Appendix E

Noise and vibration impact assessment

Sydney Harbour Bridge Southern Cycleway

Review of Environmental Factors
Noise and Vibration Assessment

Report Date: Friday, 17 November 17
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Glossary

'A' Weighted	A spectrum adaption that is applied to measured noise levels to approximate human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Feasible and reasonable	Consideration of best practice noise and vibration mitigation measures f taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.
Frequency	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.
Hz	Hertz—units of frequency.
L_{eq}	Equivalent Noise Level—energy averaged noise level over the measurement time.
$L_{eq,\ (15\ min)}$	A-weighted energy averaged noise level over a 15-minute period. Used in the EPA Interim Construction Noise Guideline (ICNG).
$L_{eq,\ (15\ hour)}$	A-weighted energy averaged noise level over the 15-hour daytime period from 7 am to 10 pm. Used in the EPA Road Noise Policy (RNP).
$L_{eq,\ (9\ hour)}$	A-weighted energy averaged noise level over the 9-hour night-time period from 10 pm to 7 am. Used in the EPA Road Noise Policy (RNP).
mm/s	Millimetres per second—unit of vibration velocity.
$m/s^{1.75}$	Units of VDV.
Noise Management Level (NML)	Construction noise management level. Where the construction noise levels are above the NML, additional consideration of feasible and reasonable noise mitigation is required.
Peak Particle Velocity (PPV)	The maximum speed of a particle in a particular component direction due to vibration during a measurement.
Rating Background Level (RBL)	The Rating Background Level for each period is the median value of the average background values for the period over all of the days measured. There is an RBL value for each period (day, evening and night).

Vibration	Refers to the oscillation of an object back and forth, normally the ground.
Vibration Dose Value (VDV)	A measure used to assess the level of vibration over a defined time period, such as a day, evening or night. Often used for the assessment of intermittent construction vibration that may rise and fall across a day.

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Executive Summary

Introduction

This noise and vibration assessment has been prepared for the proposed upgrades to the Sydney Harbour Bridge Southern Cycleway. The construction noise and vibration and operational noise impacts of the proposal have been assessed against the relevant guidelines. These include:

- Construction noise and vibration
  - *Interim Construction Noise Guideline* (ICNG), Department of Environment & Climate Change (DECC)
  - *Construction Noise and Vibration Guideline* (CNVG), Roads and Maritime Services
- Operational road noise
  - *Noise Criteria Guideline* (NCG), Road and Maritime Services.

Relevant assessment criteria applicable to construction noise and vibration impacts from the proposal have been determined in accordance with the ICNG and CNVG. Utilising a quantitative methodology, nearby noise sensitive receivers have been assessed on a Noise Catchment Area (NCA) basis providing a logical grouping of receivers based on number of identified receivers and their location in relation to the works. Vibration sensitive structures have been assessed through safe working distances from a selection of potential plant and equipment likely to generate ground-borne vibration.

Construction noise

The detailed noise assessment provides worst-case scenario predicted levels at nearby receivers for likely maximum and typical noise impacts. It has been identified that a number of construction activities may exceed a sound power level of 120 dB(A) (refer to Appendix C for a detailed list of activities and plant items). The maximum noise levels are likely to be generated through the use of plant items such as pneumatic hammers, rock hammers, concrete saws and chainsaws. These high source levels result in predicted noise levels at nearby sensitive receivers exceeding the Noise Management Levels (NMLs) as determined in accordance with the requirements of the ICNG.

The most potentially affected noise sensitive receivers are those located in close proximity and with direct line of sight to the proposed work locations. These include high-rise commercial and/or residential towers to the south; residential townhouses and some commercial and religious land uses to the west and north; the Sydney Observatory, Fort Street Public School and the National Trust centre directly adjacent to the works as well as commercial and residential structures to the east.

Construction vibration

The CNVG provides guidelines for minimum working distances for vibration-intensive activities. The distances are noted as being indicative and are likely to vary depending on the particular item of plant and local geotechnical conditions. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Generally, the separation distance from the nearest receivers is sufficient to mitigate the potential impacts. As such it is considered that structural or cosmetic damage impacts from vibration intensive works are unlikely for most of the adjacent receivers.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied. In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

The proposal alignment is located adjacent to a number of buildings and structures that have been identified as being heritage listed or of significance from a heritage perspective. No heritage structures are predicted to exceed the most stringent criterion of 3 mm/s. The exception is where demolition of sections of the Sydney Harbour Bridge itself is required.

It is recommended that a review of the vibration sensitivity of each structure with regard to current structural condition be conducted in order to confirm the appropriateness of the minimum working distance assessment and apply additional management protocols if required. The heritage structures include, but are not limited to:

- Parts of the Sydney Harbour Bridge
- National Trust Centre
- Sydney Observatory
- Observatory Park buildings, including:
  - Boer War Memorial
  - Bandstand
  - Various fences and landscaping
- Fort Street Public School, including:
  - Buildings and their interiors
  - Various fig trees and grounds
- Bureau of Meteorology weather station

The Sydney Observatory and the Bureau of Meteorology site hold instruments (such as telescopes and meteorological sensors) that may be sensitive to ground-borne vibration. Predicted vibration levels indicate that compliance with the nominated trigger levels is likely for most construction activities. Exceedance of the trigger levels may occur if a vibratory roller is used. It is therefore recommended that vibration monitoring be conducted upon commencement of construction to confirm the predictions and assumptions relating to site-specific ground-vibration propagation characteristics. This may allow for the minimum working distances to be modified.

Construction noise and vibration mitigation measures

Exceedances are predicted at several identified sensitive receivers for various construction activities likely to be involved in the proposal. Therefore, all feasible and reasonable mitigation measures must be implemented in order to minimise the impacts of construction noise and vibration. The CNVG presents standard and additional mitigation measures that must be implemented depending on the level of NML exceedance.

The predicted NML exceedances have resulted in the requirement for project specific mitigation measures. These measures include the use of temporary noise barriers and equipment enclosures as well as planning of work in order to minimise the duration of exposure at individual receiver locations.

Additional management protocols for construction vibration related impacts for heritage structures and sensitive equipment may include:

- Conducting a pre-construction dilapidation survey and monitor the condition of the structure throughout construction.
- Conducting vibration monitoring during construction applying the revised vibration targets determined as part of the pre-construction assessment.
- Conducting a vibration measurement investigation in order to determine the sensitivity of the structure in question to ground-borne vibration. This would only be required in specific cases where a structure was deemed to have a particular sensitivity to vibration.

It is also recommended that a Construction Noise and Vibration Management Plan (CNVMP) be prepared once a more detailed construction methodology and design has been developed and before the commencement of work.

Operational noise

The Noise Criteria Guideline (NCG) (Roads and Maritime 2015) provides the basis for the determination of road traffic noise criteria for Roads and Maritime projects. The proposed work is not considered ‘redeveloped’ or ‘new’ as its main purpose is not to increase traffic flow volumes. It is therefore reasonable to assume the proposal would be defined as ‘minor works’ as according to the Guideline.

The proposal requires alterations to the Kent Street merge lane onto the Bradfield Highway to be carried out within Precinct 4 of the works. The change in L_{Aeq} road traffic noise levels due to the minor realignment would be less than 1 dB, and is considered to be an imperceptible change.

The proposal currently indicates that the lane taper length would remain unchanged and that the proposed acceleration lane length would increase from 110 m to 118 m. The maximum noise levels due to acceleration during the night-time period are not predicted to change.

1 Introduction

Roads and Maritime Services proposes to upgrade the southern approach to the cycleway on the western side of the Sydney Harbour Bridge (SHB) in order to improve cyclist access as well as pedestrian and cyclist safety.

Resonate Acoustics has been engaged by Coffey Environments Australia to prepare a noise and vibration impact assessment to be included in a Review of Environmental Factors (REF) for the proposal. The proposed works include:

- Provision of a dedicated bi-directional cycleway facility from the Kent Street cycleway to the SHB cycleway. Upgrade of the existing pedestrian footpath from Kent Street to Fort Street Public School. Cyclists and pedestrians will be separated through delineation and contrasting surface treatments.
- Provision of a pedestrian footpath from Fort Street Public School to Watson Road.
- Removal of existing footbridge crossing the Cahill Expressway, including approach ramps, and replace with a new cyclist and pedestrian bridge crossing the Cahill Expressway.
- Removal of existing pedestrian and cyclist ramp on the southern approach to the Cahill Expressway and replace with a new spiral ramp for cyclists and pedestrians with an improved gradient.
- Removal of a 60 metre section of existing concrete retaining wall adjacent to the Incident Response Area to accommodate the proposed cycleway alignment.
- Construction of a 62 metre section of new concrete retaining wall with a maximum height of 4.5 metres between the proposed cycleway alignment and the Incident Response Area.
- Modification of merge treatment between Kent Street and Clarence Street on-ramps from general lane change to a zipper merge.
- Reconfiguration of existing fitness area in Observatory Hill to accommodate proposed cycleway alignment.
- Ancillary works for construction, including construction compounds and stockpile sites.
- Utility relocations, including water, sewer mains, telecommunications, electricity and gas services.

Figure 1 provides an overview of the proposed work precincts, identified potential noise and vibration sensitive receivers and relevant noise monitoring locations. Two site compounds are proposed for the project. The details of these locations are:

- Site office, ablutions and compound located at the foot of the Sydney Harbour Bridge Cycleway southern portal on the existing exercise area,
- Site compound located within the car park and frontage of the National Trust Centre adjacent to the Cahill Expressway cutting.

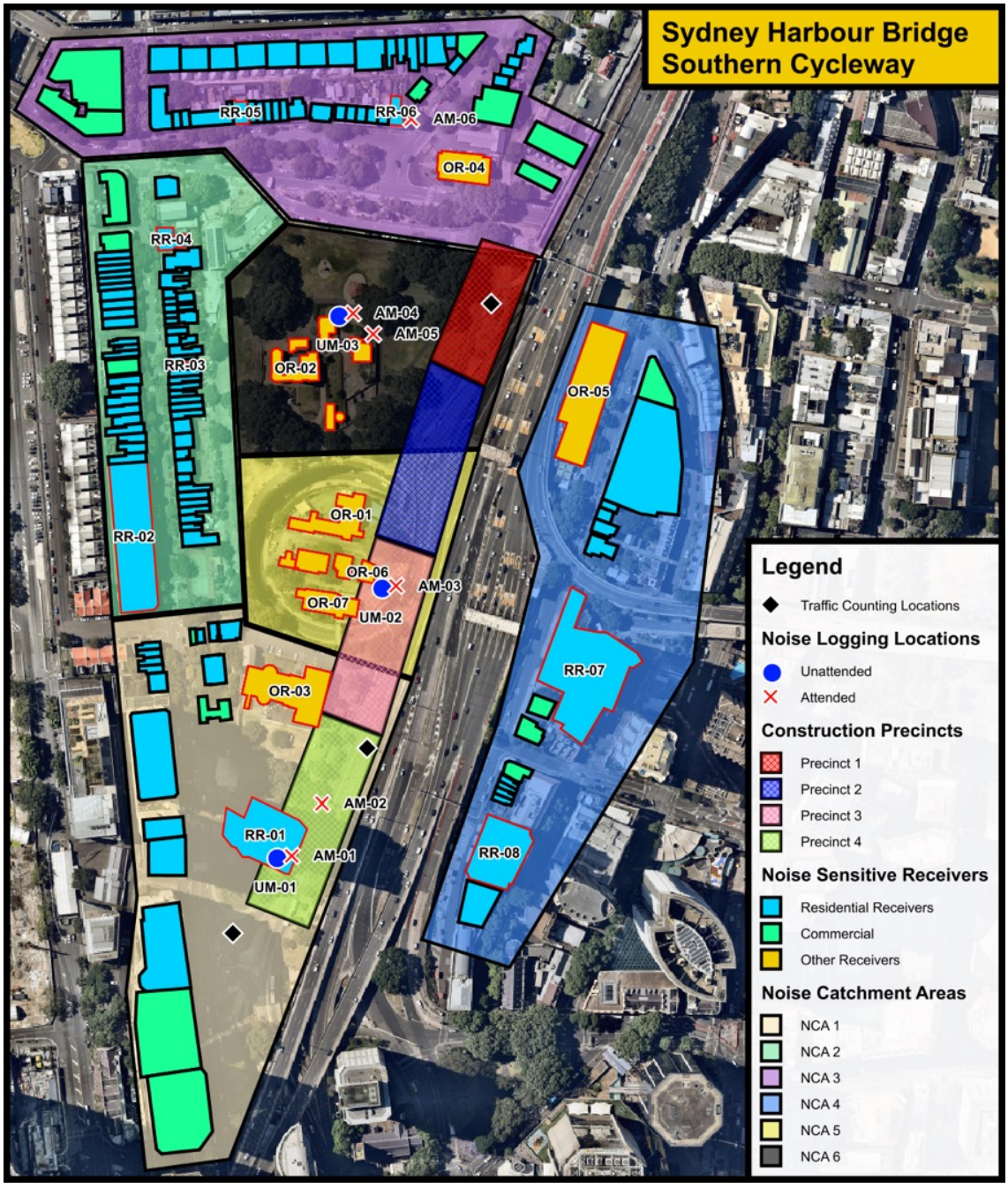


Figure 1 Site map in context

1.1 Construction work

The proposal is divided into four precincts due to the size of the project footprint. A detailed summary of the proposed construction activities for each precinct are summarised in Table 1. Due to the operational requirements of the existing cycleway infrastructure and surrounding roadways, Roads and Maritime are proposing to undertake a significant amount of the work outside of standard construction hours and/or during scheduled Sydney Harbour Bridge maintenance shutdown periods and road closures. This includes night work as well as the potential for 24-hour scheduling in some instances. Where longer road closure periods are required, partial closures from Friday night to Monday morning is the preferred option.

Table 1 Proposed construction methodology

Precinct	Stage	Description of works
1	1	Establish northern side site compound: a) Clear existing parkland area including removal of large trees and exercise equipment. b) Establish site sheds and facilities.
	2	Construction of temporary detour for cyclists through the Harbour Bridge Stairs.
	3	Construct ramp along Roads and Maritime's Incident Response Area: a) Install new drainage pipes, pits and grates along eastern alignment of new retaining wall. b) Install new safety barrier along western side of northbound Bradfield Highway lanes. c) Install contiguous piles for new retaining wall. d) Excavate for new ramp and install wall lining, stormwater and floor slab. e) Demolish existing retaining wall and parapet. f) Modify remaining retaining wall and parapet to ensure stability and suitable finish.
	4	Construction of on-grade cycleway: a) Place new concrete cycleway. b) Finish cycleway, handrails, lighting, line marking, etc.
	5	Reinstate parkland and exercise area at the completion of works.
2	1	Relocation/protection of existing Cahill Expressway utilities: a) The conduits and cables installed by LBA along the existing retaining wall will need to be protected before being incorporated into the backfill behind the new retaining wall. b) There may be a requirement to relocate the existing pit in the Roads and Maritime Incident Response Area.
	2	Construction of new kerb and retaining wall along Roads and Maritime Incident Response Area to support widening for cycleway:

Precinct	Stage	Description of works
		a) Cut existing pavement. b) Construct foundation for new kerb and retaining wall. c) Install new kerb. d) Install new retaining wall (likely to be precast 'L' shaped wall). e) Backfill against new retaining wall and modify existing Upper Fort Street drainage.
	3	Construction of new cycleway alignment: a) Install new handrail along retaining wall. b) Demolish existing kerb and handrail. c) Construct new shared path. d) Finish cycleway, handrails, lighting, landscaping, etc.
3	1	Establish southern side site compound in National Trust Centre frontage and car park.
	2	Preparatory works: a) Relocate gas main penetrating the southern approach. b) Install physical protection over firefighting and traffic management equipment in the Cahill Expressway cut. c) Install lifting frame under existing span to ensure bridge remains in one piece when lifted. d) Remove handrails. e) Chip away concrete to expose integrally cast steel I-beam at both ends.
	3	Demolition of span: a) Install large (200t) crane on the median triangle to the east of the span. b) Cut fixed end (south end) and remove expansion joint in footway (north end). c) Lift span onto awaiting wide-load truck and drive truck away to site where span can be unloaded and demolished.
	4	Reinstatement of existing Cahill Expressway retaining wall below northern abutment.
	5	Demolition of southern approach: a) Remove handrails. b) Smash down pathway and walls with excavator mounted hammer. Materials to be removed by small truck via the Gallery access road.
	6	Construction of new abutments on the northern and southern sides.
	7	Install new span: a) Position truck with structural steel components in the Cahill Expressway cutting.

Precinct	Stage	Description of works
		b) Position large mobile crane in the cutting. c) Erect structural steel components and bolt together in situ.
	8	Pour deck slab: a) Pour concrete deck slab. b) Finish cycleway, handrails, lighting, etc.
	9	Remove trees and clear the area.
	10	Install piles for pier foundations: a) Small piling rig (~20t) is required due to access limitation along access road to Gallery. This should be sufficient for small diameter piles as rock is visible in the adjacent cutting within 5 m depth.
	11	Construct on-ground ramp section adjacent to Cahill Expressway.
	12	Construct concrete pile caps and piers on the western side (to allow access for crane to centre of structure to minimise crane size.
	13	Install structural steel span sections on western side using small crane that can access the site via the Gallery access road.
	14	Construct remaining concrete pile caps and piers.
	15	Install remaining structural steel span sections using similar crane.
	16	Pour deck slab: a) Pour concrete deck slab. b) Finish cycleway, handrails, lighting etc.
4	1	Relocation of utilities.
	2	Adjust kerb line on east side of Kent Street on-ramp.
	3	Demolish existing central median within Kent Street on-ramp and install temporary pavement.
	4	Install temporary traffic barriers along edge of works on Kent Street on-ramp.
	5	Adjust stormwater to suit revised kerb alignment.
	6	Adjust existing retaining wall, ramp and stairs north of the existing National Trust stairs.
	7	Construct new kerb and pavement.
	8	Reinstate central median within Kent Street on-ramp.
	9	Finishing works (asphalt, line marking, sign posting, etc.).

2 Existing Environment

The proposal site is located within the Millers Point & Dawes Point Village Precinct, classified by the NSW Office of Environment and Heritage as a heritage conservation area. This precinct contains various noise and vibration sensitive receivers, including residential, commercial and heritage-type structures. Figure 1 identifies residential, commercial and other land uses (including heritage conservation structures).

2.1 Noise and vibration sensitive receivers

A selection of noise and vibration sensitive receivers located within the study area are summarised in Table 2. These receivers are representative of areas surrounding the proposal that have the potential to be impacted by construction noise and vibration.

These receivers were selected on the basis that they would be representative of the worst-case construction noise levels for the various work precincts (as identified in Table 1). The identified receivers then define the noise catchment areas (NCAs), which represent a logical grouping of receivers based on potential impact from the works. These NCAs are further characterised by background noise level obtained via unattended noise monitoring and assessed by additional attended measurements and potential impacts from the work. The NCAs are identified in Figure 1 and representative receivers within these catchment areas are shown in Table 2.

Table 2 Representative nearby sensitive receivers

ID	NCA	Description	Address	Land use	Minimum distance (m)
RR-01	1	Observatory Tower	168 Kent Street, Millers Point	Mixed-use residential	10
RR-02	2	Private residence	89-113 Kent Street, Millers Point	Residential	110
RR-03	2	Private residence	50 Kent Street, Millers Point	Residential	150
RR-04	2	Private residence	20 Kent Street, Millers Point	Residential	186
RR-05	3	Private residence	34 Argyle Place, Millers Point	Residential	188
RR-06	3	Private residence	64 Argyle Place, Millers Point	Residential	114
RR-07	4	Shangri-La Hotel	176 Cumberland Street, Sydney	Hotel	95
RR-08	4	Private residences	194-200 Cumberland Street, Sydney	Residential	91
OR-01	5	Fort Street Public School	Upper Fort Street, Millers Point	Educational	20

ID	NCA	Description	Address	Land use	Minimum distance (m)
OR-02	6	Sydney Observatory	Watson Road, Millers Point	Museum/Observatory	49
OR-03	1	National Trust Centre	Upper Fort Street, Millers Point	Museum	20
OR-04	3	The Garrison Church	60 Lower Fort Street, Millers Point	Place of worship	53
OR-05	4	King George V Recreation Centre	15 Cumberland Street, Sydney	Sport and recreation	66
OR-06	5	BoM Observatory Hill[1]	Upper Fort Street	Weather observation station	12
OR-07	5	Environmental Education Centre	Upper Fort Street	Educational	10

(1) Not considered a noise sensitive receiver; however, weather observation equipment may be vibration sensitive and has been included in the vibration assessment.

Heritage structures

The construction work proposed will be undertaken in close proximity to an array of heritage-listed structures as identified in the *City Plan Heritage Report*, dated March 2015. These include, but are not limited to:

- Parts of the Sydney Harbour Bridge
- National Trust Centre
- Sydney Observatory
- Observatory Park buildings, including:
  - Boer War Memorial
  - Bandstand
  - Various fences and landscaping
- Fort Street Public School, including:
  - Buildings and their interiors
  - Various fig trees and grounds
- Bureau of Meteorology weather station

The potential impact of construction vibration to the integrity of the heritage structures has been reviewed as part of the assessment.

2.2 Noise monitoring

Noise monitoring was conducted in December 2016 in order to formulate criteria for construction noise management and operational road traffic levels. The locations of these monitoring activities are shown in Figure 1.

Unattended noise monitoring methodology

The purpose of unattended noise measurements is to obtain L_{Aeq} and L_{A90} prevailing ambient noise levels for sensitive receivers located in close proximity to the proposed work site. These measurements were undertaken for a minimum period of one week.

Unattended noise monitoring was conducted at three locations:

- Observatory Tower (Level 5)
- Fort Street Public School
- Sydney Observatory

These locations were selected on the basis of their proximity to the various stages of the proposal to best represent the surrounding area.

The equipment used in the monitoring process included Rion NL-21 and NL-42 sound level meters. These meters were configured to capture L_{Aeq} and L_{A90} measurements for each 15-minute window over the logging period. All instruments carry current calibration certification. Calibration was checked before and after logging and the level of drift was less than 0.5 dB in all cases.

It is a requirement that noise data is captured during periods of favourable weather conditions avoiding adverse impacts of wind and rain on background noise levels. In order to assess weather conditions for the measurement period, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) IDN066062 at Sydney Observatory Hill.

Noise data has been excluded from the processed results if:

- Rain was observed during a measurement period, and/or
- Wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground, and these values are divided by 1.5 for the purpose of estimating wind speed at 1.5 m above ground.

See Appendix B for a detailed summary of noise logger data and exclusions based on the above weather conditions.

Unattended noise monitoring results

Table 3 provides a summary of the prevailing environmental noise conditions for the study area. The Rating Background Level (RBL) and L_{Aeq} noise levels are provided for each assessment period.

The RBL for each period is the median value of the average background values for the period over all of the days measured. There is an RBL value for each period (day, evening and night).

The L_{Aeq} or equivalent noise level is the energy averaged noise level over the measurement period.

Table 3 Summary of unattended noise surveys

ID	Location	Noise level, dB(A)					
		Day (7 am to 6 pm)		Evening (6 pm to 10 pm)		Night-time (10 pm to 7 am)	
		RBL	L_{eq}	RBL	L_{eq}	RBL	L_{eq}
UM-01	Observatory Tower (Level 5)	69	73	68	72	55	68
UM-02	Fort Street Public School	64	67	63	66	53	63
UM-03	Sydney Observatory	53	58	55	60	46	56

Attended noise monitoring

Attended noise measurements were undertaken at several locations in order to characterise the existing background noise. A summary of these results is presented in Table 4. A more detailed summary can be found in Appendix A.

The equipment used in the monitoring process was a Casella CEL-63X. This meter was configured to capture 1/3-octave band spectra as well as broadband overall noise levels, including L_{A90}, L_{Aeq} and L_{Amax}. The instrument carries current calibration certification. Calibration was checked before and after each measurement and the level of drift was less than 0.5 dB in all cases.

Table 4 Summary of attended noise surveys

ID	Location	Time (min)	Fast Max dB(A)	L_{eq} dB(A)	L_{10} dB(A)	L_{90} dB(A)
AM-01	Observatory Tower (UM-01)	15	81	70	72	68
AM-02	Observatory Tower (roadside)	15	93	73	76	67
AM-03	Fort Street Public (UM-02)	15	87	70	72	67
AM-04	Sydney Observatory (UM-03)	15	79	57	58	54
AM-05	Sydney Observatory (east)	15	82	64	66	62
AM-06	Corner Lower Fort Street & Argyle Place	15	94	76	76	60

3 Operational Road Traffic Noise Criteria

3.1 Noise Criteria Guideline (NCG)

The proposal requires alterations to the Kent Street merge lane onto the Bradfield Highway to be carried out within Precinct 4 of the works. For these reasons, an operational assessment of any potential increase in road traffic noise as a result of the work is required.

The Noise Criteria Guideline (NCG) (Roads and Maritime 2015) provides the basis for the determination of road traffic noise criteria for Roads and Maritime projects. This guideline implements the intention of the EPA's NSW Road Noise Policy (RNP).

According to section 5.5 of the NCG, 'minor works' are defined as work that is primarily intended to improve safety, including minor straightening of curves, installing traffic control devices, intersection widening and turning bay extensions or making minor road realignments. The proposed work is not considered 'redeveloped' or 'new' as its main purpose is not to increase traffic flow volumes. It is therefore reasonable to assume the proposal would be defined as 'minor works' as according to the Guideline.

Based on the description of proposed works and review of proposal inputs, the noise criteria for 'minor works' have been applied. In the first instance, criteria are derived from Section 6.6 of the Guideline, which relates to 'minor works' and states:

> *Roads and Maritime applies existing road criteria (RNP Table 8…) where minor works increase noise levels by more than 2.0 dB(A) relative to the existing noise levels at the worst affected receiver…*

4 Construction Noise and Vibration Criteria

4.1 Construction noise criteria

Interim Construction Noise Guideline (ICNG)

The *Interim Construction Noise Guideline* (ICNG), prepared by the NSW Department of Environment & Climate Change (DECC) and released in 2009, details construction noise assessment criteria and calls for the application of feasible and reasonable measures to mitigate construction noise and vibration. For the purpose of this assessment, the ICNG has been used for the assessment of construction noise and vibration.

The ICNG defines various working hours for which different construction noise assessment procedures apply. Standard working hours, during which the majority of construction work will occur, are:

- 7 am to 6 pm, Monday to Friday
- 8 am to 1 pm, Saturday
- No work on Sundays or public holidays.

Any works outside of these hours would be classified as Out of Hours Works (OoHW).

The ICNG also prescribes noise management levels (NMLs) depending on the time that construction work is to be carried out. These NMLs should be achieved at noise sensitive locations where it is feasible and reasonable to do so.

Construction Noise and Vibration Guideline (Roads and Maritime Services)

The Roads and Maritime Construction Noise and Vibration Guideline (CNVG) defines time periods to which construction activity should be limited, where feasible and reasonable to do so. These working hours are set out in Table 5.

Table 5 CNVG constructions hours

Construction hours	Monday to Friday	Saturday	Sunday/Public holiday
Standard construction hours	7 am to 6 pm	8 am to 1 pm	No work
Construction activities with impulsive or tonal noise emissions	8 am to 5 pm	9 am to 1 pm	No work
Blasting	9 am to 5 pm	9 am to 1 pm	No blasting

The CNVG also outlines the method for identification of all feasible and reasonable mitigation measures. The CNVG provides the mitigation measures most relevant to the proposal.

Residential and aged care land uses

Table 6 presents the NMLs for residential receivers for both standard working hours and periods outside of the standard working hours. The NMLs apply at the property boundary most exposed to construction noise or, if the residence is more than 30 metres from the boundary, then they apply at the most noise affected position within 30 metres of the residence.

Table 6 ICNG NMLs for residential receivers

Time of day	$L_{eq\ (15min)}$ NML, dB(A)	Notes
Standard hours: 7 am – 6 pm, Monday – Friday 8 am – 1 pm, Saturday	**Noise affected** RBL + 10 dB(A)	May be some community reaction to noise. Actions: Where the predicted or measured construction noise level exceeds the noise-affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected 75 dB(A)	May be strong community reaction to noise. Actions: Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Out of Hours Work	**Noise affected** RBL + 5 dB(A)	Actions: Strong justification typically required for these works. All feasible and reasonable work practices should be adopted. Where all feasible and reasonable work practices have been adopted and noise level is more than 5 dB(A) above the NML, negotiation should be undertaken with the community.

Active recreation areas

For the purposes of this assessment, Observatory Hill Park on Upper Fort Street has been classified as an active recreation area due to its heavy use as a physical exercise area. For active recreation areas, the ICNG recommends a NML of 65 dB(A) when the field is in use. It should also be noted that the existing ambient L_{Aeq} noise levels range between 60-65 dB(A) which is in the range of the noise management levels for active and passive recreation areas.

Other sensitive land uses

Table 7 ICNG NMLs for other sensitive land uses

Land use	**Management level $L_{Aeq(15\ min)}$ (Applies when properties are being used)**
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)
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

It should be noted the existing ambient L_{Aeq} noise levels in the vicinity of Fort Street Public School and the Observatory Hill Environmental Education Centre are in the range of 65 dB(A). This would suggest the windows and doors would be closed in order to achieve the internal NML of 45 dB(A). Therefore, a minimum façade insertion loss of 20 dB has been assumed in order to determine an external NML of 65 dB(A).

Commercial and industrial premises

The ICNG also recommends a NML of 70 dB(A) for commercial land uses, such as offices and retail outlets, applicable during the time of day for which the commercial land use is occupied.

Other noise sensitive commercial premises, such as cafes, restaurants and museums, should be assessed on a project-by-project basis in consideration of the recommended maximum internal noise levels provided by AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors.* Classified as "museum" type occupancies, the Sydney Observatory and National Trust carry a recommended maximum interior L_{eq} of 45 dB(A).

In the case of the National Trust Centre, the existing daytime and evening ambient L_{eq} noise levels are in the range of 65 dB(A). This would suggest windows and doors would be closed in order to achieve the internal NML of 45 dB(A). Therefore, a minimum façade insertion loss of 20 dB has been assumed in order to determine an external NML of 65 dB(A).

As the existing daytime and evening ambient L_{eq} noise levels in the vicinity of the Sydney Observatory are in the range of 55 dB(A) and visual inspection of the facilities indicates that doors and windows remain open during operational hours. Typically, a façade insertion loss performance of 10 dB may be achieved where windows are open. For this reason, a NML of 55 dB has been chosen.

Sleep disturbance

The CNVG considers night works exceeding an external L_{Amax} sound pressure level at a receiver of 65 dB(A) to impact upon occupant sleep amenity. This criterion has been factored into the analysis of potential airborne noise impacts generated by the proposal.

Ground-borne noise

Ground-borne noise will not be a controlling factor with respect to construction noise impacts. No underground works will occur and therefore air-borne noise levels will exceed the ground-borne noise levels. As such a detailed ground-borne noise assessment is not required for this project.

4.2 Construction vibration criteria

Ground vibration generated by construction can have a range of effects on buildings and building occupants, with the main effects generally classified as:

- Human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- Effects on building structures – vibration that may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on building contents and building structural damage. Building occupants will normally feel vibration readily at levels well below those that may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[1]
- British Standard BS 7385 Part 2-1993 *Evaluation and Measurement for Vibration in Buildings*
- Human comfort: Assessing Vibration – a technical guideline (the Guideline)

Cosmetic and structural damage

The DIN 4150-3 structural and cosmetic damage assessment criteria for different types of buildings are presented in Table 8. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

[1] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended in Table 8 would not necessarily result in damage. Rather it recommends these values as maximum levels of short-term construction vibration at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as the Standard considers a reduction in serviceability of the structure is deemed to have occurred if:

- Cracks form in plastered surfaces of walls.
- Existing cracks in the building are enlarged.
- Partitions become detached from loadbearing walls or floors.

Table 8 DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV) mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	< 10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

The guideline values from BS7385 relating to cosmetic damage from transient vibration are reproduced in Table 9.

Table 9 Transient vibration guide values for cosmetic damage (BS7385)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		Frequency range	
		4-15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

(1) Values referred to are at the base of the building.

(2) For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

DIN4150 and BS7385 state that exceedances of the guidance values do not necessarily mean that damage will occur, but that more detailed analysis may be required in order to quantify the site specific relationship between vibration levels, strain and the potential for damage. If required, the additional analysis may include more detailed vibration, strain or displacement measurements combined with engineering analysis.

BS7385 also states that *a building of historical value should not (unless it is structural unsound) be assumed to be more vibration sensitive*.

Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Guideline). The vibration assessment criteria defined in this guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction works as part of the SHB Southern Cycleway upgrades would be expected to be intermittent in nature with the potential for some impulsive activities (e.g. demolition works).Table 10 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted Root-Mean-Square vibration velocity levels (V_{rms}). The Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 10 Daytime V_{rms} management levels for continuous and impulsive vibration

Receiver	Continuous vibration V_{rms}, mm/s		Impulsive vibration V_{rms}, mm/s	
	Preferred	Maximum	Preferred	Maximum
Residences – daytime	0.2	0.4	6	12
Residences – night-time	0.14	0.28	2	4
Offices, schools, place of worship	0.4	0.8	13	26
Workshops	0.8	1.6	13	26

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 11.

Table 11 VDV management levels for intermittent vibration

Receiver	VDV – Intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Residences – daytime	0.2	0.4
Residences – night-time	0.13	0.26
Offices, schools, places of worship	0.4	0.8
Workshops	0.8	1.6

Effects on building contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. For most receivers, the controlling vibration criterion will be the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on most building contents.

However, the Sydney Observatory and the Bureau of Meteorology sites hold instruments (such as telescopes and meteorological sensors) that may be sensitive to ground-borne vibration. Detailed information relating to the type and sensitivity of the equipment located within these sites is not currently known. It is therefore appropriate to provide a generic set of criteria commonly applied to the assessment of vibration on sensitive equipment. A specific criterion will be selected at a later stage once detailed investigations have been carried out in consultation with the Sydney Observatory and the Bureau of Meteorology.

The future detailed study should refer to the generic vibration criteria (VC) curves presented in Figure 2 (reproduction of Table 1 and Figure 1 from *Generic Criteria for Vibration-Sensitive Equipment, Colin G. Gordon, SPIE Proceedings Volume 1619, 1991*).

The VC curves are defined as root-mean-square velocity (V_{rms}) spectra in one-third-octave frequency bands, arriving at a curve of allowable levels for each one-third-octave frequency band. The VC curves are named alphabetically and sequentially from VC-A to VC-G in order of increasing sensitivity. The vibration criteria curves described in *ISO2631-2:2003 Mechanical vibration and shock - Evaluation of human exposure to whole body vibration* relating to operating theatres, offices, residences and operating theatres are also presented.

Table 1: Application and interpretation of the generic vibration criterion (VC) curves (as shown in Figure 1)

Criterion Curve (see Figure 1)	Max Level (1) micrometers/ sec,rms	Detail Size (2) microns	Description of Use
Workshop (ISO)	800	N/A	Distinctly feelable vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	400	N/A	Feelable vibration. Appropriate to offices and nonsensitive areas.
Residential Day (ISO)	200	75	Barely feelable vibration. Appropriate to sleep areas in most instances. Probably adequate for computer equipment, probe test equipment and low-power (to 20X) microscopes.
Op. Theatre (ISO)	100	25	Vibration not feelable. Suitable for sensitive sleep areas. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

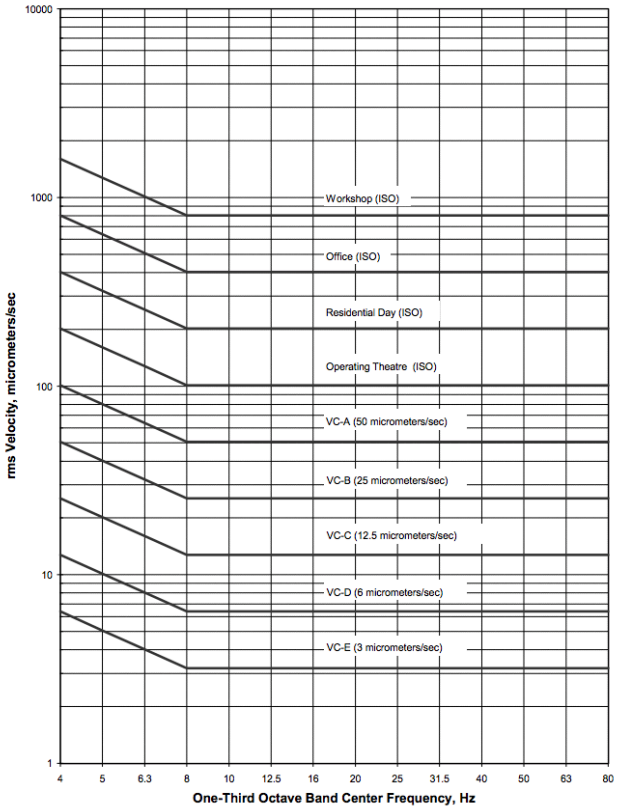
Notes:

(1) As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

(2) The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation that the vibration requirements of many items depend upon the detail size of the process.

Figure 2 Generic VC Curves for sensitive equipment

Figure 1: Generic Vibration Criterion (VC) Curves for Vibration-Sensitive Equipment - Showing also the ISO Guidelines for People in Buildings (see Table 1 for description of equipment and uses)



5 Road traffic noise assessment

5.1 Operational assessment

In order to improve cyclist and pedestrian safety, it is proposed that the on-grade cycleway between Kent Street and the existing bridge be widened to meet appropriate cycle lane and footpath widths (Precinct 4). This work will therefore impact the existing merge lane from Kent Street onto the Bradfield Highway. This is the only aspect of the proposal with the potential to influence road traffic noise levels.

The proposed traffic design to accommodate this work includes:

- Demolition of the median strip between lanes
- Realignment of merge taper
- Modification to an existing traffic island

According to Section 5.5 of the NCG, ‘minor works’ are defined as work that is primarily intended to improve safety, including minor straightening of curves, installing traffic control devices, intersection widening and turning bay extensions or making minor road realignments. The proposed work is not considered ‘redeveloped’ or ‘new’ as its main purpose is not to increase traffic flow volumes. It is therefore reasonable to assume the proposal would be defined as ‘minor works’ as according to the Guideline.

A desktop review of a potential road traffic noise level increase has been conducted with regard to source-receiver distance and traffic sensitivity.

Distance sensitivity

According to the current design specification, the distance between the proposed modified road alignment and nearby sensitive receivers will increase marginally. The change in road traffic noise levels due to the minor realignment would be less than 1 dB, and is considered to be an imperceptible change.

Traffic flow sensitivity

The proposal would not result in an increase of road traffic volumes, and therefore road traffic noise levels are unlikely to change as a result of this. The proposal currently indicates that the lane taper length would remain unchanged and that the proposed acceleration lane length would increase from 110 to 118 metres.

This is likely to result in a rate of acceleration equal to or less than the current situation in order to achieve the required merge speed, because there is a greater distance over which to achieve the same speed. The maximum noise levels due to acceleration during the night-time period are therefore not expected to change.

5.2 Existing road traffic noise levels and traffic volumes

As vehicle movements on the SHB have been determined as the main contributing noise source, for the purposes of this operational assessment, background noise monitoring and traffic counting were simultaneously conducted adjacent to the proposed work as a reference for future comparison if required. Table 12 summarises the road traffic noise levels from noise logging location UM-01 (Observatory Tower). The daytime and night-time L_{Aeq} road traffic noise levels as well as the 90th, 50th and 10th percentile L_{Amax} noise levels are presented.

Table 12 Road traffic noise levels

ID	L_{eq} (dBA)		Highest L_{max} (dBA)			Percentile (dBA)		
	Day (15 hr)	Night (9 hr)	1st	2nd	3rd	95	50	10
UM-01	73	68	92	85	85	90	80	75

Traffic counting was conducted by Northern Transport Planning and Engineering over a 48-hour period on Tuesday, 13 December 2016 and Wednesday, 14 December 2016. Table 13 presents a summary of the traffic counting conducted adjacent to the noise measurement location and includes all lanes of the Bradfield Highway and the Kent Street merge.

Table 13 Kent Street traffic count summary

Location	Daytime, 7 am – 10 pm (15 hr)		Night-time, 10 pm – 7 am (9 hr)	
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles
Kent Street	8449	322	1197	45
All other lanes	99722	7007	19772	1084

6 Construction noise and vibration assessment

6.1 Construction noise assessment

In order to quantify noise emissions from the proposed construction works, noise modelling software (SoundPLAN v7.4) has been utilised to predict the $L_{Aeq(15minute)}$ noise levels at nearby receivers. The calculations include the source noise levels of the anticipated equipment, the location of selection of nearby sensitive receivers, the number of plant items likely to be operating at any given time and the distance between the equipment and the receivers.

Construction noise source levels for typical road construction plant and equipment expected to be used as part of the project are shown in Appendix C. Total sound power levels are then provided for each major stage of the works. The typical noise levels are based on previous measurements conducted by Resonate Acoustics and on data from Roads and Maritime's Construction Noise and Vibration Guideline. The predicted noise level results are presented as a summary of the worst-case and typical noise impacts for each NCA when the work is located at the nearest position within the proposal area to the sensitive receiver in question.

In practice, the noise levels will vary due to the fact that plant will move around the worksites and will not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the works.

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works.

Noise management levels

NMLs for the identified noise sensitive receivers have been calculated based on the unattended background noise measurements and in line with the ICNG criteria in Table 6. The NMLs relevant to this assessment are presented in Table 14.

Table 14 NMLs for representative residential receivers

ID	NCA	Land use	Noise Management Levels dB(A)			
			Day (standard hours)	Day (OoHW)	Evening	Night
RR-01	1	Residential	79	74	73	60
RR-02	2	Residential	63	58	60	51
RR-03	2	Residential	63	58	60	51
RR-04	2	Residential	63	58	60	51
RR-05	3	Residential	63	58	60	51
RR-06	3	Residential	63	58	60	51
RR-07	4	Residential	74	69	68	58
RR-08	4	Residential	74	69	68	58
OR-01	5	Other (Educational)	65	N/A	N/A	N/A
OR-02	6	Other (Museum)	55	55	55	55
OR-03	1	Other (Museum)	65	65	N/A	N/A
OR-04	3	Other (Place of worship)	65	65	65	N/A
OR-05	4	Other (Sporting recreation facility)	70	70	70	N/A
OR-06	5	Other (Weather observation station)	N/A	N/A	N/A	N/A
OR-07	5	Other (Educational)	65	N/A	N/A	N/A

The background noise level-based NML has been used where it is greater than the 75 dB(A) highly noise affected level noting the prevailing high levels of road traffic noise.

Predicted noise levels

In order to explain the potential construction noise impacts that may result from the works, the following figures and tables have been developed:

- The various construction stages and associated work activities have been categorised based on the estimated SWLs resulting in either a typical noise impact or a maximum noise impact (due to the use of high noise generating equipment such as rock hammers or concrete saws).
- Predicted NML exceedances have been presented graphically and in tabular form (where the tables describe the number and category of exceedance per noise catchment area) for each potentially affected noise sensitive receiver adjacent to the project alignment as follows:
  - Daytime (maximum noise impact) – refer to Figure 3, Table 15.
  - Daytime (typical noise impact) – refer to Figure 4, Table 16.
  - Night-time (maximum noise impact) – refer to Figure 5, Table 17.
  - Night-time (typical noise impact) – refer to Figure 6, Table 18.
  - Predicted noise levels exceeding 75 dB(A) (maximum noise impact) – refer to Figure 7.
  - Predicted noise levels exceeding 75 dB(A) (typical noise impact) – refer to Figure 8.
- The 'Typical' scenario represents the worst case $L_{Aeq(15minute)}$ noise levels for construction activities with SWLs ranging between 110 dB(A) and 115 dB(A). Refer to Appendix C for a description of the associated activities.
- The 'Maximum' scenario represents the worst case $L_{Aeq(15minute)}$ noise levels for construction activities with SWLs ranging between 115 dB(A) and 120 dB(A). Refer to Appendix C for a description of the associated activities.
- The figures allow for the range of NML exceedances to be determined for each receiver location.
- On a representative night, construction noise levels would vary depending on the location and operation of individual plant items. Therefore, the overall noise level experienced at a particular receiver location would vary with time over a given night and would typically be less than the maximum presented values.
- The assessment has been conducted on the basis of a minimum distance from any receiver to the extent of works. It is anticipated that the works will not be conducted at these minimum distances for the entire duration of the project. A summary of the proposed duration of works is presented in Section 6.2.
- The NML exceedances are categorised based on the requirements of the CNVG noise mitigation categories such that the range of noise mitigation measures that may be applicable to each receiver can be identified by cross referencing with Table 23.
- The range of predicted noise levels at the representative noise sensitive receiver locations is presented in Table 19.

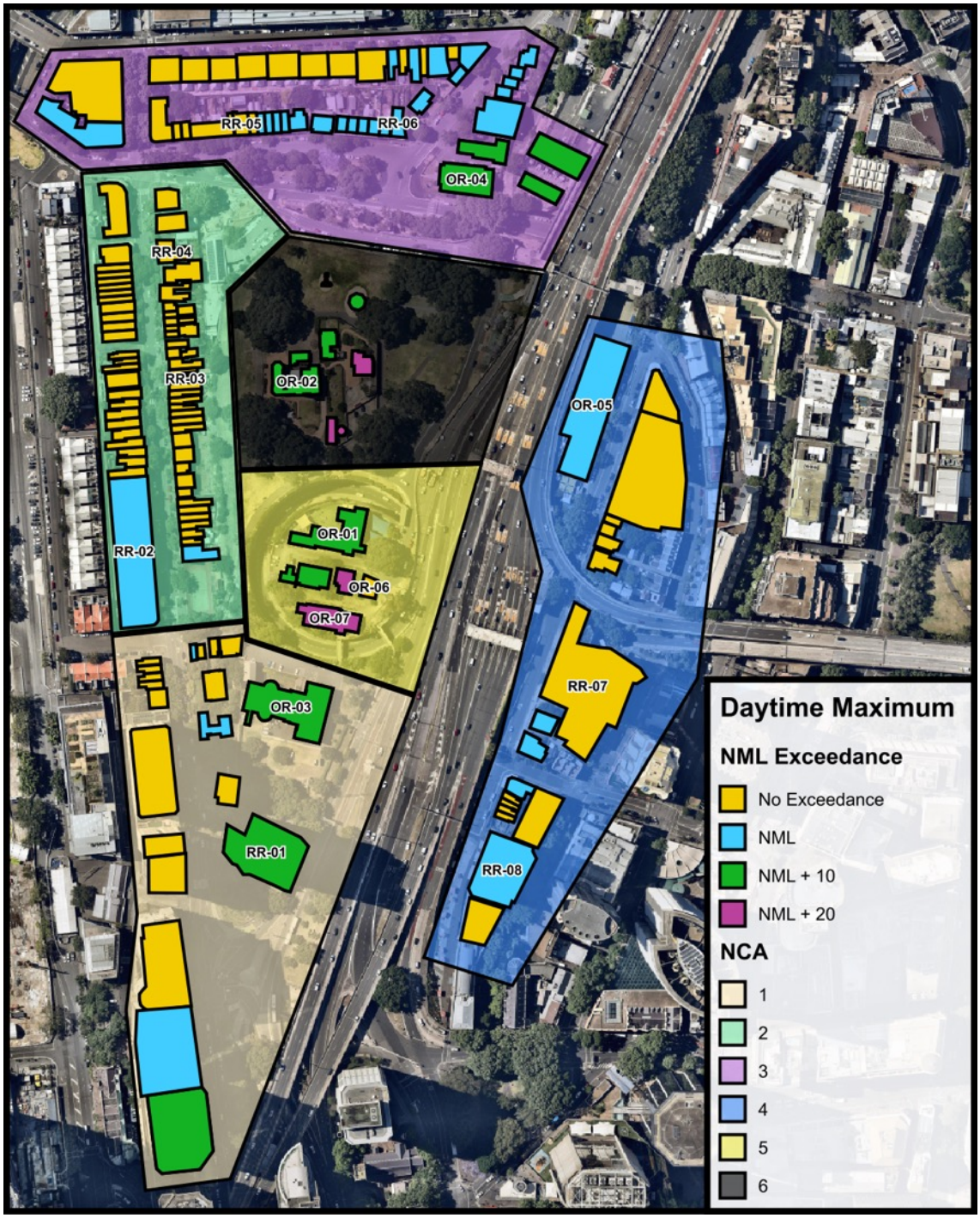


Figure 3 Daytime maximum noise impact

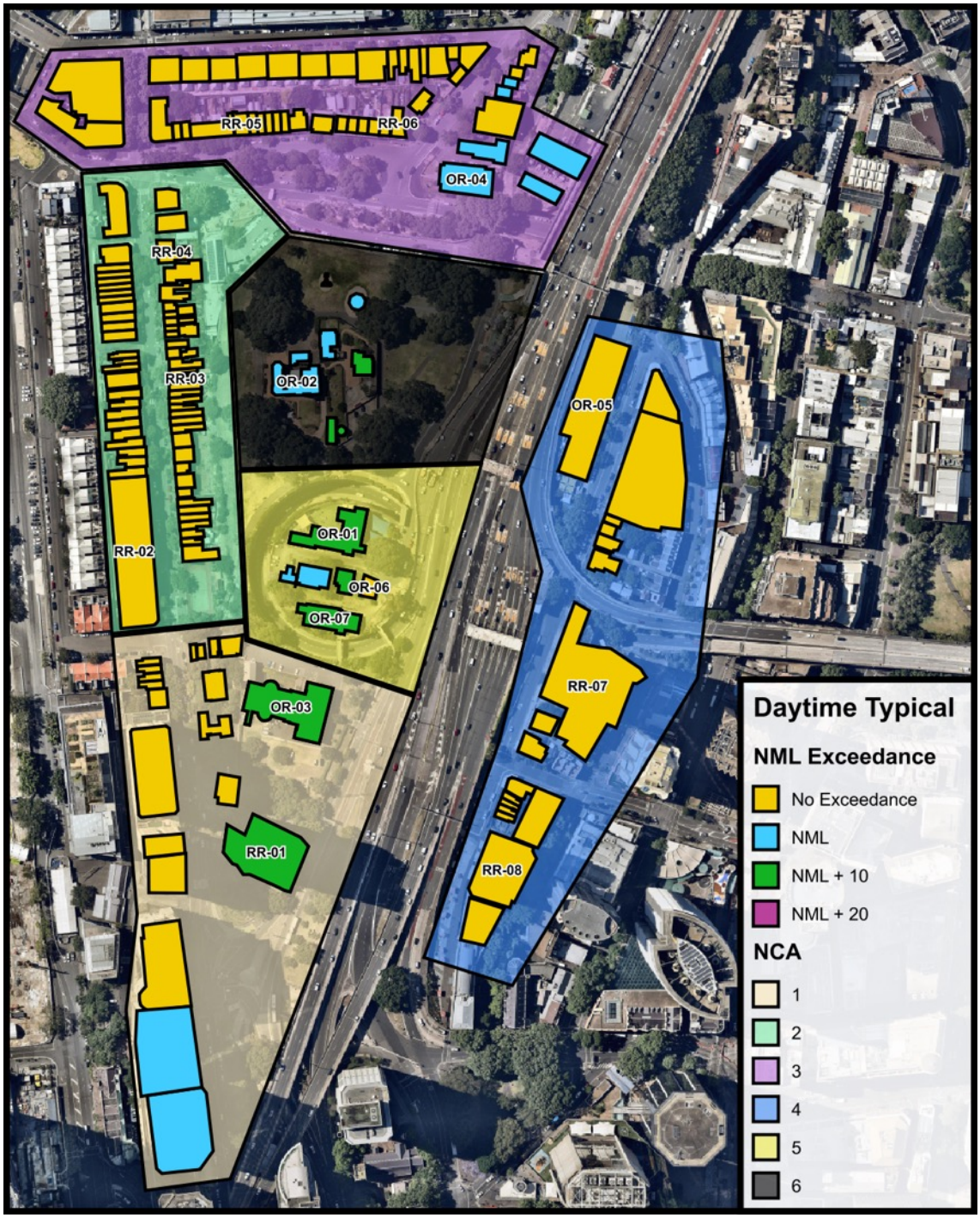


Figure 4 Daytime typical noise impact

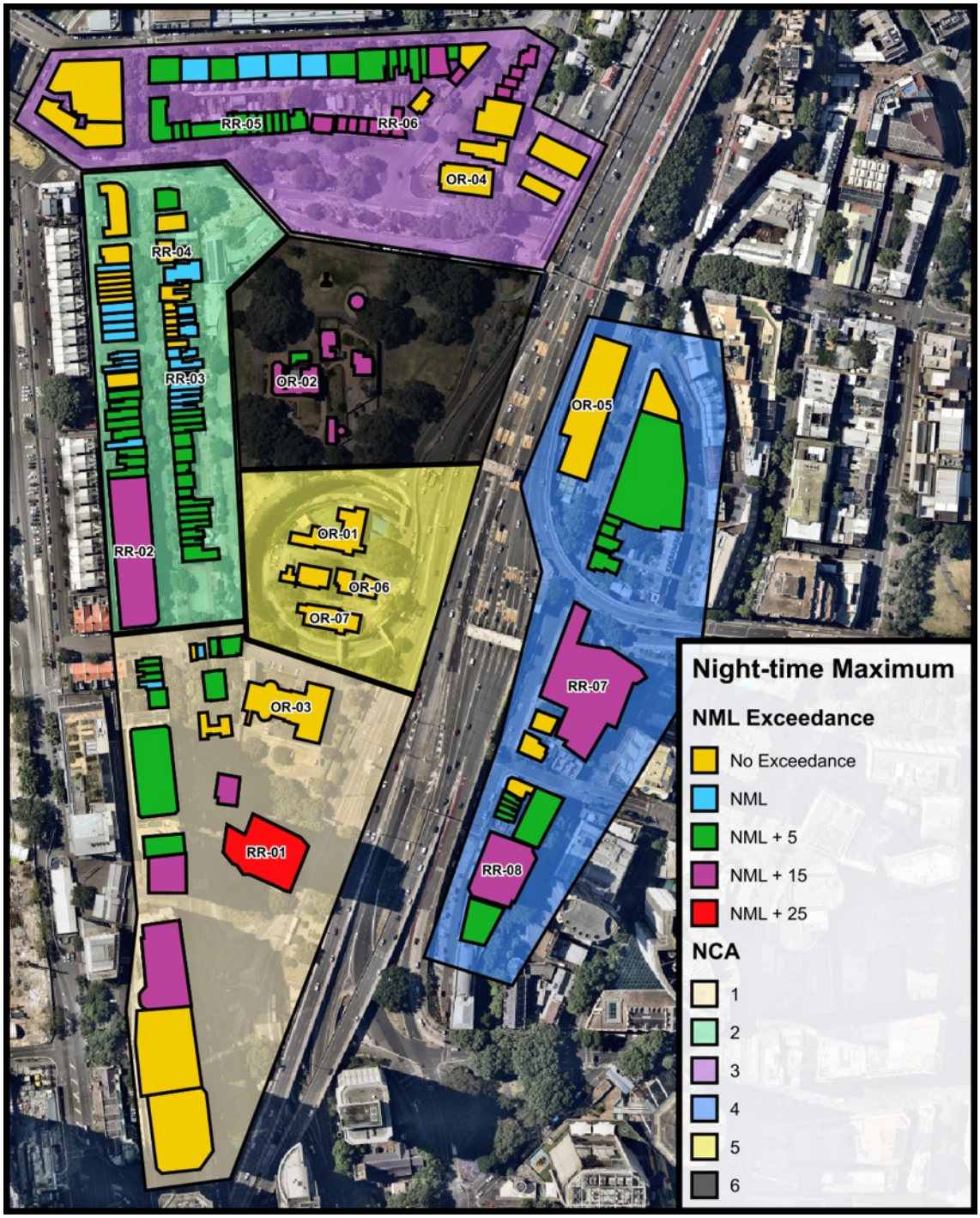


Figure 5 Night-time maximum noise impact

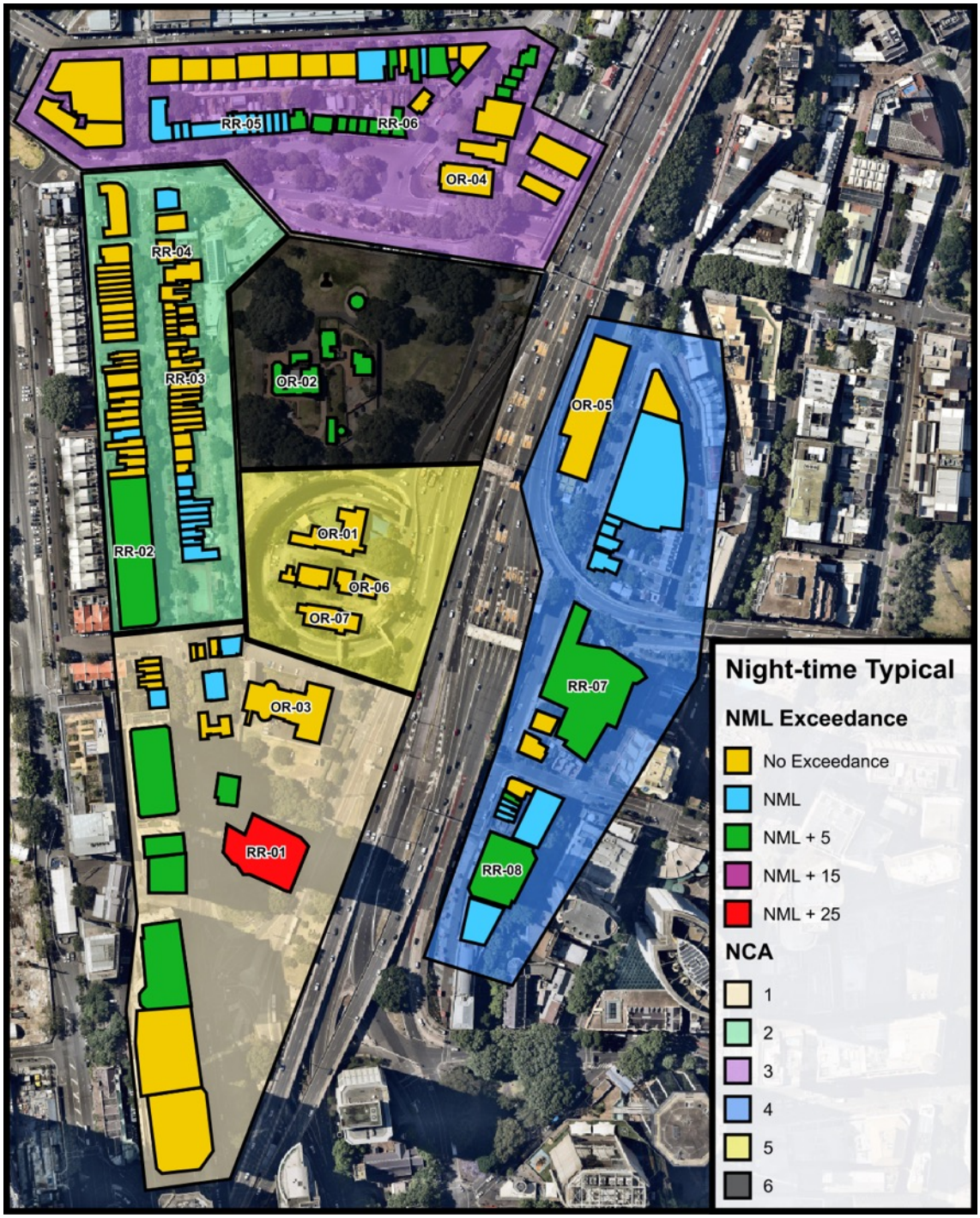


Figure 6 Night-time typical noise impact

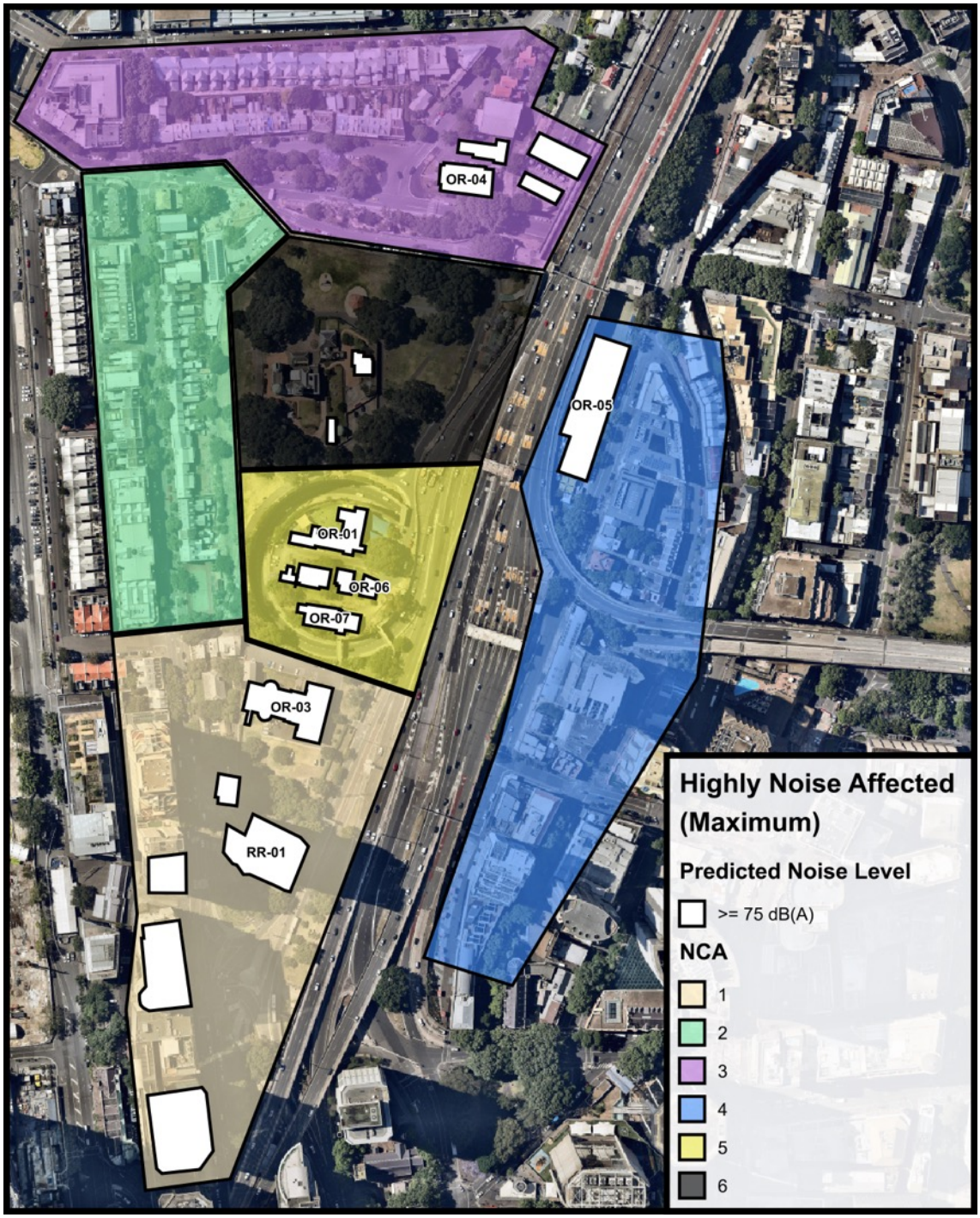


Figure 7 Highly noise affected land uses (maximum)

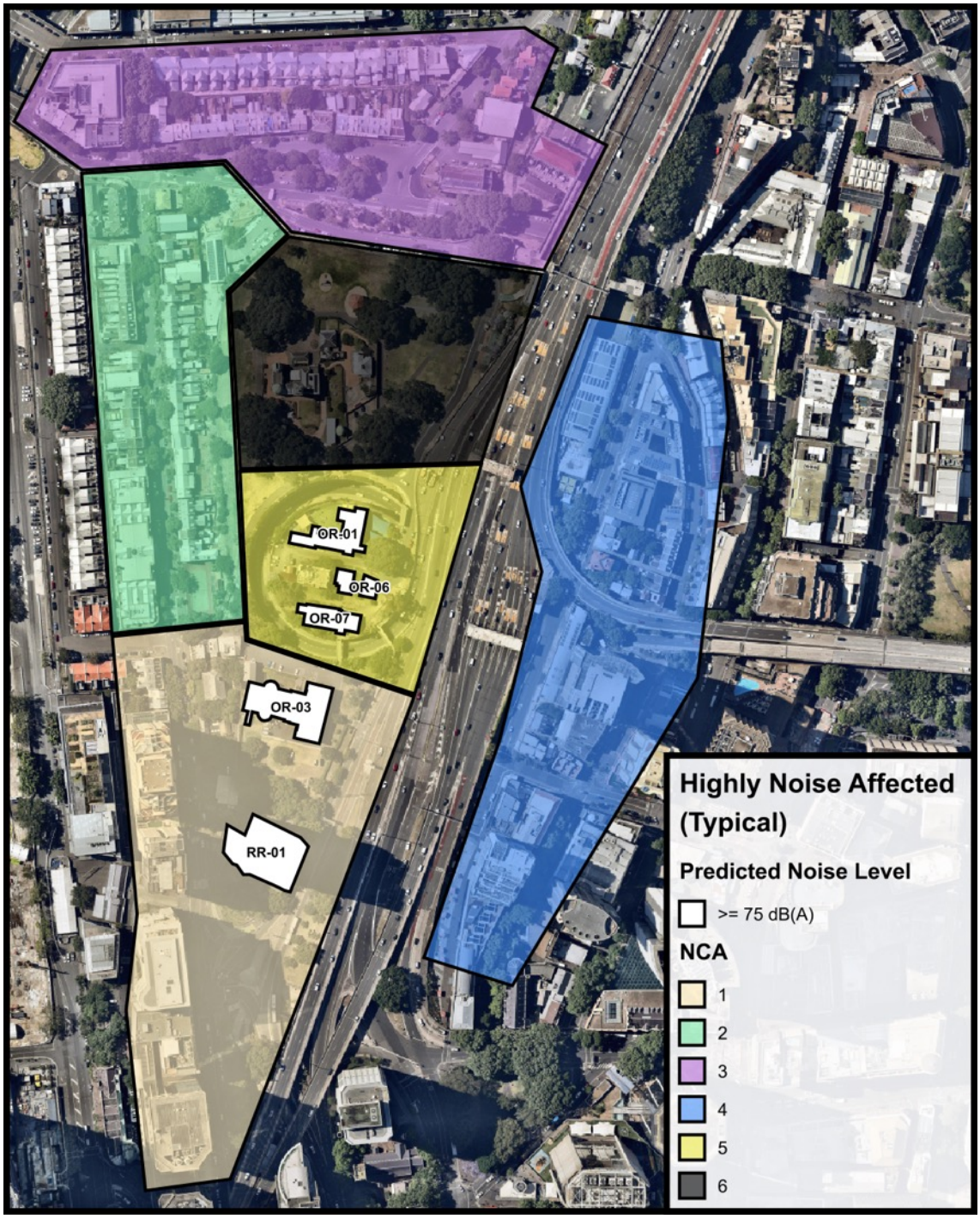


Figure 8 Highly noise affected land uses (typical)

Table 15 Number of NML exceedances per NCA for the 'Daytime Maximum Scenario' (refer to Figure 3)

Noise Catchment Area	Noise Management Level Exceedance Category		
	NML	NML + 10	NML + 20
NCA 1	6	3	-
NCA 2	2	-	-
NCA 3	33	4	-
NCA 4	5	-	-
NCA 5	4	4	2
NCA 6	9	9	3

Table 16 Number of NML exceedances per NCA for the 'Daytime Typical Scenario' (refer to Figure 4)

Noise Catchment Area	Noise Management Level Exceedance Category		
	NML	NML + 10	NML + 20
NCA 1	4	2	-
NCA 2	-	-	-
NCA 3	8	-	-
NCA 4	-	-	-
NCA 5	4	3	-
NCA 6	9	3	-

Table 17 Number of NML exceedances per NCA for the 'Night-time Maximum Scenario' (Refer to Figure 5)

Noise Catchment Area	Noise Management Level Exceedance Category			
	NML	NML + 5	NML + 15	NML + 25
NCA 1	16	14	4	1
NCA 2	49	27	1	-
NCA 3	43	39	18	1
NCA 4	17	17	2	-
NCA 5	-	-	-	-
NCA 6	9	9	6	-

Table 18 Number of NML exceedances per NCA for the 'Night-time Typical Scenario' (Refer to Figure 6)

Noise Catchment Area	Noise Management Level Exceedance Category			
	NML	NML + 5	NML + 15	NML + 25
NCA 1	9	6	1	1
NCA 2	13	1	-	-
NCA 3	34	21	1	-
NCA 4	16	4	-	-
NCA 5	-	-	-	-
NCA 6	9	7	-	-

Table 19 Predicted noise impact at nearby representative sensitive receivers

ID	NCA	Land use	Predicted Construction Noise Levels dB(A)	
			Maximum Noise Impact ($L_{Aeq(15minute)}$)	Typical Noise Impact ($L_{Aeq(15minute)}$)
RR-01	1	Residential	92	84
RR-02	2	Residential	66	58
RR-03	2	Residential	55	47
RR-04	2	Residential	48	40
RR-05	3	Residential	62	54
RR-06	3	Residential	67	59
RR-07	4	Residential	72	64
RR-08	4	Residential	73	65
OR-01	5	Other (Educational)	82	74
OR-02	6	Other (Museum)	75	67
OR-03	1	Other (Museum)	85	77
OR-04	3	Other (Place of worship)	74	68
OR-05	4	Other (Sporting recreation facility)	71	63
OR-06	5	Other (Weather observation station)	N/A	N/A
OR-07	5	Other (Educational)	90	82

6.2 Duration of construction noise exposure

An indicative description of the proposed construction program for the proposal is presented in Appendix D.

A summary of the program relevant to noise exposure is provided below:

- The total construction duration is anticipated to be 36 to 40 weeks.
- Where possible, work will be undertaken during the daytime period to minimise potential noise out of hours noise impacts.
- In order to maintain public safety and protect workers on site, a large portion of the works is likely to occur during the evening and night-time periods. This is mostly due to the proximity of the work to high-volume traffic zones on the Bradfield Highway and the Cahill Expressway.
- For the purposes of this assessment, it is anticipated that out of hours works would occur on a weekly basis and that the works would be managed in accordance with the Respite Period and Duration Respite mitigation measures described in the CNVG and Section 7 of this report. The potential for out of hours works would be further assessed and evaluated by the Construction Contractor in consultation with sensitive receivers.
- It is currently proposed that works would occur simultaneously across all precincts.

6.3 Discussion of predicted construction noise levels

Noise Catchment Area 1

The predicted construction noise levels within this noise catchment area range between 66 dB(A) and 92 dB(A) with NML exceedances ranging between 0 dB(A) and 19 dB(A) for the daytime period and 6 dB(A) and 32 dB(A) for the night-time period. The predicted maximum noise levels indicate that certain activities may exceed the sleep disturbance criterion. The maximum construction noise levels are likely to be a result of the following:

- Demolition of the existing bridge span and approach ramp within Precinct 3 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.
- Median and kerb works along the Kent St merge taper within Precinct 4 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

The predicted night-time NML exceedances are in excess of 25 dB at the most potentially affected receiver (The Observatory Tower) for typical construction activities. It is therefore necessary to consider additional project specific noise mitigation measures for work affecting sensitive receivers within this noise catchment area.

Construction activities conducted during the OoHW night-time period that exceed the NMLs by more than 5 dB(A) should be limited to two consecutive nights per week except where there is a duration respite as per the CNVG. It is acknowledged, however, that respite offers may be counterproductive in further minimising the potential noise impact on the community for longer duration projects where best efforts are being made to control/reduce construction noise levels through the implementation of standard mitigation measures (see Section 7). In this instance, and where it can be strongly justified, it may be appropriate to increase the work duration to enable the project to be completed in a timely manner. The affected community would be engaged to seek support for extended work duration.

Notwithstanding the above measures, OoHW can and should be planned such that duration of exposure to construction noise at individual receivers is minimised on a night by night basis. The following measures should be considered:

- Commence works with a high noise intensity during the evening period with the aim of ceasing the use of plant items such as rock-breakers and road saws prior to midnight.
- Commence high noise generating activities adjacent to the most potentially affected receiver and then move the work front further way from the receiver as the night progresses.
- Whilst the predicted noise levels presented in this report are considered to represent a worst case scenario for each receiver, it also reasonable to assume that these noise levels would not be constant throughout a given night or for the duration of the project. In order to demonstrate this, a case study is presented below for kerb demolition works within Precinct 4. The chart presents noise levels versus time over a typical night-time period from the perspective of the most potentially affected façade of The Observatory Tower and assumes the following:
  - The kerb demolition commences at 10pm directly adjacent to the sensitive receiver.
  - Temporary noise barriers/enclosures are utilised to reduce noise levels from rock breakers and road saws.
  - Operation of high noise generating plant items cease at midnight.
  - Works move towards the north of the Precinct as the night progresses (i.e. approximately 60m north of the receiver location).
  - Work site demobilisation commences at approximately 5am.
- A review of Figure 9 demonstrates:
  - Whilst maximum predicted noise levels would occur initially, these would not be sustained throughout the night.
  - Implementation of the Respite Period 2 measure would also limit works to a maximum of two consecutive nights with at least a one-week respite period between blocks of night works.

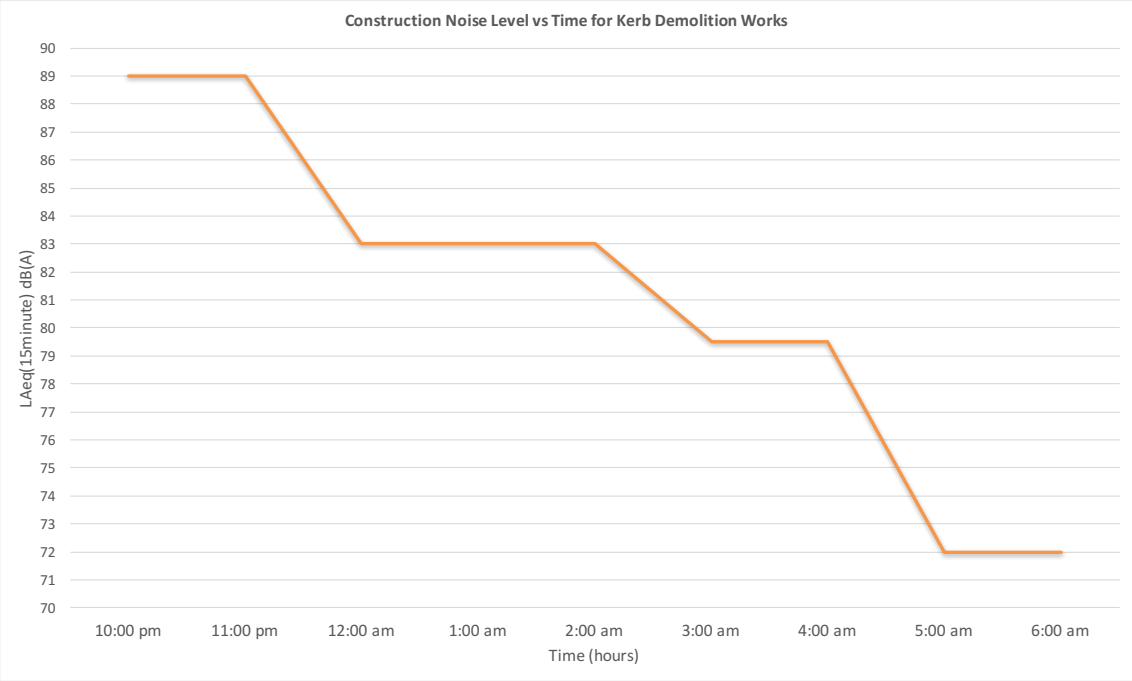


Figure 9 Chart demonstrating reduction in noise level versus time for kerb demolition works (Precinct 4)

Noise Catchment Area 2

The predicted construction noise levels within this noise catchment area range between 40 dB(A) and 66 dB(A) with NML exceedances ranging between 0 dB(A) and 3 dB(A) for the daytime period and 0 dB(A) and 15 dB(A) for the night-time period. The predicted maximum noise levels indicate that certain activities may exceed the sleep disturbance criterion. The maximum construction noise levels are likely to be a result of the following:

- Demolition of existing bridge span within Precinct 3 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.
- Kerb and retaining wall works within Precinct 1 and Precinct 2 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

Noise Catchment Area 3

The predicted construction noise levels within this noise catchment area range between 50 dB(A) and 71 dB(A) with NML exceedances ranging between 0 dB(A) and 8 dB(A) for the daytime period and 0 dB(A) and 20 dB(A) for the night-time period. The predicted maximum noise levels indicate that certain activities may exceed the sleep disturbance criterion. The maximum construction noise levels are likely to be a result of the following:

- Kerb and retaining wall works within Precinct 1 and Precinct 2 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

Noise Catchment Area 4

The predicted construction noise levels within this noise catchment area range between 62 dB(A) and 74 dB(A) with one minor NML exceedance for the daytime period and a range of 4 dB(A) to 16 dB(A) for the night-time period. The predicted maximum noise levels indicate that certain activities may exceed the sleep disturbance criterion. The maximum construction noise levels are likely to be a result of the following:

- Demolition of existing bridge span within Precinct 3 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.
- Median and kerb works along the Kent St merge taper within Precinct 4 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.
- Kerb and retaining wall works within Precinct 1 and Precinct 2 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

Noise Catchment Area 5

The predicted construction noise levels within this noise catchment area will range between 73 dB(A) and 90 dB(A) with NML exceedances ranging between 8 dB(A) and 25 dB(A) for the daytime period and no predicted exceedances during the night-time period due to hours of operation of receivers within this NCA. The maximum construction noise levels are likely to be a result of the following:

- Demolition of existing bridge span within Precinct 3 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.
- Kerb and retaining wall works within Precinct 1 and Precinct 2 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

In order to reduce the impact of high noise generating works at Fort Street Public School, consideration should be given to completing high noise generating activities during the evening period after normal school operating hours.

Noise Catchment Area 6

The predicted construction noise levels within this noise catchment area will range between 61 dB(A) and 76 dB(A) with NML exceedances ranging between 6 dB(A) and 21 dB(A) for the daytime and night-time periods. The maximum construction noise levels are likely to be a result of the following:

- Kerb and retaining wall works within Precinct 1 and Precinct 2 requiring the use of high sound power level plant items such as an excavator with hammer attachment and concrete saws.

Construction traffic

As this area is subject to a relatively high road traffic noise exposure, the relatively small increase of construction vehicles as a result of the proposal is would have an insignificant effect on existing road traffic noise levels. Further consideration of noise impacts due to construction traffic is therefore not required.

6.4 Construction vibration

Minimum working distances

The CNVG provides guidelines for minimum working distances for vibration-intensive activities with respect to the stated standards and guidelines. The minimum working distances for building damage should be complied with at all times. The distances are noted as being indicative and are likely to vary depending on the particular item of plant and local geotechnical conditions. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied. In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

Table 20 presents the recommended minimum working distances for vibration intensive plant.

Table 20 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

Vibration intensive activities

The currently anticipated schedule of plant to be used to construct the proposal includes the following vibration intensive plant:

- Excavator with hammer attachment (2 m minimum distance for human response)
- Small vibratory roller (20 m minimum distance for human response)
- Pile boring (4 m minimum distance for human response)

A summary of the minimum distances to each of the representative assessment receiver locations for each stage of proposed construction works is provided in Table 21. Locations at which work is predicted to occur within the recommended minimum distances are highlighted.

Table 21 Construction stage minimum distance to receivers

Receiver	Minimum Distance (m)			
	Precinct 1	Precinct 2	Precinct 3	Precinct 4
RR-01	308	212	75	10
RR-02	195	129	110	153
RR-03	165	150	157	253
RR-04	190	186	220	327
RR-05	188	206	272	394
RR-06	114	153	247	382
RR-07	155	129	95	113
RR-08	288	223	91	94
OR-01	105	34	20	75
OR-02	61	49	73	190
OR-03	213	120	20	20
OR-04	53	113	216	352
OR-05	66	74	115	230
OR-06	128	18	12	83
OR-07	153	40	10	62

Generally, the separation distance from the nearest receivers is sufficient to mitigate the potential impacts. As such it is considered that structural or cosmetic damage impacts from vibration intensive works are generally unlikely for most the adjacent receivers.

Where work is proposed within the safe working distances the mitigation measures outlined in Section 7 should be implemented to reduce the impacts as far as practicable.

Heritage structures

The proposal alignment is located adjacent to a number of buildings and structures that have been identified as being heritage listed or of significance from a heritage perspective (refer to Section 2).

BS7385 states that a building of historical value should not (unless it is structural unsound) be assumed to be more vibration sensitive, and therefore, compliance with the minimum distances provided in Table 21, is likely to result in low risk of cosmetic damage to the nominated structures in this category.

Notwithstanding the above, no heritage structures are predicted to exceed the most stringent DIN4150 criterion of 3 mm/s. The exception is where demolition of sections of the Sydney Harbour Bridge itself is required.
It is recommended that a review of the vibration sensitivity of each structure with regard to current structural condition be conducted in order to confirm the appropriateness of the minimum working distance assessment and apply additional management protocols if required. The heritage structures include, but are not limited to:

- Parts of the Sydney Harbour Bridge
- National Trust Centre
- Sydney Observatory
- Observatory Park buildings, including:
  - Boer War Memorial
  - Bandstand
  - Various fences and landscaping
- Fort Street Public School, including:
  - Buildings and their interiors
  - Various fig trees and grounds
- Bureau of Meteorology weather station

Additional management protocols may include:

- Conduct a pre-construction dilapidation survey and monitor the condition of the structure throughout construction.
- Conduct vibration monitoring during construction applying the revised vibration targets determined as part of the pre-construction assessment.
- Conduct a vibration measurement investigation in order to determine the sensitivity of the structure in question to ground-borne vibration. This would only be required in specific cases where a structure was deemed to have a particular sensitivity to vibration.

Effects on building contents

The Sydney Observatory and the Bureau of Meteorology site hold instruments (such as telescopes and meteorological sensors) that may be sensitive to ground-borne vibration.

A high level prediction of construction induced ground-borne vibration to the Sydney Observatory and the Bureau of Meteorology site from the nearest construction zone has been conducted for the use of a small vibratory roller and for a pile-boring rig. Assumptions on the ground conditions have been made and source vibration levels are based on the safe working distance table. The levels are presented below:

- Sydney Observatory (assumed setback distance from source of 45m)
  - Pile boring: 0.1 mm/s V_{rms}
  - Small vibratory roller: 0.2 mm/s V_{rms}
- Bureau of Meteorology site (assumed setback distance from source of 15m)
  - Pile boring: 0.25 mm/s V_{rms}
  - Small vibratory roller: 1 mm/s V_{rms}

The predicted vibration levels are less than the Residential (ISO) VC curve for both the pile-boring rig and the small vibratory roller at the Sydney Observatory. The predicted vibration levels are less than the Office (ISO) VC curve for the pile-boring rig but in excess of the Workshop (ISO) VC curve at the Bureau of Meteorology site.
A detailed vibration assessment will be required for these sites at a later stage of project development in order to confirm appropriate equipment specific criteria and potential impacts.

Notwithstanding, it is recommended that vibration monitoring be conducted upon commencement of construction in order to confirm the predictions and assumptions relating to site-specific ground-vibration propagation characteristics. This may allow for the minimum working distances to be confirmed.

7 Construction noise and vibration mitigation

7.1 Standard mitigation measures

Exceedances are predicted at several identified sensitive receivers for various construction activities involved in the proposal. Therefore, efforts should be made to implement all feasible and reasonable mitigation measures in order to minimise the impacts of construction noise and vibration.

Appendix B of the CNVG presents a detailed table of standard mitigation measures. The CNVG states that the standard mitigation measures should be implemented on all construction projects. The standard mitigation measures include items such as:

- Community consultation or notification
- Site inductions and staff training
- Preparation of work specific construction noise and vibration management plans
- Validation noise and vibration measurements
- Selection of the quietest available plant and equipment
- Scheduling of noise and vibration intensive work
- Use of temporary noise barrier / enclosure and/or planning work to use natural topographical shielding
- Dilapidation surveys and vibration monitoring.

Table 22 provides a detailed summary of the CNVG standard mitigation measures that should be implemented as part of the project.

Table 22 CNVG standard mitigation measures applicable to the proposal

Action required	Applies to:	Details
Management measures		
Implementation of any project specific mitigation measures required.	Airborne noise.	Implementation of any project specific mitigation measures required (see Table 26).
Implement community consultation or notification measures (refer to Appendix C for further details of each measure).	Airborne noise. Ground-borne noise & vibration.	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night time period, any operational noise benefits from the works (where applicable) and contact telephone number. 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. Please contact Roads and Maritime Communication and Stakeholder Engagement for guidance. Website (If required). Contact telephone number for community. Email distribution list (if required). Community drop in session (if required by approval conditions).
Site inductions	Airborne noise. Ground-borne noise & vibration.	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	Airborne noise.	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.

Action required	Applies to:	Details
Verification	Airborne noise Ground-borne noise and vibration.	Where specified under Appendix C of the CNVG, a noise verification program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Where required, attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise. Ground-borne noise and vibration.	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement of activities with the potential to cause property damage.
Source controls		
Construction hours and scheduling	Airborne noise. Ground-borne noise and vibration.	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours works	Airborne noise. Ground-borne noise and vibration.	Please refer to Table 25 for more details on the following respite measures: • Respite Offers (RO) • Respite Period 1 (R1) • Respite Period 2 (R2) • Duration Respite (DR)
Equipment selection	Airborne noise. Ground-borne noise and vibration.	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits. Ensure plant including the silencer is well maintained.
Plant noise levels	Airborne noise.	The noise levels of plants and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix H of the CNVG.

Action required	Applies to:	Details
Rental plant and equipment	Airborne noise.	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 Table 2 of the CNVG.
Use and siting of plant	Airborne noise.	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers. Only have necessary equipment on site.
Plan worksites and activities to minimise noise and vibration	Airborne noise. Ground-borne vibration.	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flows, parking and loading/unloading areas to minimise reversing movements within the site. 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. Very noisy activities should be scheduled for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11.00 pm. Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations, whether at an institution or within a residence, such as before or during Higher School Certificate and at the end of higher education semesters. If programmed night work is postponed the work should be re-programmed and the approaches in the CNVG apply again.
Reduced equipment power	Airborne noise. Ground-borne vibration.	Use only the necessary size and power.
Non-tonal and ambient sensitive reversing alarms	Airborne noise.	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 any out of hours work. Consider the use of ambient sensitive alarms that adjust output to the ambient noise level.

Action required	Applies to:	Details
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise.	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.
Engine compression brakes	Construction vehicles.	Limit the use of engine compression brakes at night and in residential areas. 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.	Airborne noise.	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 form noisy activities	Airborne noise.	Use of 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.
Receptor controls		
Structural surveys and vibration monitoring	Ground-borne vibration.	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.

7.2 Additional mitigation measures

The CNVG recommends additional mitigation measures where all feasible and reasonable efforts cannot achieve the NMLs and maximum vibration levels for the proposed works.

Detailed construction noise and vibration impact assessments will be prepared during the construction phase based on detailed programming information. The detailed assessments will identify the specific additional mitigation measures required for the work in question based on the requirements of the CNVG.

A review of the predicted noise levels as presented in the figures and tables described below indicate the potential locations at which additional mitigation measures may be required.

- Daytime (maximum noise impact) – refer to Figure 3, Table 15.
- Daytime (typical noise impact) – refer to Figure 4, Table 16.
- Night-time (maximum noise impact) – refer to Figure 5, Table 17.
- Night-time (typical noise impact) – refer to Figure 6, Table 18.
- Predicted noise levels exceeding 75 dB(A) (maximum noise impact) – refer to Figure 7.
- Predicted noise levels exceeding 75 dB(A) (typical noise impact) – refer to Figure 8

The additional mitigation measures include controls such as:

- Widespread community consultation via letterbox drops, phone calls and one-on-one briefings,
- Respite offers which involves scheduling of work to provide specific receivers with a break from continuous construction work,
- Alternative accommodation for highly intrusive night-time work.

Guidelines to the additional mitigation measures are described in detail as follows:

- Table 23 details the additional mitigation measures for airborne noise impacts,
- Table 24 details the additional mitigation measures for ground-borne vibration impacts.

Table 23 CNVG additional mitigation measures (airborne noise)

Construction hours	dB(A) above RBL	dB(A) above NML	Additional mitigation measure type		Mitigation Levels
All periods >75 dB(A)			Notification Verification	Phone calls Respite offer	> 75 dB(A)
Standard: Mon-Fri (7am – 6pm), Sat (8am – 1pm) Sun/Public Holiday (Nil)					
Noticeable	5 to 10	0	-		NML
Clearly Audible	10 to 20	<10	-		NML
Moderately Intrusive	20 to 30	10 to 20	Notification Verification		NML+10
Highly Intrusive	>30	>20	Notification Verification		NML+20
OoHW Period 1: Mon-Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)					
Noticeable	5 to 10	< 5	-		NML
Clearly Audible	10 to 20	5 to 15	Notification Respite Period 1	Duration Respite	NML+5
Moderately Intrusive	20 to 30	15 to 25	Verification Notification	Respite Period 1 Duration Respite	NML+15
Highly Intrusive	> 30	> 25	Verification Individual briefings Notification Respite Period 1	Duration Respite Phone calls Specific notifications	NML+25
OoHW Period 2: Mon-Fri (10pm – 7am) Sat (10 pm – 8am) Sun/Public Holiday (6pm – 7am)					
Noticeable	5 to 10	< 5	Notification		NML
Clearly Audible	10 to 20	5 to 15	Verification Notification	Respite Period 2 Duration Respite	NML+5
Moderately Intrusive	20 to 30	15 to 25	Verification Individual briefings Notification Phone calls	Specific notifications Respite Period 2 Duration Respite	NML+15
Highly Intrusive	> 30	> 25	Alternative Accommodation Verification Individual Briefings Notification	Phone calls Specific notifications Respite Period 2 Duration Respite	NML+25

Table 24 CNVG additional mitigation measures (vibration)

Construction hours	Additional mitigation measure type		Apply to:
Standard: Mon-Fri (7am – 6pm), Sat (8am – 1pm) Sun/Public Holiday (Nil)			
Predicted vibration levels exceeds maximum levels	Verification Notification	Respite Offer	All
OoHW Period 1: Mon-Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)			
Predicted vibration levels exceeds maximum levels	Verification Individual Briefings Notification Respite Offer	Phone calls Respite Offer Specific notifications	All
OoHW Period 2: Mon-Fri (10pm – 7am) Sat (10 pm – 8am) Sun/Public Holiday (6pm – 7am)			
Predicted vibration levels exceeds maximum levels	Alternative Accommodation Verification Individual Briefings Notification	Phone calls Respite Offer Specific notifications	All

Detailed description of CNVG additional mitigation measures

Table 25 provides a detailed description of each category of additional mitigation measures outlined in Table 23 and Table 24 above.

Table 25 Description of CNVG additional mitigation measures

Mitigation measure	Abbreviation	Description
Notification	N	Advanced warning of works and potential disruptors 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 for projects may also specify requirements for notification to the community about works that may impact on them.

Mitigation measure	Abbreviation	Description
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. The exact conditions under which specific notifications would proceed are defined in the relevant Additional Mitigation Measures (Table 23 to Table 24). This form of communication is used to support periodic notifications, or to advertise unscheduled works.
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.

Mitigation measure	Abbreviation	Description
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 11 pm.
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 project 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 (Tables C1-C3). 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	Please see Appendix F for more details about verification of Noise and Vibration levels as part of routine checks of noise levels or following reasonable complaints. This verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

7.3 Project specific mitigation measures

The additional mitigation measures generally relate to receiver-based actions such as notifications, measurements and briefings. Therefore, a further table of activity specific source related controls to be implemented, where reasonable and feasible, are presented in Table 26.

Table 26 Project specific mitigation measures

Precinct	Mitigation action	Responsibility
1	Minimise the use of reversing alarms via one-way traffic management	Site supervisor
	Erect a temporary noise barrier between the work area and nearest sensitive receivers	Site supervisor
	Complete work during daytime and evening period where possible	Site supervisor
	Erect a temporary noise barrier / enclosure around concrete saws, jackhammers and other high noise generating plant items	Site supervisor
2	Minimise the use of reversing alarms via one-way traffic management	Site supervisor
	Erect a temporary noise barrier between the work area and nearest sensitive receivers	Site supervisor
	Complete work during daytime and evening period where possible	Site supervisor
3	Complete work during daytime and evening period where possible	Site supervisor
	Erect a temporary noise barrier between the work area (mulcher in particular) and nearest sensitive receivers	Site supervisor
	Erect a temporary noise barrier / enclosure around concrete saws, jackhammers and other high noise generating plant items	Site supervisor
	Minimise the use of reversing alarms via one-way traffic management	Site supervisor
4	Erect a temporary noise barrier / enclosure around concrete saws, jackhammers and other high noise generating plant items	Site supervisor
	Minimise the use of reversing alarms via one-way traffic management	Site supervisor
	Complete work during daytime and evening period where possible	Site supervisor

7.4 Vibration mitigation

- The potential impacts from vibration are to be considered in the site-specific Construction Noise and Vibration Management Plans, to be developed during the detailed design phase when more information is available on the schedule for the works and the equipment to be used.
- The safe working distances should be maintained as per Table 20, with distances between works and sensitive receivers maximised wherever possible.
- All plant should be properly maintained.
- Low vibration alternatives for plant should be implemented where possible.
- Plant that have high and low vibration operating settings should be run on the lowest effective vibration setting.
- Vehicle movements along uneven surfaces should be restricted to minimum speed adjacent to vibration sensitive receivers.
- The vibration sensitivity of nearby structures and sensitive equipment should be reviewed with respect to structural integrity (particularly those of heritage significance) and/or vibration monitoring be conducted at commencement of construction. These structures include:
  - Parts of the Sydney Harbour Bridge
  - National Trust Centre
  - Sydney Observatory
  - Observatory Park buildings
  - Fort Street Public School
  - Bureau of Meteorology weather station
- Consider demarcating areas of heritage significance, irrespective of sensitivity, such that the risk of accidental damage is minimised. An example of this may be where works abut the existing retaining walls on the Sydney Harbour Bridge approach.

8 Cumulative impacts

It is likely that the proposal would be constructed simultaneously to other projects within the surrounding area, such as the Sydney Harbour Bridge Step-Free Pedestrian Lifts and the redevelopment of Fort Street Public School. Table 27 sets out a timeline during which nearby sensitive receivers may be affected by cumulative construction noise and vibration impacts, specifically in relation to the proposal.

Table 27 Potential cumulative noise and vibration impacts

Description	Time period											
	2018				2019				2020			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SHB Southern Cycleway (the proposal)						•	•	•	•			
SHB Step-Free Pedestrian Lifts (southern site)	•	•	•	•								
Fort Street Public School redevelopment					•	•	•	•	•	•	•	•

As shown in Table 27, the proposal may have construction works concurrent with those for the proposed Fort Street Public School redevelopment. Where works do occur concurrently, and particularly for Southern Cycleway works within Precinct 2 and Precinct 3, cumulative noise impacts may occur at the following identified sensitive receivers within this report:

- NCA 1 (Observatory Tower, National Trust Centre)
- NCA 2 (residential receivers on Kent Street)
- NCA 5 (Environmental Education Centre)
- NCA 6 (Sydney Observatory)

Furthermore, the proposals in combination, have the potential to expose sensitive receivers to noisy construction activities for a total duration of approximately three years. The potential for construction fatigue must be considered and managed for these receivers.

A Construction Noise and Vibration Management Plan prepared for the Southern Cycleway Project should include a protocol for managing cumulative impacts of concurrent projects, such as the Fort Street Public School redevelopment or any future Roads and Maritime projects that may occur within the surrounding area.

For periods where cumulative construction noise and vibration may occur, Roads and Maritime should implement all feasible and reasonable mitigation measures for its proposals in order to minimise the impact on nearby sensitive receivers.

Such measures might include future consultation with building contractors for the school redevelopment to schedule work across construction sites to minimise concurrent use of noise and/or vibration intensive plant and equipment. Noting the proximity of the school to the Sydney Observatory, the potential vibration impacts associated with the school redevelopment should be considered.

9 Conclusion

Resonate Acoustics has been engaged by Coffey Environments Australia to prepare a noise and vibration impact assessment for a Review of Environmental Factors (REF) for the proposal.

Due to the locality of the proposal area, several potentially affected noise and vibration sensitive receivers have been identified including structures of heritage significance including parts of the Sydney Harbour Bridge. Unattended and attended background noise measurements were undertaken to characterise the prevailing environmental noise at these receivers.

Both operational road traffic and construction noise and vibration impacts have been assessed based upon the existing environmental noise levels and the current proposal design and construction methodology.

Based on the description of the proposal and a review of proposal inputs relevant to operational road traffic noise, such as traffic flows, road alignments, the noise criteria for ‘minor works’ have been applied. The review showed that any potential increase in road traffic noise as a result of the proposal would be less than 2 dB. Therefore, no further consideration of reasonable and feasible mitigation for operational noise is required.

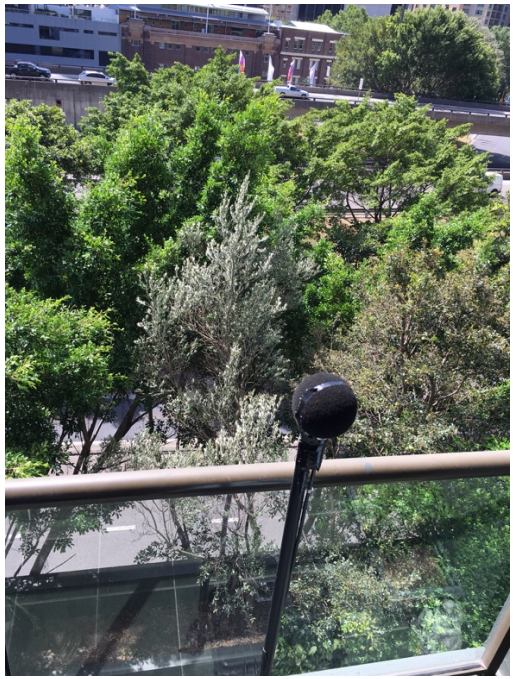
Predicted worst-case exceedances of established NMLs and vibration criteria for nearby sensitive receivers indicate that feasible and reasonable mitigation measures are likely to be required, as set out in Section 7. The range of NML exceedances indicates preference should be given to conduct work during the daytime where feasible and reasonable to do so, and where possible schedule noise intensive work outside of the night-time period in order to minimise the risk of sleep disturbance.

This document may be subject to review pending finalised design input and construction methodology and timing from Roads and Maritime.

Appendix A

Attended noise measurement summary

AM-01

Location/description	Observatory Tower (at location of UM-01)	
Measurement details	1/3 octave Z-weighted	
Duration (min)	15	
Weather conditions	Sunny, light breeze.	
Noise observations	• Direct line of sight to Cahill Expressway, Kent Street, Clarence Street, Bradfield Highway. • Predominantly road traffic noise. • Some wind noise from trees at ground level. • Slight impacts of Circular Quay water traffic.	

AM-02

Location/description	Observatory Tower – Street-level on existing shared pavement
Measurement details	1/3 octave Z-weighted
Duration (min)	15
Weather conditions	Sunny, light breeze.
Noise observations	• Direct line of sight to Cahill Expressway, Kent Street, Clarence Street, Bradfield Highway. • Predominantly road traffic noise. • Some wind noise from trees at ground level. • Slight impacts of Circular Quay water traffic.

AM-03

Location/description	Fort Street Public School (UM-02)
Measurement details	1/3 octave Z-weighted
Duration (min)	15
Weather conditions	Sunny, light breeze.
Noise observations	• Direct line of sight to Cahill Expressway, Kent Street, Clarence Street, Bradfield Highway. • Predominantly road traffic noise. • Some wind noise from trees. • Slight impacts of Circular Quay water traffic.

AM-04

Location/description	Sydney Observatory – At location of UM-03	
Measurement details	1/3 octave Z-weighted	
Duration (min)	15	
Weather conditions	Sunny, light breeze.	
Noise observations	• Reduction in road traffic noise by breaking line of sight with Cahill Expressway. • Minimal other noise influencing measurement.	

AM-05

Location/description	Sydney Observatory – NE corner with direct sight lines to Upper Fort St and Bradfield Hwy
Measurement details	1/3 octave Z-weighted
Duration (min)	15
Weather conditions	Sunny, light breeze.
Noise observations	• Direct line of sight with Cahill Expressway. • More significant road traffic noise.

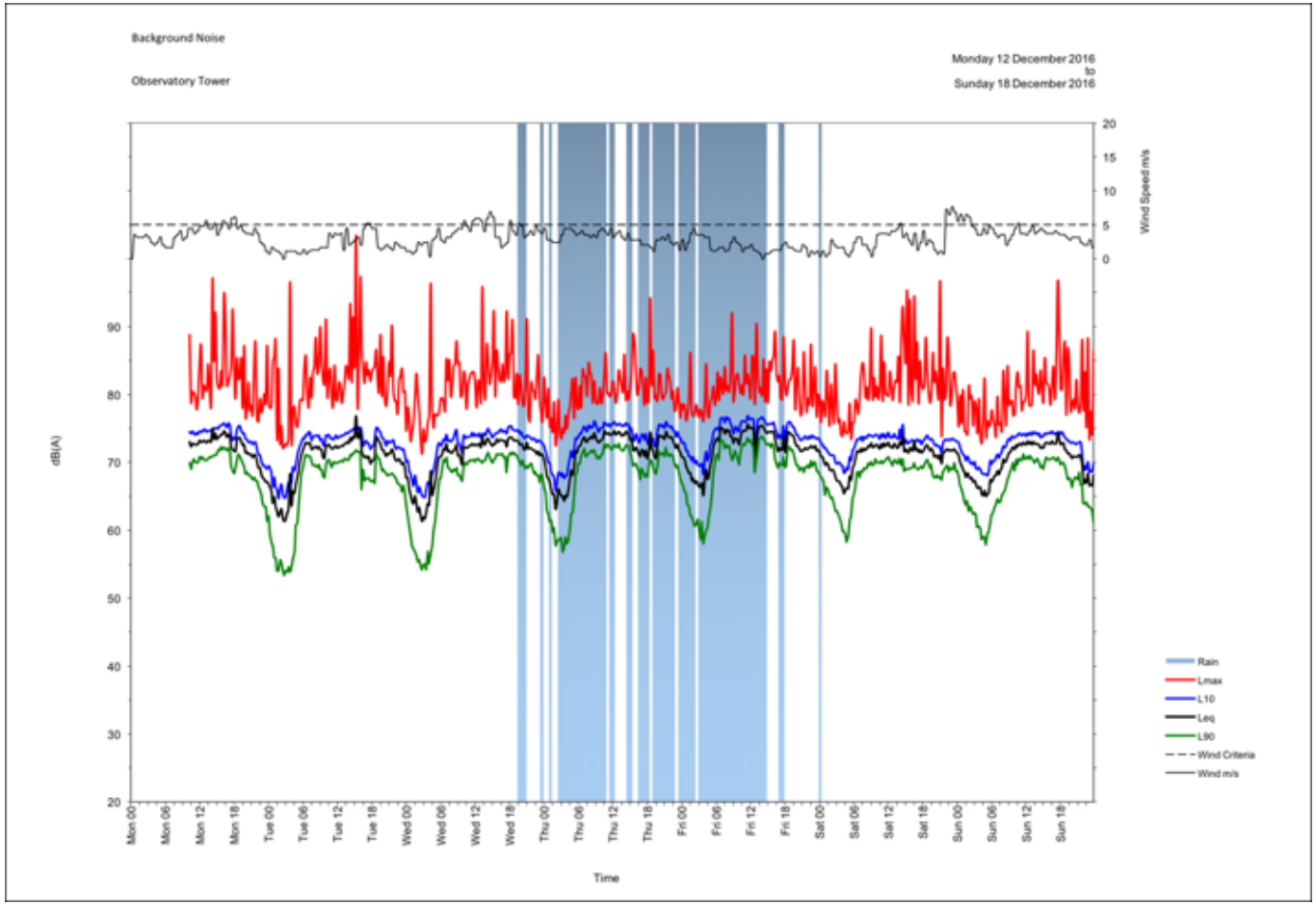
AM-06

Location/description	Corner of Argyle Pl and Lower Fort St
Measurement details	1/3 octave Z-weighted
Duration (min)	15
Weather conditions	Sunny, light breeze.
Noise observations	• Large amounts of construction noise on Argyle Street. • Church bells tolling from wedding ceremony.

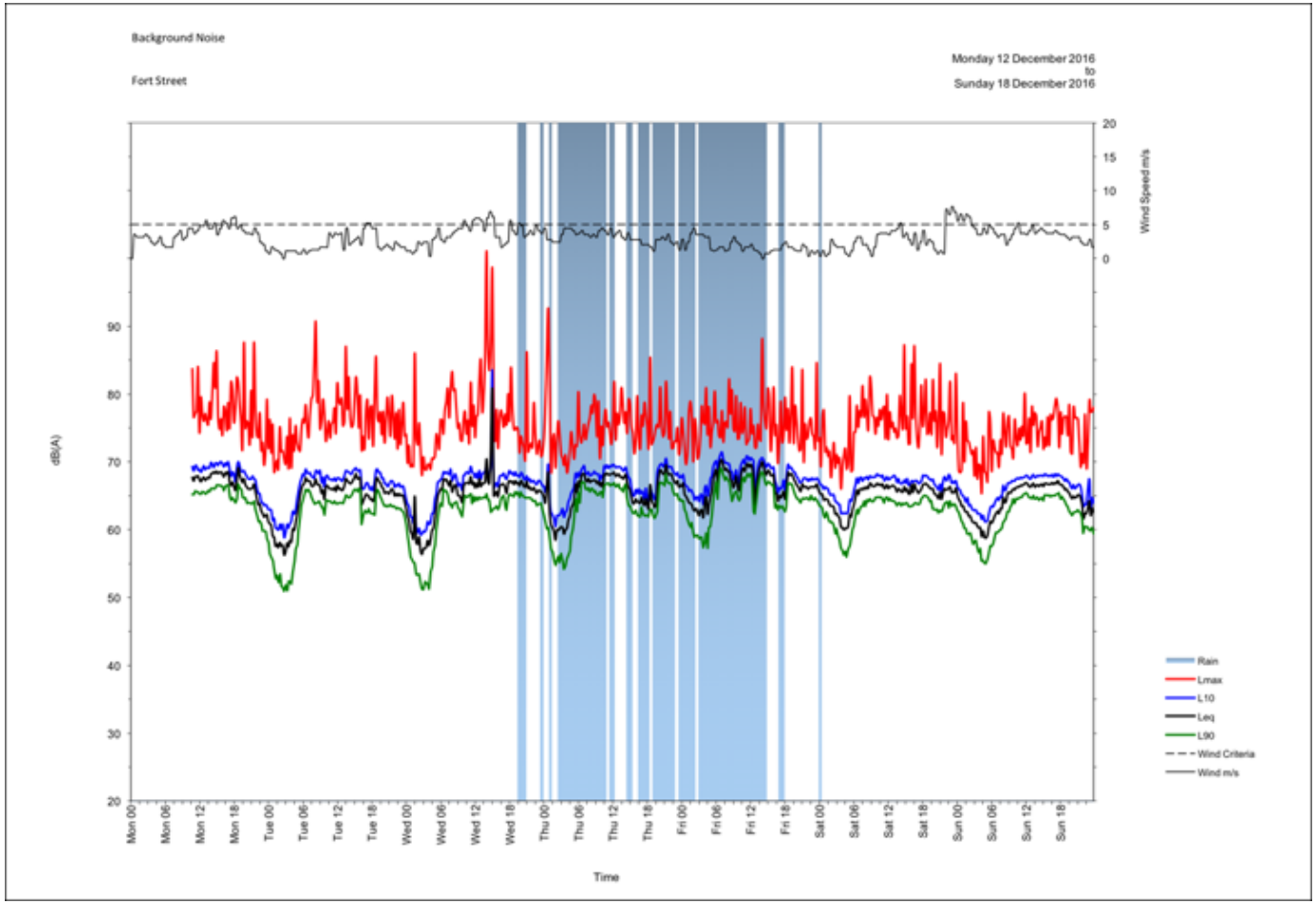
Appendix B

Unattended noise measurement data

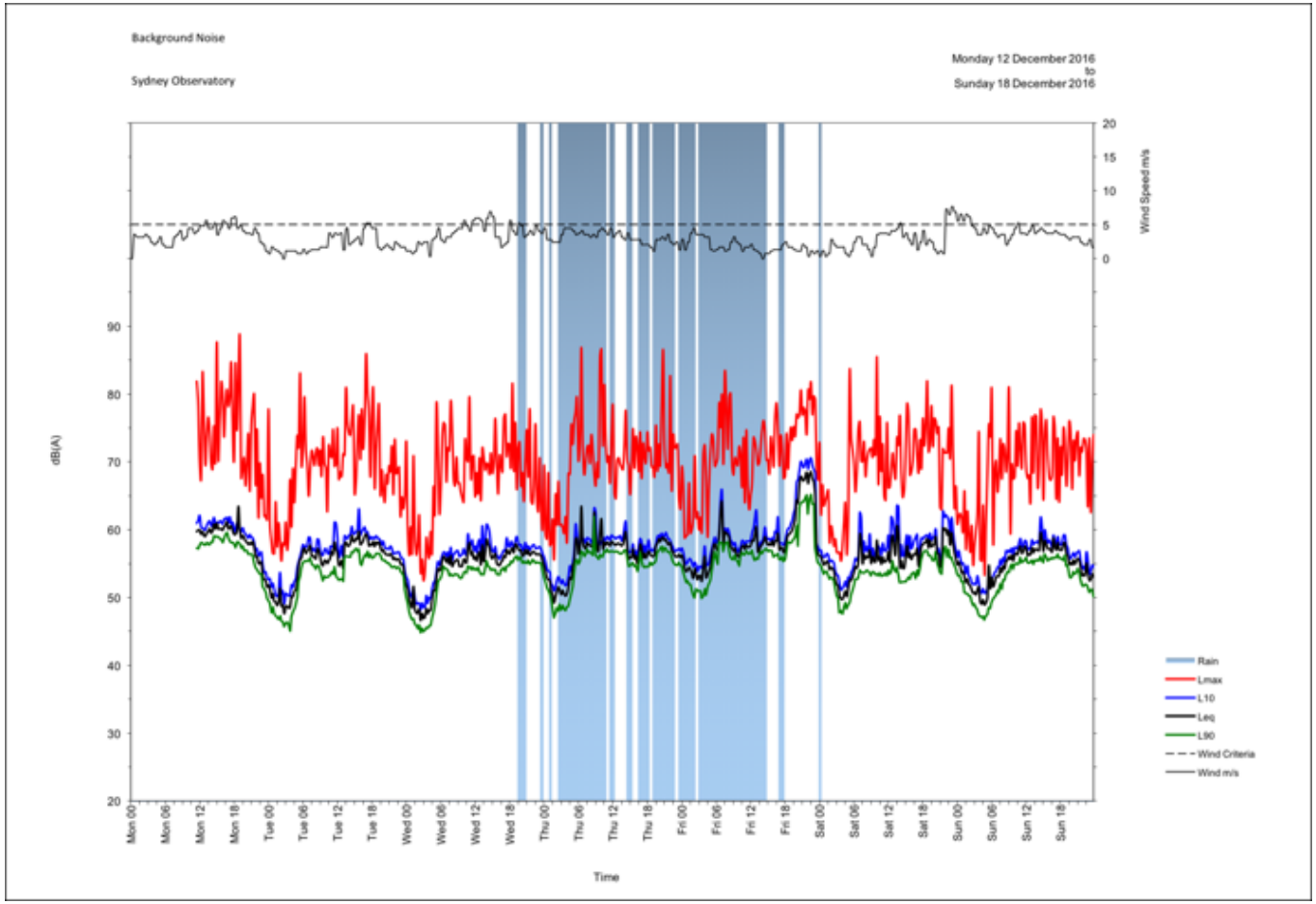
UM-01 – Observatory Tower



UM-02 – Fort Street Public School



UM-03 – Sydney Observatory



Appendix C

Construction plant and equipment

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
1	1a	Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Total				**109**
	1b	Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Total				**109**
	2	Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Total				**109**
	3a	Lighting tower	98	2	15	101
		Excavator	110	1	10	108
		Hand tools	104	1	10	102
		Concrete saw	118	1	5	113
		Utes and light vehicles	103	1	15	103
		Total				**115**

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
	3b	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Franna crane	98	1	8	95
		Tipper truck	108	1	10	106
		Total				**110**
	3c	Lighting tower	98	2	15	101
		Excavator	110	1	10	108
		Bored piling rig	110	1	8	107
		Concrete pump	109	1	10	107
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Total				**117**
	3d	Lighting tower	98	2	15	101
		Excavator	110	1	10	108
		Backhoe	111	1	10	109
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Roller	109	1	10	107
		Total				**114**
	3e	Lighting tower	98	2	15	101
		Excavator (hammer attachment)	121	1	12	120
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Total				**120**
	3f	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Generator	103	1	10	103
		Total				**110**
	4a	Concrete pump	109	1	15	107
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	10	113
		Hand tools	104	1	10	102
		Total				**116**

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
	4b	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Generator	103	1	15	103
		Line marking truck	108	1	5	103
		Total				**110**
	5	Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Total				**109**
2	1a	Lighting tower	98	2	15	101
		Hand tools	104	1	10	92
		Generator	103	1	15	103
		Tipper truck	108	1	10	106
		Utes and light vehicles	103	2	15	106
		Total				**111**
	1b	Lighting towers	98	2	15	101

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	103	1	10	101
		Generator	103	1	15	103
		Total				**109**
	2a	Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	103	1	10	101
		Concrete saw	118	1	5	113
		Lighting towers	98	2	15	101
		Vacuum sucker truck	109	1	10	107
		Excavator with hammer attachment	121	1	8	118
		Total				**120**
	2b	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Concrete pump	109	1	10	107
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Total				**116**
	2c	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Roller	109	1	10	107
		Tipper truck	108	1	10	106
		Total				**112**
	2d	Lighting tower	98	2	15	101
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Franna crane	98	1	10	96
		Total				**109**
	2e	Lighting tower	98	2	15	101
		Excavator	110	1	10	108
		Backhoes	111	1	10	109
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Roller	109	1	10	107

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Total				**114**
	3a	Lighting Tower	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	10	101
		Total				**106**
	3b	Lighting Tower	98	2	15	101
		Excavator with hammer attachment	121	1	8	118
		Excavators	110	1	10	108
		Hand tools	104	1	10	102
		Tipper truck	108	1	10	106
		Total				**119**
	3c	Lighting towers	98	2	15	101
		Concrete vibrator	113	1	10	111
		Concrete pump	109	1	10	107
		Concrete agitator	113	1	15	113
		Hand tools	104	1	10	102
		Total				**116**
	3d	Lighting towers	98	1	15	98

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Generator	103	1	15	103
		Total				**110**
3	1	Hand tools	94	1	15	94
		Light vehicles	103	1	10	101
		Tipper truck	108	1	10	106
		Utes and light vehicles	103	1	15	103
		Total				**109**
	2a	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Excavator with hammer attachment	121	1	8	118
		Franna crane	98	1	10	96
		Total				**119**
	2b	Lighting tower	98	2	15	101

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper trucks	108	1	10	106
		Franna crane	98	1	10	96
		Total				**110**
	2c	Lighting towers	98	2	15	101
		Hand tool	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper trucks	108	1	10	106
		Franna crane	98	1	10	96
		Total				**110**
	2d	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Total				**110**
	2e	Lighting tower	98	2	15	101
		Excavator	110	1	10	108

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Excavator with hammer attachment	121	1	8	118
		Hand tools	104	1	10	102
		Total				**119**
	3a	Lighting tower	98	2	15	101
		Excavator	110	1	10	108
		Excavator with hammer attachment	121	1	8	118
		Hand tools	104	1	10	102
		Total				**119**
	3b	Lighting tower	98	2	15	101
		Tipper truck	108	1	10	106
		Hand tools	104	1	10	102
		Oxy-acetylene torch	107	1	10	105
		Total				**110**
	3c	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Semi-trailer	108	1	10	106
		Large mobile crane	108	1	10	106
		Total				**111**

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
	4	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	108	1	10	106
		Excavator	110	1	10	108
		Total				**112**
	5a	Utes and light vehicles	103	1	15	103
		Hand tools	104	1	10	102
		Tipper truck	108	1	10	106
		Lighting tower	98	2	15	101
		Total				**110**
	5b	Utes and light vehicles	103	1	15	103
		Hand tools	104	1	10	102
		Tipper truck	108	1	10	106
		Excavator with hammer attachment	121	1	8	118
		Lighting tower	98	2	15	101
		Total				**119**
	6	Lighting tower	98	2	15	101

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Tipper truck	103	1	10	101
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Concrete pumps	109	1	10	107
		Total				**117**
	7a	Utes and light vehicle	103	1	15	103
		Semi-trailer	108	1	10	106
		Lighting towers	98	2	15	101
		Total				**109**
	7b	lighting towers	98	2	15	101
		Excavator	110	1	10	108
		Hand tools	104	1	10	102
		Large mobile crane	108	1	10	106
		Total				**111**
	7c	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Large mobile crane	108	1	10	106
		Generator	103	1	15	103
		Total				**112**
	8a	Lighting towers	98	1	15	98
		Concrete vibrator	113	1	10	111
		Concrete pump	109	1	10	107
		Concrete agitator	113	1	15	113
		Total				**116**
	8b	Lighting towers	98	2	15	101
		Hand tools	104	1	15	104
		Utes and light vehicles	103	1	15	103
		Air tools	105	1	15	105
		Total				**111**
	9	Hand tools	104	1	10	102
		Rigid body truck	108	1	10	106
		Chain saw	118	1	5	113

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Mulcher	116	1	10	114
		Total				**117**
	10	Bored piling rig	110	1	10	108
		Hand tools	104	1	10	102
		Concrete pump	109	1	10	107
		Concrete agitators	113	1	15	113
		Total				**115**
	11	Lighting towers	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Concrete vibrator	113	1	10	111
		Concrete pump	109	1	10	107
		Concrete agitators	113	1	15	113
		Total				**116**
	12	Concrete vibrator	113	1	10	111
		concrete pumps	109	1	10	107
		Concrete agitators	113	1	15	113
		Hand tools	104	1	10	102

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Total				**116**
	13	Franna crane	98	1	10	96
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Generator	103	1	15	103
		Total				**110**
	14	Concrete vibrator	113	1	10	111
		Concrete pumps	109	1	10	107
		Concrete agitator	113	1	15	113
		Hand tools	104	1	10	102
		Total				**116**
	15	Franna crane	98	1	10	96
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Generator	103	1	15	103
		Total				**110**

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
	16a	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Concrete vibrator	113	1	10	111
		Concrete pump	109	1	10	107
		Concrete agitator	113	1	15	113
		Total				**116**
	16b	Hand tools	104	1	10	102
		Air compressor	107	1	10	105
		Air tools	105	1	10	103
		Utes and light vehicles	103	1	15	103
		Generator	103	1	15	103
		Total				**110**
4	1	Hand tools	104	1	10	102
		Utes and light vehicles	103	1	15	103
		Total				**106**
	2	Excavator with hammer attachment	121	1	5	116
		Concrete saw	118	1	5	113

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Excavator	110	1	10	108
		Franna crane	98	1	10	96
		Lighting towers	98	2	15	101
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Concrete pump	109	1	10	107
		Total				**120**
	3	Excavator with hammer attachment	121	1	5	116
		Concrete saw	118	1	5	113
		Excavator	110	1	10	108
		Franna crane	98	1	10	96
		Lighting tower	98	2	15	101
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Concrete pump	109	1	10	107
		Total				**120**
	4	Utes and light vehicles	103	2	15	106
		Tipper truck	108	1	10	106

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Hand tools	104	1	10	102
		Lighting tower	98	2	15	101
		Total				**110**
	5	Excavator with hammer attachment	121	1	5	116
		Concrete saw	118	1	5	113
		Excavator	110	1	10	108
		Franna crane	98	1	10	96
		Lighting tower	98	2	15	101
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Concrete pump	109	1	10	107
		Total				**120**
	6	Lighting tower	98	2	15	101
		Hand tools	104	1	10	102
		Concrete saw	118	1	5	113
		Utes and light vehicles	103	1	15	103
		Total				**114**
	7	Lighting tower	98	2	15	101

Precinct	Scenario	Plant	Typical L_W dB(A)	Number of plant	Assumed operating time (minutes/15-minute assessment period)	Estimated L_W dB(A)
		Concrete vibrator	113	1	10	111
		Concrete agitator	113	1	15	113
		Concrete pump	109	1	10	107
		Total				**116**
	8	Lighting tower	98	1	15	98
		Concrete vibrator	113	1	15	113
		Concrete agitator	113	1	15	113
		Concrete pump	109	1	15	109
		Total				**117**
	9	Lighting tower	98	2	15	101
		Generator	103	1	15	103
		Asphalt paver	114	1	10	112
		Hand tools	104	1	10	102
		Air tools	105	1	10	103
		Air compressor	107	1	10	105
		Roller	109	1	10	107
		Line marking truck	108	1	10	106
		Total				**116**

Appendix D

Indicative construction staging program

Task No	Task	Duration (weeks)	Notes
1	**General**		
1.1	Award of contract		Anticipated during to occur during Standard Hours
1.2	Prepare and approve management plans	8	Includes TCP's, ROL's and community notices
1.3	Establish construction compounds (north and south)	2	Assuming compound in existing exercise area (north) and in Gallery carpark area (south)
1.4	Establish cyclist detour	1	Will require some temporary works and traffic controls
2	**Precinct 1: Harbour Bridge Link & Incident Response Area**		
2.1	Construction of temporary detour for cyclists through the Harbour Bridge Stairs	1	Anticipated during to occur during Standard Hours
2.3	Construction of retaining wall and new ramp along Bradfield Hwy including demolition of existing retaining wall / parapet section	12	Assuming extensive night works for piling and pile cap construction
2.4	Construction of on grade pathway through Roads and Maritime's Incident Response Area	2	Anticipated during to occur during Standard Hours
2.5	Construction of on grade pathway through existing park land	2	Anticipated during to occur during Standard Hours
3	**Precinct 2: Incident Response Area & Fort St Public School**		
3.1	Relocation of existing Cahill Expressway utilities	4	Assume only pit protection for Primus and modification of Roads and Maritime's utilities on existing retaining wall
3.2	Construction of new kerb and retaining wall along Roads and Maritime's Incident Response Area to support widening for cycleway	8	Assume precast 'L' shaped panels used and founded on concrete base slab. Will require night works for delivery and installation of precast concrete.
3.3	Construction of new cycleway alignment	4	Anticipated during to occur during Standard Hours
4	**Precinct 3: Bridge Crossing & S.H Ervin Gallery Frontage**		
4.1	Demolition of Existing Cycleway Bridge		Anticipated during to occur during Standard Hours

Task No	Task	Duration (weeks)	Notes
4.1.1	Preparatory works	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.1.2	Demolition of span	2	Assume that 2 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.1.3	Reinstatement of existing Cahill Expressway retaining wall below northern abutment	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.1.4	Demolition of southern approach	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.2	Construction of New Cycleway Bridge		Anticipated during to occur during Standard Hours
4.2.1	Shop drawings and approval	8	Anticipated during to occur during Standard Hours
4.2.2	Fabrication of steel components	10	Anticipated during to occur during Standard Hours
4.2.3	Construction of new abutments	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.2.4	Install new span	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.2.5	Pour deck slab and finishing works	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.3	Construction of Elevated Spiral		Anticipated during to occur during Standard Hours
4.3.1	Shop drawings and approval	8	Anticipated during to occur during Standard Hours
4.3.2	Fabrication of steel components	8	Anticipated during to occur during Standard Hours
4.3.3	Remove trees and clear the area	2	Assume that 2 night closures of Cahill Expressway are required allowing for 1 full closure per week

Task No	Task	Duration (weeks)	Notes
4.3.4	Install piles for pier foundations	2	Anticipated during to occur during Standard Hours
4.3.5	Construct on ground ramp section	4	Assume that 4 night closures of Cahill Expressway are required allowing for 1 full closure per week
4.3.6	Construct concrete pile caps and piers on the western side (to allow access for crane to centre of structure to minimise crane size)	2	Anticipated during to occur during Standard Hours
4.3.7	Install structural steel span sections on western side using smaller crane that can access the site via the Gallery access road	1	Anticipated during to occur during Standard Hours
4.3.8	Construct remaining concrete pile caps and piers	2	Anticipated during to occur during Standard Hours
4.3.9	Install remaining structural steel span sections using similar crane	1	Anticipated during to occur during Standard Hours
4.3.10	Pour deck slab and finishing works	4	Anticipated during to occur during Standard Hours
5	**Precinct 4: S.H. Ervin Gallery to Kent**		
5.1	Relocation of utilities	4	Assume 8 night closures of the Kent St on ramp are required allowing for 2 full closures per week
5.2	Adjust kerb line on east side of Kent St On Ramp	4	Assume 8 night closures of the Kent St on ramp are required allowing for 2 full closures per week
5.3	Demolish existing central median within Kent St On Ramp and install temporary pavement	4	Assume 8 night closures of the Kent St on ramp are required allowing for 2 full closures per week
5.4	Install temporary traffic barriers along edge of works on Kent St On Ramp	1	Assume 2 night closures of the Kent St on ramp are required allowing for 2 full closures per week
5.5	Adjust stormwater to suit revise kerb alignment	4	Assume 8 night closures of the Kent St on ramp are required allowing for 2 full closures per week

Task No	Task	Duration (weeks)	Notes
5.6	Adjust existing retaining wall, ramp and stairs north of the existing National Trust stairs	6	Anticipated during to occur during Standard Hours
5.7	Construct new kerb and pavement	4	Assume 8 night closures of the Kent St on ramp are required allowing for 2 full closures per week
5.8	Reinstate central median within Kent St On Ramp	2	Assume 4 night closures of the Kent St on ramp are required allowing for 2 full closures per week
6	**General**		
6.1	Disestablish site compounds	1	Anticipated during to occur during Standard Hours
6.2	Reinstatement and landscaping works (including exercise area)	1	Anticipated during to occur during Standard Hours