the approaches in the CNVG apply again. |
| Reduced equipment power | Use only the necessary size and power |

| Action Required | Details |
|---|---|
| Non-tonal and ambient sensitive reversing alarms | Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for out of hours work.<br>Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level. |
| Minimise disturbance arising from delivery of goods to construction sites | Loading and unloading of material/deliveries is to occur as far as possible from sensitive receivers.<br>Select site access points and roads as far as possible away from sensitive receivers.<br>Dedicated loading/unloading areas to be shielded if close to sensitive receivers.<br>Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.<br>Avoid or minimise these out of hours movements where possible. |
| Engine compression braking | Limit the use of engine compression brakes at night and in residential areas.<br>Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'in-service test procedure' and standard. |
| **Path Controls** | |
| Shield stationary noise sources such as pumps, compressors, fans etc. | Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding. |
| Shield sensitive receivers from noisy activities | Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant. |

### 4.5.2 Additional noise mitigation measures

The following is a summary of the additional noise mitigation measures that would be considered:

- Prior to the commencement of work, sensitive receivers would be notified to advise that noise from the works may at times be audible
- All potentially impacted receivers would be kept informed of the nature of works to be carried out, the expected noise levels and duration, and be given contact details for enquiries and noise complaints
- A complaints handling procedure would be developed and implemented by the construction contractor. The complaints handling procedure would comply with Roads and Maritime and EPA requirements for recording, investigation and responding to complaints
- In accordance with the requirements of the CNVG, additional mitigation measures should be provided to a receiver (such as notification, respite period, etc.) based on the level of exceedance above the established NMLs and if a receiver is highly noise affected.

Where the NML at a receiver is exceeded after the standard mitigation measures from Section 4.5.1 have been implemented, additional noise mitigation measures as per Appendix C of the CNVG would be considered as follows:

- Notification (N) - Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions may also specify requirements for notification to the community about works that may impact on them.
- Specific notifications (SN) – Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops.
- Phone calls (PC) - Phone calls detailing relevant information made to identified/affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs. Where the resident cannot be telephoned then an alternative form of engagement should be used.
- Individual briefings (IB) - Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Where the resident cannot be met with individually then an alternative form of engagement should be used.
- Respite Offers (RO) – Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
- Respite Period 1 (R1) – Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month.
- Respite Period 2 (R2) – Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these

periods of work should be separated by not less than one week and 6 nights per month. Where possible, high noise generating works shall be completed before 11pm.

- Duration Respite (DR) - Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the proposal to gain support for Duration Respite.
- Alternative Accommodation (AA) – Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels. The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
- Verification (V) – Verification of noise and vibration levels as part of routine checks of noise levels or following reasonable complaints should include measurement of the background noise level and construction noise.

The additional mitigation (AM) measures from Appendix C of the CNVG and the relevant codes corresponding to the type of additional mitigation measure are reproduced in Table 4-7.

**Table 4-7 – Additional airborne noise mitigation measures as per CNVG**

| Predicted Airborne $L_{Aeq(15min)}$ Noise Level at Receiver | | | Additional Mitigation Measures | Additional Mitigation Measure Code |
|---|---|---|---|---|
| **Perception** | **dB(A) above RBL** | **dB(A) above NML** | | |
| **All hours** | | | | |
| 75dB(A) or greater (residences only) | | | N, V, SN, RO | HA |
| **Standard hours: Mon - Fri (7am - 6pm), Sat (8am - 1pm), Sun/Public Holiday (Nil)** | | | | |
| Noticeable | 5 to 10 | 0 | - | - |
| Clearly audible | 10 to 20 | < 10 | - | - |
| Moderately intrusive | 20 to 30 | 10 to 20 | N, V | **AM2** |
| Highly intrusive | > 30 | > 20 | N, V | **AM2** |
| **OOHW Period 1: Mon - Fri (6pm - 10pm), Sat (7am - 8am and 6pm - 10pm), Sun/Public Holiday (8am - 6pm)** | | | | |
| Noticeable | 5 to 10 | < 5 | - | - |
| Clearly audible | 10 to 20 | 5 to 15 | N, R1, DR | AM3 |
| Moderately intrusive | 20 to 30 | 15 to 25 | V, N, R1, DR | AM4 |
| Highly intrusive | > 30 | > 25 | V, N, R1, DR, SN, PC, IB | AM5 |
| **OOHW Period 2: Mon - Fri (10pm - 7am) Sat (10pm - 8am), Sun/Public Holiday (6pm - 7am)** | | | | |
| Noticeable | 5 to 10 | < 5 | N | **AM1** |
| Clearly audible | 10 to 20 | 5 to 15 | V, N, R2, DR | AM4 |
| Moderately intrusive | 20 to 30 | 15 to 25 | V, N, R2, DR, SN, PC, IB | AM5 |
| Highly intrusive | > 30 | > 25 | V, N, R2, DR, SN, PC, IB, AA | AM6 |

Notes:
N = Notification (letterbox drop or equivalent)
V = Verification of predicted noise level
SN = Specific Notification
IB = Individual Briefings
PC = Phone Call
R1 = Respite Period 1
R2 = Respite Period 2
DR = Duration Respite
AA = Alternative Accommodation
RO = Respite Offers

Based on Table 4-7 and the predicted exceedances of the NMLs, the additional mitigation measures required in accordance with the CNVG for the affected receivers are presented APPENDIX C for the day and evening / night periods, respectively.

# 5 Construction vibration assessment

## 5.1 Vibration criteria

Construction vibration is associated with three main types of impact:

- Disturbance to building occupants
- Potential damage to buildings
- Potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the metre (m), although common industrial standards include millimetre (mm)
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared ($m/s^2$).

Construction vibration goals are summarised in the following sections.

### 5.1.1 Disturbance to buildings occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC *Assessing Vibration; a technical guideline* (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 *Evaluation of human exposure to vibration in buildings (1-80Hz)*. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 5-1 provides definitions and examples of each type of vibration.

**Table 5-1 – Types of vibration**

| Type of Vibration | Definition | Examples |
|---|---|---|
| Continuous vibration | Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time) | Machinery, steady road traffic, continuous construction activity (such as vibratory rolling) |

| Type of Vibration | Definition | Examples |
|---|---|---|
| Impulsive vibration | A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds | Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. |
| Intermittent vibration | Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude | Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers.<br>Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria. |

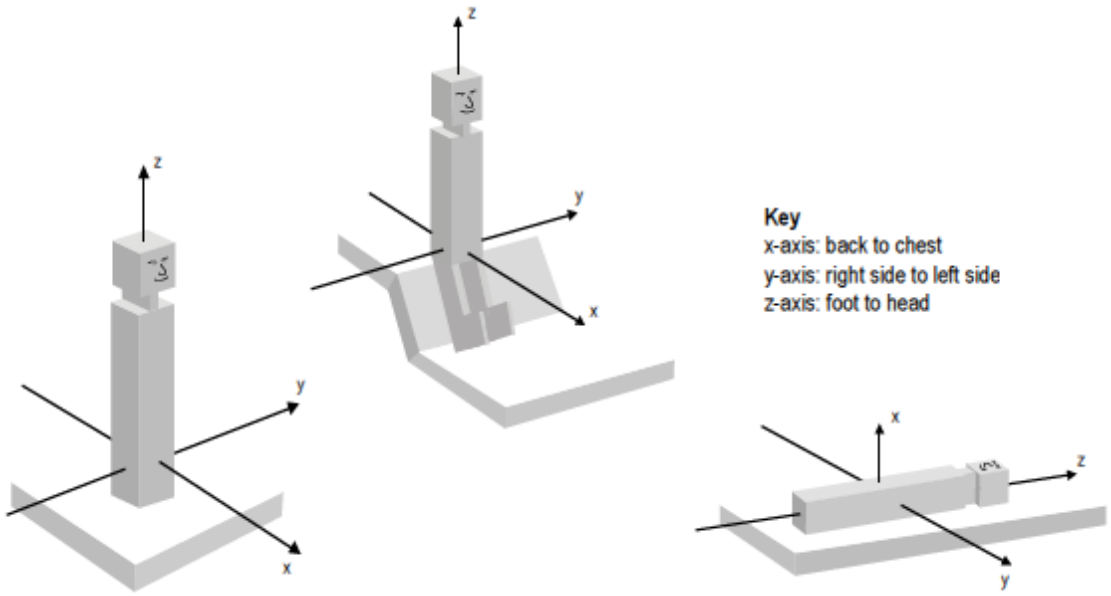
Source: Assessing Vibration; a technical guideline, Department of Environment and Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *"Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472)."*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 5-1. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

**Figure 5-1 – Orthogonal axes for human exposure to vibration**




The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and values for the type of receivers surrounding the site are reproduced in Table 5-2.

**Table 5-2 – Preferred and maximum levels for human comfort**

| Location | Assessment Period[1] | Preferred Values | | Maximum Values | |
|---|---|---|---|---|---|
| | | z-axis | x- and y-axis | z-axis | x- and y-axis |
| **Continuous Vibration (Weighted RMS Acceleration, $m/s^2$, 1-80Hz)** | | | | | |
| Residences | Daytime | 0.010 | 0.0071 | 0.020 | 0.014 |
| | Night-time | 0.007 | 0.005 | 0.014 | 0.010 |
| Offices, schools, educational institutions and places of worship | Day- or night-time | 0.020 | 0.014 | 0.040 | 0.028 |
| **Impulsive Vibration (Weighted RMS Acceleration, $m/s^2$, 1-80Hz)** | | | | | |
| Residences | Daytime | 0.30 | 0.21 | 0.60 | 0.42 |
| | Night-time | 0.10 | 0.071 | 0.20 | 0.14 |
| Offices, schools, educational institutions and places of worship | Day- or night-time | 0.64 | 0.46 | 1.28 | 0.92 |

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and values for the type of receivers surrounding the site are reproduced in Table 5-3.

**Table 5-3 – Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)**

| Location | Daytime[1] | | Night-time[1] | |
|---|---|---|---|---|
| | Preferred Value | Maximum Value | Preferred Value | Maximum Value |
| Residences | 0.20 | 0.40 | 0.13 | 0.26 |
| Offices, schools, educational institutions and places of worship | 0.40 | 0.80 | 0.40 | 0.80 |

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

### 5.1.2 Building damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage; however, guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *"7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components*" (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls*
> - *existing cracks in the building are enlarged*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

**British Standard**

British Standard 7385: Part 2 *Evaluation and measurement of vibration in buildings*, can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 5-4 sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" (p.5).

**Table 5-4 – BS 7385 structural damage criteria**

| Group | Type of Structure | Damage Level | Peak Component Particle Velocity[1], mm/s | | |
|---|---|---|---|---|---|
| | | | 4Hz to 15Hz | 15Hz to 40Hz | 40Hz and above |
| 1 | Reinforced or framed structures Industrial and heavy commercial buildings | Cosmetic | 50 | 50 | 50 |
| 2 | Un-reinforced or light framed structures Residential or light commercial type buildings | Cosmetic | 15 to 20 | 20 to 50 | 50 |

Notes: 1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

**German Standard**

German Standard DIN 4150 - Part 3 *Structural vibration in buildings - Effects on Structure* (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases. The criteria applicable to the receiver structure types surrounding the site are presented in Table 5-5.

**Table 5-5 – DIN 4150-3 structural damage criteria**

| Group | Type of Structure | Vibration Velocity, mm/s | | | |
|---|---|---|---|---|---|
| | | At Foundation at Frequency of | | | Plane of Floor Uppermost Storey |
| | | 1Hz to 10Hz | 10Hz to 50Hz | 50Hz to 100Hz | 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 Group 1 or 2 and have intrinsic value (eg buildings under a preservation order) | 3 | 3 to 8 | 8 to 10 | 8 |

The DIN 4150-3 is typically used for the assessment of heritage items which are classified as Group 3 structures in Table 5-5.

## 5.2 Vibration sources

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity.

Typical vibration levels from construction equipment most likely to cause significant vibration are summarised in Table 5-6 based on library data and measurements from past projects. Potential vibration generated to receivers for the proposal would be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

**Table 5-6 – Typical ground vibration generated by construction plant**

| Activity | Typical Ground Vibration |
|---|---|
| Bored Piling | Typical ground vibration from bored piling rigs is approximately 3mm/s at distances of approximately 5m and at distances greater than 10m, vibration levels are usually below 0.2mm/s. |
| Jackhammers | Typical ground vibration from jackhammers is 2mm/s at distances of approximately 5m and at distances greater than 10m, vibration levels are usually below 1mm/s. |
| Excavators / Graders | Typical ground vibration from excavators and graders range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s. |
| Compactor | Compactors typically generate 20mm/s at distances of approximately 5m, 2mm/s at distances of 15m. At distances greater than 30m, vibration are usually below 0.3mm/s. |
| Vibratory rollers | Ground vibration caused by vibratory rollers can range up to 1.5mm/s at distances of 25m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, especially dwellings.<br>Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller). |
| Truck traffic | Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 - 0.2mm/s at the footings of buildings located 10 - 20m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher.<br>In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded. |

Site specific buffer distances for vibration significant plant items (e.g. pile boring, vibratory rollers, compactors, excavators) should be measured on site. Unlike noise, vibration cannot be 'predicted'. There are many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (e.g. BS5228-2:2009) and should not be considered specific for the proposal.

## 5.3 Potential vibration impacts

Vibration generated by construction plant was estimated based on the proposed plant items presented in Section 4.2 and potential vibration impacts are summarised in Table 5-7. The assessment is relevant to the identified residential and commercial type buildings surrounding the proposal.

**Table 5-7 – Potential vibration impact assessment for residential and commercial properties**

| NCA | Approximate distance to nearest buildings from works | Assessment on Potential Vibration Impacts | |
|---|---|---|---|
| | | Structural Damage Risk | Human Disturbance |
| 1 | >50m | **Very Low** risk of structural damage | **Very Low** risk of adverse comment |
| 2 | >50m | **Very Low** risk of structural damage | **Very Low** risk of adverse comment |
| 3 | <10m | **High** risk of structural damage from vibratory rolling<br>**Medium** risk of structural damage from other activities | **High** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |
| 4 | <10m | **High** risk of structural damage from vibratory rolling<br>**Medium** risk of structural damage from other activities | **High** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |
| 5 | <10m | **High** risk of structural damage from vibratory rolling<br>**Medium** risk of structural damage from other activities | **High** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |
| 6 | <10m | **High** risk of structural damage from vibratory rolling<br>**Medium** risk of structural damage from other activities | **High** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |
| 7 | <10m | **High** risk of structural damage from vibratory rolling<br>**Medium** risk of structural damage from other activities | **High** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |
| 8 | >50m<br>(commercial receivers) | **Very Low** risk of structural damage | **Very Low** risk of adverse comment |
| 9 | 21m to 30m | **Low** risk of structural damage from vibratory rolling<br>**Very Low** risk of structural damage from other activities | **Medium** risk of adverse comment as a result of compacting, truck traffic and/ or vibratory rolling |

For heritage items, the risk of damage will be dependent on the condition and construction of the item. Dilapidation studies of heritage items will help inform of the level of risk from construction vibration impacts.

Vibratory rolling is expected to be undertaken within 100 metres of residences and commercial buildings for various stages of works and so may impact human comfort within those buildings.

Recommendations for reducing potential vibration impacts, including minimum working distances for construction plant are provided in Section 5.4.

## 5.4 Vibration mitigation

### 5.4.1 Recommended minimum buffer distances

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Accordingly, based on our database containing vibration measurements from past projects and library information, Table 5-8 presents the recommended minimum working distances for high vibration generating plant.

For heritage items, the minimum working distances will need to be determined on a site by site basis during detailed design pending dilapidation studies of the heritage items.

**Table 5-8 – Recommended minimum working distances for vibration intensive plant**

| Plant Item | Rating / Description | Minimum Working Distance | |
|---|---|---|---|
| | | Cosmetic Damage | Human Response |
| Vibratory Roller[1] | < 50 kN (Typically 1-2 tonnes) | 5m | 15m – 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 (Typically > 18 tonnes) | 25m | 100m |
| Pile Boring[1] | ≤ 800 mm | 2m (nominal) | N/A |
| Jackhammer[1] | Hand held | 1m (nominal) | Avoid contact with structure |
| Compactors[2] | - | 15m | 100m |
| Grader[2] | ≤ 20 tonne | 2m (nominal) | 10m |
| Excavators[2] | ≤ 30 Tonne (travelling/ digging) | 10m | 15m |
| Truck Movements[2] | - | - | 10m |

Notes: 1. TCA Construction Noise Strategy (Rail Projects) November 2011
2. Renzo Tonin & Associates project files, databases and library

### 5.4.2 Vibration management measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort and structural damage vibration limits:

- Attended vibration monitoring would be undertaken to determine site-specific minimum working distances for structural damage and human response. Site-specific minimum working distances would be determined whenever significant vibration generating plant would be working close to or within the recommended minimum working distances listed in Table 5-8.

- Further attended vibration monitoring would be conducted whenever significant vibration generating plant items are operating close to or within the determined minimum working distances. Locations for vibration monitoring during particular works would be determined by the construction contractor.
- Where vibration is found to be excessive, management measures would be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.
- Dilapidation surveys would be undertaken for identified potential vibration impacts.
- Notification by letterbox drop would be carried out for all occupied buildings within 100m of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property.
- Complaints from vibration impacts would be addressed as part of a complaints handling procedure which would be developed and implemented by the construction contractor. The complaints handling procedure would comply with Roads and Maritime and EPA requirements for recording, investigation and responding to complaints.

# 6 Operational noise assessment

## 6.1 Traffic noise criteria

This section presents the relevant noise criteria and limits related to road traffic noise emissions from the operation of the proposal.

The key reference documents relevant to road traffic noise management for the proposal include:

- NSW Road Noise Policy (RNP – NSW EPA, ex DECCW, March 2011)
- Noise Criteria Guideline (NCG – NSW Roads and Maritime, April 2015)
- Noise Mitigation Guidelines (NMG – NSW Roads and Maritime, April 2015)
- Environmental Noise Management Manual (ENMM – NSW Roads and Maritime, 2001)

Noise criteria are assigned to sensitive receivers using the NCG, which provides guidance on how to apply the NSW RNP. The assessment timeframe for the criteria are the year of opening and 10 years after opening.

The study area extends to where noise levels are dominated by other roads that are not being assessed as part of the proposal. This is up to a maximum distance of 600 metres from the proposal works.

### 6.1.1 Residential land use

The proposal involves the redevelopment of the existing road corridor. Based on a road redevelopment, a summary of the applicable traffic noise criteria in accordance with the NCG for residential receivers is presented in Table 6-1.

**Table 6-1 – NCG criteria for residential land uses**

| Road Category | Type of Development | Assessment Criteria, dB(A) | |
|---|---|---|---|
| | | Day (7am – 10pm) | Night (10pm – 7am) |
| Freeway/ arterial/ sub-arterial roads | Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial road corridors | $L_{Aeq(15hour)}$ 60 (external) | $L_{Aeq(9hour)}$ 55 (external) |

The criteria set out in Table 6-1 are the noise levels that the proposal would aim to achieve at residential receivers. All feasible and reasonable noise mitigation measures would be considered in the design of the proposal.

### 6.1.2 Sensitive land use developments

The NCG also sets guidelines for the assessment of traffic noise on sensitive land uses such as schools, places of worship, recreation areas and childcare facilities. The applicable road traffic noise criteria for these sensitive land uses are presented in the following table.

**Table 6-2 – NCG criteria for sensitive land uses**

| Existing sensitive land use | Assessment Criteria, dB(A) | | Additional considerations |
|---|---|---|---|
| | Day (7am-10pm) | Night (10pm-7am) | |
| School classrooms | $L_{Aeq,1hour}$ 40 (internal) when in use | – | In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000). |
| Places of worship | $L_{Aeq,1hour}$ 40 (internal) | $L_{Aeq,1\ hour}$ 40 (internal) | The criteria are internal, i.e. the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what in these areas may be affected by road traffic noise. |
| Open space (active use) | $L_{Aeq,15hour}$ 60 (external) when in use | | Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. |
| Open space (passive use) | $L_{Aeq,15hour}$ 55 (external) when in use | | Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading.<br>In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses. |
| Childcare facilities | Sleeping rooms $L_{Aeq,1hour}$ 35 (internal)<br>Indoor play areas $L_{Aeq,1hour}$ 40 (internal)<br>Outdoor play areas $L_{Aeq,1hour}$ 55 (external) | – | Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria.<br>Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility. |

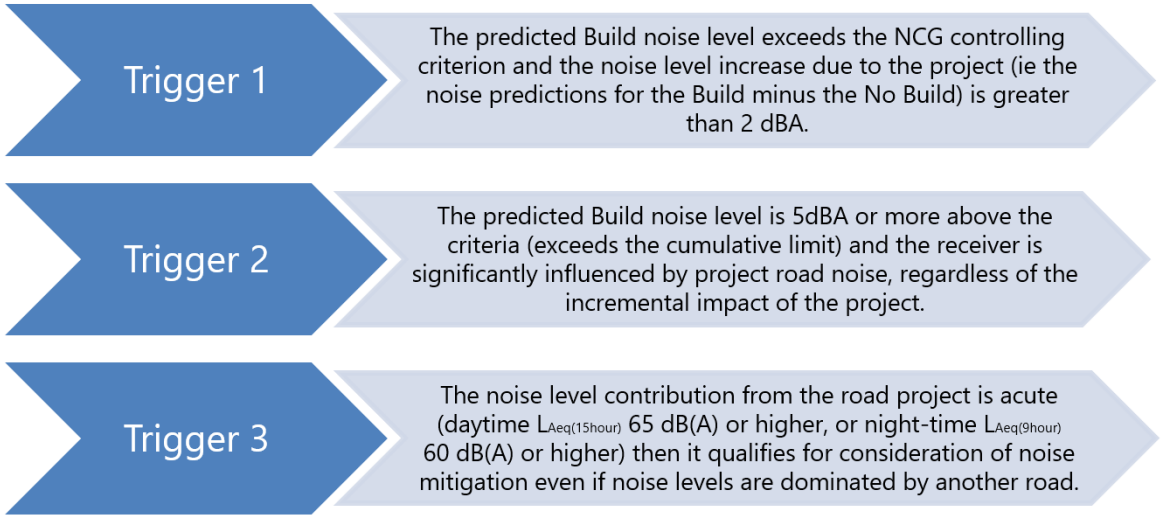
| Existing sensitive land use | Assessment Criteria, dB(A) | | Additional considerations |
|---|---|---|---|
| | Day (7am-10pm) | Night (10pm-7am) | |
| Mixed use development | – | – | Each component of use in a mixed use development should be considered separately.<br>For example, in a mixed use development containing residences and child care facility, the residential component should be assessed against the appropriate criteria for residences and the child care component should be assessed against the appropriate criteria for child care facilities. |

## 6.2 Guidance on the evaluation of noise mitigation measures

The Roads and Maritime *Noise Mitigation Guideline* (NMG, 2015) provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they would be achieved.

The NMG notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Where source measures are not practical, or do not provide sufficient noise reduction, additional methods are required to reduce levels to within acceptable margins. Such additional methods may include the use of noise barriers and/or consideration for at-property treatment of residences.

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These triggers are:




The eligibility of receivers for consideration of additional noise mitigation is determined before the benefit of additional noise mitigation (quieter pavement and noise barriers) is included. The

requirement for the proposal is to provide reasonable and feasible additional mitigation for these eligible receivers to meet the NCG controlling criterion. If the NCG criterion cannot be satisfied with quieter pavement and noise barriers, then the receiver is eligible for consideration of at-property treatment.

## 6.3 Noise modelling inputs

### 6.3.1 Building heights

Detailed information of the heights of individual buildings along the route was provided as SoundPLAN building objects.

### 6.3.2 Road pavement

When pavement surfaces are not dense graded asphalt or similar, corrections are included in the noise model, typically reflecting a noise increase for concrete pavements, and a noise decrease for quiet pavements such as open graded asphalt (OGAC). The road pavement surface for the proposal is to be dense graded asphalt and therefore, no pavement correction was used in the prediction of future traffic noise levels.

### 6.3.3 Traffic flow and composition summary

Traffic surveys were undertaken concurrently with the long term unattended noise monitoring surveys. These traffic volumes and speeds have been used only for the specific purpose of validating and calibrating the noise model.

Ten long-term, unattended tube count traffic surveys were undertaken on Euston Road, McEvoy Street, Bourke Street, Lachlan Street, South Dowling Street, Dacey Avenue, Alison Road and Anzac Parade by Austraffic (All Traffic Surveys (NSW) Pty Ltd) during the period between 1 and 24 February 2017. The unattended traffic (TU) locations (ie. tube counters) are identified as TU1 to TU10 in Table 6-3.

The existing 15 hour and 9 hour volumes, compositions and vehicle speeds used for validation of the noise model are presented in Table 6-3.

**Table 6-3 – Existing 2017 traffic volumes, compositions and speeds**

| Traffic Monitoring Location ID | Traffic Count Location | Direction | 7am – 10pm (15 hour) | | | 10pm – 7am (9 hour) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] |
| TU1 (near NCA 2) | Euston Road, between Maddox Street and Huntley Street | Northbound | 7,940 | 7 | 36 | 1,376 | 9 | 44 |
| | | Southbound | 13,202 | 8 | 42 | 1,731 | 6 | 49 |

| Traffic Monitoring Location ID | Traffic Count Location | Direction | 7am – 10pm (15 hour) | | | 10pm – 7am (9 hour) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] |
| TU2 (near NCA 3) | McEvoy Street, between Stokes Avenue and Loveridge Street | Eastbound | 9,617 | 6 | 38 | 1,276 | 5 | 48 |
| | | Westbound | 13,091 | 6 | 39 | 1,900 | 5 | 48 |
| TU3 (near NCA 5) | McEvoy Street, between Pitt Street and Elizabeth Street | Eastbound | 6,966 | 5 | 39 | 1,141 | 4 | 42 |
| | | Westbound | 8,914 | 5 | 40 | 1,532 | 3 | 45 |
| TU4 (near NCA 6) | McEvoy Street, west of Young Street | Eastbound | 7,367 | 4 | 36 | 1,202 | 3 | 43 |
| | | Westbound | 6,463 | 4 | 35 | 1,120 | 4 | 43 |
| TU5 (near NCA 5) | Bourke Street, between Lachlan Street and Potter Street | Northbound | 8,030 | 5 | 37 | 1,291 | 5 | 44 |
| | | Southbound | 5,409 | 5 | 32 | 781 | 5 | 40 |
| TU6 (near NCA 7) | Bourke Street, south of Archibald Street | Northbound | 6,253 | 5 | 30 | 1,109 | 6 | 37 |
| | | Southbound | 10,072 | 8 | 45 | 1,325 | 8 | 48 |
| TU7 (near NCA 7) | Lachlan Street, east of Sam Sing Street | Eastbound | 4,692 | 6 | 36 | 957 | 6 | 46 |
| | | Westbound | 9,862 | 6 | 46 | 1,687 | 7 | 50 |
| TU8 (near NCA 6 & 8) | South Dowling Street, between Lachlan Street and Danks Street | Northbound | 18,524 | 5 | 44 | 3,725 | 7 | 52 |
| | | Southbound | 23,074 | 5 | 32 | 5,141 | 4 | 49 |
| TU9 (near NCA 7) | South Dowling Street, south of Coles Express | Northbound | 12,564 | 4 | 37 | 2,754 | 5 | 47 |
| | | Southbound | 20,041 | 6 | 42 | 5,640 | 6 | 53 |
| TU10 (near NCA 9) | Dacey Avenue, west of pedestrian foot bridge | Eastbound | 12,424 | 7 | 52 | 2,235 | 7 | 54 |
| | | Westbound | 15,442 | 7 | 50 | 2,408 | 6 | 53 |

Notes: 1. Based on vehicle speeds from 2017 traffic survey

The traffic volumes used for the traffic noise predictions and assessment have been based on traffic data provided by Arup. Traffic volumes and compositions for the opening year (year 2021) and the design year (year 2031 – 10 years after the opening) have been provided.

The 15 hour and 9 hour traffic volumes, compositions and vehicle speeds for the proposal corridor, which are necessary for the calculation of $L_{Aeq(15\ hour)}$ and $L_{Aeq(9\ hour)}$ traffic noise levels, are presented in Table 6-4 for the 'no build' and 'build' scenarios. It is assumed that traffic volumes would not change due to the proposal as the proposal would not increase the traffic carrying capacity of the existing road corridor. Therefore, traffic volumes, compositions and vehicle speeds would be the same for the 'no build' and 'build' scenarios.

**Table 6-4 – Future 2021 and 2031 volumes, compositions and speeds – 'no build' and 'build'**

| Road | Direction | 7am – 10pm (15 hour) | | | 10pm – 7am (9 hour) | | |
|---|---|---|---|---|---|---|---|
| | | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] |
| **Year 2021 'No Build' and "Build" Scenarios** | | | | | | | |
| Proposal corridor, between Maddox Street and Bunnings | Eastbound | 12,275 | 6.34% | 50 | 2,209 | 6.34% | 50 |
| | Westbound | 13,494 | 6.34% | 50 | 1,751 | 6.34% | 50 |
| Proposal corridor, between Bunnings and Fountain Street | Eastbound | 12,888 | 6.34% | 50 | 2,095 | 6.34% | 50 |
| | Westbound | 14,301 | 6.34% | 50 | 1,943 | 6.34% | 50 |
| Proposal corridor, between Fountain Street and Wyndham Street | Eastbound | 13,624 | 6.34% | 50 | 2,130 | 6.34% | 50 |
| | Westbound | 15,114 | 6.34% | 50 | 2,739 | 6.34% | 50 |
| Proposal corridor, between Wyndham Street and Botany Road | Eastbound | 6,474 | 6.34% | 50 | 1,325 | 6.34% | 50 |
| | Westbound | 15,173 | 6.34% | 50 | 2,376 | 6.34% | 50 |
| Proposal corridor, between Botany Road and George Street | Eastbound | 11,628 | 6.34% | 50 | 1,916 | 6.34% | 50 |
| | Westbound | 9,054 | 6.34% | 50 | 1,447 | 6.34% | 50 |
| Proposal corridor, between George Street and Pitt Street | Eastbound | 10,513 | 6.34% | 50 | 1,800 | 6.34% | 50 |
| | Westbound | 9,713 | 6.34% | 50 | 1,527 | 6.34% | 50 |
| Proposal corridor, between Pitt Street and Elizabeth Street | Eastbound | 9,652 | 6.34% | 50 | 1,673 | 6.34% | 50 |
| | Westbound | 9,493 | 6.34% | 50 | 1,474 | 6.34% | 50 |
| Proposal corridor, between Elizabeth Street and Bourke Street | Eastbound | 8,671 | 6.34% | 50 | 1,491 | 6.34% | 50 |
| | Westbound | 6,412 | 6.34% | 50 | 1,050 | 6.34% | 50 |
| Proposal corridor, between Bourke Street and Lachlan Street | Eastbound | 9,920 | 6.34% | 50 | 1,637 | 6.34% | 50 |
| | Westbound | 10,923 | 6.34% | 50 | 1,783 | 6.34% | 50 |
| Proposal corridor, between Lachlan Street and South Dowling Street | Eastbound | 6,310 | 6.34% | 50 | 1,139 | 6.34% | 50 |
| | Westbound | 6,705 | 6.34% | 50 | 870 | 6.34% | 50 |
| Maddox Street – North of Proposal Corridor[2] | Northbound | 4,820 | 3.57% | 50 | 851 | 5.96% | 50 |
| | Southbound | 4,225 | 8.02% | 50 | 746 | 13.37% | 50 |
| Maddox Street – South of Proposal Corridor[2] | Northbound | 4,777 | 1.96% | 50 | 843 | 3.26% | 50 |
| | Southbound | 2,899 | 8.49% | 50 | 512 | 14.15% | 50 |
| Fountain Street – North of Proposal Corridor[2] | Northbound | 4,760 | 7.57% | 50 | 840 | 12.61% | 50 |
| | Southbound | 3,188 | 8.80% | 50 | 563 | 14.67% | 50 |
| Wyndham Street – North of Proposal Corridor[2] | Northbound | 5,287 | 7.43% | 50 | 933 | 12.38% | 50 |
| | Southbound | 2,193 | 7.28% | 50 | 387 | 12.14% | 50 |
| Wyndham Street – South of Proposal Corridor[2] | Northbound | 3,315 | 4.87% | 50 | 585 | 8.12% | 50 |
| | Southbound | 2,907 | 8.29% | 50 | 513 | 13.82% | 50 |
| Botany Road – North of Proposal Corridor[2] | Northbound | 7,276 | 8.14% | 50 | 1,284 | 13.56% | 50 |
| | Southbound | 11,178 | 9.65% | 50 | 1,973 | 16.08% | 50 |
| Botany Road – South of Proposal Corridor[2] | Northbound | 7,531 | 7.89% | 50 | 1,329 | 13.16% | 50 |
| | Southbound | 6,928 | 9.86% | 50 | 1,223 | 16.43% | 50 |

| Road | Direction | 7am – 10pm (15 hour) | | | 10pm – 7am (9 hour) | | |
|---|---|---|---|---|---|---|---|
| | | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] |
| George Street – South of Proposal Corridor[2] | Southbound | 1,012 | 10.95% | 50 | 179 | 18.25% | 50 |
| Pitt Street – South of Proposal Corridor[2] | Northbound | 400 | 5.13% | 50 | 71 | 8.55% | 50 |
| | Southbound | 408 | 4.30% | 50 | 72 | 7.17% | 50 |
| Elizabeth Street – North of Proposal Corridor[2] | Northbound | 10,328 | 9.14% | 50 | 1,823 | 15.24% | 50 |
| | Southbound | 11,501 | 7.82% | 50 | 2,030 | 13.03% | 50 |
| Elizabeth Street – South of Proposal Corridor[2] | Northbound | 7,973 | 9.34% | 50 | 1,407 | 15.56% | 50 |
| | Southbound | 8,288 | 7.99% | 50 | 1,463 | 13.31% | 50 |
| Bourke Street – North of Proposal Corridor[2] | Northbound | 9,087 | 9.61% | 50 | 1,604 | 16.02% | 50 |
| | Southbound | 6,231 | 9.09% | 50 | 1,100 | 15.15% | 50 |
| Bourke Street – South of Proposal Corridor[2] | Northbound | 7,327 | 9.11% | 50 | 1,293 | 15.19% | 50 |
| | Southbound | 8,058 | 8.99% | 50 | 1,422 | 14.98% | 50 |
| South Dowling Street – North of Proposal Corridor[2] | Northbound | 9,826 | 6.64% | 50 | 1,734 | 11.06% | 50 |
| | Southbound | 13,549 | 7.74% | 50 | 2,391 | 12.90% | 50 |
| South Dowling Street – South of Proposal Corridor[2] | Northbound | 13,753 | 7.57% | 50 | 2,427 | 12.62% | 50 |
| | Southbound | 18,539 | 7.52% | 50 | 3,272 | 12.53% | 50 |
| **Year 2031 'No Build' and Build' Scenarios** | | | | | | | |
| Proposal corridor, between Maddox Street and Bunnings | Eastbound | 12,657 | 6.34% | 50 | 2,345 | 6.34% | 50 |
| | Westbound | 15,196 | 6.34% | 50 | 2,320 | 6.34% | 50 |
| Proposal corridor, between Bunnings and Fountain Street | Eastbound | 13,321 | 6.34% | 50 | 2,255 | 6.34% | 50 |
| | Westbound | 16,087 | 6.34% | 50 | 2,588 | 6.34% | 50 |
| Proposal corridor, between Fountain Street and Wyndham Street | Eastbound | 14,240 | 6.34% | 50 | 2,353 | 6.34% | 50 |
| | Westbound | 16,377 | 6.34% | 50 | 3,259 | 6.34% | 50 |
| Proposal corridor, between Wyndham Street and Botany Road | Eastbound | 6,710 | 6.34% | 50 | 1,391 | 6.34% | 50 |
| | Westbound | 15,581 | 6.34% | 50 | 2,482 | 6.34% | 50 |
| Proposal corridor, between Botany Road and George Street | Eastbound | 11,983 | 6.34% | 50 | 1,975 | 6.34% | 50 |
| | Westbound | 9,894 | 6.34% | 50 | 1,771 | 6.34% | 50 |
| Proposal corridor, between George Street and Pitt Street | Eastbound | 10,829 | 6.34% | 50 | 1,855 | 6.34% | 50 |
| | Westbound | 10,609 | 6.34% | 50 | 1,878 | 6.34% | 50 |
| Proposal corridor, between Pitt Street and Elizabeth Street | Eastbound | 9,942 | 6.34% | 50 | 1,725 | 6.34% | 50 |
| | Westbound | 10,371 | 6.34% | 50 | 1,810 | 6.34% | 50 |
| Proposal corridor, between Elizabeth Street and Bourke Street | Eastbound | 9,121 | 6.34% | 50 | 1,600 | 6.34% | 50 |
| | Westbound | 7,005 | 6.34% | 50 | 1,272 | 6.34% | 50 |
| Proposal corridor, between Bourke Street and Lachlan Street | Eastbound | 11,181 | 6.34% | 50 | 2,141 | 6.34% | 50 |
| | Westbound | 11,033 | 6.34% | 50 | 1,865 | 6.34% | 50 |
| Proposal corridor, between Lachlan Street and South Dowling Street | Eastbound | 7,072 | 6.34% | 50 | 1,498 | 6.34% | 50 |
| | Westbound | 7,356 | 6.34% | 50 | 1,080 | 6.34% | 50 |

| Road | Direction | 7am – 10pm (15 hour) | | | 10pm – 7am (9 hour) | | |
|---|---|---|---|---|---|---|---|
| | | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] | Total Vehicles | % Heavy Vehicles | Speed (km/h)[1] |
| Maddox Street – North of Proposal Corridor[2] | Northbound | 4,208 | 2.18% | 50 | 743 | 3.63% | 50 |
| | Southbound | 4,709 | 8.25% | 50 | 831 | 13.75% | 50 |
| Maddox Street – South of Proposal Corridor[2] | Northbound | 5,610 | 2.84% | 50 | 990 | 4.73% | 50 |
| | Southbound | 4,148 | 8.60% | 50 | 732 | 14.33% | 50 |
| Fountain Street – North of Proposal Corridor[2] | Northbound | 4,437 | 5.76% | 50 | 783 | 9.59% | 50 |
| | Southbound | 5,134 | 7.68% | 50 | 906 | 12.80% | 50 |
| Wyndham Street – North of Proposal Corridor[2] | Northbound | 4,616 | 8.84% | 50 | 815 | 14.73% | 50 |
| | Southbound | 2,295 | 7.17% | 50 | 405 | 11.95% | 50 |
| Wyndham Street – South of Proposal Corridor[2] | Northbound | 3,681 | 5.42% | 50 | 650 | 9.03% | 50 |
| | Southbound | 2,814 | 8.06% | 50 | 497 | 13.43% | 50 |
| Botany Road – North of Proposal Corridor[2] | Northbound | 7,880 | 8.10% | 50 | 1,391 | 13.51% | 50 |
| | Southbound | 10,583 | 9.61% | 50 | 1,868 | 16.02% | 50 |
| Botany Road – South of Proposal Corridor[2] | Northbound | 7,659 | 8.13% | 50 | 1,352 | 13.55% | 50 |
| | Southbound | 7,361 | 9.83% | 50 | 1,299 | 16.38% | 50 |
| George Street – South of Proposal Corridor[2] | Southbound | 1,029 | 6.64% | 50 | 182 | 11.06% | 50 |
| Pitt Street – South of Proposal Corridor[2] | Northbound | 417 | 9.41% | 50 | 74 | 15.69% | 50 |
| | Southbound | 408 | 6.38% | 50 | 72 | 10.64% | 50 |
| Elizabeth Street – North of Proposal Corridor[2] | Northbound | 10,141 | 8.84% | 50 | 1,790 | 14.73% | 50 |
| | Southbound | 11,960 | 7.79% | 50 | 2,111 | 12.98% | 50 |
| Elizabeth Street – South of Proposal Corridor[2] | Northbound | 8,823 | 8.64% | 50 | 1,557 | 14.39% | 50 |
| | Southbound | 9,078 | 8.35% | 50 | 1,602 | 13.92% | 50 |
| Bourke Street – North of Proposal Corridor[2] | Northbound | 10,557 | 8.67% | 50 | 1,863 | 14.45% | 50 |
| | Southbound | 8,330 | 9.43% | 50 | 1,470 | 15.71% | 50 |
| Bourke Street – South of Proposal Corridor[2] | Northbound | 7,897 | 8.85% | 50 | 1,394 | 14.75% | 50 |
| | Southbound | 9,605 | 8.81% | 50 | 1,695 | 14.69% | 50 |
| South Dowling Street – North of Proposal Corridor[2] | Northbound | 11,067 | 6.72% | 50 | 1,953 | 11.21% | 50 |
| | Southbound | 16,133 | 7.32% | 50 | 2,847 | 12.20% | 50 |
| South Dowling Street – South of Proposal Corridor[2] | Northbound | 16,346 | 7.60% | 50 | 2,885 | 12.67% | 50 |
| | Southbound | 17,621 | 7.60% | 50 | 3,110 | 12.66% | 50 |

Notes:
1. Vehicles speeds based on posted speed
2. Peak hour traffic volumes were provided for the side streets. The peak hour volumes were converted to 15hr and 9 hr volumes based on the following assumptions:
   - Peak hour traffic volumes are 10% of the 24hr volume;
   - The 15hr daytime volume is 85% of the 24hr volume; and
   - The 9hr daytime volume is 15% of the 24hr volume;

All traffic noise predictions in Sections 6.4 and 6.5 are based on the traffic volume, heavy vehicle proportions and vehicle speed data set out in the above tables.

## 6.4 Traffic noise prediction modelling

### 6.4.1 Noise prediction model

A base noise model was provided by Jacobs and updated with the latest design for the proposal. Noise modelling was undertaken using the Road Traffic Noise Module in the SoundPLAN (Version 7.4) noise modelling software. This method is recognised and accepted by both Roads and Maritime and the EPA.

The traffic noise prediction model adopted by SoundPLAN is based on a method developed by the United Kingdom Department of Environment entitled *Calculation of Road Traffic Noise* (1988) known as the CoRTN88 method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board. The model predicts noise levels for free-flowing traffic and a modified method has been developed which enables an accurate prediction of noise from high truck exhausts to be taken into account.

The method predicts the $L_{10(1hr)}$ noise levels, and a correction of -3dB(A) is applied to obtain the $L_{eq(1hr)}$ noise levels. The $L_{eq(1hr)}$ noise levels for the day time period 7am to 10pm are used to determine the daily $L_{eq(15hr)}$ noise levels. Similarly, the $L_{eq(1hr)}$ noise levels for the night time period 10pm to 7am are used to derive the night time $L_{eq(9hr)}$ noise levels.

Table 6-5 following sets out the inputs and assumptions used in the traffic noise prediction model.

**Table 6-5 – Summary of SoundPLAN noise modelling inputs**

| Input Parameters | Data Acquired From |
|---|---|
| Traffic volumes, compositions and speeds | Noise model verification: traffic data obtained from traffic survey conducted concurrently with the noise monitoring. Vehicle speeds based on traffic speeds as surveyed (see Table 6-3)<br>Noise prediction modelling: 2021 and 2031 predicted traffic volumes provided by Arup. Vehicle speeds based on posted speeds (see Table 6-4) |
| Gradient of roadway | Design drawings provided by Jacobs |
| Source heights and corrections | • 0.5m for car exhaust<br>• 1.5m for car and truck engines<br>• 3.6m for truck exhaust |
| Ground topography at receiver and road | 1m ground contours provided by Jacobs |
| Ground absorption | Detailed within CoRTN88. Numeric values varied between 0 (hard surface) to 1 (soft ground).<br>• 0.75 used for all soft ground areas<br>• 0 used for water surfaces. |
| Receiver heights | 1.5m above ground level for ground floor, 4.5m above ground level for first floor levels and plus 3m for each additional floor level |
| Facade correction | +2.5dB(A) |
| $L_{10}$ to $L_{eq}$ correction | -3dB(A) |

| Input Parameters | Data Acquired From |
|---|---|
| Correction for Australian conditions | The Austroads Research Report (ARR), "An Approach to the Validation of Road Traffic Noise Models" (2002):<br>• -1.7 dB(A) for 'at façade' conditions<br>• -0.7 dB(A) for 'free field' conditions |
| Road pavement corrections | Dense graded asphalt (DGA) = 0dB(A) |
| Roadside barriers | No existing roadside barriers |
| Existing traffic noise levels ($L_{Aeq}$) | Based on long term monitoring undertaken by Jacobs |
| Calculation search radius | 3,000m |
| Noise contour maps | • 25m grid spacing<br>• 1.5m height<br>• Contour Bands<br>- Construction: 5dB(A) bands from 55dB(A) to 75dB(A)<br>- Operational: 5dB(A) bands from 45dB(A) to 65dB(A) |

### 6.4.2 Model validation

The model was validated and calibrated using the long-term noise monitoring results and the concurrent traffic classification counts. Table 6-6 summarises the results of the traffic noise model validation, providing a comparison between the modelled traffic noise levels for existing conditions and the measured traffic noise levels.

**Table 6-6 – Noise model verification results**

| ID | Address | $L_{Aeq(15\ hour)}$ Daytime Noise Level | | | $L_{Aeq(9\ hour)}$ Night Time Noise Level | | |
|---|---|---|---|---|---|---|---|
| | | Measured | Modelled | Variation | Measured | Modelled | Variation |
| NU1 | Unit 48, 95 Euston Road, Alexandria (Level 3) | 68.5 | 68.7 | 0.2 | 63.1 | 62.6 | -0.5 |
| NU3 | Unit M05, 147-161 McEvoy Street, Alexandria (Level 2) | 67.2 | 67.6 | 0.4 | 62.7 | 61.6 | -1.1 |
| NU6 | 921 Bourke Street, Waterloo (Sydney Water site facing McEvoy Street) | 62.6 | 61.8 | -0.8 | 56.6 | 56.4 | -0.2 |
| NU7 | 921 Bourke Street, Waterloo (Sydney Water site facing Bourke Street) | 62.4 | 60.9 | -1.5 | 56.5 | 55.6 | -0.9 |
| NU8 | 10 Lachlan Street, Waterloo (level 12 terrace) | 62.7 | 61.0 | -1.7 | 58.0 | 56.2 | -1.8 |
| NU10 | 879 South Dowling Street, Waterloo (Sydney Water site) | 64.3 | 64.1 | -0.2 | 61.8 | 60.4 | -1.4 |
| | | | **Median** | **-0.5** | | **Median** | **-1.0** |

The noise model validation results presented in Table 6-6 show that the noise model output results are generally in good agreement with noise monitoring for the daytime and night time periods, so there is a reasonable level of confidence that can be placed on the noise model for predicting future traffic noise levels for the daytime and night time periods.

Overall, the median variations between measured and modelled results for the daytime and night time periods are -0.5dB(A) and -1.0dB(A), which are within the ±2dB(A) allowance for traffic noise validation; and within the ±1dB(A) allowance for not including a calibration factor in future traffic noise predictions.

Therefore, for the prediction of day and night time traffic noise levels, no calibration factors are required to be included when generating the operational noise predictions for future traffic noise scenarios.

## 6.5 Traffic noise model prediction result

Operational noise modelling has been conducted based on the traffic volumes presented in Section 6.3.3. The scenarios predicted are:

- **'Opening Year'**, where noise levels are the predicted noise levels for 2021 for both the 'build' and 'no build' options, for the day and night periods.
- 'Design Year', where noise levels are the predicted noise levels for 2031 for both the 'build' and 'no-build' options, for the day and night periods.

Noise modelling for the above scenarios was completed at noise sensitive locations potentially affected by the traffic noise from the proposal. In accordance with the NCG, these receivers are typically within 600m either side of the proposal.

The predicted noise levels are assessed against the NCG traffic noise criteria as defined in Section 6.1. The predicted noise contours for the design year (2031) for the day and night periods are presented in APPENDIX D. The results for the number of receivers impacted upon for the design year 2031 are summarised in Table 6-7.

Detailed noise modelling results for the proposal for the day and night time periods can be requested from Roads and Maritime Services.

**Table 6-7 – Number of receivers impacted due to build option for design year 2031**

| NCA | Total Number of Receivers Assessed in NCA | Day Period – Number of Receivers | | | | Night Period – Number of Receivers | | | | Requiring Further Treatment |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exceed NCG Noise Criteria Level [1] | >2dB(A) Increase [2] | Exceed Cumulative Noise Limit | Experience Acute Noise Levels [≥ 65dB(A)] | Exceed NCG Noise Criteria Level[1] | >2dB(A) Increase[2] | Exceed Cumulative Noise Limit | Experience Acute Noise Levels [≥ 60dB(A)] | |
| NCA 1 | 560 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NCA 2 | 5,307 | 94 | 0 | 8 | 8 | 90 | 0 | 8 | 8 | 8 |
| NCA 3 | 8,248 | 308 | 0 | 52 | 54 | 279 | 0 | 52 | 54 | 54 |
| NCA 4 | 570 | 201 | 0 | 29 | 29 | 179 | 0 | 29 | 29 | 29 |
| NCA 5 | 7,069 | 272 | 0 | 28 | 15 | 224 | 0 | 15 | 15 | 28 |
| NCA 6 | 7,026 | 449 | 0 | 159 | 160 | 417 | 0 | 157 | 159 | 161 |
| NCA 7 | 8,431 | 578 | 0 | 103 | 109 | 527 | 0 | 103 | 109 | 109 |
| NCA 8 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NCA 9 | 4,187 | 63 | 0 | 0 | 0 | 56 | 0 | 0 | 0 | 0 |
| **TOTAL** | 43,785 | 1,979 | 0 | 379 | 375 | 1,785 | 0 | 364 | 374 | 389 |

Notes: 1. NCG noise criteria level based on 'Redeveloped Road' criteria as per RNP

2. >2dB(A) increase based on comparison between 'build option' and 'no build option' for the design year 2031

3. Includes sensitive receiver at 2A Kellick Street, Waterloo (Our Lady of Mt Carmel Catholic Primary)

From Table E.1, exceedance of the NCG noise criteria was predicted for 1,979 receivers during the day period and 1,785 receivers during the night period in the year 2031, 10 years after the opening of the proposal.

Traffic noise levels in the year 2031 are predicted to generally increase marginally by no more than 2dB(A) at all receivers.

The assessment identified 379 receivers would exceed the cumulative limits for the day period and 364 receivers during the night period in the year 2031. Furthermore, the assessment identified 375 receivers would exceed the acute noise threshold for the day period and 374 receivers during the night period in the year 2031.

Overall, from Table E.1 389 receivers were identified as requiring additional noise mitigation treatment due to them exceeding the NCG noise criteria and/or exceeding the cumulative / acute noise limits. An assessment of all reasonable and feasible noise mitigation options to reduce traffic noise levels at the affected receivers to within the applicable noise limits is presented in Section 6.7.

APPENDIX E presents an aerial map showing the location of the receivers identified as requiring additional noise mitigation treatment.

During the detailed design stage of the proposal, further investigation of all reasonable and feasible noise control options would be required as a result of any exceedances of the applicable NCG noise criteria. All reasonable and feasible noise mitigation treatments would be considered for the affected receivers as part of the proposal to reduce traffic noise levels at residences to within the applicable noise limits.

## 6.6 Maximum noise level assessment

Maximum noise levels generated by road traffic noise have the potential to cause disturbance to sleep. Noise emanating from the proposal has been assessed qualitatively for its potential to disturb sleep. The effect of traffic noise on sleep is discussed in Section 5.4 of the RNP. The following information extracted from that section is pertinent.

The disruption of a person's normal sleep patterns, or sleep disturbance, due to road traffic noise, has been the subject of numerous research studies conducted over the last 30 years. Despite intensive research, the triggers for and effects of sleep disturbance have not yet been conclusively determined. Sleep disturbance occurs through changes in sleep state and awakenings. Awakenings are better correlated to subjective assessments of sleep quality than are changes in sleep state, which generally require objective measurement.

A summary of the current literature concerning sleep disturbance due to noise indicates that the main noise characteristics that influence sleep disturbance are the number of noisy events heard distinctly above the background level, the emergence of these events and the highest noise level.

For continuous traffic flow, $L_{Aeq}$ appears to be acceptably correlated with sleep disturbance, since under these conditions there are few emergent noise events above the main hum of the traffic. However, for intermittent traffic flow, which often occurs at night, some other measure that takes into account the emergence, described by measures such as ($L_{AFmax} - L_{Aeq}$) or ($L_{AFmax} - L_{AF90}$), the highest level of noise and the number of events may be needed to obtain a better correlation with sleep disturbance.

From the research on sleep disturbance to date the RNP concludes that:

- $L_{Amax}$ (the maximum A-weighted noise level) internal noise levels below 50-55 dB(A) are unlikely to awaken people from sleep (corresponding to approximately 60-65 dB(A) externally); and,
- One or two noise events per night, with maximum internal noise levels of 65-70 dB(A) (corresponding to approximately 75-80 dB(A) externally), are not likely to affect health and wellbeing significantly.

According to the RNP, triggers for and effects of sleep disturbance from exposure to intermittent noise such as noise from road traffic are still being studied, and there appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise.

The cause of most maximum noise emissions from the proposal would be from heavy vehicles (eg. during engine compression braking, gear changes etc) travelling along the proposal during the night time period. The highest maximum noise levels would typically be during compression braking events where heavy vehicles would reduce speeds to negotiate curves in the road or stopping at traffic signals.

Given that the traffic volumes remain the same for the 2031 'Build' scenario as the 2031 'No Build' scenario, there would be no change to the number of heavy vehicles accessing the proposal corridor at night time. With the improved intersection capacities at the four (4) upgraded intersections, it would be reasonable to expect that fewer truck braking and acceleration locations would be required in the future 'Build' scenario along the proposal corridor and the incidence of night time maximum noise level events across the study area would be reduced. A more detailed sleep disturbance assessment would be undertaken during the detailed design stage of the proposal to confirm this.

## 6.7 Noise mitigation options

Final noise mitigation treatments would not be decided until the 'detailed design phase' to allow for all design changes to be considered in the noise assessment. Nevertheless, the following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

The NMG sets out that priority would first be given to reducing noise during corridor planning and road design where there may be greater opportunity to provide cost effective integrated outcomes with

better urban design. Following corridor planning and road design, Section 7 of the NMG indicates the following priority order for noise mitigation:

*"Options for noise mitigation measures are listed below in the order of preference:*

1. *Quieter pavement surfaces*
2. *Noise mounds*
3. *Noise walls*
4. *At-property treatments"*

All reasonable and feasible traffic management and road design options to minimise noise have been considered in the concept design. Therefore, the following sections assess the feasibility and reasonableness of the remaining mitigation options in accordance with the order of priority stated above.

### 6.7.1 Quieter pavements

The NMG sets out that a quieter pavement surface is the preferred form of noise mitigation as it reduces source noise levels and provides protection to both external and internal sensitive areas and also has the least visual impact. Quieter pavements would be considered where there are groups of four or more receivers that exceed the NCG criteria.

The implementation of low noise pavement as a potential noise mitigation option has been reviewed and it has been determined that:

- Low noise pavement is most beneficial at speeds of 70km/h and above. The posted speed for the proposal corridor is 50km/h and use of low noise pavement at this speed would not achieve the full noise benefit from this mitigation measure.
- There are several intersections along the project corridor where accelerating and decelerating traffic would occur.
- High shear stresses are experienced by pavement surfaces at intersections from vehicle braking, accelerating and turning movements. Open graded asphalt is not recommended for use at heavily trafficked intersections due to its relatively low shear resistance and potential for oil droppings to soften the binder and fill the voids, reducing its noise absorbing ability.
- Adopting short sections of open graded asphalt surfacing is impractical due to the close proximity of intersections along the proposal corridor and introduces unnecessary complications and safety risks. A consistent dense grade asphalt surface is considered more favourable for its durability and better resistance to shear stress.

- Furthermore, the structural capacity of existing pavement would be impacted should open graded asphalt be applied to replace the current dense graded wearing course due to its lower flexural stiffness.

Given the above, it was determined that the application of a quiet pavement is not considered to be a reasonable and feasible option for the proposal.

### 6.7.2 Noise barriers

The NMG sets out that like quieter pavement surfaces, a noise mound or noise wall provides protection to both external and internal sensitive areas. Noise mounds are preferred over a noise wall because a noise wall typically has a higher visual impact. However, noise walls are often more feasible than a mound as the site footprint can be much smaller. In accordance with the NMG, noise barriers should be considered where there are four or more closely spaced receivers.

Noise barriers are reasonable and feasible where residences are closely grouped, where the barriers do not cause access difficulties to properties, and where they are visually acceptable. In accordance with the NMG barriers are not cost-effective for isolated dwellings (ie. less than four receivers). In addition, where driveway access is required it is preferred not to use noise barriers as the overall noise reduction provided by the barrier is compromised by the need to install an access gate.

The use of noise mounds or barriers is not a feasible mitigation option for this proposal due to matters relating to visual impact, access requirements, security, the presence of significant trees, state heritage considerations and space constraints.

### 6.7.3 At-property treatment

Given that the implementation of quieter pavements and noise barriers have been determined to not be feasible and reasonable noise mitigation options, at-property treatment should be considered for any receivers predicted to exceed the NCG noise requirements.

The operational noise assessment in Section 6.5 has identified 389 receivers belonging to 48 residential, educational, hotel and child care buildings as being potentially eligible for at-property treatment subject to it being both feasible and reasonable to apply those treatments.

The **feasibility** of providing at-property acoustic treatment to buildings depends on it being practical and safe to install and maintain. For example, the installation of upgraded glazing to multi-level residential buildings may require safe access for installation from within the dwelling. Any requirement for external scaffolding and hoarding to access high treatment areas, or to protect pedestrians from falling objects, is likely to not be cost-effective. It would likely also not be feasible to install mechanical ventilation to a tenancy (which allows for its windows and doors to be kept closed) if there are no existing service ducts.

The **reasonableness** of providing at-property treatment involves assessing whether the overall noise benefit outweighs the cost of the treatment. For example, building element treatments are more effective when they are applied to masonry structures than lightly clad timber framed structures. Treatment of light clad buildings in a poor state of repair with open under floor areas would not be considered cost-effective. The NMG sets an upper cost limit for acoustic treatment of $30,000 per dwelling; however, this limit would be confirmed prior to formally offering treatment to the owners of impacted buildings.

The Waterloo Precinct major urban renewal area was recently determined by the Minister for Planning to be of State Planning Significance. The Waterloo Precinct is adjacent to the proposal and would involve the redevelopment of the existing social housing in the Waterloo Estate to deliver new and more social housing in a mixed community with new affordable and private housing. Due to the temporary nature of the existing buildings, treatment would not be offered to the social housing units at:

- 312-314 George Street, Waterloo
- 341 George Street, Waterloo
- 33 John Street, Waterloo
- 250 Pitt Street, Waterloo
- 251 Cope Street, Waterloo
- 63 McEvoy Street, Waterloo

Even so, Roads and Maritime would continue to work with the owners of the Waterloo Estate to confirm this approach prior to the construction of the A2MP proposal.

The A2MP proposal falls within the major Green Square urban renew area within which there has been extensive urban renewal over the previous decade. This growth is expected to continue into the future. Roads and Maritime considers that the responsibility for the acoustic design of new developments located in such areas of high existing traffic noise, such as along the A2MP road corridor, falls primarily on owners, developers and the planning authority providing development consent, taking into account of the level of affordability, type and mix of development the latter is encouraging for an area.

Roads and Maritime has undertaken a survey identifying developments approved over the previous decade to identify which of the 48 impacted buildings have likely already been treated for high existing noise levels from existing traffic as a result of their consented building approval. These 30 buildings are listed in Table 6-8**Error! Reference source not found.**.

Roads and Maritime would undertake additional acoustic design survey during the detailed design phase to confirm if the level of acoustic treatment within these 30 newly-developed buildings is already equivalent to the acoustic treatments that would be offered by the NMG and the Roads and Maritime *At-Receiver Noise Treatment Guideline* before committing to offering additional at-property treatment.

This review would also consider the feasibility of installation and would identify which units within each building identified are eligible.

**Table 6-8 – Newly approved developments to be investigated during detailed design phase**

| Building address | Facades qualifying for consideration of mitigation | Land Use |
|---|---|---|
| 57-63 Euston Rd, Alexandria | South-eastern | Residential |
| 33-47 Euston Road, Alexandria | South-eastern | Residential |
| 147-161 McEvoy Street, Alexandria western building | South-Eastern and South-Western | Residential |
| 147-161 McEvoy Street, Alexandria eastern building | North-eastern & south-eastern | Residential |
| 145 McEvoy street, Alexandria western building | South and south-western | Residential |
| 145 McEvoy street, Alexandria eastern building | Southern | Residential |
| 105-109 McEvoy Street, Alexandria | Western and southern | Residential |
| 64-68 McEvoy Street, Alexandria | Western and north-western | Residential |
| 312-314 George St, Waterloo | Southern | Residential |
| 341 George Street, Waterloo | Southern | Residential |
| 250 Pitt Street, Waterloo eastern building | Southern | Residential |
| 250 Pitt Street, Waterloo south-western building | Southern | Residential |
| 2 Kensington Street, Waterloo | Southern | Residential |
| 10 Lachlan Street, Waterloo western building | Southern | Residential |
| 10 Lachlan Street, Waterloo eastern building | Southern | Residential |
| 8 Lachlan Street, Waterloo western building | Southern and western | Residential |
| 8 Lachlan Street, Waterloo eastern building | Southern | Residential |
| 6 Lachlan Street, Waterloo | Southern and eastern | Residential |
| 52-54 McEvoy Street, Waterloo | Western and northern | Residential |
| 40-46 McEvoy Street, Waterloo | Northern | Residential |
| 34-38 McEvoy Street, Waterloo | Northern | Residential |
| 810 Elizabeth Street, Waterloo | Northern | Residential |
| 1-11 Hunter Street, Waterloo western building fronting McEvoy Street | Northern | Residential |
| 1-11 Hunter Street, Waterloo - eastern building on SW corner of Hunter/McEvoy intersection | Northern | Residential |
| 830 Bourke Street, Waterloo north-western building | North-western | Residential |

| Building address | Facades qualifying for consideration of mitigation | Land Use |
|---|---|---|
| 830 Bourke Street, Waterloo south-western building | North-western | Residential |
| 11A Lachlan Street, Waterloo | Northern | Residential |
| 15 Lachlan Street, Waterloo | Northern | Residential |
| 29 Lachlan Street, Waterloo | Northern | Residential |
| 33 Lachlan Street, Waterloo | Northern | Residential |

The remaining 18 properties are listed in Table 6-9**Error! Reference source not found.** and indicated in APPENDIX E. These properties that are eligible for at-property treatment are subject to site inspections confirming that it is feasible and reasonable to apply those treatments. Any feasible and reasonable acoustic treatments proposed would be considered in consultation with the landowners and delivered in accordance with Roads and Maritime's *At-Receiver Noise Treatment Guideline*.

**Table 6-9 – Properties eligible for at-property acoustic treatment**

| Building address | Eligible Facades | Land Use |
|---|---|---|
| 168-170 Botany Road, Alexandria | Eastern | Residential |
| 172-176 Botany Road, Alexandria | Eastern | Residential |
| 178-182 Botany Road, Alexandria | Eastern | Residential |
| 220 Botany Road, Alexandria | North-eastern | Hotel |
| 4 Kellick Street, Waterloo south-western building | Southern and eastern | Educational |
| 4 Kellick Street, Waterloo southern building | Southern and eastern | Educational |
| 35 McEvoy Street, Waterloo | Western and southern | Residential |
| 33 McEvoy Street, Waterloo | Southern | Residential |
| 31 McEvoy Street, Waterloo | Southern | Residential |
| 29 McEvoy Street, Waterloo | Southern | Residential |
| 796 Elizabeth Street, Waterloo | Western | Residential |
| 798 Elizabeth Street, Waterloo | Western | Residential |
| 800 Elizabeth Street, Waterloo | Western | Residential |
| 802 Elizabeth Street, Waterloo | Western | Residential |
| 804 Elizabeth Street, Waterloo | Western | Residential |
| 806 Elizabeth Street, Waterloo | Western and eastern | Residential |
| 808 Elizabeth Street, Waterloo | Western, southern and eastern | Residential |
| 853 South Dowling Street, Waterloo | Northern, north-eastern and eastern | Hotel |

At-property treatment is considered for dwellings that remain above the NCG criteria after all other noise mitigation measures are exhausted. Property treatment is generally limited to the acoustic treatment of building elements and the installation of acoustic screen walls close to the receiver where they also protect outdoor living spaces. Identified sensitive receivers adjacent to the road corridor that remain above the NCG criteria are assessed against existing development consent conditions when considering property treatments.

The NCG's noise criteria are external noise goals, and building treatment only reduces noise levels inside a dwelling. Therefore, any building treatment would be designed to achieve the internal noise levels that would have been achieved had the proposal complied with the NCG criteria externally.

According to the NMG, building treatments (in no particular order) may comprise of the following:

- Installation of courtyard screen walls
- Fresh air ventilation systems that draw air into a building, and meet Building Code of Australia requirements with the windows and doors shut
- Upgraded windows and glazing and solid core doors on the exposed facades of masonry or insulated weather board structures (not for light framed structures)
- Upgrading window and door seals and appropriate treatment of sub-floor ventilation
- Sealing of wall vents
- Sealing of the underfloor below the bearers
- Sealing of eaves

The following table provides guidance on the level of treatment required in relation to the exceedance above the NCG external assessment criteria and has been extracted from Appendix B of the RMS *At-Receiver Noise Treatment Guideline* (Draft, June 2017).

**Table 6-10 – Residential at-property treatment options**

| Construction | Treatment Package Type | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Exceedance, dBA** | **1-5** | **6-8** | **9-11** | **12-14** | **>14** |
| All | • Optional ceiling fans[1]<br>• Mechanical ventilation (MV)[2]<br>• New acoustic seals for windows<br>• Seal around window architraves / door jambs<br>• Seal all vents and openings | • As per Category 1 treatments<br>• External solid core door (40mm) with perimeter acoustic seals, drop seals and threshold seals | | | |
| Brick veneer, double brick or concrete<br>Window area less than or equal to 20% floor<br>area | | For 6 dBA exceedance:<br>• 6.38mm laminate and roof insulation (R4.0 215mm thick)<br>• or 6.5mm lam with acoustic interlayer<br>For 7 dBA exceedance:<br>• 8.5mm lam with acoustic interlayer or 10.38mm lam<br>For 8 dBA exceedance:<br>• 8.5mm lam with acoustic interlayer or 10.5mm lam with acoustic interlayer or 10mm acrylic panel with nominally 100mm gap or >4mm secondary window with 100mm gap or equivalent | • Roof insulation (R4.0 215mm thick)<br>For 9 dBA exceedance:<br>• 8.5mm lam with acoustic interlayer or 10.38mm lam<br>Otherwise:<br>• 10.5mm lam with acoustic interlayer or 10mm acrylic panel with nominally 100mm gap or >4mm secondary window with 100mm gap or equivalent | • >4mm secondary window with 100mm gap, or equivalent<br>• Roof insulation (R4.0 215mm thick) | • >6mm secondary window with nominally 100mm gap, or equivalent<br>• Roof insulation (R4.0 215mm thick) |
| Brick veneer, double brick or concrete<br>Sliding door area less than or equal to 50%<br>wall area | • 6.38mm lam, or equivalent | • 6.5mm lam with acoustic interlayer, or equivalent<br>• Roof insulation (R4.0 215mm thick)<br>Or<br>• 8.5mm lam with acoustic interlayer, or equivalent | • 8.5mm lam with acoustic interlayer or >4mm secondary window with nominally 100mm gap, or equivalent<br>• Roof insulation (R4.0 215mm thick) | • >6mm secondary window with nominally 100mm gap, or equivalent<br>• Roof insulation (R4.0 215mm thick) | • >6mm secondary window with nominally 100mm gap, or equivalent<br>• Roof insulation (R4.0 215mm thick) |

| Construction | Treatment Package Type | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Exceedance, dBA** | **1-5** | **6-8** | **9-11** | **12-14** | **>14** |
| Lightweight<br>Window area less than or equal to 20% floor<br>area | • Seal subfloor<br>• Roof insulation (R4.0 215mm thick) | • As per Category 1 treatments<br>For 8 dBA exceedance:<br>• 10mm acrylic panel with nominally 100mm gap, or equivalent<br>• Re-sheet wall lining (1x 6mm fibre cement sheeting with nominal board weight of 11 kg/m$^2$ and 1 x 13mm plasterboard with nominal board weight of 10.5 kg/m$^2$ to finish, or equivalent)<br>• Wall insulation (R2.7 90mm thick)<br>Otherwise:<br>• 10mm acrylic panel with 100mm gap, or equivalent<br>• Additional wall lining (1 x 13mm plasterboard with nominal board weight of 10.5 kg/m$^2$ to finish, or equivalent) | • As per Category 1 treatments<br>• 10mm acrylic panel with nominally 100mm gap, or equivalent<br>• Re-sheet wall lining (1x 6mm fibre cement sheeting with nominal board weight of 11 kg/m$^2$ and 1 x 13mm plasterboard with nominal board weight of 10.5 kg/m$^2$ to finish, or equivalent)<br>• Wall insulation (R2.7 90mm thick)<br>• Resilient mount to isolate wall lining and stud | • As per Category 1 treatments<br>• >4mm secondary window with nominally 100mm gap, or equivalent<br>• Re-sheet wall lining (1x 6mm fibre cement sheeting with nominal board weight of 11 kg/m$^2$ and 1 x 13mm plasterboard with nominal board weight of 10.5 kg/m$^2$ to finish, or equivalent)<br>• Wall insulation (R2.7 90mm thick)<br>• Resilient mount to isolate wall lining and stud | • As per Category 1 treatments<br>• >6mm secondary window with nominally 100mm gap, or equivalent<br>• Re-sheet wall lining (1x 6mm fibre cement sheeting with nominal board weight of 11 kg/m$^2$ and 1 x 13mm plasterboard with nominal board weight of 10.5 kg/m$^2$ to finish, or equivalent)<br>• Wall insulation (R2.7 90mm thick)<br>• Resilient mount to isolate wall lining and stud |

Notes: 1. Ceiling fans should have Direct Current (DC) electric motors to minimise noise.

2. Mechanical ventilation (MV) should be installed so that fresh air is ducted from an unaffected building façade. Mechanical fan noise should meet the recommended noise level in AS2107.

It is noted that there are a number of physical factors that can influence the level of noise reduction actually achieved from outside-to-inside a dwelling, which include:

- existence of balconies on a facade causing reflections and amplification of sound
- orientation of each facade exposed to road noise for each room
- number of facades exposed to road noise for each room
- area size of all facades exposed to road noise for each room
- surface areas of windows / doors per room
- surface areas of walls / roofs / floors per room
- possible entry of noise via roof / sub-floor
- type of construction, thickness and condition of windows / doors / walls / roofs / floors per room
- size, volume and layout of each room
- type of floor covering, curtains and other soft furnishings in each room

Given that the above details are unique for each dwelling, it is recommended that field inspections of each affected property be undertaken during the detailed design stage of the proposal in order to conduct detailed noise modelling for the affected habitable rooms of each dwelling.

# 7 Conclusion

A noise and vibration assessment for the construction and operation of the proposal has been completed. The results of the assessment are summarised below.

Construction Noise and Vibration Assessment

- Construction noise is likely to exceed the construction noise management levels during the day, evening and night periods for the majority of receivers within the vicinity of the construction works. All reasonable and feasible noise mitigation measures in accordance with the CNVG would be applied during the construction phase. Additional mitigation measures where the standard mitigation measures are not sufficient would also be provided and details have been presented.
- The risk of structural damage during construction is generally assessed as being high risk. For human response from construction vibration, the risks of adverse comment from the nearest receivers were determined to be medium to high. Vibration mitigation measures and indicative minimum working distances have been provided.

Traffic Noise Assessment

- Quiet pavements and noise barriers were determined to not be feasible and reasonable options for mitigating traffic noise impacts.
- Traffic noise levels at the design year 2031 for the 'build' option were predicted to exceed the NCG noise criteria level at 1,979 receivers during the day period and 1,785 receivers during the night period.
- Traffic noise levels at the design year 2031 for the 'build' option were predicted not to increase by more than 2dB(A) compared to the 'no build' option at any receiver.
- Traffic noise level at the design year 2031 for the 'build' option were predicted to exceed the cumulative noise limits at 379 receivers during the day period and 364 receivers during the night period.
- Traffic noise level at the design year 2031 for the 'build' option were predicted to be 'acute' at 375 receivers during the day period and 374 receivers during the night period.
- As a result of the exceedances, and a review of receivers that exceed the NCG noise criteria and/or are acute, a total of 389 receivers belonging to 48 buildings have been identified for consideration of further treatment.
- Review of feasibility and reasonableness of the 48 buildings reduced the number of buildings for consideration of further treatment to 18 buildings.

# APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

| | |
|---|---|
| Absorption Coefficient α | The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective. |
| Adverse weather | Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter. |
| Air-borne noise | Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver. |
| 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. |
| Amenity | A desirable or useful feature or facility of a building or place. |
| AS | Australian Standard |
| Assessment period | The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am. |
| Assessment Point | A location at which a noise or vibration measurement is taken or estimated. |
| Attenuation | The reduction in the level of sound or vibration. |
| Audible Range | The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits. |
| A-weighting | A filter applied to the sound recording made by a microphone to approximate the response of the human ear. |
| 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. 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 if measured as an overall level or an L90 noise level when measured in octave or third-octave bands. |
| Barrier (Noise) | A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings. |
| Berm | Earth or overburden mound. |
| Buffer | An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use. |
| Bund | A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound. |
| BS | British Standard |
| CoRTN | United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" |

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| Decibel [dB] | The units of sound measurement. The following are examples of the decibel readings of every day sounds:<br>0dB The faintest sound we can hear, defined as 20 micro Pascal<br>30dB A quiet library or in a quiet location in the country<br>45dB Typical office space. Ambience in the city at night<br>60dB CBD mall at lunch time<br>70dB The sound of a car passing on the street<br>80dB Loud music played at home<br>90dB The sound of a truck passing on the street<br>100dB The sound of a rock band<br>110dB Operating a chainsaw or jackhammer<br>120dB Deafening |
| dB(A) | A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter is denoted as dB(A). Practically all noise is measured using the A filter. |
| dB(C) | C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications. |
| Diffraction | The distortion of sound waves caused when passing tangentially around solid objects. |
| DIN | German Standard |
| ECRTN | Environmental Criteria for Road Traffic Noise, NSW, 1999 |
| EPA | Environment Protection Authority |
| Field Test | A test of the sound insulation performance in-situ. See also 'Laboratory Test'<br>The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion.<br>A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions. |
| Fluctuating Noise | Noise that varies continuously to an appreciable extent over the period of observation. |
| 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. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz. |
| Ground-borne noise | Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above. |
| Habitable Area | Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom.<br>Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods. |
| Heavy Vehicle | A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes). |
| IGANRIP | Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007 |

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| Impulsive 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. |
| INP | NSW Industrial Noise Policy, EPA 1999 |
| Intermittent noise | The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more. |
| Intrusive noise | Refers to noise that intrudes above the background level by more than 5 dB(A). |
| ISEPP | State Environmental Planning Policy (Infrastructure), NSW, 2007 |
| ISEPP Guideline | Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008 |
| L1 | The sound pressure level that is exceeded for 1% of the time for which the given sound is measured. |
| L10 | The sound pressure level that is exceeded for 10% of the time for which the given sound is measured. |
| L10(1hr) | The L10 level measured over a 1 hour period. |
| L10(18hr) | The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day. |
| L90 | The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A). |
| LAeq or Leq | The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq. |
| LAeq(1hr) | The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant). |
| LAeq(8hr) | The LAeq noise level for the period 10pm to 6am. |
| LAeq(9hr) | The LAeq noise level for the period 10pm to 7am. |
| LAeq(15hr) | The LAeq noise level for the period 7am to 10pm. |
| LAeq (24hr) | The LAeq noise level during a 24 hour period, usually from midnight to midnight. |
| Lmax | The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax. |
| Lmin | The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin. |
| Loudness | A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB. |
| Microphone | An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal. |
| NCA | Noise Catchment Area. An area of study within which the noise environment is substantially constant. |
| Noise | Unwanted sound |
| Pre-construction | Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads). |
| Reflection | Sound wave reflected from a solid object obscuring its path. |
| RING | Rail Infrastructure Noise Guideline, NSW, May 2013 |

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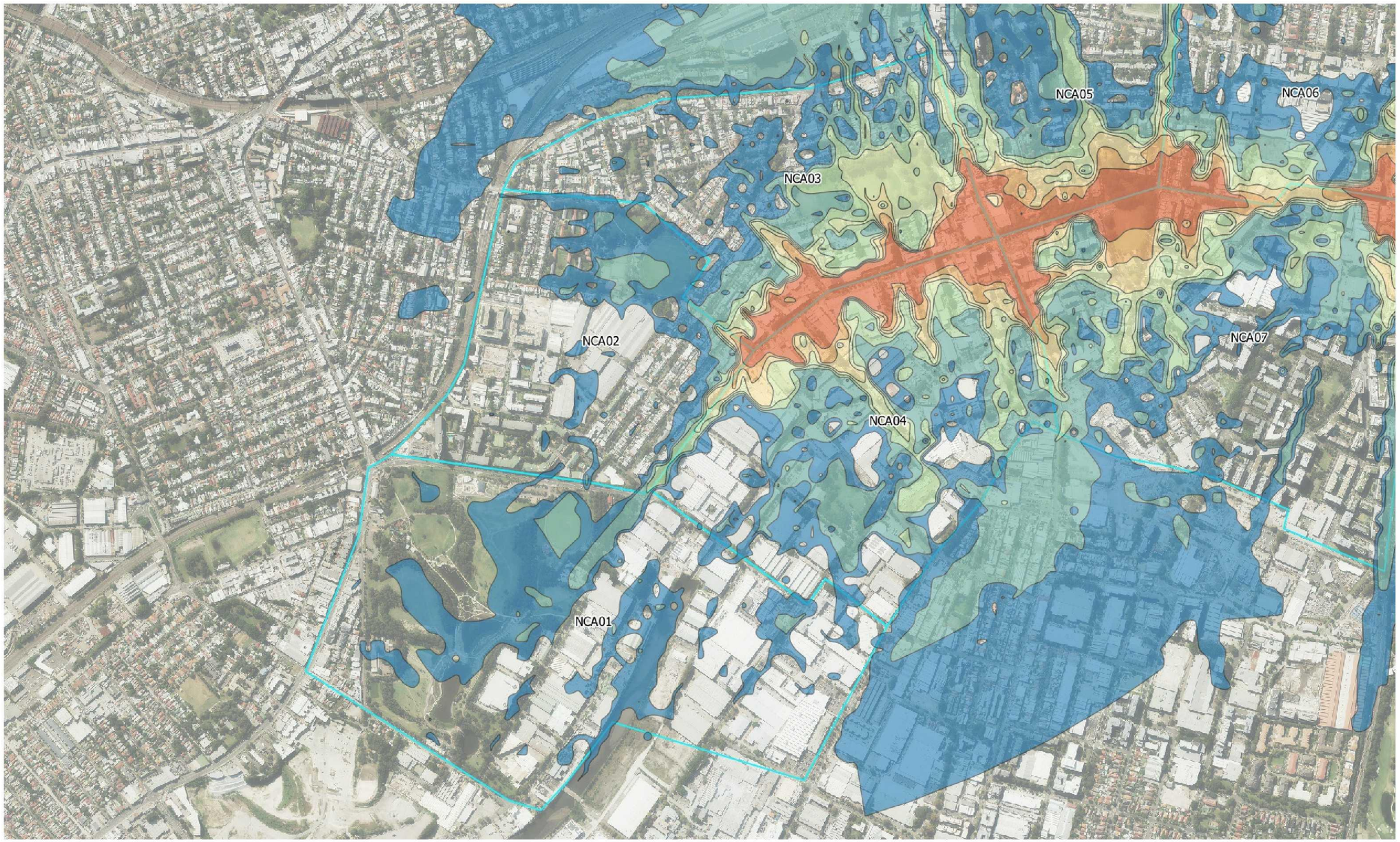
|---|---|
| RMS | Root Mean Square value representing the average value of a signal. |
| Rw | Weighted Sound Reduction Index<br>A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory.<br>The term supersedes the value STC which was used in older versions of the Building Code of Australa. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w.<br>The higher the value the better the acoustic performance of the building element. |
| R'w | Weighted Apparent Sound Reduction Index.<br>As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement.<br>The higher the value the better the acoustic performance of the building element. |
| RNP | Road Noise Policy, NSW, March 2011 |
| Sabine | A measure of the total acoustic absorption provided by a material.<br>It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine.<br>Sabine is usually calculated for each individual octave band (or third-octave). |
| SEL | Sound Exposure Level (SEL) 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 | A fluctuation of air pressure which is propagated as a wave through air. |
| Sound absorption | The ability of a material to absorb sound energy by conversion to thermal energy. |
| Sound Insulation | Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w. |
| 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 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 of 1 pico watt. |
| Sound pressure level | The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal. |
| Spoil | Soil or materials arising from excavation activities. |
| STC | Sound Transmission Class<br>A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory.<br>The term has been superseded by Rw. |
| Structure-borne Noise | Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine.<br>Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example).<br>Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'. |
| Tonal Noise | Sound containing a prominent frequency and characterised by a definite pitch. |

| | |
|---|---|
| Transmission Loss | The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another.<br>For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w. |

# APPENDIX B Predicted construction noise contours




## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

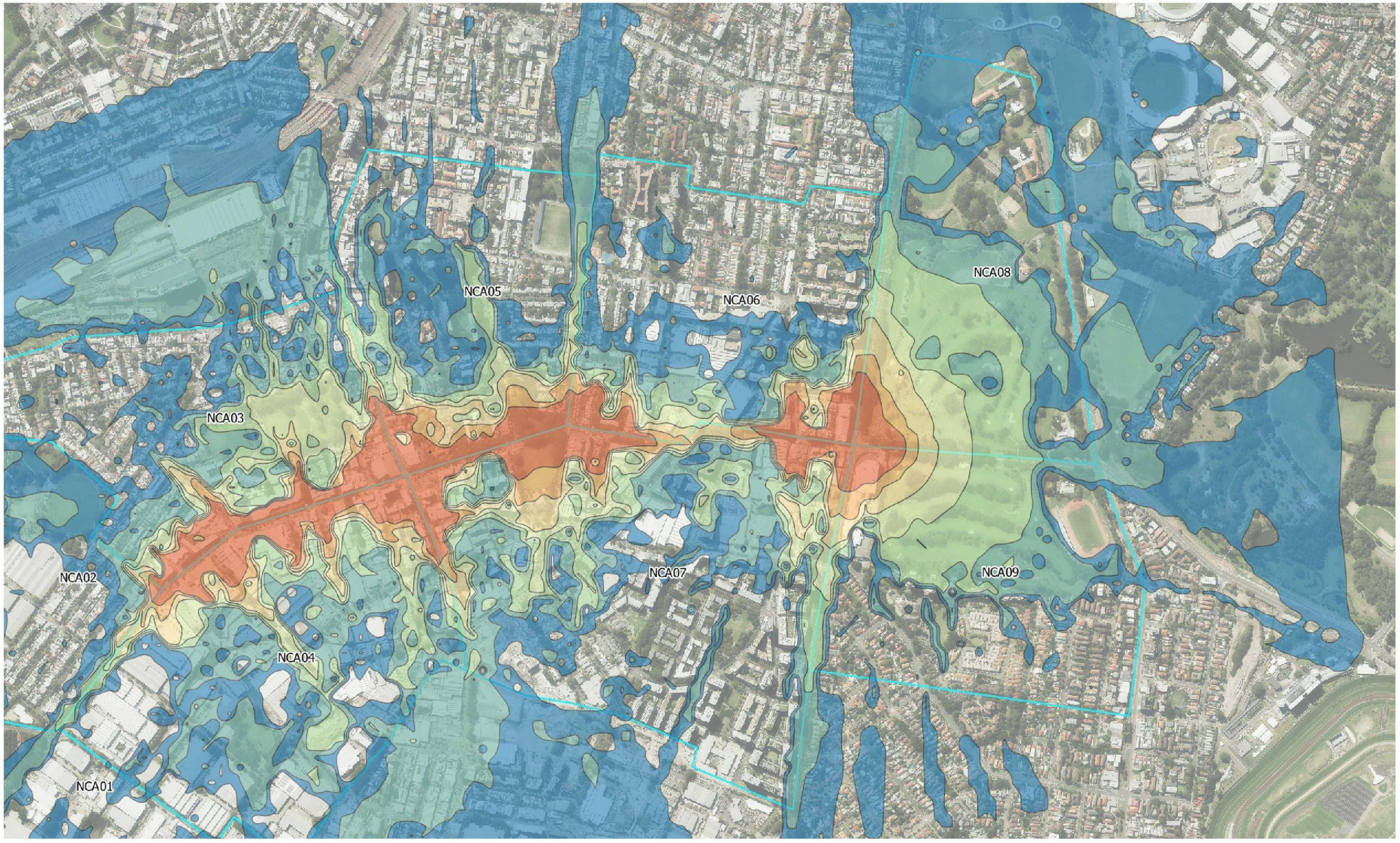
Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours
Utilities



Figure No: TL052-01.6.1.2 App B1 (r0)-1
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**




## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours Utilities



Figure No: TL052-01.6.1.2 App B1 (r0)-2 Rev: R0
Date: 15-11-2019 Sheet: A3
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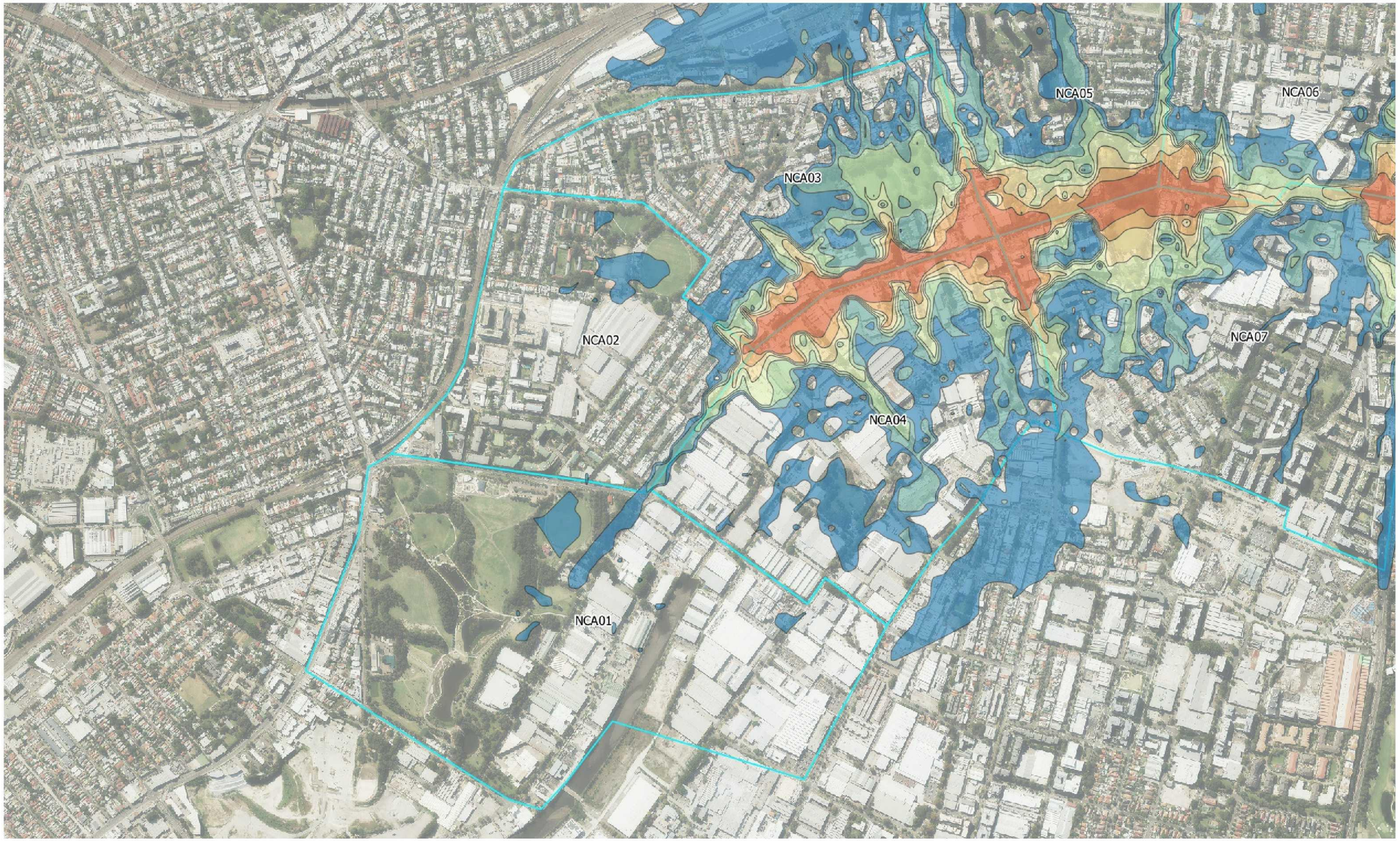


## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours Civil Works



Figure No: TL052-01.6.1.2 App B2 (r0)-1
Date: 15-11-2019
Created by: DK
Rev: R0
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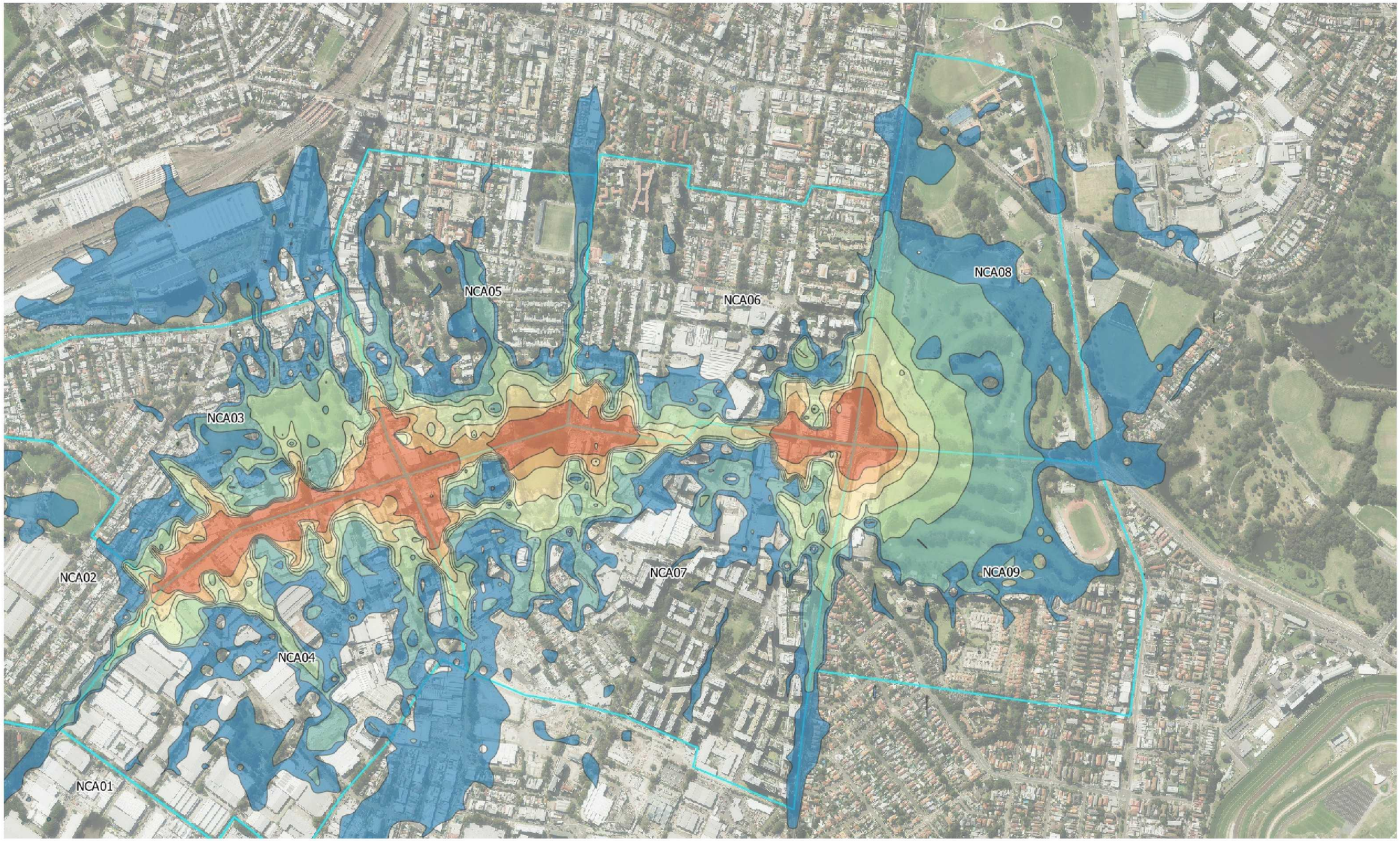



## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours
Civil Works



Figure No: TL052-01.6.1.2 App B2 (r0)-2
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**


## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours Compound Sites



Figure No: TL052-01.6.1.2 App B3 (r0)-1
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**


## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

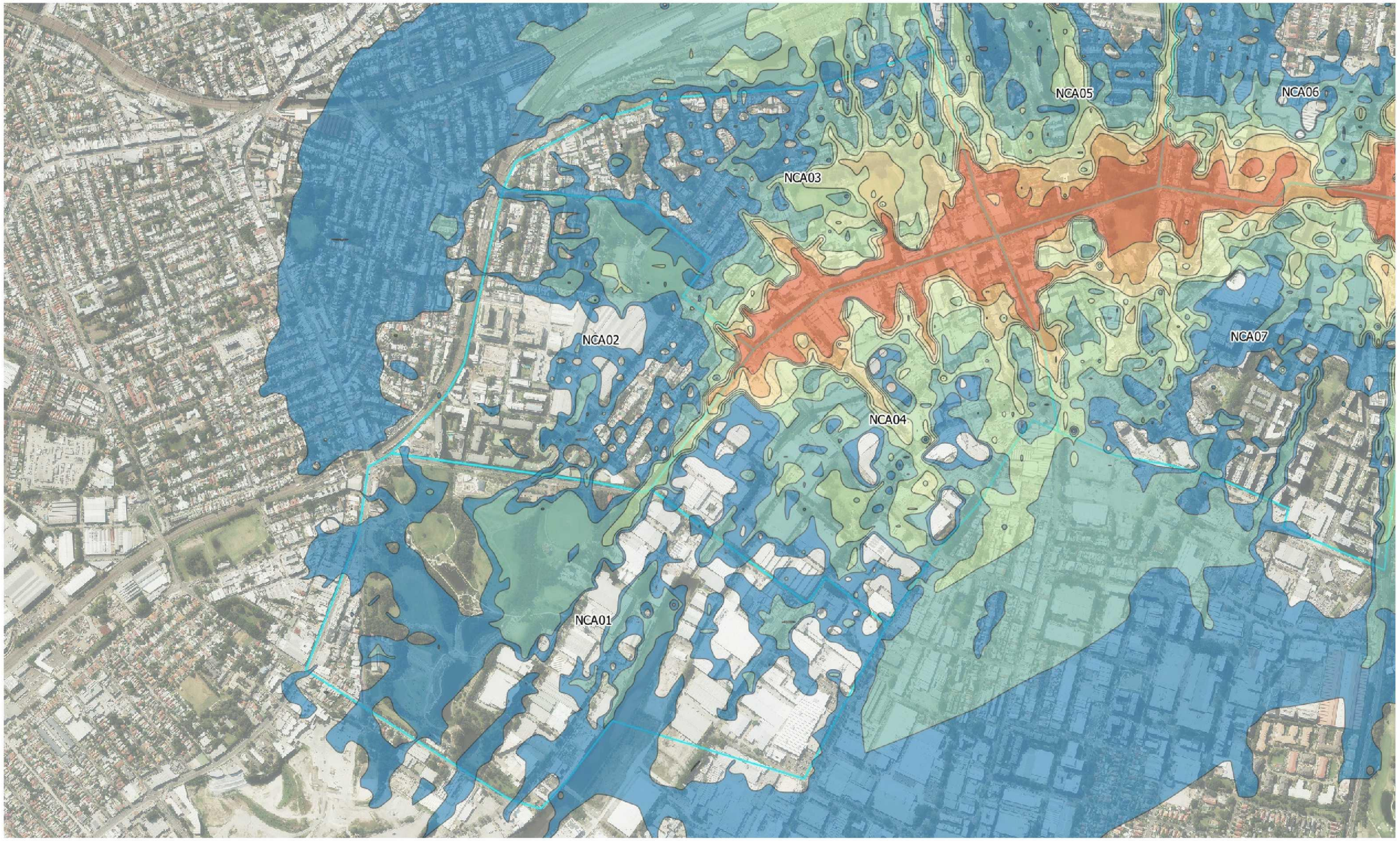
Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours Compound Sites



Figure No: TL052-01.6.1.2 App B3 (r0)-2
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**




## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park
Clearways and Intersection
Upgrades

Description:
Construction Noise Contours
Utilities, Civil Works and Compound Site



Figure No: TL052-01.6.1.2 App B4 (r0)-1
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
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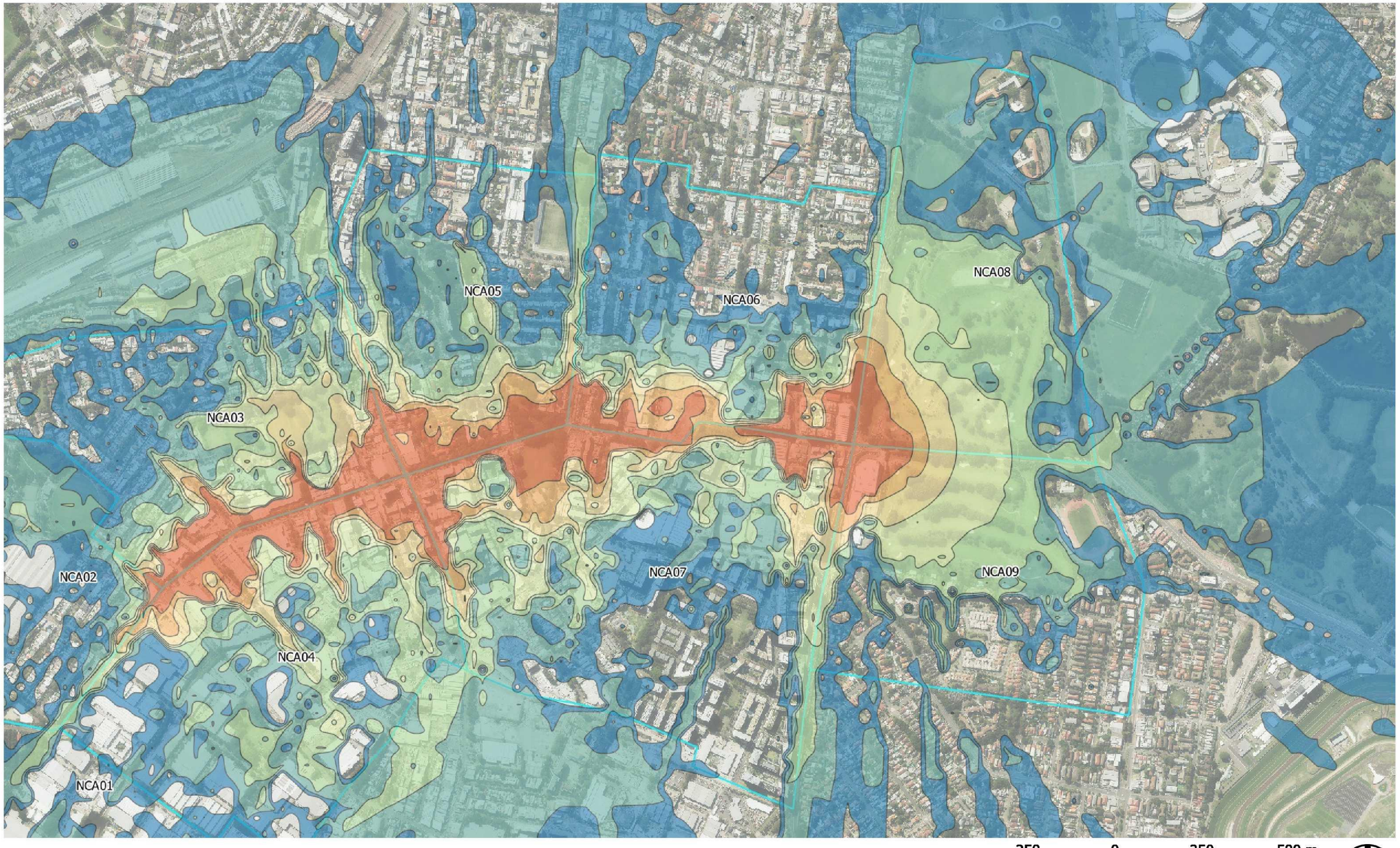



## Legend

Noise Catchment Area (NCA)

**Noise Contours, dB(A)**

45 50 55 60 65 70 75

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
*inspired to achieve*

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

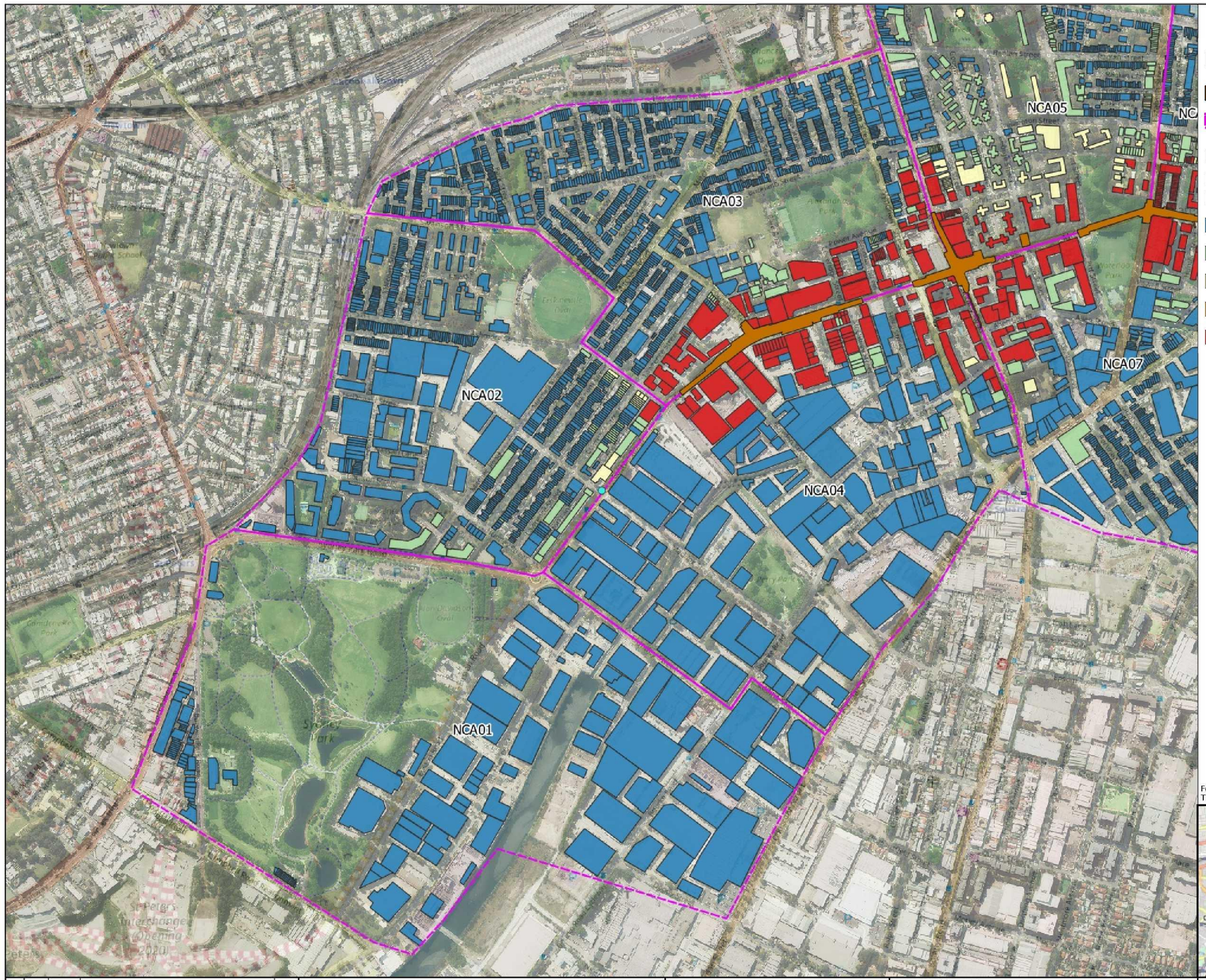
Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Construction Noise Contours
Utilities, Civil Works and Compound Site



Figure No: TL052-01.6.1.2 App B4 (r0)-2
Date: 15-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**

# APPENDIX C Additional construction noise mitigation measures

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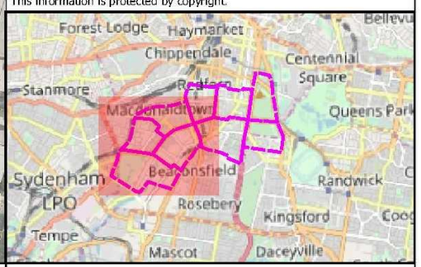


| REV | BY | DATE | DESCRIPTION | APPD. |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |

A3 Original | Co-ordinate System: UTM Zone 56S

SCALES 0 100 200 300 400 500 m
1:9000

NOTE: Do not scale from this drawing.

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RENZO TONIN & ASSOCIATES
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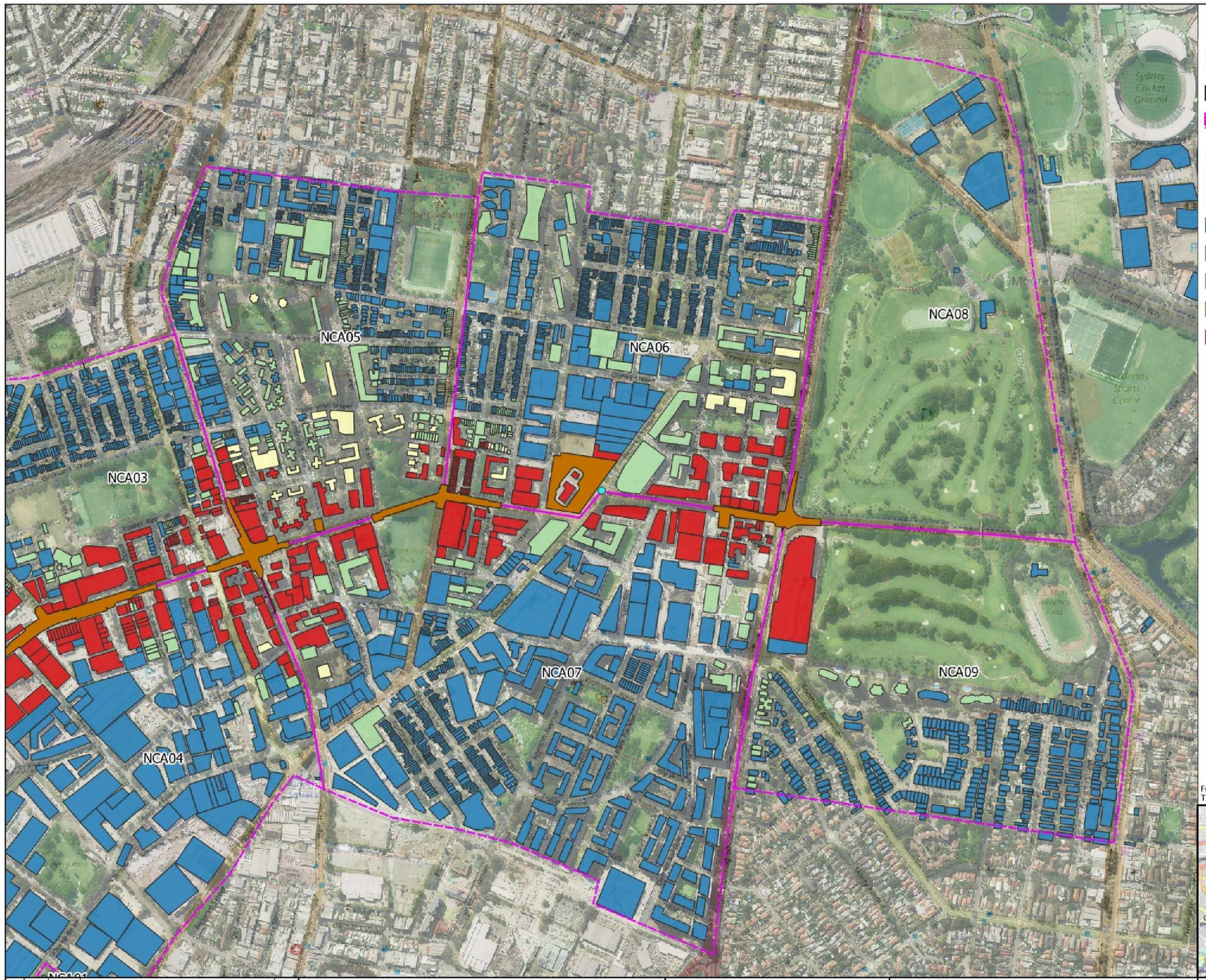
ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Standard Hours

Status: | Sheet 1 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-1 | Rev. No.

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## Legend

- Construction Sites & Compounds
- NCAs

**Buildings**

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)

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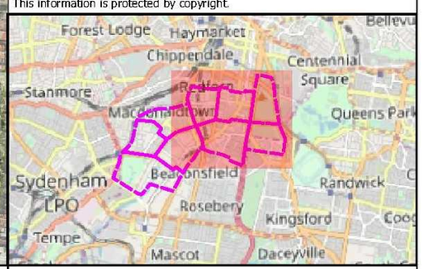


| REV | BY | DATE | DESCRIPTION | APPD |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |

A3 Original | Co-ordinate System: UTM Zone 56S

SCALES: 0 100 200 300 400 500 m — 1:9000

NOTE: Do not scale from this drawing.

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ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Standard Hours

Status: | Sheet 2 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-2 | Rev. No.

Plot Date: 19/11/19 - 16:56 Composer: Appendix D Out of Hours Works - Day.qpt
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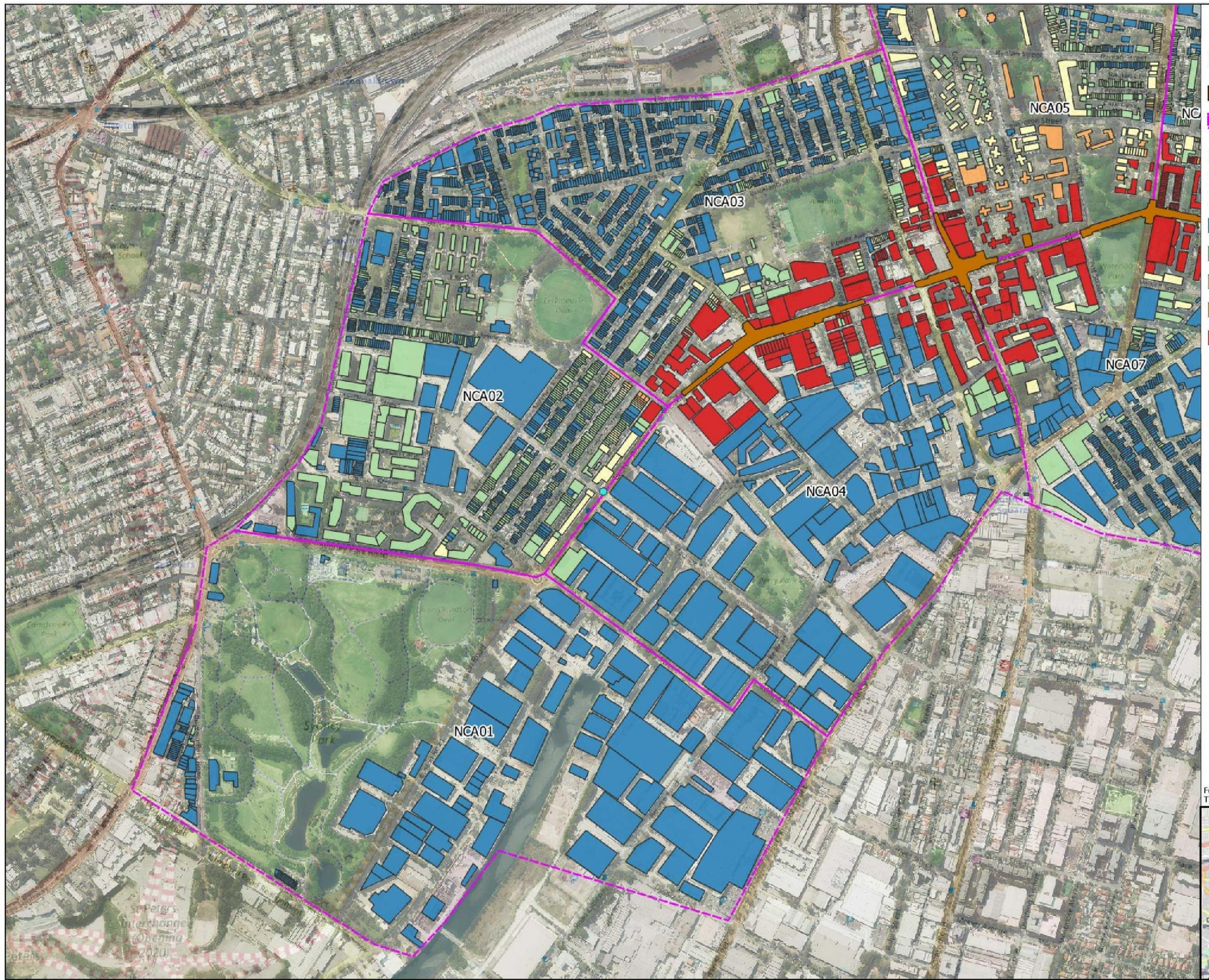


## Legend

- Construction Sites & Compounds
- NCAs

**Buildings**

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)

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| | | | | |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |
| REV | BY | DATE | DESCRIPTION | APPD. |
| A3 Original | | | Co-ordinate System: UTM Zone 56S | |

SCALES 0 100 200 300 400 500 m
1:9000

NOTE: Do not scale from this drawing.

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ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Out of Hours Works - Day

Status: Sheet 1 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-1 Rev. No.

Plot Date: 19/11/19 - 16:56 Composer: Appendix D Out of Hours Works - Day.qpt
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## Legend

- Construction Sites & Compounds
- NCAs

### Buildings

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)

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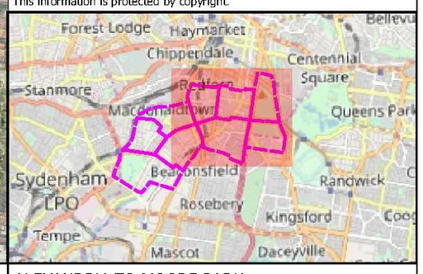


| REV | BY | DATE | DESCRIPTION | APPD |
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| r0 | MS | 19.11.2019 | Prepare figures | WCH |

A3 Original | Co-ordinate System: UTM Zone 56S

SCALES: 0 100 200 300 400 500 m — 1:9000

NOTE: Do not scale from this drawing.

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1/418A Elizabeth St., SURRY HILLS, NSW 2000
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ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Out of Hours Works - Day

Status: | Sheet 2 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-2 | Rev. No.

Plot Date: 19/11/19 - 16:57 Composer: Appendix D Out of Hours Works - Evening
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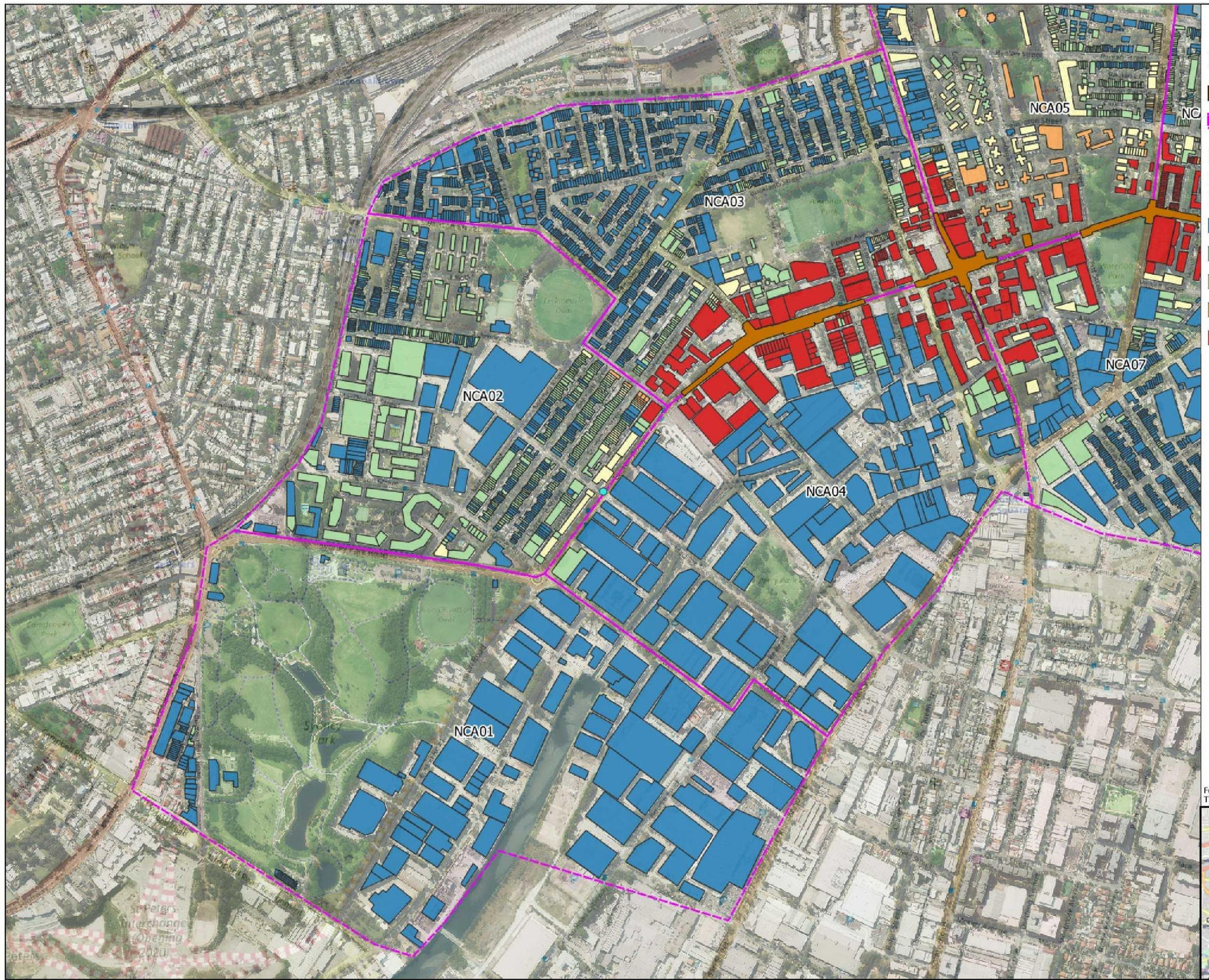


## Legend

- Construction Sites & Compounds
- NCAs

### Buildings

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)




| | | | | |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |
| REV | BY | DATE | DESCRIPTION | APPD. |
| A3 Original | | | Co-ordinate System: UTM Zone 56S | |

SCALES 0 100 200 300 400 500 m
1:9000

NOTE: Do not scale from this drawing.

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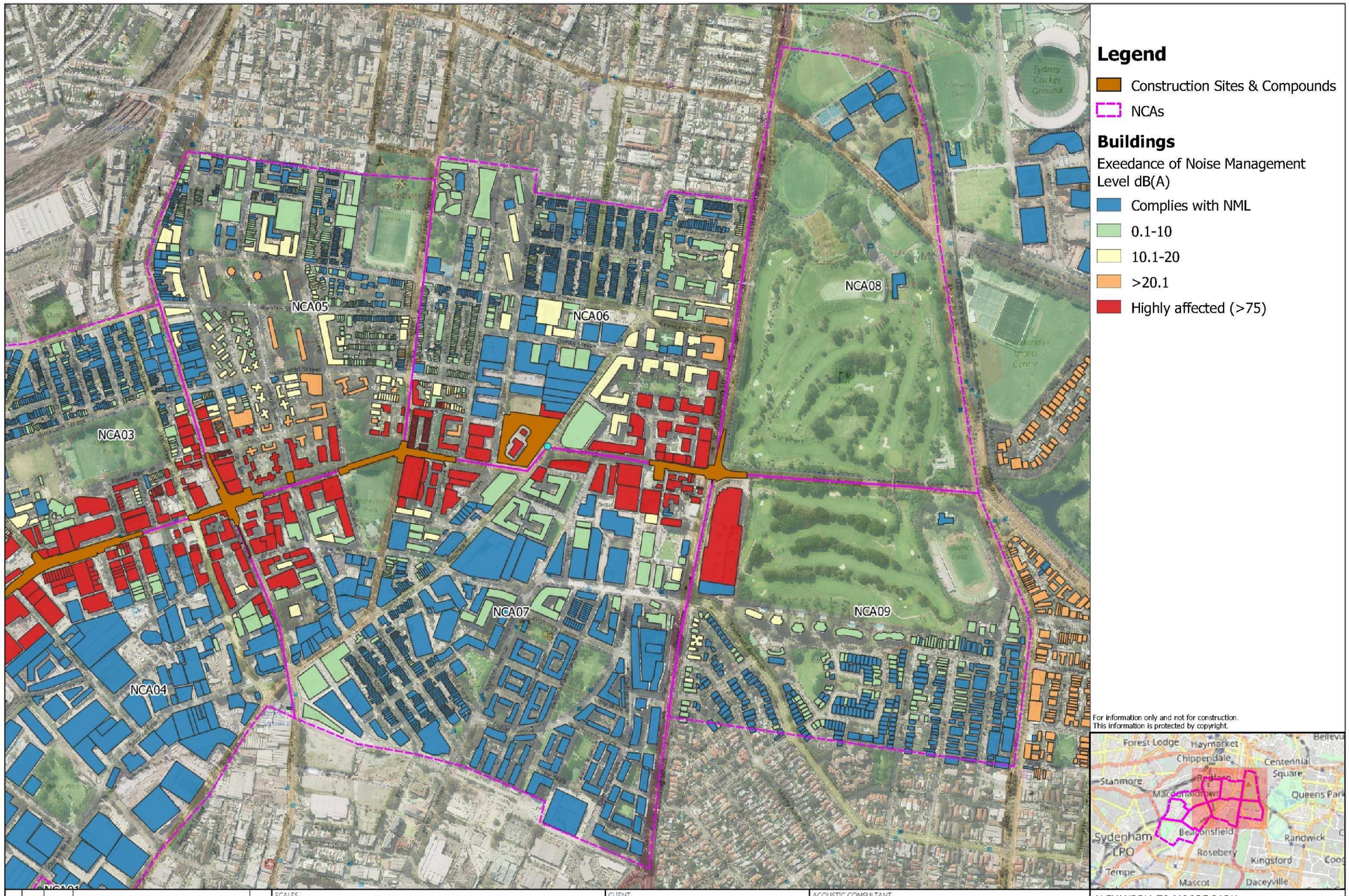
# ALEXANDRIA TO MOORE PARK
## Clearways and Intersection Upgrades
### Additional Construction Noise Mitigation Measures Out of Hours Works - Evening

Status: Sheet 1 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-1 Rev. No.

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| REV | BY | DATE | DESCRIPTION | APPD |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| r0 | MS | 19.11.2019 | Prepare figures | WCH |

A3 Original | Co-ordinate System: UTM Zone 56S

SCALES
0 100 200 300 400 500 m
1:9000
NOTE: Do not scale from this drawing.

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RENZO TONIN & ASSOCIATES
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SYDNEY OFFICE
1/418A Elizabeth St., SURRY HILLS, NSW 2000
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ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Out of Hours Works - Evening

Status: | Sheet 2 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-2 | Rev. No.

Plot Date: 19/11/19 - 16:58 Composer: Appendix D Out of Hours Works - Night
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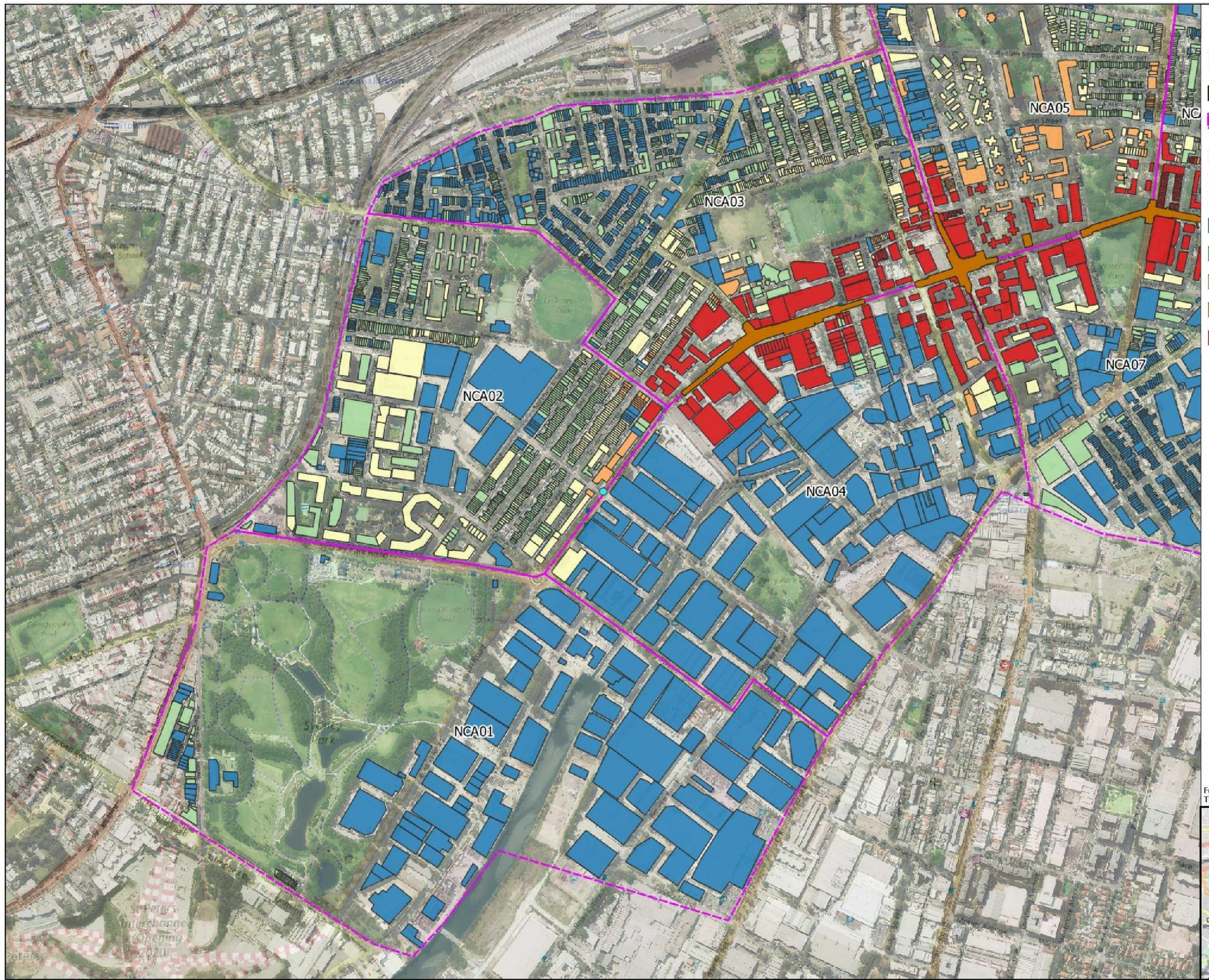


## Legend

- Construction Sites & Compounds
- NCAs

**Buildings**

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)

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| | | | | |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |
| REV | BY | DATE | DESCRIPTION | APPD. |
| A3 Original | | | Co-ordinate System: UTM Zone 56S | |

SCALES: 0 100 200 300 400 500 m — 1:9000

NOTE: Do not scale from this drawing.

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SYDNEY OFFICE
1/418A Elizabeth St., SURRY HILLS, NSW 2000
Ph (02) 8218 0500 Fax (02) 8218 0501

ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades

Additional Construction Noise Mitigation Measures
Out of Hours Works - Night

Status: Sheet 1 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-1 Rev. No.

Plot Date: 19/11/19 - 16:59 Composer: Appendix D Out of Hours Works - Night
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## Legend

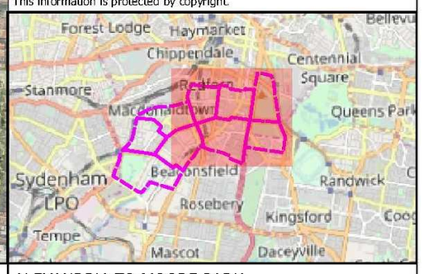
- Construction Sites & Compounds
- NCAs

### Buildings

Exeedance of Noise Management Level dB(A)

- Complies with NML
- 0.1-10
- 10.1-20
- >20.1
- Highly affected (>75)






| REV | BY | DATE | DESCRIPTION | APPD |
|---|---|---|---|---|
| r0 | MS | 19.11.2019 | Prepare figures | WCH |

A3 Original | Co-ordinate System: UTM Zone 56S

SCALES: 0 100 200 300 400 500 m — 1:9000

NOTE: Do not scale from this drawing.

CLIENT: JACOBS

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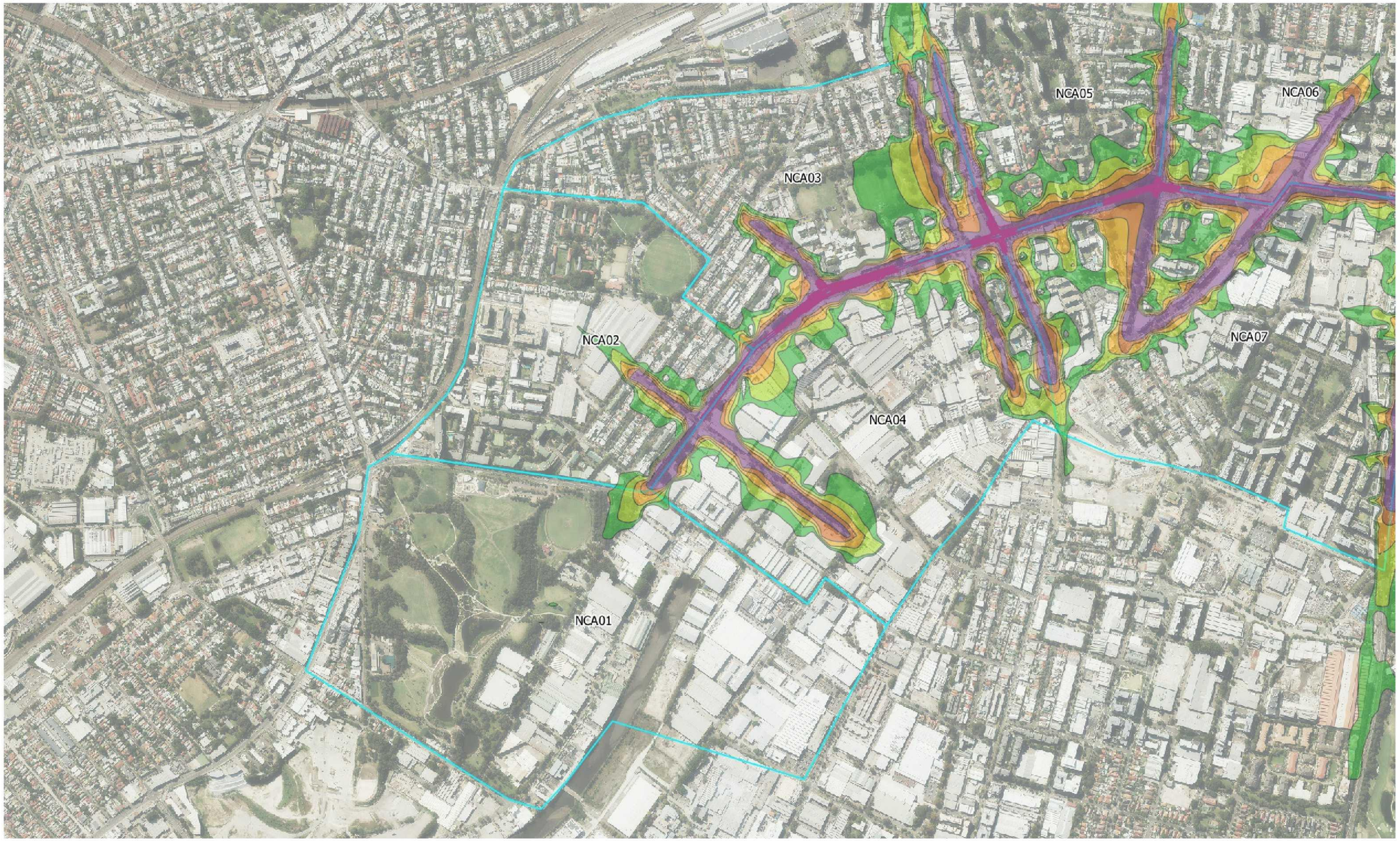
1/418A Elizabeth St., SURRY HILLS, NSW 2000
Ph (02) 8218 0500 Fax (02) 8218 0501

ALEXANDRIA TO MOORE PARK
Clearways and Intersection Upgrades
Additional Construction Noise Mitigation Measures
Out of Hours Works - Night

Status: | Sheet 2 of 2
Drawing No. TL052-01.6.1.2 App C (r0)-2 | Rev. No.

# APPENDIX D Predicted traffic noise contours




**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
No Build - 2031 Day



Figure No: TL052-01.6.1.2 App D (r0)-1
Date: 13-11-2019
Created by: DK

Rev: R0
Sheet: A3
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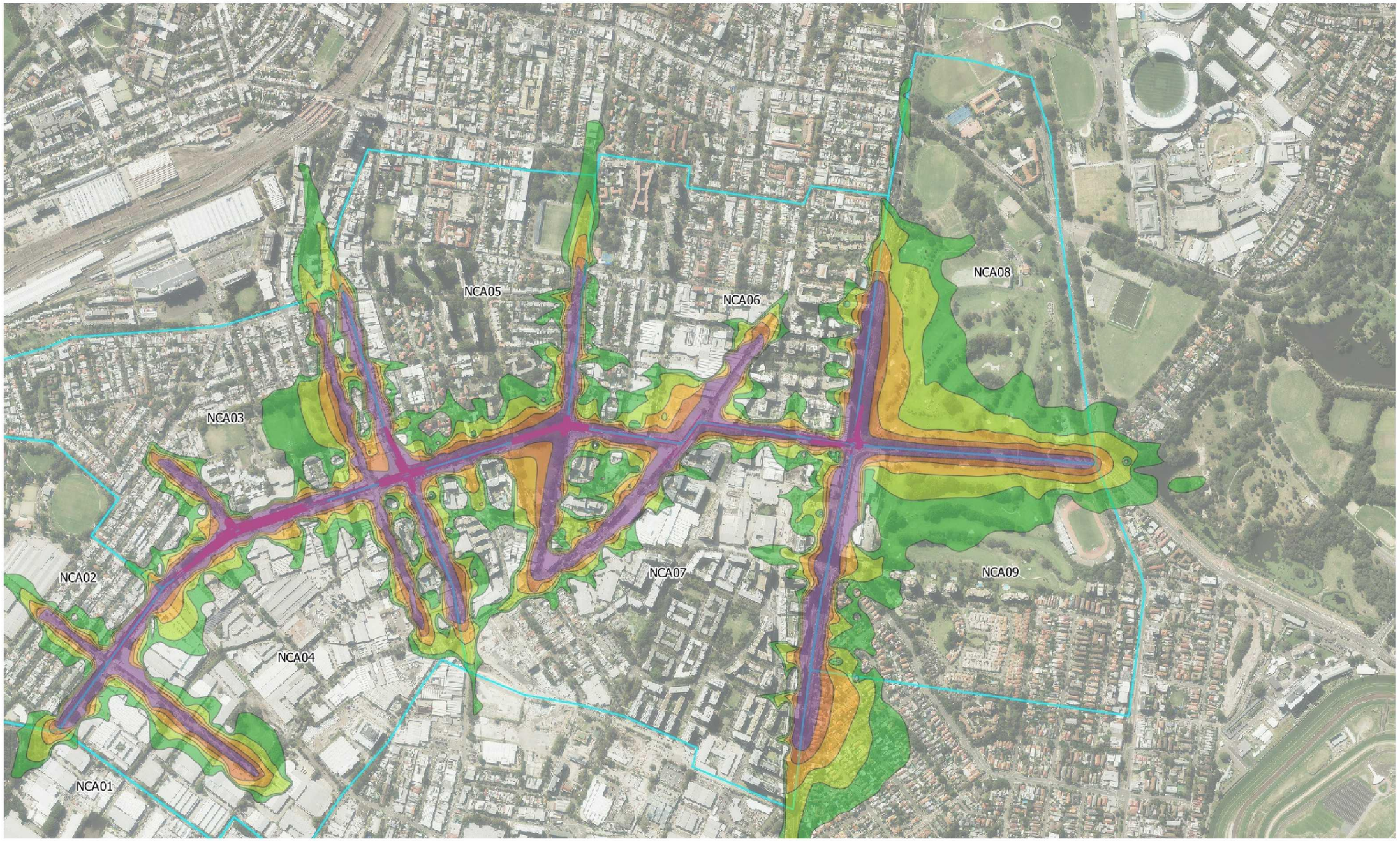



**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

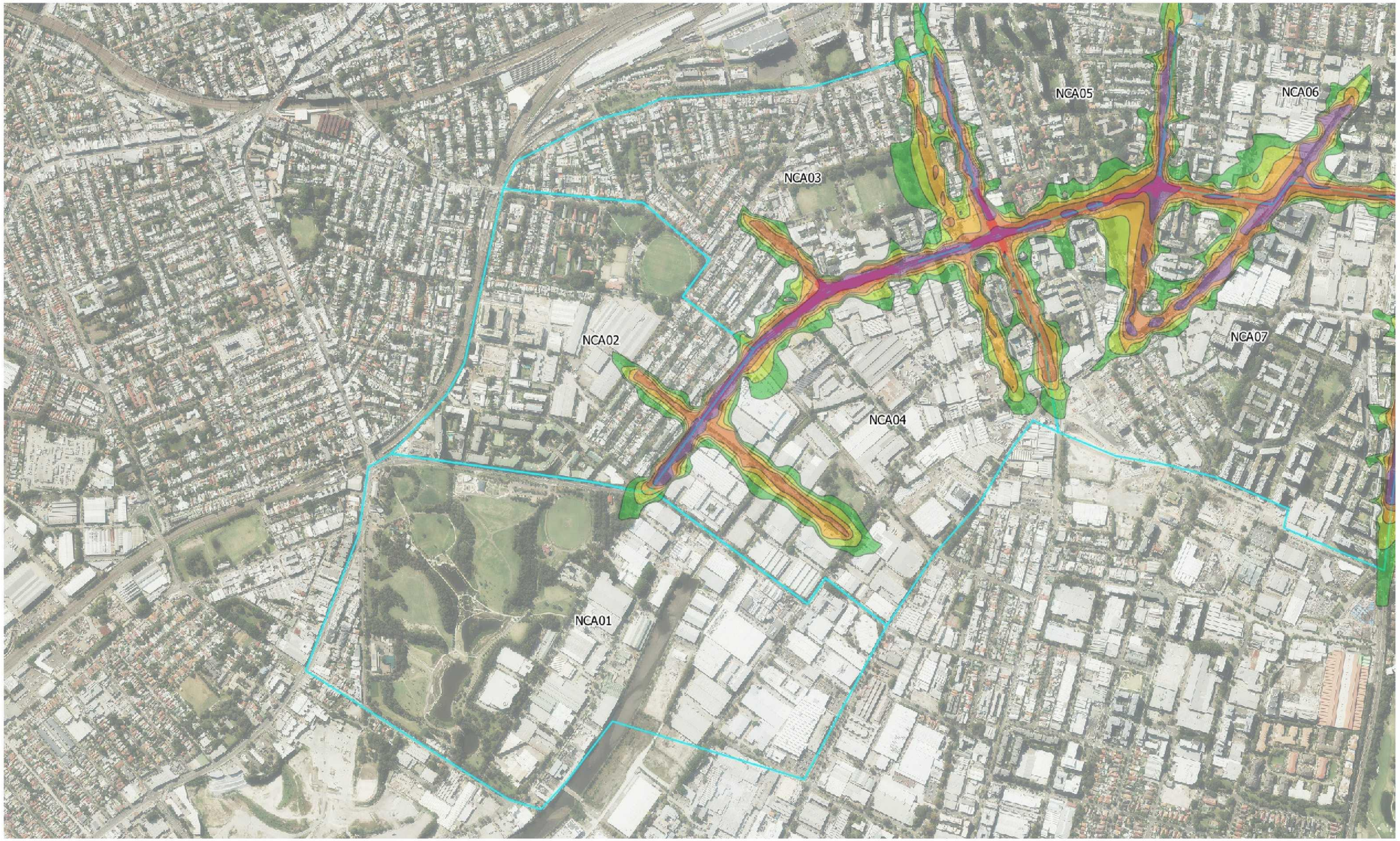
Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
No Build - 2031 Day



Figure No: TL052-01.6.1.2 App D (r0)-2
Date: 13-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**




**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

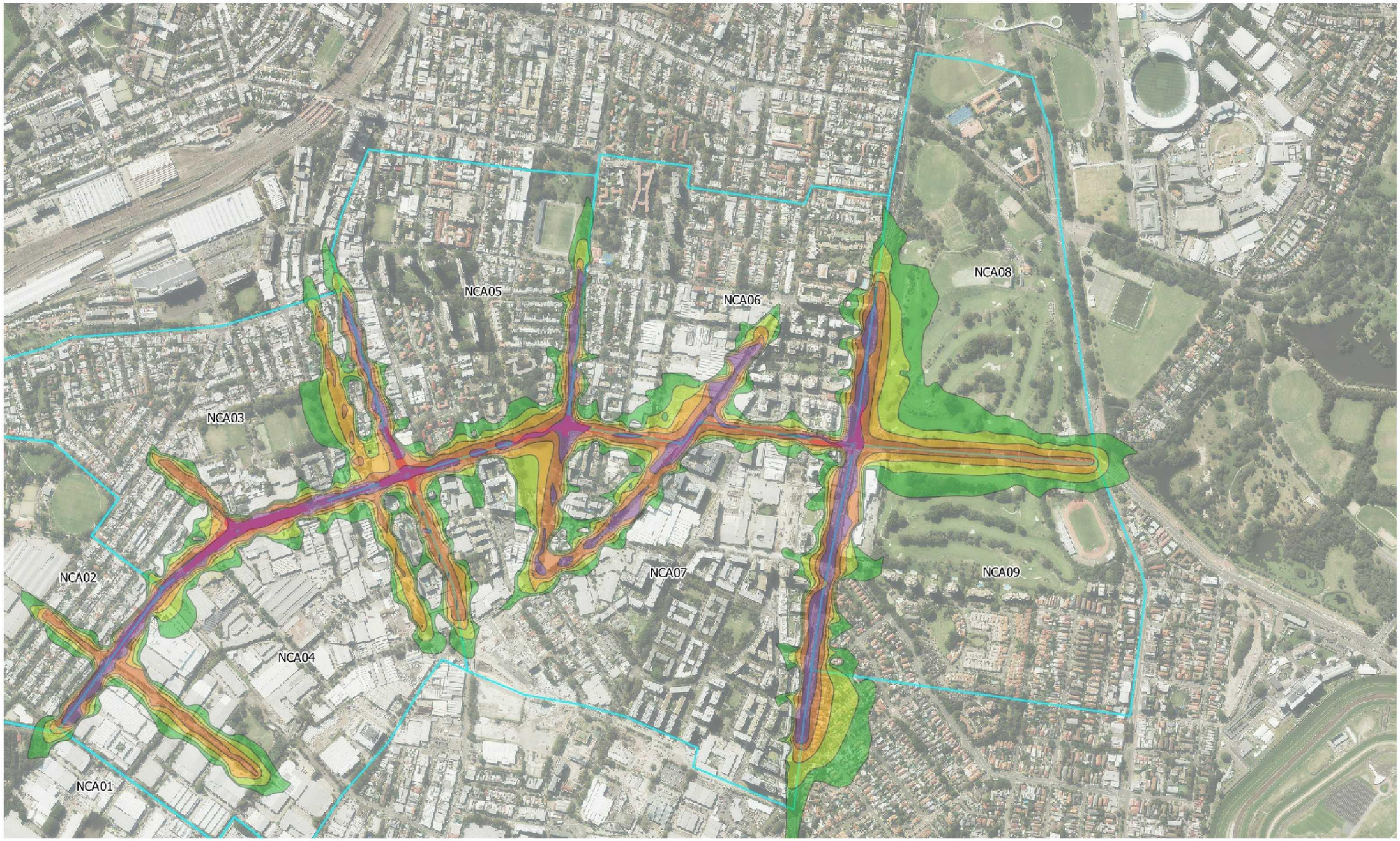
Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
No Build - 2031 Night



Figure No: TL052-01.6.1.2 App D (r0)-1
Date: 13-11-2019
Created by: DK

Rev: R0
Sheet: A3
Scale: **1:10000**




**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

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Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
No Build - 2031 Night



Figure No: TL052-01.6.1.2 App D (r0)-2
Date: 13-11-2019
Created by: DK
Rev: R0
Sheet: A3
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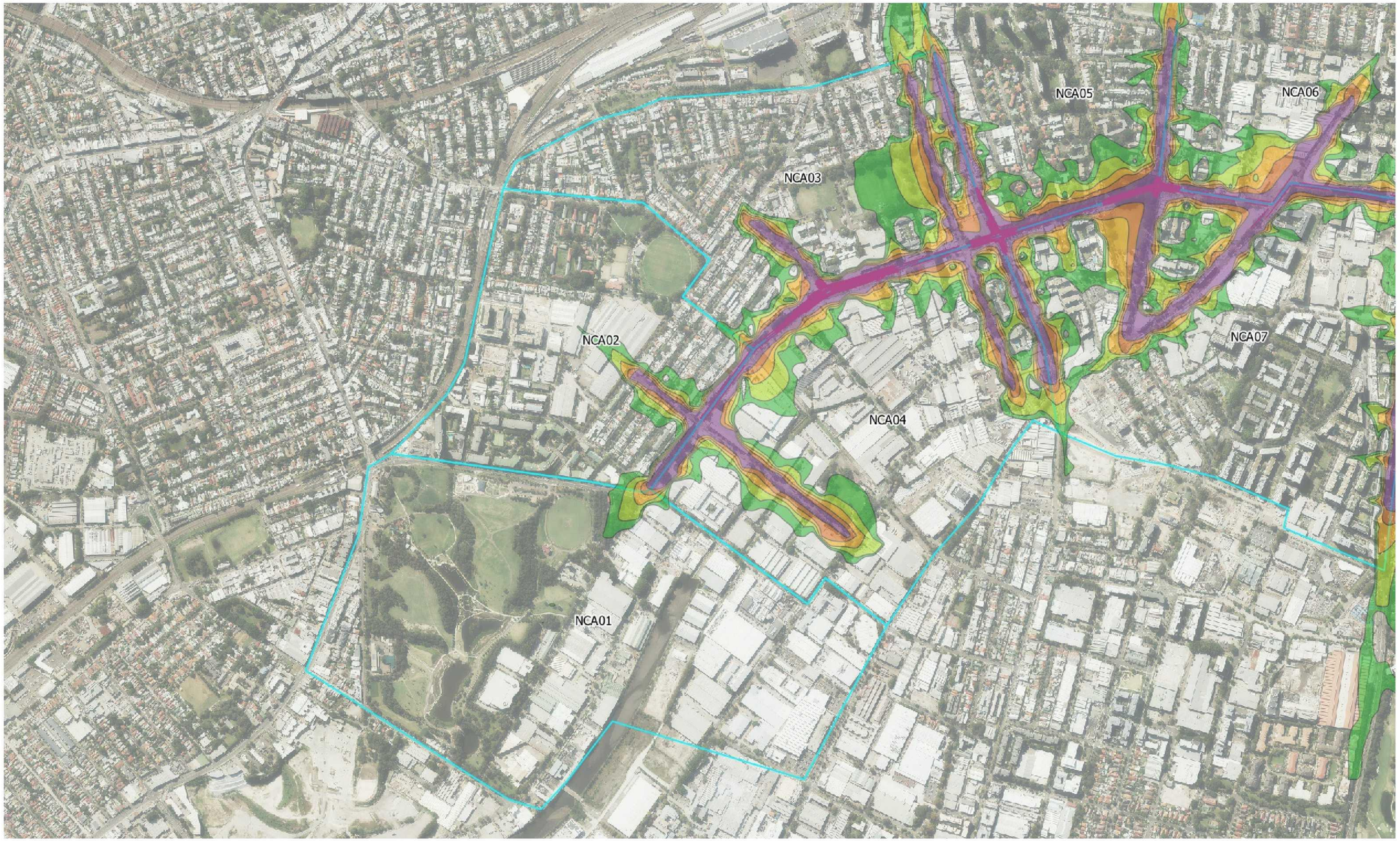


**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:
RENZO TONIN & ASSOCIATES
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1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
Build - 2031 Day



Figure No: TL052-01.6.1.2 App D (r0)-1
Rev: R0
Date: 13-11-2019
Sheet: A3
Created by: DK
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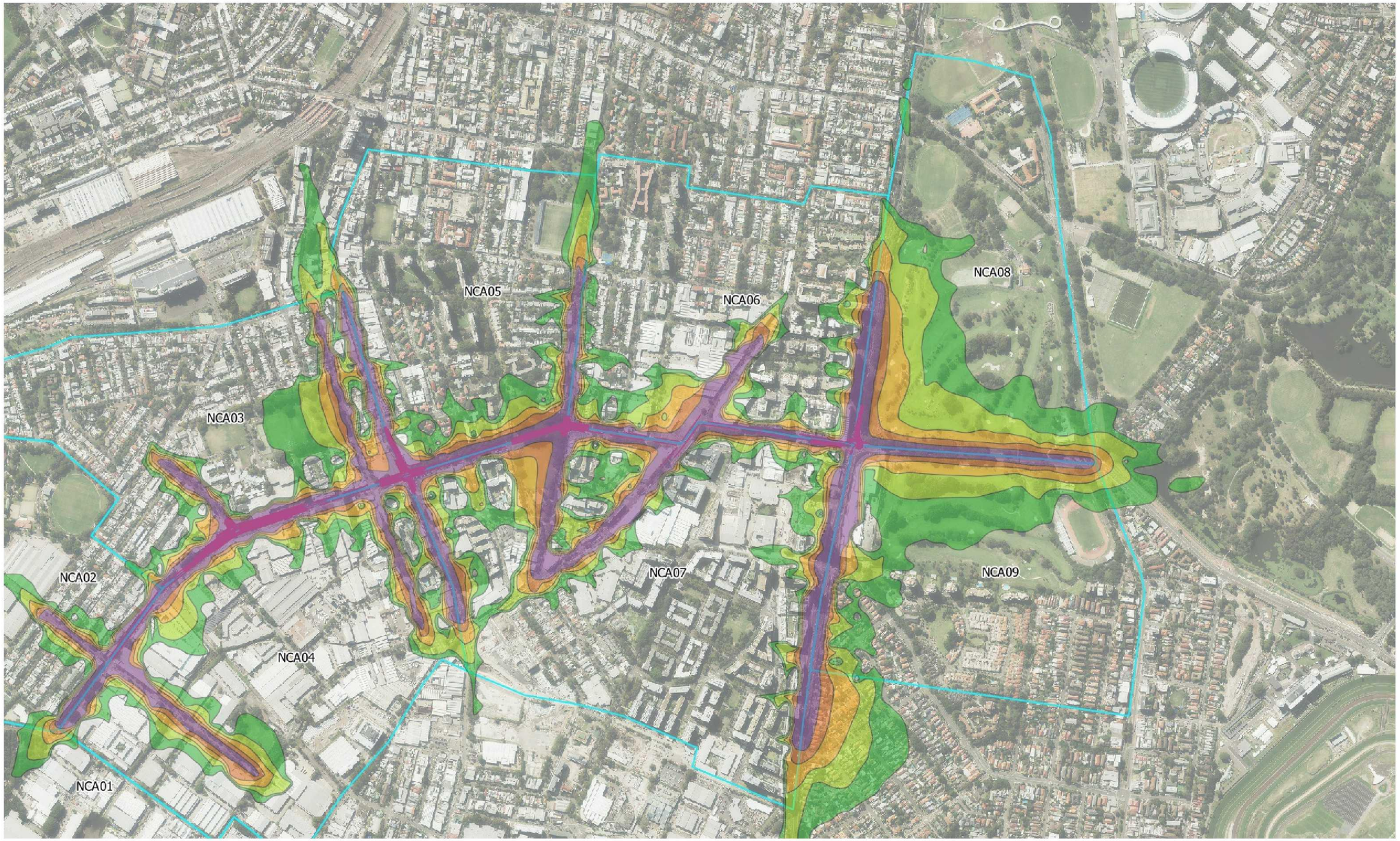


**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:
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P: 02 8218 0500 F: 02 8218 0501

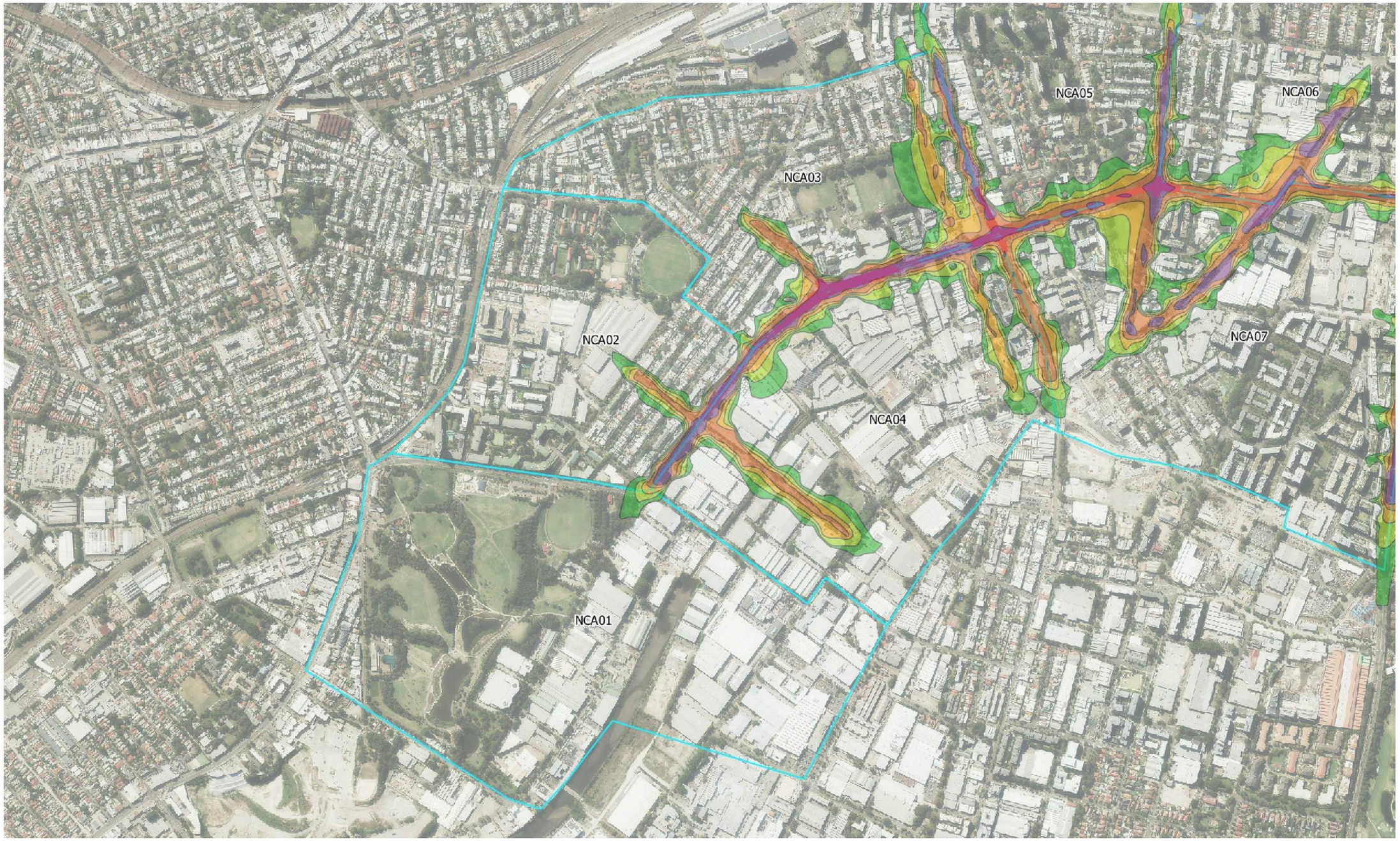
Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
Build - 2031 Day



Figure No: TL052-01.6.1.2 App E (r0)-2
Date: 13-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**




**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

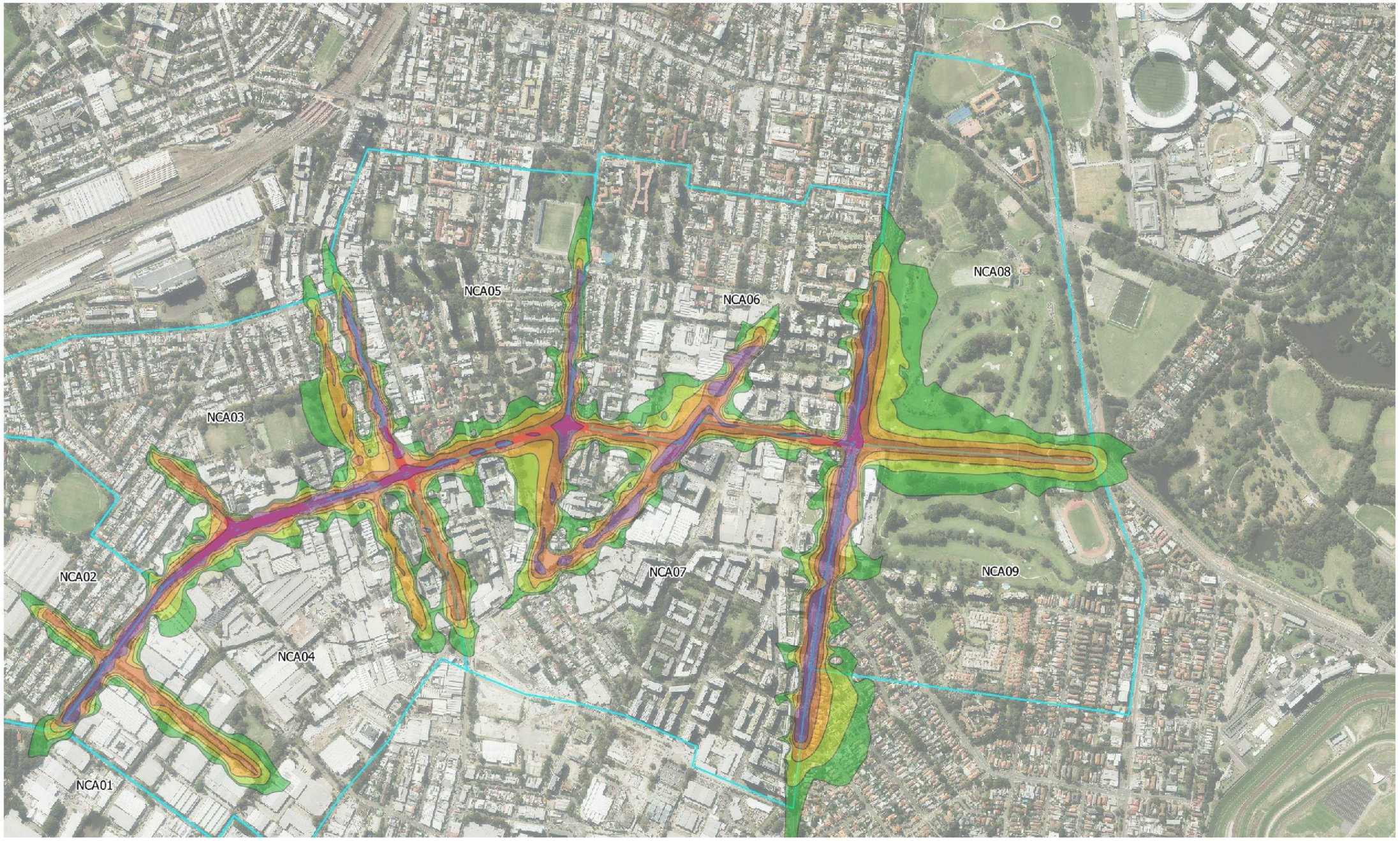
Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Predicted Traffic Noise Contours
Build - 2031 Night



Figure No: TL052-01.6.1.2 App D (r0)-1
Date: 13-11-2019
Created by: DK

Rev: R0
Sheet: A3
Scale: **1:10000**




**Legend**

- Noise Catchment Area (NCA)
- Project Design

**Noise Contours, dB(A)**

45 50 55 60 65

250 0 250 500 m

Consultant:
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inspired to achieve
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P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

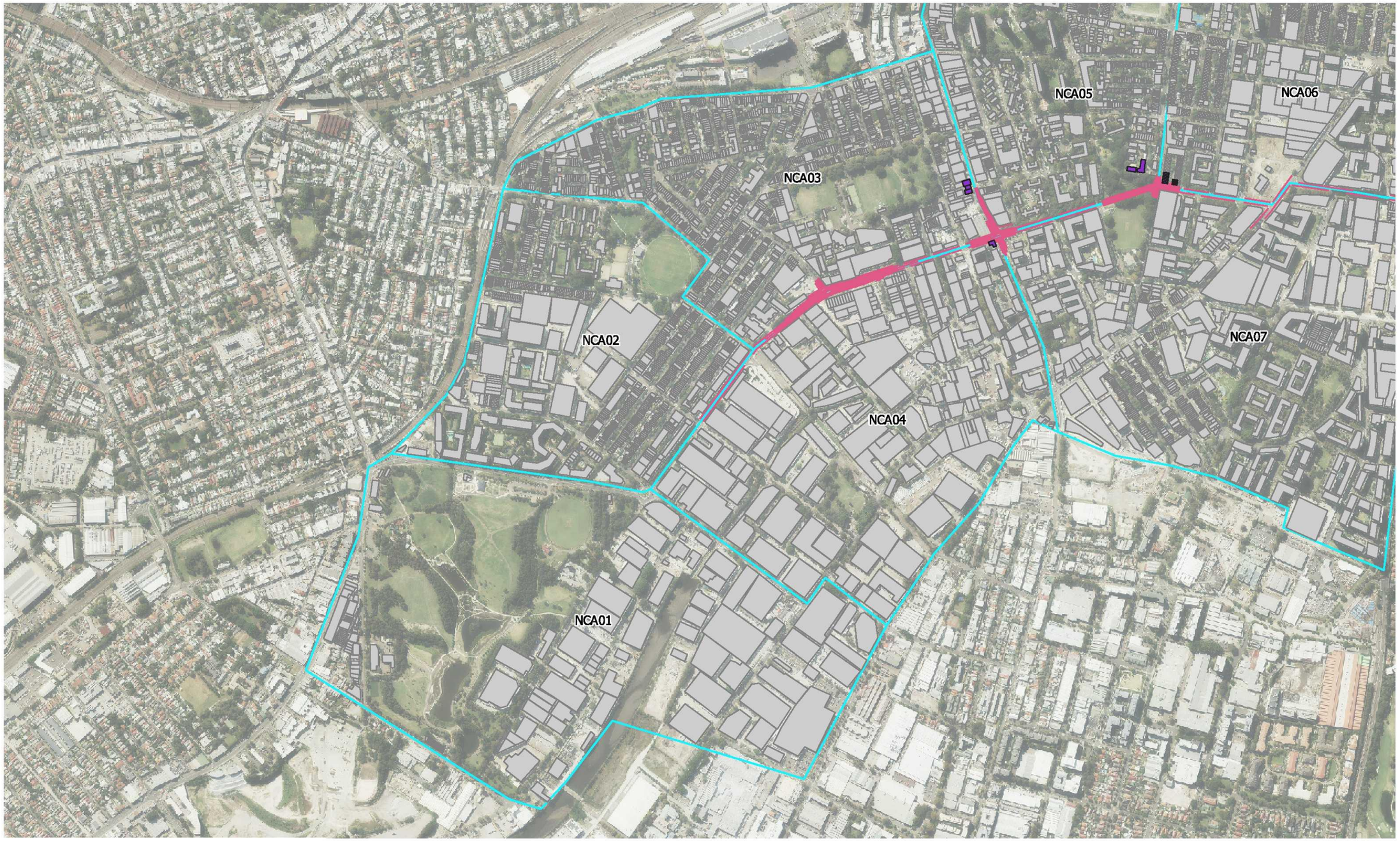
Description:
Predicted Traffic Noise Contours
Build - 2031 Night



Figure No: TL052-01.6.1.2 App D (r0)-2
Date: 13-11-2019
Created by: DK

Rev: R0
Sheet: A3
Scale: **1:10000**

# APPENDIX E Receivers identified for at-property treatment




## Legend

- Noise Catchment Area (NCA)
- Project Design

**Eligibility for At-Property Acoustic Treatment**

- Eligible
- Not Eligible

250 0 250 500 m

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park
Clearways and Intersection
Upgrades

Description:
Operational Noise Assessment
Buildings Eligible for Operational Noise Mitigation



Figure No: TL052-01.6.1.2 App E (r0)-1
Date: 21-11-2019
Created by: DK
Rev: R0
Sheet: A3
Scale: **1:10000**


## Legend

- Noise Catchment Area (NCA)
- Project Design

**Eligibility for At-Property Acoustic Treatment**

- Eligible
- Not Eligible

250 0 250 500 m

Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client:
Jacobs

Project:
Alexandria to Moore Park Clearways and Intersection Upgrades

Description:
Operational Noise Assessment
Buildings Eligible for Operational Noise Mitigation



Figure No: TL052-01.6.1.2 App E (r0)-2
Rev: R0
Date: 21-11-2019
Sheet: A3
Created by: DK
Scale: **1:10000**