WestConnex

Australian Government
BUILDING OUR FUTURE

NSW GOVERNMENT

M4-M5 Link

Environmental Impact Statement

August 2017

Appendix J

Volume 2D

Since finalisation of the Environmental Impact Statement, the project has been declared by Ministerial Order to be State significant infrastructure and critical State significant infrastructure under sections115U(4) and 115V of the *Environmental Planning and Assessment Act 1979*. The Ministerial Order also amended Schedule 5 of *State Environmental Planning Policy (State and Regional Development) 2011*. The project remains subject to assessment under Part 5.1 of the *Environmental Planning and Assessment Act 1979* and requires the approval of the Minister for Planning.

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Appendix

WestConnex

Appendix J

Technical working paper: Noise and vibration

WestConnex

Roads and Maritime Services

WestConnex – M4-M5 Link

Technical working paper: Noise and vibration

August 2017

Prepared for

Roads and Maritime Services

Prepared by

SLR Consulting Australia Pty Ltd

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Glossary of terms and abbreviations

Term	Definition
AS	Australian Standard
BS	British Standard
CEMP	Construction Environmental Management Plan
CNVMP	Construction Noise and Vibration Management Plan
CORTN	Calculation of Road Traffic Noise
CSSI	Critical State Significant Infrastructure
dB	Decibels
dBA	A-weighted decibels
dBL	Linear weighted decibels
DECC	Department of Environment and Climate Change NSW
DECCW	Department of Environment, Climate Change and Water NSW
DGA	Dense Graded Asphalt
DIN	Deutsches Institut für Normung
DP&E	(NSW) Department of Planning and Environment
ECRTN	Environmental Criteria for Road Traffic Noise (replaced by the RNP)
EIS	Environmental Impact Statement
ENMM	Environmental Noise Management Manual
EPA	(NSW) Environment Protection Authority
EPL	Environment Protection Licence
ICNG	Interim Construction Noise Guideline
$L_{A1(1minute)}$	The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level
L_{A90}	The "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15minute)}$ construction Noise Management Levels (NMLs) are based on the L_{A90} background noise levels.
$L_{Aeq(1hour)}$	The 'energy average noise level' evaluated for a specific one-hour period.
$L_{Aeq(9hour)}$	The 'energy average noise level' evaluated over the night-time period (10.00 pm to 7.00 am).
$L_{Aeq(15hour)}$	The 'energy average noise level' evaluated over the daytime period (7.00 am to 10.00 pm). The L_{Aeq} can be likened to the average of all the noise events occurring in the relevant time period.
$L_{Aeq(15minute)}$	The "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts
L_{AFmax}	The maximum fast time weighted noise level from road traffic noise occurring at a particular location.
LPI	NSW Land and Property Information

Term	Definition
MIC	Maximum Instantaneous Charge
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NCG	Noise Criteria Guideline
NMG	Noise Mitigation Guideline
NML	Noise Management Level.
OEH	Office of Environment and Heritage
OGA	Open Graded Asphalt
OOHW	Out of Hours Work
RIC	Relative Increase Criteria as described in the NMG
RBL	Rating Background Level
RMS	Root Mean Square
Roads and Maritime	(NSW) Roads and Maritime Services
RTA	(NSW) Roads and Traffic Authority (now Roads and Maritime)
SEARs	Secretary’s Environmental Assessment Requirements
SLR	SLR Consulting Australia
SPL	Sound Pressure Level
SWL	Sound Power Level
VDV	Vibration Dose Value

Executive summary

Introduction

SLR Consulting Australia (SLR) has been engaged by NSW Roads and Maritime Services (Roads and Maritime) to assess the potential noise and vibration impacts associated with the construction and operation of the WestConnex M4-M5 Link project (the project). This report has been prepared to inform the environmental impact assessment (EIS).

Existing environment

The study area for this technical paper extends from each of the interface areas of the earlier WestConnex projects in Haberfield (M4 East) and St Peters (New M5) and runs via Darley Road, Rozelle, Iron Cove and Pyrmont Bridge Road. For summary purposes, the study area has been divided into 56 separate Noise Catchment Areas (NCAs) which reflect the land uses within and surrounding the study area and assist in the identification of impacts on receivers likely to be affected by the works and operations.

Noise monitoring surveys consisting of up to two weeks of continuous noise measurements and/or 15-minute operator-attended noise measurements were carried out at 23 locations within the study area. These were supplemented by a further 11 noise measurements undertaken previously for the M4 East and New M5 projects, both of which interface with the project. The noise monitoring results have been used for validation of the noise model, estimation of existing maximum road traffic noise events, determination of noise goals (fixed facilities and construction activities) and spot-checks to assess the suitability of construction noise mitigation measures.

The operator-attended noise monitoring identified the local noise sources that contributed to the ambient noise environment. It was identified that ambient noise levels are typically dominated by the major roads adjacent to the study area (including Victoria Road, City West Link, The Crescent, Parramatta Road, Wattle Street and Princes Highway). Adjacent to the major roads, existing measured noise levels are typically already above the operational road traffic noise goals for the project.

Relevant guidelines

Operational road traffic noise has been assessed according to guidance contained in the *Noise Criteria Guideline* (NCG) (Roads and Maritime, 2015) and *Noise Mitigation Guideline* (NMG) (Roads and Maritime, 2015). This guidance is consistent with the *NSW Road Noise Policy* (RNP) (NSW Environment Protection Agency (EPA), 2011). Reference is also made to the *Model Validation Guideline* (Roads and Maritime, draft document) and the *NCG application notes* (Roads and Maritime, 2016).

Noise from operation of proposed fixed operational facilities is assessed with guidance from the *NSW Industrial Noise Policy* (INP) (EPA 1999).

Construction noise has been assessed in accordance with the *Construction Noise and Vibration Guideline* (CNVG) (Roads and Maritime, 2016) and the *Interim Construction Noise Guideline* (ICNG) (EPA, 2009) which references *Assessing Vibration: A Technical Guideline* (EPA, 2006) for human comfort vibration guidance. Guidance for assessing potential structural damage from vibration is taken from Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use – Part 2: Use of Explosives* (Standards Australia, 2006), BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings* Part 2 (British Standards Institution (BSI), 1993), and DIN 4150: Part 3-1999 *Structural vibration - Effects of vibration on structures* (Deutsches Institut für Normung (DIN), 1999).

Construction noise and vibration assessment

The prediction of noise and vibration during construction was undertaken using three-dimensional models of the existing ground and project design. Sources of noise and vibration were modelled at the locations anticipated to form the construction areas for the project and to account for plant and equipment likely to be required to construct the project. Predicted noise levels are compared to Noise

Management Levels (NMLs), established in accordance with the assessment guidelines, to identify the requirement for mitigation and/or management measures.

Consistent with most major construction projects in urban areas, noise impacts are likely as works require the use of noise intensive equipment at times and are generally in the near vicinity of sensitive receivers. At any particular location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are undertaken, and the character of the noise or vibration emissions.

Haberfield – Option A

Activities for Option A in the Haberfield area would occur within three construction ancillary facilities (Wattle Street civil and tunnel site C1a, Haberfield civil and tunnel site C2a and Northcote Street civil site C3a) on Parramatta Road, Wattle Street, and Northcote Street (consistent with the sites used during construction of the M4 East project).

In this area, up to 19 receivers are predicted to incur high noise impacts (>20 dBA above NML) during pavement and infrastructure works associated with the construction of the project. This activity requires the use of a concrete saw however the duration of this activity is anticipated to be relatively short at around two weeks. Longer-term activities (up to the duration of construction of the project) include onsite traffic movements, tunnelling support and building fitout however the predicted noise impacts from these activities are minor (less than 10 dBA above NML). While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to noise impacts from the interfacing M4 East project. These receivers are those adjoining the Northcote Street civil site (C3a) and Wattle Street that have line of sight to the Wattle Street civil and tunnel site (C1a). The requirement for consideration of additional feasible and reasonable mitigation on the basis of longer term impacts will be evaluated in consultation with Roads and Maritime and the community during detailed design and considered when preparing the site specific construction noise and vibration impact statements (CNVIS) for this area. Up to five receivers (mainly to the north of Wattle Street) may be highly noise affected during the short-duration pavement and infrastructure works, and establishment of the construction facilities.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Wattle Street and Parramatta Road).

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project. Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. As such, airborne noise emissions from the Haberfield Option A construction ancillary facilities are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

No vibration intensive works are proposed from the Haberfield Option A construction ancillary facilities as part of the M4-M5 Link project.

Haberfield – Option B

Activities for Option B in the Haberfield area would occur within three construction ancillary facilities (Parramatta Road West civil and tunnel site (C1b), Haberfield civil site (C2b) and Parramatta Road East civil site (C3b)), which are situated on Parramatta Road and Wattle Street adjacent to the M4 East project footprint.

Up to 42 receivers are predicted to incur high noise impacts (>20 dBA above NML) during pavement and infrastructure works, which require the use of a concrete saw. However, the duration of this activity is anticipated to be relatively short at around two weeks. Longer-term activities (up to the duration of construction of the project) include onsite car parking, deliveries and storage, tunnelling activities and spoil handling. The predicted noise impacts from these activities are typically less than 10 dBA above NML however up to three receivers are predicted with high (>20 dBA above NML) exceedances during night-time tunnelling activities. This could be reduced to two receivers by using an upgraded acoustic shed and could be limited to less than 20 dBA by limiting the total sound power level of equipment operating within the shed to 110 dB. Up to 13 receivers may be highly noise affected during the short-duration demolition works.

Cumulative tunnelling works are predicted to result in five receivers potentially experiencing a high (>20 dBA above NML) exceedance which could be reduced to one receiver by using an upgraded acoustic shed.

Impacts are predicted at receivers which would likely have been exposed to noise impacts from the interfacing M4 East project. These receivers adjoin the Parramatta Road West civil and tunnel cite (C1b), Parramatta Road East civil site (C3b) and Haberfield civil site (C2b), between Walker Avenue and Chandos Street. The requirement for consideration of additional feasible and reasonable mitigation on the basis of long term impacts will be evaluated in consultation with Roads and Maritime and the community during detailed design and considered when preparing the site specific CNVIS for this area. Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Parramatta Road) due to the existing high volumes of traffic on Parramatta Road.

The majority of works with the potential to cause ground-borne noise impacts in this area, including excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project. Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. Based on the excavation of the access tunnel at this site, eight residential receivers are predicted to exceed the night-time ground-borne NML for up to a maximum of around 20 days. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to 22 buildings in this area have been identified within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the Haberfield Option B construction ancillary facility. For this scenario, around 66 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. No heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the Haberfield Option B construction ancillary facility.

Darley Road

Activities in the Darley Road civil and tunnel site (C4) will be located on land adjacent to the Leichhardt North light rail stop, between City West Link and Darley Road.

Up to 99 receivers are predicted to incur high noise impacts (>20 dBA above NML) during out of hours pavement and infrastructure works, which require the use of a rock-breaker, however the duration of this activity is anticipated to be relatively short at around two weeks. Longer-term activities (up to the duration of the project) include onsite car parking, deliveries and storage, tunnelling activities and spoil handling. The predicted noise impacts from these activities are typically minor (less than 10 dBA above NML) however up to 26 are predicted with moderate (up to 20 dBA) NML exceedances during night-time tunnelling activities. Up to 22 receivers (surrounding the site) may be highly noise affected during the short-duration line marking works and road adjustments.

Cumulative tunnelling works, which represents a number of construction activities which have the potential to operate concurrently, are not predicted to result in any highly noise affected receivers. 26 receivers are predicted to have moderate NML exceedances which could be reduced to four receivers by using an upgraded acoustic shed. A similar scale of improvement is predicted for the minor (less than 10 dBA) impacted receivers.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Darley Road) due to the existing traffic volumes on Darley Road and City West Link.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. Based on the excavation of the access tunnel at this site, 10 residential receivers are predicted to exceed the night-time ground-borne NML for up to around 14 days. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to five buildings in this area have been identified within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the Darley Road civil and tunnel site. Around 74 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. One heritage listed item has been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the Darley Road construction ancillary facility.

Rozelle

Activities within the Rozelle study area would occur within three construction ancillary facilities (Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and Victoria Road civil site C7), bounded by Anzac Bridge (east) to Catherine Street (west) including the Rozelle Rail Yards.

Up to 61 receivers are predicted with high noise impacts (>20 dBA above NML) during out of hours roadworks, which require the use of multiple road work equipment concurrently. This activity would be carried out at different locations over the course of 3.5 years and as such would not impact the same receiver for the total duration of the works.

Up to 29 receivers (predominantly towards the east of the site) may be highly noise affected during the utility adjustment works at some point within the anticipated 64-week activity schedule when works are located immediately adjacent to the receiver. Cumulative longer-term site works, represented by a number of construction activities which have the potential to operate concurrently are not predicted to result in any highly noise affected receivers. Impacts are predicted at receivers that would likely have been exposed to noise impacts from the interfacing CBD and South East Light Rail (CSELR) Rozelle maintenance depot. These receivers are those adjoining Lilyfield Road between Justin Street and Ryan Street and those adjoining Brenan Street between Starling Street and White Street. The requirement for consideration of additional feasible and reasonable mitigation on the basis of long term impacts will be evaluated in consultation with Roads and Maritime and the community during detailed design and considered when preparing the site specific CNVIS for this area.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (City West Link, The Crescent and Victoria Road).

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. Based on the excavation of the ventilation tunnels at this site, 63 residential receivers are predicted to exceed the night-time ground-borne NML for up to around 16 days for each road-header. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

In the Rozelle area, there are several ventilation tunnels, mainline tunnels and access ramps which may be under construction simultaneously and/or consecutively. During simultaneous construction, ground-borne noise levels would be dominated by the closest road-header to the receiver, however, where multiple road-headers are operating at a similar distance from the receiver this may result in ground-borne noise impacts marginally higher than the predicted noise levels. Consecutive construction with road-headers would not increase the level of ground-borne noise but may increase the duration of impacts at any one receiver. Detailed scheduling of road-header works would be determined at a later design stage.

Up to 124 buildings in this area have been identified within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. Around 345 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. 19 heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Iron Cove

Activities within the Iron Cove study area would occur within the Iron Cove Link civil site (C8) located on Victoria Road, east of the Iron Cove Bridge, between Byrnes Street and Springside Street, as well construction of the Iron Cove tunnel portals and ramps east of the Iron Cove Bridge.

Up to 146 receivers are predicted with high noise impacts (>20 dBA above NML) during night-time utility adjustment works, which would require the use of a concrete saw. While this activity may last for around 104 weeks overall, the duration at any one receiver would be substantially less as works move around the site.

Longer-term activities (up to the duration of the project) include onsite car parking, deliveries and storage and supporting infrastructure however the predicted noise impacts from these activities are typically minor (less than 10 dBA above NML).

Up to 53 receivers (surrounding the site) may be highly noise affected during the daytime demolition works at some point within the anticipated 24-week activity schedule when works are located immediately adjacent to the receiver.

Cumulative impacts, which represents a number of construction activities which have the potential to operate concurrently are not predicted to result in any highly noise affected receivers.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Victoria Road).

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. As such, airborne noise emissions from the Iron Cove Link civil site are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

Up to 45 buildings in this area have been identified within the minimum cosmetic damage vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. Under this scenario, around 107 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration. No heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Pyrmont Bridge Road

Activities within the Pyrmont Bridge Road study area would occur within the Pyrmont Bridge Road tunnel site (C9) located near the intersection of Pyrmont Bridge Road and Parramatta Road, generally in the area between Gordon Street and Mallet Street.

Up to 14 receivers are predicted with high noise impacts (>20 dBA above NML) during out of hours pavement and infrastructure works, which require the use of a rock-breaker however the duration of this activity is anticipated to be relatively short at around two weeks. Longer-term activities (up to the duration of construction of the project) include onsite car parking and deliveries and storage. The predicted noise impacts from these activities are typically minor (less than 10 dBA above NML) however up to four receivers are predicted with moderate (up to 20 dBA) NML exceedances during night-time spoil handling activities. This could be reduced to one receiver by using an upgraded acoustic shed. A similar scale of improvement is predicted for the minor (less than 10 dBA) impacted receivers.

Up to four receivers (mainly to the north of the site) may be highly noise affected during the pavement and infrastructure works at some point within the anticipated two-week activity schedule when works are located immediately adjacent to the receiver. Cumulative, which represents a number of construction activities which have the potential to operate concurrently are not predicted to result in any highly noise affected receivers.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Pyrmont Bridge Road and Parramatta Road).

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. Based on the excavation of the access tunnel at this site, three residential receivers and two other sensitive receivers are predicted to exceed the night-time ground-borne NML for up to around 16 days. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to 33 buildings in this area have been identified within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. For this scenario, around 73 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration. Five heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

St Peters

Activities within the St Peters study area would occur within the Campbell Road civil and tunnel site (C10) located on the southern side of Albert Street and Campbell Lane in St Peters. The site is currently part of the Campbell Road construction compound for the New M5 project.

No receivers are predicted with high noise impacts (>20 dBA above NML) during the proposed works at this site. Activities lasting up to 72 weeks include onsite vehicle movements, tunnelling support and ventilation building construction. The predicted noise impacts from these activities are typically minor (less than 10 dBA above NML) however one receiver is predicted with moderate (up to 20 dBA) NML exceedances during night-time cumulative activities. This could be eliminated by using an upgraded acoustic shed. No receivers are predicted to be highly noise affected during the proposed works at this site. While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to noise impacts from the interfacing New M5 project. These receivers are those which front Campbell Road. The requirement for consideration of additional feasible and reasonable mitigation on the basis of long term impacts will be evaluated in consultation with Roads and Maritime and the community during detailed design and considered when preparing the site specific CNVIS for this area.

Predicted noise from construction traffic on the public roads is not predicted to result in a noticeable increase in noise levels at receivers along the proposed haulage routes (Campbell Road and Princes Highway).

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, dive structures and tunnel stubs, are being undertaken as part of the New M5 project works. Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in a separate section below. As such, airborne noise emissions from the site are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

No vibration intensive works are proposed from the Campbell Road civil and tunnel site (C10) as part of the M4-M5 Link project.

Ground-borne noise – mainline tunnels

No surface works associated with the mainline tunnel alignment would occur outside of the areas discussed above and therefore the impacts at receivers for the construction of the mainline tunnels would be limited to ground-borne noise and vibration.

At residential locations greater than 30 metres from the nearest tunnel (taking into account the tunnel depth and the horizontal distance), exceedances of the ground-borne NML of 35 dBA during night-time periods are unlikely.

Based on a progression rate of around 20 metres per week for the excavation using road-headers, potential ground-borne noise impacts are predicted at the following locations:

- In Haberfield (near Wattle Street, north of Martin Street), where the tunnel ramps climb to meet with the Wattle Street tunnel stubs, 46 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 44 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In the vicinity of the Rozelle interchange (primarily to the north of Lilyfield Road and around Catherine Street), where the tunnel ramps climb to meet City West Link, 225 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 45 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Due to the number of tunnels being constructed in this area the duration of impacts may extend in these locations due to consecutive construction works, as discussed in the Rozelle section above
- In the vicinity of the Iron Cove Link tunnel portals (south of Victoria Road between Toelle Street and Cambridge Street), where the tunnel ramps climb to meet Victoria Road, 29 receivers are predicted to experience noise levels above the criteria for up to around 17 days for each road-header. Ground-borne noise levels of up to around 42 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In Annandale (between Moore Street, Catherine Street, Reserve Street and Annandale Street) where the tunnels veer north towards the Rozelle interchange, 48 receivers are predicted to experience noise levels above the criteria for up to around 12 days for each road-header. Ground-borne noise levels of up to around 37 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In the vicinity of the St Peters interchange (west of Sydney Park), where the tunnel ramps climb to meet St Peters tunnel stubs, 39 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 44 dBA $L_{Aeq(15minute}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver.

While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Construction noise and vibration mitigation

Residual noise impacts should be managed in accordance with recommended mitigation measures outlined in this report, relevant guidelines, and contractor procedures.

In addition to standard mitigation measures recommended in the assessment guidelines, the following measures have been recommended to be implemented during construction where practicable:

- Schedule operation of the high noise items of plant to less sensitive periods, such as daytime hours
- Increase the height of standard two metre hoarding around construction ancillary facilities to four metres adjacent to sensitive receivers at all sites except the Campbell Road civil and tunnel site (C10) in St Peters. Predicted impacts related to this site are minor
- Upgraded acoustic sheds which have a greater sound transmission loss through the building envelope than standard single skin steel constructions as outlined in **section 5**
- Notification (letters, phone calls or individual briefings) to the surrounding community to provide information regarding the anticipated works schedule
- Noise monitoring during construction to verify the predicted impacts and confirm the performance of in-situ mitigation methods
- Where high noise and/or vibration impacts out of hours cannot be avoided, consider respite offers or alternative accommodation in consultation with the affected receivers

- The number of receivers identified within the safe working distance for human comfort vibration can be reduced by restricting use of the rock-breaker to further inside the site boundary – a separation distance of more than 73 metres is required to keep all receivers outside the safe working distance
- Vibration trials and/or attended vibration monitoring should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria.

Operational road traffic noise assessment

The assessment compares noise levels predicted due to the project in 2023 (modelled as the year 'at opening') and 2033 (modelled as 10 years after opening) with those predicted without the project. Impacts associated with the project only are accounted for by assessing the *'Do Something'* traffic scenario. Cumulative impacts are accounted for by assessing an additional scenario (the *'Do Something Plus'* traffic scenario) which uses road traffic inputs for the full WestConnex scheme in addition to key infrastructure/ development proposals in the Greater Sydney area (including the proposed future Sydney Gateway, the proposed future Western Harbour Tunnel and Beaches Link, and the F6 Extension projects).

In the *'Do Something'* scenario, even without additional noise mitigation (ie over and above road design and traffic management), the project is predicted to reduce the overall number of sensitive receivers with an exceedance of the relevant noise goals by up to four per cent in the daytime opening year scenario. This is mainly due to areas where the project reduces traffic, such as sections of Victoria Road in Rozelle, where surface traffic is significantly reduced.

The change in road traffic noise exposure is generally anticipated to be less than 2 dBA in areas such as The Crescent and parts of Johnston Street where traffic volume is forecasted to increase. This change in road traffic noise exposure is considered by the EPA to be barely perceptible. At Victoria Road east of the Iron Cove Bridge, where substantial building structures would be removed to accommodate the proposed road widening, exposure to road traffic noise is anticipated to increase by over 5 dBA at the immediately adjacent receivers and would require mitigation measures to be considered to mitigate operational noise impact. If the Haberfield Option B construction ancillary facilities are selected, consideration of additional noise mitigation at six residential receivers including multi-storey buildings would be required due reduced screening benefit with the removal of intervening shielding.

The *'Do Something'* scenario assessment identifies a total of 431 sensitive receivers (within 200 individual buildings) that qualify for consideration of additional noise mitigation under the assessment guidelines. The majority of these receivers have existing high levels of equivalent continuous road traffic noise remaining 5 dBA or more above the noise criterion.

As a result in changes in the distribution of traffic, the cumulative *'Do Something Plus'* scenario assessment identifies fewer overall triggered receivers with a total of 409 sensitive receivers that qualify for consideration of additional noise mitigation. A total of 441 receivers (212 individual lots) have been identified as eligible for consideration of additional noise mitigation in either the *'Do Something'* scenario or the cumulative *'Do Something Plus'* scenario.

The maximum noise level assessment identifies that residential receivers south of Victoria Road adjacent to the Iron Cove Link tunnel portals and those west of Victoria Road at Rozelle are predicted to experience increases in maximum noise levels. This is due to demolition of acquired buildings which results in reduced noise screening. It is noted that some receivers in this catchment would be eligible for consideration of at-property treatments as part of the project.

The operational assessment has identified the potential noise benefits associated with the use of low noise pavement, noise barrier and at-property treatment. However, due to engineering uncertainties as well as unresolved urban design challenges, a provisional noise mitigation option in the form of at-property treatment has been recommended. A preferred noise mitigation option (low noise pavement, noise barrier, architectural treatments, a combination or other) would be determined during detailed design taking into account whole-of-life engineering considerations and the overall social, economic and environmental benefits. The preference would be given to noise mitigation measures that reduce outdoor noise levels and the number of at-property treatment.

Ventilation facilities noise impact assessment

The prediction of industrial noise from fixed facilities associated with the operation of the project was undertaken using three-dimensional models of the existing ground and project design.

The major sources of fixed facilities noise are in-tunnel jet fans (near the tunnel portals), ventilation facilities, substations and water treatment plants. As the specific plant and equipment for each of the fixed facilities are subject to further consideration during detailed design, indicative sound power level data has been assumed for the typical equipment.

It is important to note that as the sound power level data is indicative, the equipment and sound power levels must be finalised in detailed design when more information is known.

Additionally, the INP modifying factors for tonal noise etc should be considered when undertaking the assessment of the final plant and equipment.

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the Haberfield, Darley Road, Rozelle and St Peters areas.

Noise emissions from fixed facilities in the Iron Cove area are predicted to exceed the criteria by up to 12 dBA at the most-affected receivers either side of Callan Street, Rozelle, adjacent to the proposed substation. This assumes the substation noise source is at the closest point to the nearest residence, with no shielding from a substation building or intervening walls.

Should a +5 dBA INP modifying correction be required to be applied to the indicative sound power levels, receivers in adjacent to the fixed facilities at Darley Road, Iron Cove and St Peters have been identified as most likely to exceed the criteria.

The selected mechanical equipment should be reviewed and assessed for compliance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

1 Introduction

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

Together with the other components of the WestConnex program of works and the proposed future Sydney Gateway, the project would facilitate improved connections between western Sydney, Sydney Airport and Port Botany and south and south-western Sydney, as well as better connectivity between the important economic centres along Sydney's Global Economic Corridor and local communities.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) for the project. A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

1.1 Overview of WestConnex and related projects

The M4-M5 Link is part of the WestConnex program of works. Separate planning applications and assessments have been completed for each of the approved WestConnex projects. Roads and Maritime has commissioned Sydney Motorway Corporation (SMC) to deliver WestConnex, on behalf of the NSW Government. However, Roads and Maritime is the proponent for the project.

In addition to linking to other WestConnex projects, the M4-M5 Link would provide connections to the proposed future Western Harbour Tunnel and Beaches Link, the Sydney Gateway (via the St Peters interchange) and the F6 Extension (via the New M5).

The WestConnex program of works, as well as related projects, are shown in **Figure 1-1** and described in **Table 1-1**.

Table 1-1 WestConnex and related projects

Project	Description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the EP&A Act granted on 21 December 2014. Open to traffic.
M4 East	Extension of the M4 Motorway in tunnels between Homebush and Haberfield via Concord. Includes provision for a future connection to the M4-M5 Link at the Wattle Street interchange.	Planning approval under the EP&A Act granted on 11 February 2016. Under construction.
King Georges Road Interchange Upgrade	Upgrade of the King Georges Road interchange between the M5 West and the M5 East at Beverly Hills, in preparation for the New M5 project.	Planning approval under the EP&A Act granted on 3 March 2015. Open to traffic.

Project	Description	Status
New M5	Duplication of the M5 East from King Georges Road in Beverly Hills with tunnels from Kingsgrove to a new interchange at St Peters. The St Peters interchange allows for connections to the proposed future Sydney Gateway project and an underground connection to the M4-M5 Link. The New M5 tunnels also include provision for a future connection to the proposed future F6 Extension.	Planning approval under the EP&A Act granted on 20 April 2016. Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) granted on 11 July 2016. Under construction.
M4-M5 Link (the project)	Tunnels connecting to the M4 East at Haberfield (via the Wattle Street interchange) and the New M5 at St Peters (via the St Peters interchange), a new interchange at Rozelle and a link to Victoria Road (the Iron Cove Link). The Rozelle interchange also includes ramps and tunnels for connections to the proposed future Western Harbour Tunnel and Beaches Link project.	The subject of this EIS.
Related projects		
Sydney Gateway	A high-capacity connection between the St Peters interchange (under construction as part of the New M5 project) and the Sydney Airport and Port Botany precinct.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
Western Harbour Tunnel and Beaches Link	The Western Harbour Tunnel component would connect to the M4-M5 Link at the Rozelle interchange, cross underneath Sydney Harbour between the Birchgrove and Waverton areas, and connect with the Warringah Freeway at North Sydney. The Beaches Link component would comprise a tunnel that would connect to the Warringah Freeway, cross underneath Middle Harbour and connect with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst Parkway between Seaforth and Frenchs Forest.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
F6 Extension	A proposed motorway link between the New M5 at Arncliffe and the existing M1 Princes Highway at Loftus, generally along the alignment known as the F6 corridor.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.

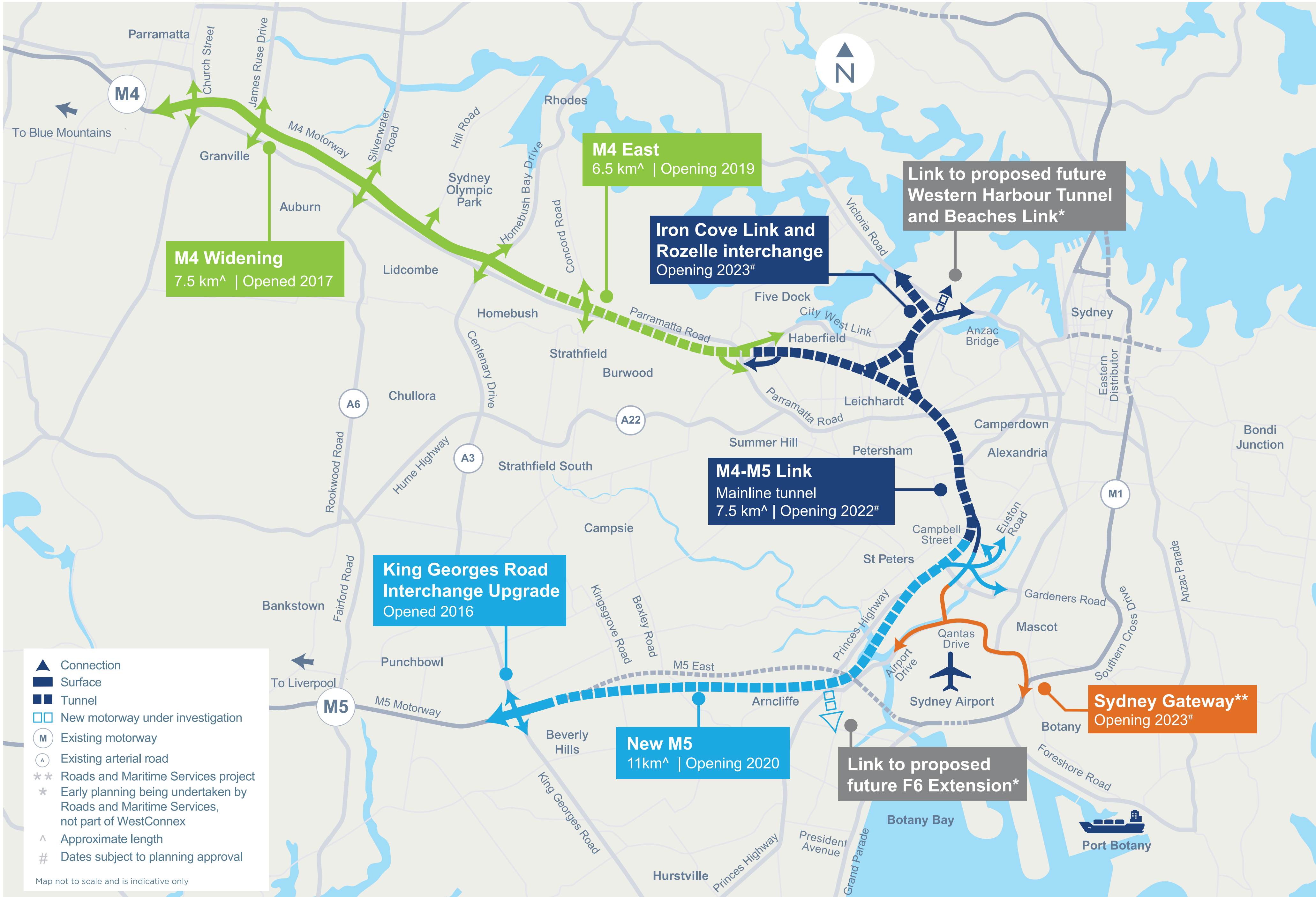


Figure 1-1 Overview of WestConnex and related projects

1.2 Purpose of this report

SLR Consulting Australia (SLR) has been engaged by Roads and Maritime to assess the potential noise and vibration impacts associated with the construction and operation of the project. This report has been prepared to inform the environmental assessment and be included in the EIS as a technical paper.

1.3 SEARs and Agency comments

The NSW Department of Planning and Environment (DPE) has issued a list of Secretary's Environmental Assessment Requirements (SEARs) which were most recently amended on 3 May 2017, that inform the environmental impact assessment. **Table 1-2** displays the SEARS that are specific to the noise and vibration assessment and also provides a cross-reference to the relevant section(s) of this report where these requirements are addressed.

Letters from other NSW government agencies were also issued alongside the SEARs. Letters referencing noise and vibration were issued by Inner West Council (IWC) formally known as Ashfield and Marrickville City Council, NSW Health and Port Authority of NSW. **Table 1-3** provides details of the noise and vibration requirements outlined in these letters and provides a cross reference to the relevant section(s) of this report where these have been addressed.

Table 1-2 How SEARs have been addressed in this report

Secretary's Environmental Assessment Requirements	
4. Noise and Vibration - Amenity	
Requirement	**Section where addressed in Report**
1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must address the redistribution of traffic and include consideration of impacts to sensitive receivers (on affected floors of residential buildings), include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise). 2. An assessment of construction noise and vibration impacts which must address: a) the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant), b) the intensity and duration of noise and vibration impacts (both air and ground-borne); c) the nature, sensitivity and impact to receivers; d) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management); e) the potential for works outside standard construction hours, including estimated duration and timing, predicted levels, exceedances and number of potentially affected receivers and justification for the activity ¡in terms of the Interim Construction Noise Guideline (DECCW, 2009); f) potential noise and vibration mitigation measures, including timing of implementation; g) figures illustrating the existing and predicted noise levels; h) a cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities); and i) a cumulative noise and vibration assessment of the impacts from the project and the construction of other key infrastructure	Construction noise and vibration impacts are assessed in **Chapter 5** Operational noise impacts are assessed in **Chapter 6** Sensitive receivers identified in the study area are outlined in **Chapter 3**

Secretary's Environmental Assessment Requirements	
projects including, but not limited to, the New M5 and M4 East 3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	
5. Noise and Vibration - Structural	
Requirement	**Section where addressed in Report**
1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage). 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Construction noise and vibration impacts are assessed in **Chapter 5**. Potential impacts on heritage items are assessed in **Appendix U** (Technical working paper: Non-Aboriginal heritage) of the EIS Operational noise impacts are assessed in **Chapter 6** Sensitive receivers identified in the study area are outlined in **Chapter 3**

Table 1-3 How agency comments have been addressed in this report

Agency letters	
Ashfield Council	
Requirement	**Section where addressed in Report**
• 4.1 Urban Design and works to ameliorate the spatial impacts of the portals. • The new portals and their 'land cuttings' for the associated entry and exit laneways have the potential to create a poor visual setting, including for adjacent residential areas. Vehicles using entry and exit laneways are also likely to create high levels of noise for adjoining properties, including nearby residences. The following details must therefore be provided in the EIS: – the design of any 'noise screening walls or devices'. – the design of 'noise screening walls or devices', accompanied with a report by a qualified acoustic engineer, explaining how effective they will be in reducing noise impacts for adjoining properties. – how any residual areas which are part of the portal/roadway works will be treated and designed. – how any visually exposed parts of the portal/slip lanes will be visually screened, such as side walls. – landscaping treatments around the portal sites and entry/exit laneways. – In addition to plans and elevations, the above should be graphically demonstrated in three dimensions to enable the public to adequately evaluate the proposals. • It is critical that the health impacts of the WestConnex proposal are rigorously and systematically considered in the assessment process for this major roadway. There are significant physical and mental health implications associated with major roadways. These include:	Operational noise mitigation measures are discussed in **section 6.4** to **section 6.6** Operational road traffic noise impacts, including sleep disturbance and cumulative impacts, are assessed in **Chapter 6** Health impacts are assessed in EIS **Appendix K** (Technical working paper: Human health risk assessment)

Agency letters	
– Additional traffic noise – implications for mental health due to stress and loss of sleep -Increased danger from traffic – implications for the community's health (especially vulnerable groups) • The SEARs should also specify a requirement for the EIS to address cumulative impacts of the proposal across all major issues – traffic, noise, vibration, social, health, visual, heritage, biodiversity, environmental, climate change, flooding, water quality, etc.	
City of Sydney	
Requirement	**Section where addressed in Report**
• Sensitive receivers should include (but not be limited to) users of formal and informal recreational space, schools, childcare centres, high-density residential (existing and planned), businesses, hospitals, health and research facilities, universities and other tertiary education colleges. • The noise and vibration study area and assessment should include the following: – assessment of impacts on the health of surrounding Central Sydney local communities i.e. Parramatta Road to Railway Square and adjoining residential communities and surrounding communities of Annandale and Glebe; – impacts on the health of surrounding local communities as a result of increased use of surface and feeder roads as a result of toll avoidance; – assessment of the potential population health effects on urban renewal sites including (but not limited to) future mixed use (high density) development along Parramatta Road; – assessment of the potential population health effects on recreational users of Victoria Park and other relevant recreational areas; – assessment of the inter-relationship and consequential impact of the project on the broader aims of government to improve the amenity in Central Sydney in the context of increased pedestrian numbers.	Sensitive receivers identified in the study area are outlined in **Chapter 3** Operational noise impacts are assessed in **Chapter 6** Health impacts are assessed in EIS **Appendix K** (Technical working paper: Human health risk assessment)
Marrickville Council	
Requirement	**Section where addressed in Report**
• A detailed social impact assessment needs to be carried out to provide a comparison of the impacts of all options in relation to community health as well as the physical and mental health of individuals. This should include, but is not exclusive to, opportunities for engagement in healthy activity, social inclusion, crime, access to education, housing affordability, community severance, family cohesion, cohesion of social/support networks, nutrition and secure access to food, and air/water quality. – The assessment should consider potential impacts, such as community severance, health impacts from noise, vibration and air pollution and potential lost opportunity to engage in active and healthy behaviour and social interaction. • [Recommend analysis of] Impact on local schools including noise, air pollution, danger from increased traffic volumes including at road crossings as well as reduced likelihood in children travelling actively to school and the associated impact of this on childhood	Operational noise impacts are assessed in **Chapter 6** Construction noise and vibration impacts are assessed in **Chapter 5** Health impacts are assessed in EIS **Appendix K** (Technical working paper: Human health risk assessment)

Agency letters	
obesity, social awareness and other learning and development factors must also be addressed. • The socio-economic disadvantage index score for Marrickville is 1,022. In spite of its higher income levels by NSW standards, a greater proportion of Marrickville residents are unemployed (6.0%), compared to Inner West Sydney (5.5%) and NSW (5.7%). Disadvantaged residents will be more likely to remain in areas that are significantly affected by air and noise pollution. • Construction and demolition phase impacts on local communities should be analysed including noise, vibration, dust, amenity, access, and the impacts of transportation of waste materials, for example through increased truck movements.	
NSW Health	
Requirement	**Section where addressed in Report**
• The proponent should provide a comprehensive assessment of noise and vibration impacts during both construction and operation of the project. A cumulative noise and vibration impact assessment should be undertaken to include impacts from all other projects such as New M5 and the Sydney Gateway. It should include the potential benefits of any proposed mitigation strategies. Specific emphasis should be put on protecting vulnerable population groups and individuals. • The proposal is within close proximity to the Royal Prince Alfred Hospital (RPA). We recommend that an assessment of the likely impact the proposal will have on patients, equipment and infrastructure at RPA. For example, consideration of vibrational impacts on RPA's nuclear cyclotron.	Construction noise and vibration impacts, including tunnelling works, are assessed in **Chapter 5** Operational road traffic noise impacts, including cumulative impacts, are assessed in **Chapter 6**
Port Authority of NSW	
Requirement	**Section where addressed in Report**
• The Port Authority also requests that the standard SEARS requiring the Proponent to assess impacts from construction and operation on potentially affected properties includes specific references to the operations and land uses at Glebe Island and White Bay.	Construction noise and vibration impacts are assessed in **Chapter 5** Operational noise impacts are assessed in **Chapter 6** Sensitive receivers identified in the study area are outlined in **Chapter 3**

1.4 Structure of this report

The assessment of noise and vibration includes:

- Description of the project features and construction activities (see **Chapter 2**)
- Assessment guidelines and methodology (see **Chapter 4**)
- Ambient noise surveys to determine the existing noise environment within the study area (see **Chapter 3**)
- Identification of receivers along the alignment that are potentially sensitive to noise and vibration (see **section 3.1**)
- Assessment of predicted noise and vibration impacts and consideration of potential mitigation and management measures during the construction of the project (see **Chapter 5**)
- Consideration of cumulative impacts of the project during construction (see **Chapter 5**) and operation (see **section 6.3**)
- Assessment of predicted noise impacts due to the operation of the project and consideration of potential mitigation measures (see **Chapter 6**).

1.5 Terminology

The assessment has used specific acoustic terminology throughout. An explanation of common terms is included as **Annexure A** for reference.

2 The project

2.1 Project location

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The local context of the project is shown in **Table 2-1**.

2.2 Overview of the project

Key components of the project are shown in **Table 2-1** and would include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project)
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project)
  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- An underground interchange at Leichhardt and Annandale (the Inner West subsurface interchange) that would link the mainline tunnels with the Rozelle interchange and the Iron Cove Link (see below)
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would connect the M4-M5 Link mainline tunnels with:
  - City West Link
  - Anzac Bridge
  - The Iron Cove Link (see below)
  - The proposed future Western Harbour Tunnel and Beaches Link
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange, including:
  - Tunnels that would allow for underground mainline connections between the M4 East and New M5 motorways and the proposed future Western Harbour Tunnel and Beaches Link (via the M4-M5 Link mainline tunnels)
  - A dive structure and tunnel portals within the Rozelle Rail Yards, north of the City West Link / The Crescent intersection
  - Entry and exit ramps that would extend north underground from the tunnel portals in the

  Rozelle Rail Yards to join the mainline connections to the proposed future Western Harbour Tunnel and Beaches Link
  - A ventilation outlet and ancillary facilities as part of the Rozelle ventilation facility (see below)
- Twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge (the Iron Cove Link). Underground entry and exit ramps would also provide a tunnel connection between the Iron Cove Link and the New M5 / St Peters interchange (via the M4-M5 Link mainline tunnels)
- The Rozelle surface works, including:
  - Realigning The Crescent at Annandale, including a new bridge over Whites Creek and modifications to the intersection with City West Link
  - A new intersection on City West Link around 300 metres west of the realigned position of The Crescent, which would provide a connection to and from the New M5/St Peters interchange (via the M4-M5 Link mainline tunnels)
  - Widening and improvement works to the channel and bank of Whites Creek between the light rail bridge and Rozelle Bay at Annandale, to manage flooding and drainage for the surface road network
  - Reconstructing the intersection of The Crescent and Victoria Road at Rozelle, including construction of a new bridge at Victoria Road
  - New and upgraded pedestrian and cyclist infrastructure
  - Landscaping, including the provision of new open space within the Rozelle Rail Yards
- The Iron Cove Link surface works, including:
  - Dive structures and tunnel portals between the westbound and eastbound Victoria Road carriageways, to connect Victoria Road east of Iron Cove Bridge with the Iron Cove Link
  - Realignment of the westbound (southern) carriageway of Victoria Road between Springside Street and the eastern abutment of Iron Cove Bridge
  - Modifications to the existing intersections between Victoria Road and Terry, Clubb, Toelle and Callan streets
  - Landscaping and the establishment of pedestrian and cycle infrastructure
- Five motorway operations complexes; one at Leichhardt (MOC1), three at Rozelle (Rozelle West (MOC2), Rozelle East (MOC3) and Iron Cove Link (MOC4)), and one at St Peters (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets, offices, on-site storage and parking for employees
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels
- Three new ventilation facilities, including:
  - The Rozelle ventilation facility at Rozelle
  - The Iron Cove Link ventilation facility at Rozelle
  - The Campbell Road ventilation facility at St Peters
- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities. Water treatment would occur at
  - Two operational water treatment facilities (at Leichhardt and Rozelle)
  - The constructed wetland within the Rozelle Rail Yards
  - A bioretention facility for stormwater runoff within the informal car park at King George Park at

Rozelle (adjacent to Manning Street). A section of the existing informal car park would also be upgraded, including sealing the car park surface and landscaping

- Treated water would flow back to existing watercourses via new, upgraded and existing infrastructure
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities. A Utilities Management Strategy has been prepared for the project that identifies management options for utilities, including relocation or adjustment. Refer to **Appendix F** (Utilities Management Strategy) of the EIS.

The project does not include:

- Site management works at the Rozelle Rail Yards. These works were separately assessed and determined by Roads and Maritime through a Review of Environmental Factors under Part 5 of the EP&A Act (refer to **Chapter 2** (Assessment process) of the EIS)
- Ongoing motorway maintenance activities during operation
- Operation of the components of the Rozelle interchange which are the tunnels, ramps and associated infrastructure being constructed to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

Temporary construction ancillary facilities and temporary works to facilitate the construction of the project would also be required.

2.2.1 Staged construction and opening of the project

It is anticipated the project would be constructed and opened to traffic in two stages (as shown in **Table 2-1**).

Stage 1 would include:

- Construction of the mainline tunnels between the M4 East at Haberfield and the New M5 at St Peters, stub tunnels to the Rozelle interchange (at the Inner West subsurface interchange) and ancillary infrastructure at the Darley Road motorway operations complex (MOC1) and Campbell Road motorway operations complex (MOC5)
- These works are anticipated to commence in 2018 with the mainline tunnels open to traffic in 2022. At the completion of Stage 1, the mainline tunnels would operate with two traffic lanes in each direction. This would increase to generally four lanes at the completion of Stage 2, when the full project is operational.

Stage 2 would include:

- Construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels at the Inner West subsurface interchange (built during Stage 1)
  - Ancillary infrastructure at the Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3) and Iron Cove Link motorway operations complex (MOC4)
  - Connections to the surface road network at Lilyfield and Rozelle
  - Construction of tunnels, ramps and associated infrastructure as part of the Rozelle interchange to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project
- Stage 2 works are expected to commence in 2019 with these components of the project open to traffic in 2023.

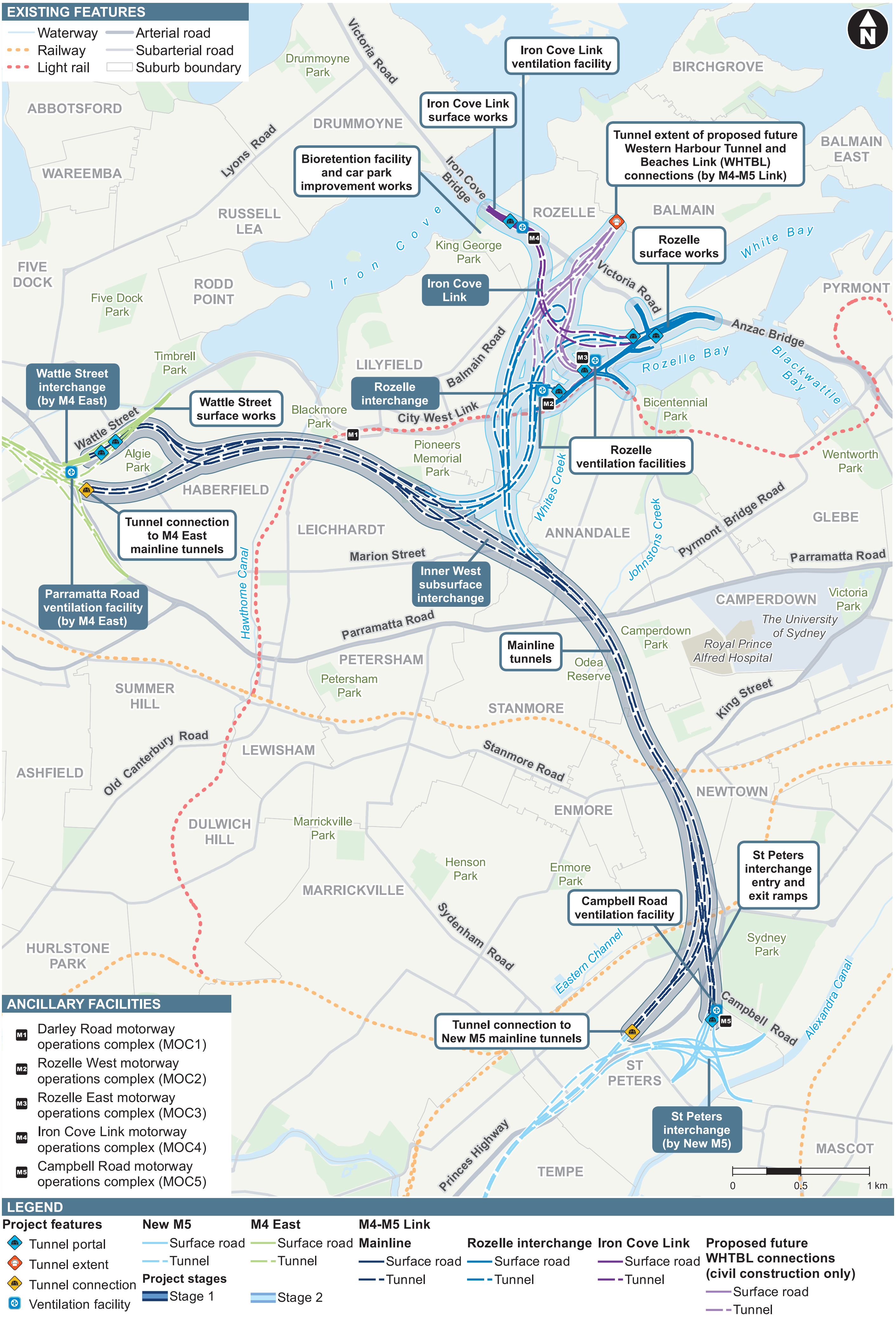


Figure 2-1 Overview of the project

2.3 Construction activities

An overview of the key construction features of the project is shown in **Figure 2-2** and would generally include:

- Enabling and temporary works, including provision of construction power and water supply, ancillary site establishment including establishment of acoustic sheds and construction hoarding, demolition works, property adjustments and public and active transport modifications (if required)
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure
- Haulage of spoil generated during tunnelling and excavation activities
- Fitout of the road tunnels and support infrastructure, including ventilation and emergency response systems
- Construction and fitout of the motorway operations complexes and other ancillary operations buildings
- Realignment, modification or replacement of surface roads, bridges and underpasses
- Implementation of environmental management and pollution control facilities for the project.

A more detailed overview of construction activities is provided in **Table 2-1**.

Table 2-1 Overview of construction activities

Component	Typical activities
Site establishment and enabling works	• Vegetation clearing and removal • Utility works • Traffic management measures • Install safety and environmental controls • Install site fencing and hoarding • Establish temporary noise attenuation measures • Demolish buildings and structures • Carry out site clearing • Heritage salvage or conservation works (if required) • Establish construction ancillary facilities and access • Establish acoustic sheds • Supply utilities (including construction power) to construction facilities • Establish temporary pedestrian and cyclist diversions
Tunnelling	• Construct temporary access tunnels • Excavation of mainline tunnels, entry and exit ramps and associated tunnelled infrastructure and install ground support • Spoil management and haulage • Finishing works in tunnel and provision of permanent tunnel services • Test plant and equipment
Surface earthworks and structures	• Vegetation clearing and removal • Topsoil stripping • Excavate new cut and fill areas • Construct dive and cut-and-cover tunnel structures • Install stabilisation and excavation support (retention systems) such as sheet pile walls, diaphragm walls and secant pile walls (where required) • Construct required retaining structures • Excavate new road levels
Bridge works	• Construct piers and abutments • Construct headstock • Construct bridge deck, slabs and girders

Component	Typical activities
	• Demolish and remove redundant bridges
Drainage	• Construct new pits and pipes • Construct new groundwater drainage system • Connect drainage to existing network • Construct sumps in tunnels as required • Construct water quality basins, constructed wetland and bioretention facility and basin • Construct drainage channels • Construct spill containment basin • Construct onsite detention tanks • Adjustments to existing drainage infrastructure where impacted • Carry out widening and naturalisation of a section of Whites Creek • Demolish and remove redundant drainage
Pavement	• Lay select layers and base • Lay road pavement surfacing • Construct pavement drainage
Operational ancillary facilities	• Install ventilation systems and facilities • Construct water treatment facilities • Construct fire pump rooms and install water tanks • Test and commission plant and equipment • Construct electrical substations to supply permanent power to the project
Finishing works	• Line mark to new road surfaces • Erect directional and other signage and other roadside furniture such as street lighting • Erect toll gantries and other control systems • Construct pedestrian and cycle paths • Carry out earthworks at disturbed areas to establish the finished landform • Carry out landscaping • Closure and backfill of temporary access tunnels (except where these are to be used for inspection and/or maintenance purposes) • Site demobilisation and preparation of the site for a future use

Twelve construction ancillary facilities are described in this EIS (as listed below). To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

The construction ancillary facilities required to support construction of the project include:

- Construction ancillary facilities at Haberfield (Option A), comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- Construction ancillary facilities at Ashfield and Haberfield (Option B), comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)

  - Parramatta Road East civil site (C3b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)
- Iron Cove Link civil site (C8)
- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

The number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

The construction ancillary facilities would be used for a mix of civil surface works, tunnelling support, construction workforce parking and administrative purposes. Wherever possible, construction ancillary facilities would be co-located with the project footprint to minimise property acquisition and temporary disruption. The layout and access arrangements for the construction ancillary facilities are based on the concept design only and would be confirmed and refined in response to submissions received during the exhibition of this EIS and during detailed design.

2.3.1 Construction program

The total period of construction works for the project is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. An indicative construction program is shown in **Table 2-2**.

Table 2-2 Indicative construction program

Construction activity	Indicative construction timeframe 2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mainline tunnels																								
Site establishment and establishment of construction ancillary facilities			■	■	■	■	■	■	■	■														
Utility works and connections			■	■	■	■	■	■																
Tunnel construction				■	■	■	■	■	■	■	■	■	■											
Portal construction				■	■	■	■	■																
Construction of permanent operational facilities												■	■	■	■	■								
Mechanical and electrical fitout works														■	■	■								
Establishment of tolling facilities															■	■								
Site rehabilitation and landscaping																■	■	■	■					
Surface roadworks																	■	■	■					
Demobilisation and rehabilitation																			■	■				
Testing and commissioning																■	■	■	■	■				
Rozelle interchange and Iron Cove Link																								
Site establishment and establishment of construction ancillary facilities				■	■	■	■	■	■															
Utility works and connections and site remediation				■	■	■	■	■																
Tunnel construction									■	■	■	■	■	■	■	■	■							
Portal construction						■	■	■	■															
Construction of surface roadworks						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Construction of permanent operational facilities						■	■	■	■	■	■	■	■	■	■	■								
Mechanical and electrical fitout works													■	■	■	■	■	■	■	■				
Establishment of tolling facilities																		■	■					

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Site rehabilitation and landscaping																								
Demobilisation and rehabilitation																								
Testing and commissioning																								

Figure 2-2 Overview of project footprint and ancillary facilities

2.4 Noise and vibration specific aspects

While all feasible and reasonable mitigation measures would be confirmed during detailed design according to the finalised requirements of the project, potential features required to mitigate noise and vibration impacts due to construction and operation of the project may include a combination of:

- Temporary acoustic sheds at tunnelling sites to reduce noise impact during construction
- Layout of construction ancillary facilities to provide separation distances between noisy activities and the closest sensitive receivers and, locating temporary buildings along a boundary to provide shielding
- Temporary noise barriers/hoarding adjacent to construction compounds and tunnelling sites to reduce noise impact during construction
- Quieter road pavement in selected locations to reduce operational noise impacts
- Permanent noise barriers in certain locations to reduce operational noise impacts
- At-property treatments, such as the double-glazing of windows, to reduce internal operational noise impacts
- Appropriate design of operational facilities such as ventilation buildings and outlets to control operational noise impacts.

3 Existing environment

3.1 Noise and vibration sensitive receivers

The study area for this technical paper extends from each of the interface areas of the earlier WestConnex projects in Haberfield (M4 East) and St Peters (New M5) and runs via Darley Road, Rozelle, Iron Cove and Pyrmont Bridge Road.

The sensitivity of receivers to noise and vibration depends on the occupancy type or use of outdoor space / recreational area and the nature of the activities performed. Sensitivity to noise is a subjective response varying for different individuals and can vary depending on the existing noise environment.

For the purpose of this assessment, receivers potentially sensitive to noise and vibration have been categorised as:

- Residential dwellings
- Commercial and industrial properties
- Other – Education institutions
- Other – Childcare centres
- Other – Medical (hospital wards or other uses including medical centres)
- Other – Places of worship
- Other – Outdoor open areas (passive and active recreation).

The receivers within the study area have been identified from site inspections and desktop review and are identified on the site map in **Annexure B-1**.

Other sensitive receivers and items of heritage importance in the study area have been identified and are listed in the tables in **Annexure B-2** and **Annexure B-3** respectively.

3.2 Noise catchment areas

For assessment purposes, the study area has been divided into multiple Noise Catchment Areas (NCAs). These NCAs include a variety of land uses within and surrounding the project and assist in the identification of impacts upon groups of receivers likely to be affected by the same works.

A description of each NCA is provided in **Table 3-1**. The location of the various NCAs and sensitive receivers are shown in detail in **Figure 3-1** to **Figure 3-3** and **Annexure B-1**.

Table 3-1 Noise catchment areas and surrounding land uses

NCA description		
Reference	**Min. distance (m)[1]**	**Description**
Haberfield		
NCA00	40	South of Parramatta Road between Bland Street and Orpington Street. Land use consists of residential receivers.
NCA01	<5	South of Parramatta Road between Iron Cove Creek and Bland Street. Land use comprises of a mix of residential receivers, special use facilities, active and passive recreation areas and commercial receivers fronting Parramatta Road.
NCA02	<5	North of Parramatta Road between Henley Marine Drive and Walker Avenue. Land use comprises of a mix of residential and commercial receivers, a place of worship and a childcare centre.
NCA03	20	Catchment adjoins either side of Wattle Street between Ash Lane and Ramsay Street. Land use consists of residential receivers.
NCA04	30	Catchment area adjoins Ramsay Street and the western side of Wattle Street. Land use consists of residential receivers, isolated commercial receivers and a passive recreational area
NCA05	n/a[2]	South of Dobroyd Parade between Hawthorne Parade and Martin Street. Land use consists of residential receivers with isolated commercial receivers and educational facilities
NCA06	<5	North of Parramatta Road between Walker Avenue and Alt Street residences. Land use consists of residential and commercial receivers and an educational facility on Ramsay Street
NCA07	<5	North of Parramatta Road between Dalhousie Street and Bland Street residences. Land use comprises of a mix of residential and commercial facilities, other sensitives and active and passive recreation areas.
Darley Road, Leichhardt		
NCA08	120	South of City West Link between Hawthorne Parade and Darley Road. Land use comprises of commercial receivers and active and passive recreation areas
NCA09	45	North of City West Link between Norton Street and Lilyfield Road. Land use comprises of a mix of residential and commercial receivers and two childcare centres
NCA10	200	North of Perry Street between Lilyfield Road and Wharf Road. Land use comprises of a mix of residential receivers, isolated commercial receivers and special use facilities.
NCA11	100	North of City West Link between Norton Street, Balmain Road and Perry Street. Land use comprises of a mix of residential receivers, isolated commercial receivers and special use facilities.

NCA description		
Reference	**Min. distance (m)[1]**	**Description**
NCA12	100	South of City West Link between Norton Street, Balmain Road and William Street. Land use comprises of a mix of residential and commercial receivers, a place of worship and the Sydney Buses Leichhardt depot.
NCA13	15	South of Darley Road between Norton Street and William Street. Land use consists of residential receivers and isolated commercial receivers.
NCA14	n/a[2]	South of William Street between Darley Road and Norton Street. Land use comprises of a mix of residential receivers, isolated commercial receivers and special use facilities.
Rozelle, Lilyfield, Annandale, Glebe and Pyrmont		
NCA15	30	South of City West Link between Balmain Road, Moore Street and Starling Street/Paling Street. Land use comprises of a mix of residential receivers, isolated commercial receivers, a childcare centre and passive recreation area.
NCA16	35	North of Lilyfield Road between Balmain Road, Lamb Street and O'Neill Street. Land use comprises of a mix of residential receivers, isolated commercial receivers and a medical centre.
NCA17	30	North of City West Link between Lilyfield Road, Balmain Road and the boundary of the project in the Rozelle Rail Yard. Land use consists of commercial receivers and the Sydney Light Rail Lilyfield Depot.
NCA18	<5	North of City West Link between Lilyfield Road, Victoria Road and the Sydney Light Rail Lilyfield Depot. Land use consists of commercial receivers and the Rozelle Rail Yard, which will become the project site.
NCA19	25	North of Lilyfield Road between Lamb Street, Foucart Street and Balmain Road. Land use comprises of a mix of residential receivers, isolated commercial receivers and a childcare centre.
NCA20	45	South of City West Link between Whites Creek, Moore Street and Starling Street/Paling Street. Land use comprises of a mix of residential receivers, isolated commercial receivers and passive recreation areas.
NCA21	20	West of Johnston Street between Piper Street, Railway Parade and Whites Creek. Land use comprises of a mix of residential receivers, isolated commercial receivers and an educational facility.
NCA23	90	East of Johnston Street between The Crescent, Piper Street and Johnstons Creek, including commercial premises on the east side of The Crescent. Land use comprises of a mix of residential receivers, commercial receivers, an educational facility and a passive recreation area.
NCA24	20	North of Lilyfield Road between Foucart Street, Gordon Street, Victoria Road and Darling Street. Land use comprises of a mix of residential and commercial receivers, special use facilities and active and passive recreation areas.

NCA description		
Reference	**Min. distance (m)[1]**	**Description**
NCA25	<5	West of Victoria Road between Gordon Street and Lilyfield Road, including residences on the south side of Lilyfield Road. Land use comprises of a mix of residential receivers, isolated commercial receivers and special use facilities.
NCA26	<5	Catchment area adjoins either side of the western approach to Anzac Bridge, between Victoria Road, Robert Street, White Bay, Johnstons Bay and Rozelle Bay. Land use consists of a mix of commercial and industrial receivers including port facilities.
NCA27	90	East of The Crescent between Rozelle Bay and Blackwattle Bay. Land use comprises of a mix of residential receivers, isolated commercial receivers, special use facilities and active and passive recreation areas.
NCA28	400	Catchment area adjoins either side of the eastern approach to Anzac Bridge, between Johnstons Bay and Blackwattle Bay. Land use comprises of a mix of residential and commercial receivers.
NCA29	50	North of Victoria Road between Robert Street and Evans Street. Land use comprises of a mix of residential and commercial receivers and special use facilities.
NCA39	n/a[2]	South of Moore Street/Booth Street between Norton Street and Johnston Street. Land use comprises of a mix of residential receivers and commercial receivers, special use facilities and a passive recreation area.
Iron Cove		
NCA30	200	North of Victoria Road between Evans Street and Darling Street. Land use comprises of a mix of residential and commercial receivers and special use facilities.
NCA31	20	North of Victoria Road between Darling Street and Wellington Street. Land use comprises of a mix of residential and commercial receivers, special use facilities and an active recreation area.
NCA32	10	South of Victoria Road between Darling Street and Moodie Street residences. Land use comprises of a mix of residential and commercial receivers and special use facilities.
NCA33	<5	South of Victoria Road between Moodie Street residences and Toelle Street. Land use comprises of a mix of residential and commercial receivers.
NCA34	<5	North of Victoria Road between Wellington Street and Terry Street. Land use comprises of a mix of residential and commercial receivers.
NCA35	10	North of Victoria Road between Terry Street and Parramatta River. Land use comprises of a mix of residential receivers, isolated commercial receivers, an educational facility and active and passive recreation areas.

NCA description		
Reference	**Min. distance (m)[1]**	**Description**
NCA36	<5	South of Victoria Road between Toelle Street and Parramatta River. Land use comprises of a mix of residential receivers, isolated commercial receivers and active and passive recreation areas.
NCA37	300	North of Balmain Road between Wharf Street, Manning Street and Parramatta River. Land use comprises of a mix of special use facilities and active and passive recreation areas.
NCA38	400	Catchment area adjoins either side of Victoria Road, north of Parramatta River. Land use comprises of a mix of residential and commercial receivers, special use facilities and active and passive recreation areas.
Pyrmont Bridge Road		
NCA22	300	Catchment area adjoins either side of Johnston Street, between Piper Street, Booth Street, Whites Creek Valley Park and Johnstons Creek. Land use comprises of a mix of residential receivers, isolated commercial receivers and passive recreation areas.
NCA40	160	East of Johnston Street between Booth Street, Johnstons Creek and Parramatta Road. Land use comprises of a mix of residential and commercial receivers and special use facilities.
NCA41	<5	North of Parramatta Road between Booth Street/Mallett Street and Johnstons Creek. Land use comprises of a mix of residential and commercial receivers and a place of worship.
NCA42	25	South of Parramatta Road between Mallett Street and Salisbury Road. Land use comprises of a mix of residential and commercial receivers, special use facilities and active and passive recreation areas.
NCA43	35	South of Parramatta Road, east of Mallett Street. Land use comprises of a mix of residential and commercial receivers and special use facilities.
NCA44	20	North of Parramatta Road, east of Booth Street. Land use comprises of a mix of residential and commercial receivers.
NCA45	n/a[2]	Catchment area extends from Salisbury Road in the north to the Illawarra Rail Line/St Peters Rail Station in the south. Land use comprises of a mix of residential and commercial receivers and special use facilities.
St Peters		
NCA46	750	North of Sydney Park Road between Concord Street, Coulson Street and Maddox Street. Land use comprises of a mix of residential receivers and isolated commercial receivers.
NCA47	150	East of Euston Road, between Maddox Street and Campbell Road. Land use consists of commercial receivers.
NCA48	50	South of Sydney Park Road between Barwon Park Road, Campbell Road and Euston Road. Land use comprises of a passive recreation area and isolated commercial receivers.

NCA description		
Reference	**Min. distance (m)[1]**	**Description**
NCA49	75	Catchment area adjoins either side of Barwon Park Road, between Campbell Road and Crown Street. Land use comprises of a mix of residential and commercial receivers.
NCA50	<5	Catchment area adjoins either side of Princes Highway, between Mary Street, Church Street/Applebee Street and May Street. Land use comprises of a mix of residential and commercial receivers, an educational facility and an active recreation area.
NCA51	225	North of Campbell Street between Applebee Street and the Illawarra Rail Line/St Peters Rail Station. Land use comprises of a mix of residential and commercial receivers and active and passive recreation areas.
NCA52	225	South of the Illawarra Rail Line between Campbell Street, Sutherland Street and Princes Highway premises. Land use comprises of a mix of residential and commercial receivers, an educational facility and active and passive recreation areas.
NCA53	n/a[2]	West of Princes Highway, south of Sutherland Street. Land use comprises of a mix of residential and commercial receivers.
NCA54	n/a[2]	East of Princes Highway between Canal Street and Alexandra Canal. Land use comprises of a mix of residential and commercial receivers.
NCA55	190	East of Burrows Road. Land use comprises of a mix of residential and commercial receivers.

Notes:

1. Approximate minimum horizontal offset distance from the nearest receiver building facade (receiver of any type) to the nearest point that construction works are occurring
2. No surface works are proposed in this NCA. Receivers in this catchment would therefore only be potentially affected by impacts from tunnelling works during construction

Figure 3-1 **Site plan and NCA boundary map (western section)**

Figure 3-2 **Site plan and NCA boundary map (northern section)**

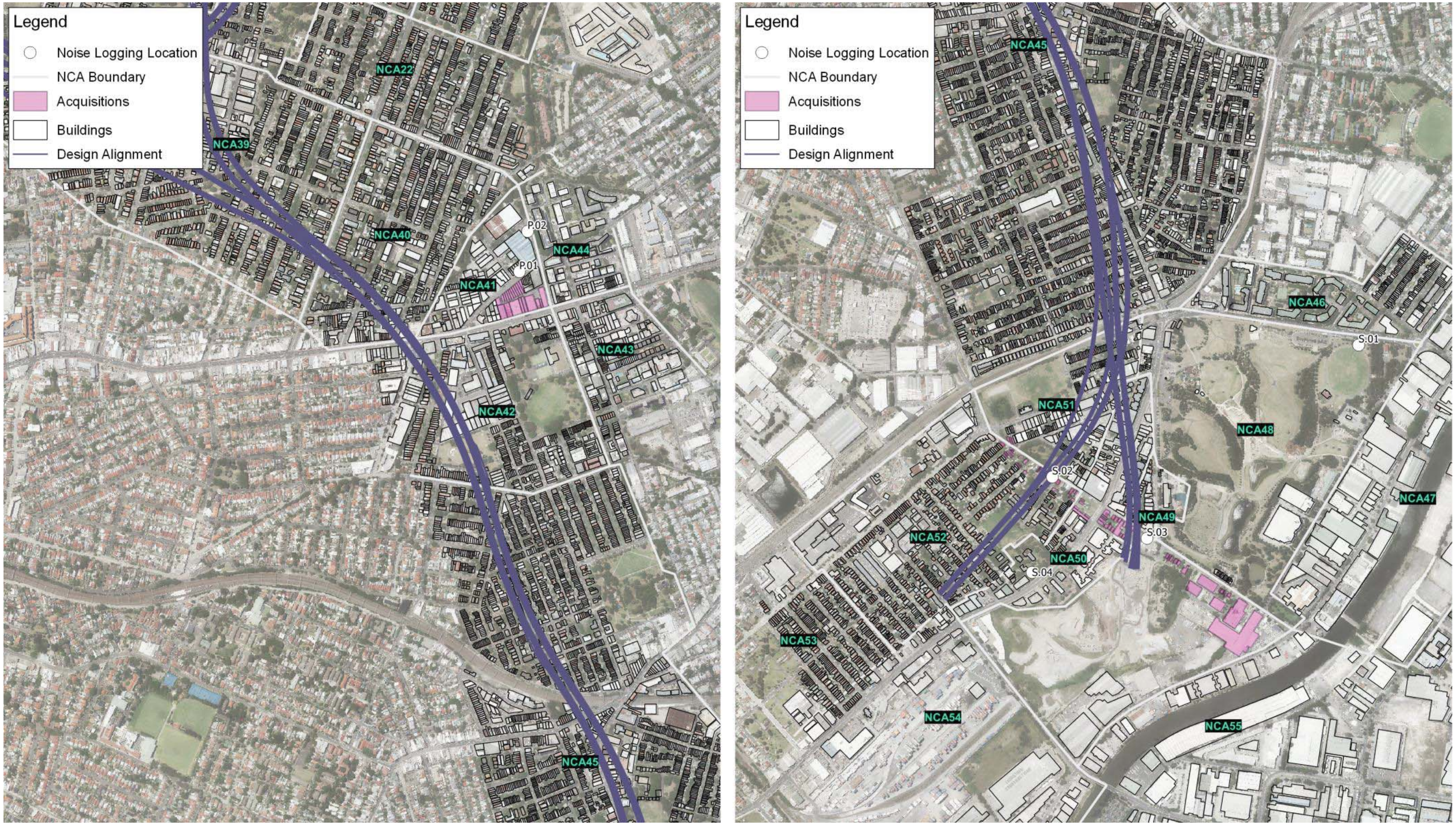


Figure 3-3 **Site plan and NCA boundary map (southern section)**

3.3 Purpose of noise monitoring

The measured noise levels within the study area are used to identify the existing levels of environmental noise. These measured noise levels inform the following key aspects of this assessment:

- Validation of the noise model. Due to the large number of noise sensitive receivers considered in this assessment, it is not practicable to measure noise at each receiver. Representative locations suitable for validation of a prediction model (see **section 4.8.3**) are therefore required. Loggers in these locations are used to quantify existing road traffic noise levels, generally near the roads so as to minimise the influence of other ambient noise sources
- Estimation of existing maximum road traffic noise events. Loggers in these locations are used to quantify existing maximum noise levels representative of the immediately adjacent receivers
- Determine noise goals for fixed facilities and construction activities at the most exposed locations. Loggers in these locations are used to quantify existing background noise levels representative of the immediately adjacent receivers
- Spot-checks to assess the suitability of construction noise mitigation measures. Loggers in these locations are used to quantify existing background noise levels representative of receivers located further back than the nearest receivers in key NCAs.

Operator attended measurements of ambient noise were completed during the noise logging surveys to determine the various noise sources in the locality that influence the existing noise environment, this is further discussed in **section 3.6**.

3.4 Noise monitoring locations

A noise monitoring survey was undertaken across the study area between July 2016 and November 2016 at 23 locations. This survey has been supplemented by noise measurements undertaken previously at 11 locations during 2014 and 2015 for the M4 East[1] and New M5[2] projects.

Noise monitoring equipment was deployed with consideration of other noise sources that may influence the measurements, accessibility and security, and with the consent of relevant land owners. The noise monitoring locations are identified in **Table 3-2** and on the site plan drawings in **Annexure B-1**.

Table 3-2 Noise monitoring locations

Noise monitoring							
ID	NCA	Noise monitoring location address	Noise monitoring period	Purpose			
				Background	Validation	Spot-check	Max noise
R.01	NCA24	Southern end of Hutcheson St, Rozelle	18/07/16-2/08/16	✓	✓		✓
R.02	NCA25	22 Lilyfield Rd, Rozelle	21/07/16-2/08/16	✓	✓		✓
R.03	NCA29	69 Victoria Rd, Rozelle	18/07/16-2/08/16	✓	✓		✓
R.04	NCA26	27 Victoria Rd, Rozelle	26/07/16-2/08/16		✓		✓
R.05	NCA18	Adjacent to City West Link, Rozelle Rail Yard - East	18/07/16-2/08/16		✓		✓

[1] WestConnex M4 East EIS – Construction and Operational Noise and Vibration Impact Assessment.

[2] WestConnex New M5 EIS – Technical Working Paper: Noise and Vibration.

Noise monitoring							
ID	**NCA**	**Noise monitoring location address**	**Noise monitoring period**	**Purpose**			
				Background	**Validation**	**Spot-check**	**Max noise**
R.06	NCA18	Adjacent to City West Link, Rozelle Rail Yard - West	18/07/16-2/08/16		✓		✓
R.07	NCA26	24 Chapman Rd, Annandale	18/07/16-2/08/16				✓
R.08	NCA23	279 Johnston St, Annandale - West	18/07/16-2/08/16		✓	✓	✓
R.09	NCA23	279 Johnston St, Annandale - East	18/07/16-2/08/16	✓	✓		✓
R.10	NCA23	Adjacent to The Crescent, Annandale	21/07/16-2/08/16			✓	✓
R.11[1]	NCA20	Adjacent to Brenan St, Lilyfield	26/07/16		✓		✓
R.12	NCA19	104 Cecily St, Lilyfield	20/09/16-27/09/16			✓	
R.13[2]	NCA24	50 Burt St, Rozelle	14/09/16-27/09/16			✓	
R.14	NCA20	54 Gladstone St, Lilyfield	14/09/16-27/09/16	✓		✓	
R.15	NCA21	55 Pritchard St, Annandale	18/10/16-25/10/16	✓			
R.16[1]	NCA27	Adjacent to Eglinton Rd, Glebe	11/11/16-17/11/16	✓			
I.01[2]	NCA35	28 Warayama Pl, Rozelle	26/09/16-4/10/16	✓	✓		✓
I.02	NCA33	198 Victoria Rd, Rozelle	13/09/16-4/10/16	✓	✓		✓
I.03	NCA36	9 Toelle St, Rozelle	18/10/16-25/10/16	✓			
L.01	NCA13	123 Frances St, Leichhardt	14/09/16-27/09/16	✓			
L.02	NCA09	99 Charles St, Lilyfield	19/09/16-27/09/16	✓			
P.01[2]	NCA41	62 Pyrmont Bridge Rd, Camperdown	28/10/16-4/11/16	✓			
P.02	NCA41	Coates Hire, Booth St, Camperdown	14/09/16-27/09/16				
H.01[2,3]	NCA02	1A Wattle St, Haberfield	26/03/14-8/04/14	✓			
H.02[3]	NCA06	141 Alt St, Haberfield	26/03/14-9/04/14	✓			
H.03[3]	NCA01	119 Alt St, Ashfield	26/03/14-9/04/14	✓			
H.04[3]	NCA03	35 Wattle St, Haberfield	26/03/14-4/04/14	✓			
H.05[3]	NCA06	259 Ramsay St, Haberfield	26/03/14-9/04/14				
H.06[3]	NCA04	68 Wattle St, Haberfield	26/03/14-9/04/14	✓			
S.01[4]	NCA48	400 Sydney Park Rd, Alexandria	5/12/14-19/12/14	✓			
S.02[4]	NCA52	108 Campbell St, St Peters	31/08/15-10/09/15	✓			
S.03[4]	NCA49	18 Campbell St, St Peters	5/12/14-21/12/14	✓			
S.04[4]	NCA50	187-211 Princes Hwy, St Peters	5/12/14-19/12/14	✓			
S.05[4]	NCA54	608 Princes Hwy, Tempe	5/12/14-19/12/14	✓			

Notes:

1. Extended attended measurements have been conducted in lieu of unattended monitoring at these locations
2. Loggers at these locations at a height of three metres to obtain line of sight of the road over boundary wall
3. Noise monitoring details and results for these locations are sourced from M4 East EIS
4. Noise monitoring details and results for these locations are sourced from New M5 EIS

Noise monitoring equipment was set up with microphones at 1.5 metres above the ground level unless otherwise noted. All microphones were fitted with wind shields.

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

3.5 Unattended airborne noise monitoring

3.5.1 Methodology

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

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

3.5.2 Noise monitoring results

The results of the unattended ambient noise surveys are summarised in **Table 3-3** as the Rating Background Level (RBL) noise levels for the ICNG daytime, evening and night-time periods, and the L_{Aeq} (energy averaged) noise levels for the RNP daytime (15-hour) and night-time (9-hour) periods. The 24 hour daily noise levels at each monitoring location are graphically presented in **Annexure C**.

Table 3-3 Summary of unattended noise logging results

Noise monitoring							
Noise monitoring location	Noise level (dBA)						
	ICNG defined time periods[1]			RNP defined time periods[2]			
	Daytime RBL	Evening - RBL	Night-time - RBL	Daytime - $L_{Aeq(15hour)}$	Night-time - $L_{Aeq(9hour)}$	Daytime - $L_{Aeq(1hour)}$	Night-time - $L_{Aeq(1hour)}$
R.01	54	52	44	64	58	66	66
R.02	51	51	45	57	54	58	59
R.03	61	60	44	70	68	72	72
R.04	65	63	51	71	67	72	72
R.05	61	60	51	70	67	71	71
R.06	57	55	47	63	60	64	64
R.07	55	52	43	65	60	66	67
R.08	49	46	38	63	58	65	65
R.09	49	45	36	61	55	62	62
R.10	54	45	39	65	58	67	66
R.11[3]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
R.12	37	38	32	n/a	n/a	n/a	n/a
R.13	41	39	32	n/a	n/a	n/a	n/a
R.14	44	42	35	n/a	n/a	n/a	n/a
R.15	48	48	42	n/a	n/a	n/a	n/a
R.16[3]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
I.01	65	60	46	72	68	74	73
I.02	63	58	43	73	69	75	74
I.03	44	40	31	n/a	n/a	n/a	n/a
L.01	51	47	40	n/a	n/a	n/a	n/a
L.02	51	49	42	n/a	n/a	n/a	n/a
P.01	51	49	41	n/a	n/a	n/a	n/a

Noise monitoring							
Noise monitoring location	Noise level (dBA)						
	ICNG defined time periods[1]			RNP defined time periods[2]			
	Daytime RBL	Evening - RBL	Night-time - RBL	Daytime - $L_{Aeq(15hour)}$	Night-time - $L_{Aeq(9hour)}$	Daytime - $L_{Aeq(1hour)}$	Night-time - $L_{Aeq(1hour)}$
P.02	53	50	46	n/a	n/a	n/a	n/a
H.01[4]	58	58	52	n/a	n/a	n/a	n/a
H.02[4]	46	46	43	n/a	n/a	n/a	n/a
H.03[4]	46	46	38	n/a	n/a	n/a	n/a
H.04[4]	58	55	44	n/a	n/a	n/a	n/a
H.05[4]	60	58	44	n/a	n/a	n/a	n/a
H.06[4]	56	53	43	n/a	n/a	n/a	n/a
S.01[5]	57	51	40	n/a	n/a	n/a	n/a
S.02[5]	50	46	39	n/a	n/a	n/a	n/a
S.03[5]	54	45	40	n/a	n/a	n/a	n/a
S.04[5]	52	50	44	n/a	n/a	n/a	n/a
S.05[5]	58	56	49	n/a	n/a	n/a	n/a

Notes:

1. ICNG Governing Periods – Day: 7.00 am to 6.00 pm Monday to Saturday, 8.00 am to 6.00 pm Sunday; Evening: 6.00 pm to 10.00 pm; Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday
2. RNP Assessment Time Periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am (weekly data)
3. Extended attended measurements have been conducted in lieu of unattended monitoring at these locations. Attended measurements are detailed **Annexure C**
4. Noise monitoring data for these locations are taken from the M4 East EIS assessment
5. Noise monitoring data for these locations are taken from the New M5 EIS assessment

3.6 Attended airborne noise monitoring

Attended airborne noise monitoring was conducted at each of the unattended locations as part of the M4–M5 Link project noted in **Table 3-2** (23 in total). At each location the attended measurements were performed for 15 minutes using a calibrated Brüel and Kjær 2260 Precision Sound Level Meter. Wind speeds were less than 5 m/s at all times, and all measurements were performed at a height of 1.5 metres above ground level.

During each measurement the observer noted the various noise sources in the locality and their various contributions to the overall measured noise level. Calibration of the sound level meter was checked before and after each measurement and the variation in calibration at all locations was found to be within acceptable limits at all times.

Detailed observations of the noise environment at each of the attended monitoring locations are provided in **Annexure C**. The attended monitoring data is generally consistent with the results of the unattended noise monitoring and shows that existing ambient noise levels are typically dominated by the major roads in the area.

4 Assessment methodology

4.1 Construction noise and vibration guidelines and policies

4.1.1 List of guidelines

The Roads and Maritime *Construction Noise and Vibration Guideline,* August 2016 (CNVG) outlines Roads and Maritime's approach to assessing and mitigating construction noise. This guideline should be read in conjunction with other relevant policy and guidelines discussed in this section.

All guidelines referenced in this noise and vibration assessment are listed in **Table 4-1**.

Table 4-1 Construction noise and vibration guidelines and policies

Noise and vibration guidelines and policies	
Construction noise and vibration	
Guideline/policy name	**When guideline is used**
Construction Noise and Vibration Guideline (Roads and Maritime 2016)	Assessment of airborne noise, ground-borne noise and vibration impacts on sensitive receivers
Interim Construction Noise Guideline (DECC 2009)	Assessment of airborne noise and ground-borne noise impacts on sensitive receivers
Assessing Vibration: a technical guideline (DECC 2006)	Assessment of vibration impacts on sensitive receivers
BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings* Part 2, BSI, 1993	Assessment of vibration impacts on non-heritage sensitive structures (damage)
DIN 4150:Part 3-1999 *Structural vibration - Effects of vibration on structures*, Deutsches Institut für Normung, 1999	Screening assessment of vibration impacts on heritage sensitive structures (damage)
Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives*	Assessment of blasting impacts on sensitive receivers

4.1.2 Airborne noise

The *Interim Construction Noise Guideline* (ICNG) (DECC 2009) sets out ways to assess and manage the impacts of demolition and construction noise on residences and other sensitive land uses. It does this by presenting assessment approaches that are tailored to the scale of the proposed works.

The ICNG requires project specific Noise Management Levels (NMLs) to be established for noise affected receivers. In the event construction noise levels are predicted to be above the NMLs, feasible and reasonable work practices are investigated to minimise noise emissions.

Residential receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at adjacent residential receivers based on measured $L_{A90(15minute)}$ rating background noise levels (RBL), as described in **Table 4-2**.

Table 4-2 Determination of NMLs for residential receivers

Time of day	NML $L_{Aeq(15minute)}$	How to apply
Standard hours Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected level RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noise intensive activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	RBL[1] + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Notes:

1. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours) as described in the NSW Industrial Noise Policy

Commercial receivers

The ICNG notes that due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories:

- Industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.

The external noise levels should be assessed at the most-affected occupied point of the premises.

Other sensitive land uses

The ICNG's quantitative assessment method provides NMLs for other sensitive land uses, such as educational institutions, hospitals, medical facilities and outdoor recreational areas. These land uses are considered potentially sensitive to construction noise only when the properties are in use.

The ICNG does not however provide an NML for all classifications of sensitive land use. Where sensitive land uses with no classification are identified within a construction noise catchment, the following guidance is given:

> *The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).*

The project specific $L_{Aeq(15minute)}$ NMLs for other non-residential noise sensitive receivers from the ICNG are provided in **Table 4-3**.

Table 4-3 NMLs for other sensitive receivers

Land use	NML $L_{Aeq(15minute)}$ (Applied when the property is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. reading, meditation)	External noise level 60 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS 2107 for specific uses.

For sensitive receivers such as schools and places of worship, the NMLs presented in **Table 4-3** are based on internal noise levels. For the purpose of this assessment, it is conservatively assumed that all schools and places of worship have openable windows that can open. On the basis that external noise levels are typically 10 dBA higher than internal noise levels when windows are open, an external NML of 55 dBA $L_{Aeq(15minute)}$ has been adopted.

Other noise-sensitive receivers require separate project specific noise goals and, as per the guidance in the ICNG, NMLs for these receivers have been derived from the internal levels presented in AS 2107.

The ICNG and AS2107 do not provide specific guideline noise levels for childcare centres. Childcare centres generally have internal play areas and sleeping areas. For internal play areas an internal NML of 55 dBA $L_{Aeq(15minute)}$ has been adopted together with an internal NML of 40 dBA $L_{Aeq(15minute)}$ (when in use) for sleeping areas.

On the assumption that windows and doors of childcare centres may be opened, an external NML of 65 dBA $L_{Aeq(15minute)}$ for play areas has been applied at the facade and would also be applicable to external play areas. For sleeping areas on the assumption that windows are open, an external NML of 50 dBA $L_{Aeq(15minute)}$ has been applied. Given specific layouts for childcare centres are unknown during the preparation of the EIS, a NML of 50 dBA has been used to assess construction noise impacts to childcare centres.

Sleep disturbance

The most recent guidance in relation to sleep disturbance is contained in the EPA's *Application Notes - NSW Industrial Noise Policy* (2010). The pertinent section of the Application Notes states the following:

> *"DECC*[W] *reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, DECC*[W] *recognised that current sleep disturbance criterion of an L_{A1}, (1 minute) not exceeding the L_{A90}, (15 minute) by more than 15 dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DECC*[W] *will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or L_{A1}, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *How often high noise events will occur*
> - *Time of day (normally between 10 pm and 7 am)*
> - *Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods)*
> - *The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under "fast" time response. DECC[W] will accept analysis based on either LA1, (1 minute) or LAmax".*

For the purposes of this assessment a night-time sleep disturbance "screening criterion" noise goal of RBL +15 dBA has been used. The term 'screening criterion' indicates a noise level that is intended as a guide to identify the likelihood of sleep disturbance. It is not a firm criteria to be met, however where the criterion is met sleep disturbance is considered to be unlikely. When the screening criterion is not met, a more detailed analysis is required.

With regard to reaction to potential sleep disturbance awakening events, the RNP gives the following guidance:

> *From the research on sleep disturbance to date it can be concluded that:*
>
> - *maximum internal noise levels below 50–55 dBA are unlikely to awaken people from sleep*
> - *one or two noise events per night, with maximum internal noise levels of 65–70 dBA, are not likely to affect health and wellbeing significantly.*

4.1.3 Road traffic noise

When trucks and other vehicles are operating within the boundaries of construction ancillary facilities, road vehicle noise contributions are included in the predicted $L_{Aeq(15minute)}$ noise emissions and assessed against the criteria in **section 4.1.2**.

When construction related traffic moves onto the public road network a different noise assessment methodology is appropriate, as vehicle movements are regarded as 'additional road traffic' rather than as part of the construction works and as such would be assessed under the Roads and Maritime *Noise Criteria Guideline* (NCG) (2015). The NCG documents Roads and Maritime's approach to implementing the *Road Noise Policy* (RNP).

The NCG requires that an initial screening test should be applied by evaluating whether noise levels would increase by more than 2 dBA (an increase in the number of vehicles of around 60 per cent) due to construction traffic or a temporary reroute due to a road closure. Where increases are 2 dBA or less then no further assessment is required as noise level changes would most likely not be perceptible to most people.

Where noise levels increase by more than 2 dBA (ie 2.1 dBA or greater) further assessment is required using criteria presented in the NCG (see **Table 4-4**).

Table 4-4 NCG criteria for assessing construction vehicles on public roads

NCG criteria			
Road category	**Type of project/land use**	**Assessment criteria (dBA)**	
		Daytime (7 am - 10 pm)	**Night-time (10 pm - 7 am)**
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

4.1.4 Ground-borne noise

The CNVG provides residential NMLs for ground-borne noise, which are applicable when ground-borne noise levels are higher than the corresponding airborne construction noise levels. The CNVG provides ground-borne noise levels at residences for evening and night-time periods only, as the objectives aim to protect amenity and minimise potential sleep disturbance. The following ground-borne noise levels are applicable for residences:

- Evening 40 dBA $L_{Aeq(15minute)}$
- Night-time 35 dBA $L_{Aeq(15minute)}$.

For commercial receivers such as offices and retail areas, the CNVG does not provide guidance in relation to acceptable ground-borne noise levels. For the purpose of this assessment, an internal NML of 60 dBA $L_{Aeq(15minute)}$ has been adopted in order to assist in identifying potential impacts. This is consistent with the internal NMLs adopted for commercial receivers on similar large infrastructure projects and take guidance from Australian Standard 2107.

These NMLs are applicable to residences and commercial receivers located above tunnelling works, and could also apply to other construction activities such as rock-breaking in an adjoining building where ground-borne noise levels may be higher than airborne noise levels. This situation may occur at construction ancillary facilities where airborne noise impacts are shielded by noise barriers or other structures, or noise sensitive areas within residential or commercial buildings which are not directly affected by the airborne noise component of nearby construction works.

4.1.5 Vibration

The effects of vibration on buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed (human comfort)
- Those where the building contents may be affected (effects on building contents)
- Those in which the integrity of the building or the structure itself may be prejudiced (structural damage).

Human comfort vibration

The EPA's *Assessing Vibration: a technical guideline* (2006) provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV) rather than a continuous vibration level. The VDV is dependent upon the level and duration of the vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the guideline for intermittent nature are presented in **Table 4-5**.

Table 4-5 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Human comfort vibration (*Assessing Vibration: a technical guideline*)				
Location	**Daytime**[1]		**Night-time**[1]	
	Preferred value	**Maximum value**	**Preferred value**	**Maximum value**
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, school, educational intuitions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. Daytime is 7:00 am to 10:00 pm and night-time is 10:00 pm to 7:00 am
2. Examples include hospital operating theatres and precision laboratories where operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source BS 6472-1992

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 found in most buildings that is not particularly vibration sensitive. For most receivers, the controlling vibration criterion is the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on typical building contents.

Where appropriate, objectives for the satisfactory operation of vibration sensitive critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives.

Structural damage vibration

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* and British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor in nature, is readily repairable and does not affect the structural integrity of the building.

The recommended vibration limits from BS 7385 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings are shown in **Table 4-6**.

Table 4-6 Transient vibration guide values for minimal risk of cosmetic damage (BS 7385)

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

Notes:

1. The guide values relate predominately to transient vibration which does not give rise to resonant responses in structures and low-rise buildings. In the event continuous vibration gives rise to magnification of vibration by resonance (specific conditions where the structure can readily store and transfer vibration energy), then the guide values may need to be reduced by up to 50 percent

Heritage and vibration sensitive structures

The Roads and Maritime CNVG notes that separate guidance for assessment of heritage structures is contained in the German Standard DIN 4150: Part 3-1999 *Structural vibration – Effects of vibration on structures*, Deutsches Institut für Normung, 1999.

For continuous long-term vibration or repetitive vibration with the potential to cause fatigue effects, DIN 4150 provides the following Peak Particle Velocity (PPV) values as safe limits, below which superficial cosmetic damage is not to be expected:

- 10 mm/s for commercial buildings and buildings of similar design
- 5 mm/s for dwellings and buildings or similar design
- 2.5 mm/s for buildings of particular sensitivity (structurally unsound).

For short-term vibration events (ie those unlikely to cause resonance or fatigue), DIN 4150 provides the criteria shown in **Table 4-7**. These are maximum levels measured in any direction at the foundation or in the horizontal axes in the plane of the uppermost floor.

Table 4-7 DIN 4150 structural damage – safe limits for short-term building vibration

Group	**Type of structure**	**Peak particle velocity (mm/s)**			
		At foundation			**Plane of floor of uppermost storey**
		1 Hz to 10 Hz	**10 Hz to 50 Hz**	**50 Hz to 100 Hz[1]**	**All frequencies**
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 at 10 Hz increasing to 40 at 50 Hz	40 at 50 Hz increasing to 50 at 100 Hz	40
2	Dwellings and buildings of similar design and/or use	5	5 at 10 Hz increasing to 15 at 50 Hz	15 at 50 Hz increasing to 20 at 100 Hz	15
3	Structures that because of their particular sensitivity to vibration (structurally unsound), do not correspond to those listed in Lines 1 or 2	3	3 at 10 Hz increasing to 8 at 50 Hz	8 at 50 Hz increasing to 10 at 100 Hz	8

Notes:

1. For frequencies above 100 Hz the upper value in this column should be used

The minimum ’safe limit’ of peak vibration velocity at low frequencies for commercial buildings and buildings of similar design is 20 mm/s (Group 1). For dwellings and buildings of similar design and/or use it is 5 mm/s (Group 2) and for structures which may be particularly sensitive to ground vibration, such as historic buildings which are structurally unsound (Group 3), it is 3 mm/s. This latter criterion could also be applied to buried archaeological artefacts.

As opposed to the ‘minimal risk of cosmetic damage’ approach adopted in BS 7385 (95 per cent probability of no effect), the ’safe limits’ given in DIN 4150 are the levels up to which no damage due to vibration effects has been observed for the particular class of building.

’Damage’ is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

4.1.6 Blasting

Project blasting criteria (human comfort)

Guidance in relation to acceptable overpressure and vibration from blasting is provided in the ICNG, which specifies that the assessment should be based on the levels in the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC 1990).

For airblast overpressure the criteria is stated as:

- Recommended maximum level of 115 dBL (linear peak) – this may be exceeded on up to five per cent of the total number of blasts over a period of 12 months
- A maximum level of 120 dBL (linear peak) should not be exceeded at any time.

For ground vibration the criteria is stated as:

- Recommended maximum level of 5 mm/s (peak particle velocity) – this may be exceeded on up to 5 per cent of the total number of blasts over a period of 12 months
- A maximum level of 10 mm/s (peak particle velocity) should not be exceeded at any time.

This criteria relates to sensitive sites (includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people).

The blast vibration criteria identified in ANZECC 1990 are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as near to mining sites. For projects with a shorter duration of blasting of 12 months or less (such as this one), a higher vibration criteria may be reasonable. For this project the location of the blast moves along the alignment such that any one receiver would be affected for only a short proportion of the overall construction program.

Table J4.5(A) in Appendix J of AS2187 presents vibration limits designed to safeguard human comfort in relation to blasting that have been used by some authorities as it defines clearer vibration limits which are dependent on the specific duration of the project. Based on the limitations of ANZECC 1990 and further guidance in AS2187 it is recommended that a human comfort vibration limit of 10 mm/s (peak particle velocity) for blasting operations lasting less than 12 months be applied to this project which is consistent with the conditions of approval for previous WestConnex projects.

Project blasting criteria (control of damage)

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 as they “are applicable to Australian conditions”. The criteria are presented in **Table 4-6**.

BS7385 states that “a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive”. Nominating appropriate criteria for heritage buildings generally require site inspections and should be confirmed during detailed design.

In relation to damage from airblast, AS2187 notes that from Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBL.

Recommended blasting hours

For blasting, the recommended standard hours of construction in NSW are applicable:

- 9:00 am to 5:00 pm Monday to Friday
- 9:00 am to 1:00 pm Saturday
- No blasting on Sundays and public holidays.

Other hours may be worked if approved by the relevant authority.

4.2 Construction airborne noise prediction methodology

4.2.1 Modelling

Identifying scenarios

People are usually more tolerant to noise and vibration during the construction phase of a project than during normal operation. This response results from recognition that the construction emissions are of a temporary nature – especially if the most noise-intensive construction impacts occur during the less sensitive daytime period. For these reasons, acceptable noise and vibration levels are normally higher during construction than during operations.

Construction often requires the use of heavy machinery that can generate high noise and vibration levels at nearby buildings and receivers. For some equipment, there is limited opportunity to mitigate the noise and vibration levels in a cost-effective manner and hence the potential impacts should be minimised by using feasible and reasonable management techniques.

At any particular location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are undertaken, and the character of the noise or vibration emissions.

A number of construction scenarios have been developed to assess the likely impacts associated with the project. These scenarios, shown in **Table 4-8**, are referenced throughout the assessment in **Chapter 5** and have been used to group a number of similar construction activities. It should be noted that these scenarios may change during detailed design when additional information regarding construction activities and staging is available.

Table 4-8 Summary of work scenarios and associated activities

Scenario	Typical activities
Site establishment Prior to the construction of the project, various activities will be required to be undertaken at each construction site to establish the works area	• Demolition of existing structures • Services and utility diversions • Traffic management changes and measures • Establishment of construction facilities and access • Installation of environmental controls • Vegetation clearance and topsoil stripping
Earthworks	• Construction of dive, cut and cover tunnel and ventilation shaft structures • Construction of retaining and drainage structures
Tunnelling works Road-headers would be launched from various points along the alignment to excavate the mainline tunnels	• Tunnelling (road-headers and drill and blast) • Spoil handling • Temporary ventilation • Water treatment plant • Supporting services (car parking and laydown activities) • Electrical and mechanical fitout

Scenario	Typical activities
Surface roadworks	• Piling • Bridge works • Concrete works • Road paving and line marking
Construction of operational facilities	• Ventilation building construction/fitout • Substation, and water treatment plants
Site rehabilitation and landscaping	• Landscaping • Final earth grading

Source location

Consistent with the requirements of the ICNG, this assessment provides a 'realistic worst case' noise impact assessment for construction scenarios based on proposed works within a 15-minute period. This is typically associated with works located nearest to a particular receiver.

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

- The position of the works within the site and distance to the nearest sensitive receiver
- The overall duration of the works
- The intensity of the noise levels
- The time at which the works are undertaken
- The character of the noise.

Noise levels at sensitive receivers can be significantly lower than the worst case scenario when the construction works move to a more distant location in a works area. This concept is shown in **Figure 4-1**.

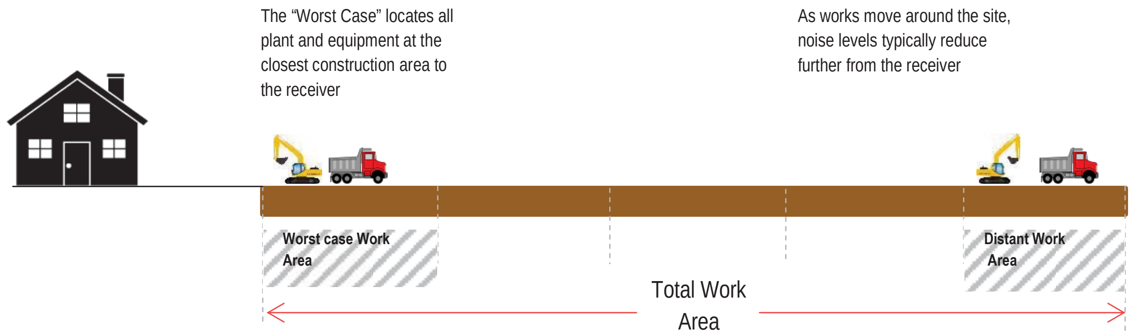


Figure 4-1 Conceptual illustration of work areas

Calculation type

To quantify noise levels from the construction activities a computer noise prediction model using the ISO 9613 algorithms was developed using SoundPLAN software. Local terrain, receiver buildings and structures have been digitised in the noise model to develop a three-dimensional representation of the construction ancillary facilities and surrounding environment. In accordance with the Roads and Maritime CNVG, noise levels are predicted at all receivers in the noise catchment areas surrounding the works.

4.2.2 Working hours

The majority of above ground construction works would be undertaken during the standard working hours of between:

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

There would generally be no above ground construction works on Sundays or public holidays, with the exception of those activities required to be undertaken outside of standard construction hours (outlined below).

Proposed construction hours are summarised in **Table 4-9**. Construction activities required for the project would be managed in six broad categories:

Table 4-9 Construction hours

Activity	Construction hours	Comments or exception
Tunnelling, tunnelling support and underground construction activities		
Tunnelling and underground excavation	24 hours a day, up to seven days a week.	• Activities that support tunnelling works may need to occur 24 hours a day, up to seven days a week
Underground construction and tunnel fitout	24 hours a day, up to seven days a week.	• Activities that support underground construction and tunnel fitout may need to occur 24 hours a day, up to seven days a week • Deliveries for underground construction and tunnel fitout may need to occur 24 hours a day, up to seven days a week
Surface construction activities		
Demolition and surface construction activities	7.00 am to 6.00 pm on weekdays, 8.00 am to 1.00 pm on Saturdays, no works on Sundays or public holidays.	• Non-intrusive preparatory work, repairs or maintenance may be carried out on Saturday afternoons between 1.00 pm and 5.00 pm or Sundays between 8.00 am and 5.00 pm. • Activities requiring the temporary possession of roads or to accommodate road network requirements may need to be carried out outside the standard daytime construction hours during periods of low demand to minimise safety impacts and inconvenience to commuters
Construction traffic for material supply and spoil handling		
Construction traffic for material supply to, and spoil handling from, tunnelling and underground excavation	24 hours a day, up to seven days a week.	• Spoil handling from the Darley Road civil and tunnel site (C4) would only occur between 7.00 am and 6:00 pm Monday to Friday and 8.00 am and 1.00 pm on Saturdays. No spoil would be removed from this site on Sundays or public holidays.
Blasting and rock-breaking		
Blasting	Between 9.00 am and 5.00 pm, Mondays to Fridays and 9.00 am to 1.00 pm on Saturdays	• Blasting would occur up to six days a week (Monday to Saturday). Blasts would be limited to one single detonation in any one day per receiver group, unless otherwise agreed by the NSW EPA through consultation on the project Construction Noise and Vibration Management Plan.
Rock-breaking (with potential for impulsive or tonal noise impact at a sensitive receiver)	Between 8.00 am and 6.00 pm Monday to Friday and 8.00 am to 1.00 pm Saturdays, with respite periods.	• Respite periods would be scheduled to minimise the frequency and duration of extended rock-breaking activities with potential for impulsive or tonal noise emissions.
Minor or ancillary activities		
Minor activities	At any time	• Minor activities would include activities that do not

Activity	Construction hours	Comments or exception
		lead to an exceedance of the applicable noise management level at an affected receiver.
Activities authorised by an environment protection licence	As specified in the environment protection licence.	• Construction activities would be managed as required by the Environment Protection Licence.
Emergency or directed activities		
Emergency or directed activities	At any time	• Activities would be carried out as directed by a relevant authority • Activities would be carried out if required to prevent an imminent loss of life or environmental damage.

A summary of the proposed construction work hours at each construction ancillary facility is provided in **Table 4-10**.

Table 4-10 Construction work hours at construction ancillary facilities

Construction ancillary facility	Type of construction activity	Construction work hours
Wattle Street civil and tunnel site (C1a)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Haberfield civil and tunnel site (C2a)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Northcote Street civil site (C3a)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
	Construction workforce parking	• 24 hours a day, seven days a week
Parramatta Road West civil and tunnel site (C1b)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Haberfield civil site (C2b)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Parramatta Road East civil site (C3b)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
	Construction workforce parking	• 24 hours a day, seven days a week
Darley Road civil and tunnel site (C4)	Tunnelling and spoil handling[2]	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Rozelle civil and tunnel site (C5)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
The Crescent civil site (C6)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays

Construction ancillary facility	Type of construction activity	Construction work hours
Victoria Road civil site (C7)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Iron Cove Link civil site (C8)	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Pyrmont Bridge Road tunnel site (C9)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays
Campbell Road civil and tunnel site (C10)	Tunnelling and spoil handling	• 24 hours a day, seven days a week
	Civil construction[1]	• 7.00 am to 6.00 pm Monday to Friday • 8.00 am to 1.00 pm Saturdays

Notes:

1. Some works outside of standard construction hours may be required
2. Spoil haulage from the Darley Road civil and tunnel site (C4) would occur between 7.00 am and 6.00 pm Monday to Friday and 8.00 am and 1.00 pm on Saturdays

4.3 Construction road traffic noise prediction methodology

The proposed access to the construction ancillary facilities is summarised in **Table 4-11**. Wherever possible, access is proposed to be gained directly from major arterial roads.

Table 4-11 Indicative access routes to and from construction ancillary facilities

Site	Access and egress points (heavy vehicles)	Access and egress points (light vehicles)
Wattle Street civil and tunnel site (C1a)	Parramatta Road then Wattle Street via M4-M5 Link entry and exit ramps	Parramatta Road then Wattle Street northern (eastbound) carriageway (right in, right out)
Haberfield civil and tunnel site (C2a)	Below ground via the WestConnex M4 East tunnels Above ground: Wattle Street (left in, left out)	Parramatta Road then Wattle Street southern (westbound) carriageway (left in, left out) Walker Avenue
Northcote Street civil site (C3a)	Parramatta Road (left-in, left-out)	Wolseley Street Wattle Street (left-out)
Parramatta Road West civil and tunnel site (C1b)	Parramatta Road (left-in, left-out) Alt Street	Parramatta Road (left-in, left-out) Alt Street
Haberfield civil site (C2b)	Wattle Street (left-in, left-out) Parramatta Road (left-in, left-out)	Wattle Street (left-in, left-out) Parramatta Road (left-in, left-out)
Parramatta Road East civil site (C3b)	Parramatta Road (left-in, left-out)	Parramatta Road (left-in, left-out) Alt Street Bland Street
Darley Road civil and tunnel site (C4)	City West Link then Darley Road (right in, left out)	City West Link then Darley Road (right in, left out)

Site	Access and egress points (heavy vehicles)	Access and egress points (light vehicles)
Rozelle civil and tunnel site (C5)	City West Link (left in, right out)	Lilyfield Road
The Crescent civil site (C6)	The Crescent (left in, right out)	The Crescent
Victoria Road civil site (C7)	Victoria Road (left-in, left-out)	Victoria Road (left in, left out) Hornsey Street
Iron Cove Link civil site (C8)	Victoria Road (left in, left out)	Victoria Road (left in, left out) Toelle Street
Pyrmont Bridge Road tunnel site (C9)	Parramatta Road (left in) Pyrmont Bridge Road (left out)	Pyrmont Bridge Road
Campbell Road civil and tunnel site (C10)	Albert Road via Campbell Road and Princes Highway	Albert Road via Campbell Road

4.3.1 Estimating duration

The overall effect of a project and the likelihood of adverse community reaction depends on both the level of noise and the duration of the works. While the assessment has been based on realistic worst case noise predictions, it is noted that noise levels will likely be less than the worst case level for significant periods of time.

Noise levels will typically be seen to decrease at a receiver as works move away and as such, it is important to correlate the duration of the potential impacts along with the corresponding level. Approximate durations have been estimated by comparing the size of the likely work area in relation to the overall work site.

Actual impact durations may vary depending on site conditions and finalised methodology and would be considered in the site specific Construction Noise and Vibration Management Plan (CNVMP).

4.3.2 Cumulative construction activities

Concurrent noise impacts warrant assessment where more than one works activity operates at the same time and in the same location such that the same receiver is potentially impacted by noise from more than one works. Although the construction timeframes shown for each works area have activities extending for relatively long durations over the construction phase, in practice, noise impacts from above ground construction activities generally move around the site which would result in the worst case impacts at any given receiver being of far shorter duration.

Activities associated with fixed sites such as compounds, spoil handing sites and tunnelling support sites would be restricted to within the general locality of the site and likely affect the same nearby receivers for potentially longer periods than the mainline tunnel works.

A cumulative impact assessment has been included for activities identified to have the potential to operate concurrently within a restricted locality to one another that also impact a similar grouping of receivers.

4.4 Construction ground-borne noise prediction methodology

Ground-borne noise impacts at the various sensitive receivers above the proposed tunnelling works have been predicted using a three-dimensional model which uses elevation data for all receivers in the study area, together with the horizontal and vertical information supplied for the underground section of the road alignment.

Figure 4-2 presents indicative ground-borne noise levels for road-headers as measured on other Sydney tunnelling projects. As the figure demonstrates, ground-borne noise levels reduce as the distance between plant and the receiver increases.

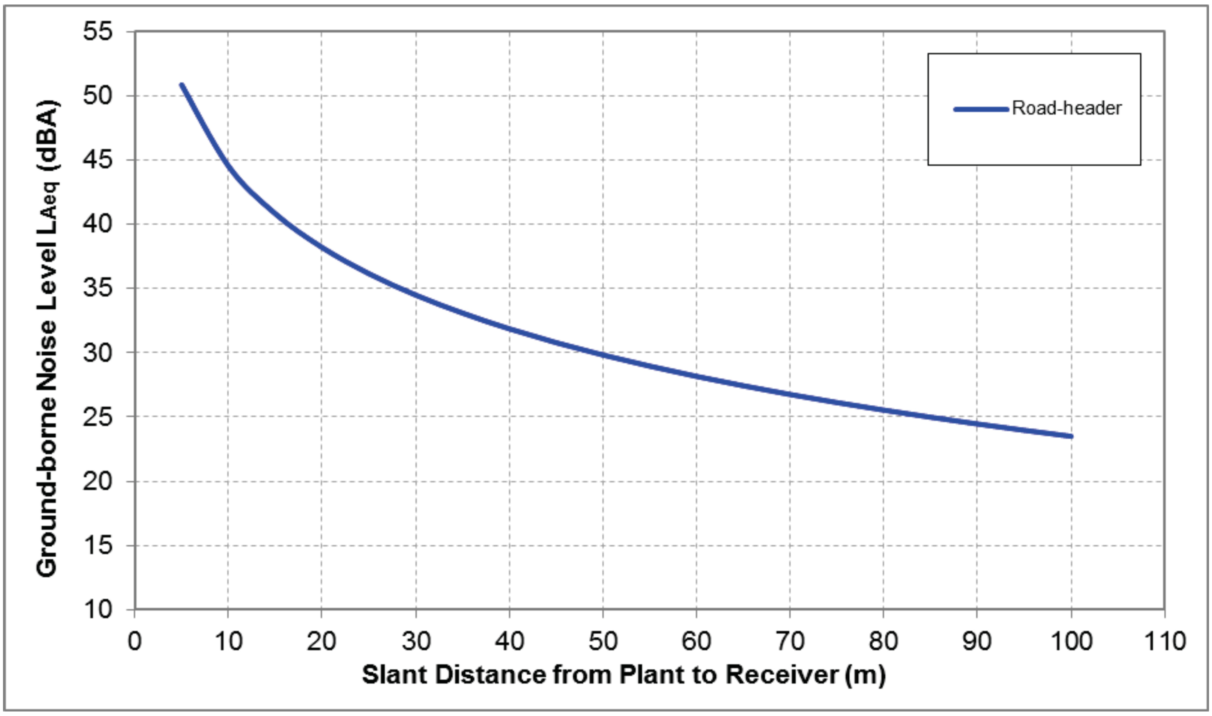


Figure 4-2 Indicative ground-borne noise levels from road-headers

Source: Australian Acoustical Society Technical Meeting – Tunnelling Noise and Vibration Management, Wilkinson Murray, December 2003

The ground-borne noise model calculates the three-dimensional slant distance from the tunnel crown to each sensitive receiver situated above the alignment, where tunnelling works are proposed.

4.5 Construction vibration prediction methodology

Propagation of vibration emitted from a source is site specific with the level of vibration potentially experienced at a receiver dependent upon the vibration energy generated by the source, the predominant frequencies of vibration, the localised geotechnical conditions and the interaction of structures and features which can dampen vibration.

While the ground dampening characteristics may vary between the ground types likely to be found in study area (understood to largely comprise sandstone and shale), this is expected to have negligible effect on the vibration predicted at the relatively short distances to the nearest receivers. It should be noted that the source frequency can change with different ground types and local site conditions should be considered further during the detailed design. The recommended minimum working distances for construction plant in **Table 4-12** are referenced from the CNVG and DIN 4150.

Consistent with BS 7385 and the Assessing Vibration guideline, the recommendations are for the practical management of potential vibration to minimise the likelihood of cosmetic damage to buildings and disturbance or annoyance in humans. The human comfort (response) minimum working distances are conservative, developed with reference to the more stringent objectives for continuous vibration for typical residential building constructions.

Table 4-12 Recommended minimum working distances for vibration intensive plant

Plant item	Rating/description	Minimum working distance			
		Cosmetic damage			Human response[1]
		Residential and light commercial[1]	Group 2 (typical)[2]	Group 3 (structurally unsound)[2]	
Vibratory roller	< 50 kn (Typically 1-2t	5 m	7 m	11 m	15 m to 20 m
	< 100 kn (Typically 2-4t)	6 m	8 m	13 m	20 m
	< 200 kn (Typically 4-6t)	12 m	16 m	15 m	40 m
	< 300 kn (Typically 7-13t)	15 m	20 m	31 m	100 m
	> 300 kn (Typically 13-18t)	20 m	26 m	40 m	100 m
	> 300 kn (Typically > 18t)	25 m	33 m	50 m	100 m
Small hydraulic hammer	300 kg - 5 to 12t excavator	2 m	3 m	5 m	7 m
Medium hydraulic hammer	900 kg - 12 to 18t excavator	7 m	10 m	15 m	23 m
Large hydraulic hammer	1600 kg - 18 to 34t excavator	22 m	29 m	44 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	3 m to 26 m[4]	5 m to 40 m[4]	20 m to 100 m[4]
Pile boring	≤ 800 mm	2 m (nominal)	3 m	5 m	4 m
Jackhammer	Hand held	1 m (nominal)	2 m	3 m	2 m
Road-header[3]	Tunnelling	2 m	3 m	5 m	7 m

Notes:

1. Criteria referenced from Roads and Maritime CNVG
2. Criteria referenced from DIN 4150
3. Measurement from SLR Database
4. Corresponds to the higher guideline range

4.6 Identifying construction mitigation and management

4.6.1 Standard mitigation

The CNVG outlines a number of standard mitigation measures for construction activities likely to result in adverse noise or vibration impact.

Where identified in the impact assessment (refer to **Chapter 5**), particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG noting that, additional site specific measures may also be recommended.

Standard mitigation measures which may be considered appropriate for the project are shown in **Table 4-13**.

Table 4-13 Recommended standard construction noise mitigation measures

Standard mitigation	
Management measures	
Action required	**Details**
Implementation of any project specific mitigation measures required	Implementation of any project specific mitigation measures required
Implement community consultation or notification	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) • Contact telephone numbers. Notification should be a minimum of seven calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. As a minimum the induction must 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 • Employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios onsite. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Where specified, 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	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.
Building condition survey	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement, and after completion, of activities with the potential to cause property damage.
Carry out location and activity specific noise assessments	Location and activity specific noise assessments must be carried out, particularly in relation to any works proposed outside standard daytime construction hours, to identify affected receivers and potential impacts, and allow appropriate mitigation measures to be selected and implemented.

Standard mitigation	
Source controls	
Action required	**Details**
Construction hours and scheduling	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 periods during normal hours and out of hours work	As a guide, high noise and vibration generating activities near receivers 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 duration of each block of work and respite should be flexible to accommodate the usage and amenity at nearby receivers Unless negotiated with the community with consultation documented and approved by the Roads and Maritime project manager or permitted under an environmental protection licence, there should be no more than: • Two consecutive nights per week and no more than six nights a month. • Three consecutive evenings per week and no more than six evenings a month. For out of hours work, these periods of work should be separated by not less than one week
Equipment selection.	Use quieter and less vibration emitting methods where feasible and reasonable. Ensure plant, including the silencer, is well maintained.
Rental plant and equipment.	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used onsite unless compliant with the criteria in Table 2 of the CNVG.
Use and siting of plant.	The offset distance between noise intensive plant and adjacent sensitive receivers is to be maximised. Plant used intermittently is to be throttled down or shut down. Noise-emitting plant is to be directed away from sensitive receivers. Only have necessary equipment onsite.
Plan construction ancillary facilities and activities to minimise noise and vibration	Locate compounds away from sensitive receivers and discourage access from local roads Plan traffic flow, 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 period when students are studying for examinations such as before or during Higher School Certificates and at the end of higher educational semesters If programed night work is postponed the work should be re-programed considering the approaches noted within this table.
Reduced equipment power	Use only the necessary size and power.

Standard mitigation	
Non-tonal and ambient sensitive reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction ancillary facilities.	Loading and unloading of materials/deliveries is to occur as far as possible away from sensitive receivers. Select site access points and roads as far as possible away 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 out of hours movements where possible.
Blasting regime	The noise and vibration impacts of blasting operation can be minimised by • Choosing the appropriate blast charge configurations • Ensuring appropriate blast-hole preparation • Optimising blast design, location, orientation and spacing • Utilising knowledge of prevailing meteorological conditions. • AS 2187.2 *Explosive-Storage, transport and use, part 2: use of explosives provides* more detailed advice on ground vibration and air blast overpressure impact minimisation options.
Engine compression brakes	Limit the use of engine compression brakes near 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.	Stationary noise sources should be enclosed or shielded where feasible and reasonable while ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Use structure 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	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At location where there are high risk receptors, vibration monitoring should be conducted during the activities causing vibration.

4.6.2 Additional mitigation measures – Construction Noise and Vibration Guideline

In many instances, impacts from construction noise and vibration are unavoidable where works are undertaken in proximity to surrounding receivers. Therefore, the Roads and Maritime CNVG includes a list of additional mitigation measures which aim to manage the potential noise and vibration impacts.

The additional mitigation measures described in the CNVG are summarised below. The objective of these additional noise mitigation measures is to engage, inform and provide project-specific messages to the community, recognising that advanced warning of potential disruptions can assist in reducing the impact.

- **Notification (letterbox drop or equivalent) –** Advanced warning of works and potential disruptions can assist in reducing the impact to 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 seven calendar 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.
- **Specific notifications (SN) –** Specific notifications are letterbox drops (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 should provide additional information to that covered in the general notifications and be targeted at highly affected receivers
- **Phone calls (PC) –** Phone calls detailing relevant information are to be 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 and or adopted 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 three 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 conducted during the OOHW period 1 (Monday to Friday 6:00 pm to 10:00 pm, Saturday 7:00 am to 8:00 am and 1:00 pm – 10:00 pm, Sunday/Public Holiday 8:00 am to 6:00 pm) 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 six evenings per month
- **Respite period 2 (R2) –** Night time construction noise in OOHW period 2 (Monday to Friday 10:00 pm to 7:00 am, Saturday 10:00 pm to 8:00 am, Sunday/Public Holiday 6:00 pm to 7:00 am) 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 six nights per month. Where possible, high noise generating works shall be completed before 11 pm.
- **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 (refer to Tables C1-C3 of the CNVG). 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

- ***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 that 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
- **Verification (V) –** Refer to Appendix F of the CNVG 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.

A summary of the CNVG requirement for additional airborne noise mitigation is provided in **Table 4-14**.

Table 4-14 Additional mitigation measures matrix – airborne construction noise

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures	
Perception	**dBA above RBL**	**dBA above NML**	**Type[1]**	**Mitigation levels[1]**
All hours				
75 dBA or greater			N, V, PC, RO	HA
Standard hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Hol (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly audible	10 to 20	< 10	-	NML
Moderately intrusive	20 to 30	10 to 20	N, V	NML+10
Highly intrusive	> 30	> 20	N, V	NML+20
OOHW period 1: Mon - Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)				
Noticeable	5 to 10	< 5	-	NML
Clearly audible	10 to 20	5 to 15	N, R1, NR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, N, R1, NR	NML+15
Highly intrusive	> 30	> 25	V, IB, N, R1, NR, PC, SN	NML+25
OOHW period 2: Mon - Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)				
Noticeable	5 to 10	< 5	N	NML
Clearly audible	10 to 20	5 to 15	V, N, R2, NR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, IB, N, PC, SN, R2, NR	NML+15
Highly intrusive	> 30	> 25	AA, V, IB, N, PC, SN, R2, NR	NML+25

Notes:

1. The following abbreviations are used: Alternative Accommodation (AA), Respite Period 1 (R1), Verification (V), Phone Calls (PC), Individual Briefings (IB), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Negotiated Respite (NR), Highly Affected (HA), Respite Offer (RO)

A summary of the CNVG requirement for additional ground-borne noise mitigation is provided in **Table 4-15**.

Table 4-15 Additional mitigation measures matrix – ground-borne construction noise

Predicted ground-borne $L_{Aeq(15min)}$ noise level at receiver		Additional mitigation measures	
Perception	**dBA above GB NML**	**Type[1]:**	**Apply to[2]:**
Standard hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Hol (Nil)			
N/A	Only vibration is applicable during standard hours		
OOHW period 1: Mon - Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)			
Clearly audible	< 10	N	All
Moderately intrusive	10 to 20	V, N, R1, DR, SN	All
Highly intrusive	> 20	V, IB, N, PC, SN, R1, DR	All
OOHW period 2: Mon - Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)			
Clearly audible	< 10	V, N, SN	All
Moderately intrusive	10 to 20	AA, V, IB, N, PC, RP, SN, R2, DR	All
Highly intrusive	> 20	AA, V, IB, N, PC, RP, SN, R2, DR	All

Notes:

1. The following abbreviations are used: Alternative Accommodation (AA), Respite Period 1 (R1), Validation of predicted noise levels (V), Phone Calls (PC), Individual Briefings (IB), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Duration respite (DR)
2. All affected receivers

A summary of the CNVG requirement for additional vibration mitigation is provided in Table 4-16.

Table 4-16 Additional mitigation measures matrix – construction vibration

Predicted vibration level at receiver	Additional mitigation measures	
	Type[1]:	**Apply to[2]:**
Standard hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Hol (Nil)		
Predicted vibration exceeds maximum human comfort levels	V, N, RP	All
OOHW period 1: Mon - Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)		
Predicted vibration exceeds maximum human comfort levels	V, IB, N, RO, PC, RP, SN	All
OOHW period 2: Mon - Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)		
Predicted vibration exceeds maximum human comfort levels	AA, V, IB, N, PC, RP, SN	All

Notes:

1. The following abbreviations are used: Alternative Accommodation (AA), Respite Period 1 (R1), Validation of predicted noise levels (V), Phone Calls (PC), Individual Briefings (IB), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Duration respite (DR)
2. All affected receivers

4.6.3 Mitigation spot-check

It is common for receivers to be grouped into catchment areas for construction noise during an environmental assessment. NCAs can provide a logical grouping of receivers affected by the same works to assist with assessment, consultation or notification.

Noise logging should be completed in a location that is representative of the worst case impact (exceedance of background level by construction noise) to determine the background noise level and criteria. Additional spot-check measurements should be completed to understand the range in background noise levels and associated criteria within the catchment which may vary between receiver locations or between alternate facades with different exposure.

The spot-checks should be used to provide greater certainty that the mitigation measures designed to manage the impact at the assumed worst case receiver address the noise impact across the catchment. While it may not be possible to accurately identify the background noise level at each receiver, noise levels should be predicted for all receivers within the catchment.

4.7 Operational noise guidelines and policies

4.7.1 List of guidelines

Guidelines referenced in the operational noise assessment are listed in **Table 4-17**.

Table 4-17 Operational noise and vibration guidelines and polices

Noise and vibration guidelines and policies	
Operational noise and vibration	
Guideline/policy name	**When guideline is used**
Road Noise Policy, NSW EPA, 2011	Operational road traffic noise assessment
Noise Criteria Guideline, Roads and Maritime, December 2014, Roads and Maritime 14.583	Operational road traffic noise assessment (criteria)
Noise Mitigation Guideline, Roads and Maritime, December 2014, Roads and Maritime 14.584	Operational road traffic noise assessment (consideration of mitigation)
Model Validation Guideline, Roads and Maritime 2016	Operational road traffic noise assessment (model validation)
Application Notes – Noise Criteria Guideline	Operational road traffic noise assessment (criteria)
Environmental Noise Management Manual, Roads and Traffic Authority, 2001	Operational road traffic noise assessment
Industrial Noise Policy, NSW EPA, 1999	Fixed facility noise assessment

4.7.2 Operational road traffic

The NSW Government issued the *Road Noise Policy* (RNP) on 1 July 2011. The document identifies strategies that address the issue of road traffic noise from:

- Existing roads
- New road projects
- Road redevelopment projects
- New traffic-generating developments.

This assessment is undertaken with guidance from the NCG. The NCG documents Roads and Maritime's interpretation of the RNP. The NCG provides a consistent approach to identifying road noise criteria for Roads and Maritime projects.

Although it is not mandatory to achieve the noise assessment criteria in the NCG, project proponents need to provide justification if it is not considered feasible or reasonable to achieve them.

The guideline recognises that there are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors in established urban areas is typically more limited. The NCG criteria are applicable both at the time of project opening and also in a future design year, typically taken to be ten years after project completion.

The NCG sets out four key principles aimed to guide the assessment. These are:

- Criteria are based on the road development type that a receiver would be affected by due to the road project
- Adjacent and nearby residences should not have significantly different criteria for the same road
- Criteria for the surrounding road network are assessed where a road project generates an increase in traffic noise greater than 2 dBA on the surrounding road network
- Protect existing quiet areas from excessive changes in amenity due to traffic noise.

Noise assessment criteria

Noise criteria are assigned to sensitive receivers using the NCG. The NCG provides guidance on how to implement the RNP. The assessment timeframe for the criteria are in the year of opening (for this project, 2023 is used) and 10 years after opening (for this project, 2033 is used).

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project will influence noise levels (see **Table 4-18**). For each facade of the residence the most stringent applicable criteria are to be used in the assessment.

Criteria are based on the road development type (new or redeveloped) a residence is affected by due to the road project. In some instances residences may be exposed to noise from both new and redeveloped roads. In this instance the proportion of noise from each road is used to establish transition zone criteria.

A further check is made to prevent large increases in noise levels using the relative increase criteria.

Assessment scenarios

The RNP requires the following four assessment scenarios to be assessed:

- **2023 No Build** (ie without the project): This scenario represents the existing road network in the study area in the absence of the project. The year 2023 is taken to be the nominal year of opening for the project
- **2023 Build** (ie with the project): This scenario assumes that the project is constructed and operational. The forecast road traffic volumes including the project at the 2023 nominal opening year are used in the model
- **2033 No Build** (ie without the project): This scenario represents the existing road network in the study area in the absence of the project. The forecast road traffic volumes 10 years after the nominal opening year due to general traffic growth that would have occurred without the project are included
- **2033 Build** (ie with the project): This scenario assumes that the project is constructed and operational. The forecast road traffic volumes 10 years after the nominal opening year are included in this scenario.

Criteria by road type

The project consists of multiple new and redeveloped road segments as shown in **Annexure D**, with transition zones at the Iron Cove Link and the Rozelle interchange.

In accordance with the NCG, a road is considered to be new where the road is a new tunnel/bypass or has been substantially realigned (more than six times the existing lane width tolerance band and/or existing grade). However, consideration can also be given to whether a road has been substantially realigned for distances less than six times the existing lane width using local context for guidance such as the removal of properties which currently shield adjoining properties from the road to accommodate a new road. This is consistent with the NCG.

The above situation occurs in the vicinity of Iron Cove Bridge where the upgraded section of Victoria Road has been moved to a new location within the tolerance band but over the existing housing footprint. The criteria for residences are summarised in **Table 4-18**.

Table 4-18 NCG criteria – residential

Road category	Type of project/land use	Assessment criteria (dBA)	
		Daytime (7 am - 10 pm)	**Night-time (10 pm - 7 am)**
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 (external)	$L_{Aeq(9hour)}$ 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
	4. Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1]	Between $L_{Aeq(15hour)}$ 55-60 (external)	Between $L_{Aeq(9hour)}$ 50-55 (external)
	5. Existing residences affected by increases in traffic noise of 12 dBA or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15hour)}$ 42-55 (external)	Between $L_{Aeq(9hour)}$ 42-50 (external)
	6. Existing residences affected by increases in traffic noise of 12 dBA or more from redevelopment of existing freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15hour)}$ 42-60 (external)	Between $L_{Aeq(9hour)}$ 42-55 (external)
Local roads	7. Existing residences affected by noise from new local road corridors.	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)
	8. Existing residences affected by noise from redevelopment of existing local roads		
	9. Existing residences affected by additional traffic on existing local roads generated by land use developments		

Notes:

1. The criteria assigned to the entire residence depend on the proportion of noise coming from the new and redeveloped road. Please refer to Roads and Maritimes' NCG for further information
2. The criteria at each facade are determined from the existing traffic noise level plus 12 dBA

The criteria for residences presented in **Table 4-18** are applicable for aged care facilities.

The criteria for other sensitive receivers are summarised in **Table 4-19**. Further information on the sensitive land use receivers is provided in **section 3.1**.

Table 4-19 NCG criteria – other sensitive land uses

Existing sensitive land use	Assessment criteria (dBA)[1]		Additional considerations
	Daytime (7.00 am – 10.00 pm)	Night-time (10.00 pm – 7.00 am)	
School classrooms	$L_{Aeq(1hour)}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Places of worship	$L_{Aeq(1hour)}$ 40 (internal)	$L_{Aeq(1hour)}$ 40 (internal)	The criteria are internal, ie the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established which activities in these areas may be affected by road traffic noise.
Open space (active use)	$L_{Aeq(15hour)}$ 60 (external) when in use	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
Open space (passive use)	$L_{Aeq(15hour)}$ 55 (external) when in use	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, eg playing chess, reading.
Childcare centres	Sleeping rooms $L_{Aeq(1hour)}$ 35 (internal) Indoor play areas $L_{Aeq(1hour)}$ 40 (internal) Outdoor play areas $L_{Aeq(1hour)}$ 55 (external)	-	Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
Aged care facilities	-	-	Residential land use noise assessment criteria should be applied to these facilities, see **Table 4-18.**
Hospital wards	$L_{Aeq(1hour)}$ 35 (internal)	$L_{Aeq(1hour)}$ 35 (internal)	-

Notes:

1. Internal NCG noise criteria have been converted to external noise criteria for the purposes of assessment with external noise level predictions. Where detailed information relating to building construction is not available, the EPA recommends a 10 dBA factor to convert internal to external noise levels on the basis that facades with windows open typically provide around 10 dBA attenuation from inside to outside (refer to guidance contained in the ICNG and INP)

For sensitive receivers such as schools, places of worship and childcare centres, the NCG criteria presented in **Table 4-19** are based on internal noise levels.

Potential road traffic noise impacts on the surrounding road network

The NCG criteria requires consideration of the surrounding road network where the proposed project is predicted to increase noise levels by more than 2 dBA at receivers from the No Build to Build scenarios. The impacted surrounding road network is then assessed as a project road where noise levels have increased by more than 2 dBA.

This assessment considers potential increases in traffic noise on the surrounding road network within the extent of the study area of the project. This approach meets the principles of the NCG.

Noise mitigation

The NMG provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they should be achieved.

The NMG process is summarised in the flowchart in **Figure 4-3**.

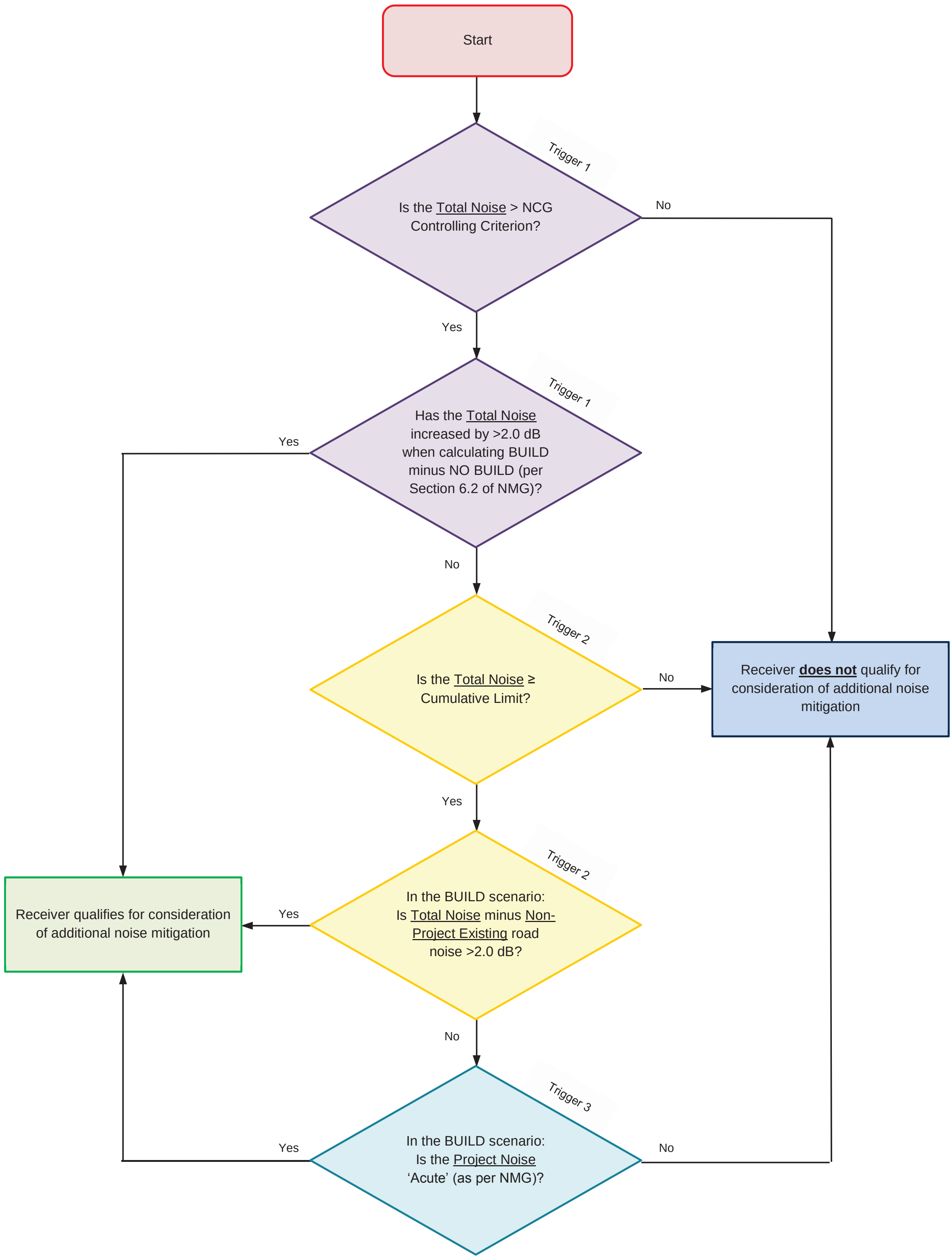


Figure 4-3 Feasible and reasonable noise mitigation (following the NMG)

The information presented in **Figure 4-3** indicates that the NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These are:

Trigger 1

- The predicted Build noise level exceeds the NCG controlling criterion and the noise level increase due to the project (ie the noise predictions for the Build minus the No Build) is greater than 2 dBA.

Trigger 2

- The predicted Build noise level is 5 dBA or more above the NCG controlling criterion (exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project.

Trigger 3

- The noise level contribution from the road project is acute (daytime $L_{Aeq(15hour)}$ 65 dBA or higher, or night-time $L_{Aeq(9hour)}$ 60 dBA or higher) even if noise levels are dominated by a non-project road.

The eligibility of receivers for consideration of additional noise mitigation (over and above road design and traffic management measures) is determined before the benefit of additional noise mitigation (low noise pavement and noise barriers) is included. The requirement for the project is to provide feasible and reasonable additional mitigation for these eligible receivers to meet the NCG controlling criterion.

As highlighted in the NMG, once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages, triggered receivers with residual exceedances of the NCG controlling criteria shall be assessed to determine if they qualify for additional noise mitigation.

For receivers that qualify for consideration of additional noise mitigation measures, potential noise mitigation measures are identified, in the order of preference from the list below:

- 1 Quieter road pavement surfaces
- 2 Noise mounds
- 3 Noise barriers
- 4 At-property treatments.

The redevelopment of existing road corridors, especially in established urban areas, offers a limited range of noise control measures because of the inherent limitations to using corridor route adjustment, the proximity of existing residents to the road and limited road redesign options.

The NMG defines what feasible and reasonable factors may be considered when investigating noise mitigation measures.

'Feasibility' relates to engineering considerations (what can be practically built) and may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources
- Safety issues, such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access requirements
- Maintenance requirements.

'Reasonableness' relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected
- The cost of mitigation, including the total cost and cost variations with different benefits provided
- Community views and wishes
- Visual impacts
- Existing and future noise levels, including changes in noise levels
- The benefits arising from the proposed road or road development.

Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to noise impacts, noise mitigation benefits, the cost effectiveness of noise mitigation and community views.

Maximum noise levels

A maximum noise level assessment has been conducted in accordance with the procedure *Preparing an Operational Noise and Vibration Assessment* (Roads and Maritime, 2011) using guidance contained in Practice Note iii of the Environmental Noise Management Manual (ENMM).

It is noted that the RNP and ENMM both state that while a maximum noise level assessment is required to be undertaken for new and upgraded road infrastructure projects, it should only be used as a tool to help prioritise and rank mitigation strategies, and should not be applied as a decisive criterion in itself. The objective of the maximum noise level assessment is to determine whether maximum noise levels are likely to increase or decrease as a result of the project.

Maximum noise level events were measured as part of the ambient noise study described in **section 3**.

The maximum noise level assessment includes an evaluation of the number and distribution of night-time passby events in accordance with the ENMM. A maximum noise level event is defined within the ENMM as being any passby where:

- The maximum noise level of the event is greater than 65 dBA L_{AFmax}; and
- The L_{AFmax} – $L_{Aeq(1hour)}$ is greater than or equal to 15 dBA.

It should be noted that strategies are currently being implemented to reduce road traffic noise across the State road network which may reduce the number of maximum noise levels events over the longer term.

These strategies include local council requirements to include noise mitigation in new dwellings, metropolitan plans to increase the use of public transport, state wide plans for upgrades of major transport routes, and national initiatives to reduce heavy vehicle engine brake noise and road freight haulage.

In addition, state wide strategies for sharing freight with rail modes are expected to result in reduced noise from heavy vehicle freight on roads in many areas and a corresponding reduction in high noise level events from road traffic.

4.7.3 Operational fixed facilities

Industrial noise from fixed facilities associated with the operation of the project have the potential to adversely affect nearby receivers. The following fixed facilities have been considered as part of this assessment:

- **In-tunnel jet fans** – airflow is achieved in the underground sections of tunnels through the use of jet fans. Jet fan noise emitted from the various tunnel portals therefore has the potential to adversely affect sensitive receivers situated in proximity to the portals. Various types of jet fans are likely to be used depending on the situation, and they are proposed to be situated at separation distances of around 100 metres throughout the tunnels. Tunnel portals associated with the project are located at Wattle Street in Haberfield, at three locations (western, central and eastern) in Rozelle, at Victoria Road, east of the Iron Cove Bridge at Rozelle and at the St Peters Interchange. It is noted that while the EIS is only assessing construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project, jet fans within the Western Harbour Tunnel portals at Rozelle have been included in the Rozelle fixed facilities operational noise modelling

- **Ventilation facilities** – airflow is achieved in the ventilation locations through the use of jet fans which ventilate to the atmosphere via an exhaust outlet. Ventilation facilities associated with the project are located at Haberfield, Rozelle, Iron Cove and St Peters. The ventilation exhaust outlets are proposed at around 25 metres high above local ground at Haberfield, 35 metres at Rozelle, 20 metres at Iron Cove, and 22 metres at St Peters
- **Substations** – required to distribute power to the infrastructure associated with the operation of the project. Substations associated with the project are located at Haberfield, Darley Road, Rozelle, Victoria Road east of the Iron Cove Bridge and St Peters
- **Water treatment plants** – required to treat water runoff throughout the project sites and tunnels. Water treatment plants associated with the project are located at Darley Road and Rozelle.

The locations of these facilities are shown in **Figure 4-4** to **Figure 4-6**.

Figure 4-4 Location of fixed facilities – Haberfield (left) and Darley Road (right)

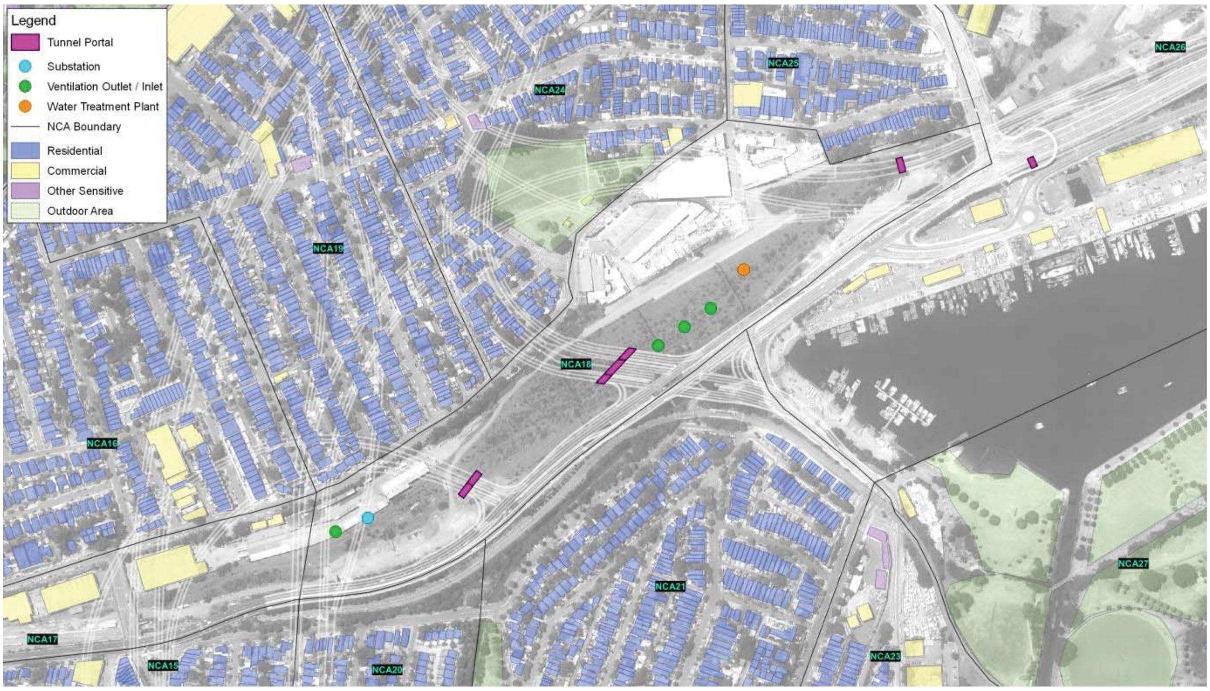


Figure 4-5 **Location of fixed facilities – Rozelle**

Figure 4-6 **Location of fixed facilities – Iron Cove (left) and St Peters (right)**

Fixed facilities noise criteria

The *NSW Industrial Noise Policy* (INP) (EPA, 1999) sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. These criteria are to be met at the most-affected boundary of the receiver property. The more stringent of these two criteria usually defines the proposal specific noise levels. For both amenity and intrusiveness, night-time criteria are typically more stringent than daytime or evening criteria.

In addition to intrusiveness and amenity, the risk of sleep disturbance must also be assessed. Sleep disturbance is assessed in accordance with the screening criterion described in the online Application Notes to the INP and the more detailed review of sleep disturbance contained in the RNP.

INP criteria for intrusive noise

To provide for protection against intrusive noise, the INP states that the L_{Aeq} noise level of the source, measured over a period of 15 minutes, should not be more than 5 dBA above the ambient (background) L_{A90} noise level (or RBL), measured during the daytime, evening and night-time periods at the nearest sensitive receivers.

The intrusiveness criteria are determined from the RBL's in **Table 3-3** from sensitive receiver locations nearest to the facilities.

INP criteria for amenity

To provide protection against impacts on amenity, the INP specifies suitable maximum L_{Aeq} period noise levels for particular land uses and activities during the daytime, evening and night-time periods.

For this assessment, the existing residences potentially affected by noise from ventilation facilities are considered to be 'urban'. According to the INP, an 'urban' area is characterised by an acoustic environment dominated by 'urban hum' or industrial source noise, through traffic with characteristically heavy and continuous traffic flows during peak hours, located near commercial districts or industrial districts. The relevant INP amenity criteria are presented in **Table 4-20**.

Table 4-20 INP amenity noise levels

Type of receiver	Indicative noise amenity area	Period	Recommended L_{Aeq} Noise level (dBA)	
			acceptable	recommended maximum
Residence	Urban	Day	60	65
		Evening	50	55
		Night	45	50

According to the INP, where existing transportation L_{Aeq} noise levels exceed the 'acceptable' noise level by 10 dBA or more, and the existing noise level is unlikely to decrease in future, the noise criteria should be taken to be the existing noise level minus 10 dBA. This approach may be applicable to areas with high traffic noise.

INP modifying factor adjustments

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

To account for this additional annoyance, the INP describes modifying factors to be applied when assessing amenity and intrusiveness. The definition of the modifying factors is described in **Table 4-21**.

Table 4-21 INP modifying factor adjustments

Factor	Assessment/ measurement	When to apply	Correction[1]	Comments
Low Frequency Noise	Measurement of C-weighted and A-weighted level	Measure/assess C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	+5 dB[2]	C-weighting is designed to be more responsive to low-frequency noise
Tonal Noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: —5 dB or more if the centre frequency of the band containing the tone is above 400 Hz —8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive —15 dB or more if the centre frequency of the band containing the tone is below 160 Hz	+5 dB[2]	Narrow-band frequency analysis may be required to precisely detect occurrence

Notes:

1. Corrections to be added to the measured or predicted levels
2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range

Sleep disturbance

The current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background (or RBL) plus 15 dBA (as described in the Application Notes to the INP), and to undertake further analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period. Where the screening criterion cannot be met, the additional analysis should consider the level of exceedance as well as factors such as:

- How often high noise events would occur
- The time of day (normally between 10.00 pm and 7.00 am)
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

The RNP provides a review of research into sleep disturbance. From the research to date, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA LAFmax are unlikely to awaken people from sleep
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA LAFmax, are not likely to affect health and wellbeing significantly.

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dB, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions. The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA L_{AFmax} are not likely to affect health and wellbeing significantly.

Noise goal summary

A summary of the operational noise goals for the fixed facilities is provided in **Table 4-22**. Assuming continuous operation of industrial noise sources, the more stringent of the intrusiveness or the amenity criteria sets the noise goals, as highlighted in the table.

The noise goals are based on the night-time period only given the existing noise levels are at their lowest during this period and the corresponding noise goals are consequently at their most stringent.

Table 4-22 Summary of operational noise goals for fixed facilities

Area	NCAs	Applicable noise logger	Receiver type	Existing night-time noise levels (dBA)		Operational noise goals (dBA)		
				RBL	LAeq	LAeq(15minute) Intrusive[1]	LAeq(period) Amenity[1,2,3]	LA1(60second) Sleep dist. screening level
Haberfield	NCA01	H.03	Residential	38	56	43	45	53
	NCA02	H.01	Residential	52	64	57	45	67
	NCA03	H.04	Residential	44	69	49	45	59
	NCA06	H.02	Residential	43	56	48	45	58
Darley Road	NCA09	L.02	Residential	42	55	47	45	57
	NCA13	L.01	Residential	40	57	45	45	55
Rozelle	NCA15	R.14	Residential	35	48	40	45	50
	NCA16	R.01	Residential	44	58	49	45	47
	NCA19	R.01	Residential	44	58	49	45	47
	NCA20	R.14	Residential	35	48	40	45	50
	NCA21	R.15	Residential	42	53	47	45	57
	NCA24	R.01	Residential	44	58	49	45	47
	NCA25	R.02	Residential	45	54	50	45	60
	NCA27	R.16	Residential	42	52	47	45	57
Iron Cove	NCA33	I.02	Residential	43	69	48	45	58
	NCA34	I.02	Residential	43	69	48	45	58
	NCA35	I.01	Residential	46	68	51	45	61
	NCA36	I.02	Residential	43	69	48	45	58
St Peters	NCA46	S.01	Residential	40	62	45	45	55
	NCA48	S.03	Residential	40	61	45	45	55
	NCA49	S.03	Residential	40	61	45	45	55
	NCA50	S.04	Residential	42	63	47	45	57
	NCA51	S.02	Residential	39	63	44	45	54

Notes:

1. A grey highlight indicates the controlling design criteria (ie the lower of the intrusiveness and amenity criteria)
2. Criteria are identified as controlling as noise source is continuous throughout the period
3. No existing industrial noise sources were present therefore amenity criteria has been set as ANL for urban areas

4.8 Operational road traffic noise prediction methodology

4.8.1 Study area

The principles under which the study area boundary for the assessment has been defined are as follows:

- A 600 metre boundary width either side of the main project road alignment (as recommended in the RNP)
- A boundary length up to the physical extent of the works. While not required under the NCG, due to the relatively small gap between the Rozelle interchange area and the Iron Cove interchange area, the length of the boundaries have been extended in order to include receivers on Victoria Road located between these two areas.

The adjacent collector roads, sub-arterial and arterial roads were modelled in order to identify the contributions from project and non-project existing roads separately. Roads where design or engineering changes are proposed have generally been considered as project roads. The roads modelled as project roads are listed in **Table 4-23.**

Table 4-23 Project roads included in the operational noise model

Road name	Section	Comment
Victoria Road	Iron Cove – between Iron Cove Bridge and Wellington St	Alignment change and widening
Victoria Road	Rozelle - between Robert St and City West Link Intersection	Alignment change and widening
City West Link	Between Catherine St to the western extents of the Anzac Bridge	Alignment change and connections to new ramps
The Crescent	Between Johnston St and City West Link Intersection	Alignment change and widening

Roads where no significant design or engineering changes are proposed have been considered as non-project existing roads. Significant design or engineering changes do not include normal tie-in works (eg line marking) where these intersect with a project road. The roads modelled as non-project existing roads are shown on the road classification maps in **Annexure D**. The study boundary is also shown in **Annexure D**.

4.8.2 Modelling

Ground, roads and buildings

The noise model was developed from a combination of survey road corridor ground topography, aerial photography and Light Detection and Ranging (LiDAR) information supplied by SMC.

The predictions for the No Build scenarios make use of the existing road alignment geometry, with existing noise barriers and features within the road corridor being included in this scenario.

The Build scenarios make use of the proposed design of the project which includes proposed modifications to the access ramps, widening works for the various roads, new tunnel portals and changes to existing levels such as cuttings and embankments.

An example screenshot from the Build noise model scenario is provided in **Figure 4-7**.

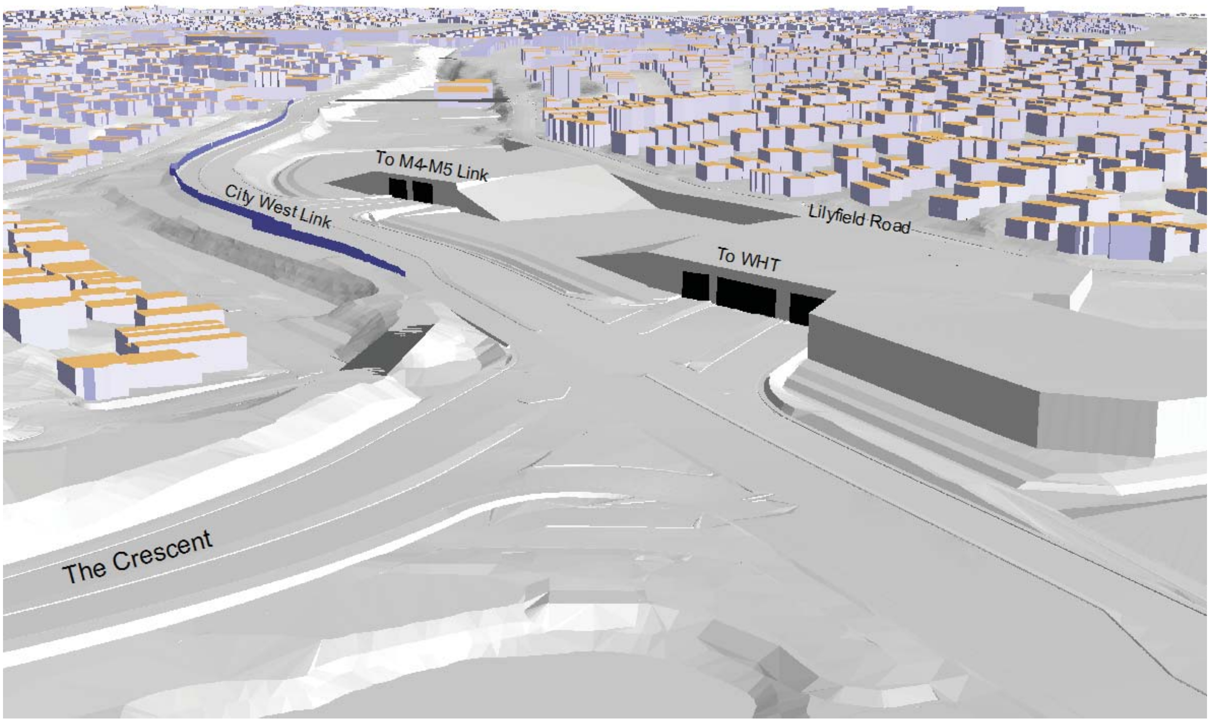


Figure 4-7 **Example noise model screenshot – view looking west towards the proposed tunnel portals, with City West Link to the left of the image**

Traffic

The traffic data utilised in the operational noise model incorporates population and employment projections, and growth in demand (regional growth, vehicle trips attracted from competing routes and induced demand as a result of improved travel times). Reference should be made to the corresponding traffic and transport report for further details relating to the traffic forecast methodology and potential limitations of the data.

The project has a number of related key projects, four of which are approved or under construction at the time of writing (WestConnex Stage 1a – M4 Widening, Stage 1b – M4 East, Stage 2 – New M5 and King Georges Road Interchange Upgrade). Other non-WestConnex projects (Sydney Gateway, Western Harbour Tunnel and Beaches Link, and F6 Extension) are currently in the early planning stages and are not yet approved. Most notable of these projects with regard to M4-M5 Link is the construction of future access ramps at the Rozelle interchange for the Western Harbour Tunnel and Beaches Link project.

The traffic volume scenarios relating to these key projects are described below and in **Table 4-24**:

- **Do Nothing** (ie without the project or other approved WestConnex stages): This scenario represents the existing road network in the study area in the absence of the project. The traffic data for this scenario does not include any stages of WestConnex or the interfacing projects.
- **Do Minimum** (ie without the project): This scenario represents the existing road network in the study area in the absence of the project. The traffic data includes the approved WestConnex stages.
- **Do Something** (ie with the project): This scenario assumes that the project goes ahead and includes the proposed project design. The traffic data includes the M4-M5 Link and the approved WestConnex stages.
- **Do Something Plus** (ie with the project and other projects that interface, overlap or have potentially concurrent impacts): This scenario assumes that the project goes ahead and includes the proposed project design. The traffic data includes the M4-M5 Link and the approved WestConnex stages, together with other major interfacing non-WestConnex projects.

Table 4-24 Traffic scenarios and interfacing projects

Assessment scenario	Traffic scenario	WCX stage 1a	WCX stage 1b	WCX stage 2	WCX M4-M5 Link	King Georges Road	Sydney Gateway	Western Harbour Tunnel[1,2]	Beaches Link	F6 Extension
2023										
No build	Do Nothing									
	Do Minimum	✓	✓	✓		✓				
Build	Do Something	✓	✓	✓	✓	✓				
	Do Something Plus	✓	✓	✓	✓	✓	✓	✓		
2033										
No build	Do Nothing									
	Do Minimum	✓	✓	✓		✓				
Build	Do Something	✓	✓	✓	✓	✓				
	Do Something Plus	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

1. The operation of the Western Harbour Tunnel ramps at Rozelle are not assessed within this technical paper. Operational impacts will be the subject of future environmental assessment and approval

Due to the ongoing traffic growth within the Sydney road network, there is potential for increases in noise in areas within the M4-M5 Link study area due to other projects. For this reason, assessment of the cumulative '*Do Something Plus'* scenario is considered in addition to the '*Do Something'* scenario.

Due to the short-term nature of the '*Do Minimum'* interim scenario, the assessment of project impacts and cumulative impacts uses the '*Do Nothing'* traffic as the No Build baseline for the assessment (see **Chapter 6**).

Traffic data for the Build and No Build assessment scenarios (see **section 4.7.2**) for both project opening (2023) and the future design year (2033) was provided by the project team and references the outputs of the strategic traffic model (WRTM v2.3). Traffic volumes are presented in **Annexure E-2**.

Calculation type

Noise modelling of the study area was carried out using the *Calculation of Road Traffic Noise* (CORTN) (UK Department of Transport, 1988) algorithms.

The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers.

The algorithm output of CORTN (designed as an L_{A10} predictor) has been modified to calculate the relevant daytime $L_{Aeq(15hour)}$ and night-time $L_{Aeq(9hour)}$ road traffic noise emission levels at noise sensitive receivers, as required by the RNP.

The CORTN traffic source line as modelled in SoundPLAN has also been modified to incorporate four effective noise sources (and associated heights) for the centre line of each carriageway. This is because the three distinct noise sources of heavy vehicles (representing the tyres, engine and the exhaust, with different noise emission levels and different heights) are important in determining the noise propagation where barriers are present. The four effective noise sources used comprise a *'CAR'* source with height of 0.5 metres above pavement and three *'TRUCK'* sources at three separate heights representing the noise emission from truck tyres (0.5 metres), truck engines (1.5 metres) and truck exhausts (3.6 metres).

The SoundPLAN noise models were set up to calculate noise levels at receiver points for all facades and all potentially affected floors of each noise sensitive receiver identified within the study area.

All floors of multi-storey receiver buildings have been included in the assessment and evaluated for mitigation against the NMG triggers. The assessment counts each floor along with an estimation of the number of separate dwellings within each floor as a separate receiver. The precise number of individual receivers would be confirmed during detailed design.

Tunnel portals

The assessment utilises the SoundPLAN calculation algorithm for portal noise emissions. This considers traffic flow, length of tunnel and portal opening and generates four separate noise sources evenly distributed across the tunnel opening. SLR has undertaken a comparison with the Olafsen paper presented at Internoise 96 - *Noise from Tunnel Openings – An Engineering Approach* (Olafsen, 1996) and found both methods to give reasonably consistent sound power levels. On this basis, the approach taken for this assessment is considered appropriate.

4.8.3 Noise model validation

The purpose of model validation is to demonstrate that the noise model produced for the existing situation is an accurate representation of the real world within the limitations of the prediction algorithm and to identify errors associated with geospatial data and modelling approach. This is to provide greater confidence in the recommendations and assessment completed for the proposed situation which will be validated post completion.

The noise modelling procedures and algorithms used in this assessment have been shown to give reliable results which are within normal accepted tolerances. Project specific model validation is undertaken to confirm that noise predictions at individual receiver locations are within the generally accepted tolerance for model accuracy of +/- 2 dBA.

Noise model validation is undertaken by comparing measured noise levels to predicted noise levels for the existing roads. Comparison of measured and predicted levels has been performed by undertaking single point receiver calculations at noise model locations coinciding with the ambient monitoring locations. Model validation locations typically included those with a direct line of sight or those near to the subject roads.

All roads modelled within the operational study area have been modelled with a surface of Dense Grade Asphalt (DGA) with a 0 dBA surface correction.

Traffic counting was undertaken concurrently with the ambient noise monitoring survey. Traffic counting equipment was deployed at locations near the noise logging locations. The traffic data inputs for the validation situation are summarised in **Annexure E-1**.

The traffic counts are used for the purpose of validating the noise model and relate only to the period over which the noise logging was undertaken. Consequently, these are of limited use in providing long-term traffic volumes and speeds and also may not be representative of existing volumes.

The noise model validation is summarised in **Table 4-25**.

Table 4-25 Model validation summary

Noise monitoring location		Noise level (dBA $L_{Aeq\ period}$)					
ID	Address	Measured		Predicted		Difference, predicted minus measured	
		Daytime	Night-time	Daytime	Night-time	Daytime	Night-time
R.01	Hutcheson Street, Rozelle	64.1	57.6	64.8	58.6	0.7	1.0
R.02	22 Lilyfield Road, Rozelle	57.2	54.0	58.0	54.5	0.8	0.5
R.03	69 Victoria Road, Rozelle	70.5	67.9	71.7	67.8	1.2	-0.1
R.04	27 Victoria Road, Rozelle	71.0	67.3	71.9	67.6	0.9	0.3
R.05	Rozelle Rail Yard – East	70.0	67.2	71.6	68.5	1.6	1.3
R.06	Rozelle Rail Yard – West	62.9	60.0	65.2	62.1	2.3[1]	2.1[1]
R.07	The Crescent - North (24 Chapman Road, Annandale)	65.1	59.4	66.7	61.3	1.6	1.9
I.01	28 Warayama Place Rozelle	72.5	68.5	73.4	68.5	0.9	0.0
I.02	198 Victoria Road	73.5	68.9	71.8	67.7	-1.7	-1.2
R.08	279 Johnston Street, Annandale – West	63.2	58.3	64.7	58.6	1.5	0.3
R.09	279 Johnston Street, Annandale - East	60.9	54.9	61.5	56.1	0.6	1.2
R.11[2]	Brenan Street, Rozelle	61.5	-	63.3	-	1.8	-
					Median	1.1	0.5

Notes;

1. Marginal over-prediction outside the normal tolerance (±2 dBA) due to localised shielding
2. Short-term (three-hour daytime) attended monitoring was conducted at this location (refer to **section 3.6**)

Based on the information presented in **Table 4-25**, the noise model predictions are found to be within the normally accepted tolerances (+/- 2 dBA) at all logger locations with the exceptions as noted. Application of calibration factors is therefore not required

4.8.4 Summary of noise modelling parameters

A summary of the modelling parameters is provided in **Table 4-26**.

Table 4-26 Summary of baseline noise model inputs and parameters

Input parameter	Source of data	
Ground topography	Combination of surveyed road corridor data and LIDAR point cloud survey	
Proportion of absorbing ground	0.5 (CORTN)	
Receiver locations	Aerial photography and LIDAR point cloud	
Vehicle speed (Build and No Build)	Main carriageway Existing access ramps New ramps Secondary network roads	As sign posted As sign posted 60 km/h As sign posted
Source heights and source correction (dBA)	Car exhaust Truck tyres Truck engines Truck exhausts	0.5 m (0.0 dBA) 0.5 m (-5.4 dBA) 1.5 m (-2.4 dBA) 3.6 m (-8.5 dBA)
Road surface corrections (applied to all modelled source lines as a surface correction)	New Ramps Surrounding network roads	0.0 dBA 0.0 dBA
Number and location of sensitive receiver points	All sensitive receiver buildings, all facades and all floors, excluding facades shorter than 2.0 metres. Facade point located at the centre of the facade	
Receiver location (@ 1 m from facade)	Ground floor[1] First floor[1]	1.5 m 4.3 m
Facade correction	+2.5 dBA	
ARRB	-1.7 dBA for facade conditions -0.7 dBA for free-field conditions	
L_{A10} to L_{Aeq}	-3 dBA	
$L_{Aeq(period)}$ to $L_{Aeq(1hour)}$ correction[2]	$L_{Aeq(15hour)}$ to $L_{Aeq(1hour)}$ +1.3 dBA $L_{Aeq(9hour)}$ to $L_{Aeq(1hour)}$ +5.2 dBA	

Notes:

1. These are typical heights above ground level, the height of some receivers were adjusted according to site survey information
2. Derived from monitoring data presented in **section 3**. Corrections are based on the median of the individual monitoring results at the representative locations

4.8.5 Identifying impacts

The predicted noise levels at all facades of the receiver were compared to the corresponding assessment criteria. An analysis against the NMG mitigation triggers was undertaken to determine the extent of project impacts. The comparison (Build minus No Build) for 2023 indicates the potential for any noise issues at the commencement of the project. The comparison for 2033 indicates the potential for noise impacts in the longer term once the project is well established and the surrounding road network has stabilised, as well as the change in traffic flows after implementation of the full WestConnex scheme and other connecting projects.

The noise impacts without mitigation have been identified with existing noise barriers in place and the reference DGA pavement (see **section 4.8.3**) for all new and modified sections of road. The retained noise barriers are located adjacent to the eastbound carriageway on the northern side of Victoria Road (around 2.5 metres in height) and adjacent to the westbound carriage on the southern side of City West Link (around three metres in height). A small section of the eastern end of the existing City West Link noise barrier, near the intersection with The Crescent, would be required to be removed to allow for the new intersection layout. The retained barriers are shown in **Figure 4-8**.

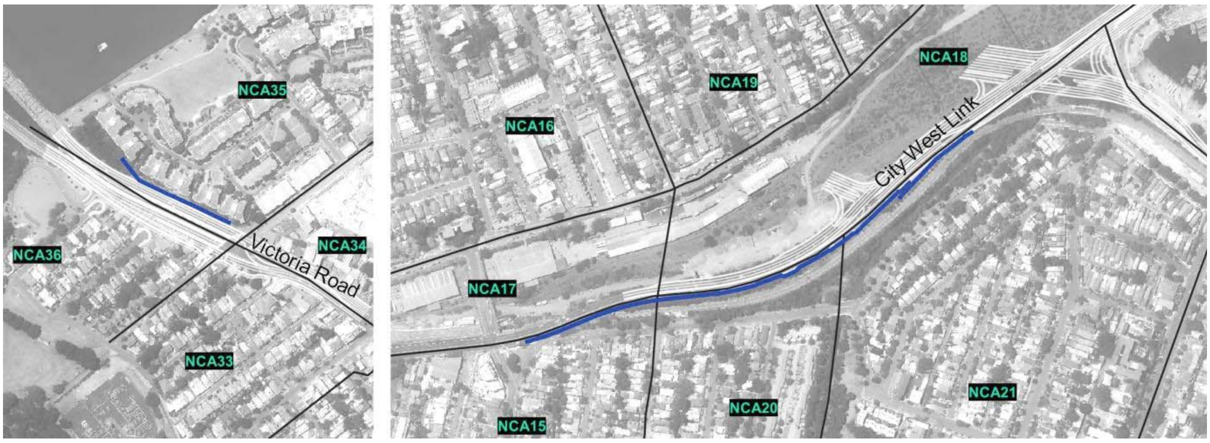


Figure 4-8 Retained existing noise barriers (shown in blue)

Predicted noise levels at receivers which are above the NCG controlling criteria do not necessarily qualify for additional noise mitigation. As per the discussion in **section 4.8.6**, consideration of reasonableness is used to decide which of those receivers are eligible for additional noise mitigation measures.

4.8.6 Identifying additional mitigation

Low noise pavement such as porous asphalt may be effective at reducing noise at the source. However, the choice of road pavement surfaces and textures must meet a number of criteria including skid resistance, water shedding and design life as well as potential noise generating characteristics. The road pavement surface's noise performance throughout its duration and the need to maintain that performance by cleaning or replacing the pavement are also important considerations.

The noise assessment considers the use of quieter noise pavement in the form of dense graded asphalt across the extent of the project. Use of other pavement surfaces, such as open graded asphalt (OGA), to further reduce road traffic noise at the source will be investigated during detailed design taking into account whole-of-life engineering considerations and the overall social, economic and environmental effects.

In sensitive receiver locations where exceedances of the operational noise criteria are predicted, new or increased height noise barriers have been considered where four or more eligible properties are found to be closely spaced. Where the number of exceeding receivers is found to be three or less, the specification of noise barriers is not considered to be a reasonable or cost-effective approach and at-property treatment of these receivers should be considered. This approach is consistent with the NMG.

4.8.7 Identifying noise barriers

Noise barriers are typically most efficient when receivers are located at ground floor level. As the height above ground of a receiver increases, the noise reduction due to the barrier is usually seen to reduce due to the increased line-of-sight over the top of the barrier to the road corridor (ie reduced path length difference).

It is not uncommon for upper floors of multi-storey buildings to see little to no reduction in noise levels from nearby barriers because of their elevation. The process of determining reasonable barrier heights would therefore generally be less likely to result in noise barriers being considered a reasonable option if upper floors formed part of the analysis. With consideration of this, the assessment and optimisation of noise barriers for the project makes use of noise predictions at ground and first floor only, with architectural treatments to be investigated for higher floors.

The NMG approach identifies the number of receivers (noting that a two storey residence is counted as two receivers) that receive at-residence treatment versus barrier height to establish an initial design height and then conducts a weighted analysis to find the optimal mix of barrier height and at-property treatments. This prioritises at-road mitigation and minimises the use of at-property treatments, as per the intent of the RNP.

The NMG approach to barrier optimisation is presented in **Figure 4-9** and **Figure 4-10** and described as follows:

- Step 1-3: The approach is to first identify the maximum barrier height (up to eight metres) where no receivers require at-property treatment. The initial design height is then established by identifying the height where, of the receivers that benefit from the noise barrier, two thirds no longer require at-property treatment. A value of two thirds is defined in the NMG as further increases in barrier height have been shown to have diminishing benefits with respect to increasing barrier heights
- Step 4: Weightings are then applied which consider the cost and the overall noise benefits the barrier provides to the wider community. The total points weighting at each barrier height is the sum of the weightings for barrier area, number of at-property treatments and exceedances of 50 dBA $LA_{eq(15hour)}$ daytime or 45 dBA $LA_{eq(9hour)}$ night-time noise levels (based on the World Health Organisation (WHO) criteria)
- Step 5: A low point in the weighting curve between the initial design height and the maximum barrier height corresponds to the most reasonable barrier height in terms of community benefit and weighted cost. The practicability of the design and maximum barrier heights are then reviewed taking into account engineering considerations as well as social, economic and environmental benefits.

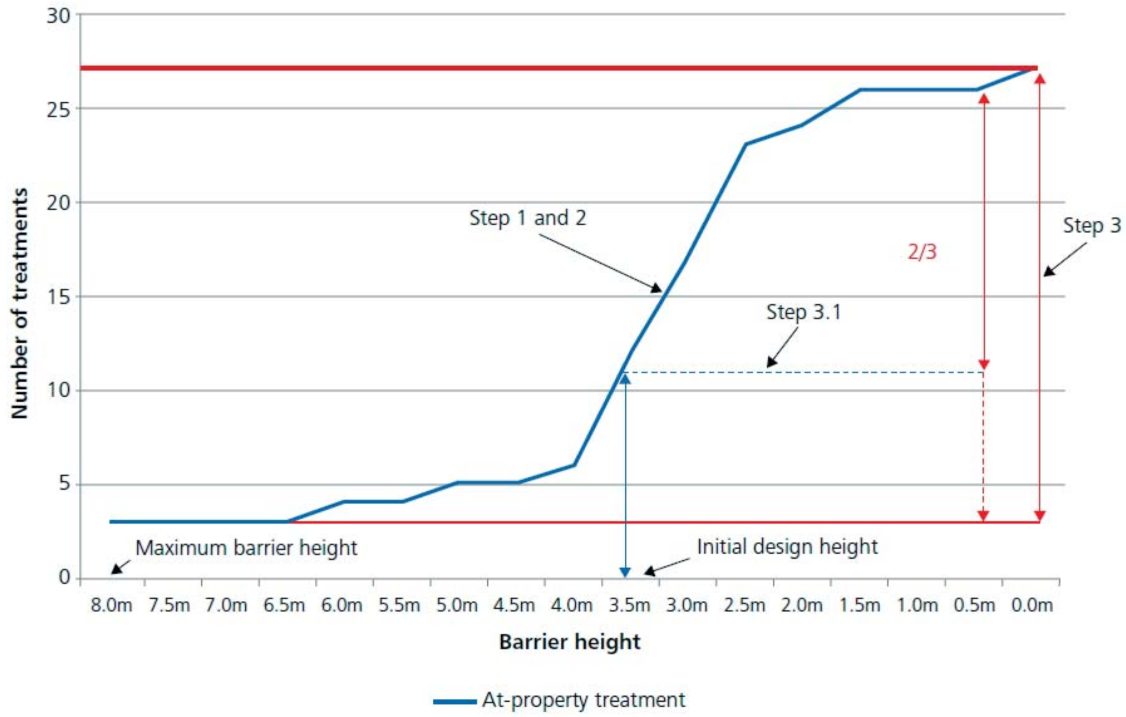


Figure 4-9 **NMG optimisation process – Steps 1-3**

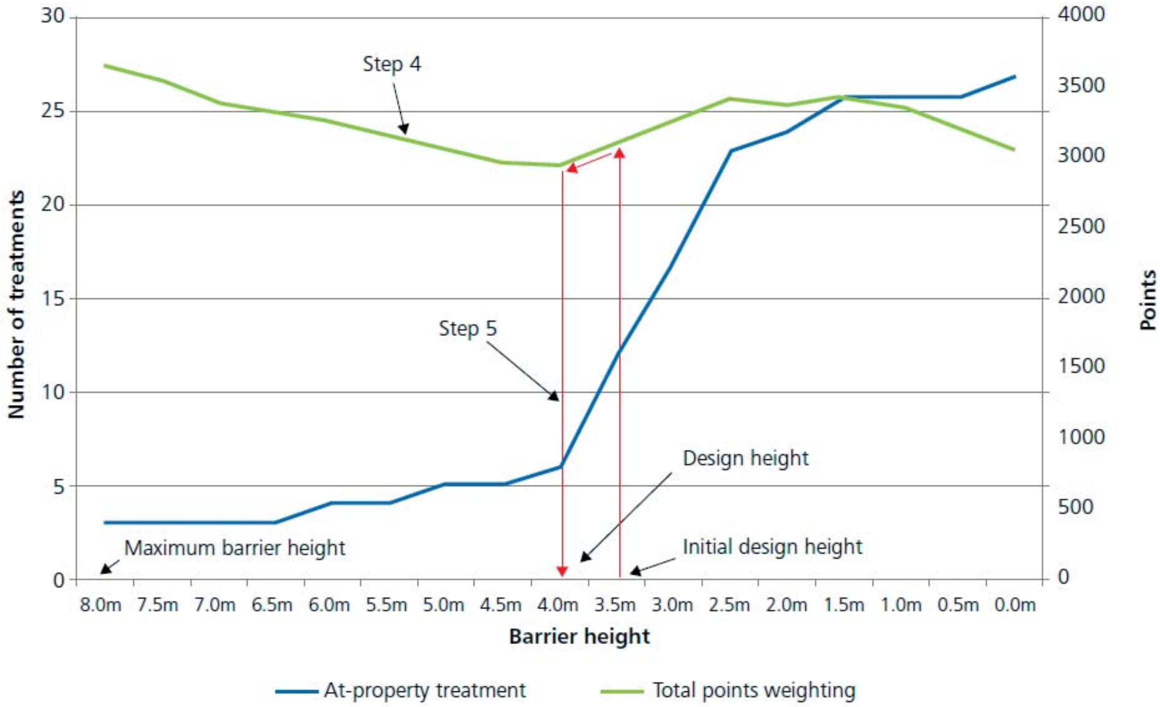


Figure 4-10 **NMG optimisation process – Steps 4-5**

As a guide, noise barriers are considered to be a reasonable noise mitigation option where they are capable of providing a noise attenuation benefit (referred to as an insertion loss) of:

- 5 dBA at representative receivers for barrier heights of up to 5 metres
- 10 dBA at representative receivers for barrier heights above 5 metres high and up to 8 metres high.

In certain situations the requirements for the barrier cannot always be met. In this case further feasible and reasonable considerations are undertaken in consultation with Roads and Maritime.

Where an existing barrier is relocated as part of the works, the top of noise wall height of the replacement section of the noise barrier is kept consistent with the existing height unless the optimised barrier height is greater.

4.8.8 Identifying potential at-property treatments

At this stage in the assessment, the identification of at property treatments is indicative only, as further consideration must be given to Roads and Maritime's At-receiver Noise Treatment Guideline as well as to the following points at the design stage in order to confirm the final extent of treatments required:

- The build date of the property and the related conditions of consent which may require that the property has been built to account for existing high levels of road traffic noise
- Caution should be exercised before providing treatments for buildings in a poor state of repair, as they will be less effective and may not provide any appreciable noise reduction benefit
- Heritage advice should be sought if the treatments have the potential to impact the heritage significance of a property. In extreme cases this could result in a decision not to proceed with a treatment on the grounds that it was not considered to be a reasonable or feasible mitigation option.

At-receiver traffic noise mitigation measures may replace or supplement at-road mitigation, only in the following circumstances, subject to a reasonable and feasible assessment:

- Isolated single residences or isolated groups of closely spaced residences as defined in the NMG
- Where the affected community expresses a preference for at-receiver treatment and the cost is less than a combination of a barrier and at-receiver treatment
- Where noise barriers or quieter pavements alone do not achieve the level of noise mitigation (insertion loss) required
- Where the only applicable noise criteria are internal (eg places of worship, hospitals or schools and childcare centres where play areas meet external criteria)
- Where other noise mitigation measures have been shown not to be feasible or reasonable.

These treatments are generally limited to acoustic treatment of the building elements (doors, windows, vents, etc) or courtyard fences where they reduce noise to habitable rooms. The installation of courtyard fences close to the dwelling may also provide some mitigation for outdoor living spaces.

The overall goal of the architectural treatment is to provide similar acoustic amenity and internal noise levels to those experienced within a receiver where the external noise criteria have been met.

In most instances, assuming brick construction and standard glazing, this goal equates to internal noise levels that are around 20 dBA less than the external noise criteria with windows closed. In practice there will be some variation in reduction due to the design of the existing building and other limitations such as building condition. A 20 dBA goal results in internal noise levels that are consistent with other guidelines. These guidelines include the *State Environmental Planning Policy (Infrastructure) 2007 (NSW)* and Australian Standard 2107. The 20 dBA goal also provides protection against a large increase in internal noise level in accordance with the NCG and RNP relative increase criterion.

Building element treatments are more effective when they are applied to masonry structures than lightly clad timber frame structures. The architectural treatments provided by Roads and Maritime typically include:

- Fresh air ventilation systems that meet the National Construction Code of Australia requirements with the windows and doors closed
- Upgraded windows and glazing and solid core doors on the exposed facades of the substantial structures only (eg masonry or insulated weather board cladding with sealed underfloor). These techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls
- Upgrading window or door seals and appropriately treating sub-floor ventilation
- The sealing of wall vents
- The sealing of the underfloor below the bearers
- The sealing of eaves.

Alternative at-receiver treatments are:

- The installation of courtyard fences that break line of site between the affected facade window and the road where they are feasible and reasonable and are preferred by the owner.

Inspections should be completed before treatment packages are installed. Treatment packages should only be recommended and considered feasible and reasonable where they are predicted to provide a noticeable improvement in noise reduction (3 dBA or greater) than the existing window, door and facade system. In some instances partial treatment packages may be considered feasible and reasonable where the existing system forms part of the recommended package.

During the installation phase of the acoustic treatments, ownership details would be obtained for all receivers identified as eligible for consideration of at-property treatment. This phase also identifies the location of internal habitable areas for each receiver and subsequently the most appropriate form of at-property treatment to be installed.

4.9 Operational fixed facilities noise prediction methodology

4.9.1 Ventilation facilities

Fresh air supply to the tunnels and ventilation exhaust would be managed by the ventilation facilities. These would generally consist of jet fans with baffle-type attenuators located within the ventilation building and outlets. It is assumed that the ventilation buildings (both intake and outlet buildings) will be constructed such that the breakout noise (ie the noise transmitted externally through the building structure itself) is at least 10 dBA below the noise emanating from the ventilation outlet at the nearest most affected receiver location. The ventilation facilities are assumed to be operational 24 hours per day, seven days per week.

Indicative sound power level data for the proposed ventilation outlets is presented in **Table 4-27**. It is important to note that this is the sound power level at the top of the outlet, and assumes appropriate attenuators are installed.

Table 4-27 Indicative sound power level of ventilation outlets

Ventilation exhaust	Octave band frequency (Hz) / sound power level SWL (dBL re 1pW)								Sound power level LW
	63	125	250	500	1k	2k	4k	8k	
Outlet	105	88	62	50	45	54	65	68	105

Notes:

1. Equipment and sound power levels are indicative and may change subject to detailed design
2. The stated sound power level is at the top of the outlet, and assumes appropriate attenuators are installed

4.9.2 Tunnel jet fans

The nearest tunnel jet fans are typically located at a distance of at least 100 metres from the tunnel portals. For the purpose of this assessment, calculations assume a conservative distance of 50 metres from the nearest jet fans to the various tunnel portals. Four jet fans have been included in the calculation for each assessment location and are assumed to be operational 24 hours per day, seven days per week.

Indicative sound power level data for the proposed tunnel jet fans is presented in **Table 4-28**.

Table 4-28 Indicative sound power level of jet fans in tunnel

Jet fan	Octave band frequency (Hz) / sound power level LW (dBL re 1pW)								Sound power level LW
	63	125	250	500	1k	2k	4k	8k	
1250 mm	108	100	94	87	95	91	87	87	109

Notes:
1. Equipment and sound power levels are indicative and may change subject to detailed design

4.9.3 Substations

At this stage of the assessment, the specifications for the substations are not yet finalised. For the purpose of this assessment, each substation has been assumed to house four 3.15 MVA transformers.

Indicative sound power level data for the proposed transformers is presented in **Table 4-29**.

Table 4-29 Indicative sound power level of transformers at substations

MVA	Octave band frequency (Hz) / sound power level LW (dBL re 1pW)						Sound power level LW
	63	125	250	500	1k	2k	
3.15	75	83	73	67	67	65	84
3.15	75	83	73	67	67	65	84
3.15	75	83	73	67	67	65	84
3.15	75	83	73	67	67	65	84
Total	**81**	**89**	**79**	**73**	**73**	**71**	**90**

Notes:
1. Equipment and sound power levels are indicative and may change subject to detailed design.

4.9.4 Water treatment plants

At this stage of the assessment, the specifications for the water treatment plants are not yet finalised. For the purpose of this assessment, indicative sound power level data for the proposed water treatment plants is presented in **Table 4-30**.

Table 4-30 Indicative sound power level of water treatment plants

Equipment	Octave band frequency (Hz) / sound power level LW (dBL re 1pW)							Sound power level LW
	63	125	250	500	1k	2k	4k	
Blower	90	87	80	81	76	72	69	93
Pump	71	72	74	74	77	74	70	82
Total	**90**	**87**	**80**	**81**	**76**	**82**	**69**	**93**

Notes:
1. Equipment and sound power levels are indicative and may change subject to detailed design

4.9.5 Predicted modifying factors

Given the indicative nature of the assessment, it is recommended that all finalised plant items are assessed during detailed design with consideration of the INP modifying factors. Where modifying factors are found to be applicable they should be added to the assessment and compliance with the INP criteria checked at all receivers.

4.10 Key assumptions

The key assumptions for each individual component of the noise and vibration assessment are identified in **Table 4-31**.

Table 4-31 Key assessment assumptions

Noise and vibration assessment assumptions
Description
Potential noise barriers - any recommended noise barriers are subject to further considerations during detailed design such as construction limitations, design refinements, overshadowing, urban design, community preference and impacts to local connectivity.
Internal NCG noise criteria have been converted to external noise criteria for the purposes of assessment with external noise level predictions. Where detailed information relating to building construction is not available, the EPA recommends a 10 dBA factor to convert internal to external noise levels on the basis that facades with windows open typically provide around 10 dBA attenuation from inside to outside (refer to guidance contained in the ICNG and INP). For non-residential receivers this assumption may be overly conservative as the facade area to window ratios are often larger when compared to residential receivers.
During the installation phase of the acoustic treatments, ownership details would be obtained for all receivers identified as eligible for consideration of at-property treatment and the final number and layout of individual eligible dwellings would be confirmed.
All floors of multi-storey receiver buildings have been included in the assessment and evaluated against the appropriate operational road traffic noise criteria. The assessment counts each floor along with an estimate on of the number of individual dwellings (apartments) as a separate receiver however internal floor plans have not been considered (eg to identify habitable rooms, or an accurate count of individual dwellings within the block).
Operational ground-borne noise and vibration due to the movement of cars and trucks inside the tunnel is considered to be negligible and would not be expected to cause any noticeable impact at the surface level properties. As such, this noise and vibration source has not been considered further in this report. Ground-borne noise from the construction of the M4-M5 Link tunnels has been assessed and is presented in **Chapter 5**.

5 Assessment of construction impacts

The proposed works are occurring in a number of distinct areas, therefore the potential construction noise impacts from the project have been assessed and are summarised in the following sections based on location.

Construction noise goals have been determined based on the relevant government guidelines and industry standards (see **section 4.1**). Potential noise levels have been predicted at sensitive receivers for the proposed activities and where levels are above the goals, feasible and reasonable impact mitigation measures are considered.

5.1 Haberfield

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed in the Haberfield area.

Two options for construction ancillary facilities around Haberfield are described and assessed in this technical paper:

- **Option A**, comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- **Option B**, comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)
  - Parramatta Road East civil site (C3b).

The construction ancillary facilities that comprise these options have been grouped together in this technical paper and are denoted by the suffix a (for **Option A)** or b (for **Option B**) eg C1a Wattle Street civil and tunnel site.

5.1.1 Works description – Option A

The Haberfield Option A works area consists of three construction ancillary facilities – Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a) and Northcote Street Civil Site (C3a) which all fall within the M4 East project footprint. The indicative layout is shown in **Figure 5-1**.

Wattle Street civil and tunnel site (C1a)

The existing Wattle Street civil and tunnel site, located on the northern side of Wattle Street would be used for the project to support tunnelling activities launched from the Wattle Street ramps. The entry and exit ramps for the M4-M5 Link tunnels which would be built by the M4 East project would be used for spoil handling during tunnelling works and would utilise an acoustic roller door to minimise noise.

Haberfield civil and tunnel site (C2a)

The Parramatta Road ventilation facility would be located on the north eastern corner of Parramatta Road and Wattle Street intersection. The facility would be constructed as part of the M4 East project and fitted out as part of the M4-M5 Link project. Heavy vehicle access to, and egress from the site would be via Parramatta Road, with light vehicles utilising the Northcote Street civil site (C3a) and Wattle Street civil and tunnel site (C1a) for parking.

Northcote Street civil site (C3a)

This site is currently occupied by the Northcote Street tunnel site as part of the M4 East project. At the completion of the M4 East project, Northcote Street would be reopened to traffic and the footpath along Parramatta Road reinstated. The existing tunnel site facilities would be removed and the site would be used primarily as a car park and laydown area for the duration of the M4-M5 Link project works at Haberfield.

Figure 5-1 Indicative site layout – Haberfield Option A

Works schedule

Subject to planning approval, tunnelling at Haberfield is planned to start in the third quarter of 2019 along with the fitout of the ventilation building constructed under the M4 East project, with completion planned for the end of 2022. The total period of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction program for Haberfield is shown in **Table 5-1**.

Table 5-1 Indicative construction program and duration – Haberfield Option A

Activity	2019				2020				2021				2022			
	Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Wattle Street civil and tunnel site (C1a)																
Initial roadworks and traffic management			■													
Site establishment and utility works			■	■	■	■										
Below ground site set up					■	■										
Tunnelling					■	■	■	■	■	■						
Civil and mechanical fitout										■	■	■				
Testing and commissioning												■	■	■	■	
Site rehabilitation and landscaping															■	■
Haberfield civil and tunnel site (C2a)																
Initial roadworks and traffic management			■													
Site establishment			■	■	■	■										
Below ground site set up				■	■	■										
Temporary ventilation for Wattle Street ramps and mainline (tunnelling support activities)				■	■											
Fit-out of ventilation station and substation						■	■	■	■	■	■	■				
Tunnelling					■	■	■	■	■	■						
Civil and mechanical fitout										■	■	■				
Testing and commissioning												■	■	■	■	
Site rehabilitation and landscaping															■	■
Northcote Street civil site (C3a)																
Make good existing construction ancillary facility from previous M4 East Contractor				■	■	■										
Construct car park				■	■											
Construct laydown area				■	■											
Operation of car park and laydown area					■	■	■	■	■	■	■	■	■	■		
Site rehabilitation and landscaping															■	■

Construction activities

A number of scenarios have been developed to assess potential impacts associated with construction works at Haberfield. **Table 5-2** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-2 Construction activities and period of operation – Haberfield Option A

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2,3] Day	Day OOH	Eve	Night
Site establishment	OPTA-01	1	Installation of environmental controls	✓			
	OPTA-02	2	Pavement and infrastructure works	✓	✓	✓	✓
	OPTA-03	4	Establishment of construction facilities	✓			
Tunnelling and supporting works	OPTA-04	132	Onsite car parking	✓	✓	✓	✓
	OPTA-05	132	Workshop, deliveries, maintenance, and storage	✓	✓	✓	✓
	OPTA-06 OPTA-07	132 72	Onsite truck movements – Wattle Street tunnel (C1a) and Northcote Street civil (C3a)	✓	✓	✓	✓
	OPTA-08	72	Tunnelling support activities	✓	✓	✓	✓
Construction	OPTA-09	33	Ventilation building fit out and installation	✓			
	OPTA-10	1	Wattle St line marking	✓	✓	✓	✓
Site rehabilitation and landscaping	OPTA-11	12	Site rehabilitation and landscaping	✓			

Notes

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for pavement infrastructure works. Pavement and infrastructure works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations for Haberfield is provided in **Table 5-3.**

Table 5-3 Activities assessed for cumulative construction noise – Haberfield Option A

Cumulative ID	Activity works ID	Activity	Comment	Period of works
OPTA-12	OPTA-04	Onsite car parking	Tunnelling works along with supporting activities from both sites C1a and C2a have the potential for cumulative impacts due to works typically operating within a restricted locality within the site.	All Periods
	OPTA-05	Workshop, deliveries, maintenance, and storage		
	OPTA-06 OPTA-07	Onsite truck movements		
	OPTA-08	Tunnelling support activities		

5.1.2 Airborne noise – Option A

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works at Haberfield are outlined in **Table 5-4**.

Table 5-4 Residential NMLs for the project – Haberfield Option A

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime period	Daytime period	Evening period	Night period	
NCA01	H.03	Residential	56	51	51	43	53
NCA02	H.01	Residential	68	63	63	57	67
NCA03	H.04	Residential	68	63	60	49	59
NCA04	H.06	Residential	66	61	58	48	58
NCA05	L.02	Residential	61	56	54	47	57
NCA06	H.02	Residential	56	51	51	48	58
NCA07	H.02	Residential	56	51	51	48	58

Notes:

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship the NMLs presented in **section 4.1.2** are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-5**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Potential ground-borne noise impacts from works within the tunnel are assessed in **section 5.7.1**.

Table 5-5 **Sound power levels for construction equipment – Haberfield Option A**

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2] LWA Item	LWA Activity[4]	LWAmax Activity
Site establishment works	OPTA-01	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	OPTA-02	Pavement and infrastructure works	Truck	1	98	116	123
			Concrete saw[1]	1	120		
			Grader	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Back hoe	1	102		
	OPTA-03	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
Tunnelling and supporting works	OPTA-04	Onsite car parking	Car parking	10	73	97	105
			Water pump	1	97		
	OPTA-05	Workshop, deliveries, maintenance, and storage	Truck	1	98	103	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	OPTA-06	Northcote civil	Trucks	6	103	98	108
	OPTA-07	Wattle ramps	Trucks	6	103	98	108
	OPTA-08	Tunnelling support activities	Ventilation fans [2,3]	1	90	91	98
			Water treatment plant [2,3]	1	82		
Construction	OPTA-09	Wattle St line marking	Line marking plant	1	109	109	117
			Ute	1	98		
			Truck	1	98		
	OPTA-10	Ventilation building installation	Mobile crane	1	101	102	107
			Truck	1	103		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
Site rehabilitation and landscaping	OPTA-11	Site rehabilitation and landscape	Truck	1	98	105	111
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of the finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise mitigation

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facility of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable.
- **Doors on Wattle Street access ramps** – Doors required to control dust from tunnelling works would also provide a noise benefit.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-6** to **Table 5-10** for residential, commercial and other sensitive receivers. The noise levels are representative of impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) against the relevant NMLs and a summary of the impact assessment is presented in detail in **Annexure F-1**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs – impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs – impacts would typically be moderate
Noise levels >20 dBA above NMLs – impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-11**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-1**.

Table 5-6 Predicted worst case noise levels – Haberfield Option A – residential daytime

NCA	NML	Predicted $L_{Aeq(15minute)}$ noise level (dBA)[1]											
		OPTA-01	OPTA-02	OPTA-03	OPTA-04	OPTA-05	OPTA-06	OPTA-07	OPTA-08	OPTA-09	OPTA-10	OPTA-11	OPTA-12
Residential - Standard Daytime													
NCA01	56	55	63	61	44	50	41	32	34	52	50	53	51
NCA02	68	74	75	80	63	64	47	52	41	<30	50	71	64
NCA03	68	69	77	75	53	58	33	48	45	<30	46	66	59
NCA04	66	62	66	68	47	57	<30	32	46	<30	37	59	58
NCA05	61	49	56	55	37	44	<30	<30	34	45	34	46	45
NCA06	56	66	72	72	53	54	31	36	42	<30	57	63	57
NCA07	56	47	55	53	36	41	<30	<30	<30	<30	40	44	43

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-7 Predicted worst case noise levels – Haberfield Option A – residential evening

NCA	NML	Predicted $L_{Aeq(15minute)}$ noise level (dBA)[1]											
		OPTA-01	OPTA-02	OPTA-03	OPTA-04	OPTA-05	OPTA-06	OPTA-07	OPTA-08	OPTA-09	OPTA-10	OPTA-11	OPTA-12
Residential - Evening													
NCA01	51	-	63	-	44	50	41	32	34	52	-	-	51
NCA02	63	-	75	-	63	64	47	52	41	<30	-	-	64
NCA03	60	-	77	-	53	58	33	48	45	<30	-	-	59
NCA04	58	-	66	-	47	57	<30	32	46	<30	-	-	58
NCA05	54	-	56	-	37	44	<30	<30	34	45	-	-	45
NCA06	51	-	72	-	53	54	31	36	42	<30	-	-	57
NCA07	51	-	55	-	36	41	<30	<30	<30	<30	-	-	43

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-8 Predicted worst case noise levels – Haberfield Option A – residential night-time

NCA	NML	Predicted $L_{Aeq(15minute)}$ noise level (dBA)[1]											
		OPTA-01	OPTA-02	OPTA-03	OPTA-04	OPTA-05	OPTA-06	OPTA-07	OPTA-08	OPTA-09	OPTA-10	OPTA-11	OPTA-12
Residential - Night-time													
NCA01	43	-	63	-	44	50	41	32	34	52	-	-	51
NCA02	57	-	75	-	63	64	47	52	41	<30	-	-	64
NCA03	49	-	77	-	53	58	33	48	45	<30	-	-	59
NCA04	48	-	66	-	47	57	<30	32	46	<30	-	-	58
NCA05	47	-	56	-	37	44	<30	<30	34	45	-	-	45
NCA06	48	-	72	-	53	54	31	36	42	<30	-	-	57
NCA07	48	-	55	-	36	41	<30	<30	<30	<30	-	-	43

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-9 Predicted worst case noise levels – Haberfield Option A – commercial

NCA	NML	Predicted $L_{Aeq(15minute)}$ noise level (dBA)[1]											
		OPTA-01	OPTA-02	OPTA-03	OPTA-04	OPTA-05	OPTA-06	OPTA-07	OPTA-08	OPTA-09	OPTA-10	OPTA-11	OPTA-12
Commercial													
NCA01	70	63	71	69	51	58	49	34	38	<30	60	63	59
NCA02	70	66	74	72	43	61	46	49	38	<30	51	63	61
NCA03	70	-	-	-	-	-	-	-	-	-	-	-	-
NCA04	70	45	53	51	34	40	<30	<30	30	<30	35	42	41
NCA05	70	36	44	42	<30	31	-	<30	<30	<30	<30	33	32
NCA06	70	59	63	65	44	50	31	33	40	<30	58	61	51
NCA07	70	46	53	52	35	41	<30	<30	<30	<30	40	43	42

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-10 Predicted worst case noise levels – Haberfield Option A – other sensitive receivers

NCA	NML	Predicted $L_{Aeq(15minute)}$ noise level (dBA)											
		OPTA-01	OPTA-02	OPTA-03	OPTA-04	OPTA-05	OPTA-06	OPTA-07	OPTA-08	OPTA-09	OPTA-10	OPTA-11	OPTA-12
Other Sensitive													
NCA01	Refer to note 1	47	54	53	36	42	30	<30	<30	36	43	46	43
NCA02		61	64	67	50	56	36	44	39	49	52	58	57
NCA03		-	-	-	-	-	-	-	-	-	-	-	-
NCA04		49	55	55	36	44	<30	<30	32	35	32	46	45
NCA05		40	47	46	<30	35	-	<30	<30	<30	<30	37	36
NCA06		37	45	43	<30	<30	<30	<30	<30	<30	<30	34	31
NCA07		47	55	53	36	42	<30	<30	30	37	40	44	43

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities

Table 5-11 Overview of NML exceedances – Haberfield Option A

Activity ID	Activity	Weeks [1]	Activity duration within overall project program [2]				Number of receivers: Total	Highly noise affected [4]	NML exceedance receiver count [3]: Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
OPTA-01	Installation of environmental controls	1					1820	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-02	Pavement and infrastructure works	2					1820	5	91	9	-	250	22	2	250	27	2	632	143	19	575	126	22
OPTA-03	Establishment of construction facilities	4					1820	5	65	13	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-04	Onsite car parking	132					1820	-	-	-	-	3	-	-	3	-	-	16	-	-	22	1	-
OPTA-05	Workshop, deliveries, maintenance, and storage	132					1820	-	1	-	-	10	-	-	10	-	-	84	-	-	33	1	-
OPTA-06	Onsite truck movements - Northcote	132					1820	-	-	-	-	-	-	-	-	-	-	-	-	-	17	-	-
OPTA-07	Onsite Truck movements Wattle St Ramps	132					1820	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
OPTA-08	Tunnelling support activities	72					1820	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-09	Wattle Street Line marking	1					1820	-	-	-	-	1	-	-	1	-	-	5	-	-	131	7	
OPTA-10	Ventilation Building Installation	72					1820	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-11	Site rehabilitation and Landscape	33					1820	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-12	Cumulative works scenario	72					1820	-	2	-	-	15	-	-	15	-	-	115	-	-	47	2	-

Notes:

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 13%) of activity duration within overall proposal program. Where percentage is less than 13%, 13% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables indicate that:

- The highest noise levels and NML exceedances are predicted during pavement and infrastructure works (OPTA-02), which require the use of a concrete saw
- The greatest impacts are predicted in NCA01, NCA03 and NCA06 where receivers are situated in relatively close proximity to the works site. Noise levels in NCA02 are also predicted to be comparable to these catchments
- Works associated with tunnelling activities (OPTA-04 to OPTA-08) have the longest duration of impacts
- Minor NML exceedances are predicted for commercial receivers in NCA01 and NCA02 during pavement and infrastructure works (OPTA-02) and establishment of construction facilities (OPTA-03) works only.

NML exceedances

The following section discusses key potential construction noise impacts in the Haberfield area only. All works scenarios in this area have been assessed and are presented in **Annexure F-1**.

Table 5-6 shows that the activity with potential for the greatest exceedance of the NMLs is the pavement and infrastructure works (OPTA-02). **Figure 5-2** indicates the distribution of exceedances for activity OPTA-02 (at night) for receivers within the Haberfield study area.

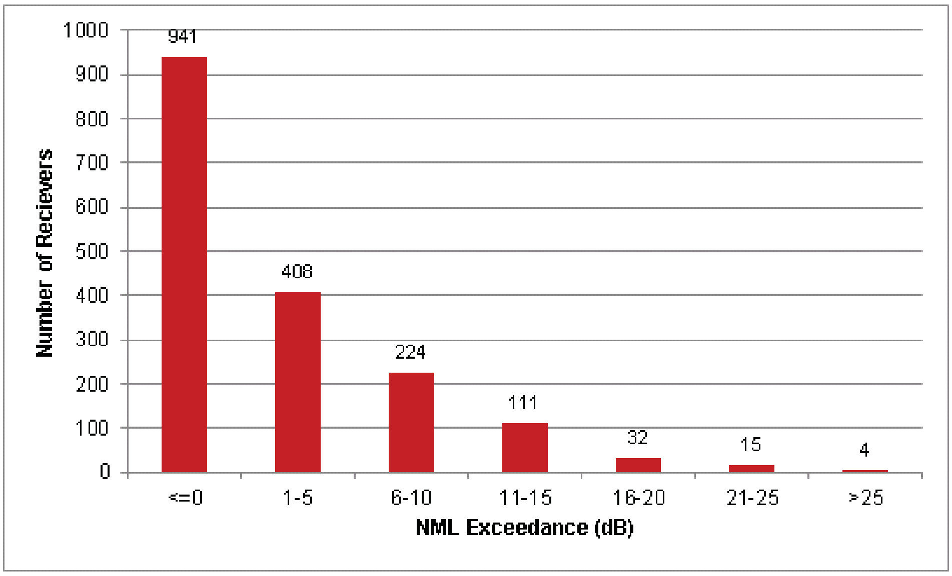


Figure 5-2 Activity OPTA-02 noise level exceedance, night-time – Haberfield Option A

The above graph shows that while the worst case impacts may result in a greater than 25 dBA exceedance of NMLs, this is limited to a small number of receivers (four only), with the majority of the receivers in this area being subject to considerably lower or no impact.

All work activities comprise the use of a number of individual items of plant, (see listing in **Table 5-5**) though typically one item of plant will dominate the noise. The operation and location of the dominant item typically controls the level of noise emissions shown in **Table 5-6**. For pavement works (OPTA-02) the operation of the concrete saw dominates the noise predictions and therefore mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA.

Site establishment works (OPTA-01, OPTA-02 and OPTA-03) account for a relatively small percentage of the total works duration (up to four weeks) and this should be considered when evaluating mitigation and management measures for identified exceedances.

NML exceedances of up to 12 dBA (during the night period) are predicted during the operation of the workshops, deliveries, maintenance, and storage areas (OPTA-05). These exceedances are due to the operation of laydown areas particularly within NCA02 where receivers adjoin the Northcote Street civil site (C3a). **Figure 5-3** indicates the distribution of exceedances for activity OPTA-05 (night) for receivers within the Haberfield study area.

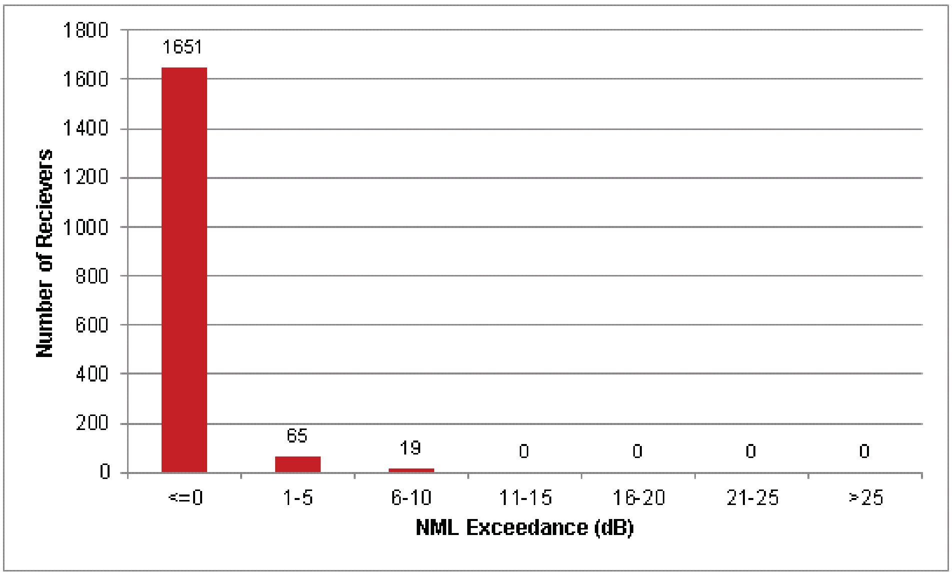


Figure 5-3 **Activity OPTA-05 noise level exceedance, night-time – Haberfield Option A**

The above graph shows that while the worst case impacts may result in up to 10 dBA exceedances of the NMLs, this is limited to a small number of receivers, with the majority of the receivers in this area being subject to considerably lower or no impact.

The operation of laydown areas (OPTA-05) forms part of the tunnelling and supporting works scenario. Tunnelling works and supporting activities (OPTA-04, to OPTA-08) account for the majority of the total works duration at Haberfield. The extended duration of these works should be considered when evaluating mitigation and management measures.

The cumulative scenario (OPTA-12), which includes the operation of all activities detailed in **Table 5-3**, results in exceedances of up to 12 dBA over the night-time NMLs. **Table 5-6** shows that the cumulative scenario is dominated by the operation of laydown areas (OPTA-05) and as such by controlling the noise emissions of this activity, the overall noise emissions would be reduced. **Figure 5-4** indicates the distribution of exceedances for the cumulative activity OPTA-12 (at night) for receivers within the Haberfield area.

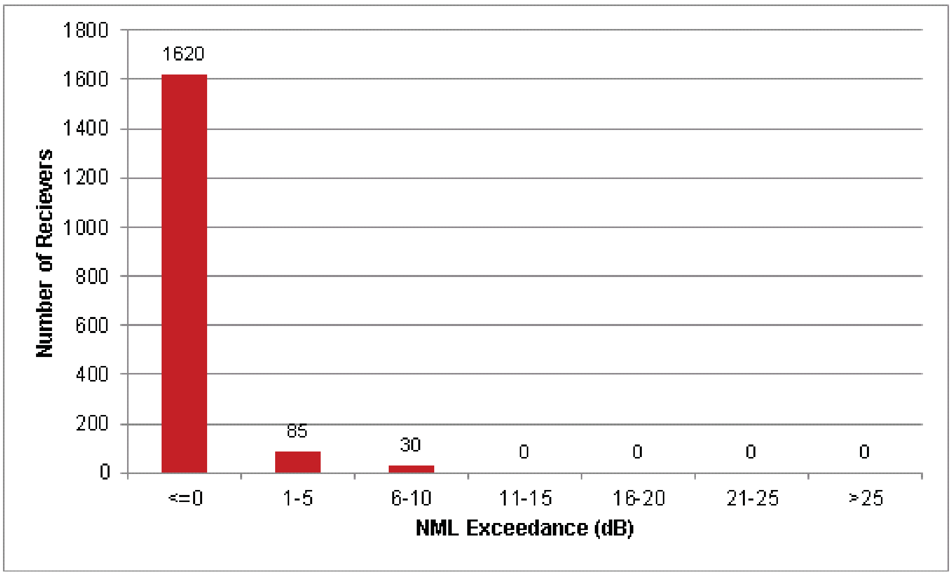


Figure 5-4 **Activity OPTA-11 noise level exceedance, night-time – Haberfield Option A**

The above graph shows that while the worst case impacts may result in up to 10 dBA exceedances of the NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower or no impact.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of Highly Noise Affected receivers in the study area has been determined and is summarised in **Table 5-12**. The table shows the number of residential receivers separated by works activity.

Table 5-12 **Predicted number of highly noise affected residential receivers by works – Haberfield Option A**

Works	Activity	Period		
		Day	Eve	Night
OPTA-01	Installation of environmental controls	-	-	-
OPTA-02	Pavement and infrastructure works	5	5	5
OPTA-03	Establishment of construction facilities	5	-	-
OPTA-04	Onsite car parking	-	-	-
OPTA-05	Workshop, deliveries, maintenance, and storage	-	-	-
OPTA-06	Onsite truck movements - Northcote	-	-	-
OPTA-07	Onsite Truck movements Wattle St Ramps	-	-	-
OPTA-08	Tunnelling support activities	-	-	-
OPTA-09	Wattle St line marking			
OPTA-10	Ventilation Building Installation	-	-	-
OPTA-11	Site rehabilitation and Landscape	-	-	-
OPTA-12	Cumulative works scenario	-	-	-

The above table shows that receivers are predicted to be Highly Noise Affected during certain works activities. The highest numbers are apparent during:

- OPTA-02 – Pavement and infrastructure works, where five receivers are predicted to be highly noise affected
- OPTA-03 - Establishment of construction works, where five receivers predicted to be highly noise affected.

Both of these works activities require the use of highly noise intrusive equipment such as concrete saws. It is important to note that both activities OPTA-02 and OPTA-03 are expected to occur for a relatively short period time and that the use of the most noise intrusive equipment (concrete saws) would be expected to be only occurring sporadically throughout the duration of works.

The location of the Highly Noise Affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-5**

Figure 5-5 Highly noise affected residential receivers – Haberfield Option A

The most impacted receivers are typically surrounding dwellings which have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-13**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-10** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-13 Overview of other sensitive receiver NML exceedances – Haberfield Option A

Works ID	Activity	Number of other sensitive receivers exceeding NMLS														
		Education			Medical			Place of Worship			Childcare			Remaining[1]		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
OPTA-01	Installation of environmental controls	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
OPTA-02	Pavement and infrastructure works	-	-	-	-	-	-	1	-	-	4	-	-	-	-	-
OPTA-03	Establishment of construction facilities	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-
OPTA-04	Onsite car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-05	Workshop, deliveries, maintenance, and storage	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
OPTA-06	Onsite truck movements - Northcote	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-07	Onsite Truck movements Wattle St Ramps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-08	Tunnelling support activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-09	Wattle St line marking															
OPTA-10	Ventilation Building Installation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTA-11	Site rehabilitation and Landscape	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
OPTA-12	Cumulative works scenario	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-

Notes:

1. The ‘Remaining’ category includes public buildings, libraries, café/bars, etc.

The above table shows the following:

- Other sensitive receivers in this precinct are generally predicted be subject to relatively minor noise impacts. Receivers in the education, medical and remaining categories would not be subject to any NML exceedances
- Only one ‘other sensitive receiver’ in this area would be subject to worst case exceedances of 11 to 20 dBA above NML during the higher noise generating activities. This receiver is the Kingdom Hall of Jehovah’s Witnesses at 12 Wattle St, Haberfield (located within NCA02).

The recommended ‘standard’ and ‘additional’ noise mitigation as discussed in **section 7.9** along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-1**.

NCA01

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Parramatta Road and are attributed to pavement works which may be required at the Northcote Street Civil site (C3a). The duration of these works is estimated to be two weeks, during which OOHW would be required at times
- Operations within the Northcote Street civil site (C3a) laydown area (OPTA-05) are predicted to result in exceedances of between 1 and 10 dBA at 48 receivers during night-time operations. For these 48 receivers, 90 per cent of exceedances are less than 5 dBA. The expected duration of these works is up to 132 weeks and as such mitigation should be considered for these impacts

- The cumulative scenario (OPTA-12) is predicted to result in exceedances (up to 10 dBA) at 72 receivers for up to 72 weeks. For these 72 receivers, 88 per cent of exceedances are predicted to be less than 5 dBA.

NCA02

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Parramatta Road and Wattle Street and are attributed to pavement works which may be required at any of the three construction ancillary facilities. The duration of these works is estimated to be two weeks during which out of hours works would be required at times
- Operations within the Northcote Street civil site (C3a) laydown area (OPTA-05) are predicted to result in exceedances of between 1 and 10 dBA at five receivers during night-time operations. These receivers adjoin the Northcote Street civil site to the north. For these five receivers, three receivers are predicted to experience exceedances of less than 5 dBA. The expected duration of these works is up to 132 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (OPTA-12) is predicted to result in exceedances (up to 10 dBA) at seven receivers during the night-time period. For these seven receivers, four are predicted to experience exceedances of less than 5 dBA.

NCA03

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Wattle Street civil and tunnel site (C1a). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the Wattle Street civil and tunnel site (surface works) laydown area (OPTA-05) are predicted to result in exceedances (up to 10 dBA) at 12 receivers during night-time operations. For these 12 receivers, only six would experience an exceedance of up to 10 dBA, with six receivers predicted to be less than 5 dBA. The expected duration of these works is up to 132 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (OPTA-12) is predicted to result in exceedances (up to 10 dBA) at 13 receivers. As identified previously, exceedances of the cumulative works scenario are dominated by the operation of laydown areas (OPTA-05). By controlling noise emission from these works the exceedances of the overall cumulative assessment will reduce.

NCA04

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Wattle Street civil and tunnel site (C1a). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the Wattle Street civil and tunnel site (surface works) laydown area (OPTA-05) are predicted to result in exceedances (up to 10 dBA) at four receivers during night-time operations. The expected duration of these works is up to 132 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (OPTA-12) is predicted to result in exceedances (up to 10 dBA) at six receivers. As identified previously, exceedances of the cumulative works scenario are dominated by the operation of laydown areas (OPTA-05). By controlling noise emission from these works the exceedances of the overall cumulative assessment will reduce.

NCA05

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Wattle Street civil and tunnel site and Haberfield civil and tunnel site (C1a and C2a). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times.

NCA06

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Wattle Street civil and tunnel site and Haberfield civil and tunnel site (C1a and C2a). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the Haberfield civil and tunnel site (C2a) laydown and car parking areas (activity OPTA-05 and OPTA-06) are predicted to result in exceedances of between 1 and 10 dBA at 15 receivers during night-time operations. For these 15 receivers, 73 per cent of exceedances are less than 5 dBA. The expected duration of these works is up to 132 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (OPTA-12) is predicted to result in night-time exceedances (up to 10 dBA) at 17 receivers. For these 17 receivers, 50 per cent of exceedances are predicted to be less than 5 dBA.

NCA07

- Pavement and infrastructure works (OPTA-02) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Parramatta Road. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times. Of the 21 receivers predicted to exceed the night-time criteria, 20 receivers have predicted exceedances less than 5 dBA.

Sleep disturbance

A review of the predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-1** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred.

Based on the noise impact assessment of the proposed works, the recommended project-specific mitigation measures (in addition to the standard suite of measures in **Table 4-13**) are summarised in **Table 5-14.**

Table 5-14 Recommended site specific noise mitigation measures – Haberfield Option A

Activity	Mitigation description	Reason	Recommendations
OPTA-02	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	OPTA-02 has been identified as having the potential for the highest impacts within the Haberfield civil and tunnel site. The concrete saw is the dominant item of plant.	Limit the use of the concrete saw during out of hour's works where feasible. Use mobile acoustic hoarding around smaller items to minimise noise.
Activities within construction ancillary facilities (C1a, C2a and C3a) OPTA-04 OPTA-05 OPTA-06	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified for works conducted within each compound site.	Investigate locations where hoarding (>2m) can be utilised to control source emissions.
	Non-tonal reversing beepers (or an equivalent) must be fitted and used on all construction vehicles and mobile plant regularly used onsite.		
	Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.		

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-1**.

Table 5-14 recommended increasing the height of hoarding (from two to four metres) to mitigate the potential impacts associated with the operation of laydown areas (OPTA-05). By mitigating this works activity, it is expected that the impacts identified for the cumulative scenario (OPTA-11) would also be controlled.

All site hoarding as shown in **Figure 5-5** has been investigated at a height of four metres.

Table 5-15 provides the predicted distribution of exceedances (at night-time) both 'with' and 'without' the recommended mitigation for receivers within this study area.

Table 5-15 NML exceedance distribution with and without mitigation – Haberfield Option A

Activity id	Activity	Time period	Number of receivers with NML exceedance					
			Without mitigation			With mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
OPTA-04	Onsite car parking	Night	16	-	-	7	-	-
OPTA-05	Workshop deliveries, maintenance and storage	Night	84	-	-	69	-	-
OPTA-12	Cumulative scenario	Night	115	-	-	96	-	-

Table 5-15 indicates that with the inclusion of in-situ mitigation measures in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure G** and represent the maximum predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. Detailed in **Table 5-16**, the counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures.

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure H**.

Table 5-16 CNVG additional noise mitigation counts – Haberfield Option A

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment works					
NCA01	-	174	220	8	-
NCA02	-	19	17	-	-
NCA03	-	22	23	10	2
NCA04		38	7	-	-
NCA05	-	91	11	-	-
NCA06	6	41	40	9	-
NCA07	-	26	-	-	-
Scenario – Tunnelling and supporting works					
NCA01	-	42	-	-	-
NCA02	-	-	-	-	-
NCA03	-	11	-		-
NCA04	-	2	-	-	-
NCA05	-	-		-	-
NCA06	-	15	1	-	-
NCA07	-	-	-	-	-
Scenario – Construction and Site rehabilitation and landscaping					
NCA01	-	-	-	-	-
NCA02	-	-	-	-	-
NCA03	-	-	-	-	-
NCA04	-	-	-	-	-
NCA05	-	-	-	-	-
NCA06	-	-	-	-	-
NCA07	-	-	-	-	-

Notes:
1. Refer to **section 4.6.2** for descriptions of the various additional mitigation measures

Consecutive construction impacts

The CNVG recognises that mitigation measures aimed at short term works may be less effective where longer term impacts are apparent and requires additional consideration of reasonable and feasible management measures to minimise impacts on the community.

When evaluating the extent of noise impacts within the Haberfield area, it is noted that this area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved M4 East project, currently under construction. This project, together with the M4-M5 Link, tie in to Wattle Street in Haberfield, where receivers will likely be exposed to extended impacts associated with the construction of these infrastructure projects, which would likely occur consecutively.

Previous and ongoing works in the Haberfield area are assumed to follow those outlined in the EIS for M4 East, generally consisting of the following activities:

- Pavement and infrastructure works
- Tunnelling and supporting activities
- Car parking
- Landscaping
- Ventilation building construction.

These type of activities therefore have general similarities with the works proposed for the M4-M5 Link and involve similar construction activities for both projects.

The indicative construction program for M4-East and M4-M5 Link are shown below in **Table 5-17**.

Table 5-17 Indicative construction program – Haberfield Option A

Project	2016				2017				2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
M4 East																												
M4-M5 Link																												

The impacts discussed in this report (refer to **section 5.1**) consider the duration of the M4-M5 Link project in isolation, whereas the potential impacts from the identified consecutive projects are likely to be perceived to be longer for receivers near to Wattle Street. While the majority of the highly noise intrusive works are anticipated to be associated with the M4 East project (expected to be complete in second quarter of 2019), the M4-M5 Link project is predicted to result in impacts (of a lesser degree) for similar receivers in the area (ie on Wattle Street). The short-term noise intensive works are generally associated with discrete activities which occur over a number of days or weeks in moving locations rather than throughout the entire project at fixed locations. Therefore, the focus of assessing consecutive impacts is to identify works activities which repeat (or are similar to other activities) over extended periods. The longer-term impacts associated with compound activity may continue between separate projects in the area and may appear to be of a similar nature to the community.

Excluding short-term works such as pavement and utility works, receivers located within NCA02, NCA03 and NCA06, which front both Parramatta Road and Wattle Street, are predicted to experience up to 10 dBA exceedances of the project NMLs (in the night-time period) during construction of the M4-M5 Link project. While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to significant noise impacts from the M4 East project. The likely impacted receivers are generally located at:

- Receivers adjoining the Northcote Street civil site (C3a). This site is currently the Haberfield tunnel site for the M4 East project, with an acoustic shed located at the site
- Receivers which adjoin Wattle Street and have line of sight to the Wattle Street civil and tunnel site (C1a).

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, if options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be appropriately considered when preparing the site specific construction noise and vibration impact statements (CNVIS) for this area. Feasible and reasonable considerations for providing at-receiver treatments should include:

- Time of day of the impacts and exceedance of criteria
- Time of impacts at the affected receivers
- How long the mitigation will provide benefit to the receiver during the project
- Optimal design of acoustic sheds, noise barriers/hoarding and management measures to reduce the impacts as far as practicable.
- Due to the variability of construction noise, it is envisaged that community input through the consultation phase would provide appropriate information to assist the project to address potential consecutive noise impacts from construction projects in this area.

5.1.3 Construction road traffic noise – Option A

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-18**.

Table 5-18 Construction traffic forecast – Haberfield Option A

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C1a - Wattle Street civil and tunnel site	133	50
C2a - Haberfield civil and tunnel site	136	90
C3a - Northcote Street civil site	100	150

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-19** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-19 Construction road traffic noise assessment – Haberfield Option A

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C1a - Wattle Street civil and tunnel site	Light & heavy	Wattle Street	<0.5	<0.5
C2a - Haberfield civil and tunnel site	Light & heavy	Wattle Street	<0.5	<0.5
C3a - Northcote Street civil site	Light & heavy	Parramatta Rd	<0.5	<0.5

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available.

The information above indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The Construction Traffic and Access Management Plan and site inductions should include instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.1.4 Ground-borne noise – Option A

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is assessed in **section 5.7**.

As such, the nature of the construction works at the construction ancillary facilities at Haberfield (Option A) (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to result in any adverse impacts for these works.

5.1.5 Vibration – Option A

Vibration intensive works at the Haberfield Option A site such as demolition of existing buildings, piling works and rock-breaking are to be undertaken by the M4 East project, and as such, are not considered further in this assessment.

Vibration from tunnelling works associated with construction of the M4-M5 Link mainline tunnels and connections to the Wattle Street ramps is assessed in **section 5.7**.

5.1.6 Works description – Option B

The Haberfield Option B works area consists of three construction ancillary facilities – Parramatta Road West civil and tunnel site (C1b), Haberfield civil site (C2b) and Parramatta Road East civil site (C3b), which are adjacent to the M4 East project. The indicative layout is shown in **Figure 5-6**.

Key construction activities to be carried out include:

- Demolition of existing buildings and structures (C1b and C3b only)
- Utility treatments including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities (C1b and C3b only)
- Establishment of site offices, amenities and temporary infrastructure (all sites)
- Laydown and storage of materials (all sites)
- Delivery of materials, plant and equipment (all sites)
- Construction of an acoustic shed (C1b only)
- Construction of a temporary access tunnel (C1b only)
- Tunnel excavation of the eastbound and westbound mainline tunnels and the Wattle Street entry and exit ramps using road-headers, as well as stockpiling of excavated material and spoil haulage (C1b only)
- Mechanical and electrical fitout of a section of the Parramatta Road ventilation facility (that will be built as part of the M4 East project) (C2b only)
- Demobilisation including works to prepare the site for a permissible future use (all sites).

Parramatta Road West civil and tunnel site (C1b)

The Parramatta Road West civil and tunnel site (C1b) would be used if Option B is selected as the preferred construction option at Haberfield.

The Parramatta Road West civil and tunnel site (C1b) would be located west of Parramatta Road around Alt Street and Bland Street at Ashfield. The site is currently occupied by a commercial car dealership and several commercial properties. Residential properties including single dwelling and apartment blocks are located to the immediate west and north. A construction site for the M4 East project is located to the south.

The site would be used for tunnelling support during construction and would include temporary site offices, a workshop and storage facilities, a laydown area, entry and exit points for construction traffic, a temporary substation, temporary ventilation for the tunnels, a temporary water treatment plant and sediment pond, workforce amenities and car parking.

An acoustic shed with a roller door would be established on the site to minimise noise from out of hours tunnelling and spoil handling. In addition, temporary noise mitigation measures may include noise barriers and other temporary structures such as site buildings, which would be positioned to minimise effects from noise on surrounding properties.

Construction traffic would enter and exit the site to and from the western (northbound) carriageway of Parramatta Road via new driveways.

Spoil handling on the site would occur 24 hours a day, seven days a week, within an acoustic shed. Excavated spoil from tunnelling would only be stockpiled within the acoustic shed. Heavy vehicle movements associated with the removal of spoil from tunnelling would only occur via access and egress directly to and from Parramatta Road.

Haberfield civil site (C2b)

The Haberfield civil site (C2b) would be used for civil construction if Option B is selected as the preferred construction option at Haberfield. If Option A is selected as the preferred option, the Haberfield civil and tunnel site (C2a) would be used (refer to **section 5.1**).

The Haberfield civil site would be located at the south-eastern corner of the Parramatta Road and Wattle Street intersection, extending along Parramatta Road between Wattle Street and Walker Avenue. This construction ancillary facility would use land that is currently being used as a construction ancillary facility for the M4 East project.

The Haberfield civil site (C2b) would be used to support civil construction of a substation, and fitout of permanent operational infrastructure including the Parramatta Road ventilation facility (being constructed as part of the M4 East project). The site would include temporary site offices, workshop and storage facilities, laydown areas, ingress and egress for heavy and light vehicles, workforce amenities and car parking.

Heavy vehicles delivering materials and equipment would enter and exit the Haberfield civil site (C2b) via the westbound Wattle Street carriageways. Light vehicles would enter and leave the site via Wattle Street and Walker Avenue.

Parramatta Road East civil site (C3b)

The Parramatta Road East civil site (C3b) would be used where Option B is selected as the preferred construction option at Haberfield.

The Parramatta Road East civil site (C3b) would be located east of Parramatta Road at Haberfield between Alt Street and Bland Street. The site is currently occupied by a commercial car dealership. Residential properties are located to the immediate east and north. A construction site for the M4 East project is located to the south.

The Parramatta Road East civil site (C3b) would be used to support tunnelling construction activities that would occur at the Parramatta Road West civil and tunnel site (C1b) and to provide construction workforce parking. The site would include temporary site offices, ingress and egress for light vehicles, workforce amenities and car parking.

Figure 5-6 **Indicative site layout – Haberfield Option B**

Works schedule

Subject to planning approval, tunnelling at Haberfield is planned to start in the fourth quarter of 2018 along with the fitout of the ventilation building constructed under the M4 East project, with completion planned for the third quarter of 2022. The total period of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction program for Haberfield is shown in **Table 5-20**.

Table 5-20 Indicative construction program and duration – Haberfield Option B

Activity	2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Parramatta Road West civil and tunnel site (C1b)																				
Site establishment and utility works				■	■	■														
Construction of temporary access tunnel						■	■													
Tunnelling								■	■	■	■	■	■							
Civil and mechanical fitout													■	■	■	■	■			
Testing and commissioning																	■	■		
Site rehabilitation																		■		
Haberfield civil site (C2b)																				
Initial road works and traffic management							■													
Site establishment and utility works							■	■	■											
Fitout of Parramatta Road ventilation facility and substation										■	■	■	■	■	■	■				
Civil and mechanical fitout														■	■	■	■			
Testing and commissioning																■	■	■	■	
Site rehabilitation and landscaping																			■	
Parramatta Road East civil site (C3b)																				
Site establishment and utility works				■	■	■														
Use of car park and site amenities during construction						■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Demobilisation																			■	

Construction activities

A number of scenarios have been developed to assess potential impacts associated with construction works at Haberfield. **Table 5-21** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-21 Construction activities and period of operation – Haberfield Option B

Scenario	Works ID	Indicative duration (Weeks)[1]	Activity	Period of works[2,3] Day	Day OOH	Eve	Night
Site establishment	OPTB-01	4	Demolition of existing buildings	✓			
	OPTB-02	2	Utility works[4]	✓			
	OPTB-03	1	Installation of environmental controls	✓			
	OPTB-04	2	Pavement and infrastructure works	✓	✓	✓	✓
	OPTB-05	4	Establishment of construction facilities	✓			
Tunnelling and supporting works	OPTB-06	168	Onsite car parking	✓	✓	✓	✓
	OPTB-07	168	Workshop, deliveries, maintenance, and storage	✓	✓	✓	✓
	OPTB-08	168	Spoil handling inside acoustic shed	✓	✓	✓	✓
	OPTB-09	168	Tunnelling support activities	✓	✓	✓	✓
Construction	OPTB-10	84	Ventilation building fit out and installation	✓			
Site rehabilitation and landscaping	OPTB-11	12	Site rehabilitation and landscape	✓			

Notes:

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for pavement infrastructure works. Pavement and infrastructure works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays
4. The utility works activity represents utility works required within the footprint of the proposed construction facilities. Utility works that may be required outside of the project footprint are discussed in **section 5.8**

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations for Haberfield is provided in **Table 5-22.**

Table 5-22 Activities assessed for cumulative construction noise – Haberfield Option B

Cumulative id	Activity works ID	Activity	Comment	Period of works
OPTB-12	OPTB-06	Onsite car parking	Tunnelling works along with supporting activities from both sites C2b and C3b have the potential for cumulative impacts due to works typically operating within a restricted locality within the site.	All Periods
	OPTB-07	Workshop, deliveries, maintenance, and storage		
	OPTB-08	Spoil handling inside acoustic shed		
	OPTB-09	Tunnelling support activities		

5.1.7 Airborne noise – Option B

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works at Haberfield are outlined in **Table 5-23**.

Table 5-23 Residential NMLs for the project – Haberfield Option B

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime period	Daytime period	Evening period	Night period	
NCA00	H.03	Residential	56	51	51	43	53
NCA01	H.03	Residential	56	51	51	43	53
NCA02	H.01	Residential	68	63	63	57	67
NCA03	H.04	Residential	68	63	60	49	59
NCA04	H.06	Residential	66	61	58	48	58
NCA05	L.02	Residential	61	56	54	47	57
NCA06	H.02	Residential	56	51	51	48	58
NCA07	H.02	Residential	56	51	51	48	58

Notes:

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship the NMLs presented in **section 4.1.2** are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-24**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Potential ground-borne noise impacts from works within the tunnel are assessed in **section 5.7.1**.

Table 5-24 Sound power levels for construction equipment – Haberfield Option B

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					L_{WA}		L_{WAmax}
					Item	Activity[4]	Activity
Site Establishment	OPTB-01	Demolition of existing buildings	Diamond saw[1]	1	120	120	124
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	OPTB-02	Utility works	Concrete saw[1]	1	120	117	123
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)	1	100		
	OPTB-03	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	OPTB-04	Pavement and infrastructure works	Truck	1	98	118	124
			Suction truck	1	100		
			Excavator (breaker)[1]	1	121		
			Concrete pump	1	106		
	OPTB-05	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
Tunnelling and supporting works	OPTB-06	Onsite car parking	Car parking	10	73	97	105
			Water pump	1	97		
	OPTB-07	Workshop, deliveries, maintenance, and storage	Truck	1	98	103	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
			Water tanker	1	98		
	OPTB-08	Spoil handling inside acoustic shed	Tipper truck	2	100	117	119
			Excavator	2	112		
			Front end loader	2	115		
			Compressor for air scrubber	2	75		
			Ventilation scrubber	2	98		
	OPTB-09	Tunnelling support activities	Substation[2]	1	66	82	98
			Water treatment plant [2,3]	1	82		
Construction	OPTB-10	Ventilation building fitout and installation	Mobile crane	1	101	102	107
			Trucks	1	98		
Site rehabilitation and landscaping	OPTB-11	Site rehabilitation and landscape	Truck	1	98	105	111
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of the finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facility of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable
- **Acoustic shed** – An acoustic shed of solid construction such as sheet steel would be incorporated at this site where practicable.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-25** to **Table 5-29** for residential, commercial and other sensitive receivers. The noise levels are representative of impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) against the relevant NMLs and a summary of the impact assessment is presented in detail in **Annexure F-1b**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs	– impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs	– impacts would typically be moderate
Noise levels >20 dBA above NMLs	– impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-30**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-1b**.

Table 5-25 Predicted worst case noise levels – Haberfield Option B – residential daytime

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]											
		OPTB-01	OPTB-02	OPTB-03	OPTB-04	OPTB-05	OPTB-06	OPTB-07	OPTB-08	OPTB-09	OPTB-10	OPTB-11	OPTB-12
Residential - Standard Daytime													
NCA00	56	69	66	57	65	63	43	45	56	<30	38	54	57
NCA01	56	86	83	74	77	80	53	69	70	34	50	71	70
NCA02	68	56	53	72	77	78	50	63	42	41	50	69	63
NCA03	68	53	50	60	70	66	40	56	40	33	46	57	56
NCA04	66	49	46	49	59	55	35	45	36	<30	37	46	46
NCA05	61	48	45	44	54	50	30	40	36	<30	34	41	40
NCA06	56	86	83	74	76	80	63	55	56	42	57	71	64
NCA07	56	80	77	68	78	74	57	47	56	<30	40	65	59

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-26 Predicted worst case noise levels – Haberfield Option B – residential evening

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]											
		OPTB-01	OPTB-02	OPTB-03	OPTB-04	OPTB-05	OPTB-06	OPTB-07	OPTB-08	OPTB-09	OPTB-10	OPTB-11	OPTB-12
Residential – Evening													
NCA00	51	-	-	-	65	-	43	45	56	<30	-	-	57
NCA01	51	-	-	-	77	-	53	69	72	34	-	-	72
NCA02	63	-	-	-	77	-	50	63	42	41	-	-	63
NCA03	60	-	-	-	70	-	40	56	40	33	-	-	56
NCA04	58	-	-	-	59	-	35	45	36	<30	-	-	46
NCA05	54	-	-	-	54	-	30	40	36	<30	-	-	40
NCA06	51	-	-	-	76	-	63	55	56	42	-	-	64
NCA07	51	-	-	-	78	-	57	47	56	<30	-	-	59

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-27 Predicted worst case noise levels – Haberfield Option B – residential night-time

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]											
		OPTB-01	OPTB-02	OPTB-03	OPTB-04	OPTB-05	OPTB-06	OPTB-07	OPTB-08	OPTB-09	OPTB-10	OPTB-11	OPTB-12
Residential – Nigh-time													
NCA00	43	-	-	-	65	-	43	45	56	<30	-	-	57
NCA01	43	-	-	-	77	-	53	69	72	34	-	-	72
NCA02	57	-	-	-	77	-	50	63	42	41	-	-	63
NCA03	49	-	-	-	70	-	40	56	40	33	-	-	56
NCA04	48	-	-	-	59	-	35	45	36	<30	-	-	46
NCA05	47	-	-	-	54	-	30	40	36	<30	-	-	40
NCA06	48	-	-	-	76	-	63	55	56	42	-	-	64
NCA07	48	-	-	-	78	-	57	47	56	<30	-	-	59

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-28 Predicted worst case noise levels – Haberfield Option B – commercial

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]											
		OPTB-01	OPTB-02	OPTB-03	OPTB-04	OPTB-05	OPTB-06	OPTB-07	OPTB-08	OPTB-09	OPTB-10	OPTB-11	OPTB-12
Commercial													
NCA00	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA01	70	87	84	75	75	81	54	71	54	38	60	72	71
NCA02	70	53	50	61	68	67	43	57	40	37	51	58	57
NCA03	70	-	-	-	-	-	-	-	-	-	-	-	-
NCA04	70	50	47	44	54	50	32	40	36	<30	35	41	42
NCA05	70	-	-	-	-	-	-	-	-	-	-	-	-
NCA06	70	87	84	75	70	81	64	56	52	40	58	72	65
NCA07	70	74	71	62	76	68	51	46	57	<30	37	59	58

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-29 Predicted worst case noise levels – Haberfield Option B – other sensitive receivers

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)											
		OPTB-01	OPTB-02	OPTB-03	OPTB-04	OPTB-05	OPTB-06	OPTB-07	OPTB-08	OPTB-09	OPTB-10	OPTB-11	OPTB-12
Other Sensitive													
NCA00	Refer to note 1	41	38	30	39	36	<30	<30	<30	<30	<30	<30	31
NCA01		64	61	52	59	58	39	48	47	<30	36	49	51
NCA02		57	54	61	66	67	44	57	43	39	52	58	57
NCA03		-	-	-	-	-	-	-	-	-	-	-	-
NCA04		44	41	42	52	48	<30	38	32	<30	32	39	39
NCA05		42	39	36	45	42	<30	32	<30	<30	<30	33	32
NCA06		42	39	32	41	38	<30	<30	31	<30	<30	<30	33
NCA07		67	64	55	63	61	43	45	53	<30	40	52	54

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities

Table 5-30 Overview of NML exceedances – Haberfield Option B

Activity ID	Activity	Weeks [1]	Activity duration within overall project program [2]				Number of receivers																
							Total	Highly noise affected [4]	NML exceedance receiver count [3]														
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
OPTB-01	Demolition of existing buildings	4					1747	13	155	40	9	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-02	Utility works	2					1747	9	88	26	9	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-03	Installation of environmental controls	1					1747	-	43	9	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-04	Pavement and infrastructure works	2					1747	7	121	34	3	290	53	19	286	53	19	717	172	42	617	140	37
OPTB-05	Establishment of construction facilities	4					1747	7	62	27	5	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-06	Onsite car parking	168					1747	-	4	-	-	8	2	-	8	2	-	25	2	-	27	5	-
OPTB-07	Workshop, deliveries, maintenance, and storage	168					1747	-	5	1	-	25	2	-	24	2	-	65	6	2	26	4	1
OPTB-08	Spoil handling inside acoustic shed	168					1747	-	5	2	-	29	2	1	29	2	1	107	10	3	15	2	1
OPTB-09	Tunnelling support activities	168					1747	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
OPTB-10	Ventilation building fit out and installation	84					1747	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-11	Site rehabilitation and landscape	12					1747	-	30	5	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-12	Cumulative	168					1747	-	21	4	-	54	7	1	52	7	1	188	19	5	46	9	2

Notes;

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 13%) of activity duration within overall proposal program. Where percentage is less than 13%, 13% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables indicate that:

- The highest noise levels and NML exceedances are predicted during demolition of existing buildings (OPTB-01), which requires the use of a rock-breaker
- The greatest impacts are predicted in NCA01, NCA06 and NCA07 where receivers are situated in relatively close proximity to the works site. Noise levels in NCA00 are also predicted to be relatively high
- Works associated with tunnelling activities (OPTB-06 to OPTB-09) have the longest duration of impacts
- NML exceedances are predicted for commercial receivers in NCA01, NCA06 and NCA07 for a number of work activities, with the highest exceedances predicted during the demolition of existing properties and utility adjustment works, OPTB-01 and OPTB-02 respectively.

NML exceedances

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-1b**.

Table 5-30 shows that the activity with potential for the greatest exceedance of the NMLs is the pavement and infrastructure works (OPTB-04). **Figure 5-7** indicates the distribution of exceedances for activity OTB-04 (at night) for receivers within the Haberfield study area.

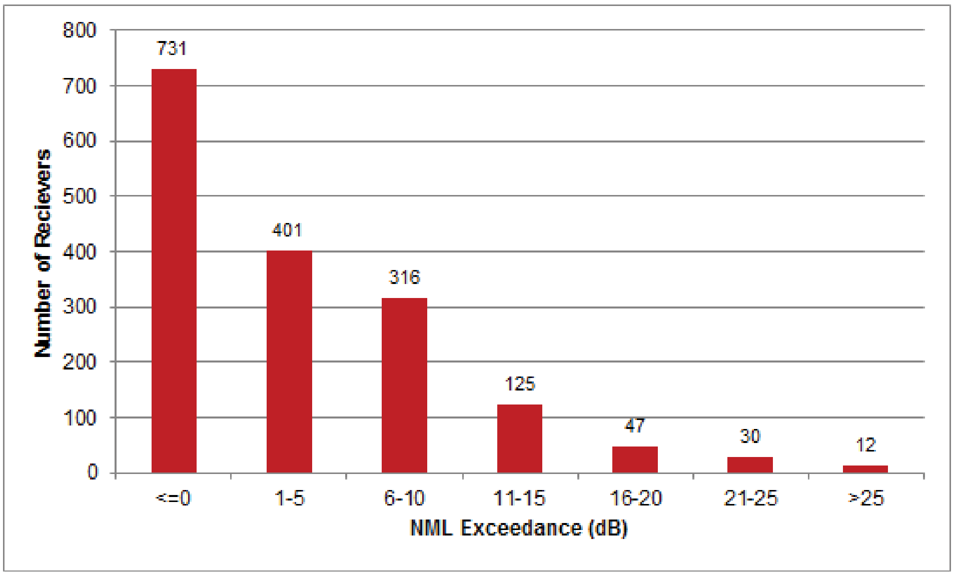


Figure 5-7 Activity OPTB-04 noise level exceedance, night-time – Haberfield Option B

All work activities comprise the use of a number of individual items of plant, (refer to listing in **Table 5-24**) though typically one item of plant will dominate the noise. The operation and location of the dominant item typically controls the level of noise emissions shown in **Table 5-24**. For pavement works (OPTB-04) the operation of the rock-breaker dominates the noise predictions and as such mitigation and management measures should focus on the operation of this item. It is estimated that when the rock-breaker is not in operation, NML exceedances would generally reduce by up to 6 dBA.

Site establishment works (OPTB-01 to OPTB-05) account for a relatively small percentage of the total works duration (up to 24 weeks) and this should be considered when evaluating mitigation and management measures for identified exceedances.

NML exceedances greater than 25 dBA (during the night period) are predicted during the spoil handling works within the site shed (OPTB-08). Predictions have been based on a standard site shed with only a basic acoustic attenuation performance. Mitigation of these exceedances should investigate upgrading the acoustic performance of the shed to control noise emissions. **Figure 5-8** indicates the distribution of exceedances for spoil handling works within the site shed (OPTB-08) (night) prior to mitigation for receivers within the Haberfield study area.

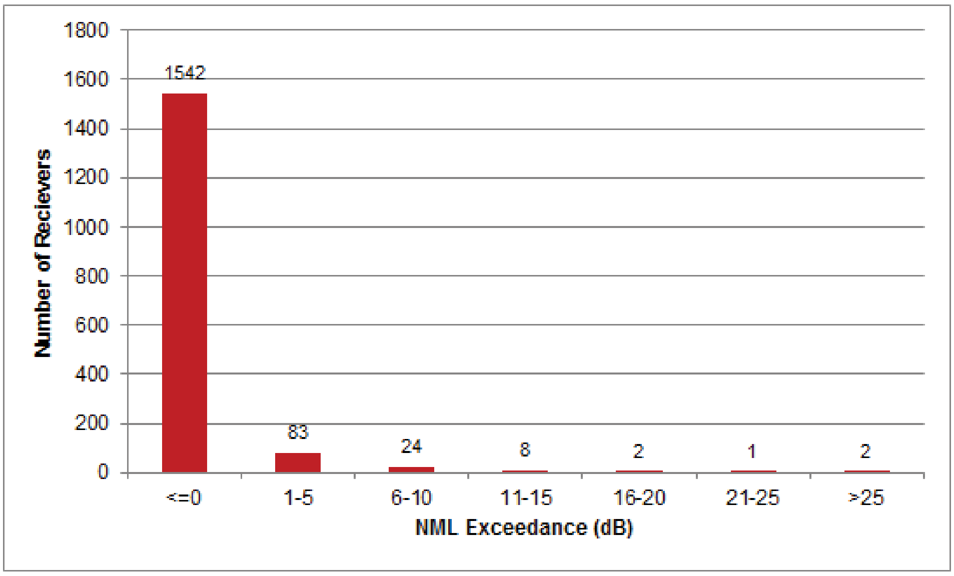


Figure 5-8 **Activity OPTB-08 noise level exceedance, night-time – Haberfield Option B**

The above graph shows that while the worst case impacts may result in greater than 25 dBA exceedance of NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to consideraly lower impacts.

The extended duration of the tunnelling activities (OPTB-06 and OPTB-09) should be considered when evaluating mitigation and management measures.

The cumulative scenario (OPTB-12), which includes the operation of all activities detailed in **Table 5-22**, results in exceedances greater than 25 dBA over the night-time NMLs. **Table 5-27** shows that the cumulative scenario is dominated by the operation of laydown areas (OPTB-07) and the spoil handling works within the site shed (OPTB-08). By controlling the noise emissions of these activities, the overall noise emissions would be reduced. **Figure 5-9** indicates the distribution of exceedances for the cumulative activity (OPTB-12) (at night) for receivers within the Haberfield area.

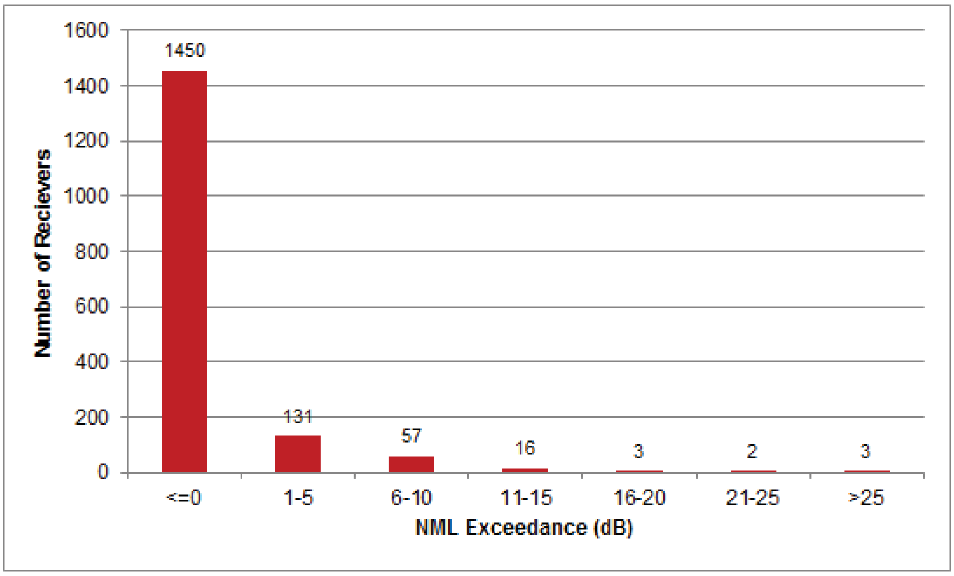


Figure 5-9 Activity OPTB-11 noise level exceedance, night-time – Haberfield Option B

The above graph shows that while the worst case impacts may result in greater than 25 dBA exceedances of the NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower or no impact.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of Highly Noise Affected receivers in the study area has been determined and is summarised in **Table 5-31**. The table shows the number of residential receivers separated by works activity.

Table 5-31 Predicted number of highly noise affected residential receivers by works – Haberfield Option B

Works	Activity	Period		
		Day	Eve	Night
OPTB-01	Demolition of existing buildings	13	-	-
OPTB-02	Utility works	9	-	-
OPTB-03	Installation of environmental controls	-	-	-
OPTB-04	Pavement and infrastructure works	7	7	7
OPTB-05	Establishment of construction facilities	7	-	-
OPTB-06	Onsite car parking	-	-	-
OPTB-07	Workshop, deliveries, maintenance, and storage	-	-	-
OPTB-08	Spoil handling inside acoustic shed	-	-	-
OPTB-09	Tunnelling support activities	-	-	-
OPTB-10	Ventilation building fit out and installation	-	-	-
OPTB-11	Site rehabilitation and landscape	-	-	-
OPTB-12	Cumulative	-	-	-

The above table shows that receivers are predicted to be Highly Noise Affected during certain works activities. The highest numbers are apparent during:

- OPTB-01 – Demolition of existing buildings, where 13 receivers are predicted to be highly noise affected.

All activities indicated to result in highly noise affected residential receivers include the use of highly noise intrusive equipment such as diamond/concrete saws and rock-breakers. It is important to note that activities that may result in highly noise affected receivers are expected to occur for a relatively short period of time and that the use of the most noise intensive equipment would only sporadically be required at times throughout the duration of works.

The location of the highly noise affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-10**.

Figure 5-10 Highly noise affected residential receivers – Haberfield Option B

The most impacted receivers are typically dwellings which surround and have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-32**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-29** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-32 Overview of other sensitive receiver NML exceedances – Haberfield Option B

Works ID	Activity	Number of other sensitive receivers exceeding NMLS														
		Education			Medical			Place of Worship			Childcare			Remaining[1]		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
OPTB-01	Demolition of existing buildings	1	1	-	-	-	-	1	-	-	1	1	-	-	-	-
OPTB-02	Utility works	2	-	-	-	-	-	-	-	-	1	1	-	-	-	-
OPTB-03	Installation of environmental controls	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
OPTB-04	Pavement and infrastructure works	2	-	-	-	-	-	-	1	-	3	-	-	-	-	-
OPTB-05	Establishment of construction facilities	2	-	-	-	-	-	-	1	-	2	-	-	-	-	-
OPTB-06	Onsite car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-07	Workshop, deliveries, maintenance, and storage	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
OPTB-08	Spoil handling inside acoustic shed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-09	Tunnelling support activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-10	Ventilation building fit out and installation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPTB-11	Site rehabilitation and landscape	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
OPTB-12	Cumulative	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-

Notes:

1. The ‘Remaining’ category includes public buildings, libraries, café/bars, etc.

The above table shows the following:

- Other sensitive receivers in this precinct are generally predicted be subject to relatively minor noise impacts
- Three ‘other sensitive receivers’ in this area would be subject to worst case exceedances of 11 to 20 dBA above NML during the higher noise generating activities. These receivers are:
  - Childcare centre – The Infants Home at17 Henry Street, Haberfield (located in NCA01)
  - Place of Worship - Kingdom Hall of Jehovah’s Witnesses at 12 Wattle St, Haberfield (located within NCA02)
  - Educational facility - Juvenile Justice – Yasmar training facility (located within NCA07).

The recommended ‘standard’ and ‘additional’ noise mitigation as discussed in **section 4.6**, along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-1**.

NCA00

- Demolition and pavement and infrastructure works (OPTB-01 and OPTB-04) are identified has having a number of exceedances of the daytime NMLs within NCA00. Exceedances are generally at receivers which adjoin Bland Street to the south of the Parramatta Road West civil and tunnel site (C1b), and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks

- Operations within the site shed (OPTB-08) are predicted to result in exceedances (up to 15 dBA) at 26 receivers during night-time operations. For these 26 receivers, only one would experience an exceedance of near to 15 dBA, with 21 receivers predicted to experience exceedances less than 5 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (OPTB-12) is predicted to result in exceedances (up to 15 dBA) at 38 receivers. Exceedances of the cumulative works scenario are dominated by spoil handling works within the site shed (OPTB-08). By controlling noise emission from activity OPTB-08, the exceedances of the overall cumulative assessment will reduce.

NCA01

Receivers within NCA01 are likely to experience the greatest noise impacts during construction works at Haberfield Option B construction ancillary facilities. This is due to their proximity to the works area along with the removal of adjoining existing structures which currently provide shielding from a high traffic noise environment. It is recommended that where feasible and reasonable, operational road traffic mitigation should be installed early on in the construction phase, if required. Additionally, when considering possible management and mitigation measures for these receivers, it is important to take into account the duration of the total works as it is likely that these receivers will be exposed to construction impacts for an extended period. The discussion of impacts in this NCA is provided below.

- Demolition and pavement and infrastructure works (OPTB-01 and OPTB-04) are identified as having a number of exceedances of the daytime NMLs within NCA01. Exceedances are generally at receivers which adjoin the Parramatta Road West civil and tunnel site (C1b) and the Parramatta Road East civil site (C3b), and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks
- Operations within the site shed (OPTB-08) are predicted to result in exceedances of NMLs at 72 receivers during night-time operations. For these 72 receivers, only two would experience an exceedance of greater than 25 dBA, with 60 receivers predicted to experience exceedances less than 10 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (OPTB-12) is predicted to result in exceedances of NMLs at 116 receivers. Exceedances of the cumulative works scenario are dominated by spoil handling works within the site shed (OPTB-08) and operation of laydown areas (OPTB-07) within the Parramatta Road West civil and tunnel site (C1b). By controlling noise emission from activity OPTB-08, the exceedances of the overall cumulative assessment will reduce.

NCA02

- Pavement and infrastructure works (OPTB-04) are identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Haberfield civil site (C2b). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the Haberfield civil site (C2b) laydown areas (OPTB-07) are predicted to result in exceedances of between 1 and 10 dBA at three receivers during night-time operations. For these three receivers, two receivers are predicted to exceed by less than 5 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts.

NCA03, NCA04 and NCA05

NCA03, NCA04 and NCA05 are predicted to experience a similar level of NML exceedance from common sources. The discussion of impacts for these NCAs has been grouped together below.

- Pavement and infrastructure works (OPTB-04) is identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Wattle Street and are attributed to pavement works which may be required at the Haberfield civil site (C2b). The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the Haberfield civil site (C2b) laydown areas (OPTB-07) are predicted to result in exceedances of between 1 and 10 dBA at six receivers during night-time operations. For these six receivers, four receivers are predicted to exceed by less than 5 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts.

NCA06

- Demolition and pavement and infrastructure works (OPTB-01 and OPTB-04) are identified as having a number of exceedances of the daytime NMLs within NCA06. Exceedances are generally at receivers which are located near to the Alt Street and Parramatta Road intersection, to the north of the Parramatta Road East civil site (C3b), and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks
- Operations within the Parramatta Road West civil and tunnel site (C1b) and the Parramatta Road East civil site (C3b), in particular car parking movements (OPTB-06) which is predicted to result in exceedances of between 1 and 15 dBA at 13 receivers during night-time operations. These receivers generally adjoin the Parramatta Road East civil site to the east. For these 13 receivers, 10 receivers are predicted to experience exceedances of less than 5 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (OPTB-12) is predicted to result in exceedances (up to 20 dBA) at 33 receivers. Exceedances of the cumulative works scenario are dominated by laydown, car parking and tunnelling operations (OPTB-06, OPTB-07 and OPTB-08). The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts.

NCA07

- Demolition and pavement and infrastructure works (OPTB-01 and OPTB-04) are identified has having a number of exceedances of the daytime NMLs within NCA07. Exceedances are generally at receivers which adjoin Parramatta Road to the south of the Parramatta Road East civil site (C3b), and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks
- Operations within the site shed (OPTB-08) are predicted to result in exceedances (up to 10 dBA) at 13 receivers during night-time operations. For these 13 receivers, only four would experience an exceedance of in the region of 10 dBA, with nine receivers predicted to experience exceedances less than 5 dBA. The expected duration of these works is up to 168 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (OPTB-12) is predicted to result in exceedances (up to 15 dBA) at 16 receivers. Exceedances of the cumulative works scenario are dominated by spoil handling works within the site shed (OPTB-08). By controlling noise emission from activity OPTB-08, the exceedances of the overall cumulative assessment will reduce.

Sleep disturbance

A review of the predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-1b** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project specific mitigation measures (in addition to the standard suite of measures **Table 4-13**) are summarised in **Table 5-33**.

Table 5-33 Recommended site specific noise mitigation measures – Haberfield Option B

Activity	Mitigation description	Reason	Recommendations
OPTB-01, OPTB-02, OPTB-04	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	The site establishment works is predicted to have a number exceedances during all time periods.	Use mobile acoustic hoarding around smaller items to minimise noise Employ quieter methods to remove kerb and gutter, i.e. deeper cuts and remove material in blocks with excavator.
OPTB-08	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified during all time periods for operations within the site shed.	Basic sheet steel shed construction was considered during the unmitigated predictions. It is recommended that an acoustic enclosure be included.

Activity	Mitigation description	Reason	Recommendations
All scenarios	Use structures such as site sheds and or hoarding to shield residential receivers from works activities. Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite. Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.	Exceedances have been identified various activities within all construction ancillary facilities.	Investigate locations where hoarding (>2m) can be utilised to control noise from trucks in the queuing area.

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-1b**.

The in-situ mitigation measures investigated are:

- Increasing site hoarding to four metres in select areas, refer to **Figure 5-16**
- Upgrading the acoustic shed performance
- Upgrading acoustic shed and limiting the total sound power level of equipment operating within the shed to 110 dBA.

The minimum transmission loss of the acoustic shed including operable elements is noted below in **Table 5-34**. It should be noted that where residual impacts are predicted following the inclusion of the upgraded shed, further investigation should be undertaken during detailed design.

Table 5-34 Acoustic shed acoustic performance – Haberfield Option B

Indicative upgraded shed construction	Octave band transmission loss (dB)						
	63	125	250	500	1000	2000	4000
Double Leaf: (1 x 0.48mm Steel) - 202mm Steel Stud + 75mm Fibreglass 32 kg/m³ - (1 x 0.42mm Steel)	10	12	24	36	46	55	61

All site hoarding as shown in **Figure 5-16** has been investigated at a height of four metres.

Table 5-35 provides the predicted distribution of exceedances (at night-time) both ‘with’ and ‘without’ the recommended mitigation for receivers within this study area.

Table 5-35 NML exceedance distribution with and without mitigation – Haberfield Option B

Activity ID	Activity	Time period	Number of receivers with NML exceedance					
			Without Mitigation			With mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
OPTB-06	Onsite car parking	Night	25	2	-	15	-	-
OPTB-07	Workshop, deliveries, maintenance and storage	Night	65	6	2	61	4	-
Upgraded acoustic shed (internal 117 dBA SWL)								
OPTB-08	Spoil handling inside acoustic shed	Night	107	10	3	18	2	1
OPTB-12	Cumulative operations	Night	188	19	5	105	5	1
Upgraded acoustic shed as above, with restricted internal sound power level to 110 dBA								
OPTB-08	Spoil handling inside acoustic shed	Night	107	10	3	4	2	-
OPTB-12	Cumulative operations	Night	188	19	5	79	6	-

Table 5-35 indicates that with the inclusion of in-situ mitigation measures in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure G-1b** and represent the maximum predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. Detailed in **Table 5-36**, the counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures (acoustic shed with internal 117 dBA SWL).

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure H**.

Table 5-36 CNVG additional noise mitigation counts – Haberfield Option B

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment works					
NCA00	1	112	81	3	-
NCA01	18	135	247	26	6
NCA02	-	5	11	-	-
NCA03	-	18	23	3	-
NCA04	-	36	2	-	-
NCA05	-	33	2	-	-
NCA06	18	18	31	23	1
NCA07	9	29	17	8	2
Scenario – Tunnelling and supporting works					
NCA00	-	3	-	-	-
NCA01	-	34	15	3	-
NCA02	-	-	-	-	-
NCA03	-	4	-	-	-
NCA04	-	-	-	-	-
NCA05	-	-	-	-	-
NCA06	-	14	2	-	-
NCA07	-	2	-	-	-
Scenario – Construction and Site rehabilitation and landscaping					
NCA00	-	-	-	-	-
NCA01	2	-	-	-	-
NCA02	-	-	-	-	-
NCA03	-	-	-	-	-
NCA04	-	-	-	-	-
NCA05	-	-	-	-	-
NCA06	-	-	-	-	-
NCA07	-	-	-	-	-

Notes:

1. See **section 4.6.2** for descriptions of the various additional mitigation measures

Consecutive construction impacts

The CNVG recognises that mitigation measures aimed at short term works may be less effective where longer term impacts are apparent and requires additional consideration of reasonable and feasible management measures to minimise impacts on the community.

When evaluating the extent of noise impacts within the Haberfield construction area, it is noted that this area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved and currently under construction WestConnex M4 East project. This project, together with the M4-M5 Link, tie in to Wattle Street and Parramatta Road in Haberfield, where receivers will likely be exposed to extended impacts associated with the construction of these infrastructure projects, which will occur consecutively.

Previous and ongoing works in the Haberfield area are assumed to follow those outlined in the EIS for M4 East, generally consisting of the following activities:

- Pavement and infrastructure works
- Tunnelling and supporting activities
- Car parking
- Landscaping

- Ventilation building construction.

These type of activities therefore have general similarities with the works proposed for the M4-M5 Link and involve similar construction activities for both projects.

The indicative construction program for M4-East and M4-M5 Link is shown below in **Table 5-37**.

Table 5-37 Indicative construction program – Haberfield Option B

Project	2016				2017				2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
M4 East																												
M4-M5 Link																												

The impacts discussed in this report (refer to **section 5.1**) consider the duration of the M4-M5 Link project in isolation, whereas the potential impacts from the identified consecutive projects are likely to be perceived to be longer for receivers near to Wattle Street and Parramatta Road.

The short-term noise intensive works are generally associated with discrete activities which occur over a number of days or weeks in moving locations rather than throughout the entire project at fixed locations. Therefore, the focus of assessing consecutive impacts is to identify works activities which repeat (or are similar to other activities) over extended periods. The longer-term impacts associated with compound activity may continue between separate projects in the area and may appear to be of a similar nature to the community.

Excluding short-term works such as pavement and utility works, receivers located within NCA00, NCA01, NCA06 and NCA07, which front both Parramatta Road and Walker Avenue, are predicted to experience greater than 20 dBA exceedances of the project NMLs (in the night-time period) during construction of the M4-M5 Link project. The likely impacted receivers are generally located at:

- Receivers adjoining the Parramatta Road West civil and tunnel cite (C1b), Parramatta Road East civil site (C3b) and Haberfield civil site (C2b), between Walker Avenue and Chandos Street.

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, if options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be appropriately considered when preparing the site specific construction noise and vibration impact statements (CNVIS) for this area. Feasible and reasonable considerations for providing at-receiver treatments should include:

- Time of day of the impacts and exceedance of criteria
- Time of impacts at the affected receivers
- How long the mitigation will provide benefit to the receiver during the project
- Optimal design of acoustic sheds, noise barriers/hoarding and management measures to reduce the impacts as far as practicable
- Due to the variability of construction noise, it is envisaged that community input through the consultation phase would provide appropriate information to assist the project to address potential consecutive noise impacts from construction projects in this area.

5.1.8 Construction road traffic noise – Option B

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-38**.

Table 5-38 Construction traffic forecast – Haberfield Option B

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C1b - Parramatta Road West civil and tunnel site	140	10
C2b - Haberfield civil site	10	20
C3b - Parramatta Road East civil site	30	150

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip.
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period.

The proposed haulage routes are presented in **Table 5-39** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-39 Construction road traffic noise assessment – Haberfield Option B

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C1b - Parramatta Road West civil and tunnel site	Light & heavy	Parramatta Rd	<0.5	<0.5
C2b - Haberfield civil and tunnel site	Light & heavy	Wattle St	<0.5	<0.5
C3b - Parramatta Road East civil site	Light & heavy	Parramatta Rd	<0.5	<0.5

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available.

The information above indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should include instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.1.9 Ground-borne noise – Option B

Predicted ground-borne noise levels

The majority of works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

As such, the nature of the majority of construction works at the Haberfield Option B site (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible.

However, tunnelling works associated with the access tunnel to the mainline tunnel alignment have the potential to result in ground-borne noise impacts at the nearest sensitive receivers.

The ground-borne noise assessment is based on the worst case predicted L_{Aeq} internal ground-borne noise level when the tunnelling works are at their closest point below each sensitive receiver.

Table 5-40 summarises the maximum ground-borne noise levels from road-header tunnelling works associated with the Haberfield Option B mainline access tunnel. Ground-borne noise contour maps are provided in **Annexure I**. The exceedances listed in **Table 5-40** assume that the tunnelling works will occur 24 hours a day, and therefore consider potential exceedances of the more stringent night-time ground-borne NMLs.

Table 5-40 Worst case predicted ground-borne noise levels during tunnelling – Haberfield Option B access tunnel

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA00	27	-	-	-
NCA01	53	8	-	-
NCA06	29	-	-	-
NCA07	24	-	-	-

The worst case ground-borne noise levels are predicted to be compliant with the more stringent 35 dBA $L_{Aeq(15minute)}$ night-time criterion at the majority of sensitive receivers which are potentially affected by ground-borne noise from tunnelling works.

In NCA01, where the construction access tunnel ramp dives down from ground elevation to meet with the main line tunnel, sensitive receivers above this section are predicted to be subject to ground-borne noise levels up to around 53 dBA $L_{Aeq(15minute)}$, which exceeds the both the evening and night-time criteria.

Based on a progression rate of around 20 metres per week, the most affected sensitive receivers are likely to experience noise levels above the night-time criterion for up to around 20 days.

While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due unforeseen site conditions.

The ground-borne noise predictions are based on the nearest sensitive receivers above or adjacent to the proposed tunnel alignment. The ground-borne noise impacts would reduce for sensitive receivers offset horizontally from the access tunnel due to the increased slant distance.

Managing ground-borne noise impacts

Table 5-40 indicates that there are eight residential receivers where ground-borne noise levels are predicted to exceed the night-time NML by up to 18 dB. With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works location, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops
- Individual briefings to inform the residents about the impacts of the works and mitigation measures that will be implemented. Where the resident cannot be met with individually then an alternative form of engagement should be used
- Respite periods may be offered to the affected residents during works where noise levels are predicted to exceed the NML by 10 dBA or more
- Alternative accommodation options may be offered to the affected residents for the periods where noise levels are predicted to exceed the NML by 10 dBA or more.

5.1.10 Vibration – Option B

Estimated working distances and vibration intensive plant

The proposed works have been analysed to determine best estimate minimum working distances for the vibration intensive mechanical plant proposed for the construction activities. Proposed vibration intensive construction plant are listed in **Table 5-41** and compared to the minimum working distances listed in **Table 4-12** in order to determine potential vibration impacts of the main construction scenarios. Estimated minimum working distances for the site works and tunnelling works are shown graphically in **Annexure J**.

Refer to **section 5.2.1** for a discussion of indicative duration for the construction activities.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

Table 5-41 Construction vibration assessment summary – Haberfield Option B

<table>
<tr><th rowspan="3">Work scenario</th><th rowspan="3">Vibration intensive equipment</th><th rowspan="3">NCA</th><th colspan="4">Number of buildings within minimum working distance for highest vibration plant item</th></tr>
<tr><th colspan="3">Cosmetic Damage</th><th rowspan="2">Human Response</th></tr>
<tr><th>Residential and Light Commercial</th><th>Group 2 (Typical)</th><th>Group 3 (Structurally Unsound)[1]</th></tr>
<tr><td rowspan="4">Surface works – roadworks, demolition of existing buildings, construction of site buildings and works within the site</td><td rowspan="4">Bored piling
Jackhammer
Rock-breaker[2]</td><td>NCA00</td><td>-</td><td>-</td><td>-</td><td>2</td></tr>
<tr><td>NCA01</td><td>10</td><td>10</td><td>-</td><td>24</td></tr>
<tr><td>NCA06</td><td>9</td><td>11</td><td>-</td><td>23</td></tr>
<tr><td>NCA07</td><td>3</td><td>7</td><td>-</td><td>17</td></tr>
</table>

Work scenario	Vibration intensive equipment	NCA	Number of buildings within minimum working distance for highest vibration plant item			
			Cosmetic Damage			Human Response
			Residential and Light Commercial	Group 2 (Typical)	Group 3 (Structurally Unsound)[1]	
Tunnelling works - access tunnel to mainline tunnel alignment	Road-header[2]	NCA00	-	-	-	-
		NCA01	-	-	-	1
		NCA06	-	-	-	-
		NCA07	-	-	-	-

Notes:

1. This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration (following inspection) to be confirmed during detailed design
2. Proposed highest vibration plant item for these works

Cosmetic damage assessment summary

The separation distance(s) between the proposed works and the nearest sensitive receivers would generally be sufficient so that nearby buildings are unlikely to suffer 'cosmetic damage' for most of the proposed construction equipment. However, based on the arrangement of the work zones, some items of construction equipment have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Construction with large rock-breakers has the potential to generate some of the most significant construction vibration impacts due to the high vibration characteristics of the plant.

The assessment presented in **Table 5-41** indicates that during surface works, up to 22 buildings in the vicinity of the works may be within the minimum working distances should a large rock-breaker be used at the outer extents of the Haberfield Option B construction ancillary facility. In practice, it is unlikely that a rock-breaker would be required at all areas and therefore the vibration impacts presented in this assessment should be considered a worst case scenario. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Human comfort vibration assessment summary

The assessment presented in **Table 5-41** indicates the proposed surface works using a large rock-breaker may result in a significant number of receivers (around 66 receivers in the vicinity) within the nominated minimum working distance for human comfort vibration.

In relation to human comfort (response), the minimum working distances in **Table 4-12** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are permitted, as discussed in BS 6472-1.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers and other high vibration plant items. In practice vibration impacts from most construction activities would be intermittent within the duration of the project. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Cumulative vibration impacts

Due to the intermittent nature of construction works, vibration impacts due to multiple works scenarios are considered unlikely to result in concurrent vibration peaks, but rather, may increase the effective duration of the exposure to vibration. Vibration impacts due to multiple simultaneous works would therefore be managed in the same manner as for single works scenarios (dependant on the operating equipment).

Managing vibration impacts

Table 5-41 indicates that, as discussed above, there are around 66 receivers within the nominated minimum working distance for human comfort vibration. With reference to the CNVG vibration mitigation measures outlined in **Table 4-16**, vibration intensive works at the Haberfield Option B site are proposed only during standard construction hours. The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path/equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

Vibration trials and/or attended vibration monitoring or should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria. Building condition surveys should also be completed both before and after the works at any potentially affected properties to identify existing damage and any project related damage. At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.2 Darley Road

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed at Darley Road.

5.2.1 Works description

Darley Road civil and tunnel site (C4) would be located adjacent to the Leichhardt North light rail top, between City West Link and Darley Road. The site will include:

- Temporary site offices
- Workshop and storage facilities
- Laydown area entry and exit points for haulage of tunnel spoil
- Temporary substation
- Temporary ventilaition plant
- Water tretament plant
- Car parking.

The site has residential receivers located directly to the south as shown in **Figure 5-11** below.

Road-headers would be launched from this site and would initially excavate the construction decline, then the mainline tunnels traveling in an easterly and westerly direction. An acoustic shed would be established on the site to minimise noise from out of hours tunnelling and spoil handling. Heavy vehicle access to and egress from the site would be via Darley Road. Heavy vehicles will turn left to enter City West Link westbound. There will be temporary changes to two intersections to control the flow of heavy vehicles in and out of Darley Road.

Figure 5-11 provides an indicative site layout map for the Darley Road civil and tunnel site (C4).

Figure 5-11 Indicative site layout – Darley Road civil and tunnel site

Works schedule

Subject to planning approval, construction at the Darley Road civil and tunnel site is planned to start in the third quarter of 2018, with completion planned by the end of 2022. The total duration of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction program for Darley Road is shown in **Table 5-42**.

Table 5-42 Indicative construction program and duration – Darley Road

Scenario	2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Darley Road civil and tunnel site (C4)																				
Site establishment and utility works			■	■	■															
Construction of temporary access tunnel				■	■															
Tunnelling					■	■	■	■	■	■	■	■	■							
Construction of motorway operational infrastructure										■	■	■	■							
Civil and mechanical fitout											■	■	■	■	■					
Testing and commissioning															■	■	■	■	■	
Site rehabilitation and landscaping																		■	■	■

Construction activities

A number of scenarios have been developed to assess potential impacts associated with construction works at Darley Road. **Table 5-43** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-43 Construction activities and period of operation – Darley Road

Scenario	Works ID	Indicative duration (Weeks)[1]	Activity	Period of works[2,3]			
				Day	Day OOH	Eve	Night
Site establishment and initial road and traffic management works	DAR-01	4	Demolition of existing buildings	✓			
	DAR-02	2	Site clearing	✓			
	DAR-03	2	Utility works[4]	✓			
	DAR-04	1	Installation of environmental controls	✓			
	DAR-05	2	Pavement and infrastructure works	✓	✓	✓	✓
	DAR-06	2	Line marking works and road adjustments	✓	✓	✓	✓
	DAR-07	3	Construct new signalised intersection	✓	✓	✓	✓

Scenario	Works ID	Indicative duration (Weeks)[1]	Activity	Period of works[2,3]			
				Day	Day OOH	Eve	Night
	DAR-08	1	Place barriers to new queuing area	✓	✓	✓	✓
	DAR-09	4	Establishment of construction facilities	✓			
Tunnelling and supporting works	DAR-10	204	Onsite car parking	✓	✓	✓	✓
	DAR-11	204	Workshop, deliveries, maintenance, and storage	✓			
	DAR-12	36	Construction of tunnel shaft and declines (outside acoustic shed)	✓			
	DAR-13	96	Spoil handling inside acoustic shed	✓	✓	✓	✓
	DAR-14[4]	96	Onsite truck movements[5]	✓			
	DAR-15	96	Tunnelling support activities	✓	✓	✓	✓
Site rehabilitation and landscaping	DAR-16	12	Site rehabilitation and landscape	✓			

Notes;

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for traffic management works. Traffic management works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds and vehicle movements along the road network. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays
4. The utility works activity represents utility works required within the footprint of the proposed construction facilities. Utility works that may be required outside of the project footprint are discussed in **section 5.8**
5. As discussed in **section 4.2.2**, spoil haulage from Darley Road is limited to standard daytime hours only

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations is provided in **Table 5-44**.

Table 5-44 Activities assessed for cumulative construction noise – Darley Road

Cumulative ID	Activity works ID	Activity	Comment	Period of works
DAR-17	DAR-10	Onsite car parking	Tunnelling works along with supporting activities have the have the potential for cumulative impacts due to works typically operating within a specific location in the site.	Day
	DAR-13	Spoil handling within acoustic shed		
	DAR-14	Onsite truck movements		
	DAR-15	Tunnelling support activities		
DAR-18 Night Only	DAR-10	Onsite car parking		Night
	DAR-13	Spoil handling within acoustic shed		
	DAR-15	Tunnelling support activities		

5.2.2 Airborne noise

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works at Darley Road are outlined in **Table 5-45**.

Table 5-45 Residential NMLs for the project – Darley Road

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime Period	Daytime Period	Evening Period	Night Period	
NCA05	L.02	Residential	61	56	54	47	57
NCA09	L.02	Residential	61	56	54	47	57
NCA10	L.02	Residential	61	56	54	47	57
NCA11	L.02	Residential	61	56	54	47	57
NCA12	L.01	Residential	61	56	52	45	55
NCA13	L.01	Residential	61	56	52	45	55
NCA14	L.01	Residential	61	56	52	45	55

Notes:
1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship the NMLs presented in **section 4.1.2** are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-46**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Works within the tunnel are assessed in the ground-borne noise assessment in **section 5.7.1**.

Table 5-46 Sound power levels for construction equipment – Darley Road

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
Site establishment and initial road and traffic management works.	DAR-01	Demolition of existing buildings	Diamond saw[1]	1	120	120	124
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	DAR-02	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	DAR-03	Utility works	Concrete saw[1]	1	120	117	23
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)	1	100		
	DAR-04	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	DAR-05	Pavement and infrastructure works	Truck	1	98	118	124
			Suction truck	1	100		
			Excavator (breaker)[1]	1	121		
	DAR-06	Line marking works and road adjustments	Line marking removal plant	1	109	115	121
			Ute	1	98		
			Road profiler	1	113		
	DAR-07	Construct new signalised intersection	Bobcat	1	104	107	110
			Excavator	1	94		
			Concrete pump	1	106		
			Truck	1	103		
	DAR-08	Place barriers to new queuing area	Franna crane	1	99	101	107
			Flatbed truck	1	100		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					L_{WA}		L_{WAmax}
					Item	Activity[4]	Activity
	DAR-09	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
Tunnelling and supporting works	DAR-10	Onsite car parking	Car parking	10	73	97	105
			Water pump	1	97		
	DAR-11	Workshop, deliveries, maintenance, and storage	Truck	1	98	103	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	DAR-12	Construction of tunnel shaft and declines (outside acoustic shed)	Piling rig (bored)	1	108	114	118
			Mobile crane	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Excavator	1	109		
			Concrete truck/agitator	1	106		
			Truck	1	98		
	DAR-13	Spoil handling inside acoustic shed	Tipper truck	2	100	117	119
			Excavator	2	112		
			Front end loader	2	115		
			Compressor for air scrubber	2	75		
			Ventilation scrubber	2	98		
	DAR-14	Onsite truck movements	Truck	6	103	97	108
	DAR-15	Tunnelling support activities	Substation[2]	1	66	82	98
			Water treatment	1	82		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
			plant [2,3]				
Site rehabilitation and landscaping	DAR-16	Site rehabilitation and landscape	Truck	1	98	105	111
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of the finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facilities of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable
- **Acoustic shed** – An acoustic shed of solid construction such as sheet steel would be incorporated at this site where practicable.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-47** to **Table 5-51** for residential, commercial and other sensitive receivers. The noise levels are representative of the worst case impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) to the relevant NMLs and a summary of the impact assessment are presented in detail in **Annexure F-2**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs – impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs – impacts would typically be moderate
Noise levels >20 dBA above NMLs – impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-52**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-2**.

Table 5-47 Predicted worst case noise levels – Darley Road – residential daytime

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]																	
		DAR-01	DAR-02	DAR-03	DAR-04	DAR-05	DAR-06	DAR-07	DAR-08	DAR-09	DAR-10	DAR-11	DAR-12	DAR-13	DAR-14	DAR-15	DAR-16	DAR-17	DAR-18
Residential - Standard Daytime																			
NCA05	61	53	47	51	42	54	51	43	35	48	31	37	47	40	30	<30	39	42	41
NCA08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA09	61	75	68	72	63	83	80	72	52	69	47	57	66	61	47	40	60	62	61
NCA10	61	57	50	54	45	60	57	49	37	51	<30	37	50	46	31	<30	42	46	46
NCA11	61	62	57	61	52	66	63	55	45	58	35	45	58	49	37	<30	49	51	49
NCA12	61	56	50	54	45	58	55	47	36	51	31	41	48	46	31	<30	42	47	46
NCA13	61	79	74	78	69	91	88	80	67	75	57	61	74	65	60	45	66	66	65
NCA14	61	59	52	56	47	58	55	47	38	53	35	43	52	46	34	<30	44	48	46

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-48 Predicted worst case noise levels – Darley Road – residential evening

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]																	
		DAR-01	DAR-02	DAR-03	DAR-04	DAR-05	DAR-06	DAR-07	DAR-08	DAR-09	DAR-10	DAR-11	DAR-12	DAR-13	DAR-14	DAR-15	DAR-16	DAR-17	DAR-18
Residential - Evening																			
NCA05	54	-	-	-	-	54	51	43	35	-	31	-	-	40	-	<30	-	-	41
NCA08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA09	54	-	-	-	-	83	80	72	52	-	47	-	-	61	-	40	-	-	61
NCA10	54	-	-	-	-	60	57	49	37	-	<30	-	-	46	-	<30	-	-	46
NCA11	54	-	-	-	-	66	63	55	45	-	35	-	-	49	-	<30	-	-	49
NCA12	52	-	-	-	-	58	55	47	36	-	31	-	-	46	-	<30	-	-	46
NCA13	52	-	-	-	-	91	88	80	67	-	57	-	-	65	-	45	-	-	65
NCA14	52	-	-	-	-	58	55	47	38	-	35	-	-	46	-	<30	-	-	46

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-49 Predicted worst case noise levels – Darley Road – residential night-time

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]																	
		DAR-01	DAR-02	DAR-03	DAR-04	DAR-05	DAR-06	DAR-07	DAR-08	DAR-09	DAR-10	DAR-11	DAR-12	DAR-13	DAR-14	DAR-15	DAR-16	DAR-17	DAR-18
Residential - Night-time																			
NCA05	47	-	-	-	-	54	51	43	35	-	31	-	-	40	-	<30	-	-	41
NCA08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA09	47	-	-	-	-	83	80	72	52	-	47	-	-	61	-	40	-	-	61
NCA10	47	-	-	-	-	60	57	49	37	-	<30	-	-	46	-	<30	-	-	46
NCA11	47	-	-	-	-	66	63	55	45	-	35	-	-	49	-	<30	-	-	49
NCA12	45	-	-	-	-	58	55	47	36	-	31	-	-	46	-	<30	-	-	46
NCA13	45	-	-	-	-	91	88	80	67	-	57	-	-	65	-	45	-	-	65
NCA14	45	-	-	-	-	58	55	47	38	-	35	-	-	46	-	<30	-	-	46

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period.

Table 5-50 Predicted worst case noise levels – Darley Road – commercial

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]																	
		DAR-01	DAR-02	DAR-03	DAR-04	DAR-05	DAR-06	DAR-07	DAR-08	DAR-09	DAR-10	DAR-11	DAR-12	DAR-13	DAR-14	DAR-15	DAR-16	DAR-17	DAR-18
Commercial																			
NCA05	70	<30	41	45	36	47	44	36	<30	42	<30	30	<30	-	<30	<30	33	32	<30
NCA08	70	57	53	57	48	62	59	51	41	54	38	42	49	45	36	<30	45	47	45
NCA09	70	65	62	66	57	75	72	64	50	63	36	46	63	54	39	<30	54	55	54
NCA10	70	53	46	50	41	58	55	47	36	47	<30	36	46	43	<30	<30	38	44	43
NCA11	70	62	57	61	52	67	64	56	46	58	34	44	58	51	37	<30	49	52	51
NCA12	70	61	55	59	50	67	64	56	43	56	36	44	56	49	37	<30	47	51	49
NCA13	70	72	71	75	66	82	79	64	63	72	44	56	72	60	51	41	63	61	60
NCA14	70	57	51	55	46	55	52	43	38	52	35	42	49	44	33	<30	43	47	45

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period.

Table 5-51 Predicted worst case noise levels – Darley Road – other sensitive receivers

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1]																	
		DAR-01	DAR-02	DAR-03	DAR-04	DAR-05	DAR-06	DAR-07	DAR-08	DAR-09	DAR-10	DAR-11	DAR-12	DAR-13	DAR-14	DAR-15	DAR-16	DAR-17	DAR-18
Other Sensitive																			
NCA05	-	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	-	-	-	<30	<30	<30
NCA08	-	59	53	57	48	59	56	48	41	54	37	43	51	44	37	<30	45	48	45
NCA09	-	64	59	63	54	70	67	59	47	60	43	47	60	53	41	31	51	54	53
NCA10	-	47	45	49	40	53	50	40	35	46	<30	30	46	39	<30	<30	37	40	39
NCA11	-	54	48	52	43	56	53	45	37	49	30	38	49	42	30	<30	40	44	42
NCA12	-	55	48	52	43	54	51	43	35	49	31	38	48	43	30	<30	40	44	43
NCA13	-	58	52	56	47	56	53	45	38	53	37	43	49	45	34	<30	44	48	46
NCA14	-	58	53	57	48	60	57	49	41	54	38	43	50	45	35	<30	45	48	46

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities.

Table 5-52 Overview of NML exceedances – Darley Road

Activity ID	Activity	Weeks[1]	Activity duration within overall project program[2]				Number of receivers																	
							Total	Highly noise affected[4]	NML exceedance receiver count[3]															
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
DAR-01	Demolition of existing buildings	4					2423	7	127	15	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-02	Site clearing	2					2423	-	49	4	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-03	Utility works	2					2423	5	125	13	-	-	-	-	-	-	-	-	-	-			
DAR-04	Installation of environmental controls	1					2423	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-05	Pavement and infrastructure works	2					2423	36	155	44	15	271	76	25	372	116	43	851	283	99	729	253	118
DAR-06	Line marking works and road adjustments	2					2423	22	101	27	11	217	52	15	283	70	29	602	211	69	505	194	85
DAR-07	Construct new signalised intersection	3					2423	6	30	9	-	61	14	1	97	20	7	250	61	17	147	39	18
DAR-08	Place barriers to new queuing area	1					2423	-	5	-	-	10	3	-	20	5	-	84	10	4	86	19	5
DAR-09	Establishment of construction facilities	4					2423	1	70	5	-	-	-	-	-	-	-	-	-	-			
DAR-10	Onsite car parking	204					2423	-	-	-	-	1	-	-	3	-	-	19	2	-	22	3	-
DAR-11	Workshop, deliveries, maintenance, and storage	204					2423	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-12	Construction of tunnel shaft and declines (outside acoustic shed)	36					2423	-	32	1	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-13	Spoil handling inside acoustic shed	96					2423	-	4	-	-	21	-	-	48	2	-	224	23	-	41	2	-
DAR-14	Onsite truck movements	96					2423	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-15	Tunnelling support activities	96					2423	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-16	Site rehabilitation and Landscape	12					2423	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-17	Cumulative tunnelling Works - day	96					2423	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-18	Cumulative tunnelling works – night	96					2423	-	4	-	-	24	-	-	53	2	-	251	26	-	55	5	-

Notes:

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 13%) of activity duration within overall proposal program. Where percentage is less than 13%, 13% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables indicate that:

- The highest noise levels and NML exceedances are predicted during pavement and infrastructure works (DAR-05), which requires the use of a rock-breaker
- The greatest impacts are predicted in NCA09 and NCA13 where receivers are situated in relatively close proximity to the works site. Noise levels in NCA11 are also predicted to be comparable to these catchments
- Works associated with tunnelling activities (DAR-10, DAR-11 and DAR-13 to DAR-15) have the longest duration of impacts
- Minor NML exceedances are predicted for commercial receivers in NCA09 and NCA13 and are generally during the site establishment works scenarios
- NMLs at other sensitive receiver types are not predicted to be exceeded by the proposed works.

NML exceedances

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-2**.

Table 5-47 indicates the activity with potential for the highest exceedance of NMLs is the pavement and infrastructure works (DAR-05). **Figure 5-12** indicates the distribution of exceedances for activity DAR-05 (at night) for all receivers within the Darley Road study area.

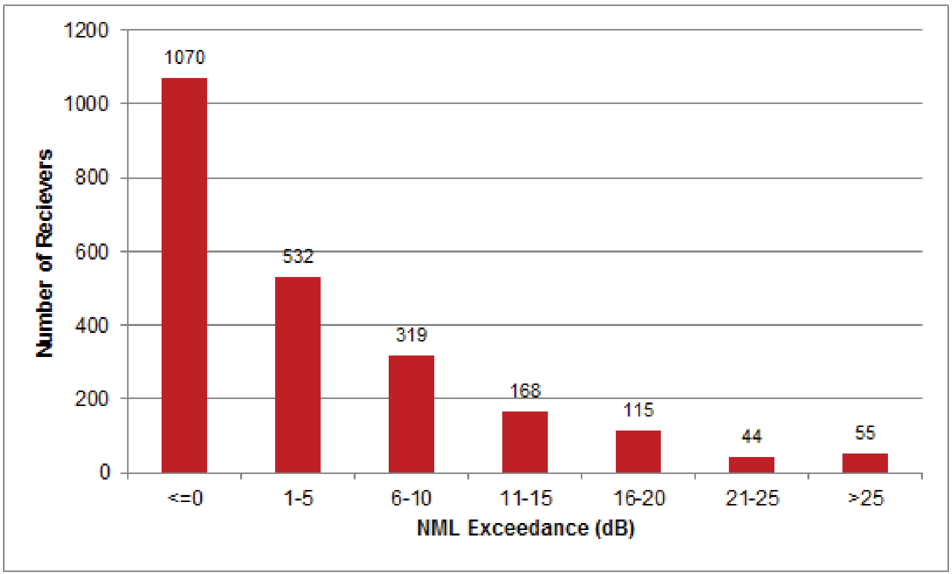


Figure 5-12 Activity DAR-06 noise level exceedance, night-time – Darley Road

Reference to the above graph shows that while the worst case impacts may result in a greater than 25 dBA exceedance of NML, this is seen to be limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower impacts.

Receivers within NCA09 and NCA13 are predicted to be most affected by works associated with the Darley Road civil and tunnel site due to their proximity to the works.

The site establishment works and initial road and traffic management scenario (DAR-01 to DAR-9) account for a relatively small percentage of the total works duration (up to four weeks) and this should be considered when evaluating mitigation and management measures for identified exceedances.

NML exceedances of up to 20 dBA (during the night period) are predicted during the spoil handling works within the site shed (DAR-13). Predictions have been based on a standard site shed with only a basic acoustic attenuation performance. Mitigation of these exceedances should investigate upgrading the acoustic performance of the shed to control noise emissions. **Figure 5-13** indicates the distribution of exceedances for spoil handling works within the site shed (DAR-13) (night) prior to mitigation for receivers within the Darley Road study area.

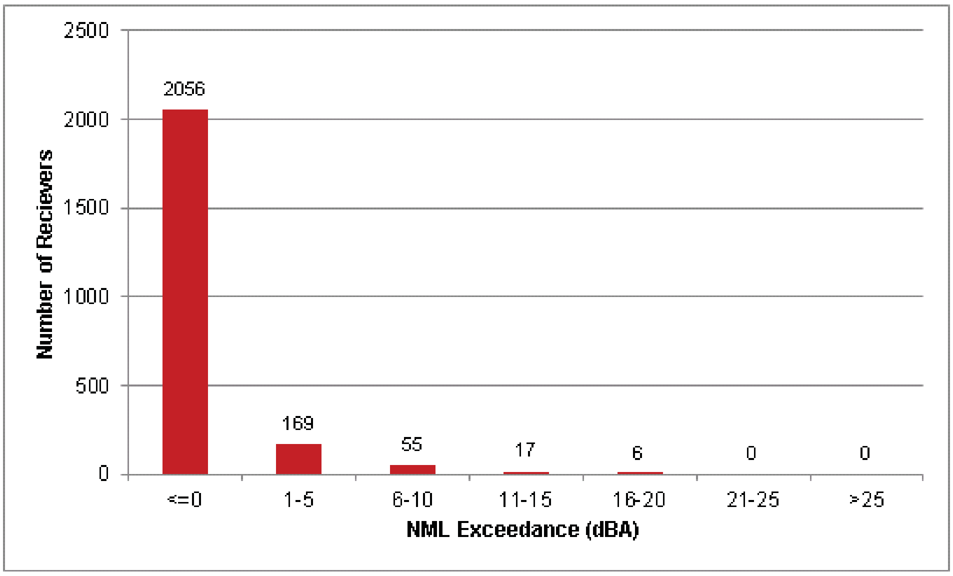


Figure 5-13 **Activity DAR-14 noise level exceedance, night-time – Darley Road**

The above graph shows that while the worst case impacts may result in up to 20 dBA exceedance of NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower impacts.

The extended duration of the tunnelling activities (DAR-10 to DAR-15) should be considered when evaluating mitigation and management measures.

The cumulative scenarios (DAR-17, DAR-18), which include the operation of all activities detailed in **Table 5-44** have exceedances of up to 20 dBA above the night-time NMLs. **Table 5-47** indicates that the cumulative scenario is dominated by spoil handling works within the site shed (DAR-13) and as such by controlling the noise emissions of this activity, the overall noise emissions would be reduced. **Figure 5-14** indicates the distribution of exceedances for the cumulative activity DAR-18 (night) for receivers within the Darley Road study area.

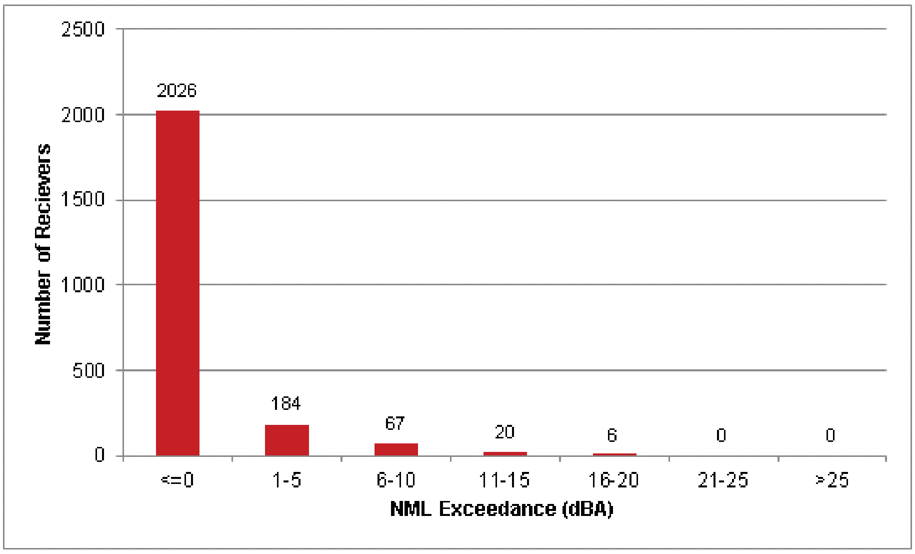


Figure 5-14 **Activity DAR-18 noise level exceedance, night-time – Darley Road**

Reference to the above graph shows that while the worst case impacts may result in up to 20 dBA exceedance of NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower impacts.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of Highly Noise Affected receivers in the study area has been determined and is summarised in **Table 5-53**. The table shows the number of residential receivers separated by works activity.

Table 5-53 Predicted number of highly noise affected residential receivers by works – Darley Road

Works	Activity	Period		
		Day	Eve	Night
DAR-01	Demolition of existing buildings	7	-	-
DAR-02	Site clearing	-	-	-
DAR-03	Utility works	5	5	5
DAR-04	Installation of environmental controls	-	-	-
DAR-05	Pavement and infrastructure works	36	36	36
DAR-06	Line marking works and road adjustments	22	22	22
DAR-07	Construct new signalised intersection	6	-	-
DAR-08	Place barriers to new queuing area	-	-	-
DAR-09	Establishment of construction facilities	1	-	-
DAR-10	Onsite car parking	-	-	-
DAR-11	Workshop, deliveries, maintenance, and storage	-	-	-
DAR-12	Construction of tunnel shaft and declines (outside acoustic shed)	-	-	-
DAR-13	Spoil handling inside acoustic shed	-	-	-
DAR-14	Onsite truck movements	-	-	-
DAR-15	Tunnelling support activities	-	-	-
DAR-16	Site rehabilitation and landscape	-	-	-
DAR-17	Cumulative works (Day)	-	-	-
DAR-18	Cumulative works scenario (Night)	-	-	-

The above table shows that receivers are predicted to be highly noise affected during certain works activities. The highest numbers are apparent during:

- DAR-05 – Pavement and infrastructure works, where 36 receivers are predicted to be highly noise affected
- DAR-06 - Line marking works and road adjustments, where 22 receivers predicted to be highly noise affected
- Both of these works activities require the use of highly noise intrusive equipment such as rock-breakers and road profilers. It is important to note that both activities DAR-05 and DAR-06 along with other activities predicted to have highly noise affected receivers are expected to occur for a relatively short period time and that the use of the most noise intrusive equipment (rock-breakers and road profilers) would be expected to be only occurring sporadically throughout the duration of the works.

The location of the highly noise affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-15**.

Figure 5-15 Highly noise affected residential receivers – Darley Road

The most impacted receivers are typically surrounding dwellings which have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-54**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-47** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-54 Overview of other sensitive receiver NML exceedances – Darley Road

Works ID	Activity	Number of other sensitive receivers exceeding NMLs														
		Education			Medical			Place of Worship			Childcare			Remaining[1]		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
DAR-01	Demolition of existing buildings	3	-	-	-	-	-	-	-	-	-	2	-	-	-	-
DAR-02	Site clearing	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-03	Utility works	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-
DAR-04	Installation of environmental controls	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-05	Pavement and infrastructure works	3	-	-	-	-	-	-	-	-	-	2	-	-	-	-
DAR-06	Line marking works and road adjustments	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-
DAR-07	Construct new signalised intersection	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-08	Place barriers to new queuing area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-09	Establishment of construction facilities	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-10	Onsite car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-11	Workshop, deliveries, maintenance, and storage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-12	Construction of tunnel shaft and declines (outside acoustic shed)	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-13	Spoil handling inside acoustic shed	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
DAR-14	Onsite truck movements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-15	Tunnelling support activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAR-16	Site rehabilitation and landscape	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-17	Cumulative works (Day)	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DAR-18	Cumulative works scenario (Night)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

Notes:

1. The 'Remaining' category includes public buildings, libraries, café/bars, etc

The above table shows the following:

- Other sensitive receivers in this precinct are generally predicted be subject to relatively minor noise impacts during the daytime. Receivers in the education, medical and remaining categories would not be subject to any NML exceedances
- Two 'other sensitive receivers' in this area would be subject to worst case exceedances of 11 to 20 dBA above NMLS during the higher noise generating activities. These receivers are:
  - Childcare centre – Explore and Develop, 372 Norton Street, Lilyfield (within NCA09)
  - Childcare centre – Billy Kids learning, 64 Charles St, Lilyfield (within NCA09).

The recommended 'standard' and 'additional' noise mitigation as discussed in **section 4.6**, along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-2**.

NCA05 and NCA08

No exceedances of the project NMLs are predicted in NCA05 and NCA08 for construction activities at Darley Road.

NCA09

- Demolition and utility adjustment activities (DAR-01 and DAR-03) are identified has having a number of exceedances of the daytime NMLs within NCA09. Exceedances are generally at receivers which adjoin City West Link to the north of the site, and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks
- Pavement and infrastructure works, line marking works and road adjustments (DAR-05 and DAR-06) are identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers located near the City West Link and James Street intersection. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the site shed (DAR-13) are predicted to result in exceedances (up to 15 dBA) at 82 receivers during night-time operations. For these 82 receivers, only five would experience an exceedance of up to 15 dBA, with 48 receivers predicted to experience exceedances less than 5 dBA. The expected duration of these works is up to 96 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (DAR-18) is predicted to result in exceedances (up to 15 dBA) at 82 receivers. As identified previously, exceedances of the cumulative works scenario are dominated by spoil handling works within the site shed (DAR-13). By controlling noise emission from activity DAR-13, the exceedances of the overall cumulative assessment will reduce.

NCA10, NCA11, NCA12 and NCA14

- Pavement and infrastructure works (DAR-05) is predicted to exceed the night-time NMLs by up to 20 dBA at 598 receivers. For these 598 receivers, 94 per cent of exceedances are predicted to be less than 10 dBA.

NCA13

- Demolition and utility works (DAR-01 and DAR-3) are identified has having a number of exceedances of the daytime NMLs within NCA13. Exceedances are generally at receivers which adjoin Darley Road, to the south of the site and are attributed to the use of rock-breakers and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to four weeks
- Pavement and infrastructure works, line marking works and road adjustments (DAR-05 and DAR-06) are identified as having the highest number of exceedances in all time periods. Exceedances are generally at receivers located near the Darley Road and James Street intersection. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the site shed (DAR-13) are predicted to result in exceedances (up to 20 dBA) at 160 receivers during night-time operations. Of these 160 receivers, six receivers experience an exceedance of greater than 15 dBA, with 116 receivers predicted to experience exceedances less than 5 dBA. The expected duration of these works is up to 96 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections

- Trucks entering the holding zone and exiting from the site during tunnelling operations (DAR-14) are predicted to exceed the evening NMLs by up to 10 dBA. Of the identified exceedances, only two receivers experience exceedances the NMLs of more than 5 dBA. The expected duration of these works is up to 96 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (DAR-18) is predicted to result in exceedances (up to 20 dBA) at 183 receivers. The highest predicted noise level at a residential location is 65 dBA. As identified previously, exceedances of the cumulative works scenario are dominated by spoil handling works within the site shed (DAR-13). By controlling noise emission from activity DAR-13, the exceedances of the overall cumulative assessment will reduce.

Sleep disturbance

Review of the predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-2** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project specific mitigation measures (in addition to the standard suite of measures **Table 4-13**) are summarised in **Table 5-55**.

Table 5-55 Recommended site specific noise mitigation measures – Darley Road

Activity	Mitigation description	Reason	Recommendations
DAR-01 to DAR-09	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	The site establishment works and initial road and traffic management scenario is predicted to have a number exceedances during all time periods.	Limit the use of the road profiler (DAR-06) during out of hour's works where feasible. Use mobile acoustic hoarding around smaller items to minimise noise Employ quieter methods to remove kerb and gutter, i.e. deeper cuts and remove material in blocks with excavator.

Activity	Mitigation description	Reason	Recommendations
DAR-13	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified during all time periods for operations within the site shed.	Basic sheet steel shed construction was considered during the unmitigated predictions. It is recommended that an acoustic enclosure be included for the Darley Road civil and tunnel site.
DAR-14 DAR-10	Use structures such as site sheds and or hoarding to shield residential receivers from works activities. Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite. Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.	Exceedances have been identified for trucks entering and exiting the site.	Investigate locations where hoarding (>2m) can be utilised to control noise from trucks in the queuing area.

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-2**.

The in-situ mitigation measures investigated are:

- Increasing site hoarding to four metres in select areas (see **Figure 5-16**)
- Upgrading the acoustic shed performance
- Upgrading acoustic shed and limiting the total sound power level of equipment operating within the shed to 110 dBA.

The minimum transmission loss of the acoustic shed including operable elements is noted below in **Table 5-56**. It should be noted that where residual impacts are predicted following the inclusion of the upgraded shed, further investigation should be undertaken during detailed design.

Table 5-56 Acoustic shed acoustic performance – Darley Road

Indicative upgraded shed construction	Octave band transmission loss (dB)						
	63	125	250	500	1000	2000	4000
Double Leaf: (1 x 0.48mm Steel) - 202mm Steel Stud + 75mm Fibreglass 32 kg/m³ - (1 x 0.42mm Steel)	10	12	24	36	46	55	61

Figure 5-16 indicates locations where increased site hoarding has been investigated.

Figure 5-16 Increased site hoarding locations – Darley Road

Table 5-57 provides the predicted distribution of exceedances (at night-time) both 'with' and 'without' the recommended mitigation for receivers within this study area.

Table 5-57 NML exceedance distribution with and without mitigation – Darley Road

Activity ID	Activity	Time period	Number of receivers with NML exceedance					
			Without Mitigation			With mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
DAR-10	Onsite car parking	Night	19	2	-	14	-	-
Upgraded acoustic shed (internal 117 dBA SWL)								
DAR-13	Spoil handling inside acoustic shed	Night	224	23	-	52	3	-
DAR-17	Cumulative Tunnelling Works	Day	13	-	-	3	-	-
DAR-18	Cumulative Tunnelling Works	Night	251	26	-	68	4	-
Upgraded acoustic shed as above, with restricted internal sound power level to 110 dBA								
DAR-13	Spoil handling inside acoustic shed	Night	224	23	-	8	-	-
DAR-17	Cumulative Tunnelling Works	Day	13	-	-	3	-	-
DAR-18	Cumulative Tunnelling Works	Night	251	26	-	23	-	-

Table 5-57 indicates that with the inclusion of in-situ mitigation measures in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure G-2** and represent the max predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. Detailed in **Table 5-58**, the counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures (acoustic shed with internal 117 dBA SWL).

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure F-2**.

Table 5-58 CNVG additional noise mitigation counts – Darley Road

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment works					
NCA05	-	172	21	-	-
NCA09	20	11	59	54	17
NCA10	-	67	15	-	-
NCA11	-	41	62	3	-
NCA12	-	28	31	-	-
NCA13	39	16	144	119	44
NCA14	-	183	176	-	-
Scenario – Tunnelling and supporting works					
NCA05	-	-	-	-	-
NCA09	-	17	1	-	-
NCA10	-	-	-	-	-
NCA11	-	-	-	-	-
NCA12	-	-	-	-	-
NCA13	-	25	11	-	-
NCA14	-	-	-	-	-
Scenario – Construction and Site rehabilitation and landscaping					
NCA05	-	-	-	-	-
NCA09	-	-	-	-	-
NCA10	-	-	-	-	-
NCA11	-	-	-	-	-
NCA12	-	-	-	-	-
NCA13	-	-	-	-	-
NCA14	-	-	-	-	-

Notes:

1. Refer to **section 4.6.2** for descriptions of the various additional mitigation measures

5.2.3 Construction road traffic noise

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-59**. The maximum daily flows have been used in the assessment in order to provide a conservative assessment.

Table 5-59 Construction traffic forecast – Darley Road

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C4 - Darley Road civil and tunnel site	100	70

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip

2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-60** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-60 Construction road traffic noise assessment – Darley Road

Site	Vehicle type	Road	Predicted traffic noise Increase (dBA)[1]	
			Daytime	Night-time
C4 - Darley Road civil and tunnel site	Light & heavy	Darley Rd	<0.5	0.6

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available

The information above indicates that construction traffic is unlikely to result in a noticeable increase in LAeq noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should include instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.2.4 Ground-borne noise

Predicted ground-borne noise levels

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

As such, the nature of the majority of construction works at the Darley Road civil and tunnel site (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible.

However, tunnelling works associated with the access tunnel to the mainline tunnel alignment have the potential to result in ground-borne noise impacts at the nearest sensitive receivers.

The ground-borne noise assessment is based on the worst case predicted L_{Aeq} internal ground-borne noise level when the tunnelling works are at their closest point below each sensitive receiver.

Table 5-61 summarises the maximum ground-borne noise levels from road-header tunnelling works associated with the Darley Road access tunnel. Ground-borne noise contour maps are provided in **Annexure I**. The exceedances listed in **Table 5-61** assume that the tunnelling works will occur 24 hours a day, and therefore consider potential exceedances of the more stringent night-time ground-borne NMLs.

Table 5-61 Worst case predicted ground-borne noise levels during tunnelling – Darley Road access tunnel

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA08	-	-	-	-
NCA09	28	-	-	-
NCA10	<20	-	-	-
NCA11	23	-	-	-
NCA12	24	-	-	-
NCA13	39	10	-	-
NCA14	21	-	-	-

The worst case ground-borne noise levels are predicted to be compliant with the more stringent 35 dBA $L_{Aeq(15minute)}$ night-time criterion at the majority of sensitive receivers with the exception of 10 receivers located within NCA13.

In NCA13, where the construction access tunnel ramp dives down from ground elevation to meet with the main line tunnel, sensitive receivers above this section are predicted to be subject to ground-borne noise levels up to around 39 dBA $L_{Aeq(15minute)}$, which exceeds the night-time criteria.

Based on a progression rate of around 20 metres per week, the most affected sensitive receivers are likely to experience noise levels above the night-time criterion for up to around 14 days.

While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

The ground-borne noise predictions are based on the nearest sensitive receivers above or adjacent to the proposed tunnel alignment. The ground-borne noise impacts would reduce for sensitive receivers offset horizontally from the access tunnel due to the increased slant distance.

Managing ground-borne noise impacts

Table 5-61 indicates that there are 10 residential receivers where ground-borne noise levels are predicted to exceed the night-time NMLs by up to 4 dB. With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works location, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NMLs, providing additional information when relevant and more specific information than covered in general letterbox drops.

5.2.5 Vibration

Estimated working distances and vibration intensive plant

The proposed works have been analysed to determine best estimate minimum working distances for the vibration intensive mechanical plant proposed for the construction activities. Proposed vibration intensive construction plant are listed in **Table 5-62** and compared to the minimum working distances listed in **Table 4-12** in order to determine potential vibration impacts of the main construction scenarios. Estimated minimum working distances for the site works and tunnelling works are shown graphically in **Annexure J**.

See **section 5.2.1** for a discussion of indicative duration for the construction activities.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

Table 5-62 Construction vibration assessment summary – Darley Road

Work scenario	Vibration intensive equipment	NCA	Number of buildings within minimum working distance for highest vibration plant item			
			Cosmetic Damage			Human Response
			Residential and Light Commercial	Group 2 (Typical)	Group 3 (Structurally Unsound)[1]	
Surface works – roadworks, demolition of existing buildings, construction of site buildings and works within the site	Bored piling Jackhammer Rock-breaker[2]	NCA08	-	-	-	-
		NCA09	-	-	1	25
		NCA10	-	-	-	-
		NCA11	-	-	-	-
		NCA12	-	-	-	-
		NCA13	5	5	-	49
		NCA14	-	-	-	-
Tunnelling works - access tunnel to mainline tunnel alignment	Road-header[2]	NCA08	-	-	-	-
		NCA09	-	-	-	-
		NCA10	-	-	-	-
		NCA11	-	-	-	-
		NCA12	-	-	-	-
		NCA13	-	-	-	-
		NCA14	-	-	-	-

Notes:

1. This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration (following inspection) to be confirmed during detailed design
2. Proposed highest vibration plant item for these works.

Heritage listed buildings identified within the cosmetic damage minimum working distances are listed in **Table 5-63**.

Table 5-63 Heritage listed items within cosmetic damage minimum working distance – Darley Road

NCA	Item name[1]	Address[1]	Construction type[2]
NCA09	Leichhardt (Charles St) Underbridge	Dulwich Hill to Rozelle Goods Line 12.405km, Leichhardt	Steel bridge structure

Notes:

1. List of Heritage items extracted from **Appendix U** (Technical working paper: Non-Aboriginal heritage) of the EIS
2. Estimated from photographic information only and should be confirmed onsite

The construction type classifications and structural integrity of all the listed heritage items should be confirmed at detailed design by a suitably qualified structural engineer. This information can then be used to verify the applicable vibration criteria and associated impacts.

Cosmetic damage assessment summary

The separation distance(s) between the proposed works and the nearest sensitive receivers would generally be sufficient so that nearby buildings are unlikely to suffer 'cosmetic damage' for most of the proposed construction equipment. However, based on the arrangement of the work zones, some items of construction equipment have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Construction with large rock-breakers has the potential to generate some of the most significant construction vibration impacts due to the high vibration characteristics of the plant.

The assessment presented in **Table 5-62** indicates that during surface works, up to five buildings in NCA13 may be within the minimum working distances should a large rock-breaker be used at the outer extents of the Darley Road construction ancillary facility. In practice, it is unlikely that a rock-breaker would be required at all areas and therefore the vibration impacts presented in this assessment should be considered a worst case scenario. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

The assessment presented in **Table 5-62** indicates that no buildings are likely to be within the minimum working distance to tunnelling works associated with the access tunnel to the mainline tunnel alignment.

Human comfort vibration assessment summary

The assessment presented in **Table 5-62** indicates the proposed surface works using a large rock-breaker may result in a significant number of receivers (around 74 receivers in the vicinity) within the nominated minimum working distance for human comfort vibration.

The assessment presented in **Table 5-62** indicates that no receivers are likely to be within the human comfort minimum working distance to tunnelling works associated with the access tunnel to the mainline tunnel alignment.

In relation to human comfort (response), the minimum working distances in **Table 4-12** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are permitted, as discussed in BS 6472-1.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers and other high vibration plant items. In practice vibration impacts from most construction activities would be intermittent within the duration of the project. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Cumulative vibration impacts

Due to the intermittent nature of construction works, vibration impacts due to multiple works scenarios are considered unlikely to result in concurrent vibration peaks, but rather, may increase the effective duration of the exposure to vibration. Vibration impacts due to multiple simultaneous works would therefore be managed in the same manner as for single works scenarios (dependant on the operating equipment).

Managing vibration impacts

Table 5-62 indicates that, as discussed above, there are around 74 receivers within the nominated minimum working distance for human comfort vibration. With reference to the CNVG vibration mitigation measures outlined in **Table 4-16**, vibration intensive works at the Darley Road civil and tunnel site are proposed only during standard construction hours. The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path/equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

Vibration trials and/or attended vibration monitoring or should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria. Building condition surveys should also be completed both before and after the works at any potentially affected properties to identify existing damage and any project related damage. At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.3 Rozelle

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed at Rozelle.

5.3.1 Works description

The Rozelle works area consists of three construction ancillary facilities; the Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and Victoria Road civil site (C7). Each construction area is discussed in detail in the following section.

Rozelle civil and tunnel site (C5)

The Rozelle civil and tunnel site (C5) is largely located within the Rozelle Rail Yards between the Rozelle light rail maintenance depot to the west (currently under construction), and Victoria Road to the east.

The site would be mainly used to support:

- Tunnelling of the Rozelle interchange and Iron Cove Link
- Construction of one new intersection on City West Link
- Construction of the cut and cover structures and entry and exit ramps that would connect the surface road network with the tunnels
- Modifications to the City West Link / The Crescent intersection to enable future use of this intersection by motorists moving between the surface road network and the proposed future Western Harbour Tunnel
- Upgrade and modification works to the surface road network including along City West Link, The Crescent and Victoria Road
- Construction of the Rozelle motorway operations complex

- Landscaping works, including construction of open space and pedestrian and cyclist facilities.

The site would include temporary site offices, workshops and storage facilities, laydown areas, entry and exit points for construction traffic, a temporary substation, temporary ventilation for the tunnels, temporary water treatment plants and sediment ponds, workforce amenities and car parking.

Road-headers would be launched from this site to excavate the Rozelle interchange, the Iron Cove Link and access ramps that would enable connections to the proposed future Western Harbour Tunnel and Beaches Link. Three acoustic sheds would be built on the site to minimise noise from out of hours tunnelling and spoil handling.

The Crescent civil site (C6)

The Crescent civil site (C6) would be located between The Crescent and Rozelle Bay on land owned by Roads and Maritime. The site would be used to support the realignment of The Crescent including the construction of the new bridge over Whites Creek, widening and improvement works to Whites Creek, and construction of the drainage outfall and culvert that would direct flows through and from the Rozelle Rail Yards to Rozelle Bay. The site would be cleared and a hardstand and laydown area, site offices, workforce amenities and car parking established.

Access to the site would be via the existing driveway on Chapman Road and an internal access road that would be shared with vehicles accessing the marina. Temporary fencing and a gate would be installed to control access to and from the site.

Victoria Road civil site (C7)

The Victoria Road civil site (C7) would be located on the western side of Victoria Road between Quirk Street and Lilyfield Road on land currently occupied by commercial properties. The existing buildings and other structures on the site would be demolished to facilitate establishment of temporary site offices, a small laydown area, workforce amenities and car parking.

Figure 5-17 and **Figure 5-18** provide an indicative site layout map for the Rozelle works area.

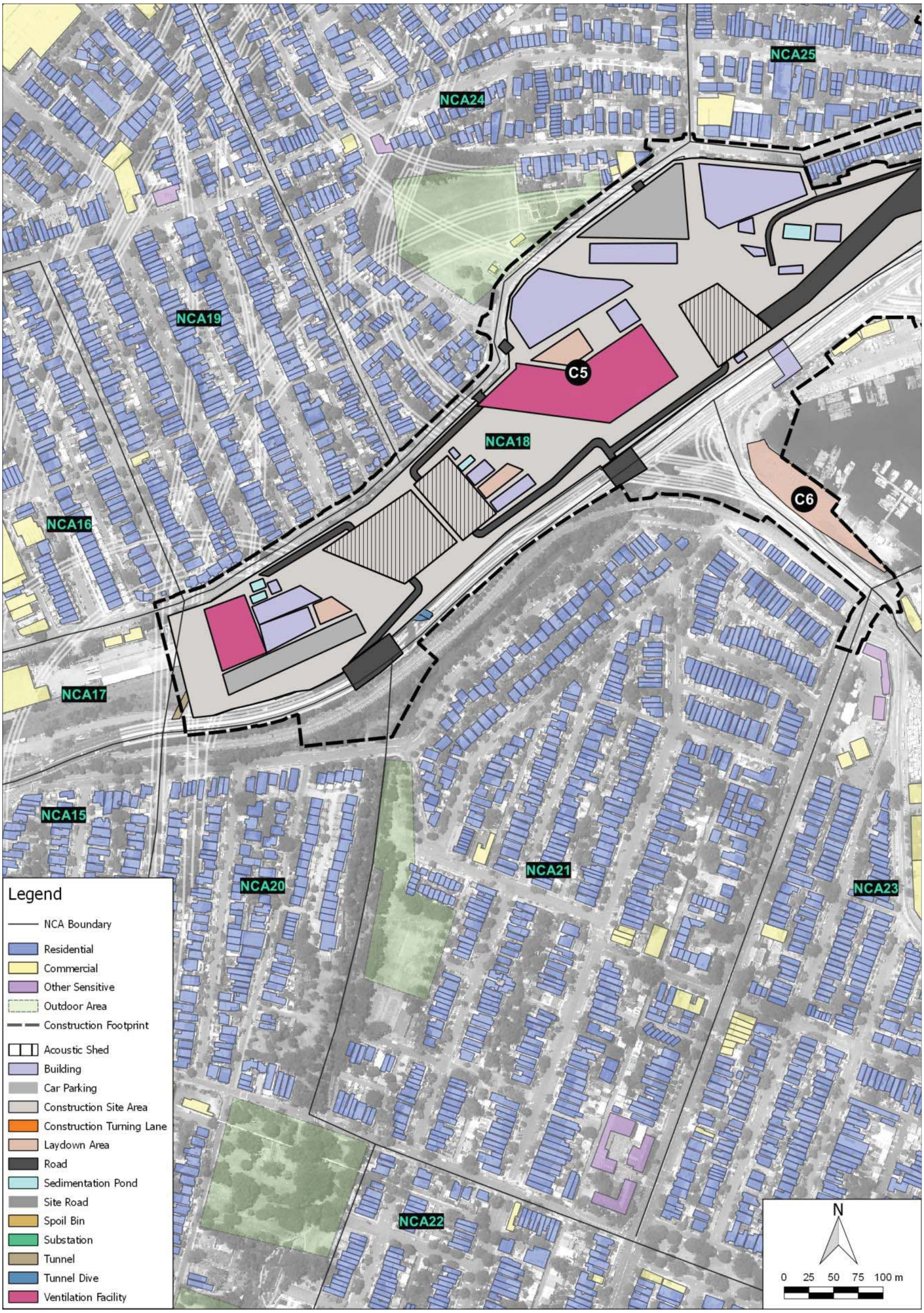


Figure 5-17 Indicative site layout – Rozelle map 1

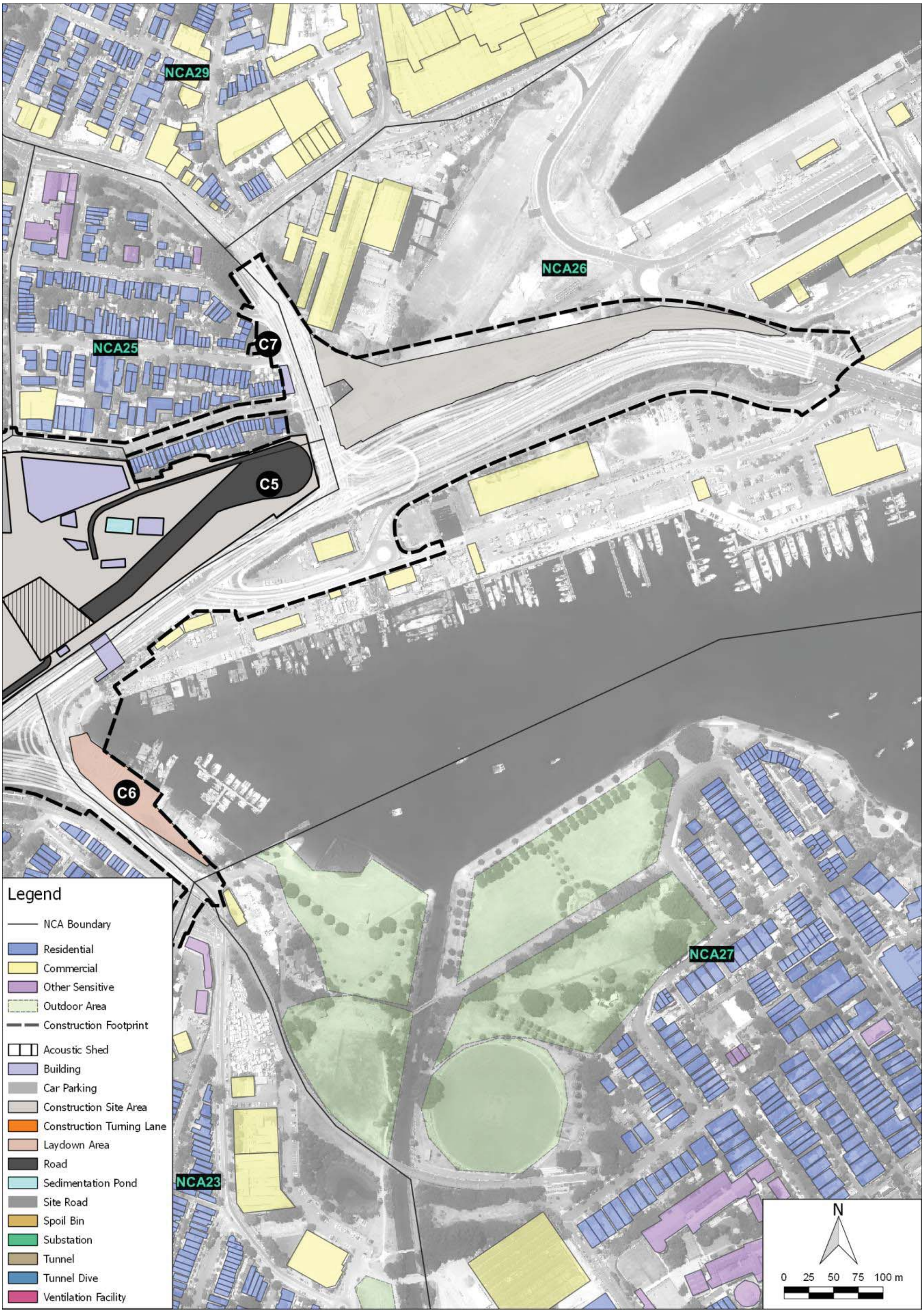


Figure 5-18 Indicative site layout – Rozelle map 2

Works schedule

Subject to planning approval, construction at Rozelle is planned to start in the fourth quarter of 2018, with completion planned for the third quarter of 2023. The total duration of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction project for Rozelle is shown in **Table 5-64**.

Table 5-64 Indicative construction program and duration – Rozelle

Works	2018				2019				2020				2021				2022				2023			
	Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Rozelle civil and tunnel site (C5)																								
Site establishment and utility works				■	■	■	■	■																
Traffic diversions and intersection works						■	■	■																
Construction of cut-and-cover and tunnel portals						■	■	■	■															
Tunnelling									■	■	■	■	■	■	■	■	■	■						
Construction of motorway operational infrastructure									■	■	■	■	■	■	■	■	■	■						
Civil and mechanical fitout													■	■	■	■	■	■	■					
Site rehabilitation and landscaping																			■	■	■			
Demobilisation																						■	■	
Testing and commissioning																			■	■	■	■	■	
The Crescent (C6)																								
Site establishment and utility works					■	■	■																	
Surface road and intersection works					■	■																		
Whites Creek widening and improvement works						■	■	■	■															
Drainage works including construction of the culvert below City West Link and upgrades to the drainage outfall to Rozelle Bay						■	■	■	■	■														
Construction of Whites Creek Bridge and demolition of existing bridge									■	■	■	■	■											
Rehabilitation and landscaping													■	■	■	■								
Victoria Road civil site (C7)																								
Site establishment and utility works					■	■	■																	
Support for the reconstruction of Victoria Road including construction of the new bridge						■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Site rehabilitation and landscaping																				■				

Construction activities

A number of scenarios have been developed to assess potential impacts associated with construction works at Rozelle. **Table 5-65** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-65 Construction activities and period of operation – Rozelle

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2,3]			
				Day	Day ooh	Eve	Night
Rozelle civil and tunnel site (C5)							
Site establishment	ROZ-01	8	Demolition of existing structures	✓			
	ROZ-02	4	Site clearing	✓			
	ROZ-03	4	Installation of environmental controls	✓			
	ROZ-04	64	Utility works[4, 5]	✓			
	ROZ-05	16	Establishment of construction facilities	✓			
	ROZ-06	16	Site drainage	✓			
Temporary road and intersection modification	ROZ-07	36	Pavement modifications	✓	✓	✓	✓
	ROZ-08	36	Pavement and infrastructure works	✓	✓	✓	✓
Tunnelling and supporting works	ROZ-09	120	Onsite car parking	✓	✓	✓	✓
	ROZ-10	120	Workshop, deliveries, maintenance, and storage - laydown areas	✓	✓	✓	✓
	ROZ-11	52	Tunnel shafts and declines	✓			
	ROZ-12	120	Onsite truck movements	✓	✓	✓	✓
	ROZ-13	120	Spoil handling above ground within acoustic shed Rozelle – New M5 to CWL	✓	✓	✓	✓
	ROZ-14	120	Spoil handling above ground within acoustic shed Rozelle – Anzac to M4-M5 Link	✓	✓	✓	✓
	ROZ-15	120	Spoil handling above ground within acoustic shed Rozelle – Western Harbour Tunnel	✓	✓	✓	✓
	ROZ-16	120	Tunnelling supporting activities	✓	✓	✓	✓
Civil and mechanical fitout	ROZ-17	84	Ventilation building installation	✓			
	ROZ-18	84	Ventilation building installation and tunnel - concrete works	✓			
Site rehabilitation	ROZ-19	60	Site rehabilitation and landscaping	✓			
Victoria road civil site (C7)							
Site establishment	ROZ-20	4	Demolition of existing structures	✓			
	ROZ-21	26	Utility works[4, 5]	✓			
	ROZ-22	1	Site clearing	✓			

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2,3]			
				Day	Day ooh	Eve	Night
	ROZ-23	1	Installation of environmental controls	✓			
General construction activities							
Civil works - CWL, Victoria Road and The Crescent road upgrades including cut-and-cover/dive structures and approach roads	ROZ-24	192	Piling	✓			
	ROZ-25	192	Earthworks and drainage works	✓			
	ROZ-26	192	Bridge works	✓	✓	✓	✓
	ROZ-27	192	Concrete works	✓	✓	✓	✓
	ROZ-28	192	Roadworks and utility works[5]	✓	✓	✓	✓
The Crescent civil site (C6)							
Site establishment	ROZ-30	2	Site clearing	✓			
	ROZ-31	2	Installation of environmental controls	✓			
	ROZ-32	2	Establishment of construction facilities	✓			
General Operations	ROZ-33	192	Workshop, deliveries, maintenance, and storage - laydown areas	✓	✓	✓	✓

Notes:

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for pavement infrastructure works, modifications, general construction activities (ROZ-26 to ROZ-28). Pavement and infrastructure works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds. General construction works will be required throughout the project footprint. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays.
4. The utility works activity represents utility works required within the footprint of the proposed construction facilities. Utility works that may be required outside of the project footprint are discussed and included in ROZ-28
5. The full scope of utility works that are required as part of the project, and the equipment that would be required to carry it out, will be confirmed during the development of the detailed design. Further details about potential noise impacts associated with utility works and appropriate management are discussed in **section 5.8**

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations is provided in **Table 5-66.**

Table 5-66 Activities assessed for cumulative construction noise – Rozelle

Cumulative ID	Works ID	Activity	Comment	Period of works
ROZ-29	ROZ-09	Onsite car parking	Tunnelling works along with supporting activities from Rozelle civil and tunnel site C5	All periods
	ROZ-10	Workshop, deliveries, maintenance, and storage - laydown areas		
	ROZ-12	Onsite truck movements		
	ROZ-13	Spoil handling above ground within acoustic shed Rozelle – New M5 to CWL		
	ROZ-14	Spoil handling above ground within acoustic shed Rozelle Anzac to M4-M5 Link		
	ROZ-15	Spoil handling above ground within acoustic shed Rozelle Western Harbour Tunnel		
	ROZ-16	Tunnelling supporting activities		

5.3.2 Airborne noise

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works are outlined in **Table 5-67**.

Table 5-67 Residential NMLs for the project – Rozelle

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime period	Daytime period	Evening period	Night period	
NCA15	R.14	Residential	54	49	47	40	50
NCA16	R.01	Residential	64	59	57	49	59
NCA19	R.01	Residential	64	59	57	49	59
NCA20	R.14	Residential	54	49	47	40	50
NCA21	R.15	Residential	58	53	53	47	57
NCA23	R.09	Residential	59	54	50	41	51
NCA24	R.01	Residential	64	59	57	49	59
NCA25	R.02	Residential	61	56	56	50	60
NCA27	R.16	Residential	59	54	54	47	57
NCA28	n/a[2]	Residential	55	50	45	40	50
NCA29	R.03	Residential	71	66	65	49	59
NCA30	R.03	Residential	71	66	65	49	59

Notes:

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday
2. No unattended noise monitoring was conducted within this NCA or nearby. Australian standard 1055 descriptions and measurement of environmental noise – part 2 Application to specific situations has been used to establish a background noise level for screening purposes only. Where the construction noise assessment predicts an exceedance of NMLs for this location, it is recommended that monitoring be conducted during the detailed design stage to confirm the existing environment

For other sensitive receivers such as schools and places of worship, the NMLs presented in **section 4.1.2**, are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-68**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Works within the tunnel are assessed in the ground-borne noise assessment in **section 5.7.1**.

Table 5-68 Sound power levels for construction equipment – Rozelle

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2] LWA Item	LWA Activity[4]	LWAmax Activity
Rozelle civil and tunnel site (C5)							
Site establishment	ROZ-01	Demolition of existing structures	Concrete saw[1]	1	120	120	128
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	ROZ-02	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	ROZ-03	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	ROZ-04	Utility works	Concrete saw[1]	1	120	117	128
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)1	1	100		
	ROZ-05	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck / agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)1	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
	ROZ-06	Site drainage	Back hoe	1	102	115	118
			Excavator	1	109		
			Bobcat	1	104		
			Truck	1	98		
			Dozer	1	110		
			Grader	1	108		
			Generator	1	95		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
Temporary road and intersection modification	ROZ-07	Pavement modifications	Truck	1	98	116	128
			Concrete saw[1]	1	120		
			Grader	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Back hoe	1	102		
	ROZ-08	Pavement and infrastructure	Slip form machine	1	102	113	115
			Bitumen spray truck	1	100		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
		works	Roller (non-vibratory)	1	100		
			Grader	1	108		
			Concrete truck / agitator	1	106		
			Paving machine	1	104		
			Water tanker	1	98		
			Back hoe	1	102		
			Truck (25t)	1	98		
			Line marking plant	1	98		
Tunnelling and supporting works	ROZ-09	Onsite car parking	Car parking	10	73	71	81
	ROZ-10	Workshop, deliveries, maintenance, and storage - laydown areas	Truck	1	98	104	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	ROZ-11	Tunnel shafts and declines	Piling rig (Bored)	1	108	114	118
			Mobile crane)	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Excavator	1	109		
			Concrete truck / agitator	1	106		
			Truck	1	98		
	ROZ-12	Onsite truck movements	Truck	22	103	102	108
	ROZ-13	Spoil handling above ground within acoustic shed Rozelle – New M5 to CWL	Tipper truck	2	97	117	119
			Excavator	2	109		
			Front end loader	2	112		
			Compressor for air scrubber	2	72		
			Ventilation scrubber	2	98		
	ROZ-14	Spoil handling above ground within acoustic shed Rozelle – Anzac Bridge to M4-M5 Link	Tipper truck	2	97	117	119
			Excavator	2	109		
			Front end loader	2	112		
			Compressor for air scrubber	2	72		
			Ventilation scrubber	2	98		
	ROZ-15	Spoil handling above ground within acoustic shed Rozelle – Western Harbour Tunnel	Tipper truck	2	97	117	119
			Excavator	2	109		
			Front end loader	2	112		
			Compressor for air scrubber	2	72		
			Ventilation scrubber	2	98		
	ROZ-16	Tunnelling supporting activities	Water treatment plant[2,3]	1	82	82	98
			Substation[2]	1	66		
Civil and mechanical fitout	ROZ-17	Ventilation building installation	Mobile crane	1	101	115	118
			Back hoe	1	102		
			Excavator	1	109		
			Bobcat	1	104		
			Truck	1	98		
			Dozer	1	110		
			Grader	1	108		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
	ROZ-18	Ventilation building installation and tunnel - concrete works	Concrete pump	1	106	106	112
			Concrete truck / agitator	1	106		
Site rehabilitation	ROZ-19	Site rehabilitation and landscaping	Hand tools	1	94	104	111
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		
Victoria Road civil site (C7)							
Site establishment	ROZ-20	Demolition of existing structures	Concrete saw[1]	1	120	120	128
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	ROZ-21	Utility works	Concrete saw[1]	1	120	117	128
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)1	1	100		
	ROZ-22	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	ROZ-23	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
General construction activities (Outside compounds)							
Civil works - CWL, Victoria Road and The Crescent road upgrades including cut-and-cover/dive structures and approach roads	ROZ-24	Piling works	Piling rig (bored)	1	108	113	118
			Mobile crane	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Concrete truck / agitator	1	106		
	ROZ-25	Earthworks and drainage works	Back hoe	1	102	116	118
			Excavator	1	109		
			Bobcat	1	104		
			Truck	1	98		
			Dozer	1	110		
			Grader	1	108		
			Generator	1	95		
			Vibratory roller	1	109		
			Water tanker	1	98		
	ROZ-26	Bridge works	Mobile crane	1	104	111	115
			Mobile crane	1	104		
			Truck	1	98		
			Excavator	1	109		
	ROZ-27	Concrete works	Concrete pump	1	106	106	112
			Concrete truck / agitator	1	106		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2] LWA Item	LWA Activity[4]	LWAmax Activity
	ROZ-28	Roadworks and utility works	Slip Form Machine	1	102	113	115
			Bitumen Spray Truck	1	100		
			Roller (non-vibratory)1	1	100		
			Excavator (	1	99		
			Concrete Truck / Agitator	1	106		
			Paving Machine	1	104		
			Water Tanker (	1	98		
			Back Hoe	1	102		
			Truck	1	98		
			Suction Truck	1	100		
			Bobcat	1	104		
			Generator	1	101		
			Franna Crane	1	99		
			Kanga Hammer	1	105		
			Auger	1	103		
			Line Marking Plant	1	98		
The Crescent civil site (C6)							
Site establishment	ROZ-30	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	ROZ-31	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	ROZ-32	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck / agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
General site operations	ROZ-33	Workshop, deliveries, maintenance, and storage - laydown areas	Truck	1	98	104	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		

Note:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of the finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facilities of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable
- **Acoustic sheds** – An acoustic shed of solid construction such as sheet steel would be incorporated at this site where practicable.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-69** to **Table 5-73** for residential, commercial and other sensitive receivers. The noise levels are representative of the worst case impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) to the relevant NMLs and a summary of the impact assessment is presented in detail in **Annexure F-3**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs	– impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs	– impacts would typically be moderate
Noise levels >20 dBA above NMLs	– impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-74**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-3**.

Table 5-69 Predicted worst case noise levels – Rozelle – residential daytime

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1,2]																																
		ROZ-01	ROZ-02	ROZ-03	ROZ-04	ROZ-05	ROZ-06	ROZ-07	ROZ-08	ROZ-09	ROZ-10	ROZ-11	ROZ-12	ROZ-13	ROZ-14	ROZ-15	ROZ-16	ROZ-17	ROZ-18	ROZ-19	ROZ-20	ROZ-21	ROZ-22	ROZ-23	ROZ-24	ROZ-25	ROZ-26	ROZ-27	ROZ-28	ROZ-29	ROZ-30	ROZ-31	ROZ-32	ROZ-33
Residential - Standard Daytime																																		
NCA15	54	54	59	54	63	60	59	57	54	-	45	54	37	45	40	44	36	58	49	50	-	-	-	-	53	63	51	53	62	50	44	39	45	35
NCA16	64	53	66	61	70	67	68	59	56	-	49	57	39	46	39	42	33	65	56	57	44	41	37	32	56	62	54	52	60	52	43	38	44	34
NCA17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA19	64	65	69	64	73	70	71	62	59	-	57	69	45	61	47	61	39	70	61	60	48	45	41	36	63	65	61	56	63	64	51	46	52	42
NCA20	54	55	59	54	63	60	60	62	59	-	47	59	40	49	40	46	31	59	50	50	42	39	35	30	58	64	56	54	62	53	44	39	45	35
NCA21	58	64	63	58	67	64	62	68	65	-	51	61	43	52	52	53	39	62	53	52	52	49	45	40	74	78	64	67	75	57	67	62	68	58
NCA22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA23	59	51	46	41	50	47	48	49	46	-	36	47	-	37	41	36	33	46	37	37	51	48	44	39	47	51	43	41	55	43	53	48	54	44
NCA24	64	79	72	67	76	73	74	64	61	30	56	70	43	56	54	58	35	73	64	63	50	47	43	38	61	62	57	52	59	61	53	48	54	44
NCA25	61	80	75	70	79	76	65	62	59	36	61	76	52	43	54	44	39	58	49	66	90	87	83	78	78	86	66	76	83	62	54	49	55	45
NCA26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA27	59	52	46	41	50	47	49	49	46	-	37	47	-	36	43	36	33	47	38	37	54	51	47	42	49	52	46	42	51	45	49	44	50	40
NCA28	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	45	39	34	44	-	-	-	-	-
NCA29	71	54	47	42	51	48	49	47	44	-	34	45	-	36	40	37	-	48	39	38	66	63	59	54	52	63	49	53	70	42	44	39	45	35
NCA30	71	54	47	42	51	48	48	48	45	-	35	48	-	37	40	38	-	48	39	38	53	50	46	41	45	52	43	42	50	44	44	39	45	35

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period
2. Where the predicted level is greater than or equal to 30 dBA

Table 5-70 Predicted worst case noise levels – Rozelle – residential evening

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1,2]																																
		ROZ-01	ROZ-02	ROZ-03	ROZ-04	ROZ-05	ROZ-06	ROZ-07	ROZ-08	ROZ-09	ROZ-10	ROZ-11	ROZ-12	ROZ-13	ROZ-14	ROZ-15	ROZ-16	ROZ-17	ROZ-18	ROZ-19	ROZ-20	ROZ-21	ROZ-22	ROZ-23	ROZ-24	ROZ-25	ROZ-26	ROZ-27	ROZ-28	ROZ-29	ROZ-30	ROZ-31	ROZ-32	ROZ-33
Residential - Evening																																		
NCA15	47	-	-	-	-	-	-	57	54	-	45	-	37	45	40	44	36	-	-	-	-	-	-	-	-	-	51	53	62	50	-	-	45	35
NCA16	57	-	-	-	-	-	-	59	56	-	49	-	39	46	39	42	33	-	-	-	-	-	-	-	-	-	54	52	60	52	-	-	44	34
NCA17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA19	57	-	-	-	-	-	-	62	59	-	57	-	45	61	47	61	39	-	-	-	-	-	-	-	-	-	61	56	63	64	-	-	52	42
NCA20	47	-	-	-	-	-	-	62	59	-	47	-	40	49	40	46	31	-	-	-	-	-	-	-	-	-	56	54	62	53	-	-	45	35
NCA21	53	-	-	-	-	-	-	68	65	-	51	-	43	52	52	53	39	-	-	-	-	-	-	-	-	-	64	67	75	57	-	-	68	58
NCA22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA23	50	-	-	-	-	-	-	49	46	-	36	-	-	37	41	36	33	-	-	-	-	-	-	-	-	-	43	41	55	43	-	-	54	44
NCA24	57	-	-	-	-	-	-	64	61	30	56	-	43	56	54	58	35	-	-	-	-	-	-	-	-	-	57	52	59	61	-	-	54	44
NCA25	56	-	-	-	-	-	-	62	59	36	61	-	52	43	54	44	39	-	-	-	-	-	-	-	-	-	66	76	83	62	-	-	55	45
NCA26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA27	54	-	-	-	-	-	-	49	46	-	37	-	-	36	43	36	33	-	-	-	-	-	-	-	-	-	46	42	51	45	-	-	50	40
NCA28	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	34	44	-	-	-	-	-
NCA29	65	-	-	-	-	-	-	47	44	-	34	-	-	36	40	37	-	-	-	-	-	-	-	-	-	-	49	53	70	42	-	-	45	35
NCA30	65	-	-	-	-	-	-	48	45	-	35	-	-	37	40	38	-	-	-	-	-	-	-	-	-	-	43	42	50	44	-	-	45	35

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period
2. Where the predicted level is greater than or equal to 30 dBA

Table 5-71 Predicted worst case noise levels – Rozelle – residential night-time

NCA	NML	ROZ-01	ROZ-02	ROZ-03	ROZ-04	ROZ-05	ROZ-06	ROZ-07	ROZ-08	ROZ-09	ROZ-10	ROZ-11	ROZ-12	ROZ-13	ROZ-14	ROZ-15	ROZ-16	ROZ-17	ROZ-18	ROZ-19	ROZ-20	ROZ-21	ROZ-22	ROZ-23	ROZ-24	ROZ-25	ROZ-26	ROZ-27	ROZ-28	ROZ-29	ROZ-30	ROZ-31	ROZ-32	ROZ-33
		Predicted LAeq(15minute) Noise Level (dBA)[1,2]																																
Residential - Night-time																																		
NCA15	40	-	-	-	-	-	-	57	54	-	45	-	37	45	40	44	36	-	-	-	-	-	-	-	-	-	51	53	62	50	-	-	45	35
NCA16	49	-	-	-	-	-	-	59	56	-	49	-	39	46	39	42	33	-	-	-	-	-	-	-	-	-	54	52	60	52	-	-	44	34
NCA17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA19	49	-	-	-	-	-	-	62	59	-	57	-	45	61	47	61	39	-	-	-	-	-	-	-	-	-	61	56	63	64	-	-	52	42
NCA20	40	-	-	-	-	-	-	62	59	-	47	-	40	49	40	46	31	-	-	-	-	-	-	-	-	-	56	54	62	53	-	-	45	35
NCA21	47	-	-	-	-	-	-	68	65	-	51	-	43	52	52	53	39	-	-	-	-	-	-	-	-	-	64	67	75	57	-	-	68	58
NCA22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA23	41	-	-	-	-	-	-	49	46	-	36	-	-	37	41	36	33	-	-	-	-	-	-	-	-	-	43	41	55	43	-	-	54	44
NCA24	49	-	-	-	-	-	-	64	61	30	56	-	43	56	54	58	35	-	-	-	-	-	-	-	-	-	57	52	59	61	-	-	54	44
NCA25	50	-	-	-	-	-	-	62	59	36	61	-	52	43	54	44	39	-	-	-	-	-	-	-	-	-	66	76	83	62	-	-	55	45
NCA26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA27	47	-	-	-	-	-	-	49	46	-	37	-	-	36	43	36	33	-	-	-	-	-	-	-	-	-	46	42	51	45	-	-	50	40
NCA28	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	34	44	-	-	-	-	-
NCA29	49	-	-	-	-	-	-	47	44	-	34	-	-	36	40	37	-	-	-	-	-	-	-	-	-	-	49	53	70	42	-	-	45	35
NCA30	49	-	-	-	-	-	-	48	45	-	35	-	-	37	40	38	-	-	-	-	-	-	-	-	-	-	43	42	50	44	-	-	45	35

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period
2. Where the predicted level is greater than or equal to 30 dBA

Table 5-72 Predicted worst case noise levels – Rozelle – commercial receivers

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1,2]																															
		ROZ-01	ROZ-02	ROZ-03	ROZ-04	ROZ-05	ROZ-06	ROZ-07	ROZ-08	ROZ-09	ROZ-10	ROZ-11	ROZ-12	ROZ-13	ROZ-14	ROZ-15	ROZ-16	ROZ-17	ROZ-18	ROZ-19	ROZ-20	ROZ-21	ROZ-22	ROZ-23	ROZ-24	ROZ-25	ROZ-26	ROZ-27	ROZ-28	ROZ-29	ROZ-30	ROZ-31	ROZ-32	ROZ-33
Commercial																																		
NCA15	70	48	49	44	53	50	51	49	46	-	38	48	-	40	35	38	-	50	41	40	-	-	-	-	46	52	44	42	52	44	39	34	40	-
NCA16	70	42	56	51	60	57	58	53	50	-	43	51	33	42	30	37	-	56	47	47	-	-	-	-	50	58	48	48	57	46	40	35	41	31
NCA17	70	47	50	45	54	51	52	50	47	-	38	48	30	40	36	38	-	51	42	41	-	-	-	-	47	53	45	43	52	44	39	34	40	30
NCA18	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA19	70	56	53	48	57	54	55	49	46	-	37	48	-	38	41	38	-	49	40	44	45	42	38	33	46	55	44	45	54	44	44	39	45	35
NCA20	70	50	45	40	49	46	46	47	44	-	35	46	-	40	37	40	-	45	36	36	-	-	-	-	45	49	44	39	46	45	36	31	37	-
NCA21	70	52	53	48	57	54	53	54	51	-	42	52	31	44	38	41	-	53	44	44	43	40	36	31	51	56	49	46	53	48	45	40	46	36
NCA22	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA23	70	52	47	42	51	48	49	50	47	-	37	47	-	34	40	32	-	43	34	38	49	46	42	37	46	51	41	41	55	43	53	48	54	44
NCA24	70	75	68	63	72	69	70	57	54	-	47	64	37	41	51	44	-	61	52	59	48	45	41	36	54	56	51	47	54	53	49	44	50	40
NCA25	70	74	67	62	71	68	62	56	53	-	48	62	37	40	50	42	-	56	47	58	42	39	35	30	55	58	49	48	55	53	50	45	51	41
NCA26	70	65	68	63	72	69	70	79	76	-	52	66	43	40	57	42	31	58	49	59	79	76	72	67	73	84	71	73	81	58	61	56	62	52
NCA27	70	55	51	46	55	52	54	54	51	-	39	50	33	33	45	33	-	52	43	42	52	49	45	40	56	65	52	49	79	47	66	61	67	57
NCA28	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	44	38	33	42	-	-	-	-	-
NCA29	70	54	47	42	51	48	49	47	44	-	34	45	-	36	38	38	-	48	39	38	66	63	59	54	55	62	53	52	72	42	43	38	44	34
NCA30	70	54	47	42	51	48	48	47	44	-	35	45	-	35	40	36	-	47	38	38	50	47	43	38	45	50	43	40	49	43	44	39	45	35

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period
2. Where the predicted level is greater than or equal to 30 dBA

Table 5-73 Predicted worst case noise levels – Rozelle – other sensitive receivers

NCA	NML	Predicted LAeq(15minute) Noise Level (dBA)[1,2]																															
		ROZ-01	ROZ-02	ROZ-03	ROZ-04	ROZ-05	ROZ-06	ROZ-07	ROZ-08	ROZ-09	ROZ-10	ROZ-11	ROZ-12	ROZ-13	ROZ-14	ROZ-15	ROZ-16	ROZ-17	ROZ-18	ROZ-19	ROZ-20	ROZ-21	ROZ-22	ROZ-23	ROZ-24	ROZ-25	ROZ-26	ROZ-27	ROZ-28	ROZ-29	ROZ-30	ROZ-31	ROZ-32	ROZ-33
Other Sensitive																																		
NCA15	-	40	40	35	44	41	42	42	39	-	31	41	-	34	-	32	-	42	33	31	-	-	-	-	40	42	38	33	40	37	-	-	-	-
NCA16	-	44	47	42	51	48	46	47	44	-	38	47	-	39	32	36	-	49	40	38	-	-	-	-	46	48	44	39	46	43	37	32	38	-
NCA17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA19	-	55	48	43	52	49	49	48	45	-	35	46	-	33	41	31	-	48	39	39	39	36	32	-	45	48	42	38	45	43	43	38	44	34
NCA20	-	48	44	39	48	45	45	44	41	-	34	45	-	36	31	36	-	45	36	35	-	-	-	-	44	47	42	37	44	41	-	-	-	-
NCA21	-	54	56	51	60	57	54	59	56	-	44	57	37	46	40	44	-	55	46	47	35	32	-	-	56	59	54	49	56	50	43	38	44	34
NCA22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA23	-	55	49	44	53	50	52	53	50	-	38	49	31	30	42	31	-	49	40	40	50	47	43	38	50	54	47	43	72	44	60	55	61	51
NCA24	-	75	68	63	72	69	69	59	56	-	46	60	38	41	45	46	34	62	53	59	49	46	42	37	56	58	53	48	55	50	46	41	47	37
NCA25	-	60	53	48	57	54	55	51	48	-	38	52	30	40	45	41	-	52	43	44	64	61	57	52	56	65	54	55	73	48	47	42	48	38
NCA26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA27	-	54	50	45	54	51	53	54	51	-	39	50	32	35	39	37	-	51	42	41	53	50	46	41	53	60	50	46	59	43	47	42	48	38
NCA28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA29	-	49	42	37	46	43	44	43	40	-	31	42	-	34	33	34	-	43	34	33	54	51	47	42	44	51	41	41	49	39	39	34	40	-
NCA30	-	53	46	41	50	47	48	47	44	-	33	45	-	33	39	35	-	46	37	37	50	47	43	38	44	48	42	38	45	42	43	38	44	34

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities

Table 5-74 Overview of NML exceedances – Rozelle

Activity ID	Activity	Weeks[1]	Activity duration within overall project program[2]				Number of receivers																	
							Total	Highly noise affected[4]	NML exceedance receiver count[3]															
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance			
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	
Rozelle Civil and tunnel site (C5)																								
ROZ-01	Demolition of existing Structures	8					5678	20	210	25	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-02	Site clearing	4					5678	1	152	13	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-03	Installation of environmental controls	4					5678	-	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-04	Utility works	64					5678	29	409	40	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-05	Establishment of construction facilities	16					5678	3	199	25	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-06	Site drainage	16					5678	-	152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-07	Pavement modifications	36					5678	-	138	-	-	419	16	-	512	28	-	1564	262	3	2283	562	40	
ROZ-08	Pavement and infrastructure works	36					5678	-	39	-	-	235	3	-	278	4	-	993	115	-	318	8		
ROZ-09	Onsite car parking	120					5678	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-10	Workshop, deliveries, Laydown Areas	120					5678	-	-	-	-	9	-	-	9	-	-	228	1	-	24	-	-	
ROZ-11	Tunnel Shafts and Declines	52					5678	3	90	18	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-12	Onsite truck movements	120					5678	-	-	-	-	-	-	-	-	-	-	2	-	-	35	8		
ROZ-13	Spoil handling Above Ground Within Acoustic Shed Rozelle – New M5 to CWL	120					5678	-	-	-	-	3	-	-	11	-	-	300	3	-	3	-	-	
ROZ-14	Spoil handling Above Ground Within Acoustic Shed Rozelle AB to M4-M5 Link	120					5678	-	-	-	-	-	-	-	-	-	-	94	-	-		-	-	
ROZ-15	Spoil handling above ground within acoustic shed Rozelle Western Harbour Tunnel	120					5678	-	-	-	-	3	-	-	7	-	-	240	3	-	3	-	-	
ROZ-16	Tunnelling Supporting activities	120					5678	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	
ROZ-17	Ventilation building installation	84					5678	-	94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ROZ-18	Ventilation building installation and Tunnel - Concrete Works	84					5678														-	-	-	

Activity ID	Activity	Weeks[1]	Activity duration within overall project program[2]				Number of receivers																	
							Total	Highly noise affected[4]	NML exceedance receiver count[3]															
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
ROZ-19	Site rehabilitation and landscaping	60					5678	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Victoria Road civil site (C7)																							
ROZ-20	Demolition of existing Structures	4					5678	20	39	23	6	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-21	Utility works	26					5678	13	30	16	5	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-22	Site Clearing	1					5678	6	27	7	1	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-23	Installation of environmental controls	1					5678	5	18	5	-	-	-	-	-	-	-	-	-	-	-	-	-
General Construction Works																							
ROZ-24	Piling	192					5678	1	89	13	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-25	Earthworks and drainage works	192					5678	24	277	45	1	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-26	Bridge Works	192					5678	-	36	-	-	190	2	-	249	2	-	787	77	-	400	20	-
ROZ-27	Concrete Works	192					5678	1	44	5	-	132	11	-	154	11	-	403	77	6	299	67	11
ROZ-28	Roadworks and utility works	192					5678	11	209	35	2	384	95	13	451	107	12	1475	315	62	617	147	32
Cumulative Assessment																							
ROZ-29	Cumulative assessment	120					5678	-	1	-	-	107	-	-	188	-	-	803	25	-	1799	467	19
The Crescent (C6)																							
ROZ-30	Site clearing	2					5678	-	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-31	Installation of environmental controls	2					5678	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-32	Establishment of construction facilities	2					5678	-	39	6	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-33	Workshop, deliveries, maintenance and storage laydown area	194					5678	-	6	-	-	19	-	-	19	-	-	42	14	-	14	3	-

Notes:

1. Approximate overall duration of the activity in all areas of the site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 25%) of activity duration within overall proposal program. Where percentage is less than 25%, 25% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables indicate that:

- The highest noise levels and NML exceedances are predicted during earthworks and drainage works (ROZ-25) and roadworks and utility works (ROZ-28) which requires the use of noisy equipment with potential for out of hours works
- The largest impacts are predicted in NCA25, where receivers are situated in relatively close proximity to the works site.

NML exceedances

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-3**.

Table 5-74 indicates that the activity with potential for the greatest exceedance of NMLs is roadworks and utility works (ROZ-28). This activity includes general roadworks, utility works, bitumen works, road forming and line marking works which would be required throughout the Rozelle works area. This activity also includes utility works which may be required at various locations without the works areas. To minimise disturbances to local traffic there is potential for these works to be conducted outside of standard construction hours. An assessment against out of hours NMLs has been included to provide guidance as to the extent of exceedances, although it should be noted that out of hours works are unlikely to be required for the entire duration of the activity. **Figure 5-19** and **Figure 5-20** indicate the distribution of exceedances for the roadworks and utility works activity (ROZ-28) during the day and night respectively.

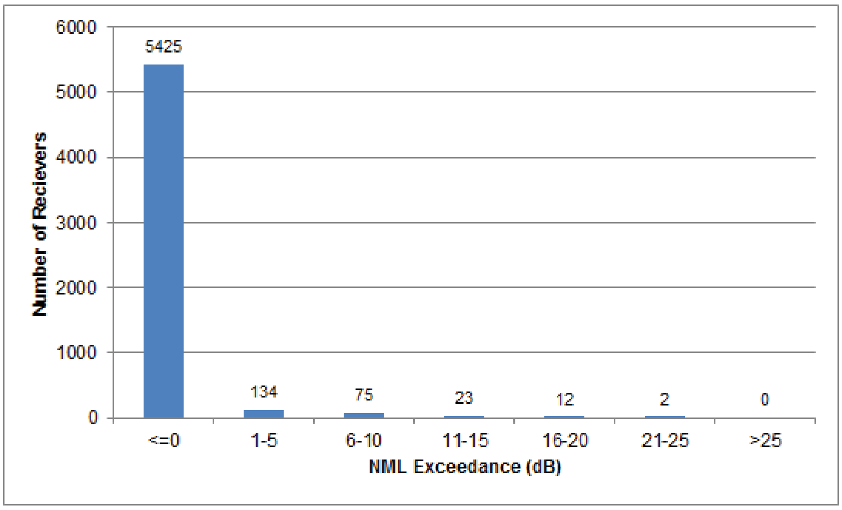


Figure 5-19 **Activity ROZ-28 noise level exceedance, daytime – Rozelle**

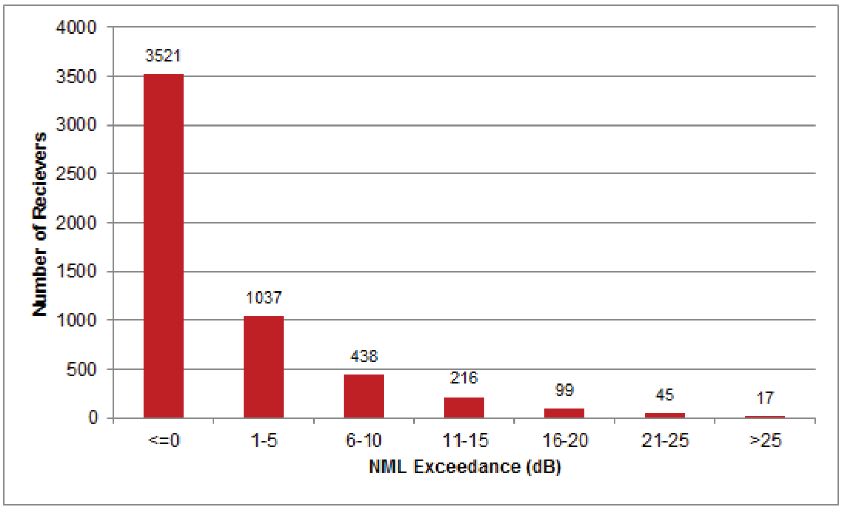


Figure 5-20 **Activity ROZ-28 noise level exceedance, night-time – Rozelle**

The above graphs shows that while the worst-case impacts may result in a greater than 25 dBA exceedance of the night-time NMLs, this is limited to a small number of receivers, with the majority of the receivers being subject to considerably lower or no impact.

All works activities comprise the use of a number of individual items of plant, (refer to listing in **Table 5-68**) though typically one item of plant will dominate the noise. The operation and location of the dominant item typically controls the level of noise emissions shown in **Table 5-74**. For roadworks works and utility works (ROZ-28) the operation of the grader, concrete truck and paving machine control the noise predictions and as such mitigation and management measures should focus on the operation of these items.

Spoil handling and tunnelling activities (ROZ-09, ROZ-10 and ROZ-12, to ROZ-15) are predicted to exceed NMLs by up to 15 dBA at the nearest most affected receiver. These activities represent works with the longest sustained operation within a confined area. The extended duration of these works should be considered when evaluating mitigation and management measures.

The cumulative scenario (ROZ-29), which includes the operation of all activities detailed in **Table 5-66**, is predicted to have night-time NML exceedances of up to 15 dBA.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of highly noise affected receivers in the study area has been determined and is summarised in **Table 5-75**. The table shows the number of residential receivers separated by works activity.

Table 5-75 Predicted number of highly noise affected residential receivers by works – Rozelle

Works	Activity	Period		
		Day	Eve	Night
Rozelle civil and tunnel site (C5)				
ROZ-01	Demolition of existing Structures	20	-	-
ROZ-02	Site clearing	1	-	-
ROZ-03	Installation of environmental controls	-	-	-
ROZ-04	Utility works	29	-	-
ROZ-05	Establishment of construction facilities	3	-	-
ROZ-06	Site drainage	-	-	-
ROZ-07	Pavement modifications	-	-	-
ROZ-08	Pavement and infrastructure works	-	-	-
ROZ-09	General worksite and car parking	-	-	-
ROZ-10	Workshop, deliveries, Laydown Areas	-	-	-
ROZ-11	Tunnel Shafts and Declines	3	-	-
ROZ-12	Onsite truck movements	-	-	-
ROZ-13	Spoil handling Above Ground Within Acoustic Shed Rozelle – New M5 to CWL	-	-	-
ROZ-14	Spoil handling Above Ground Within Acoustic Shed Rozelle AB to M4-M5 Link	-	-	-
ROZ-15	Spoil handling above ground within acoustic shed Rozelle Western Harbour Tunnel	-	-	-
ROZ-16	Tunnelling Supporting activities	-	-	-
ROZ-17	Ventilation building installation	-	-	-
ROZ-18	Ventilation building installation and Tunnel - Concrete Works	-	-	-
ROZ-19	Site rehabilitation and landscaping	-	-	-

Works	Activity	Period		
		Day	Eve	Night
Victoria Road civil site (C7)				
ROZ-20	Demolition of existing Structures	20	-	-
ROZ-21	Utility works	13	-	-
ROZ-22	Site Clearing	6	-	-
ROZ-23	Installation of environmental controls	5	-	-
General construction activities				
ROZ-24	Piling and general	1	-	-
ROZ-25	Earthworks and drainage works	24		
ROZ-26	Bridge Works	-	-	-
ROZ-27	Concrete Works	1	1	1
ROZ-28	Roadworks and utility works	11	11	11
Rozelle cumulative assessment				
ROZ-29	Cumulative Assessment	-	-	-
The Crescent civil site (C6)				
ROZ-30	Site clearing	-	-	-
ROZ-31	Installation of environmental controls	-	-	-
ROZ-32	Establishment of construction facilities	-	-	-
ROZ-33	Workshop, deliveries, maintenance and storage laydown area	-	-	-

The above table shows that receivers are predicted to be highly noise affected during certain works activities. The highest numbers are apparent during:

- ROZ-01 – Demolition of existing structures, where 20 receivers are predicted to be highly noise affected
- ROZ-04 - Utility works, where 29 receivers predicted to be highly noise affected
- ROZ-20 - Demolition of existing structures, where 20 receivers are predicted to be highly noise affected
- ROZ-25 – Earthworks and drainage works where 24 receivers are predicted to be highly noise affected.

The location of the highly noise affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-21**.

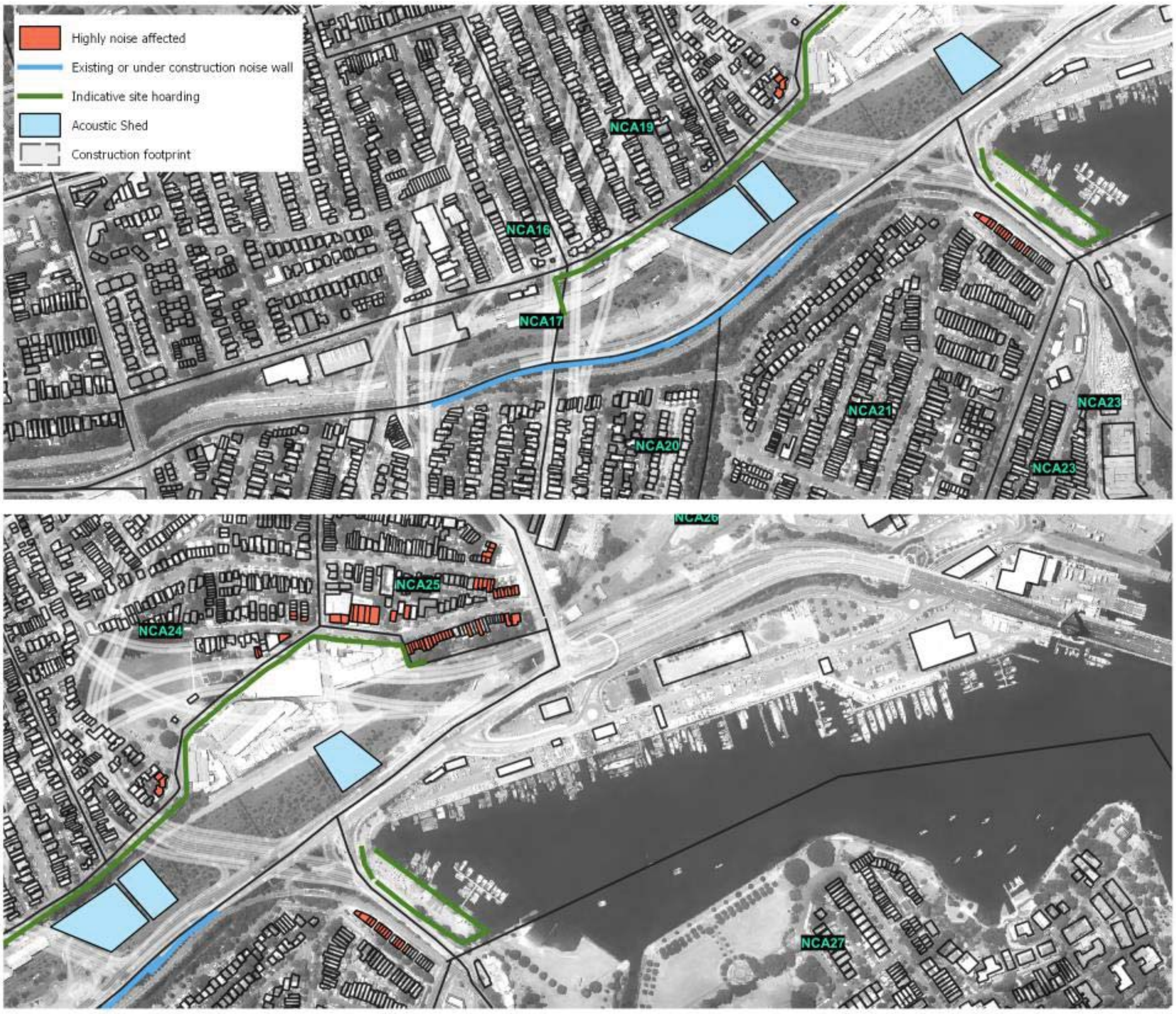


Figure 5-21 Highly noise affected residential receivers – Rozelle

The most impacted receivers are typically surrounding dwellings which have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-76**. The assessment provides further context to the predicted worst case levels presented in **Table 5-73** as it presents the number of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA, and separated by receiver type.

Table 5-76 Overview of other sensitive receiver NML exceedances – Rozelle

Works ID	Activity	Number of other sensitive receivers exceeding NMLs														
		Education			Medical			Place of Worship			Childcare			Remaining[1]		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
Rozelle civil and tunnel site (C5)																
ROZ-01	Demolition of existing Structures	1	-	-	-	-	-	1	-	-	2	-	-	1	-	-
ROZ-02	Site clearing	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ROZ-03	Installation of environmental controls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-04	Utility works	1	-	-	-	-	-	1	-	-	1	-	-	1	-	-
ROZ-05	Establishment of construction facilities	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ROZ-06	Site drainage	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ROZ-07	Pavement modifications	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-08	Pavement and infrastructure works	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-09	On site car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-10	Workshop, deliveries, Laydown Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-11	Tunnel Shafts and Declines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-12	Onsite truck movements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-13	Spoil handling Above Ground Within Acoustic Shed Rozelle – New M5 to CWL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-14	Spoil handling Above Ground Within Acoustic Shed Rozelle AB to M4-M5 Link	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-15	Spoil handling above ground within acoustic shed Rozelle Western Harbour Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-16	Tunnelling Supporting activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-17	Ventilation building installation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-18	Ventilation building installation and Tunnel - Concrete Works	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-19	Site rehabilitation and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Victoria Road civil site (C7)																
ROZ-20	Demolition of existing Structures	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
ROZ-21	Utility works										1					
ROZ-22	Site Clearing	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
ROZ-23	Installation of environmental controls	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
General construction activities																
ROZ-24	Piling works	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
ROZ-25	Earthworks and drainage works	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-
ROZ-26	Bridge Works	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
ROZ-27	Concrete Works	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
ROZ-28	Roadworks and utility works	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-
Rozelle cumulative assessment																
ROZ-29	Cumulative Assessment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Works ID	Activity	Number of other sensitive receivers exceeding NMLs Education			Medical			Place of Worship			Childcare			Remaining[1]		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
The Crescent civil site (C6)																
ROZ-30	Site clearing	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-31	Installation of environmental controls	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-32	Establishment of construction facilities	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROZ-33	Workshop, deliveries, maintenance and storage laydown area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. The 'Remaining' category includes public buildings, libraries, café/bars, etc

Other sensitive receivers in this precinct are generally predicted be subject to relatively minor noise impacts during the daytime. Receivers in the education, medical and remaining categories would not be subject to any NML exceedances

One 'other sensitive receiver' in this area would be subject to worst case exceedances of 11 to 20 dBA above NMLs during the higher noise generating activities. This receiver is a childcare centre at 5 Quirk Street, Rozelle (located within NCA25). This same receiver would also be subject to worst case exceedances of >20 dBA above NMLs during the higher noise generating activities.

The recommended 'standard' and 'additional' noise mitigation as discussed in **section 4.6**, along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-3**.

NCA15

- Pavement and infrastructure works, roadworks and utility works (ROZ-07 and ROZ-28) are identified as having a number of exceedances over all time periods in this catchment. Exceedances are generally at receivers which adjoin City West Link and are attributed to pavement works required along City West Link. For pavement works (ROZ-07) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA
- The cumulative scenario (ROZ-29) is predicted to result in exceedances of the night time NMLs of up to 10 dBA at 168 sensitive receivers. Of the total number of sensitive receivers predicted to experience exceedances, 142 would experience an exceedance of less than 5 dBA. The expected duration of the cumulative works is up to 120 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections.

NCA16

- Pavement and infrastructure works, roadworks and utility works (ROZ-07 and ROZ-28) are identified as having the highest number of exceedances over all time periods in this catchment. Exceedances are generally experienced by sensitive receivers which adjoin Lilyfield Road and are attributed to pavement works required along City West Link and within the Rozelle civil and tunnel site. For pavement works (ROZ-07) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA

- Exceedances of up to 5 dBA are predicted during the cumulative scenarios. These exceedances will be addressed by further investigating the acoustic performance of the site sheds in the ‘with mitigation’ assessment below.

NCA19, NCA20 and NCA21

NCA19, NCA20 and NCA21 are adjacent to the Rozelle civil and tunnel site. These NCAs are predicted to experience a similar degree of NML exceedance from common noise sources at both compounds. The discussion of impacts for these NCAs has been grouped together below.

- Pavement and infrastructure works, roadworks and utility works (ROZ-07 and ROZ-28) are identified as having the highest number of exceedances over all time periods in these catchments. Exceedances are generally experienced by sensitive receivers which adjoin Lilyfield Road and are attributed to pavement works required along City West Link and within the Rozelle civil and tunnel site. For pavement works (ROZ-07) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA
- Spoil handling operations inside the acoustic sheds within the Rozelle civil and tunnel site (activity ROZ-13 to ROZ-15) are predicted to result in exceedances of up to 15 dBA at 258, 38 and 204 sensitive receivers respectively during night-time operations. For the sensitive receivers predicted to experience exceedances of the night-time criteria, 94 per cent of exceedances are less than 5 dBA. The expected duration of these works is up to 120 weeks and as such mitigation and management measures should be considered for these impacts
- The cumulative scenario (ROZ-29) is predicted to result in exceedances of up to 15 dBA at 504, receivers. Of the total number of sensitive receivers predicted to experience exceedances, around 50 per cent would experience an exceedance of less than 5 dBA and 96 per cent would experience an exceedance less than 10 dBA. The expected duration of the cumulative works is up to 120 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following section.

NCA23

- Exceedances of up to 5 dBA are predicted during the cumulative scenarios. These exceedances will be addressed by further investigating the acoustic performance of the site sheds in the ‘with mitigation’ assessment below.

NCA24

- Demolition and utility works (ROZ-01 and ROZ-03) are identified has having a number of exceedances of the daytime NMLs in this catchment. Exceedances are generally at sensitive receivers which adjoin Lilyfield Road and are attributed to the use of excavators (rock-breaker) and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to 8 weeks for demolition works and 64 weeks for utility works. Of the total number of sensitive receivers predicted to experience exceedances (87 in total), 53 would experience an exceedance of less than 5 dBA
- Spoil handling operations inside the acoustic sheds within the Rozelle civil and tunnel site (activity ROZ-13 to ROZ-15) are predicted to result in exceedances of up to 10 dBA at 19, 29 and 26 sensitive receivers respectively during night-time operations. For the sensitive receivers predicted to experience exceedances of the night-time criteria, around 79 per cent of exceedances are less than 5 dBA. The expected duration of these works is up to 120 weeks and as such mitigation and management measures should be considered for these impacts
- The cumulative scenario (ROZ-29) is predicted to result in exceedances of up to 15 dBA at 88, receivers. Of the total number of sensitive receivers predicted to experience exceedances, around 70 per cent would experience an exceedance of less than 5 dBA and 96 per cent would experience an exceedance less than 10 dBA. The expected duration of the cumulative works is up to 120 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following section.

NCA25

NCA25 is predicted to experience noise impacts primarily associated with the construction activities within the eastern extent of the Rozelle civil and tunnel site and Victoria Road civil site. Given their proximity, receivers located along Lilyfield Road between Victoria Road and Gordon Street which overlook the Rozelle Rail Yards are likely to experience the greatest construction noise impact within the entire Rozelle study area. When considering possible management and mitigation measures for these receivers it is important to consider the duration of the total works as it is likely that these receivers will be exposed to construction noise impacts for an extended duration.

- Demolition and utility works (ROZ-01 and ROZ-03) are identified has having a number of exceedances of the daytime NMLs in this catchment. Exceedances are generally at sensitive receivers which adjoin Victoria Road and Lilyfield Road north of the City West Link intersection and are attributed to the use of excavators (rock-breaker) and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to two weeks
- Pavement and infrastructure works, roadworks and utility works (ROZ-07 and ROZ-28) are identified as causing the highest number of exceedances in all time periods in this catchment. Exceedances are generally experienced by sensitive receivers which overlook the Victoria road and City West Link intersection and are attributed to pavement works required along City West Link and Victoria Road. For pavement works (ROZ-07) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA
- Works associated with the operation of laydown areas within the Rozelle civil and tunnel site (ROZ-10) are predicted to result in exceedances of up to 15 dBA at 27 receivers during night-time operations. Of the receivers predicted to experience exceedances of the night-time criteria, 63 per cent of exceedances are less than 5 dBA. The expected duration of these works is up to 120 weeks and as such mitigation and management measures should be considered for these impacts
- The construction of the tunnel shaft and decline associated with the Anzac Bridge to M4-M5 Link portals (ROZ-11) is predicted to result in exceedances of up to 15 dBA at 46, receivers. Of the total number of sensitive receivers predicted to experience exceedances, 28 would experience an exceedance of less than 10 dBA. The expected duration of the cumulative works is up to 52 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (ROZ-29) is predicted to result in exceedances of the night time NMLs of up to 15 dBA at 57 sensitive receivers. Of the total number of sensitive receivers predicted to experience exceedances, 40 would experience an exceedance of less than 5 dBA. The expected duration of the cumulative works is up to 120 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections.

NCA26 to NCA30

- Roadworks and utility works (ROZ-28) has been identified as having the highest number of exceedances in all time periods. Exceedances are generally at sensitive receivers which adjoin City West Link or Victoria Road. Mitigation and management measures should focus on controlling the noise emissions from the most dominant plant item when in use.

Sleep disturbance

The predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-3** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project-specific mitigation measures (in addition to the standard suite of measures **Table 4-13**) are summarised in **Table 5-77**.

Table 5-77 Recommended site specific noise mitigation measures – Rozelle

Activity	Mitigation description	Reason	Recommendations
ALL	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	The assessment has identified a number of activities which have the potential for impacts. These activities typically involve the use of one noise intensive item of plant (i.e. concrete saw) which intern dominates the exceedance.	Limit the use of plant items such as rock-breakers, diamond saws and concrete saws during out of hour's works where feasible. Where practicable, investigate the use of temporary barriers located within the near field to works to provide shielding.
ROZ-10	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm.	Works associated with the operation of laydown areas at all compounds have been predicted to impact nearby receivers during out of hour's works.	Restricted operations during out of hour's periods where feasible.
ROZ-13 ROZ-14 ROZ-15	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified during all time periods for operations within the site shed.	Basic sheet steel shed construction was considered during the unmitigated predictions. It is recommended that an acoustic enclosure be included for the Rozelle civil and tunnel site.
All activities within compounds	Use structures such as site sheds and or hoarding to shield residential receivers from works activities. Non-tonal reversing beepers (or an equivalent mechanism) must be fitted	Works associated with the operation of laydown areas at all compounds have been predicted to impact nearby receivers during out of hour's works.	Investigate locations where hoarding (>2m) can be utilised to control noise emissions.

Activity	Mitigation description	Reason	Recommendations
	and used on all construction vehicles and mobile plant regularly used onsite.		
	Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.		
ALL	Installation of mitigation recommended as part of the operational noise assessment.	Operational mitigation measures may control construction impacts.	Early installation of mitigation measures recommended as part of the operational road traffic assessment detailed in **Chapter 6.**

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-3**.

In-situ mitigation measures investigated are:

- Increasing site hoarding to four meters in select areas
- Upgrading the acoustic shed performance.

The minimum transmission loss for the acoustic shed including operable elements is noted below in **Table 5-78**. It should be noted that where residual impacts are predicted following the inclusion of the upgraded shed, further investigation should be undertaken during detailed design.

Table 5-78 Acoustic shed acoustic performance – Rozelle

Indicative upgraded shed construction	Octave band transmission loss (dB)						
	63	125	250	500	1000	2000	4000
Double Leaf: (1 x 0.48mm Steel) - 202mm Steel Stud + 75mm Fibreglass 32 kg/m³ - (1 x 0.42mm Steel)	10	12	24	36	46	55	61

Figure 5-22 indicates locations where increased site hoarding has been investigated.

Figure 5-22 Increased site hoarding locations – Rozelle

Table 5-79 provides the predicted distribution of exceedances (at night-time) both 'with' and 'without' the recommended mitigation for receivers within this study area.

Table 5-79 NML exceedance distribution with and without mitigation – Rozelle

Activity ID	Activity	Time period	Number of Receivers with NML Exceedance					
			Without mitigation			With mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
ROZ-10	Workshop, deliveries, laydown areas	Night	228	1	-	219	1	-
ROZ-13	Spoil handling within acoustic shed (New M5 to CWL)	Night	300	3	-	11	-	-
ROZ-14	Spoil handling within acoustic shed (Anzac Bridge to M4-M5 Link)	Night	94	-	-	-	-	-
ROZ-15	Spoil handling within acoustic shed (WHT)	Night	240	3	-	4	-	-
ROZ-29	Cumulative Scenario	Night	803	25	-	396	1	-
ROZ-33	Workshop, deliveries, maintenance and storage laydown area	Night	42	14	-	44	-	-

Table 5-79 indicates that with the inclusion of in-situ mitigation measures in selected areas, a reduction of impacts is expected.

Further consideration should be given during detailed design as to controlling works operating with the laydown areas (ROZ-10), and may include localised barriers, judicious selection of plant and equipment and the management of operations during the critical night periods.

Noise contours are presented in **Annexure G-3** and represent the max predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of **Table 4-14** have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. Counts detailed in **Table 5-80** assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures.

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure H**.

Table 5-80 CNVG additional noise mitigation counts – Rozelle

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment					
NCA15	-	-	-	-	-
NCA16	-	-	-	-	-
NCA19	-	-	-	-	-
NCA20	-	-	-	-	-
NCA21	-	-	-	-	-
NCA23	-	-	-	-	-
NCA24	4	-	-	-	-
NCA25	65	-	-	-	-
NCA27	-	-	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-
NCA30	-	-	-	-	-
Scenario – Temporary road and intersection modification					
NCA15	-	204	151	4	-
NCA16	-	68	10	-	-
NCA19	-	75	88	-	-
NCA20	-	89	128	45	-
NCA21	-	126	220	17	-
NCA23	-	191	25	-	-
NCA24	-	271	81	-	-
NCA25	-	54	61	-	-
NCA27	-	14	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-
NCA30	-	-	-	-	-
Scenario – Tunnelling and supporting works					
NCA15	-	28	-	-	-
NCA16	-	-	-	-	-
NCA19	-	28	3	-	-
NCA20	-	90	8	-	-
NCA21	-	36	-	-	-
NCA23	-	-	-	-	-
NCA24	-	23	1	-	-
NCA25	18	20	11	-	-
NCA27	-	-	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-
NCA30	-	-	-	-	-
Scenario – Civil and mechanical fitout					
NCA15	-	-	-	-	-
NCA16	-	-	-	-	-
NCA19	-	-	-	-	-
NCA20	-	-	-	-	-
NCA21	-	-	-	-	-
NCA23	-	-	-	-	-
NCA24	-	-	-	-	-
NCA25	-	-	-	-	-
NCA27	-	-	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
NCA30	-	-	-	-	-
Scenario – Site rehabilitation					
NCA15	-	-	-	-	-
NCA16	-	-	-	-	-
NCA19	-	-	-	-	-
NCA20	-	-	-	-	-
NCA21	-	-	-	-	-
NCA23	-	-	-	-	-
NCA24	-	-	-	-	-
NCA25	-	-	-	-	-
NCA27	-	-	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-
NCA30	-	-	-	-	-
Scenario – General construction activities					
NCA15	-	155	111	16	-
NCA16	-	121	40	-	-
NCA19	-	-	59	86	-
NCA20	1	-	99	118	42
NCA21	18	-	155	170	21
NCA23	-	-	215	5	-
NCA24	-	-	137	36	-
NCA25	33	-	42	58	53
NCA27	-	-	-	-	-
NCA28	-	-	48	-	-
NCA29	-	-	16	-	-
NCA30	-	-	108	7	8
Scenario – General activities C6					
NCA15	-	-	-	-	-
NCA16	-	-	-	-	-
NCA19	-	-	-	-	-
NCA20	-	-	-	-	-
NCA21	-	25	17	-	-
NCA23	-	2	-	-	-
NCA24	-	-	-	-	-
NCA25	-	-	-	-	-
NCA27	-	-	-	-	-
NCA28	-	-	-	-	-
NCA29	-	-	-	-	-
NCA30	-	-	-	-	-

Notes:

1. Refer to **section 4.6.2** for descriptions of the various additional mitigation measures

Consecutive construction impacts

The CNVG recognises that mitigation measures aimed at short term works may be less effective where longer term impacts are apparent and requires additional consideration of reasonable and feasible management measures to minimise impacts on the community.

When evaluating the extent of noise impacts within the Rozelle construction area, it is noted that this area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved and currently under construction CSELR Rozelle maintenance depot.

Previous and ongoing works in the Rozelle area are assumed to follow those outlined in the EIS for CSELR, generally consisting of the following activities:

- Maintenance activity
- Stockpiling
- Car parking
- Landscaping.

These type of activities therefore have general similarities with the works proposed for the M4-M5 Link and involve similar construction activities for both projects.

The indicative construction program for CSELR and M4-M5 Link are shown below in **Table 5-81**.

Table 5-81 Indicative construction program – Rozelle

Project	2016				2017				2018				2019				2020				2021				2022				2023			
	Q				Q				Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
CSELR																																
M4-M5 Link																																

Reference: Sydney Light Rail Project, Construction Noise and Vibration Impact Statement Works Rozelle Stabling Yard Report Number 610.14954 CNVIS R5, June 2016

The impacts discussed in this report (see **section 5.3**) consider the duration of the M4-M5 Link project in isolation, whereas the potential impacts from the identified consecutive projects are likely to be perceived to be longer for receivers near to Lilyfield Road (north) and Brenan Street (south). The short-term noise intensive works are generally associated with discrete activities which occur over a number of days or weeks in moving locations rather than throughout the entire project at fixed locations. Therefore, the focus of assessing consecutive impacts is to identify works activities which repeat (or are similar to other activities) over extended periods. The longer-term impacts associated with compound activity may continue between separate projects in the area and may appear to be of a similar nature to the community.

Excluding short-term works such as site establishment works and roadworks , receivers located within NCA15 and NCA16 are predicted to experience up to a 5 dBA exceedance of the project NMLs (in the night-time period) during construction of the M4-M5 Link project. While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to noise impacts from the construction of CSELR project. The likely impacted receivers are generally located at:

- Receivers adjoining Lilyfield Road between Justin Street and Ryan Street
- Receivers adjoining Brenan Street between Starling Street and White Street.

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, if options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be considered when preparing the site specific CNVIS for this area. Feasible and reasonable considerations for providing at receiver treatments should include:

- Time of day of the impacts and exceedance of criteria
- Time of impacts at the affected receivers
- How long the mitigation will provide benefit to the receiver during the project
- Optimal design of acoustic sheds, noise barriers/hoarding and management measures to reduce the impacts as far as practicable.

The above discussion is also relevant to consecutive construction impacts from the Rozelle Rail Yards site management works, although it should be noted that these works are a significantly shorter in duration.

Due to the variability of construction noise, it is envisaged that community input through the consultation phase would provide appropriate information to assist the project to address potential consecutive noise impacts from construction projects in this area.

Mitigation spot-check

As described in **section 3.3**, additional background noise monitoring was carried out at locations setback within each NCA (ie not only at the nearest receiver location to the works). These locations (referred to as spot-checks) have been used to evaluate construction noise impacts away from the main works areas and assess the suitability of construction noise mitigation at receivers set back from the works (referred to as spot checks).

The following assessment predicts construction noise levels relative to the NMLs undertaken at the spot-check locations (see **Table 3-2**). This provides a bounded risk based approach to identifying feasible and reasonable noise mitigation and likely impacts for the NCA.

The key triggers at the spot-check locations that would require consideration of additional construction noise mitigation are the following:

- Check 1 – For daytime works, is the predicted level greater than 75 dBA (highly noise affected)
- Check 2 – For long term works outside of standard daytime construction hours, does the predicted level exceed the NML due to lower background noise levels at the spot check location
- Check 3 – For short duration works outside standard daytime construction hours, does the predicted level exceed the NML by more than 25 dBA due to lower background noise levels at the spot check location.

Predictions of the worst case construction noise levels per scenario (including in-situ mitigation) at the spot-check logger locations are presented in **Table 5-82**.

It is noted that the construction noise predictions at the spot-check locations take no account of shielding provided by fences outside of the road corridor (eg residential fences) and the noise levels may therefore considered conservative.

Table 5-82 Mitigation spot-check – Rozelle

Logger location	NCA	NMLS (day / day OOH / eve / night)	Worst case predicted construction noise level (per construction scenario)[1] $L_{Aeq(15minute)}$ (dBA)										Mitigation spot-check		
			Site establishment		Temporary road modification		Tunnelling and supporting works		Civil and mechanical fitout		Civil works		1 (Daytime >75 dBA)	2 Night (long-term works >NML[2]	3 Night (short-term works >NML + 25 dB)[3]
			Day	Night	Day	Night	Day	Night	Day	Night	Day	Night			
R.08	NCA23	59/ 54/ 50/ 41	51	-	49	49	46	36	43	-	49	46	-	-	-
R.10	NCA23	59/ 54/ 50/ 41	46	-	42	42	41	29	40	-	45	42	-	-	-
R.12	NCA19	64/ 59/ 57/ 49	56	-	52	52	51	39	50	-	52	50	-	-	-
R.13	NCA24	64/ 59/ 57/ 49	60	-	52	52	51	36	53	-	51	48	-	-	-
R.14	NCA20	54/ 49/ 47/ 40	60	-	56	56	53	43	57	-	59	58	-	**Y**	-

Notes:

1. Construction scenarios are inclusive of the works activities detailed in (ROZ-01 to ROZ-27) with the highest noise for a given period (day / night) reported
2. Long-term works are based on the tunnelling and supporting works scenario
3. Short-term works include site establishment, temporary road modifications and civil works (night)

The spot-checks indicate potential NML exceedances in NCA20 during long term works (ie during tunnelling and supporting works). This is consistent with the outcomes of the Rozelle construction noise assessment in **Table 5-80** which recommends noise mitigation measures for NCA20. The mitigation measures as previously outlined for NCA20 are therefore considered appropriate.

The impacts and mitigation would be refined in further detail during the development of the CNVMP and again following verification measurements of actual construction noise or in response to community concerns.

5.3.3 Construction road traffic noise

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-83**. The maximum daily flows have been used in the assessment in order to provide a conservative assessment.

Table 5-83 Construction traffic forecast – Rozelle

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C5 - Rozelle civil and tunnel site	517	350
C6 - The Crescent civil site	10	20
C7 - Victoria Road civil site	42	140
Proposed future Western Harbour tunnel site (cumulative impact assessment scenario only)	100	24

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-84** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-84 Construction road traffic noise assessment – Rozelle

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C5 - Rozelle civil and tunnel site	Heavy	City West Link	<0.5	0.5
	Light	Lilyfield Rd	<0.5	1.7
C6 - The Crescent civil site	Light & heavy	The Crescent	<0.5	<0.5
C7 - Victoria Road civil site	Light & heavy	Victoria Rd	<0.5	<0.5
Western Harbour tunnel site	Light & heavy	City West Link	<0.5	<0.5

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available

The information above indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should cover instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.3.4 Ground-borne noise

Predicted ground-borne noise levels

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is assessed in **section 5.7**.

Tunnelling works associated with the ventilation tunnels to the mainline tunnel alignment and access ramps in the Rozelle area have the potential to result in ground-borne noise impacts at the nearest sensitive receivers.

The ground-borne noise assessment is based on the worst case predicted L_{Aeq} internal ground-borne noise level when the tunnelling works are at their closest point below each sensitive receiver.

Table 5-85 summarises the maximum predicted ground-borne noise levels from road-header tunnelling works associated with the ventilation tunnels in the Rozelle area. Ground-borne noise contour maps are provided in **Annexure I**. The exceedances listed in **Table 5-85** assume that the tunnelling works will occur 24 hours a day, and therefore consider potential exceedances of the more stringent night-time ground-borne NMLs.

Table 5-85 Worst case predicted ground-borne noise levels during tunnelling – Rozelle ventilation tunnels

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA15	<20	-	-	-
NCA16	35	-	-	-
NCA17	-	-	-	-
NCA18	-	-	-	-
NCA19	41	36	-	-
NCA20	20	-	-	-
NCA21	24	-	-	-
NCA24	37	27	-	-
NCA25	28	-	-	-
NCA26	-	-	-	-

The worst case ground-borne noise levels are predicted to be compliant with the more stringent 35 dBA $L_{Aeq(15minute)}$ night-time criterion at the majority of sensitive receivers with the exception of 63 receivers located within NCA19 and NCA24.

In NCA19 and NCA24, where the ventilation tunnels are located beneath sensitive receivers, sensitive receivers above this section are predicted to be subject to ground-borne noise levels up to around 41 dBA $L_{Aeq(15minute)}$ in NCA19 and 37 dBA $L_{Aeq(15minute)}$ in NCA24, which exceeds the night-time criteria by 6 dBA and 2 dBA respectively.

Based on a progression rate of around 20 metres per week, the most affected sensitive receivers are likely to experience noise levels above the night-time criterion for up to around 16 days for each road-header.

While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

In the Rozelle area, there are several ventilation tunnels, mainline tunnels and access ramps which may be under construction simultaneously and/or consecutively. During simultaneous construction, ground-borne noise levels would be dominated by the closest road-header to the receiver, however, where multiple road-headers are operating at a similar distance from the receiver this may result in ground-borne noise impacts marginally higher than the predicted noise levels outlined in **Table 5-85**. Consecutive construction with road-headers would not increase the level of ground-borne noise but may increase the duration of impacts at any one receiver. Detailed scheduling of road-header works would be determined at a later design stage.

The ground-borne noise predictions are based on the nearest sensitive receivers above or adjacent to the proposed tunnel alignments. The ground-borne noise impacts would reduce for sensitive receivers offset horizontally from the access tunnel due to the increased slant distance.

Managing ground-borne noise impacts

Table 5-85 indicates that there are 63 residential receivers where ground-borne noise levels are predicted to exceed the night-time NMLs by up to 6 dB. With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works location, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NMLs, providing additional information when relevant and more specific information than covered in general letterbox drops.

5.3.5 Vibration

Estimated working distances and vibration intensive plant

The proposed works have been analysed to determine a best estimate of minimum working distances for the vibration intensive mechanical plant proposed for the construction activities. Proposed vibration intensive construction plant are listed in **Table 5-86** and compared to the minimum working distances listed in **Table 4-12** in order to determine potential vibration impacts of the main construction scenarios. Estimated minimum working distances for the site works are shown graphically in **Annexure J**.

See **section 5.2.1** for a discussion of indicative duration for the construction activities.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

Table 5-86 **Construction vibration assessment summary – Rozelle**

Work scenario	Vibration intensive equipment	NCA	Number of buildings within minimum working distance for highest vibration plant item			
			Cosmetic damage			Human response
			Residential and light commercial	Group 2 (typical)	Group 3 (structurally unsound)[1]	
Surface works – roadworks, demolition of existing buildings, construction of site buildings and works within the site	Bored piling Jackhammer Rock-breaker[2]	NCA15	-	-	-	1
		NCA16	1	3	-	13
		NCA17	-	1	-	2
		NCA18	-	-	6	-
		NCA19	11	15	-	51
		NCA20	-	-	-	21
		NCA21	22	22	6	78
		NCA23	-	-	1	1
		NCA24	6	15	2	67
		NCA25	49	60	-	100
		NCA26	7	8	1	10
		NCA27	-	-	-	1
Tunnelling works – ventilation tunnels to mainline tunnel alignment and access ramps	Road-header[2]	NCA15	-	-	-	-
		NCA16	-	-	-	-
		NCA17	-	-	-	-
		NCA18	-	-	-	-
		NCA19	-	-	-	-
		NCA20	-	-	-	-
		NCA21	-	-	-	-
		NCA23	-	-	-	-
		NCA24	-	-	-	-
		NCA25	-	-	-	-
		NCA26	-	-	-	-
		NCA27	-	-	-	-

Notes:

1. This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration (following inspection) to be confirmed during detailed design
2. Proposed highest vibration plant item for these works

Heritage listed buildings identified within the cosmetic damage minimum working distances are listed in **Table 5-87**.

Table 5-87 **Heritage listed items within cosmetic damage minimum working distance – Rozelle**

NCA	Item name[1]	Address[1]	Construction type[2]
NCA16, NCA19	Brennan's Estate Heritage Conservation Area	Rozelle	n/a
NCA18	Stormwater canal	Lilyfield Road, Rozelle	Stonework, brickwork, concrete

NCA	Item name[1]	Address[1]	Construction type[2]
NCA18	‘Cadden Le Messurier’	84 Lilyfield Road, Rozelle	Stonework, brickwork, concrete
NCA18	Former hotel	78 Lilyfield Road, Rozelle	Stonework, brickwork, concrete
NCA18	Sandstone Cutting	Former Rozelle Rail Yard - East	Sandstone
NCA18	Sandstone Cutting	Former Rozelle Rail Yard - West	Sandstone
NCA18, NCA20, NCA21	Whites Creek Stormwater Channel No 95	Railway Parade to Parramatta Road, Annandale	Stonework/concrete
NCA21	Annandale (Railway Parade) Railway Bridge	Railway Parade, Annandale	Steel structure
NCA21	Annandale Heritage Conservation Area	Annandale	n/a
NCA21	Avenue of *Phoenix canariensis*	Railway Parade, Annandale	n/a
NCA21	Street trees – row of palms	Railway Parade, Annandale	n/a
NCA21	Iron/sandstone palisade fence	Bayview Crescent, Annandale	Iron/sandstone
NCA21	Street trees – row of brush box	Bayview Crescent, Annandale	n/a
NCA23	Annandale (Johnston Street) Underbridge	Johnston Street, Annandale	Steel structure
NCA24	Easton Park	Denison Street, Rozelle	n/a
NCA24	Easton Park Heritage Conservation Area	Rozelle	n/a
NCA24	Sewage Pumping Station No 6 (SP0006)	Lilyfield Road, Rozelle	Brickwork
NCA25	Hornsey Street Heritage Conservation Area	Rozelle	n/a
NCA26	White Bay Power Station	Victoria Road, Rozelle	Brickwork, steelwork, concrete

Notes:

1. List of Heritage items extracted from **Appendix U** (Technical working paper: Non-Aboriginal heritage)
2. Estimated from photographic information and should be confirmed onsite

The construction type classifications and structural integrity of all the listed heritage items should be confirmed at detailed design by a suitably qualified structural engineer. This information can then be used to verify the applicable vibration criteria and associated impacts.

Cosmetic damage assessment summary

The separation distance(s) between the proposed works and the nearest receivers would generally be sufficient so that nearby buildings are unlikely to suffer ‘cosmetic damage’ for most of the proposed construction equipment. However, based on the arrangement of the work zones, some items of construction equipment have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Construction with large rock-breakers has the potential to generate some of the most significant construction vibration impacts due to the vibration intensive characteristics of this plant item.

The assessment presented in **Table 5-86** indicates that during surface works, up to 124 buildings in the vicinity of the works may be within the minimum working distances should a large rock-breaker be used at the outer extents of the Rozelle civil and tunnel site. In practice, it is unlikely that a rock-breaker would be required at all areas and therefore the vibration impacts presented in this assessment should be considered a worst case. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Human comfort vibration assessment summary

The assessment presented in **Table 5-86** indicates the proposed surface works using a large rock-breaker may result in a significant number of receivers (around 345) within the nominated minimum working distance for human comfort vibration.

In relation to human comfort (response), the minimum working distances in **Table 4-12** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are permitted, as discussed in BS 6472-1.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers and other high vibration plant items. In practice vibration impacts from most construction activities would be intermittent within the duration of the project. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Cumulative vibration impacts

Due to the intermittent nature of construction works, vibration impacts due to multiple works scenarios are considered unlikely to result in concurrent vibration peaks, but rather, may increase the effective duration of the exposure to vibration. Vibration impacts due to multiple simultaneous works would therefore be managed in the same manner as for single works scenarios (dependant on the operating equipment).

Managing vibration impacts

Table 5-86 indicates that, as discussed above, there are around 345 receivers within the nominated minimum working distance for human comfort vibration. With reference to the CNVG vibration mitigation measures outlined in **Table 4-16**, vibration intensive works at the Rozelle civil and tunnel site are proposed only during standard construction hours. The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path/equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

Vibration trials and/or attended vibration monitoring or should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria. Building condition surveys should also be completed both before and after the works at any potentially affected properties to identify existing damage and any project related damage. At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.4 Iron Cove

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed in the Iron Cove area.

5.4.1 Works description

The Iron Cove Link civil site (C8) would be located on Victoria Road, east of the Iron Cove Bridge, between Byrnes Street and Springside Street. The site would support the construction of the Iron Cove Link and would include the following:

- Temporary site offices
- Workshop and storage facilities
- Laydown area
- Temporary substation
- Water treatment plant
- Car parking
- Construction of twin declines and associated cut and cover structures
- Demolition of acquired properties along Victoria Road
- Ventilation facility.

Heavy vehicle access to the site will be directly onto Victoria Road. Heavy vehicles will turn left after exiting the site and head west over the Iron Cove Bridge. All tunnel spoil from the Iron Cove Link will be loaded via the Rozelle civil and tunnel site. Construction activities would change the configuration of streets which currently access Victoria Road between Byrnes Street and Springside Street. **Figure 5-23** provides an indicative site layout map for the Iron Cove Link civil site (C8).

Figure 5-23 Indicative site layout – Iron Cove

Works schedule

Subject to planning approval, construction at the Iron Cove Link civil site is planned to start in the fourth quarter of 2018, with completion planned for the end of 2023. The total duration of construction works is expected to be around five years. The indicative construction program for the Iron Cove Link civil site is shown in **Table 5-88**.

Table 5-88 Indicative construction program and duration – Iron Cove Link

Activity	2018				2019				2020				2021				2022				2023			
	Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment and utility works				■	■	■	■	■	■	■	■	■												
Traffic diversions and intersection works						■	■	■																
Construction of cut-and-cover and tunnel portals									■	■	■	■	■	■	■	■	■	■	■	■				
Construction of motorway operational infrastructure									■	■	■	■	■	■	■	■	■	■	■	■				
Site rehabilitation and landscaping																			■	■	■			
Testing and commissioning																			■	■	■	■	■	

Construction activities

A number of scenarios have been developed to assess potential impacts associated with construction works at Iron Cove. **Table 5-89** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-89 Construction activities and period of operation – Iron Cove

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2,3]			
				Day	Day 00H	Eve	Night
Site establishment works	ICL-01	24	Demolition of existing buildings	✓			
	ICL-02	1	Site Clearing	✓			
	ICL-03	1	Installation of environmental controls	✓			
	ICL-04	104	Utility works[4]	✓	✓	✓	✓
	ICL-05	2	Pavement and infrastructure works	✓	✓	✓	✓
	ICL-06	1	Establishment of construction facilities	✓			
General compound operation	ICL-07	144	Onsite car parking	✓			
	ICL-08	144	Worksite deliveries maintenance and storage	✓			
	ICL-09	144	Supporting infrastructure	✓	✓	✓	✓
Construction	ICL-10	84	Piling	✓			
	ICL-11	84	Earthworks general and drainage	✓			
	ICL-12	84	Concrete works	✓	✓	✓	✓
	ICL-13	104	Roadworks	✓	✓	✓	✓
	ICL-14	144	Ventilation station and substation	✓			
Site rehabilitation	ICL-15	12	Site rehabilitation	✓			

Notes:

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for pavement infrastructure works and utility works. Pavement and infrastructure works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds. Utility works represent adjustments to utility services within the compound footprint. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday,
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays
4. The utility works activity represents utility works required within the footprint of the proposed construction facilities. Utility works that may be required outside of the project footprint are discussed in **section 5.8**

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations is provided in **Table 5-90**.

Table 5-90 Activities assessed for cumulative construction noise – Iron Cove

Cumulative ID	Activity works ID	Activity	Comment	Period of works
ICL-16	ICL-07	Onsite car parking	A cumulative assessment has been included for the concurrent activities associated the compound operation scenario	Day
	ICL-08	Workshop, deliveries, maintenance, and storage		
	ICL-09	Supporting infrastructure		

5.4.2 Airborne noise

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs for the works are outlined in **Table 5-91**.

Table 5-91 Residential NMLs for the project – Iron Cove

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime Period	Daytime Period	Evening Period	Night Period	
NCA30	R.03	Residential	71	66	65	49	59
NCA31	I.02	Residential	73	68	63	48	58
NCA32	I.03	Residential	73	68	63	48	58
NCA33	I.01	Residential	54	49	45	36	46
NCA34	I.01	Residential	75	70	65	51	61
NCA35	I.01	Residential	75	70	65	51	61
NCA36	I.03	Residential	54	49	45	36	46
NCA38	AS2107	Residential	55	50	45	40	50

Notes:

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship the NMLs presented in **section 4.1.2** are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment included in the modelling are listed in **Table 5-92**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Works within the tunnel are assessed in the ground-borne noise assessment in **section 5.7.1**.

Table 5-92 Sound power levels for construction equipment – Iron Cove

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2] LWA Item	LWA Activity[4]	LWAmax Activity
Site establishment works	ICL-01	Demolition of existing buildings	Diamond saw[1]	1	120	122	124
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	ICL-02	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	ICL-03	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	ICL-04	Utility works	Concrete saw[1]	1	120	117	123
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)	1	100		
	ICL-05	Pavement and infrastructure works	Truck	1	98	116	123
			Concrete saw[1]	1	120		
			Grader	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Back hoe	1	102		
	ICL-06	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
General site operations	ICL-07	Onsite car parking	Car parking	3	73	97	105
			Water pump	1	97		
	ICL-08	Workshop, deliveries, maintenance, and storage	Truck	1	98	104	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	ICL-09	Supporting infrastructure	Water treatment plant[2,3]	1	82	82	98

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
Construction	ICL-10	Piling	Piling rig (bored)	1	108	113	118
			Mobile crane	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Concrete truck/agitator	1	106		
	ICL-11	Earthworks general and drainage	Back hoe	1	102	116	116
			Excavator	1	109		
			Bobcat	1	104		
			Truck	1	98		
			Dozer	1	110		
			Grader	1	108		
			Generator (small)	1	95		
			Vibratory roller	1	109		
			Water tanker	1	98		
	ICL-12	Concrete works	Concrete pump	1	106	111	115
			Concrete truck/agitator	1	106		
			Truck	1	98		
			Excavator	1	109		
	ICL-13	Roadworks	Slip form machine	1	102	113	115
			Bitumen spray truck	1	100		
			Roller (non-vibratory)	1	100		
			Grader	1	108		
			Concrete truck/agitator	1	106		
			Paving machine	1	104		
			Water tanker	1	98		
			Back hoe	1	102		
			Truck	1	98		
			Line marking plant	1	98		
	ICL-14	Ventilation station and substation	Mobile crane	1	101	107	112
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
Site rehabilitation and landscape	ICL-15	Site rehabilitation and landscape	Hand tools	1	94	104	111
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facilities of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-93** to **Table 5-97** for residential, commercial and other sensitive receivers. The noise levels are representative of the worst case impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) to the relevant NMLs and a summary of the impact assessment are presented in detail in **Annexure F-4**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs	– impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs	– impacts would typically be moderate
Noise levels >20 dBA above NMLs	– impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-98.** The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-4**.

Table 5-93 Predicted worst case noise levels – Iron Cove – residential daytime

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]															
		ICL-01	ICL-02	ICL-03	ICL-04	ICL-05	ICL-06	ICL-07	ICL-08	ICL-09	ICL-10	ICL-11	ICL-12	ICL-13	ICL-14	ICL-15	ICL-16
Residential - Standard Daytime																	
NCA30	71	56	47	42	51	50	48	30	38	<30	46	49	50	52	41	38	39
NCA31	73	60	51	46	55	54	52	33	42	<30	50	55	60	62	46	42	43
NCA32	73	67	58	53	62	61	59	38	49	32	54	59	80	82	52	49	49
NCA33	54	87	78	73	82	81	79	55	69	52	67	72	75	77	71	69	69
NCA34	75	75	66	61	70	69	67	43	57	38	64	69	69	71	60	57	57
NCA35	75	80	71	66	75	74	72	52	59	35	75	80	75	77	64	62	60
NCA36	54	91	82	77	86	85	83	66	73	31	73	84	79	81	54	73	74
NCA37	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
NCA38	55	57	49	44	53	52	50	31	39	<30	48	53	48	50	37	40	40

Notes:

1: Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-94 Predicted worst case noise levels – Iron Cove – residential evening

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]															
		ICL-01	ICL-02	ICL-03	ICL-04	ICL-05	ICL-06	ICL-07	ICL-08	ICL-09	ICL-10	ICL-11	ICL-12	ICL-13	ICL-14	ICL-15	ICL-16
Residential - Evening																	
NCA30	65	-	-	-	51	50	-	-	-	<30	-	-	50	52	-	-	-
NCA31	63	-	-	-	55	54	-	-	-	<30	-	-	60	62	-	-	-
NCA32	63	-	-	-	62	61	-	-	-	32	-	-	80	82	-	-	-
NCA33	45	-	-	-	82	81	-	-	-	52	-	-	75	77	-	-	-
NCA34	65	-	-	-	70	69	-	-	-	38	-	-	69	71	-	-	-
NCA35	65	-	-	-	75	74	-	-	-	35	-	-	75	77	-	-	-
NCA36	45	-	-	-	86	85	-	-	-	31	-	-	79	81	-	-	-
NCA37	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
NCA38	45	-	-	-	53	52	-	-	-	<30	-	-	48	50	-	-	-

Notes:

1: Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-95 Predicted worst case noise levels – Iron Cove – residential night-time

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]															
		ICL-01	ICL-02	ICL-03	ICL-04	ICL-05	ICL-06	ICL-07	ICL-08	ICL-09	ICL-10	ICL-11	ICL-12	ICL-13	ICL-14	ICL-15	ICL-16
Residential - Night-time																	
NCA30	49	-	-	-	51	50	-	-	-	<30	-	-	50	52	-	-	-
NCA31	48	-	-	-	55	54	-	-	-	<30	-	-	60	62	-	-	-
NCA32	48	-	-	-	62	61	-	-	-	32	-	-	80	82	-	-	-
NCA33	36	-	-	-	82	81	-	-	-	52	-	-	75	77	-	-	-
NCA34	51	-	-	-	70	69	-	-	-	38	-	-	69	71	-	-	-
NCA35	51	-	-	-	75	74	-	-	-	35	-	-	75	77	-	-	-
NCA36	36	-	-	-	86	85	-	-	-	31	-	-	79	81	-	-	-
NCA37	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
NCA38	40	-	-	-	53	52	-	-	-	<30	-	-	48	50	-	-	-

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-96 Predicted worst case noise levels – Iron Cove – commercial

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]															
		ICL-01	ICL-02	ICL-03	ICL-04	ICL-05	ICL-06	ICL-07	ICL-08	ICL-09	ICL-10	ICL-11	ICL-12	ICL-13	ICL-14	ICL-15	ICL-16
Commercial																	
NCA30	70	56	47	42	51	50	48	30	38	<30	46	51	54	56	42	38	39
NCA31	70	64	55	50	59	58	56	34	46	30	51	57	79	81	49	46	46
NCA32	70	62	53	48	57	56	54	34	44	<30	50	55	79	81	47	44	44
NCA33	70	84	75	70	79	78	76	39	66	43	56	64	79	81	69	66	66
NCA34	70	81	72	67	76	75	73	45	63	45	69	82	77	79	73	63	63
NCA35	70	63	54	49	58	57	55	30	45	<30	50	56	51	53	45	45	45
NCA36	70	62	53	48	57	56	54	37	44	<30	50	53	48	50	41	44	45
NCA37	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA38	70	55	46	41	50	49	47	30	37	<30	45	49	45	47	34	37	38

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-97 Predicted worst case noise levels – Iron Cove – other sensitive receivers

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]															
		ICL-01	ICL-02	ICL-03	ICL-04	ICL-05	ICL-06	ICL-07	ICL-08	ICL-09	ICL-10	ICL-11	ICL-12	ICL-13	ICL-14	ICL-15	ICL-16
Other Sensitive																	
NCA30	-	55	46	41	50	49	47	<30	37	<30	46	48	50	52	39	37	38
NCA31	-	64	55	50	59	58	56	35	46	<30	53	58	73	75	49	46	46
NCA32	-	60	51	46	55	54	52	34	42	<30	50	53	50	52	45	42	43
NCA33	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
NCA34	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
NCA35	-	45	36	31	40	39	37	<30	<30	<30	33	39	36	38	<30	<30	<30
NCA36	-	59	50	45	54	53	51	34	41	<30	47	52	47	49	43	41	42
NCA37	-	60	51	46	55	54	52	35	42	<30	51	55	50	52	45	42	43
NCA38	-	74	70	65	74	73	71	38	56	<30	60	73	77	79	45	61	56

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected "other sensitive" receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for "other sensitive receivers as result of the various types of "other sensitive" receivers within each NCA which may be affected by different activities

Table 5-98 Overview of NML exceedances – Iron Cove

Activity ID	Activity	Weeks [1]	Activity duration within overall project program [2] %				Number of receivers																
							Total	Highly noise affected [4]	NML exceedance receiver count [3]														
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep Disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
ICL-01	Demolition of existing buildings	24					1456	53	149	57	34	-	-	-	-	-	-	-	-	-			
ICL-02	Site clearing	1					1456	8	75	31	8	-	-	-	-	-	-	-	-	-			
ICL-03	Installation of environmental controls	1					1456	2	44	19	2	-	-	-	-	-	-	-	-	-			
ICL-04	Utility works	104					1456	17	111	46	15	126	61	36	111	91	55	273	107	146	251	81	157
ICL-05	Pavement and infrastructure works	2					1456	14	102	42	14	122	56	33	116	83	49	270	116	124	251	81	157
ICL-06	Establishment of construction facilities	1					1456	10	79	35	10	-	-	-	-	-	-	-	-	-			
ICL-07	On site car parking	144					1456	-	4	1	-	-	-	-	-	-	-	-	-	-			
ICL-08	Worksite deliveries maintenance and storage	144					1456	-	32	10	-	-	-	-	-	-	-	-	-	-			
ICL-09	Supporting infrastructure	144					1456	-	-	-	-	1	-	-	4	-	-	15	3	-	22	12	1
ICL-10	Piling	84					1456	4	49	9	-	-	-	-	-	-	-	-	-	-			
ICL-11	Earthworks general and drainage	84					1456	22	119	38	3	-	-	-	-	-	-	-	-	-			
ICL-12	Concrete works	84					1456	8	92	17	4	143	51	5	140	68	15	158	149	87	85	140	75
ICL-13	Roadworks	104					1456	22	119	29	5	154	64	10	124	89	24	221	133	111	85	140	75
ICL-14	Ventilation station and substation	144					1456	-	27	4	-	-	-	-	-	-	-	-	-	-			
ICL-15	Site rehabilitation	12					1456	-	35	10	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-16	Cumulative	144					1456	-	32	10	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes;

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas.
2. Approximate percentage (to nearest 25%) of activity duration within overall proposal program. Where percentage is less than 25%, 25% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables show that:

- The highest noise levels and NML exceedances are predicted during works demolition of existing buildings (ICL-01), which requires use of a diamond saw and rock-breaker
- The largest impacts are predicted in NCA33 and NCA36, where receivers are situated in relatively close proximity to the works site
- Moderate NML exceedances are predicted for commercial receivers during ICL-01, ICL-11 and ICL-13 works.

NML exceedances

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-4**.

Table 5-93 shows that the activity with the potential for the highest exceedance of NMLs in all time periods is the utility adjustment works (ICL-04). To minimise disturbances to local traffic there may be a requirement for these works to be conducted outside of standard construction hours. An assessment against out of hours NMLs has been included to provide guidance as to the extent of exceedances, although it should be noted that out of hours works are unlikely to be required for the entire duration of the activity.

A works activity comprises of a number of individual items of plant (see **Table 5-92**). Typically one item of plant will dominate the noise emissions from a particular works activity. The operation and location of the dominant item typically controls the level of noise emissions. For utility works (ICL-04) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA.

NML exceedances associated with the demolition of buildings and structures on acquired properties are predicted at a number of properties within the Iron Cove Link civil site. These exceedances are associated with the use of a rock-breaker and diamond saw. It is estimated that when these plant items are not in operation, NML exceedances would generally reduce by up to 10 dBA

NML exceedances of up to 20 dBA are predicted during the operation of the workshops, deliveries, maintenance, and storage areas (ICL-08). These exceedances are due to the operation of laydown areas, particularly within NCA33 and NCA36, where sensitive receivers adjoin the Iron Cove Link civil site. **Figure 5-24** shows that the distribution of exceedances for activity ICL-08 (day) for receivers within the Iron Cove Link civil site.

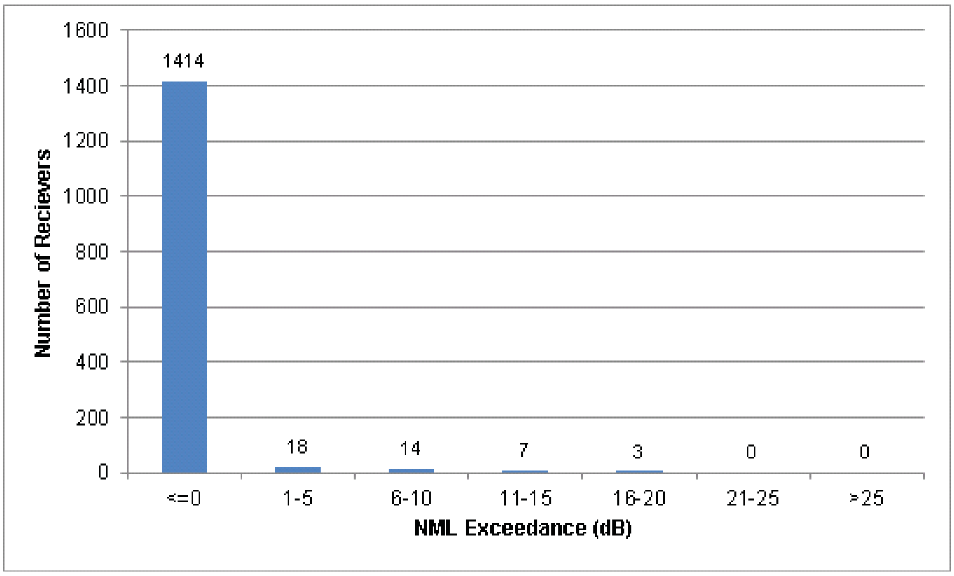


Figure 5-24 Activity ICL-08 noise level exceedance, daytime – Iron Cove

The above graph shows that while the worst case impacts may result in up to 20 dBA exceedance of the NMLs, this is limited to a small number of sensitive receivers and that the majority of sensitive receivers in this area would be subject to considerably lower noise levels.

The operation of laydown areas (ICL-08) forms part of the compound operations scenario, which occurs across the majority of the total works duration at Iron Cove. The extended duration of these works should be considered when evaluating mitigation and management measures.

The cumulative scenario (ICL-16), which includes the operation of all activities detailed in **Table 5-90**, results in exceedances of up to 20 dBA over the daytime NMLs. Predictions indicate that the cumulative scenario is dominated by worksite deliveries maintenance and storage (ICL-08) and as such by controlling the noise emissions of this activity, the overall noise emissions would be reduced.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of Highly Noise Affected receivers in the study area has been determined and is summarised in **Table 5-99**. The table shows the number of residential receivers separated by works activity.

Table 5-99 Predicted number of highly noise affected residential receivers by works – Iron Cove

Works	Activity	Period		
		Day	Eve	Night
ICL-01	Demolition of existing buildings	53	-	-
ICL-02	Site Clearing	8	-	-
ICL-03	Installation of environmental controls	2	-	-
ICL-04	Utility works	17	17	17
ICL-05	Pavement and infrastructure works	14	14	14
ICL-06	Establishment of construction facilities	10	-	-
ICL-07	On site car parking	-	-	-
ICL-08	Worksite deliveries maintenance and storage	-	-	-
ICL-09	Supporting infrastructure	-	-	-
ICL-10	Piling	4	-	-
ICL-11	Earthworks general and drainage	22	-	-
ICL-12	Concrete works	8	8	8

Works	Activity	Period		
		Day	Eve	Night
ICL-13	Roadworks	22	22	22
ICL-14	Ventilation station and substation	-	-	-
ICL-15	Site rehabilitation	-	-	-
ICL-16	Cumulative works scenario	-	-	-

The above table shows that receivers are predicted to be highly noise affected during certain works activities.

The location of the highly noise affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-25**.

Figure 5-25 Highly noise affected residential receivers – Iron Cove

The most impacted receivers are typically surrounding dwellings which have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-100**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-97** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-100 Overview of other sensitive receiver NML exceedances – Iron Cove

Works ID	Activity	Number of other sensitive receivers exceeding NMLs														
		Education			Medical			Place of Worship			Childcare			Outdoor Recreational		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
ICL-01	Demolition of existing buildings	2	-	-	-	-	-	1	-	-	5	-	-	1	1	-
ICL-02	Site Clearing	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
ICL-03	Installation of environmental controls	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ICL-04	Utility works	1	-	-	-	-	-	-	-	-	2	-	-	-	1	-
ICL-05	Pavement and infrastructure works	1	-	-	-	-	-	-	-	-	2	-	-	-	1	-
ICL-06	Establishment of construction facilities	1	-	-	-	-	-	-	-	-	1	-	-	-	1	-
ICL-07	On site car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-08	Worksite deliveries maintenance and storage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-09	Supporting infrastructure	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-10	Piling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-11	Earthworks general and drainage	1	-	-	-	-	-	-	-	-	2	-	-	1	1	-
ICL-12	Concrete works	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
ICL-13	Roadworks	-	1	-	-	-	-	1	-	-	-	-	-	-	2	-
ICL-14	Ventilation station and substation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ICL-15	Site rehabilitation	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ICL-16	Cumulative works scenario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The above table shows the following:

- Other sensitive receivers are generally predicted to be subject to relatively minor noise impacts during the daytime with no exceedances of greater than 20 dBA
- One educational facility in this area would be subject to worst case exceedances of 11 to 20 **dBA** above NMLs during the higher noise generating activities. This receiver is Rozelle Public School, located at 663 Darling St, Rozelle (within NCA31).

The recommended 'standard' and 'additional' noise mitigation as discussed in **section 4.6**, along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-4**.

NCA30

A small number of NML exceedances of up to 5 dBA are predicted during out of hours works associated with onsite car parking, workshop, deliveries, maintenance, and storage, and roadworks (ICL-04, ICL-05 and ICL-13) in this catchment. Exceedances are generally experienced by receivers which adjoin Victoria Road and are attributed to pavement works and utility and roadworks which may be required to be carried out outside of standard construction hours.

NCA31 and NCA32

NCA31 and NCA32 are predicted to experience a similar level of NML exceedance from common sources within the Iron Cove Link civil site. The discussion of impacts for these NCAs has been grouped together below.

- Pavement and infrastructure works, utility works, concrete works and roadworks (ICL-04, ICL-05, ICL-12 and ICL-13) are identified as having the greatest number of exceedances in all time periods. Exceedances are generally experienced by sensitive receivers which adjoin Victoria Road and are attributed to the potential use of noise intensive items of plant such as concrete saws
- Demolition of acquired properties (ICL-01) is predicted to exceed daytime NMLs by up to 10 dBA at 16 receivers. Exceedances are generally experienced by “other sensitive” receivers which adjoin Victoria Road and are attributed to the potential use of rock-breakers and diamond saws.

NCA33 and NCA36

Receivers within NCA33 and NCA36 are likely to experience the greatest noise impacts during construction works at Iron Cove. This is due to their proximity to the works area along with the removal of adjoining structures which currently provide shielding from a high traffic noise environment. It is recommended that where feasible and reasonable, operational road traffic mitigation should be installed early on in the construction phase, if required. Additionally, when considering possible management and mitigation measures for these receivers, it is important to take into account the duration of the total works as it is likely that these receivers will be exposed to construction impacts for an extended period. The discussion of impacts for these NCAs has been grouped together below.

Demolition of acquired properties (ICL-01) is identified as having the greatest number of exceedances during the day period. The highest exceedances are generally experienced by receivers which adjoin properties that are proposed for demolition **Figure 5-26** shows the distribution of exceedances for activity ICL-01 during the day for receivers within NCA33 and NCA36.

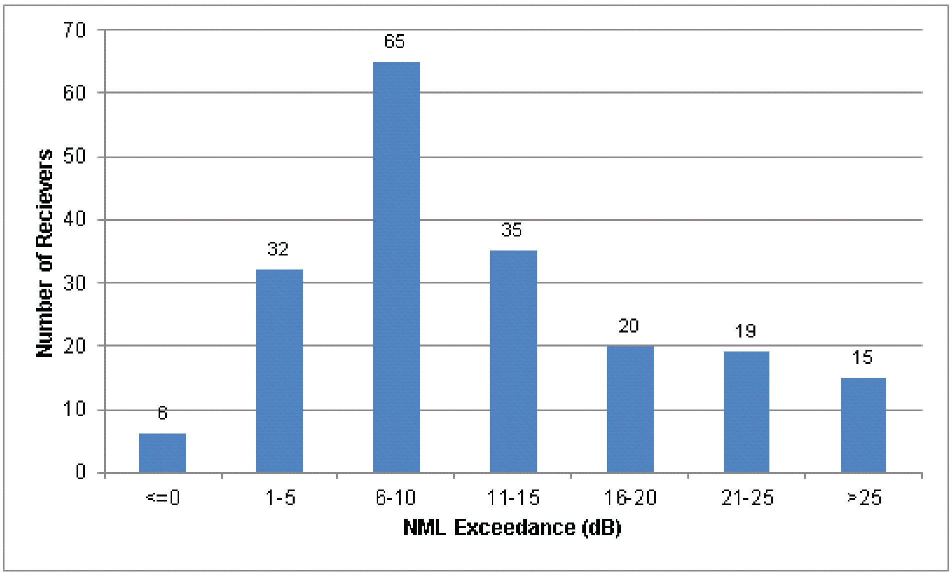


Figure 5-26 Activity ICL-01 noise level exceedance, daytime – Iron Cove

The above graph shows that while the worst case impacts may result in greater than 25 dBA exceedance of the NMLs, this is seen to be limited to a small number of receivers. Exceedances are typically attributed to the use of excavators (rock-breakers) and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to 24 weeks. The likely duration of the highest predicted noise levels will correspond to the length of time that the works are located at the closest position to receivers and is dependent on the rate of progress of the works.

- Pavement and infrastructure works, utility works, concrete works and roadworks (ICL-04, ICL-05, ICL-12 and ICL-13) are identified as having the greatest number of exceedances in all time periods. Exceedances are generally at receivers which adjoin Victoria Road. The operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA

- Noise from the operation of supporting infrastructure (ICL-09), which is required to facilitate the tunnelling of the Iron Cove Link, is predicted to exceed the night time NMLs within NCA33 and NCA36 by up to 20 dBA at 18 receivers. Supporting infrastructure includes substations and water treatment plant and would be required to operate 24 hours a day. Mitigation measures should focus on source control of these plant items, which may include measures such as localised barriers, equipment selection and location where feasible
- The cumulative scenario (ICL-16) is predicted to result in exceedances of up to 20 dBA at 42 receivers. Of the 42 receivers expected to experience exceedances of the night time NMLs, 32 are predicted experience exceedances of less than 10 dBA. As identified previously, exceedances arising from the cumulative works scenario are dominated by worksite deliveries maintenance and storage (ICL-08). By controlling noise emissions from this work activity the exceedances of the overall cumulative assessment would be reduced.

NCA34

- Pavement and infrastructure works, utility works, concrete works and roadworks (ICL-04, ICL-05, ICL-12 and ICL-13) are identified as having the greatest number of exceedances in all time periods. Exceedances are generally experienced by receivers which adjoin Victoria Road and are attributed to the use of noise intensive items of plant such as concrete saws
- Demolition of acquired properties (ICL-01) is predicted to exceed daytime NMLs by up to 15 dBA at five receivers. Exceedances are generally at commercial receivers which adjoin Victoria Road and are attributed to the use of rock-breakers and diamond saws.

NCA35

- Pavement and infrastructure works, utility works, concrete works and roadworks (ICL-04, ICL-05, ICL-12 and ICL-13) are identified as having the greatest number of exceedances in all time periods. The operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA
- Demolition of acquired properties (ICL-01) is predicted to exceed daytime NMLs by up to 5 dBA at 17 receivers. Exceedances are generally attributed to the use of rock-breakers and diamond saws.

Note that NCA35 contains a number of multistorey buildings which overlook the Iron Cove Link civil site. The existing acoustic environment for receivers adjacent to Victoria Road is dominated by traffic noise (see **section 3.6**) and may change depending on the finalised requirements for traffic management.

NCA38

Pavement and infrastructure works, utility works, concrete works and roadworks (ICL-04, ICL-05, ICL-12 and ICL-13) are identified as having the greatest number of exceedances in all time periods Exceedances are generally experienced by receivers that overlook the Iron Cove Bridge and are attributed to the use of noise intensive items of plant such as concrete saws.

Sleep disturbance

The predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-4** show that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project-specific mitigation measures (in addition to the standard suite of measures shown in **Table 4-13**) are summarised in **Table 5-101**

Table 5-101 Recommended site specific noise mitigation measures – Iron Cove

Activity	Mitigation description	Reason	Recommendations
ICL-04 ICL-05 ICL-13	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	The assessment has identified a number of activities which have the potential for impacts. These activities typically involve the use of one noise intensive item of plant (i.e. concrete saw) which intern dominates the exceedance.	Limit the use of the concrete saw during out of hour's works where feasible. Use mobile acoustic hoarding around smaller items to minimise noise.
Activities within the Iron Cove civil site	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified for works conducted within the site.	Investigate locations where hoarding (>2m) can be utilised to control source emissions. Localised hoarding should be also investigated for ICL-09 in addition to the boundary hoarding. This should be investigated in detailed design along with reducing the sound power level (SWL) of the equipment to mitigate residual impacts following the increase in site hoarding.
	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite.		
	Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.		

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-4**.

All site hoarding as shown in **Figure 5-25** has been investigated at a height of four metres.

Table 5-102 provides the predicted distribution of exceedances both 'with' and 'without' the recommended mitigation (increased site hoarding) for receivers within this study area.

Table 5-102 NML exceedance distribution with and without mitigation – Iron Cove

Activity ID	Activity	Time period	Number of receivers with NML exceedance					
			Without Mitigation			With Mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
ICL-01	Demolition of existing buildings	Day	149	57	34	164	48	15
ICL-02	Site Clearing	Day	75	31	8	62	17	3
ICL-03	Installation of environmental controls	Day	44	19	2	43	5	1
ICL-09	Supporting Infrastructure	Night	15	3	-	10	-	-

Table 5-102 indicates that with the inclusion of in-situ mitigation measures in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure G** and are representative of the max predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. Detailed in **Table 5-103,** the counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures.

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure H**.

Table 5-103 CNVG additional noise mitigation counts – Iron Cove

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment works					
NCA30	-	18	4	-	-
NCA31	-	51	62	-	-
NCA32	41	-	20	77	34
NCA33	-	2	28	9	-
NCA34	-	13	17	26	-
NCA35	26	-	-	29	25
NCA36	-	-	-	-	-
NCA38	-	74	37	-	-
Scenario – General site operations					
NCA30	-	-	-	-	-
NCA31	-	-	-	-	-
NCA32	-	-	-	-	-
NCA33	-	9	1	-	-
NCA34	-	-	-	-	-
NCA35	-	-	-	-	-
NCA36	3	-	-	-	-
NCA38	-	-	-	-	-
Scenario – Construction					
NCA30	-	5	-	-	-
NCA31	-	23	2	-	-
NCA32	-	71	20	2	3
NCA33	10	-	29	86	16
NCA34	-	5	28	8	-
NCA35	-	11	14	23	1
NCA36	14	-	9	31	14
NCA38	-	-	-	-	-
Scenario – Site rehabilitation					
NCA30	-	-	-	-	-
NCA31	-	-	-	-	-
NCA32	-	-	-	-	-
NCA33	-	-	-	-	-
NCA34	-	-	-	-	-
NCA35	-	-	-	-	-
NCA36	3	-	-	-	-
NCA38	-	-	-	-	-

Notes:
1: Refer to **section 4.6** for descriptions of the various additional mitigation measures

5.4.3 Construction road traffic noise

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-104**. The maximum daily flows have been used in the assessment in order to provide a conservative assessment.

Table 5-104 Construction traffic forecast – Iron Cove

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C8 - Iron Cove Link civil site	42	140

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-105** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-105 Construction road traffic noise assessment – Iron Cove

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C8 - Iron Cove Link civil site	Light & heavy	Victoria Rd	<0.5	<0.5

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available

The information above indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should cover instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Local road changes

Temporary changes to the local road network would be required to enable construction of the project and the operation of the Iron Cove Link civil site during construction. The Clubb Street / Victoria Road intersection would be permanently closed before the start of construction. The Toelle Street and Callan Street intersections with Victoria Road would generally remain open during construction.

There would be instances where these intersections would be closed temporarily to construct the project, however these works would be short term and would be conducted during non-peak times. Consideration would also be given to the peak periods of use of King George Park when considering temporary closures. When construction is complete, these intersections would be reopened in the same arrangement as existing (ie left-in, left-out).

Further detail on the temporary and permanent changes to the surface road network around the Iron Cove Link civil site are provided in the EIS.

As discussed in **section 4.3**, noise mitigation would be required to be considered where existing road traffic noise levels are predicted to increase by more than 2 dBA.

Impacts from temporary road changes would be assessed during detailed design, when further information regarding the required closures is available.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network

- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.4.4 Ground-borne noise

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

The nature of the construction works at the Iron Cove civil site (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

5.4.5 Vibration

Estimated working distances and vibration intensive plant

The proposed works have been analysed to determine best estimate of minimum working distances for the vibration intensive mechanical plant proposed for the construction activities. Proposed vibration intensive construction plant are listed in **Table 5-106** and compared to the minimum working distances listed in **Table 4-12** in order to determine potential vibration impacts of the main construction scenarios. Estimated minimum working distances for the site works are shown graphically in **Annexure J**.

Refer to **section 5.2.1** for a discussion of indicative duration for the construction activities.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

Table 5-106 Construction vibration assessment summary – Iron Cove

Work scenario	Vibration intensive equipment	NCA	Number of buildings within minimum working distance for highest vibration plant item			
			Cosmetic damage			Human response
			Residential and light commercial	Group 2 (typical)	Group 3 (structurally unsound)[1]	
Surface works – roadworks, demolition of existing buildings, construction of site buildings and works within the site	Bored piling Jackhammer Rock-breaker[2]	NCA31	-	-	-	-
		NCA32	-	-	-	-
		NCA33	23	29	-	62
		NCA34	1	1	-	16
		NCA35	11	15	-	29
		NCA38	-	-	-	-

Notes:

1. This identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration (following inspection) to be confirmed during detailed design
2. Proposed highest vibration plant item for these works

Cosmetic damage assessment summary

The separation distance(s) between the proposed works and the nearest sensitive receivers would generally be sufficient so that nearby buildings are unlikely to suffer 'cosmetic damage' for most of the proposed construction equipment. However, based on the arrangement of the work zones, some items of construction equipment have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Construction with large rock-breakers has the potential to generate some of the most significant construction vibration impacts due to the high vibration characteristics of the plant.

The assessment presented in **Table 5-106** indicates that during surface works, up to 45 buildings in the vicinity of the works may be within the minimum working distances should a large rock-breaker be used at the outer extents of the Iron Cove Link civil site. In practice, it is unlikely that a rock-breaker would be required at all areas and therefore the vibration impacts presented in this assessment should be considered a worst case scenario. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Human comfort vibration assessment summary

The assessment presented in **Table 5-106** indicates the proposed surface works using a large rock-breaker may result in a significant number of receivers (around 107 receivers in the vicinity) within the nominated minimum working distance for human comfort vibration.

In relation to human comfort (response), the minimum working distances in **Table 4-12** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are permitted, as discussed in BS 6472-1.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers and other high vibration plant items. In practice vibration impacts from most construction activities would be intermittent within the duration of the project. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Cumulative vibration impacts

Due to the intermittent nature of construction works, vibration impacts due to multiple works scenarios are considered unlikely to result in concurrent vibration peaks, but rather, may increase the effective duration of the exposure to vibration. Vibration impacts due to multiple simultaneous works would therefore be managed in the same manner as for single works scenarios (dependant on the operating equipment).

Managing vibration impacts

Table 5-106 indicates that, as discussed above, there are around 107 receivers within the nominated minimum working distance for human comfort vibration. With reference to the CNVG vibration mitigation measures outlined in **Table 4-16**, vibration intensive works at the Iron Cove Link civil site are proposed only during standard construction hours. The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path/equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

Vibration trials and/or attended vibration monitoring or should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria. Building condition surveys should also be completed both before and after the works at any potentially affected properties to identify existing damage and any project related damage. At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.5 Pyrmont Bridge Road

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed in the Pyrmont Bridge Road tunnel site (C9).

5.5.1 Works description

The Pyrmont Bridge Road tunnel site would be located at the intersection of Pyrmont Bridge Road and Parramatta Road, between Gordon Street and Mallet Street. The site currently comprises commercial properties. The construction site would not include the brewery on the west side of the site or the residential and commercial properties north-east of Bignell Lane. Access to the properties from Bignell Lane would be retained, which would be converted to a cul-de-sac for the duration of the works. An indicative construction layout is shown in **Figure 5-27**.

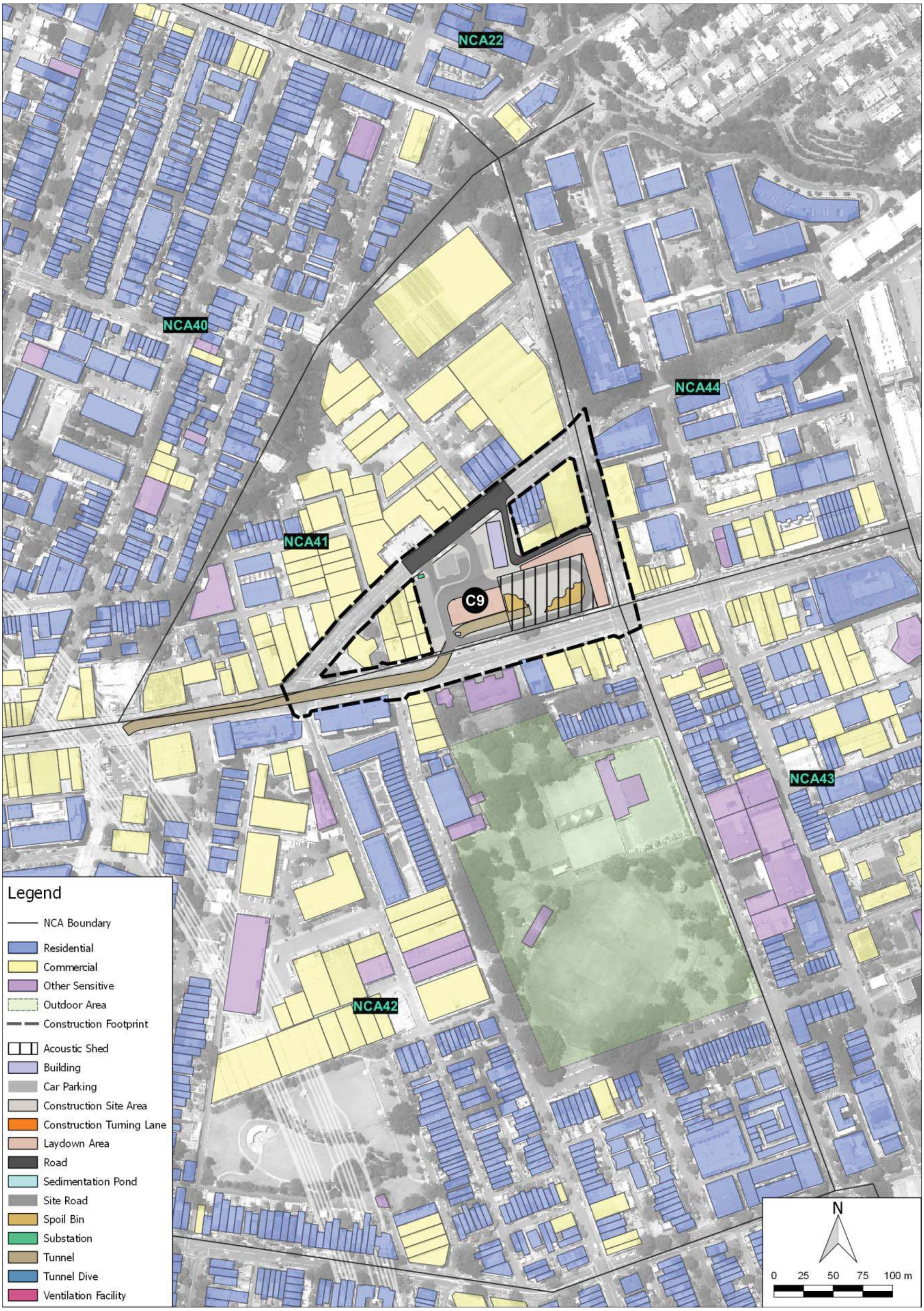


Figure 5-27 Indicative site layout – Pyrmont Bridge Road

The Pyrmont Bridge Road tunnel site would be the main mid-tunnel construction site along the eastern section of the M4-M5 Link. The site would include

- Workshop and storage facilities
- Laydown area
- Entry and exit point for haulage of tunnel spoil
- Substation
- Ventilation plant
- Water treatment plant
- Car parking.

Road-headers would be launched from this site and will initially excavate the construction decline and then the mainline tunnels traveling in a northerly and southerly direction. An acoustic shed would be established on the site to minimise noise from out of hours tunnelling and spoil handling.

Heavy vehicle access to the site would be via Parramatta Road. Heavy vehicles would turn left to enter the site from the eastbound carriageway of Parramatta Road and a site access road will be constructed to take trucks directly into the acoustic shed. Heavy vehicle egress from the site would be via Pyrmont Bridge Road.

Works schedule

Subject to planning approval, construction at the Pyrmont Bridge Road tunnel site is planned to start in the third quarter of 2018, with completion planned for the end of 2022. The total period of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction program for the site is shown in **Table 5-107**

Table 5-107 Indicative construction program and duration – Pyrmont Bridge Road

Activity	2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Initial road works and traffic management			■																	
Site establishment and utility works			■	■	■															
Construction of temporary access tunnel				■	■	■														
Tunnelling						■	■	■	■	■	■	■	■							
Civil and mechanical fitout												■	■	■						
Testing and commissioning																■	■	■	■	
Site rehabilitation																			■	■

Construction activities

A number of scenarios have been developed to assess impacts associated with construction works at the Pyrmont Bridge Road tunnel site. **Table 5-108** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-108 Construction activities and period of operation – Pyrmont Bridge Road

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2,3] Day	Day OOH	Eve	Night
Site establishment works	PYR-01	8	Demolition of existing buildings	✓			
	PYR-02	1	Site clearing	✓			
	PYR-03	1	Utility works[4]	✓			
	PYR-04	1	Installation of environmental controls	✓			
	PYR-05	2	Pavement and infrastructure works	✓	✓	✓	✓
	PYR-06	6	Establishment of construction facilities	✓			
Tunnelling and supporting works	PYR-07	180	Onsite car parking	✓	✓	✓	✓
	PYR-08	180	Workshop, deliveries, maintenance, and storage	✓	✓	✓	✓
	PYR-09	48	Construction of tunnel shaft and declines (outside acoustic shed)	✓			
	PYR-10	72	Spoil handling inside acoustic shed	✓	✓	✓	✓
	PYR-11	72	Onsite truck movements	✓	✓	✓	✓
	PYR-12	72	Tunnelling support activities	✓	✓	✓	✓
Site rehabilitation and landscaping	PYR-13	12	Site rehabilitation and landscape	✓			

Notes:

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. An assessment against all time periods as defined by the ICNG has been included for pavement infrastructure works. Pavement and infrastructure works represent modifications to roads, kerbs and pedestrian pavements to facilitate access to the construction compounds. These works have the potential for out of hours activities as described in **section 4.2.2**, although it should be noted that these works would only be undertaken during out-of-hour periods where factors discussed in **section 4.2.2** are present
3. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday,
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays.
4. The utility works activity represents utility works required within the footprint of the proposed construction facilities. Utility works that may be required outside of the project footprint are discussed in **section 5.8**

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations is provided in **Table 5-109**.

Table 5-109 **Activities assessed for cumulative construction noise – Pyrmont Bridge Road**

Cumulative ID	Activity works ID	Activity	Comment	Period of works
PYR-14	PYR-07	Onsite car parking	Tunnelling works along with supporting activities	All Periods
	PYR-08	Workshop, deliveries, maintenance, and storage		
	PYR-10	Spoil handling within acoustic shed		
	PYR-11	Onsite truck movements		
	PYR-12	Tunnelling support activities		

5.5.2 Airborne noise

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works at the Pyrmont Bridge Road tunnel site are outlined in **Table 5-110**.

Table 5-110 **Residential NMLs for the project – Pyrmont Bridge Road**

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime Period	Daytime Period	Evening Period	Night Period	
NCA40	P.01	Residential	61	56	54	46	56
NCA41	P.01	Residential	61	56	54	46	56
NCA42	P.01	Residential	61	56	54	46	56
NCA43	P.01	Residential	61	56	54	46	56
NCA44	P.01	Residential	61	56	54	46	56

Notes:

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship, the NMLs presented in **section 4.1.2**, are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-111**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Potential ground-borne noise impacts from works within the tunnel are assessed in **section 5.7.1**.

Table 5-111 Sound power levels for construction equipment – Pyrmont Bridge Road

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2] LWA Item	LWA Activity[4]	LWAmax Activity
Site establishment works	PYR-01	Demolition of existing buildings	Diamond saw[1]	1	120	120	124
			Excavator (breaker)[1]	1	121		
			Excavator	1	109		
			Truck	1	98		
			Hand tools	1	94		
	PYR-02	Site clearing	Excavator	1	104	113	118
			Dozer	1	110		
			Grader	1	108		
			Dumper	1	95		
			Truck	1	98		
	PYR-03	Utility works	Concrete saw[1]	1	120	117	23
			Excavator	1	109		
			Suction truck	1	100		
			Truck	1	98		
			Bobcat	1	104		
			Roller (non-vibratory)	1	100		
	PYR-04	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	PYR-05	Pavement and infrastructure works	Truck (25t)	1	98	118	124
			Suction truck	1	100		
			Excavator (breaker)[1]	1	121		
			Excavator	1	94		
			Concrete pump	1	106		
	PYR-06	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1,2]		
					LWA		LWAmax
					Item	Activity[4]	Activity
Tunnelling and supporting works	PYR-07	Onsite car parking	Car parking	10	73	97	105
			Water pump	1	97		
	PYR-08	Workshop, deliveries, maintenance, and storage	Truck	1	98	103	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	PYR-09	Construction of tunnel shaft and declines (outside acoustic shed)	Piling rig (bored)	1	108	114	118
			Mobile crane	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Excavator	1	109		
			Concrete truck/agitator	1	106		
			Truck	1	98		
	PYR-10	Spoil handling inside acoustic shed	Tipper truck	2	100	117	119
			Excavator	2	112		
			Front end loader	2	115		
			Compressor for air scrubber	2	75		
			Ventilation scrubber	2	98		
	PYR-11	Onsite truck movements	Truck	6	103	94	108
	PYR-12	Tunnelling support activities	Substation[2]	1	66	82	98
			Water treatment plant[2,3]	1	82		
Site rehabilitation and landscaping	PYR-13	Site rehabilitation and landscape	Truck	1	98	105	111
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA ‘penalty’ is added to predicted noise levels when using the quantitative method
2. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels of finalised equipment may differ and are subject to detailed design
3. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facilities of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable
- **Acoustic shed** – An acoustic shed of solid construction such as sheet steel would be incorporated at this site where practicable.

As these features form part of the proposed works, these are included in the assessment prior to consideration of additional mitigation.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-112** to **Table 5-116** for residential, commercial and other sensitive receivers. The noise levels are representative of the worst case impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) to the relevant NMLs and a summary of the impact assessment is presented in detail in **Annexure F-5**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs	– impacts would typically be marginal to minor
Noise levels 11 dB to 20 dBA above NMLs	– impacts would typically be moderate
Noise levels >20 dBA above NMLs	– impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

Refer to **Annexure G-5** for noise contours and indicative locations of each works activities.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-117**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-5**.

Table 5-112 Predicted worst case noise levels – Pyrmont Bridge Road – residential daytime

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]													
		PYR-01	PYR-02	PYR-03	PYR-04	PYR-05	PYR-06	PYR-07	PYR-08	PYR-09	PYR-10	PYR-11	PYR-12	PYR-13	PYR-14
Residential - Standard Daytime															
NCA40	61	62	55	56	50	55	56	34	45	54	47	35	<30	47	47
NCA41	61	84	77	78	72	82	78	49	58	67	59	51	38	69	60
NCA42	61	78	71	72	66	69	72	49	60	72	64	50	40	63	64
NCA43	61	65	58	59	53	54	59	38	48	56	51	35	<30	50	51
NCA44	61	70	63	64	58	62	64	42	53	60	57	40	31	55	57

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-113 Predicted worst case noise levels – Pyrmont Bridge Road – residential evening

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]													
		PYR-01	PYR-02	PYR-03	PYR-04	PYR-05	PYR-06	PYR-07	PYR-08	PYR-09	PYR-10	PYR-11	PYR-12	PYR-13	PYR-14
Residential – Evening															
NCA40	54	-	-	-	-	55	-	34	45	-	47	35	<30	-	-
NCA41	54	-	-	-	-	82	-	49	58	-	59	51	38	-	-
NCA42	54	-	-	-	-	69	-	49	60	-	64	50	40	-	-
NCA43	54	-	-	-	-	54	-	38	48	-	51	35	<30	-	-
NCA44	54	-	-	-	-	62	-	42	53	-	57	40	31	-	-

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-114 Predicted worst case noise levels – Pyrmont Bridge Road – residential night-time

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]													
		PYR-01	PYR-02	PYR-03	PYR-04	PYR-05	PYR-06	PYR-07	PYR-08	PYR-09	PYR-10	PYR-11	PYR-12	PYR-13	PYR-14
Residential - Night-time															
NCA40	46	-	-	-	-	55	-	34	45	-	47	35	<30	-	-
NCA41	46	-	-	-	-	82	-	49	58	-	59	51	38	-	-
NCA42	46	-	-	-	-	69	-	49	60	-	64	50	40	-	-
NCA43	46	-	-	-	-	54	-	38	48	-	51	35	<30	-	-
NCA44	46	-	-	-	-	62	-	42	53	-	57	40	31	-	-

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-115 Predicted worst case noise levels – Pyrmont Bridge Road – commercial

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]													
		PYR-01	PYR-02	PYR-03	PYR-04	PYR-05	PYR-06	PYR-07	PYR-08	PYR-09	PYR-10	PYR-11	PYR-12	PYR-13	PYR-14
Commercial															
NCA40	70	58	51	52	46	50	52	30	41	51	44	<30	<30	43	44
NCA41	70	88	81	82	76	84	82	65	69	80	67	53	54	73	67
NCA42	70	79	72	73	67	72	73	46	59	70	63	47	40	64	63
NCA43	70	75	68	69	63	60	69	42	56	61	59	40	31	60	59
NCA44	70	80	73	74	68	67	74	43	63	62	62	42	32	65	62

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-116 Predicted worst case noise levels – Pyrmont Bridge Road – other sensitive receivers

NCA	NML	Predicted LAeq(15minute) noise level (dBA)													
		PYR-01	PYR-02	PYR-03	PYR-04	PYR-05	PYR-06	PYR-07	PYR-08	PYR-09	PYR-10	PYR-11	PYR-12	PYR-13	PYR-14
Other Sensitive															
NCA40	-Refer to note 1	56	49	50	44	47	50	<30	39	50	42	<30	<30	41	42
NCA41	-	51	44	45	39	44	45	<30	31	40	38	<30	<30	36	38
NCA42	-	77	70	71	65	76	71	52	59	71	60	50	44	62	61
NCA43	-	68	61	62	56	55	62	40	47	58	54	37	<30	53	54
NCA44	-	56	49	50	44	53	50	34	39	50	48	<30	<30	41	48

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities

Table 5-117 Overview of NML exceedances – Pyrmont Bridge Road

Activity ID	Activity	Weeks [1]	Activity duration within overall project program [2] %				Number of receivers																
							Total	Highly noise affected [4]	NML exceedance receiver count [3]														
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep Disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
PYR-01	Demolition of existing buildings	8					1377	6	84	15	3	-	-	-	-	-	-	-	-	-	-	-	-
PYR-02	Site clearing	1					1377	1	25	8	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-03	Utility works	1					1377	2	27	9	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-04	Installation of environmental controls	1					1377	-	13	1	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-05	Pavement and infrastructure works	2					1377	4	16	10	2	20	16	3	19	10	4	239	12	14	551	43	17
PYR-06	Establishment of construction facilities	6					1377	2	26	9	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-07	Onsite car parking	180					1377	-	-	-	-	-	-	-	-	-	-	3	-	-	2	-	-
PYR-08	Workshop, deliveries, maintenance, and storage	180					1377	-	1	-	-	3	-	-	2	-	-	40	2	-	12	-	-
PYR-09	Construction of tunnel shaft and declines (outside acoustic shed)	48					1377	-	10	4	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-10	Spoil handling inside acoustic shed	72					1377	-	4	-	-	7	-	-	7	-	-	69	4	-	6	-	-
PYR-11	Onsite truck movements	72					1377	-	-	-	-	-	-	-	-	-	-	3	-	-	11	3	-
PYR-12	Tunnelling support activities	72					1377	-	-	-	-	-	-	-	-	-	-	-	-	-	11	1	-
PYR-13	Site rehabilitation and Landscape	12					1377	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-14	Cumulative	72					1377	-	4	-	-	7	-	-	8	-	-	72	4	-	17	3	-

Notes:

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 25%) of activity duration within overall proposal program. Where percentage is less than 25%, 25% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables show that:

- The highest noise levels and greatest NML exceedances are predicted during demolition of existing buildings (PYR-01), which requires use of a concrete saw and rock-breaker, and pavement and infrastructure works (PYR-05) which requires use of a concrete saw
- The largest impacts are predicted in NCA41 and NCA42 where receivers are situated in relatively close proximity to the works site
- Minor NML exceedances are predicted for commercial receivers in NCA41.

NML exceedances

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-5**.

Table 5-112 shows that the activity with potential for the greatest exceedance of the NMLs is the pavement and infrastructure works (PYR-05). **Figure 5-28** indicates the distribution of exceedances for activity PYR-05 (night) for receivers within the Pyrmont Bridge Road tunnel site.

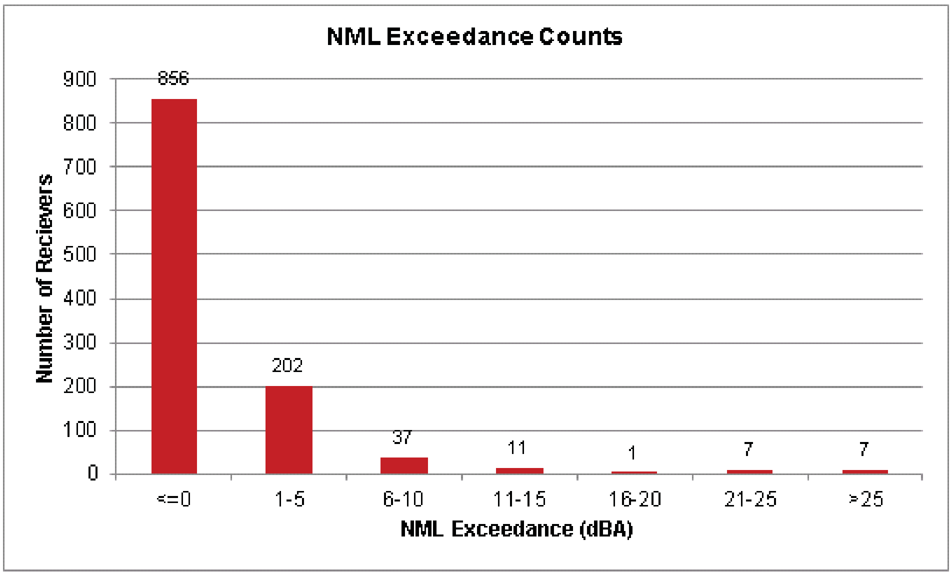


Figure 5-28 Activity PYR-05 noise level exceedance, night-time – Pyrmont Bridge Road

The above graph shows that while the worst case impacts may result in a greater than 25 dBA exceedance of NMLs, this is limited to a small number of receivers (seven only), with the majority of the receivers in this area being subject to considerably lower or no impact.

Works activities comprise the use of a number of individual items of plant (see listing in **Table 5-111**). Typically, one item of plant will dominate the noise emissions from a particular works activity. The operation and location of the dominant item typically controls the level of noise emissions shown in **Table 5-111**. For pavement works (PYR-05) the operation of the concrete saw dominates the noise predictions and as such, mitigation and management measures should focus on the operation of this item. It is estimated that when the concrete saw is not in operation, NML exceedances would generally reduce by up to 6 dBA.

Site establishment works (PYR-01 to PYR-07) account for a relatively small percentage of the total works duration (up to eight weeks) and this should be considered when evaluating mitigation and management measures for identified exceedances.

NML exceedances of up to 15 dBA (during the night period) are predicted during the operation of the workshops, deliveries, maintenance, and storage areas (PYR-08). These exceedances are due to the operation of laydown areas. **Figure 5-29** indicates the distribution of exceedances for activity PYR-08 (night).

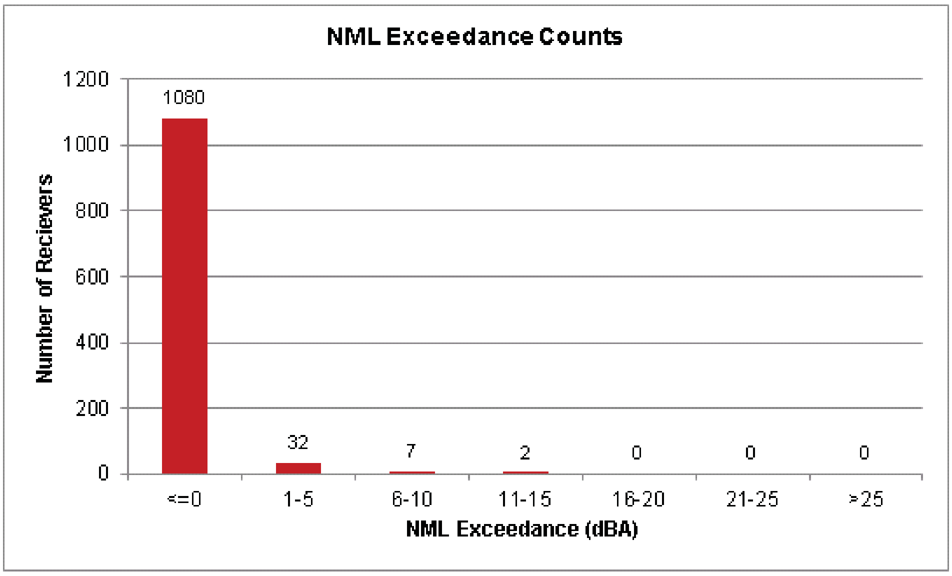


Figure 5-29 Activity PYR-08 noise level exceedance, night-time – Pyrmont Bridge Road

The above graph shows that while the worst case impacts may result in up to 15 dBA exceedance of NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower impacts.

The operation of laydown areas (PYR-08) forms part of the tunnelling and supporting works scenario. Tunnelling works and supporting activities (PYR-07, PYR-08 and PYR-10, PYR-11 and PYR-12) account for the majority of the total works duration at Pyrmont Bridge Road. The extended duration of these works should be considered when evaluating mitigation and management measures.

The cumulative scenario (PYR-14), which includes the operation of all activities detailed in **Table 5-109**, results in exceedances of up to 17 dBA over the night-time NMLs.

Table 5-112 shows that the cumulative scenario is dominated by workshop, deliveries, maintenance, and storage, and spoil handling inside acoustic shed (PYR-08 and PYR-10), and as such by controlling the noise emissions of these activities the overall noise emissions would be reduced. **Figure 5-30** indicates the distribution of exceedances for the cumulative activity PYR-11 (night) for receivers within the Pyrmont Bridge Road study area.

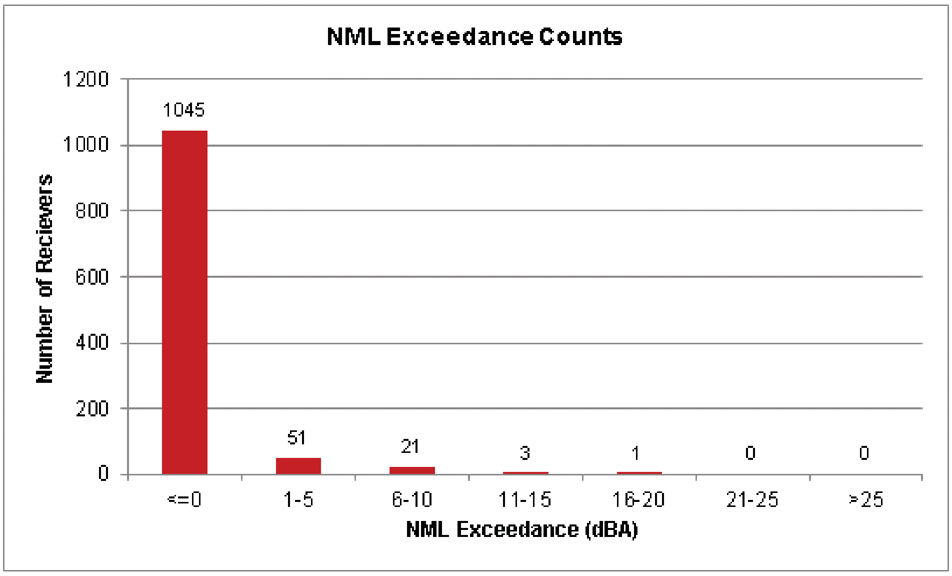


Figure 5-30 Activity PYR-14 noise level exceedance, night-time – Pyrmont Bridge Road

The above graph shows that while the worst case impacts may result in up to 15 dBA exceedance of NMLs, this is limited to a small number of receivers with the majority of the receivers in this area being subject to considerably lower impacts.

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. The number of Highly Noise Affected receivers in the study area has been determined and is summarised in **Table 5-118**. The table shows the number of residential receivers separated by works activity.

Table 5-118 Predicted number of highly noise affected residential receivers by works – Pyrmont Bridge Road

Works	Activity	Period		
		Day	Eve	Night
PYR-01	Demolition of existing buildings	6	-	-
PYR-02	Site clearing	1	-	-
PYR-03	Utility works	2	-	-
PYR-04	Installation of environmental controls	-	-	-
PYR-05	Pavement and infrastructure works	4	4	4
PYR-06	Establishment of construction facilities	2	-	-
PYR-07	Onsite car parking	-	-	-
PYR-08	Workshop, deliveries, maintenance, and storage	-	-	-
PYR-09	Construction of tunnel shaft and declines (outside acoustic shed)	-	-	-
PYR-10	Spoil handling inside acoustic shed	-	-	-
PYR-11	Onsite truck movements	-	-	-
PYR-12	Tunnelling support activities	-	-	-
PYR-13	Site rehabilitation and Landscape	-	-	-
PYR-14	Cumulative	-	-	-

The above table shows that receivers are predicted to be highly noise affected during certain works activities.

The location of the highly noise affected residential receivers, from all works and in any time period, are shown in red in **Figure 5-31**.

Figure 5-31 Highly noise affected residential receivers – Pyrmont Bridge Road

The most impacted receivers are typically surrounding dwellings which have direct line of sight to the various works locations. The predicted worst case impacts, however, would only be expected to be apparent when high noise generating works are being carried out immediately adjacent to these residential receivers.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-119**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-112** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-119 Overview of other sensitive receiver NML exceedances – Pyrmont Bridge Road

Works ID	Activity	Number of other sensitive receivers exceeding NMLs														
		Education			Medical			Place of Worship			Childcare			Remaining		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
PYR-01	Demolition of existing buildings	1	-	1	4	-	-	1	-	-	3	-	-	3	-	-
PYR-02	Site clearing	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-
PYR-03	Utility works	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-
PYR-04	Installation of environmental controls	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-05	Pavement and infrastructure works	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
PYR-06	Establishment of construction facilities	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-
PYR-07	Onsite car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-08	Workshop, deliveries, maintenance, and storage	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-09	Construction of tunnel shaft and declines (outside acoustic shed)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-10	Spoil handling inside acoustic shed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-11	Onsite truck movements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-12	Tunnelling support activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-13	Site rehabilitation and Landscape	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYR-14	Cumulative	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. The ‘Remaining’ category includes public buildings, libraries, café/bars, etc

The above table shows the following:

- Other sensitive receivers in this precinct are generally predicted be subject to relatively minor noise impacts during the daytime
- One ‘other sensitive receiver’ in this area would be subject to worst case exceedances of 11 to 20 dBA above NMLs during the higher noise generating activities. This receiver is Bridge Road School located at 127 Parramatta Road, Camperdown (within NCA42). This same receiver would also be subject to worst case exceedances of >20 dBA above NMLs during the higher noise generating activities.

The recommended ‘standard’ and ‘additional’ noise mitigation as discussed in **section 4.6**, along with recommended specific site mitigation measures would be implemented to mitigate NML exceedances at other sensitive receivers.

NCA summary

The following section provides a summary of the key activities within each NCA and should be read in conjunction with **Annexure F-5**.

NCA40

- Demolition of existing buildings (PYR-01) is identified as has having a marginal (5 dBA) exceedance of the daytime NMLs. Exceedances are generally experienced by receivers which adjoin Nelson Street to the north west of the site, and are attributed to the use of excavators (rock-breakers) and diamond/concrete saws. When these items of plant are not operating it is estimated that exceedances would reduce by up to 11 dBA. The expected duration of these works is estimated to be up to eight weeks
- Pavement and infrastructure works (PYR-05) is identified as causing the greatest number of exceedances over all time periods. Exceedances up to 10 dBA are predicted at 137 receivers during night-time works. Of these 137 receivers, only one would experience an exceedance of between 5 dBA and 10 dBA. The predicted duration of these works is two weeks, during which out of hours works would be required at times.

NCA41 and NCA42

NCA41 and NCA42 are predicted to experience a similar level of NML exceedance from common sources within the Pyrmont Bridge Road tunnel site. The discussion of impacts for these NCAs has been grouped together below.

- Pavement and infrastructure works (PYR-05) is identified as having the greatest number of exceedances over all time periods. Exceedances are generally experienced by receivers located along Pyrmont Bridge Road and Parramatta Road. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the laydown areas of the site (PYR-08) are predicted to exceed the night-time NMLs by up to 15 dBA. Of the identified exceedances, only two receivers would experience exceedances of more than 10 dBA, with 17 receivers predicted to experience exceedances of less than 5 dBA. The expected duration of these works is up to 180 weeks and as such mitigation should be considered for these impacts
- Operations within the site shed (PYR-10) are predicted to result in exceedances (up to 20 dBA) at 37 receivers during night-time operations. Of these 37 receivers, three would experience an exceedance of greater than 10 dBA, with 22 expected to experience exceedances of less than 5 dBA. The expected duration of these works is up to 72 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (PYR-14) is predicted to result in exceedances of up to 20 dBA at 39 receivers. The highest predicted noise level at a residential receiver is 64 dBA. As identified previously, exceedances of the cumulative works scenario are dominated by workshop, deliveries, maintenance, and storage, and spoil handling inside acoustic shed (PYR-08 and PYR-10). By controlling noise emission from these activities, the exceedances of the overall cumulative assessment will reduce.

NCA43

- Pavement and infrastructure works (PYR-05) is identified as resulting in the greatest number of exceedances over all time periods. Exceedances are generally experienced by receivers located along Parramatta Road. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the laydown areas of the site (PYR-08) are predicted to result in a marginal exceedance of the night-time NMLs by up to 5 dBA for 12 receivers

- Operations within the site shed (PYR-10) are predicted to result in exceedances of up to 10 dBA at 28 receivers during night-time operations. Of these 28 receivers, 92 per cent are predicted to experience exceedances of less than 5 dBA. The expected duration of these works is up to 72 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (PYR-14) is predicted to result in exceedances of up to up to 10 dBA at 29 receivers. The highest predicted noise level at a residential receiver is 52 dBA. As identified previously, exceedances of the cumulative works scenario are dominated by workshop, deliveries, maintenance, and storage, and spoil handling inside acoustic shed (PYR-08 and PYR-10). By controlling noise emissions from these activities, the exceedances of the overall cumulative assessment would be reduced.

NCA44

- Pavement and infrastructure works (PYR-05) is identified as resulting in the greatest number of exceedances over all time periods. Exceedances are generally experienced by receivers located along Parramatta Road. The duration of these works is estimated to be two weeks, during which out of hours works would be required at times
- Operations within the laydown areas of the site (PYR-08) are predicted to exceed the night-time NMLs by up to 10 dBA. Of the identified exceedances, only two receivers would experience exceedances of more than 5 dBA, with three receivers predicted to experience exceedances of less than 5 dBA. The expected duration of these works is up to 180 weeks and as such mitigation should be considered for these impacts
- Operations within the site shed (PYR-10) are predicted to result in exceedances of up to 15 dBA at seven receivers during night-time operations. Of these seven receivers, only one receiver would experience an exceedance of the NMLs by more than 10 dBA, with two receivers predicted to experience and exceedance of less than 5 dBA. The expected duration of these works is up to 72 weeks and as such mitigation should be considered for these impacts
- The cumulative scenario (PYR-14) is predicted to result in exceedances of up to 15 dBA at seven receivers. The highest predicted noise level at a residential location is 57 dBA. As identified previously, exceedances of the cumulative works scenario are dominated by workshop, deliveries, maintenance, and storage, and spoil handling inside acoustic shed (PYR-08 and PYR-10). By controlling noise emissions from these activities, the exceedances of the overall cumulative assessment would be reduced.

Sleep disturbance

Review of the predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-5** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project-specific mitigation measures (in addition to the standard suite of measures **Table 4-13**) are summarised in **Table 5-120**.

Table 5-120 Recommended site specific noise mitigation measures – Pyrmont Bridge Road

Activity	Mitigation description	Reason	Recommendations
PYR-01 to PYR-10	High noise emitting activities should be scheduled for normal working hours. If the works cannot be undertaken during the day, it should be completed before 11:00 pm where practicable.	The site establishment works and Initial road and traffic management scenario is predicted to have a number exceedances during all time periods.	Limit the use of the road profiler (PYR-06) during out of hours works where feasible.
PYR-14	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified during all time periods for operations within the site shed.	Basic sheet steel shed construction was considered during the unmitigated predictions. It is recommended that an acoustic enclosure be included for the Pyrmont Bridge Road tunnel site.
PYR-15	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified for truck entering and exiting the site.	Investigate locations where hoarding (>2m) can be utilised to control trucks in the queuing area. Use mobile acoustic hoarding around smaller items to minimise noise.
	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite.		
	Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.		
All	Where practicable, work should be scheduled to avoid major student examination period when students are studying for examinations such as before or during Higher School Certificates and a the end of higher educational semesters	Construction activities are predicted to impact a local educational facility.	Consultation with the Bridge Road School should be undertaken to identify sensitive sections of the school along with periods of examination.

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-5**.

The in-situ mitigation measures investigated are:

- Increasing site hoarding to four metres in select areas
- Upgrading the acoustic shed performance.

The minimum transmission loss of the acoustic shed including operable elements is noted below in **Table 5-121**. It should be noted that where residual impacts are predicted following the inclusion of the upgraded shed, further investigation should be undertaken during detailed design.

Table 5-121 Acoustic shed acoustic performance – Pyrmont Bridge Road

Indicative upgraded shed construction	Octave band transmission loss (dB)						
	63	125	250	500	1000	2000	4000
Double Leaf: (1 x 0.48mm Steel) - 202mm Steel Stud + 75mm Fibreglass 32 kg/m³ - (1 x 0.42mm Steel)	10	12	24	36	46	55	61

Table 5-122 provides the predicted distribution of exceedances (at night-time) both 'with' and 'without' the recommended mitigation for receivers within this study area.

All site hoarding as shown in **Figure 5-31** has been investigated at a height of four metres.

Table 5-122 NML exceedance distribution with and without mitigation – Pyrmont Bridge Road

Activity ID	Activity	Time period	Number of receivers with NML exceedance					
			Without Mitigation			With Mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
PYR-08	Workshop, deliveries, maintenance, and storage	Night	40	2	-	16	1	-
PYR-10	Spoil handling inside acoustic shed	Night	69	4	-	4	-	-
PYR-14	Cumulative	Night	72	4	-	28	1	-

Table 5-122 indicates that with the inclusion of in-situ mitigation measure in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure F-5** and represent the max predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. The counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures.

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure F-5**.

Table 5-123 CNVG additional noise mitigation counts – Pyrmont Bridge Road

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period 2)			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
Scenario – Site establishment works					
NCA40	-	130	-	-	-
NCA41	8	3	-	4	7
NCA42	-	27	11	-	-
NCA43	-	6	1	-	-
NCA44	-	-	-	-	-
Scenario – Tunnelling and supporting works					
NCA40	-	-	-	--	-
NCA41	-	7	3	-	-
NCA42	-	7	-	-	-
NCA43	-	-	-	-	-
NCA44	-	-	-	-	-
Scenario –Site rehabilitation and landscaping					
NCA40	-	-	-	-	-
NCA41	-	-	-	-	-
NCA42	-	-	-	-	-
NCA43	-	-	-	-	-
NCA44	-	-	-	-	-

Notes:

1. Refer to **section 4.6.2** for descriptions of the various additional mitigation measures

5.5.3 Construction road traffic noise

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-124**. The maximum daily flows have been used in the assessment in order to provide a conservative assessment.

Table 5-124 Construction traffic forecast – Pyrmont Bridge Road

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C9 - Pyrmont Bridge Road tunnel site	133	70

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-125** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-125 Construction road traffic noise assessment – Pyrmont Bridge Road

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C9 - Pyrmont Bridge Road tunnel site	Light & heavy	Pyrmont Bridge Road	<0.5	0.6

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available

The information above indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should include instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.5.4 Ground-borne noise

Predicted ground-borne noise levels

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

As such, the nature of the majority of construction works at the Pyrmont Bridge Road tunnel site (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible.

However, tunnelling works associated with the access tunnel to the mainline tunnel alignment have the potential to result in ground-borne noise impacts at the nearest sensitive receivers.

The ground-borne noise assessment is based on the worst case predicted L_{Aeq} internal ground-borne noise level when the tunnelling works are at their closest point below each receiver.

Table 5-126 summarises the maximum ground-borne noise levels from road-header tunnelling works associated with the Pyrmont Bridge Road access tunnel. Ground-borne noise contour maps are provided in **Annexure I**. The exceedances listed in **Table 5-126** assume that the tunnelling works will occur 24 hours a day, and therefore consider potential exceedances of the more stringent night-time ground-borne NMLs.

Table 5-126 Worst case predicted ground-borne noise levels during tunnelling – Pyrmont Bridge Road access tunnel

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA40	28	-	-	-
NCA41	30	-	-	-
NCA42	40	3	2	-
NCA43	21	-	-	-
NCA44	22	-	-	-

The worst case ground-borne noise levels are predicted to be compliant with the more stringent 35 dBA $L_{Aeq(15minute)}$ night-time criterion at the majority of receivers with the exception of three residential and two other sensitive receivers which are potentially affected by ground-borne noise from tunnelling works.

In NCA42, where the access tunnel ramp dives down from ground elevation to meet with the main line tunnel alignment, receivers above this section are predicted to be subject to ground-borne noise levels up to around 40 dBA $L_{Aeq(15minute)}$, which exceeds the night-time criteria.

Based on a progression rate of around 20 metres per week, the most affected receivers in this NCA are likely to experience noise levels above the night-time criterion for up to around 16 days.

While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

The ground-borne noise predictions are based on the nearest sensitive receivers above or adjacent to the proposed tunnel alignment. The ground-borne noise impacts would reduce for sensitive receivers offset horizontally from the access tunnel due to the increased slant distance.

Managing ground-borne noise impacts

Table 5-126 indicates that there are three residential receivers and two other sensitive receivers where ground-borne noise levels are predicted to exceed the night-time NMLs by up to 5 dBA. With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works location, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NMLs, providing additional information when relevant and more specific information than covered in general letterbox drops.

5.5.5 Vibration

Estimated working distances and vibration intensive plant

The proposed works have been analysed to determine best estimate minimum working distances for the vibration intensive mechanical plant proposed for the construction activities. Proposed vibration intensive construction plant are listed in **Table 5-127** and compared to the minimum working distances listed in **Table 4-12** in order to determine potential vibration impacts of the main construction scenarios. Estimated minimum working distances for the site works and tunnelling works are shown graphically in **Annexure J**.

See **section 5.5.1** for a discussion of indicative duration for the construction activities.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

Table 5-127 Construction vibration assessment summary – Pyrmont Bridge Road

Work scenario	Vibration intensive equipment	NCA	Number of buildings within minimum working distance for highest vibration plant item			
			Cosmetic Damage			Human Response
			Residential and Light Commercial	Group 2 (Typical)	Group 3 (Structurally Unsound)[1]	
Surface works – roadworks, demolition of existing buildings, construction of site buildings and works within the site	Bored piling Jackhammer Rock-breaker[2]	NCA40	-	-	-	-
		NCA41	21	25	2	41
		NCA42	-	6	2	17
		NCA43	-	-	-	3
		NCA44	2	2	1	12
Tunnelling works - access tunnel to mainline tunnel alignment	Road-header[2]	NCA40	-	-	-	-
		NCA41	-	-	-	-
		NCA42	-	-	-	-
		NCA43	-	-	-	-
		NCA44	-	-	-	-

Notes:

1. This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration (following inspection) to be confirmed during detailed design
2. Proposed highest vibration plant item for these works

Heritage listed buildings identified within the cosmetic damage minimum working distances are listed in **Table 5-128**.

Table 5-128 Heritage listed items within cosmetic damage minimum working distance – Pyrmont Bridge Road

NCA	Item name[1]	Address[1]	Construction type[2]
NCA41	Kerb and gutter	Chester Street, Camperdown	Stonework/concrete
NCA41	Warehouse, including interiors	52-54 Pyrmont Bridge Road, Camperdown	Brickwork
NCA42	Bridge Road School (former Camperdown Public School), including interiors	127 Parramatta Road, Camperdown	Stonework/brickwork
NCA44	Former Grace Bros Repository, including interiors	6-10 Mallett Street, Camperdown	Brickwork

Notes:

1. List of Heritage items extracted from **Appendix U** (Technical working paper: Non-Aboriginal heritage)
2. Estimated from photographic information only and should be confirmed onsite

The construction type classifications and structural integrity of all the listed heritage items should be confirmed at detailed design by a suitably qualified structural engineer. This information can then be used to verify the applicable vibration criteria and associated impacts.

Cosmetic damage assessment summary

The separation distance(s) between the proposed works and the nearest sensitive receivers would generally be sufficient so that nearby buildings are unlikely to suffer 'Cosmetic Damage' for most of the proposed construction equipment. However, based on the arrangement of the work zones, some items of construction equipment have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Construction with large rock-breakers has the potential to generate some of the most significant construction vibration impacts due to the high vibration characteristics of the plant.

The assessment presented in **Table 5-127** indicates that during surface works, up to 33 buildings in the vicinity of the works may be within the minimum working distances should a large rock-breaker be used at the outer extents of the Pyrmont Bridge Road tunnel site. In practice, it is unlikely that a rock-breaker would be required at all areas and therefore the vibration impacts presented in this assessment should be considered a worst case scenario. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

The assessment presented in **Table 5-127** indicates that no buildings are likely to be within the minimum working distance to tunnelling works associated with the access tunnel to the mainline tunnel alignment.

Human comfort vibration assessment summary

The assessment presented in **Table 5-127** indicates the proposed surface works using a large rock-breaker may result in a significant number of receivers (around 73 receivers in the vicinity) within the nominated minimum working distance for human comfort vibration.

The assessment presented in **Table 5-127** indicates that no receivers are likely to be within the human comfort minimum working distance to tunnelling works associated with the access tunnel to the mainline tunnel alignment.

In relation to human comfort (response), the minimum working distances in **Table 4-12** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and, for this reason, higher vibration levels occurring over shorter periods are permitted, as discussed in BS 6472-1.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers and other high vibration plant items. In practice vibration impacts from most construction activities would be intermittent within the duration of the project. The required locations for vibration intensive equipment should be reviewed during detailed design when more specific information is available.

Cumulative vibration impacts

Due to the intermittent nature of construction works, vibration impacts due to multiple works scenarios are considered unlikely to result in concurrent vibration peaks, but rather, may increase the effective duration of the exposure to vibration. Vibration impacts due to multiple simultaneous works would therefore be managed in the same manner as for single works scenarios (dependant on the operating equipment).

Managing vibration impacts

Table 5-127 indicates that, as discussed above, there are around 107 receivers within the nominated minimum working distance for human comfort vibration. With reference to the CNVG vibration mitigation measures outlined in **Table 4-16**, vibration intensive works at the Pyrmont Bridge Road tunnel site are proposed only during standard construction hours. The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works

- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

Vibration trials and/or attended vibration monitoring or should be undertaken prior to and during any works proposed within the minimum working distances for cosmetic damage to ensure that levels remain below the criteria. Building condition surveys should also be completed both before and after the works at any potentially affected properties to identify existing damage and any project related damage. At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.6 St Peters

This section presents an overview of works, predicted impacts and consideration of mitigation and management measures for works proposed in the St Peters area.

5.6.1 Works description

The Campbell Road civil and tunnel site would be located on the southern side of Albert Street and Campbell Lane in St Peters. The site is currently the Campbell Road construction compound for the New M5 project.

The St Peters tunnel site would be the main tunnel site at the southern end of the project. The site would include:

- Temporary site offices
- Workshop and storage facilities
- Laydown area
- Entry and exit points for haulage of tunnel spoil
- Temporary substation, ventilation and water treatment plant
- Sedimentation pond
- Workforce amenities and car parking
- Ventilation facility and motorway operations complex.

Road-headers would be launched from this site and would excavate the tunnels and ramps travelling in a northern direction. An acoustic shed would be established on the site to minimise noise from out of hours tunnelling and spoil handling. In addition, temporary noise mitigation measured would include noise barriers and other temporary structures such as site buildings, which will be provided to minimise noise impacts on the surrounding properties.

Access to and egress from the site for all vehicles would be via Campbell Street at Albert Street. There would be permanent changes to the intersection on Campbell Street at Albert Street to allow heavy vehicles to turn right into the site.

Figure 5-32 provides an indicative site layout map for the Campbell Road civil and tunnel site.

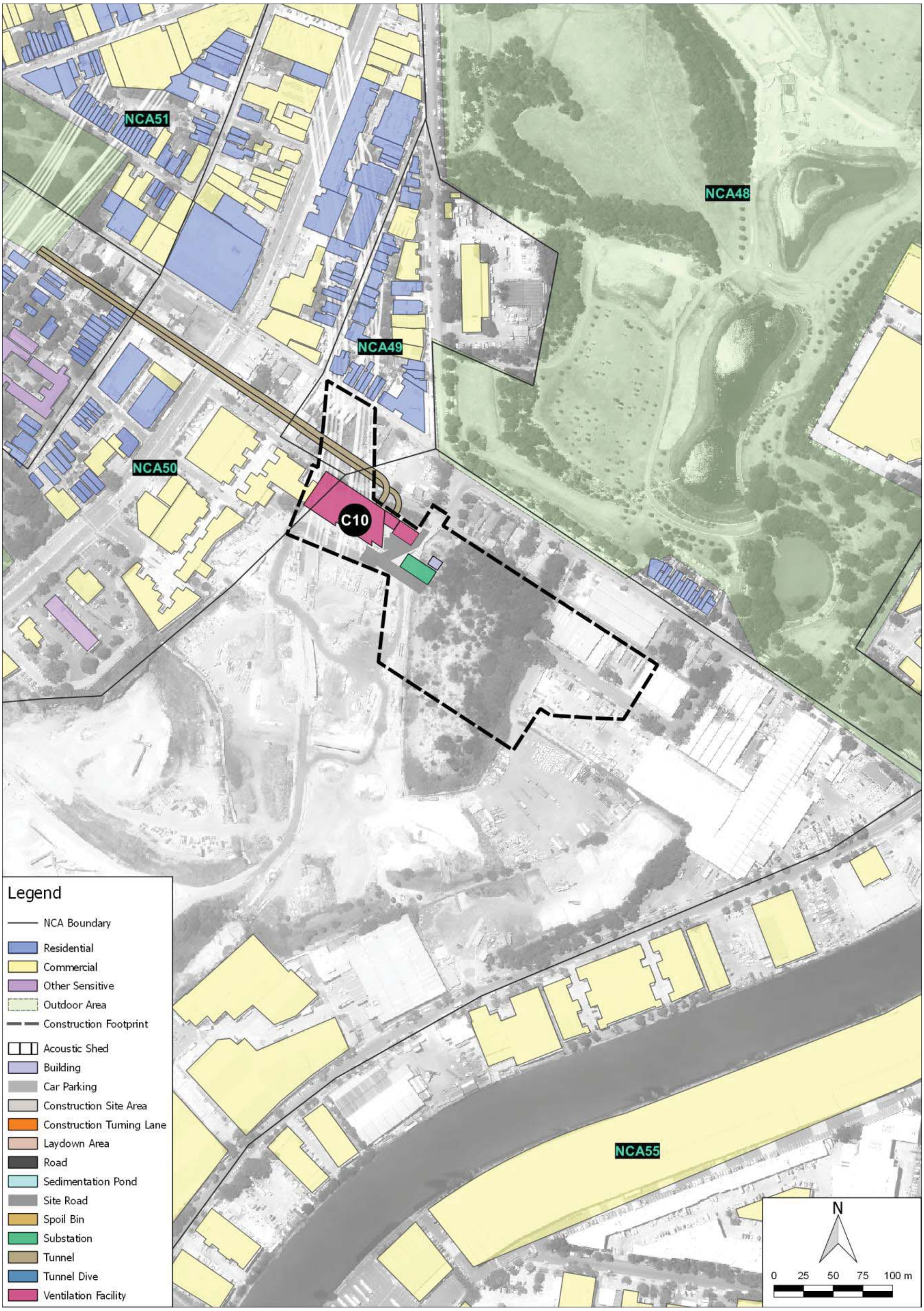


Figure 5-32 Indicative site layout – St Peters

Works schedule

Subject to planning approval, construction at the Campbell Road civil and tunnel site is planned to start in the fourth quarter of 2018, with completion planned for the end of 2022. The total period of construction works is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. The indicative construction program for the Campbell Road civil and tunnel site is shown in **Table 5-129**.

Table 5-129 Indicative construction program and duration – St Peters

Activity	2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Initial road works and traffic management				■																
Site establishment and utility works				■	■	■														
Tunnelling						■	■	■	■	■	■	■	■							
Civil and mechanical fitout													■	■	■	■				
Construction of motorway operational infrastructure												■	■	■	■	■	■			
Testing and commissioning																■	■	■	■	■
Site demobilisation and rehabilitation																			■	■

Construction activities

A number of scenarios have been developed to assess impacts associated with construction works at the Campbell Road civil and tunnel site. A construction scenario contains a number of activities. **Table 5-130** outlines the construction scenarios and corresponding activities, as well as noting the assessed periods of operation. The estimated durations of activities are also summarised, noting that the activities are intermittent during this period and would not be expected to be undertaken every day during the scheduled activity.

Table 5-130 Construction activities and period of operation – St Peters

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2]			
				Day	Day OOH	Eve	Night
Site establishment works	SPI-01	2	Installation of environmental controls	✓			
	SPI-02	4	Pavement and infrastructure works	✓			
	SPI-03	24	Establishment of construction facilities	✓			
Tunnelling and Supporting works	SPI-04	72	Onsite car parking	✓	✓	✓	✓
	SPI-05	72	Workshop, deliveries, maintenance, and storage	✓	✓	✓	✓
	SPI-06	72	Tunnelling within acoustic shed	✓	✓	✓	✓
	SPI-07	72	On-site truck movements	✓	✓	✓	✓
	SPI-08	72	Tunnelling support activities	✓	✓	✓	✓

Scenario	Works ID	Indicative duration (weeks)[1]	Activity	Period of works[2]			
				Day	Day OOH	Eve	Night
Construction	SPI-09	72	Ventilation Building Installation	✓			
	SPI-10	8	Lane configuration changes (ramp)	✓			
	SPI-11	8	Construction of tunnel cut cover (outside acoustic shed)	✓			
Site rehabilitation and landscaping	SPI-12	12	Site rehabilitation and Landscape	✓			

Notes:

1. The duration refers to the overall period during which the work activities would be undertaken. In reality the work activities are likely to be undertaken intermittently (not continuously) and the impacts would be localised in areas adjacent to where the works activity is being undertaken. The overall duration of work activities would be confirmed during detail design
2. Works periods are defined as:
   - Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 1:00 pm Saturday
   - Day out of hours Saturday 1:00 pm to 6:00 pm, Sunday and Public holidays 8:00 am to 6:00 pm
   - Evening (Eve) 6:00 pm to 10:00 pm Monday to Sunday
   - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays.

Cumulative assessment scenario

Construction scenarios with the potential to generate cumulative impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include reasonably stationary noise sources which operate for the majority of the construction period and as such a cumulative assessment of these activities has been included. A summary of the project cumulative construction operations is provided in **Table 5-131**.

Table 5-131 Activities assessed for cumulative construction noise – St Peters

Cumulative ID	Activity works ID	Activity	Comment	Period Of works
SPI-13	SPI-04	Onsite car parking	Tunnelling works along with supporting activities have the have the potential for cumulative impacts due to works typically operating within a specific location in the site.	All Periods
	SPI-05	Workshop, deliveries, maintenance, and storage		
	SPI-06	Tunnelling activities within acoustic shed		
	SPI-07	Onsite truck movements		
	SPI-08	Tunnelling support activities		

5.6.2 Airborne noise

NML summary

With reference to **section 4.1.2** and using the measured background noise levels in **section 3.5.2**, the NMLs derived for the works at St Peters are outlined in **Table 5-132**.

Table 5-132 Residential NMLs for the project – St Peters

NCA	Representative monitoring location	Receiver type	Standard construction NMLs (RBL+10dBA)	Out of hours NMLs (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15dBA)
			Daytime period	Daytime period	Evening period	Night period	
NCA47	S.01	Residential	67	62	56	45	55
NCA48	S.01	Residential	67	62	56	45	55
NCA49	S.03	Residential	64	59	50	45	55
NCA50	S.04	Residential	62	57	55	49	59
NCA51	S.02	Residential	60	55	51	44	54
NCA52	S.02	Residential	60	55	51	44	54
NCA54	S.05	Residential	68	63	61	54	64
NCA55	S.05	Residential	68	63	61	47	57

Notes

1. Out of Hours construction hours – Evening hours are 6.00 pm to 10.00 pm. Night-time hours are 10.00 pm to 7.00 am Sunday to Saturday and 10.00 pm Saturday to 8.00 am Sunday

For other sensitive receivers such as schools and places of worship, the NMLs presented in **section 4.1.2**, are applicable.

Activity source noise levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 5-133**. The activities are representative of works which have the potential to impact nearby sensitive receivers. Works within the tunnel are assessed in the ground-borne noise assessment in **section 5.7.1**.

Table 5-133 Sound power levels for construction equipment – St Peters

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1]		
					L_{WA}		L_{WAmax}
					Item	Activity[4]	Activity
Site establishment works	SPI-01	Installation of environmental controls	Excavator	1	104	108	113
			Franna crane	1	99		
			Truck	1	98		
			Bobcat	1	104		
	SPI-02	Pavement and infrastructure works	Truck	1	98	116	123
			Concrete saw[1]	1	120		
			Grader	1	108		
			Roller (non-vibratory)	1	100		
			Water tanker	1	98		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1]		
					LWA		LWAmax
					Item	Activity[4]	Activity
			Back hoe	1	102		
	SPI-03	Establishment of construction facilities	Excavator	1	109	114	117
			Back hoe	1	102		
			Mobile crane	1	100		
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
			Piling rig (bored)	1	108		
			Roller (non-vibratory)[1]	1	100		
			Water tanker	1	98		
			Bobcat	1	104		
			Truck	1	103		
Tunnelling and supporting works	SPI-04	On site car parking	Car parking	1	73	97	105
			Water pump	1	97		
	SPI-05	Workshop, deliveries, maintenance, and storage	Truck	1	98	103	107
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Water tanker	1	98		
	SPI-06	Spoil handling above ground within acoustic shed	Tipper truck	1	97	117	119
			Excavator	1	109		
			Front end loader	1	112		
			Compressor for air scrubber	1	72		
			Ventilation scrubber	1	98		
	SPI-07	Onsite truck movements	Truck	3	98	97	108
	SPI-08	Tunnelling support activities	Water treatment plant [2,3]	1	82	82	90
			Substation [3]	1	66		
Construction	SPI-09	Ventilation building installation	Mobile crane	1	101	107	112
			Concrete truck/agitator	1	106		
			Concrete pump	1	106		
	SPI-10	Lane configuration changes (Ramp)	Slip form machine	1	102	113	115
			Bitumen spray truck	1	100		
			Roller (non-vibratory)	1	100		
			Grader	1	108		
			Concrete truck / agitator	1	106		
			Paving machine	1	104		
			Water tanker	1	98		
			Back hoe	1	102		
			Truck (25t)	1	98		
			Line marking plant	1	98		

Scenario name	Works ID	Activity (ie equipment split)	Equipment (realistic worst case)	Worst case items in same location	Sound power level (dBA)[1]		
					LWA		LWAmax
					Item	Activity[4]	Activity
	SPI-11	Construction of tunnel cut cover (outside acoustic shed)	Piling rig (bored)	1	108	114	118
			Mobile crane	1	104		
			Shotcrete rig	1	106		
			Rock anchor drill	1	108		
			Excavator	1	109		
			Concrete truck/agitator	1	106		
			Truck	1	98		
Site rehabilitation and landscaping	SPI-12	Site rehabilitation and landscape	Truck	1	98	105	111
			Hand tools	1	94		
			Franna crane	1	99		
			Telehandler	1	92		
			Back hoe	1	102		

Notes:

1. In accordance with the EPA ICNG for activities identified as particularly annoying (such as jackhammering, rock-breaking and power saw operation), a 5 dBA 'penalty' is added to predicted noise levels when using the quantitative method
2. Equipment assumed to be attenuated with a minimum insertion loss of 20 dBA
3. Equipment sound power levels are referenced from the New M5 Environmental Impact Statement Technical working paper: Noise and Vibration and are indicative only. Sound power levels may change subject to detailed design
4. Activity sound power levels account for the amount of time an item of plant is anticipated to operate within each 15 minute period

Early opportunities for noise benefit

The proposed works include a number of opportunities to achieve a noise benefit from judicious use and design of the following standard construction features:

- **Site hoarding** – For construction concentrated in a single area, such as at the civil and tunnelling sites, temporary acoustic hoarding/barriers around the site perimeter should be considered where feasible and reasonable to mitigate off-site noise levels. Two metre high fencing surrounding the construction ancillary facilities of solid lapped and capped construction (as opposed to standard wire mesh fence) has been included where practicable
- **Acoustic shed** – An acoustic shed of solid construction such as sheet steel would be incorporated at this site where practicable.

As these features form part of the proposed works, these are included in the non-mitigated assessment.

Predicted noise levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 5-134** to **Table 5-138** for residential, commercial and other sensitive receivers. The noise levels are representative of the worst case impacts where works are closest to each NCA and are intended to give an overview of the noise from the proposed works.

The comparison of the predicted noise levels (without mitigation) to the relevant NMLs and a summary of the impact assessment is presented in detail in **Annexure F-6**. The detailed breakdown of works within each NCA provides indicative information on the duration of each activity along with the number of exceeding receivers for each time period.

The following tables colour the predicted noise levels based on the exceedance of the NMLs during that period and for that receiver type. A qualitative description of the NMLs exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

Noise levels 1 to 10 dBA above NMLs – impacts would typically be marginal to minor
Noise levels 11 dBA to 20 dBA above NMLs – impacts would typically be moderate
Noise levels >20 dBA above NMLs – impacts would typically be high

For most construction activities, it is expected that the actual construction noise level would generally be lower than the wost-case prediction made at the most-exposed receiver. This is because noise level varies with position of plant item or noise sensitive receiver as well as across different stages of construction.

NML exceedance – project overview

The predicted NML exceedances in this area are summarised in **Table 5-140**. The assessment presented in this table takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are shown in bands and are separated into day, evening and night-time periods, as appropriate.

The NML exceedances for individual works scenarios in this area are presented in **Annexure F-6.**

Table 5-134 Predicted worst case noise levels – St Peters – residential daytime

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]												
		SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06	SPI-07	SPI-08	SPI-09	SPI-10	SPI--11	SPI-12	SPI-13
Residential - Standard Daytime														
NCA48	67	57	61	63	41	46	42	38	<30	47	46	53	54	49
NCA49	64	57	64	63	42	48	54	45	37	59	60	70	54	56
NCA50	62	48	54	53	34	43	45	36	<30	51	53	59	45	47
NCA51	60	42	48	48	<30	37	38	31	<30	44	43	51	39	41
NCA52	60	44	52	50	31	39	42	32	<30	45	41	54	41	44
NCA54	68	38	45	44	<30	32	33	<30	<30	37	37	43	35	36
NCA55	68	39	46	45	<30	35	33	<30	<30	35	38	42	36	38

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-135 Predicted worst case noise levels – St Peters – residential evening

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]												
		SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06	SPI-07	SPI-08	SPI-09	SPI-10	SPI--11	SPI-12	SPI-13
Residential – Evening														
NCA48	56	-	-	-	41	46	42	38	<30	-	-	-	-	-
NCA49	50	-	-	-	42	48	54	45	37	-	-	-	-	-
NCA50	55	-	-	-	34	43	45	36	<30	-	-	-	-	-
NCA51	51	-	-	-	<30	37	38	31	<30	-	-	-	-	-
NCA52	51	-	-	-	31	39	42	32	<30	-	-	-	-	-
NCA54	61	-	-	-	<30	32	33	<30	<30	-	-	-	-	-
NCA55	57	-	-	-	<30	35	33	<30	<30	-	-	-	-	-

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-136 Predicted worst case noise levels – St Peters – residential night-time

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]												
		SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06	SPI-07	SPI-08	SPI-09	SPI-10	SPI--11	SPI-12	SPI-13
Residential - Night-time														
NCA48	45	-	-	-	41	46	42	38	<30	-	-	-	-	-
NCA49	45	-	-	-	42	48	54	45	37	-	-	-	-	-
NCA50	49	-	-	-	34	43	45	36	<30	-	-	-	-	-
NCA51	44	-	-	-	<30	37	38	31	<30	-	-	-	-	-
NCA52	44	-	-	-	31	39	42	32	<30	-	-	-	-	-
NCA54	54	-	-	-	<30	32	33	<30	<30	-	-	-	-	-
NCA55	47	-	-	-	<30	35	33	<30	<30	-	-	-	-	-

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-137 Predicted worst case noise levels – St Peters – commercial

NCA	NML	Predicted LAeq(15minute) noise level (dBA)[1]												
		SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06	SPI-07	SPI-08	SPI-09	SPI-10	SPI--11	SPI-12	SPI-13
Commercial														
NCA48	70	47	53	53	33	41	39	32	<30	42	42	48	44	43
NCA49	70	50	58	56	39	43	41	37	<30	47	43	54	47	46
NCA50	70	57	61	64	39	49	58	44	35	61	62	67	55	59
NCA51	70	44	51	50	31	40	41	33	<30	46	46	53	41	44
NCA52	70	39	46	45	<30	33	32	<30	<30	38	35	46	36	36
NCA54	70	50	55	56	36	46	45	37	<30	46	52	52	47	49
NCA55	70	49	54	55	35	45	40	34	<30	42	47	49	46	47

Notes:

1. Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 5-138 Predicted worst case noise levels – St Peters – other sensitive receivers

NCA	NML	Predicted LAeq(15minute) noise level (dBA)												
		SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06	SPI-07	SPI-08	SPI-09	SPI-10	SPI--11	SPI-12	SPI-13
Other Sensitive														
NCA48	Refer to note 1	57	65	63	43	46	48	42	35	54	53	61	54	51
NCA49		-	-	-	-	-	-	-	-	-			-	-
NCA50		47	53	53	34	43	44	36	<30	46	51	52	44	47
NCA51		41	48	47	<30	35	36	<30	<30	39	32	47	38	39
NCA52		46	52	52	33	42	38	33	<30	44	46	46	43	44

Notes:

1. The NML is dependent on the classification of a given sensitive receiver. As the table represents the highest predicted noise level for a particular activity, the most affected “other sensitive” receiver may change between each activity depending on the location of the works. No NMLs can be provided in this table for “other sensitive receivers as result of the various types of “other sensitive” receivers within each NCA which may be affected by different activities.

Table 5-139 Overview of NML exceedances – St Peters

Activity ID	Activity	Weeks[1]	Activity duration within overall project program[2]				Number of receivers																	
							Total	Highly noise affected[4]	NML exceedance receiver count[3]															
									Daytime			Daytime (out of hours)			Evening			Night-time			Sleep disturbance		
			25	50	75	100			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
SPI-01	Installation of environmental controls (S	2					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-02	Pavement and infrastructure works	2					1311	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-03	Establishment of construction facilities	24					1311	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-04	On site car parking	4					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-05	Workshop, deliveries, maintenance, and storage	4					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-06	Spoil handling above ground within acoustic shed	72					1311	-	-	-	-	-	-	-	6	-	-	8	-	-	1	-	-
SPI-07	Onsite truck movements	72					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
SPI-08	Tunnelling support	72					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-09	Ventilation building installation	72					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-10	Lane configuration changes (Ramp)	8					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-11	Construction of tunnel cut cover (outside acoustic shed)	8					1311	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-12	Site rehabilitation and Landscape	12					1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-13	Cumulative	72					1311	-	-	-	-	-	-	-	8	-	-	23	1	-	1	-	-

Notes:

1. Approximate overall duration of the activity in all areas of the Site. The duration of these impacts is less than the overall duration, and depends on the rate of progress in the works areas
2. Approximate percentage (to nearest 13%) of activity duration within overall proposal program. Where percentage is less than 13%, 13% is shown for illustrative purposes
3. Based on worst case noise works area (closest to receivers)
4. Based on ICNG definition (ie predicted LAeq(15minute) noise at residential receiver is 75 dBA or greater)

The above tables show that:

- The highest NML exceedances are predicted to be during works spoil handling above ground within acoustic shed (SPI-06) and the construction of the tunnel cut cover (outside) of the acoustic shed (SPI-11)
- The largest impacts are predicted in NCA49 where receivers are situated in relatively close proximity to the works site.

NML exceedances

Highly noise affected residential receivers

The ICNG considers residential receivers that are subject to predicted noise levels of 75 dBA or greater to be Highly Noise Affected. No residential receivers are predicted to be classified as highly noise affected within this study area.

Other sensitive receivers

Other sensitive receivers, such as educational facilities, hospitals and childcare centres, which are potentially affected by construction works have been assessed against the various criteria detailed in **section 4.1.2.**

The predicted NML exceedances for other sensitive receivers are summarised in **Table 5-140**. The assessment provides further context to the predicted worst case noise levels presented in **Table 5-138** as it presents the number of and type of receivers predicted to experience exceedances of the NMLs, summarised in bands of 10 dBA.

Table 5-140 Overview of other sensitive receiver NML exceedances – St Peters

Works ID	Activity	Number of other sensitive receivers exceeding NMLs														
		Education			Medical			Place of Worship			Childcare			Outdoor Recreational		
		1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
SPI-01	Installation of environmental controls (S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-02	Pavement and infrastructure works	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
SPI-03	Establishment of construction facilities	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
SPI-04	On site car parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-05	Workshop, deliveries, maintenance, and storage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-06	Spoil handling above ground within acoustic shed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-07	Onsite truck movements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-08	Tunnelling support	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-09	Ventilation building installation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-10	Lane configuration changes (Ramp)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-11	Construction of tunnel cut cover (outside acoustic shed)	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
SPI-12	Site rehabilitation and Landscape	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPI-13	Cumulative	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The above table shows that only one outdoor recreational receiver (Sydney Park) is predicted to experience a minor exceedance of the NML (less than 10 dB).

NCA summary

The following section discusses key potential construction noise impacts in this area only. All works scenarios in this area have been assessed and are presented in **Annexure F-6**.

NCA48

- The cumulative scenario (SPI-13) is predicted to result in exceedances of up to 5 dBA at 15 receivers. Exceedances of the cumulative works scenario are dominated by operations within the site shed (SPI-06). By controlling noise emissions from this activity, the exceedances of the overall cumulative assessment would be reduced.

NCA49

- Operations within the site shed (SPI-06) are predicted to result in exceedances of up to 10 dBA at eight receivers during night-time operations. Of the eight receivers predicted to experience exceedances, six would experience an exceedance greater than 5 dBA. The expected duration of these works is up to 72 weeks and as such mitigation should be considered for these impacts. Further investigation into the acoustic performance of the site shed is provided in the following sections
- The cumulative scenario (SPI-13) is predicted to result in exceedances of up to 11 dBA at nine receivers. Exceedances of the cumulative works scenario are dominated by operations within the site shed (SPI-06). By controlling noise emissions from this activity, the exceedances of the overall cumulative assessment would be reduced.

NCA50 to NCA55

- No exceedance of the project NMLs are predicted due to the significant separation between the works and sensitive receivers.

Sleep disturbance

Review of the predicted $L_{A1(1minute)}$ exceedances at the nearest noise sensitive receivers provided in **Annexure F-6** indicates that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring adjacent to residential receivers.

At this early stage in the project, the assessment has included predictions of maximum noise impacts for assessment of potential sleep disturbance, however, it is noted that the ICNG only requires the project to consider maximum noise levels where construction works are planned to extend over more than two consecutive nights.

An OOHW protocol will be developed as part of the project wide CNVMP to set parameters around how works outside standard daytime construction hours will be carried out, including timing and frequency, and the mitigation measures that will be implemented based on predicted impacts identified through location and activity specific assessments. The OOHW protocol will be developed in consultation with DP&E and the NSW EPA.

Mitigation

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG and CNVG. Standard mitigation measures to be considered appropriate for the project are shown in **Table 4-13**.

Where feasible and reasonable, mitigating impacts via means of source and or path control are preferred, where possible.

Based on the noise impact assessment of the proposed works, the recommended project-specific mitigation measures (in addition to the standard suite of measures **Table 4-13**) are summarised in **Table 5-141**.

Table 5-141 Recommended site specific noise mitigation measures – St Peters

Activity	Mitigation description	Reason	Recommendations
SPI-06	Use structures such as site sheds and or hoarding to shield residential receivers from works activities.	Exceedances have been identified during all time periods for operations within the site shed.	Basic sheet steel shed construction was considered during the unmitigated predictions. It is recommended that an acoustic enclosure be included for the Campbell Road civil and tunnel site.

Predicted noise levels with mitigation

Additional noise predictions have been made to evaluate the likely performance of the recommended in-situ mitigation measures, such as increasing the height of hoarding around the construction ancillary facilities. The effectiveness of the recommended management based mitigation measures, such as limiting the use of noisy equipment to daytime hours, can been seen by referring to the NML exceedances for individual works scenarios and time periods in **Annexure F-6**.

The in-situ mitigation measures investigated are:

- Upgrading the acoustic shed performance.

The minimum transmission loss of the acoustic shed including operable elements is noted below in **Table 5-142**. It should be noted that where residual impacts are predicted following the inclusion of the upgraded shed, further investigation should be undertaken during detailed design.

Table 5-142 Acoustic shed acoustic performance – St Peters

Indicative upgraded shed construction	Octave band transmission loss (dB)						
	63	125	250	500	1000	2000	4000
Double Leaf: (1 x 0.48mm Steel) - 202mm Steel Stud + 75mm Fibreglass 32 kg/m³ - (1 x 0.42mm Steel)	10	12	24	36	46	55	61

Table 5-143 provides the predicted distribution of exceedances (at night-time) both 'with' and 'without' the recommended mitigation for receivers within this study area.

Table 5-143 NML exceedance distribution with and without mitigation – St Peters

Activity ID	Activity	Time period	Number of receivers with NML exceedance					
			Without Mitigation			With Mitigation		
			1 to 10 dBA	11 to 20 dBA	>20 dBA	1 to 10 dBA	11 to 20 dBA	>20 dBA
SPI-10	Spoil handling inside acoustic shed	Night	8	-	-	1	-	-
SPI-13	Cumulative	Night	24	1	-	24	-	-

Table 5-143 indicates that with the inclusion of in-situ mitigation measure in selected areas, a reduction of impacts is expected.

Noise contours are presented in **Annexure F-6** and represent the max predicted noise level for each construction scenario and includes in-situ mitigation measures.

Managing residual impacts

Additional noise mitigation measures to be considered during the preparation of location and site specific assessments (CNVIS) that would be used to identify potentially affected receivers and select appropriate mitigation measures (particularly during OOHW) are described in the Roads and Maritime CNVG and are reproduced in **Table 4-14**.

Additional mitigation measures as per the requirements of the CNVG have been determined for each works scenario during standard daytime construction hours and for works at night-time where they are scheduled to occur. The counts assume that noise intensive plant items are in use during the daytime and night-time periods and include in-situ mitigation measures.

Maps showing the location of the receivers identified for additional mitigation in the daytime and night-time period are provided in **Annexure F-6**.

Table 5-144 CNVG additional noise mitigation counts – St Peters

NCA	Number of receivers eligible for additional mitigation				
	Standard daytime	Night-time (OOHW period [2])			
	N,V	N	V,N,R2,NR	V,IB,N,PC,SN,R2,DR	AA,V,IB,N,PC,SN,R2,DR
NCA48	-	-	-	-	-
NCA49	-	1	-	-	-
NCA50	-	-	-	-	-
NCA51	-	-	-	-	-
NCA52	-	-	-	-	-
NCA54	-	-	-	-	-
NCA55	-	-	-	-	-

Notes;

1. See **section 4.6.2** for descriptions of the various additional mitigation measures

Consecutive construction impacts

The CNVG recognises that mitigation measures aimed at short term works may be less effective where longer term impacts are apparent and requires additional consideration of reasonable and feasible management measures to minimise impacts on the community.

When evaluating the extent of noise impacts within the St Peters area, it is noted that this area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved and currently under construction New M5 project. This project, together with the M4-M5 Link, tie in to the St Peters interchange in St Peters, where receivers will likely be exposed to extended impacts associated with the construction of these infrastructure projects, which would likely occur consecutively.

Works in the St Peters area are assumed to follow those outlined in the EIS for the New M5 project, generally consisting of the following activities:

- Pavement and infrastructure works
- Tunnelling and supporting activities
- Car parking
- Landscaping.

These type of activities therefore have general similarities with the works proposed for the M4-M5 Link and involve similar construction activities for both projects.

The indicative construction program for the New M5 and M4-M5 Link are shown below in **Table 5-145**.

Table 5-145 Indicative construction program – St Peters

Project	2016				2017				2018				2019				2020				2021				2022			
	Q				Q				Q				Q				Q				Q				Q			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
New M5				■	■	■	■	■	■	■	■	■	■	■	■													
M4-M5 Link											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

The impacts discussed in this report (refer to **section 5.7**) consider the duration of the M4-M5 Link project in isolation, whereas the potential impacts from the identified consecutive projects are likely to be perceived to be longer for receivers near to Campbell Road. The short-term noise intensive works are generally associated with discrete activities which occur over a number of days or weeks in moving locations rather than throughout the entire project at fixed locations. Therefore, the focus of assessing consecutive impacts is to identify works activities which repeat (or are similar to other activities) over extended periods. The longer-term impacts associated with compound activity may continue between separate projects in the area and may appear to be of a similar nature to the community.

Excluding short-term works such as pavement and utility works, receivers located within NCA48 and NCA49, which front Campbell Road, are predicted to experience up to 10 dBA exceedances of the project NMLs (in the night-time period) during construction of the M4-M5 Link project. While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to significant noise impacts from the New M5 project.

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, if options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be appropriately considered when preparing the site specific CNVIS for this area. Feasible and reasonable considerations for providing at receiver treatments should include:

- Time of day of the impacts and exceedance of criteria
- Time of impacts at the affected receivers
- How long the mitigation will provide benefit to the receiver during the project
- Optimal design of acoustic sheds, noise barriers/hoarding and management measures to reduce the impacts as far as practicable.

Due to the variability of construction noise, it is envisaged that community input through the consultation phase would provide appropriate information to assist the project to address potential consecutive noise impacts from construction projects in this area.

5.6.3 Construction road traffic noise

The forecast maximum daily heavy and light vehicles associated with the construction works at this site are presented in **Table 5-146**. The maximum daily flows have been used in the assessment in order to provide a conservative assessment.

Table 5-146 Construction traffic forecast – St Peters

Site	Maximum daily construction road traffic movements forecast during works[1,2]	
	Heavy	Light
C10 - Campbell Road civil and tunnel site	133	70

Notes:

1. One direction flows. The assessment assumes all movements require an additional return trip
2. 15-hour and 9-hour flows have been estimated assuming that the daily volumes are distributed evenly throughout the period

The proposed haulage routes are presented in **Table 5-147** along with the assessment of predicted increase in noise impacts, based on the maximum daily forecast number of vehicle movements in a day added to the existing vehicle volume data, where this data is available for the road in question.

Table 5-147 Construction road traffic noise assessment – St Peters

Site	Vehicle type	Road	Predicted traffic noise increase (dBA)[1]	
			Daytime	Night-time
C10 - Campbell Road civil and tunnel site	Light & heavy	Campbell Street	<0.5	1.5

Notes:

1. Existing traffic noise levels based on traffic modelling undertaken by SMC and/or AADTs where available

The information above indicates that construction traffic is unlikely to result in a noticeable increase in LA_{eq} noise levels at receivers along the proposed routes.

With regard to potential night-time maximum noise events, construction traffic on the major roads are unlikely to significantly increase the number of maximum noise events due to the relatively high existing traffic volumes on these roads.

The traffic management plan and site inductions should include instructions for operation of vehicles entering and leaving the sites in order to minimise noise. It is recommended that planned truck marshalling areas, where required, be located away from residences in order to minimise noise impacts due to trucks idling near the sites.

Mitigation and management measures

The following measures are recommended, and should be confirmed during detailed design:

- As far as practicable, limit heavy vehicle movements outside of standard construction hours associated with construction works to access and egress directly to and from the major road network
- Appropriate training should be provided to contractors in order to minimise noise when entering and leaving the sites.

5.6.4 Ground-borne noise

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, dive structures and tunnel stubs, are being undertaken as part of the New M5 project works.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

As such, the nature of the construction works at the Campbell Road civil and tunnel site (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

5.6.5 Vibration

Vibration intensive works at the Campbell Road civil and tunnel site such as demolition of existing buildings, piling works and rock-breaking are approved to be undertaken by the New M5 project, and as such, are not considered further in this assessment.

If vibration intensive works are required, a site specific vibration assessment should be undertaken by the contractor prior to the commencement of works.

Vibration from tunnelling works associated with construction of the mainline tunnel alignment is assessed in **section 5.7**.

5.7 Mainline tunnel alignment

No surface works associated with the mainline tunnel alignment would occur outside of the areas discussed in **section 5.1** to **section 5.6** and therefore the impacts at receivers for the construction of the mainline tunnel alignment would be limited to ground-borne noise and vibration.

5.7.1 Ground-borne noise

Predicted ground-borne noise levels

Figure 5-33 shows the approximate tunnel depths (from ground elevation to the tunnel crown) for the project alignment and illustrates that the tunnel depth varies from a few metres below ground in the vicinity of the tunnel portals, to up to around 65 metres below ground at the deepest points.

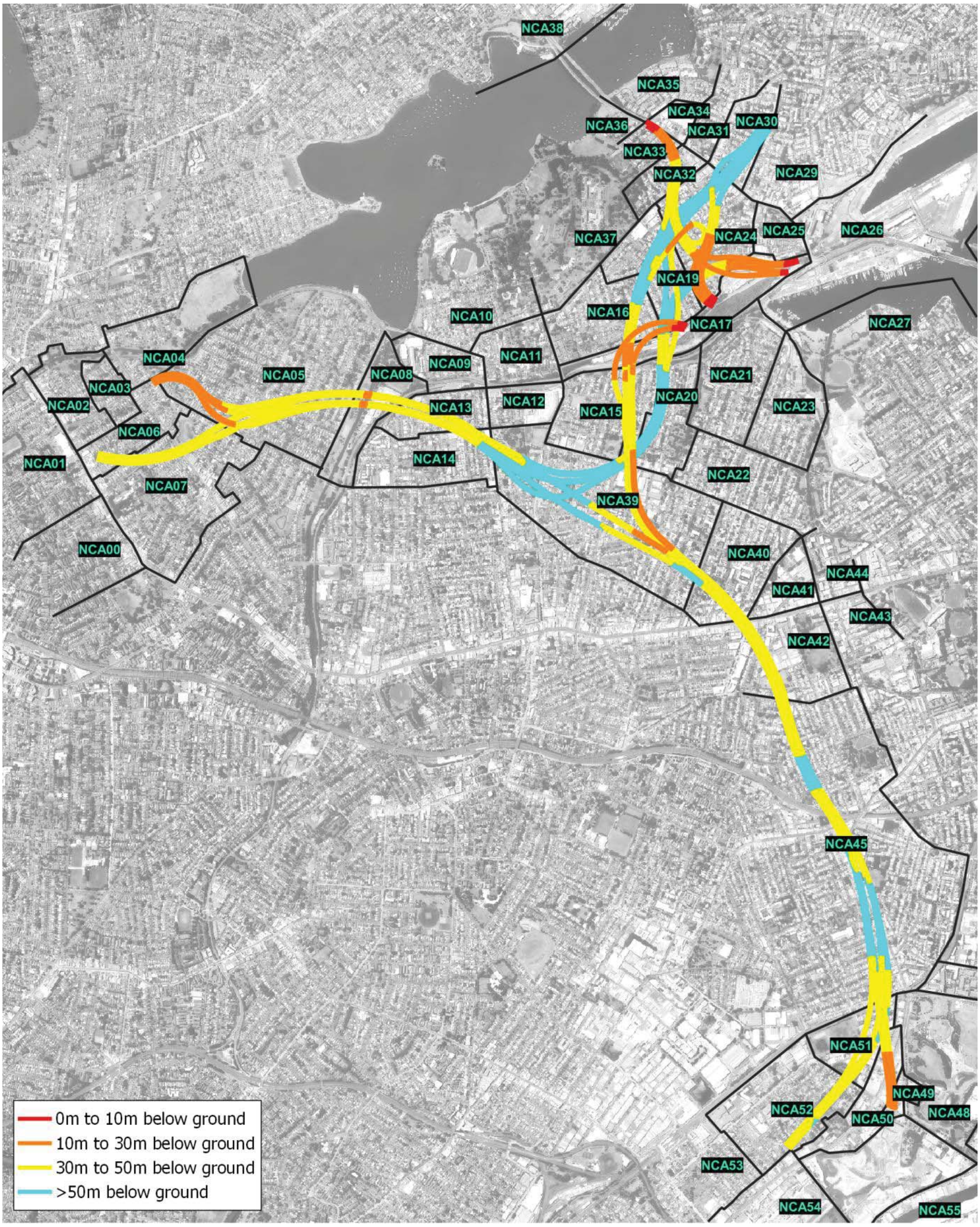


Figure 5-33 Approximate tunnel depths below existing ground elevation

The ground-borne noise assessment is based on the worst case predicted L_{Aeq} internal ground-borne noise level when the tunnelling works are at their closest point below each receiver.

Given the progression rate of the road-header works (proposed to be around 20-25 metres per week), it is anticipated that the worst case ground-borne noise impacts along the majority of the alignment would only be apparent for a relatively short period of time (ie several days for each road-header) while the tunnelling works are directly beneath a particular sensitive receiver.

As the works progress and move away, a particular receiver's exposure to ground-borne noise would notably reduce. This concept is illustrated in **Figure 5-34**, which shows the likely internal ground-borne noise levels from road-header excavation works as they progresses past a particular location.

The figure indicates that the night-time NML of 35 dBA $L_{Aeq(15minute)}$ is likely to be exceeded at a particular location as each road-header passes for the following approximate durations:

- 14 days where a slant distance of around 20 metres from the tunnels is apparent
- 17 days where a slant distance of around 15 metres from the tunnels is apparent
- 19 days where a slant distance of around 10 metres from the tunnels is apparent.

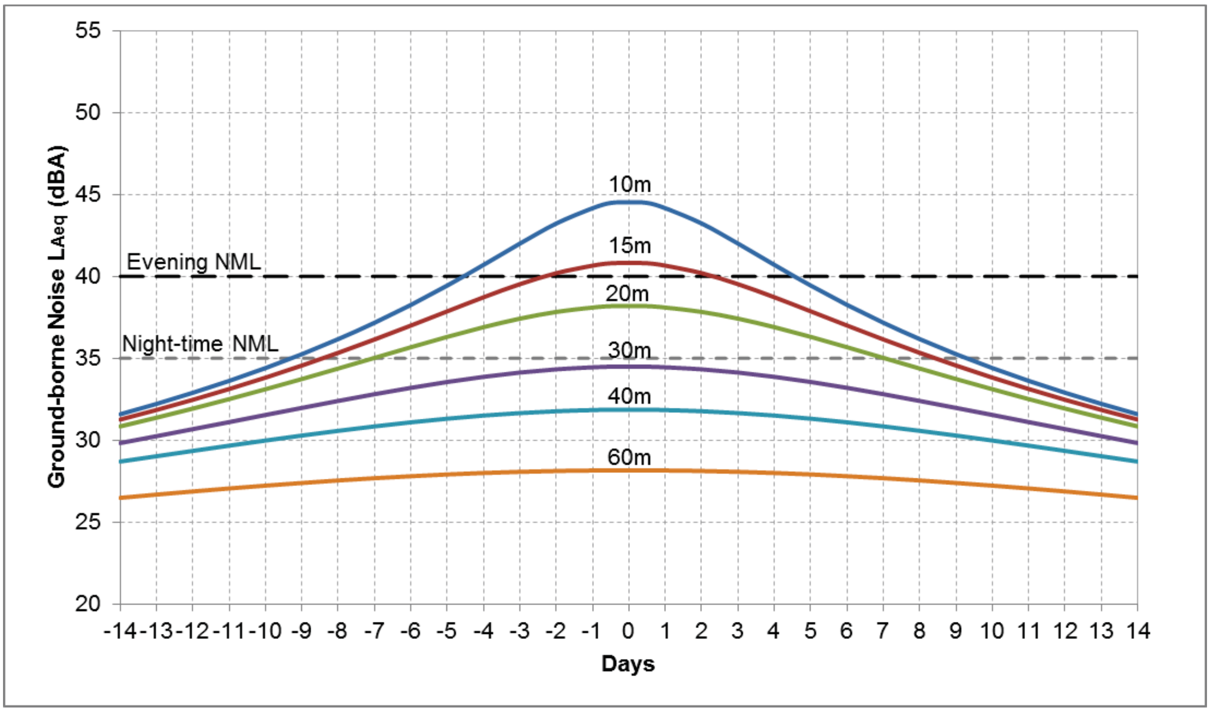


Figure 5-34 Ground-borne noise levels at slant distances from road-heading (progress = 20 m/week)

While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Table 5-148 summarises the maximum ground-borne noise levels from road-header tunnelling works. Ground-borne noise contour maps are provided in **Annexure I**. The exceedances listed in **Table 5-148** assume that the tunnelling works will occur 24 hours a day, and therefore consider potential exceedances of the more stringent night-time ground-borne NMLs.

Table 5-148 Worst case predicted ground-borne noise levels during tunnelling – mainline tunnel alignment

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA00	<20	-	-	-
NCA01	22	-	-	-
NCA02	21	-	-	-
NCA03	<20	-	-	-
NCA04	33	-	-	-
NCA05	44	46	-	-

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA06	34	-	-	-
NCA07	33	-	-	-
NCA08	-	-	-	-
NCA09	<20	-	-	-
NCA10	<20	-	-	-
NCA11	<20	-	-	-
NCA12	24	-	-	-
NCA13	33	-	-	-
NCA14	31	-	-	-
NCA15	35	1	-	-
NCA16	42	47	-	-
NCA17	-	-	-	-
NCA18	-	-	-	-
NCA19	45	45	-	-
NCA20	36	6	-	-
NCA21	<20	-	-	-
NCA22	<20	-	-	-
NCA23	<20	-	-	-
NCA24	45	132	1	-
NCA25	35	1	-	-
NCA26	-	-	-	-
NCA27	<20	-	-	-
NCA28	<20	-	-	-
NCA29	30	-	-	-
NCA30	30	-	-	-
NCA31	24	-	-	-
NCA32	37	7	-	-
NCA33	42	22	-	-
NCA34	33	-	-	-
NCA35	34	-	-	-
NCA36	26	-	-	-
NCA37	-	-	-	-
NCA38	<20	-	-	-
NCA39	37	42	-	-
NCA40	33	-	-	-

NCA	Worst case ground-borne noise level at a residential receiver (dBA $L_{Aeq(15minute)}$)	Number of residential receivers where criteria are exceeded	Number of other sensitive receivers where criteria are exceeded	Number of commercial receivers where criteria are exceeded
NCA41	25	-	-	-
NCA42	34	-	-	-
NCA43	<20	-	-	-
NCA44	<20	-	-	-
NCA45	33	-	-	-
NCA46	<20	-	-	-
NCA47	-	-	-	-
NCA48	29	-	-	-
NCA49	44	22	-	-
NCA50	41	17	-	-
NCA51	34	-	-	-
NCA52	32	-	-	-
NCA53	<20	-	-	-
NCA54	22	-	-	-
NCA55	<20	-	-	-

The worst case ground-borne noise levels are predicted to be compliant with the more stringent 35 dBA $L_{Aeq(15minute)}$ night-time criterion at the majority of receivers which are potentially affected by ground-borne noise from tunnelling works.

At residential locations greater than a slant distance of 30 metres from the nearest tunnel (ie taking into account the tunnel depth and the horizontal offset distance), exceedances of the ground-borne NML of 35 dBA $L_{Aeq(15minute)}$ during night-time periods are unlikely. At several locations however, the tunnel depth at receivers directly above the proposed alignment is less than 30 metres. The potential ground-borne noise impacts at these locations are discussed below:

In Haberfield in NCA05 (near Wattle Street, north of Martin Street), where the tunnel ramps climb to meet with the Wattle Street tunnel stubs, 46 receivers above this section are predicted to experience ground-borne noise levels above the night-time criteria. Ground-borne noise levels up to around 44 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Based on a progression rate of 20 metres per week, the most affected receivers are likely to experience noise levels above the night-time criterion for up to around 19 days for each road-header.

In the vicinity of the Rozelle interchange, primarily in NCA16, NCA19 and NCA24 (primarily to the north of Lilyfield Road and around Catherine Street) where the tunnel ramps climb to meet City West Link at ground elevation, 225 receivers above this section are predicted to experience ground-borne noise levels above the night-time criteria. Ground-borne noise levels up to around 45 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Based on a progression rate of 20 metres per week, the most affected receivers are likely to experience noise levels above the night-time criterion for up to around 19 days for each road-header. Due to the number of tunnels being constructed in this area the duration of impacts may extend in these locations due to consecutive construction works, as discussed in **section 5.3.4**.

In the vicinity of the Iron Cove Link tunnel portals in NCA32 and NCA33 (south of Victoria Road between Toelle Street and Cambridge Street), where the tunnel ramps climb to meet Victoria Road at ground elevation, 29 receivers above this section are predicted to experience ground-borne noise levels above the night-time criteria. Ground-borne noise levels up to around 42 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Based on a progression rate of 20 metres per week, the most affected receivers are likely to experience noise levels above the night-time criterion for up to around 17 days for each road-header.

In Annandale in NCA20 and NCA39 (between Moore Street, Catherine Street, Reserve Street and Annandale Street), where the tunnels veer to the north towards the Rozelle interchange, 48 receivers above this section are predicted to experience ground-borne noise levels above the night-time criteria. Ground-borne noise levels up to around 37 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Based on a progression rate of 20 metres per week, the most affected receivers are likely to experience noise levels above the night-time criterion for up to around 12 days for each road-header.

In the vicinity of the St Peters interchange in NCA49 and NCA50 (west of Sydney Park), where the tunnel ramps climb to meet the St Peters tunnel stubs, 39 receivers above this section are predicted to experience ground-borne noise levels above the night-time criteria. Ground-borne noise levels up to around 44 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Based on a progression rate of 20 metres per week, the most affected receivers are likely to experience noise levels above the night-time criterion for up to around 19 days for each road-header.

At all of the above locations, the ground-borne noise predictions are based on the nearest sensitive receivers above or adjacent to the proposed tunnel alignment. The ground-borne noise impacts would reduce for sensitive receivers offset horizontally from the proposed alignment due to the increased slant distance. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Managing ground-borne noise impacts

There are numerous receivers along the tunnel alignment where predicted ground-borne noise levels exceed the night-time NML (see **Table 5-148**). Consideration of mitigation is therefore required noting that these exceedances are generally predicted to last no more than three weeks at any one receiver. With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

There are two residential receivers in NCA19 and three residential receivers in NCA24 (in the vicinity of the tunnels portals from City West Link) where ground-borne noise levels have the potential to exceed the night-time NML by 10 dBA. At these receivers, the following mitigation measures should be considered in addition to those outlined above:

- Individual briefings to inform the residents about the impacts of the works and mitigation measures that will be implemented. Where the resident cannot be met with individually then an alternative form of engagement should be used
- Respite periods may be offered to the affected residents during works where noise levels are predicted to exceed the NML by 10 dBA or more
- Alternative accommodation options may be offered to the affected residents for the periods where noise levels are predicted to exceed the NML by 10 dBA or more.

The specific management strategy for addressing potential impacts associated with ground-borne noise outside of standard daytime construction hours will be documented in the OOHW protocol.

Sydney Metro tunnels

The tunnels for the Sydney Metro project pass above the M4-M5 Link tunnels in the vicinity of Lord Street, Newtown. At this location, the Metro tunnels are located around 20-25 metres below ground level, and the M4-M5 Link tunnels are located around 35-45 metres below ground level.

The depth of the M4-M5 Link tunnels is sufficient that ground-borne noise from the road-headers is unlikely to exceed the night-time noise criteria at the nearest receivers. Cumulative impacts from the M4-M5 Link road-headers and the Metro tunnel-boring machines (TBM's) are unlikely as the Metro TBM's would be dominant due to their shallower depth and higher vibration output. Additionally, it is unlikely that the TBM's and road-headers would both be working in this location concurrently.

As such, it is considered unlikely that there will be ground-borne noise impacts at this location due to the M4-M5 Link project.

5.7.2 Vibration

No sensitive receivers are located within the minimum working distances for road-headers during tunnelling works for the mainline tunnel alignment. As such, vibration impacts associated with tunnelling works are expected to be negligible.

Sydney Water Pressure Tunnel

The M4-M5 Link mainline tunnels are expected to pass with clearances of 12 metres and 11 metres from the Sydney Water Pressure Tunnel and the Sydney Water City Tunnel, respectively.

Both tunnels are critical infrastructure and their close proximity to the tunnelling works warrants an assessment of the impacts of vibration. These tunnels are also listed on the State heritage register.

For the purpose of the vibration assessment, the tunnels are considered to be cement lined steel pipes and the space between the pipes and surrounding rock has been filled with blue metal aggregate concrete. The Pressure Tunnel is made of 2.5 metre diameter mild steel pipe segments, each 2.7 metres long, which are joined and the City Tunnel is a continuously welded 2.1 metre diameter steel pipe. The water tunnels are located within a shale ground type.

DIN 4150 gives guideline values for evaluating the effects of vibration on buried pipework. The values are listed in **Table 5-149**. The values given may be reduced by 50 per cent without further analysis when effects of long-term vibration on buried pipework are considered. Adopting this reduction, a safe vibration threshold of 40 mm/s is obtained for the tunnels.

Table 5-149 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Pipe Material	Guideline values measured on pipe (mm/s)
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

Due to the lack of information on the condition of the cement liner and the liner to steel interface and the fact that the condition of the pipelines cannot be visually observed, a reduction of the vibration threshold presented above by around half to a PPV of 25 mm/s in the frequency bandwidth of 1 Hz to 100 Hz is recommended. It should be noted that the effects of densification or block movement caused by vibration have not been considered. These effects require assessment from a geotechnical engineer.

The excavation of the M4-M5 Link tunnels will be undertaken by road-headers, with the use of rock-breakers in certain situations. Based on the safe working distances presented in **Table 4-12**, indicative vibration levels at 11 metres (ie the proposed minimum distance between the Sydney Water pressure tunnel and the works) are:

- Small hammer <5 mm/s
- Mid hammer 5 mm/s
- Large hammer 18.5 mm/s
- Road-header <5 mm/s.

For a safe vibration threshold for the tunnels of 25 mm/s, the safe working distance is less than the anticipated offsets. As such adverse impact from the effects of direct vibration is deemed unlikely.

Royal Prince Alfred Hospital

The Royal Prince Alfred Hospital (RPA) is located either side of Missenden Road in Camperdown, in NCA43. The hospital houses a variety of equipment which may be sensitive to vibration from tunnelling activities.

The proposed mainline tunnel alignment passes to the west of RPA. The nearest RPA building to the tunnel alignment is the Camperdown Child and Family Clinical Services building. This is located around 450 metres to the east of the nearest point tunnelling works for the project. The next closest RPA buildings are around 600 metres to the east of the nearest point of tunnelling works.

5.7.3 Rock-breaking and blasting

It is understood that blasting and/or rock-breaking is proposed to excavate benches, cross passages and other voids within the tunnel sections of the project. There is potential for ground-borne noise and vibration impacts from these activities where receivers are situated above the tunnel.

Reference to the proposed tunnel depth presented in **Figure 5-33** indicates that the depth of cover varies across the project area.

As such, cross passage locations excavated by rock-breakers are likely to exceed the night-time ground-borne noise criterion of 35 dBA where residential receivers are located above. As a guide, the following ground-borne noise levels are likely from rock-breakers working at various distances from receivers:

- A slant distance of 20 metres results in around 61 dBA
- A slant distance of 40 metres results in around 47 dBA
- A slant distance of 60 metres results in around 39 dBA.

While it is noted that the predicted ground-borne noise from a rock-breaker is notably higher than a road-header at an equivalent distance, there is generally more scope to schedule rock-breaking during less sensitive time periods.

Detailed ground-borne noise predictions would be undertaken by the contractor during detailed design to determine the likely impacts from these activities. These assessments would form part of the Construction Noise and Vibration Impact Statements (CNVIS) for tunnelling activities.

As blasting required for the project would be conducted within the mainline tunnel, airborne noise and airblast overpressure impacts would be negligible at sensitive receivers in the project area.

While the proposed blasting may generate audible ground-borne noise at receivers above tunnelling works, assessment of impulsive blasting, typically conducted as a single event, against the ICNG slow weighted 15-minute L_{Aeq} criteria is not appropriate.

In order to estimate the level of ground vibration resulting from the subject tunnel blasting, the blast vibration “site law” developed from blasting the northern section of the Sydney Harbour Tunnel was employed. Geotechnical conditions for the Sydney Harbour tunnel project included sandstone rock which is considered comparable to the worst case conditions anticipated for tunnelling works on this project.

The subject site law for ground vibration is:

PVS (mm/s) = 135(R/Q0.5)-1.08

where,

PVS = Peak Vector Sum ground vibration level (mm/s)

R = Distance between charge and receiver (m)

Q = Charge mass per delay detonator (Maximum Instantaneous Charge (MIC) - kg)

Based on the above vibration site law and a typical 30 metre depth of cover, the predicted level of vibration for an MIC of 10 kg is 12 mm/s.

Measured blast emissions data indicates a dominant frequency of the vibration signal of around 20 Hz at an offset of 30 metres.

Reference to **Table 4-6** in **section 4.1.5** indicates a transient vibration guide value for the prevention of cosmetic building damage of 26 mm/s.

Where the subject building is a heritage listed item, and is considered to be structurally unsound, reference to **Table 4-7** in **section 4.1.50** indicates a transient vibration guide value for the prevention of cosmetic building damage of 4 mm/s.

The corresponding guide value for human comfort is a maximum of 10 mm/s (see **section4.1.5**). Compliance with a ground vibration level of 10 mm/s is predicted to be achieved by using an MIC of around 7 kg.

Blasting recommendations

Blasting has the potential to significantly reduce the noise and vibration impacts if managed appropriately by the contractor. Blasting is proposed as an excavation technique because the vibration impacts from blasting are of a much shorter duration for nearby sensitive receivers compared to the vibration impacts associated with mechanical excavation methods such as road-headers and rock-breakers.

If blasting is proposed by the contractor, vibration impact predictions for blasting operations should be undertaken in the detailed design phase when more information is available on the blasting scope and methods. Blasting specific noise and vibration mitigation methods should be incorporated into the CNVMP.

Blasting should be restricted to standard daytime hours only (except where approved by the relevant authority). Site investigations should be conducted prior to production blasting to define suitable blast sizes and site laws to comply with project blasting noise and vibration criteria. Dilapidation studies of nearby receiver buildings may be required where potential for exceedances of the blasting criteria are identified.

Should the predicted levels exceed the noise or vibration criteria, alternative construction and/or blasting methods would need to be considered such as penetrating cone fracture.

Other blasting methods

Electronic Detonation Blasting

In electronic detonation blasting (EDB), a delay applied electronically to the detonation of a series of small charges, resulting in a succession of small blasts. An integrated circuit chip and a capacitor internal to each detonator control the initiation time of the detonation. Generally EDB reduces the overall vibration level (peak particle velocity) and increases the frequency of the vibration event – both of which are desirable when considering the construction vibration criteria.

Specific details on the vibration events generated by this type of blasting are not available as the technique is proprietary and vibration information is not generally publically available. The use of this blasting technique is potentially feasible, however the manufacturer's data should be confirmed with independent testing / review before commencement on site.

It is understood that the EDB technique has been utilised on a number of construction projects in Australia such as the Brisbane Airport Link Project.

Penetrating Cone Fracture

The Penetrating Cone Fracture (PCF) technique has successfully been utilised on a number of construction sites in Sydney, including at the Westfield site in Bondi Junction.

Rock can be fractured by the introduction of a pulse of high pressure gas at the base of a short drill-hole. The generated gas penetrates into small micro fractures created from the percussive drilling process. These micro fractures are forced to expand and propagate into tensile cracks causing the rock to fail.

A cartridge filled with a specially formulated propellant produces gas by deflagrating when the propellant is ignited. Because the gas is confined down the hole in a very small volume, very high gas pressure is generated when the propellant is ignited.

A direct comparison between similar weights of explosive and propellants has indicated that the energy released by a PCF cartridge is around 45 per cent that of the energy of a similar size explosive charge (using traditional detonation). The difference in energy required to break the same amount of rock between PCF and conventional blasting is because PCF utilises tensile breakage rather than compressive breakage, which is generally more energy efficient.

Since PCF utilises pressurised gases from deflagrating propellant to break rock, the method does not produce a shock wave that is characteristic of high explosives. PCF cartridges are described as deflagrating products rather than detonating explosives.

Vibration levels induced by PCF are generally lower when compared to explosives of the same weight, using tradition detonation techniques. Manufacturer's data shows that at six metres vibration levels of less than 3 mm/s peak particle velocity are observed in very hard rock (30 – 50 MPa). Importantly, the frequency of the vibration generated has been shown to be typically above 100 Hz and often over 500 Hz. Vibration of this frequency and level is unlikely to have any detrimental effect even on sensitive heritage buildings, so may be appropriate for use at this site. The manufacturer's data should be confirmed with independent testing / review before commencement on site.

5.8 Utility works

Construction works associated with utility relocation and diversion works would likely be required at most compounds addressed in **Sections 5.1** to **5.6**. Works would also be required along various streets in the vicinity of the compounds and within associated work areas to allow access to and modification of utilities.

The extent and location of the utility works that would be required as part of the project is currently being investigated and will be confirmed during the development of the detailed design and construction methodologies. The types of equipment that would be required to carry out the utility works would likely comprise of typical ground excavation items, such as excavators, vacuum trucks, boring and directional drilling machines, concrete saws, rock-breakers, etc.

The M4-M5 Link project is preparing a utility management strategy which aims to outline the key utility works currently proposed as part of the M4-M5 Link project along with discussing a range of potential environmental impacts generally associated with utility adjustment.

5.8.1 Assessment

An assessment of the potential noise levels from the likely plant items associated with utility works undertaken outside of the general project footprint are provided in **Table 5-150**. Noise levels have been predicted at various offset distances to give an indication of the possible impacts with line of sight to the works.

It would be anticipated that noise impacts would be similar to the pavement and infrastructure works activity assessed within each construction ancillary facility in **Sections 5.1** to **5.6.**

Table 5-150 Potential noise levels from utility works

Equipment	Predicted noise level at distance ($L_{Aeq(15minute)}$ dBA)			
	15 m	30 m	50 m	70 m
Vacuum truck	84	78	74	71
Directional drilling	76	70	66	63
Concrete saw[1]	85	79	75	72
Excavator	77	71	67	64
Excavator (breaker)[1]	86	80	76	73
Hand tools	62	56	52	49

Notes:

1. Assumed to be working for 7.5 minutes in worst case 15 minute period

The above table shows that relatively high noise impacts (>75 dBA) are likely where noise intensive plant items are required near to adjacent receivers. On typical streets surrounding the construction ancillary facilities, residential receivers are situated around 15 metres from the road. In this situation, noise levels as high as 86 dBA are possible when noise intensive plant items are in use immediately adjacent to sensitive receivers.

Utilities are often within or immediately adjacent to trafficable parts of the road networks. As such, lane occupancies are often required to facilitate utility adjustment work. To maintain the operational integrity of the surrounding road network, utility adjustment work must often be carried out outside of standard daytime construction hours when traffic volumes are much lower. Night-time NMLs in the vicinity of most construction ancillary facilities are in the region of 40 to 50 dBA. As such, exceedances of greater than 30 dBA above NML are possible where noise intensive plant items are in use during utility adjustment work carried out during the night-time period.

During construction, noise impacts associated with utility works would be of a temporary nature and would move progressively along the utility service corridor, resulting in impacts at particular receivers for only a limited period of time.

Mitigation

Mitigation measures for the utility works would be determined when further information regarding the extent and locations of the works is known. Potential noise impacts would be managed by adopting standard management measures which would be outlined in a CNVMP. Location and activity specific noise assessments would be carried out prior to utility works required outside standard daytime construction hours to identify potentially affected receivers and the additional mitigation measures from the CNVG that would be implemented. Potential sleep disturbance impacts would also be considered within location and activity specific noise assessments.

The main measures for managing potential noise impacts from utility works involve noise source mitigation. **Table 5-151** below presents examples of noise source mitigation measures which should be considered where utility works are required.

Table 5-151 Examples of noise source mitigation measures

Mitigation measure	Details
Use and siting of noise intrusive plant	When assigning utility works locations, the offset distance between noisy plant and adjacent sensitive receivers should be maximised. Only plant necessary to the works should be on site, and noise intrusive plant should be directed away from sensitive receivers where possible.
Equipment selection	Use quieter and less vibration emitting methods where feasible and reasonable. Ensure plant, including the silencer, is well maintained.
Non-tonal and ambient sensitive reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction ancillary facilities	Loading and unloading of materials/deliveries is to occur as far as possible away from sensitive receivers. Select site access points and roads as far as possible away 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 out of hours movements where possible.
Equipment selection (including rented equipment)	Use quieter construction methods where feasible and reasonable. Ensure all equipment is well maintained. Noise emissions from rented plant and equipment should be considered prior to use.
Site inductions / behavioural practices	Information regarding all noise intrusive plant and equipment planned for or currently at site which has the potential to impact nearby sensitive receivers should be included in mandatory site inductions given to all employees, contractors and subcontractors. The inductions should include: • Permissible hours of work and site opening/closing times • Locations of nearest sensitive receivers • Any limitations on high noise producing equipment, plant and activities • Clear instructions regarding the mobility and parking of vehicles on site • Permissible delivery periods • No swearing or unnecessary shouting or loud stereos/radios onsite • No dropping of materials from height, throwing of metal items and slamming of doors.

Mitigation measure	Details
Mobile acoustic enclosure or use of localised hoarding around noise generating plant items 	Where feasible, reasonable and practicable, portable acoustic enclosures should be erected around noise intrusive plant, particularly that which does not require constant mobility.
Construction respite period during normal and out of hours work	The CNVG recommends that high noise generating activities near receivers should be carried out in continuous blocks that do not exceed three hours each, with a minimum respite period of one hour between each block. The duration of each block of work and respite should be flexible to accommodate the usage and amenity at nearby receivers.
Scheduling of construction hours and activities	Where feasible and reasonable, construction should be carried out during standard daytime working hours. Work generating high noise levels should be scheduled less sensitive time periods. For works outside standard daytime construction hours, the use of equipment with potential to generate high noise impacts (such as concrete saws and rock-breakers) should be scheduled and carried out as early as possible in the work shift, wherever practicable.

6 Assessment of operational impacts

6.1 Introduction

Operational road traffic impacts have been predicted where surface works associated with the project would occur. This corresponds to noise catchments NCA 15 to NCA 37 (see **section 3.2**).

All floors of multi-storey receiver buildings are included in the assessment and evaluated against the applicable noise criteria. It is noted that the assessment counts each floor in a multistorey dwelling as a separate receiver, for example a two storey residential building would count as two receivers.

6.2 Operational road noise predictions without mitigation

With reference to **section 4.8.2**, the approach taken in this assessment is to assess noise impacts as a result of the operation of the project by considering the '*Do Nothing'* scenario to represent the No Build (ie 'without project') impacts and the '*Do Something'* scenario to represent the Build (ie 'with project') impacts.

Predicted noise levels for the assessed scenarios are shown in **Annexure K** and **Annexure L** for the No Build and Build (without mitigation) scenarios, respectively.

The 'without mitigation' noise predictions identify receivers which qualify for consideration of additional noise mitigation, where noise level exceedances are predicted.

6.2.1 Change in noise levels without mitigation

Noise predictions throughout the study area indicate that receivers adjacent to the project are subject to existing road traffic noise impacts which exceed the NCG controlling criterion in many cases, as shown in the No Build scenarios in **Table 6-1**.

Table 6-1 Receivers over the NCG controlling criteria without mitigation

NCA	Receiver type	Floor	2023 No build		2023 Build		2033 No build		2033 Build	
			Day	Night	Day	Night	Day	Night	Day	Night
NCA15	All	All	76	76	72	70	77	76	70	70
NCA16	All	All	149	134	133	118	152	138	137	124
NCA17	All	All	0	0	0	0	0	0	0	0
NCA18	All	All	2	2	0	0	2	2	0	0
NCA19	All	All	262	227	195	184	266	233	201	187
NCA20	All	All	28	23	15	7	28	28	15	10
NCA21	All	All	270	222	242	208	333	246	250	226
NCA22	All	All	130	129	130	130	130	130	130	130
NCA23	All	All	133	125	145	134	140	131	153	149
NCA24	All	All	487	453	472	440	492	467	479	447
NCA25	All	All	286	268	293	281	290	274	293	290
NCA26	All	All	0	0	0	0	0	0	0	0
NCA27	All	All	32	45	71	200	41	85	71	222
NCA28	All	All	0	0	0	0	0	0	0	0
NCA29	All	All	224	220	211	207	228	222	211	209
NCA30	All	All	190	180	169	159	195	180	170	160
NCA31	All	All	201	173	200	172	201	173	201	172
NCA32	All	All	92	72	89	70	92	73	89	72
NCA33	All	All	54	45	61	52	56	52	63	57
NCA34	All	All	106	103	95	90	108	104	96	92
NCA35	All	All	317	301	316	298	319	304	316	301
NCA36	All	All	54	52	40	39	54	54	39	39
NCA37	All	All	66	0	66	0	69	0	65	0
NCA38	All	All	0	0	0	0	0	0	0	0
NCA39	All	All	41	40	41	41	41	41	41	41
NCA40	All	All	63	53	64	54	63	54	64	55
All	**All**	**All**	**3263**	**2943**	**3120**	**2954**	**3377**	**3067**	**3154**	**3053**

Notes:

1. Predicted noise levels at receivers which are above the NCG controlling criteria do not necessarily qualify for additional noise mitigation. As per the discussion in **section 4.7.2**, further criteria are used to determine which of those receivers are eligible for additional noise mitigation measures

The predicted change in noise levels (Build minus No Build) for the controlling year 2033 (daytime) across the study area is summarised in **Figure 6-1**.

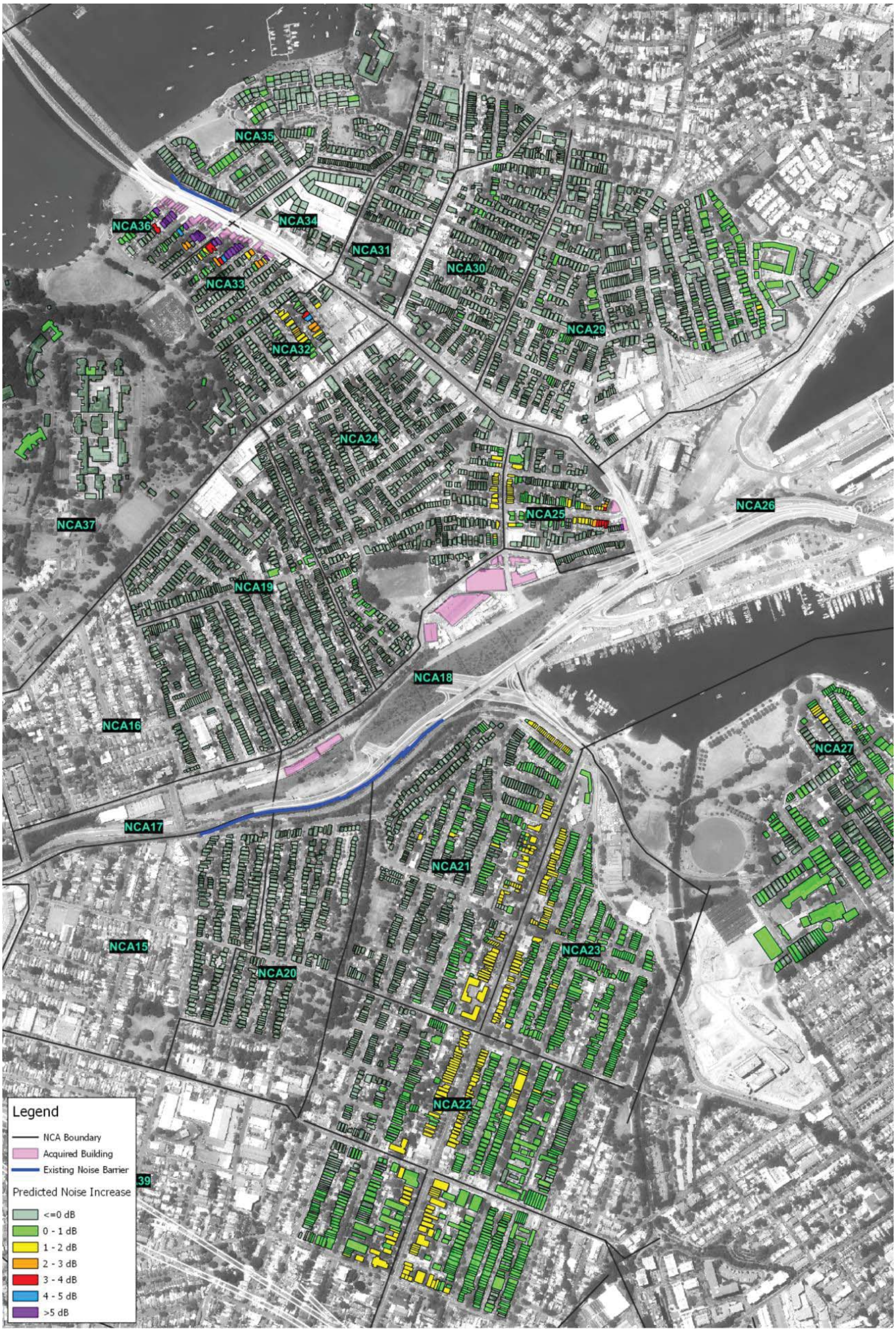


Figure 6-1 Predicted change in noise levels (Build minus No Build) without mitigation

Notes:

1. Predicted noise levels increases are for 2033 daytime scenario and are at ground floor level
2. As per the discussion in **section 4.7.2**, further criteria are used to determine which receivers are eligible for additional noise mitigation measures

The information presented in **Table 6-1** and **Figure 6-1** indicates that:

- The project is predicted to result in an overall decrease in the number of receivers with an exceedance of the NCG criteria across the study area as a whole during both the daytime and night-time periods, in both 2023 and 2033. This is mainly due to forecast reductions in traffic volumes on some parts of the surface road network as a result of the project (ie moving vehicles from surface roads to the tunnels)
- The project is predicted to result in a reduction in noise levels for around 60 percent of the receivers within the study area
- A minor (less than 2.0 dBA) increase in noise levels is predicted at around 40 per cent of the receivers. This magnitude of noise increase is noted in the RNP as being unlikely to be perceptible by the average person
- Less than 1 per cent of the receivers are predicted to experience an increase of more than 2.0 dBA due to the project
- Marginal increases (1 to 2 dBA) are seen on The Crescent and parts of Johnston Street, and also on Gordon Street, which is associated with increased volume due to redistribution of traffic
- The realignment of The Crescent and City West Link intersection results in a reduction of the existing noise barrier (around 90 metres in length), which due to localised shielding provided by the light rail embankment results in only a minor increase in noise levels in this area (near to Bayview Crescent)
- Significant reductions in noise (up to around -4 dBA) are identified along sections of Victoria Road in Rozelle, where the project is forecast to significantly reduce traffic numbers
- Large increases in noise (up to around +15 dBA) are identified in NCA33 and NCA36 (on the southern side of Victoria Road at Iron Cove in the vicinity of the proposed Iron Cove Link tunnel portals) and NCA25 (near the new Victoria Road bridge), where the project results in traffic lanes being moved closer to receivers, in combination with removing existing screening due to property acquisitions. These predicted increases are generally limited to the receivers which have partial or direct line of sight to Victoria Road once the acquired buildings are demolished. This location would be assessed further during development of the detailed design to identify appropriate noise mitigation measures to address these large predicted increases. The measures that would be considered would include low road noise pavement, noise barriers, at-property treatments and the project design.

The relatively minor change in noise levels at the majority of receivers means that the requirement for the project to consider additional noise mitigation in most areas is due to high existing noise levels (ie cumulative limit exceedances).

6.2.2 Receivers considered for additional noise mitigation

Predicted noise levels at receivers which are above the NCG controlling criteria (see **Table 6-1**) do not necessarily qualify for additional noise mitigation. As per the discussion in **section 4.7.2**, consideration of reasonableness is used to decide which of those receivers are eligible for additional noise mitigation measures.

Maps showing the location of receivers identified for consideration of additional noise mitigation are presented in **Annexure M** and are also listed in **Annexure P**. Noise level increase contours (all scenarios) are also shown on these maps.

Further discussion of the project noise impacts (without mitigation) is presented in **Table 6-2**.

Table 6-2 Receivers considered for additional noise mitigation by NCA

NCA	Receiver type	Receiver floors (buildings)	Comments
NCA15	Residential	7 (7)	An existing retained noise barrier on the southern side of City West Link provides mitigation in this area. Receivers are triggered due to cumulative limit exceedances.
	Other	-	
NCA16	Residential	-	No triggers in this NCA.
	Other	-	
NCA17	Residential	-	No triggers in this NCA.
	Other	-	
NCA18	Residential	-	No receivers (or triggers) in this NCA.
	Other	-	
NCA19	Residential	13 (6)	Triggered receivers situated adjacent and at higher elevation to Lilyfield Road. Receivers are triggered due to cumulative limit exceedances.
	Other	-	
NCA20	Residential	-	No triggers in this NCA.
	Other	-	
NCA21	Residential	17 (17)	Triggered receivers situated on Bayview Crescent on top of the embankment to the west of The Crescent, near to light rail line. Receivers are triggered due to mixed triggers (both cumulative limit exceedances and acute impacts).
	Other	1 (1)	
NCA22	Residential	-	No triggers in this NCA.
	Other	-	
NCA23	Residential	1 (1)	Minor increases predicted along The Crescent and Johnston Street, although only one triggered receiver due to greater than 2.0 dBA increase as a result of the project.
	Other	-	
NCA24	Residential	-	Other receiver is a medical facility (Balmain Sports Medicine) situated on Lilyfield Road. Receiver is triggered due to cumulative limit exceedance.
	Other	1 (1)	

NCA	Receiver type	Receiver floors (buildings)	Comments
NCA25	Residential	151 (70)	Catchment adjacent to the new Victoria Road bridge. Significant increases in noise are predicted due to the new road alignment being closer to receivers and properties fronting Victoria Road being acquired and demolished. The other receivers are an educational facility (Sydney Community College), a place of worship (15 Quirk St Rozelle) and a childcare centre (Rosebud Cottage Childcare Centre).
	Other	6 (3)	
NCA26	Residential	-	No receivers (or triggers) in this NCA.
	Other	-	
NCA27	Residential	-	Other sensitive receivers triggered due to cumulative limited exceedances are an educational facility (St Scholastica's College) and a place of worship (Sze Yup Temple).
	Other	15 (9)	
NCA28	Residential	-	No triggers in this NCA.
	Other	-	
NCA29	Residential	-	Other sensitive receivers triggered due to cumulative limited exceedances are a childcare centre (Ku Phoenix Preschool) and a medical facility (Well Adjusted Chiropractic).
	Other	3 (2)	
NCA30	Residential	-	No triggers in this NCA.
	Other	-	
NCA31	Residential	-	Other sensitive receivers triggered due to cumulative limit exceedances are an educational facility (Rozelle Public School).
	Other	8 (5)	
NCA32	Residential	3 (2)	Receivers are triggered due to mixed triggers (both cumulative limit exceedances and acute impacts).
	Other	-	
NCA33	Residential	23 (21)	Catchment to the south of the widened section of Victoria Road, near the tunnel portals. Significant increases in noise are predicted due to the new road alignment being closer to receivers and front row properties are acquired.
	Other	-	
NCA34	Residential	8 (5)	Receiver is triggered due to mixed triggers (both cumulative limit exceedances and acute impacts).
	Other	-	

NCA	Receiver type	Receiver floors (buildings)	Comments
NCA35	Residential	127 (23)	Catchment to the north of the widened section of Victoria Road, near the tunnel portals. While a minor noise reduction is predicted here due to the northbound lanes of the road moving further away, receivers are triggered here due to mixed triggers (both cumulative limit exceedances and acute impacts) at the multi-storey residential apartments.
	Other	1 (1)	
NCA36	Residential	33 (21)	Catchment to the south of the widened section of Victoria Road, near the tunnel portals. Significant increases in noise are predicted due to the new road alignment being closer to receivers and removal of existing buildings fronting Victoria Road.
	Other	1 (1)	
NCA37	Residential	-	Other sensitive receivers triggered due to cumulative limited exceedances are an educational facility (Sydney College Of The Arts).
	Other	12 (4)	
NCA38	Residential	-	No triggers in this NCA.
	Other	-	
NCA39	Residential	-	No triggers in this NCA.
	Other	-	
NCA40	Residential	-	No triggers in this NCA.
	Other	-	
ALL	**Residential**	**383 (173)**	-
	Other	**48 (27)**	
	TOTAL	**431 (200)**	

In summary, the above table shows that a total of 431 receivers (200 individual buildings) are predicted to have exceedances of the operational road traffic noise criteria for the project and are therefore considered eligible for consideration of additional noise mitigation.

The 431 exceedances fall into the following categories:

- The predicted Build noise level exceeds the NCG controlling criterion and the noise level increase due to the project is greater than 2 dBA. A total of 29 receivers are triggered on this criterion alone
- The predicted Build noise level is 5 dBA or more above the criteria (exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project. A total of 155 receivers are triggered on this criterion alone
- Where the noise level contribution from the road project is acute (daytime $L_{Aeq(15hour)}$ 65 dBA or higher, or night-time $L_{Aeq(9hour)}$ 60 dBA or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road. No receivers are triggered on this criterion alone
- There are 247 receivers triggered due to a mix of the above criteria
- The NCAs with the most triggered receivers are NCA25, NCA33, NCA35 and NCA36. These catchments are at Iron Cove an adjacent to Victoria Road.

Other sensitive receivers

The above table shows that 48 other sensitive receivers (27 individual buildings) are predicted to have exceedances of the operational road traffic noise criteria for the project and are therefore considered eligible for consideration of additional noise mitigation.

The other sensitive receivers that are eligible for consideration of additional mitigation (refer to **section 4.7.2**) are primarily located in NCA25, NCA27, NCA31 and NCA37.

Triggered receivers on all floors

Potential noise impacts have been assessed on all floors of all multi-storey buildings in the study area. The assessment shows that while the majority of the receivers identified as being eligible for consideration of additional noise mitigation are on first two floors of the affected receivers, there are a number of triggered receivers on floors three and above.

A summary of the number of triggers on each floor level are detailed below in **Table 6-3**.

Table 6-3 Receivers eligible for additional noise mitigation by floor

Floor	Triggers	Percentage of total triggers
		Individual floors
1	170	39%
2	104	24%
3	64	15%
4	40	9%
5	17	4%
6	18	4%
7	9	2%
8	9	2%
All	**431**	**100%**

Reference to the above shows that 64 per cent of the identified receivers are on the first two floors, with 15 per cent of the triggers being on level three, nine per cent being on level four, four per cent on level five, and eight per cent on floors six and above.

6.3 Cumulative operational road traffic noise assessment

To consider potential impacts of other major road projects and in response to concerns raised by local councils (**section 1.2**), potential cumulative operational noise impacts have also been evaluated. With reference to the traffic scenarios outlined in **section 4.8.2**, the cumulative operational assessment considers the assessment of impacts from the '*Do Nothing'* to '*Do Something Plus'* scenario to represent the impacts of the future cumulative traffic. This includes the following 'other key major projects' which may influence the traffic within the study area for the M4-M5 Link project.

- WestConnex Stage 1a – M4 Widening
- WestConnex Stage 1b – M4 East
- WestConnex Stage 2 – New M5
- WestConnex King Georges Road Interchange Upgrade.
- Other key projects have also been identified which are currently unapproved but in the early planning stage, these are:
  - Sydney Gateway
  - Western Harbour Tunnel and Beaches Link (Rozelle ramps not operational)
  - F6 Extension.

Most notable of these is the civil constriction of tunnels and entry and exit ramps connecting the M4-M5 Link mainline tunnels and Rozelle interchange to the proposed future Western Harbour Tunnel and Beaches Link. These elements are being constructed as part of the M4-M5 Link.

Maps showing the location of receivers which are predicted to exceed the NMG criteria (see **section 4.8.6**) in the cumulat**ive '***Do Something Plus'* scenario are presented in **Annexure N** and are also listed in **Annexure P**. A summary of the identified receivers in comparison to the *'Do Something'* scenario (accounting for both 2023 and 2033) is provided in **Table 6-4**.

Table 6-4 Cumulative noise assessment

NCA	Receiver type	Triggered receivers		Difference
		Do Something	Do Something Plus (cumulative scenario)	
NCA15	Residential	7	4	-3
	Other	-	-	-
NCA16	Residential	-	-	-
	Other	-	-	-
NCA17	Residential	-	-	-
	Other	-	-	-
NCA18	Residential	-	-	-
	Other	-	-	-
NCA19	Residential	13	11	-2
	Other	-	-	-
NCA20	Residential	-	-	-
	Other	-	-	-
NCA21	Residential	17	23	6
	Other	1	1	-
NCA22	Residential	-	-	-
	Other	-	-	-

NCA	Receiver type	Triggered receivers		Difference
		Do Something	Do Something Plus (cumulative scenario)	
NCA23	Residential	1	-	-1
	Other	-	-	-
NCA24	Residential	-	-	-
	Other	1	1	-
NCA25	Residential	151	127	-24
	Other	6	6	-
NCA26	Residential	-	-	-
	Other	-	-	-
NCA27	Residential	-	-	-
	Other	15	15	-
NCA28	Residential	-	-	-
	Other	-	-	-
NCA29	Residential	-	-	-
	Other	3	2	-1
NCA30	Residential	-	-	-
	Other	-	-	-
NCA31	Residential	-	-	-
	Other	8	8	-
NCA32	Residential	3	4	1
	Other	-	-	-
NCA33	Residential	23	23	-
	Other	-	-	-
NCA34	Residential	8	8	-
	Other	-	-	-
NCA35	Residential	127	127	-
	Other	1	1	-
NCA36	Residential	33	33	-
	Other	1	1	-
NCA37	Residential	-	-	-
	Other	12	14	2
NCA38	Residential	-	-	-
	Other	-	-	-
NCA39	Residential	-	-	-
	Other	-	-	-
NCA40	Residential	-	-	-
	Other	-	-	-

NCA	Receiver type	Triggered receivers		Difference
		Do Something	Do Something Plus (cumulative scenario)	
ALL	Residential	383	360	-23
	Other	48	49	1
	TOTAL	431	409	-22

In the cumulative scenario, the total number of receivers eligible for consideration of additional noise mitigation is predicted to decrease from 431 to 409 which is typically due to traffic being removed from surface roads and now using the M4-M5 Link (tunnels). The information presented in **Annexure M** and **Annexure N** indicates the following differences in impact between the Do Something and Do Something Plus traffic scenarios:

- More triggered receivers with the Do Something Plus scenario than the Do Something in NCA21 (south of City West Link) due to cumulative traffic volumes of potential future projects anticipated to add traffic to the surface section of the project in this area
- Less triggered receivers in the Do Something Plus scenario than the Do Something in NCA25 (adjacent to Victoria Road and Lilyfield Road) due to a reduction in traffic for this section
- Marginal differences between the scenarios elsewhere in the study area.

6.4 Additional noise mitigation – low noise pavement

The choice of road pavement surfaces and textures must meet a number of criteria including structural integrity, skid resistance, water shedding and design life as well as potential noise generating characteristics. The road pavement surface's noise performance throughout its duration and the need to maintain that performance by cleaning or replacing the pavement are also important considerations.

The noise assessment considers the use of quieter noise pavement in the form of dense graded asphalt across the extent of the project. The use of low noise pavement to further reduce road traffic noise at the source will be investigated during detailed design taking into account whole-of-life engineering considerations and the overall social, economic and environmental effects.

6.5 Additional noise mitigation – noise barriers

The noise barrier optimisation process is based on guidance in the NMG as discussed in **section 4.8.7**.

Noise barriers have been assessed where four or more triggers are apparent on the exceedance maps in **Annexure M** (based on the *'Do Something'* scenario – see **section 4.8.2**).

The optimisation results are detailed in **Annexure O** with the assessed barriers identified in **Figure 6-2** and recommendations summarised in **Table 6-5**. Noise barriers at Iron Cove (NW01 to NW03) have been assessed in two locations – one at roadside and one at the property boundary.

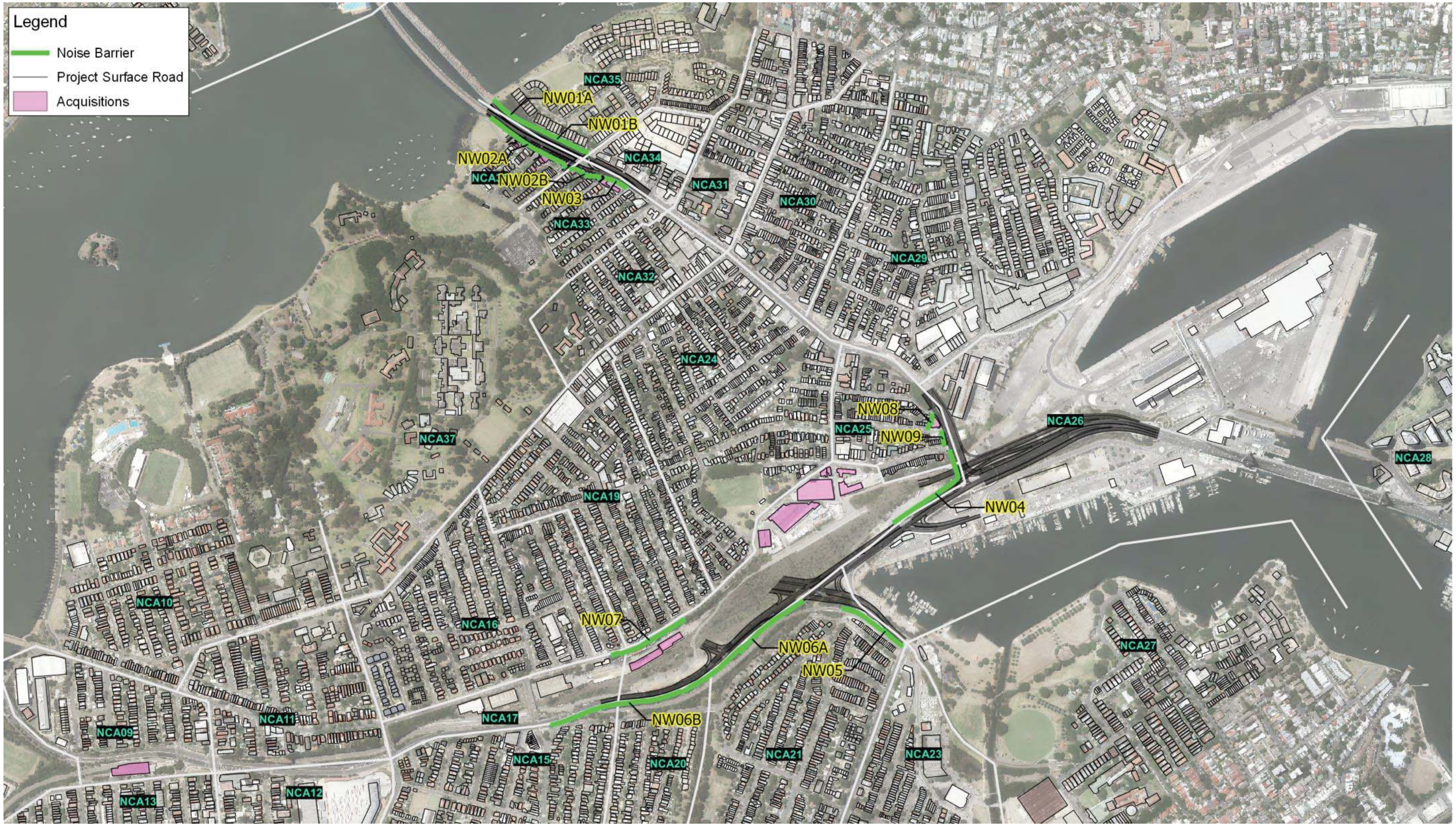


Figure 6-2 **Indicative noise barriers considered for analysis**

Table 6-5 Noise barriers considered in the study area

Barrier ID	Existing barrier height (m)[1]	Noise barrier details[2]					Comments[3]
		Type	Length (m)	Height (m)	Triggered receivers for no barrier	Remaining triggered receivers with barrier	
NW01A (Iron Cove North)	-	New	104	8	17	17	Optimised height is 8.0 m, however this height of barrier is not predicted to provide sufficient noise benefit to remove the need for any at-property treatments in this location and also does not meet the 10 dBA insertion loss requirement for barriers over 5 m (see **section 4.8.7**). The project may however want to consider a reduced height barrier (in the region of 3.5 m) which would provide a substantial benefit to a number of receivers located behind the barrier.
NW01B (Iron Cove North)	2.6	Existing	157	8	30	22[4] / 21[5]	Optimised height is 8.0 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The barrier does meet the 10 dBA requirement for barriers over 5 m (see **section 4.8.7**). A barrier in this location is not recommended for inclusion in the EIS design as such a large barrier is not likely to be feasible to construct close to the apartments due to urban design requirements. Noise mitigation measures will be further investigated during detailed design.
NW02A (Iron Cove South)	-	New	217	8[4] / 5.5[5]	33	22[4] / 10[5]	Optimised height for the roadside option is 8.0 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The barrier does meet the 10 dBA requirement for barriers over 5 m. Optimised height for the property boundary option is 5.5 m, which also meets the performance requirements. A barrier in this location is however not recommended for inclusion in the EIS design as, based on further consideration of what is feasible or reasonable in this location, the barrier may potentially sterilise future use of the adjacent land by restricting visibility and/or access. Therefore, at-property treatments are recommended for the triggered receivers instead of a barrier. To be further considered during detailed design. Noise mitigation measures will be further investigated during detailed design.

Barrier ID	Existing barrier height (m)[1]	Noise barrier details[2]					Comments[3]
		Type	Length (m)	Height (m)	Triggered receivers for no barrier	Remaining triggered receivers with barrier	
NW02B (Iron Cove South)	-	New	74	6.5[4] / 5[5]	13	4[4] / 4[5]	Optimised height for the roadside option is 6.5 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The indicative barrier meets the 10 dBA performance requirement for a barrier height over 5 m at the most benefitting receiver only (ie one receiver behind the indicative barrier). Optimised height for the property boundary option is 5 m which meets the 5 dBA performance requirement for a barrier height of up to 5 m. A barrier in this location is however not recommended for inclusion in the EIS design as, based on further consideration of what is feasible or reasonable in this location, the barrier may potentially impact future use of the adjacent land by restricting visibility and/or access. Noise mitigation measures will be further investigated during detailed design.
NW03 (Iron Cove South)	-	New	51	3.5[4] / 4.5[5]	6	4[4] / 2[5]	Optimised height for the roadside option is 3.5 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The indicative barrier meets the 5 dBA performance requirement for a barrier height of up to 5 m. Optimised height for the property boundary option is 4.5 m which meets the 5 dBA performance requirement for a barrier height of up to 5 m. A barrier in this location is however not recommended for inclusion in the EIS design as, based on further consideration of what is feasible or reasonable in this location, the barrier may potentially impact future use of the adjacent land by restricting visibility and/or access. Noise mitigation measures will be further investigated during detailed design.
NW04 (Victoria Road bridge)	-	New	258	5	39	38	Optimised height is 5.0 m, however this barrier achieves less than 5 dBA insertion loss and only removes one at-property treatment in this location. Noise contributions from access ramps in this area reduce the effectiveness of the barrier. A barrier in this location is therefore not recommended for the EIS design as the barrier is not considered reasonable.

Barrier ID	Existing barrier height (m)[1]	Noise barrier details[2]					Comments[3]
		Type	Length (m)	Height (m)	Triggered receivers for no barrier	Remaining triggered receivers with barrier	
NW05 (The Crescent)	-	New	171	4.5	16	1	Optimised height is 4.5 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The indicative barrier meets the 5 dBA performance requirement for a barrier height of up to 5 m. A barrier in this location is however not recommended for the EIS design as, based on further feasible and reasonable considerations, the barrier may impact on views from these properties in an easterly direction. Noise mitigation measures will be further investigated during detailed design.
NW06A (City West Link)	3	Existing	359	6	5	0	Optimised height is 6.0 m, however the indicative barrier does not meet 10 dBA performance requirement for a barrier height over 5 m. A barrier in this location is not recommended for the EIS design as the indicative barrier does not perform well, does not meet the performance requirements and is therefore not considered reasonable. It is recommended to retain the existing barrier in this location.
NW06B (City West Link)	3	Existing	399	8	4	4	A barrier in this location is not recommended for the EIS design as the indicative barrier is not predicted to provide sufficient noise benefit to remove the need for any at-property treatments in this location. It is recommended to retain the existing barrier in this location.
NW07 (Lilyfield Road)	-	New	197	8	4	4	This indicative barrier does not achieve the performance requirement for a barrier (see **section 4.8.7**) and is not predicted to provide sufficient noise benefit to remove the need for any at-property treatments in this location. A barrier in this location is not recommended for the EIS design as the indicative barrier is not considered reasonable. Noise contributions from Lilyfield Road limit the performance of the barrier by controlling the overall road traffic noise level at the receivers. Reduction of the project road noise has little or no effect on the overall noise levels.

Barrier ID	Existing barrier height (m)[1]	Noise barrier details[2]					Comments[3]
		Type	Length (m)	Height (m)	Triggered receivers for no barrier	Remaining triggered receivers with barrier	
NW08 (Victoria Road bridge)	-	New	36	7.5	11	7	Optimised height is 7.5 m as this height is identified as the lowest level in the points curve shown in **Annexure O** and therefore represents the design with potentially higher overall community benefit and reduced weighted cost. The indicative barrier meets the 10 dBA performance requirement for a barrier height over 5 m at the most benefitting receiver only (ie one receiver behind the indicative barrier). A barrier in this location is however not recommended for inclusion in the EIS design as, based on further consideration of what is feasible or reasonable in this location, the barrier may potentially impact future use of the adjacent land by restricting visibility and/or access. Noise mitigation measures will be further investigated during detailed design.
NW09 Victoria Road Bridge)	-	New	28	8	14	14	Optimised height is 8.0 m, however a noise barrier of this height is still not predicted to provide sufficient noise benefit to remove the need for any at-property treatments in this location. A barrier in this location is not recommended for inclusion in the EIS design as, based on further consideration of what is feasible or reasonable in this location, the barrier may potentially impact future use of the adjacent land by restricting visibility and/or access. Noise mitigation measures will be further investigated during detailed design.

Notes:

1. Existing height is the height of the existing or the replaced existing noise barrier (ie maintaining the same top of noise barrier height as the existing barrier)
2. Recommended height is subject to further considerations during detailed design such as construction limitations, overshadowing, urban design and community preference
3. However, as the preference for noise mitigation is to reduce outdoor noise level, a shorter noise barrier option is to be further considered during detailed design together with NW02A, NW02B and NW03 to achieve equitable outcomes across communities taking into account engineering and urban design considerations
4. For barrier located at the roadside
5. For barrier located at the property boundary

6.6 Discussion of at-property treatments

The noise barrier analysis undertaken for the project identifies that, of the noise barriers assessed, NW02a, NW02b, NW03 and NW05 (on the southern side of Iron Cove and at The Crescent) may provide a reasonable noise benefit, however based on further feasible and reasonable considerations, these barriers potentially have significant drawbacks from a community perspective (see **section 6.5**). The other barriers considered in the analysis, were not found to provide a reasonable noise benefit.

In relation to the possible noise barrier along the south side of Victoria Road (NW02a, NW02b and NW03), the following issues are to be considered in determining whether a noise barrier would be a feasible and reasonable option:

- Potential visual impacts
- Potential urban design impacts
- Potential community safety/crime prevention considerations such as isolated walkways
- Impacts of a barrier on traffic and pedestrian connectivity between Victoria Road and the local road network
- Potential overshadowing impacts
- Form of future development of the residual land which may itself provide a barrier to traffic noise
- Preferences of the local community as gauged during the community consultation phase.

The alternative to a noise barrier would be to install architectural treatments to address the predicted exceedances to the residential properties (see **section 4.7.2**). The preferred noise mitigation option (low noise pavement, noise barrier, architectural treatments, a combination or other) will be determined during detailed design taking into account whole-of-life engineering considerations and the overall social economic and environment benefits.

If detailed design investigation confirms the findings in this EIS, then at-property treatments for the triggered receivers summarised in **Table 6-6** would be considered instead of other noise mitigation measures. The counts presented in **Table 6-6** are the combined triggers from both the '*Do Something'* traffic scenario (see **section 6.2.2**) and the '*Do Something Plus'* traffic scenario (see **section 6.3**).

During detailed design, ownership details would be obtained for all receivers identified as eligible for consideration of at-property treatment. Once an internal inspection of the property is undertaken, consideration of the internal layout of habitable spaces and subsequently the most appropriate form of at-property treatment can be confirmed. This would also include confirmation of external criteria for other sensitive receivers on a case by case basis. External criteria for other sensitive receivers have been derived using a 10 dBA factor to convert internal to external noise levels (see **section 4.7.2**). For some non-residential receivers this assumption may be overly conservative as the facade area to window ratios are often larger when compared to residential receivers, or windows may not be openable and the internal criteria may be achievable without additional at-property treatment.

Maps showing the location of receivers identified for consideration of at-property treatment are presented in **Annexure Q**.

Table 6-6 Number of potential at-property noise treatments predicted for EIS design

NCA	Receiver floors[1]	Receiver buildings[2]
NCA15	7	7
NCA16	-	-
NCA17	-	-
NCA18	-	-
NCA19	14	7
NCA20	-	-
NCA21	24	24
NCA22	-	-
NCA23	1	1
NCA24	1	1
NCA25	157	73
NCA26	-	-
NCA27	15	9
NCA28	-	-
NCA29	3	2
NCA30	-	-
NCA31	8	7
NCA32	4	3
NCA33	23	21
NCA34	8	5
NCA35	128	25
NCA36	34	23
NCA37	14	4
NCA38	-	-
NCA39	-	-
NCA40	-	-
TOTAL	**441**[3]	**212**

Notes:

1. The count of receiver floors represents the separate floors within each building outline, however does not identify which of these are within the same dwelling (ie where two floors are under the same land title). Other sensitive outdoor areas are not included in the count
2. The count of individual buildings represents the outlines shown in **Annexure M** which approximates the vertical separations between terraces or units observed from aerial imagery, however does not account for separate dwellings within each building outline. This count essentially counts the roof outlines of each receiver. Other sensitive outdoor areas are not included in the count
3. This count is applicable to at-property treatment and therefore only includes buildings. Outdoor receivers (such as parks) are not included

6.7 Sensitivity analysis

A sensitivity analysis of the operational road traffic noise assessment and noise modelling methodology has been undertaken. This indicates how sensitive the mitigation requirements for this project are to a change in predicted noise levels. The likely change in the predicted number of receivers that are considered eligible for consideration of property treatment has been determined by applying a correction factor to the noise model predictions in 1 dBA increments. The sensitivity of the total number of at-property treatments to the modelling predictions is shown in **Figure 6-3**.

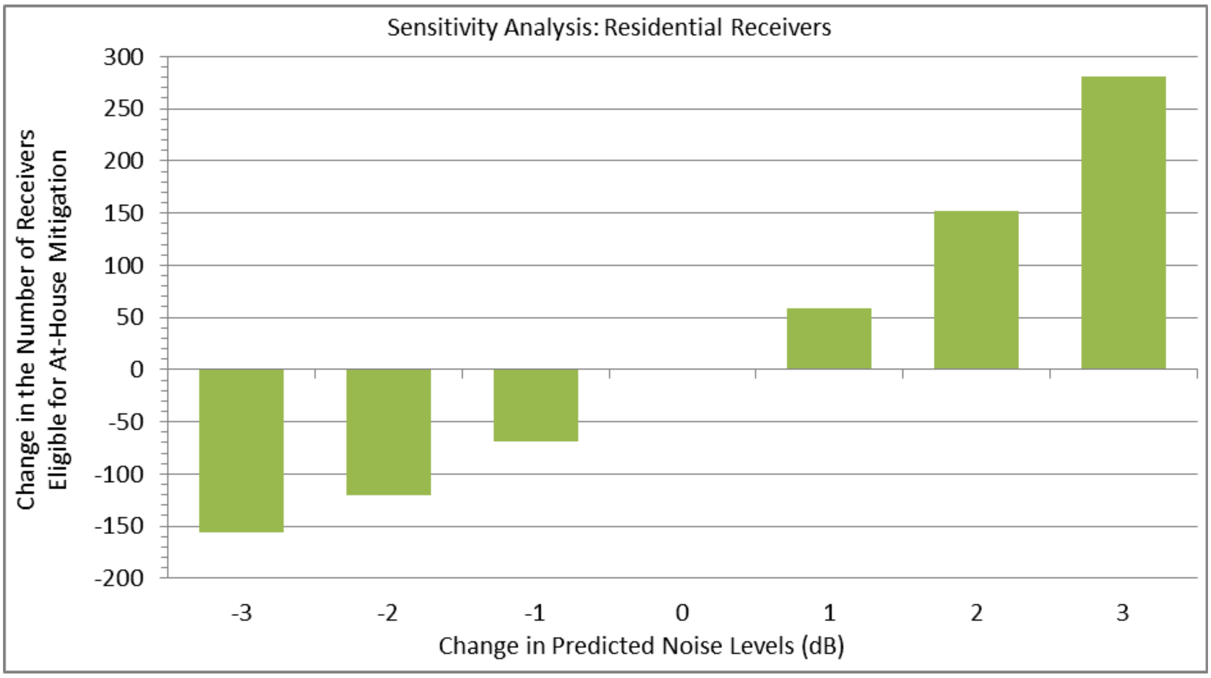


Figure 6-3 Noise model sensitivity analysis

Figure 6-3 indicates that an additional 59 receivers would be eligible for consideration of property treatment if a +1 dBA correction were to be added to the noise model predictions. A reduction of 69 receivers would be apparent if 1 dBA was subtracted from the noise model predictions.

It is recommended that the subsequent operational noise assessment undertaken during detailed design adopt, as a minimum, a sensitivity allowance of +1 dB(A) to account for uncertainty in the source emission input parameters.

6.8 Maximum road traffic noise levels

The representative results of the maximum noise level monitoring is provided in **Annexure R** which includes the maximum noise level range for the passby events in the existing situation during the period of monitoring (2016). A summary of the maximum noise level assessment is presented in **Table 6-7**.

Indicative increases in maximum noise levels have been predicted in the noise model using a source height corresponding to the approximate height of a truck exhaust.

Table 6-7 **Measured maximum noise level events**

Monitoring location	Monitoring dates	Total night-time events within the monitoring period	Measured maximum noise level (dBA L_{AFmax})	
			Range	Average
R.01	18/07/16 - 2/08/16	563	65-87	72
R.02	21/07/16 - 2/08/16	72	65-84	72
R.03	18/07/16 - 2/08/16	218	76-93	83
R.04	26/07/16 - 2/08/16	116	75-90	82
R.05	18/07/16 - 2/08/16	201	77-97	83
R.06	18/07/16 - 2/08/16	178	70-84	75
R.07	18/07/16 - 2/08/16	458	66-92	74
R.08	18/07/16 - 2/08/16	779	65-88	70
R.09	18/07/16 - 2/08/16	491	65-80	70
R.10	21/07/16 - 2/08/16	633	65-87	71
I.01	26/09/16 - 4/10/16	136	77-93	82
I.02	13/09/16 - 4/10/16	422	77-96	84

Table 6-7 shows that existing maximum noise level events typically range from 65 dBA to 90 dBA L_{AFmax} at the monitoring locations within the study area. Locations immediately adjacent to Victoria Road, City West Link and The Crescent were observed to have higher existing maximum noise levels as a result of the relatively short setback distances and no intervening screening.

Maximum noise level events towards the upper end of the range presented in **Table 6-7** are likely to be from heavy vehicle passbys, with light vehicles tending towards the lower end of the range.

Changes in the number of maximum noise events would be in line with general changes in traffic volumes forecast for the project.

The noise predictions indicate that maximum noise levels may increase at residential receivers in the following locations:

- NCA33 and NCA36 – Receivers south of Victoria Road adjacent to the Iron Cove Link tunnel portals. In this location, demolition of acquired buildings results in residences having line of sight to the widened Victoria Road where they were previously screened by existing buildings. Indicatively, typical increases of between 5 dBA and 10 dBA are predicted. A small number of receivers experience an increase of up to 18 dBA due to the removal of adjacent buildings. It is noted that some receivers in this catchment would be eligible for consideration of at-property treatments as part of the project (see **section 6.6**)
- NCA24 – Receivers west of Victoria Road at Rozelle. In this location, demolition of acquired buildings results in some residences having line of sight to Victoria Road where they were previously screened by existing buildings. Indicatively, typical increases of between 2 dBA and 10 dBA are predicted. A small number of receivers experience a higher increase due to the removal of adjacent buildings. It is noted that some receivers in this catchment would be eligible for consideration of at-property treatments as part of the project.

The change in maximum operational noise levels at receivers in other catchment areas is predicted to be negligible.

While it is noted that existing bus operations mean that the character of noise would not be expected to change, service frequency and final stop location may influence noise levels from bus operations and should be considered further during detailed design.

6.9 Operational road traffic noise assessment at Haberfield Option B

Property acquisitions or purchases of existing buildings (for demolition) would be required if the Haberfield Option B construction ancillary facilities, (Parramatta Road West civil and tunnel site (C1b) and Parramatta Road East civil site (C3b)) are selected. This would result in residential receivers that were previously screened from Parramatta Road (by these properties fronting Parramatta Road) being subject to reduced screening benefit.

Receivers which have been identified to triggered for consideration of additional noise mitigation are presented in **Figure 6-4**.

Figure 6-4 Haberfield Option B construction site – potential operational road traffic noise triggers

Figure 6-4 indicates that the removal of intervening shielding requires the consideration of additional noise mitigation at six residential receivers including multi-storey buildings.

In line with **section 4.7.2**, a preferred noise mitigation option (low noise pavement, noise barrier, architectural treatments, a combination or other) would be determined during detailed design should this option be selected.

6.10 Operational impacts at either end of project area

While no major permanent road infrastructure is proposed at either ends of the project as part of the M4-M5 Link, the future (2033 Build) traffic volumes (including other major Sydney road projects) may influence noise levels at adjacent receivers in these areas. Both ends of the M4-M5 Link interface with other stages of WestConnex; the M4 East project at Haberfield and the New M5 project at St Peters, both of which will significantly alter the road design in the respective areas.

As part of the EIS reports prepared for both the M4 East and the New M5, noise and vibration assessments were prepared to assess operational traffic noise on:

- The surface road network at Haberfield including Parramatta Road, Frederick Street/Wattle Street/Dobroyd Parade and Ramsay Street

- The surface road network at St Peters including Campbell Road, Princes Highway, Euston Road.

Both of these interfacing WestConnex projects (the M4 East and New M5 projects) are considered within the WestConnex program and as such considered a future forecast traffic scenario which included the M4-M5 Link (and other major Sydney road projects) as part of their EIS assessment of potential cumulative impacts. The cumulative scenario assessed for each of these interfacing project identified receivers which were subject to a perceptible increase in noise level of more than 2 dBA and exceeds noise criterion or where noise level remain 5 dBA above the noise criterion. Appropriate mitigation measures recommended to address these impacts can include the treatment of road surfaces, noise barriers and/or architectural treatments where feasible and reasonable.

6.10.1 Conditions of approval

The conditions of approval for both of the interfacing WestConnex projects require the proponent of each to undertake an Operational Noise and Vibration Review (ONVR) to confirm the operational noise predictions, impacts on receivers and the suitability of proposed mitigation measures. This review would be based on the final detailed design of each project and updated traffic modelling forecasts for the future traffic scenario as required by EPA *Road Noise Policy*.

Reference is made to the following Instrument of Approval for each project:

- M4 East: SSI 6307 dated 16 June 2017 (MOD 3)
- New M5: SSI 6788 dated 20 April 2016.

6.10.2 Potential changes – M4-M5 Link

For the M4-M5 Link, differences in the forecast traffic volumes on the surface road network at Haberfield and St Peters may occur as the result of a combination of factors including:

- Updated version of traffic model (WRTM v2.3)
- Updated land use, employment forecasts and future projects that form part of the cumulative operational scenario
- Changes in design of M4-M5 Link project.

The changes in forecast traffic volumes between the interfacing WestConnex projects and the M4-M5 Link and in turn differences in the operational noise assessments would be captured in a progressive manner by:

- The ONVRs being undertaken as part of the Minister’s Conditions of Approval (MCoA) for the M4 East project which is due to open in 2019 and the New M5 project which is due to open in 2020
- The ONVR that will be undertaken as part of the MCoA for the M4-M5 Link project (should that project be approved). The project is due to open in a staged manner in 2022 and 2023.

6.10.3 Mitigation for cumulative impacts

Consistent with the requirements of the NMG, the future forecast traffic volumes are required to be considered in the assessment of the final design for each project and are therefore expected to be addressed in the respective Operational Noise and Vibration Review (ONVR) for each interfacing project. This would be addressed through the following process:

- The Proponents of the M4 East and New M5 projects are required to review the suitability of the operational noise mitigation measures (refer to Condition E33 for the M4 East project and Condition E37 for the New M5 project)
- Under these conditions, the Proponent must implement the identified noise and vibration control measures of the final design and make the ONVR publicly available
- The Proponents for the M4 East and New M5 projects are also required to undertake operational noise and vibration monitoring to compare the actual noise and vibration performance of the SSI against the noise performance predicted in the Operational Noise and Vibration Review (refer to Condition E34 for the M4 East project and Condition E38 for the New M5 project)

- The Proponents for these projects must implement further feasible and reasonable mitigation measures (where required) as identified in the Operational Noise and Vibration Compliance Report in consultation with affected property owners (refer to Condition E35 for the M4 East project and Condition E39 for the New M5 project).

The Operational Noise and Vibration Compliance Report for each project is expected to include assessment of the final design with calibration of the noise model taking into account considerations such as traffic numbers and land use change (if applicable). It is therefore anticipated that any changes in design as well as forecast traffic in the as-built noise model would be used to evaluate the adequacy of noise mitigation measures during preparation of the Operational Noise and Vibration Compliance Report for each project (M4 East and the New M5).

6.11 Minor changes to project design

As with any large infrastructure project, minor design refinements are investigated as the project progresses through the design stages. Minor design changes can include reconfiguration of lane markings, provision of additional turning lanes, alteration and relocation of kerbs, etc.

The M4-M5 Link is currently evaluating the potential minor design changes in a number of locations, these include:

- Wattle Street / Parramatta Road / Frederick Street turning lane configurations
- Additional right hand turn lane on The Crescent at the intersection with Johnston Street
- Minor lane configuration changes at the St Peters interchange ramps.

As these design changes are not expected to change the volume of traffic and would be within the existing road reserves, the change to operational road traffic noise levels at adjacent receivers would be expected to be negligible.

Notwithstanding, the potential impacts from all design refinements associated with the project would be evaluated during detailed design when operational noise mitigation is reviewed prior to the project being constructed.

6.12 Fixed facilities operational noise impacts

6.12.1 Noise assessment

Noise impacts from the operation of the fixed facilities associated with the project have been predicted for the NCAs nearest to the facilities. These predicted noise levels are summarised in **Table 6-8** and shown on the noise contour maps in **Annexure S**.

Table 6-8 Predicted noise levels – fixed facilities

Area	NCAs	Noise level (dBA L_{Aeq})		
		Criteria	Predicted	Exceedance
Haberfield	NCA01	43	33	-
	NCA02	45	36	-
	NCA03	45	35	-
	NCA06	45	39	-
Darley Road	NCA09	45	41	-
	NCA13	45	45	-
Rozelle	NCA15	40	28	-
	NCA16	45	35	-
	NCA19	45	39	-
	NCA20	40	34	-

Area	NCAs	Noise level (dBA L_{Aeq})		
		Criteria	Predicted	Exceedance
	NCA21	45	39	-
	NCA24	45	34	-
	NCA25	45	33	-
	NCA27	45	24	-
Iron Cove	NCA33	45	57	12
	NCA34	45	40	-
	NCA35	45	42	-
	NCA36	45	39	-
St Peters	NCA46	45	20	-
	NCA48	45	30	-
	NCA49	45	41	-
	NCA50	45	34	-
	NCA51	44	28	-

The above results assume the presence of existing noise barriers in the Rozelle and Iron Cove areas, and the noise barriers that are being constructed in the Haberfield area as part of the M4 East project.

The above results indicate that the assessed fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the Haberfield, Darley Road, Rozelle and St Peters areas.

The selected mechanical equipment for each facility, and in particular Iron Cove Link MOC4, would be reviewed and assessed against the relevant operational noise criteria at the detailed design stage of the project. Specific plant would be selected and designed to achieve compliance with the relevant criteria. The cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

6.12.2 Modifying factors

The indicative source levels have not been found to trigger the requirement to correct the predicted noise level due to low frequency or tonal components. Notwithstanding, tonal and/or low frequency noise is often observed from fans and the predictions would be revisited during detailed design based on the actual specifications of the final selection of equipment. Based on the assessment presented in this report, receivers in NCA09, NCA13, NCA34, NCA35 and NCA49 have been identified as most likely to exceed the criteria specified in **Table 6-8** should application of a +5 dBA correction be triggered (see **section 4.7.3**).

6.12.3 Additional spot-checks

It is noted that the criteria for the most-affected receivers in Iron Cove and in NCAs north of City West Link in Rozelle, ie those adjacent to the fixed facilities, are based on RBL’s from noise logging locations at the front row of dwellings, ie R.01, R.02 and I.02. While this is suitable for the sensitive receivers near to the main roads, at receivers further back into the NCAs the RBL’s would be lower, as indicated by noise logging locations R.12, R.13 and I.03, resulting in a lower criteria than the receivers adjacent to the facilities. As a result, spot-checks of the predicted noise emissions from the fixed facilities at sensitive receivers further from the main roads were undertaken and were found to be compliant with the noise criteria established for R.12, R.13 and I.03.

6.12.4 Mitigation

It is noted that the equipment and sound power levels modelled are indicative only and may be subject to change during the detailed design phase of the project. It is envisaged that the mechanical plant noise sources associated with the fixed facilities will be controllable by common engineering methods that may consist of:

- Judicious location selection
- Noise barriers
- Silencers
- Acoustically lined ductwork
- Acoustic louvres.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7 Summary of impacts and management

7.1 Haberfield – Option A

The Haberfield Option A works area consists of three construction ancillary facilities – Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a) and Northcote Street civil site (C3a) which all fall within the M4 East footprint.

7.1.1 Construction summary

The highest predicted noise levels and greatest impacts are associated with activities that utilise noise intensive plant items, including:

- Diamond/concrete saws
- Excavators with rock-breakers.

Short duration works (up to four weeks) which are required within this study area consist of:

- Installation of environmental controls
- Pavement and infrastructure works
- Establishment of construction facilities.

During standard daytime construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to construction ancillary facilities during the use of noise intensive plant items such as concrete saws.

Works undertaken outside of standard construction hours have the potential for greater noise impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent the works areas.

Long term construction works (up to 132 weeks) required within this study area consists of:

- Tunnelling activities, including the operation of laydown areas and car parking
- Construction and fitout of ventilation facilities
- Site rehabilitation works.

During standard daytime construction hours, the highest impacts (up to 10 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the worksites.

During works outside of standard construction hours, the highest impacts (up to 10 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facilities.

Table 7-1 provides a summary of the general locations of impacts associated with the works.

Table 7-1 Location summary of construction impacts – Haberfield Option A

NCA	Location
NCA01	**Most affected receivers:** Residential and commercial receivers which are opposite the Northcote Street Civil Site (C3a) along Parramatta Road, between Page Avenue and Fredrick Street **Worst case construction scenario:** Worksite car parking and deliveries during the night-time period, and pavement and infrastructure work during all works periods **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA02	**Most affected receivers:** Residential receivers which adjoin the Northcote Street Civil Site (C3a) between Wolseley Street and Wattle Street, and receivers which front Wattle Street between Parramatta Road and Ash Lane **Worst case construction scenario:** Worksite car parking and deliveries during the night-time period, and pavement and infrastructure work during all works periods **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA03	**Most affected receivers:** Residential receivers which front Wattle Street and adjoin the Wattle Street civil and tunnel Site (C1a) and the Haberfield civil and tunnel site (C2a) between Ash lane and Ramsay Street **Worst case construction scenario:** Worksite car parking and deliveries, truck movements exiting the Wattle Street ramps during the night-time period, and pavement and infrastructure work during all works periods **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA04	**Most affected receivers:** Residential receivers which front Wattle Street between Ramsay Street and Martin Street **Worst case construction scenario:** Worksite car parking and deliveries during the night-time period, and pavement and infrastructure work during all works periods **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA05	**Most affected receivers:** Receivers which front Dobroyd Parade between Martin Street and Waratah Street **Worst case construction scenario:** Pavement and infrastructure work during all out of hour's periods. Note that no daytime impacts are predicted within this NCA. Impacts associated with short term works are predicted for outside of standard construction periods only **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA06	**Most affected receivers:** Receivers which adjoin the Haberfield civil and tunnel site (C2a) which are situated along Walker Avenue between Parramatta Road and Allum Street **Worst case construction scenario:** Worksite car parking and deliveries during the night-time period, and by pavement and infrastructure work during all works periods **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works

NCA	Location
NCA07	**Most affected receivers:** Receivers which are situated along Bland Street between Denman Avenue and Parramatta Road **Worst case construction scenario:** Minor impacts are predicted during pavement and infrastructure work during all out of hour's periods. Note that no daytime impacts are predicted within this NCA. Impacts associated with short term works and are predicted for outside of standard construction periods only **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works

Cumulative construction noise impacts

Given the number of work sites associated with the project within the Haberfield study area, it is likely that receivers would, occasionally, be subject to potential cumulative noise impacts from concurrent activities which may occur within the Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a) and the Northcote Street civil site (C3a). This would most likely be apparent during the night period where cumulative impacts are predicted to exceed the NML by up to 10 dBA.

Consecutive construction noise impacts

The Haberfield study area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved and currently under construction M4 East project. This project, together with the M4-M5 Link, tie in to Wattle Street in Haberfield, where receivers would likely be exposed to extended impacts associated with the consecutive construction of both projects.

The receivers most likely to be affected by consecutive construction impacts are:

- Receivers adjoining the Northcote Street civil site (C3a). This site is currently a tunnel site for the M4 East project, with an acoustic shed constructed across the site
- Receivers adjoining Wattle Street and Walker Avenue which have line of sight to the Wattle Street civil and tunnel site (C1a) and the Haberfield civil and tunnel site (C2a).

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, once options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be considered when preparing the site specific Construction noise and vibration impact statements (CNVIS) for this area.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Parramatta Road and Wattle Street). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increased site hoarding to height of four metres around all construction ancillary facilities.

Ground-borne noise and vibration impacts

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project works.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

As such, airborne noise emissions from the Haberfield Option A construction ancillary facilities are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

No vibration intensive works are proposed from the Haberfield Option A construction ancillary facilities as part of the M4-M5 Link project.

7.1.2 Operational impacts

In Haberfield, the M4-M5 Link would tie into the M4 East project at the new tunnel portals on Wattle Street. The surrounding roads which are likely to be affected by traffic associated with the M4-M5 Link are Parramatta Road, Ramsay Street, Frederick Street and Dobroyd Parade. Refinements to the road design through detailed design by the M4 East project may also influence noise levels at surrounding receivers. Any changes in design as well as forecast traffic in the as-built noise model would be used to evaluate the adequacy of noise mitigation measures during preparation of the Operational Noise and Vibration Compliance Report for the M4 East project.

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the Haberfield study area.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.2 Haberfield – Option B

Two options for construction ancillary facilities around Haberfield are described and assessed in this technical paper.

The preferred option will be described in the Preferred Infrastructure Report following exhibition of the EIS and discussions with stakeholders and the community

The Haberfield Option B works area consists of three construction ancillary facilities – Parramatta Road West civil and tunnel site (C1b), Haberfield civil site (C2b) and Parramatta Road East civil site (C3b) which are adjacent to the M4 East footprint.

7.2.1 Construction summary

The highest predicted noise levels and greatest impacts are associated with activities which utilise noise intensive plant items, including:

- Diamond/concrete saws
- Excavators with rock-breakers.

Short duration works (up to four weeks) which are required within this study area consist of:

- Demolition of existing structures
- Utility works
- Establishment of construction facilities.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to construction ancillary facilities during the use of noise intensive plant items such as concrete saws and rock-breakers.

Works undertaken outside of standard construction hours have the potential for greater noise impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent the works areas.

Long term construction works (up to 168 weeks) required within this study area consists of:

- Tunnelling activities, including the operation of laydown areas and car parking.
- Ventilation building fitout and installation
- Site rehabilitation works.

During standard daytime construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction site on Parramatta Road and receivers which adjoin the Parramatta Road West civil and tunnel site (C1b) to the west.

- During works outside of standard construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are on Parramatta Road and receivers which adjoin the Parramatta Road West civil and tunnel site (C1b) to the west.

Table 7-2 provides a summary of the general locations of impacts associated with the works.

Table 7-2 Location summary of construction impacts – Haberfield Option B

NCA	Location
NCA00	**Most affected receivers:** Residential receivers which are situated to the south of the Parramatta Road West civil and tunnel site (C1b) on Parramatta Road between Bland Street and Chandos Street **Worst case construction scenario:** Pavement and infrastructure works and spoil handling works within the acoustic shed during all works periods **Highest construction noise impacts:** Use of a rock-breaker during the daytime period as part of the demolition works and use of a concrete saw during the night-time period as part of the Pavement and infrastructure works
NCA01	**Most affected receivers:** Residential receivers which adjoin the Parramatta Road West civil and tunnel site (C1b) between Bland Street and the Bunnings Warehouse on Parramatta Road **Worst case construction scenario:** Pavement and infrastructure works and spoil handling works within the acoustic shed during all works periods **Highest construction noise impacts:** Use of a rock-breaker during the daytime period as part of the demolition works and use of a concrete saw during the night-time period as part of the Pavement and infrastructure works. Also, noise impacts from spoil handling works within the Parramatta Road West civil and tunnel site (C1b) during all periods
NCA02	**Most affected receivers:** Residential receivers which adjoin Wattle Street between Parramatta Road and Ash Lane **Worst case construction scenario:** Pavement and infrastructure works during all works periods associated with the Haberfield civil site (C2b) **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA03	**Most affected receivers:** Residential receivers which front Wattle Street between Ash Lane and Ramsay Street **Worst case construction scenario:** Pavement and infrastructure works during all works periods associated with the Haberfield civil site (C2b) **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works

NCA	Location
NCA04	**Most affected receivers:** Residential receivers which front Wattle street between Ramsay Street and Martin Street **Worst case construction scenario:** Pavement and infrastructure works during all works periods associated with the Haberfield civil site (C2b) **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA05	**Most affected receivers:** Receivers which front Dobroyd Parade between Martin Street and Waratah Street. **Worst case construction scenario:** Pavement and infrastructure works during all works periods associated with the Haberfield civil site (C2b) **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works
NCA06	**Most affected receivers:** Receivers which adjoin the Haberfield civil site (C2b) on Walker Avenue, between Allum Street and Parramatta Road, and residential receivers located on Alt Street which adjoin the Parramatta Road East civil site (C3b) **Worst case construction scenario:** Demolition works during the daytime period and Pavement and infrastructure works during all works periods **Highest construction noise impacts:** Use of a rock-breaker during the daytime period as part of the demolition works and use of a concrete saw during the night-time period as part of the Pavement and infrastructure works
NCA07	**Most affected receivers:** Residential receivers which are situated to the south of the Parramatta Road East civil site (C3b), between Bland Street and Chandos Street on Parramatta Road **Worst case construction scenario:** Demolition works during the daytime period and Pavement and infrastructure works during all works periods **Highest construction noise impacts:** Use of a rock-breaker during the daytime period as part of the demolition works and use of a concrete saw during the night-time period as part of the Pavement and infrastructure works

Cumulative construction noise impacts

Given the number of work sites associated with the project within the Haberfield study area, it is likely that receivers would, occasionally, be subject to potential cumulative noise impacts from construction ancillary facilities operating concurrently in the same area. This would most likely be apparent during the night period where cumulative impacts are predicted to exceed the NML by greater than 20 dBA within NCA01.

Consecutive construction noise impacts

The Haberfield study area would likely be subject to potential construction impacts from works associated with other infrastructure projects, including the approved and currently under construction M4 East project. This project, together with the M4-M5 Link, tie in to Wattle Street and Parramatta Road in Haberfield, where receivers would likely be exposed to extended impacts associated with the consecutive construction of both projects.

The receivers most likely to be affected by consecutive construction impacts are:

- Receivers adjoining the Parramatta Road West civil and tunnel cite (C1b), Parramatta Road East civil site (C3b) and Haberfield civil site (C2b), between Walker Avenue and Chandos Street.

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, once options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be considered when preparing the site specific CNVIS for this area.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Parramatta Road).

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increased site hoarding to height of 4 metres around all construction ancillary facilities
- Upgrading the acoustic shed performance
- Limiting the total internal sound power level to 110 dBA within the acoustic shed.

Ground-borne noise and vibration impacts

The majority of works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, Wattle Street dive structures and tunnel stubs, are being undertaken as part of the M4 East project.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

Based on the excavation of the access tunnel at this site, eight residential receivers are predicted to exceed the night-time ground-borne NML for up to around 20 days. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to 22 buildings in this area may be within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the Haberfield Option B construction ancillary facilities. For this scenario, around 66 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. No heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facilities.

Management of ground-borne noise impacts

With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

At receivers predicted to exceed the night-time NMLs by more than 10 dB, the following mitigation measures should be considered in addition to those outlined above:

- Individual briefings to inform the residents about the impacts of the works and mitigation measures that will be implemented. Where the resident cannot be met with individually then an alternative form of engagement should be used

- Respite periods may be offered to the affected residents during works where noise levels are predicted to exceed the NML by 10 dBA or more
- Alternative accommodation options may be offered to the affected residents for the periods where noise levels are predicted to exceed the NML by 10 dBA or more.

Management of construction vibration impacts

The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

7.2.2 Operational impacts

In Haberfield, the M4-M5 Link would tie into the M4 East project at the new tunnel portals on Wattle Street. The surrounding roads which are likely to be affected by traffic associated with the M4-M5 Link are Parramatta Road, Ramsay Street, Frederick Street and Dobroyd Parade. Refinements to the road design through detailed design by the M4 East project may also influence noise levels at surrounding receivers. Any changes in design as well as forecast traffic in the as-built noise model would be used to evaluate the adequacy of noise mitigation measures during preparation of the Operational Noise and Vibration Compliance Report for the M4 East project.

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the Haberfield study area.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.3 Darley Road

The Darley Road civil and tunnel site (C4) works area would be located adjacent to the Leichhardt North light rail stop, between City West Link and Darley Road.

7.3.1 Construction summary

The highest predicted noise levels and greatest impacts are associated with activities which utilise noise intensive plant items, including:

- Diamond/concrete saws
- Road profilers
- Excavators with rock-breakers.

Short duration works (up to four weeks) which are required within this study area consist of:

- Site establishment works
- Traffic management works.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to construction ancillary facilities during the use of noise intensive plant items such as concrete saws, rock-breaker and road profilers.

Works undertaken outside of standard construction hours have the potential for greater noise impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent the works areas.

Long term construction works (up to 204 weeks) required within this study area consists of:

- Tunnelling activities, including the operation of laydown areas and car parking.
- Construction of declines
- Site rehabilitation works.

During standard daytime construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facility on the southern (opposite) side of Darley Road.

During works outside of standard construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facility on the southern (opposite) side of Darley Road.

Table 7-3 provides a summary of the general locations of impacts associated works.

Table 7-3 Location summary of construction impacts – Darley Road

NCA	Location
NCA05	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA08	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA09	**Most affected receivers:** Residential receivers which front the north side of City West Link between Charles Street and Norton Street. **Worst case construction scenario:** Pavement and infrastructure works and spoil handling works within the acoustic shed during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a rock-breaker during the night-time period as part of the pavement and infrastructure works.
NCA10	**Most affected receivers:** Residential receivers which front Lilyfield Road and which have line of sight to the works down Francis Street and James Street. **Worst case construction scenario:** Minor impacts are predicted only during the night period.
NCA11	**Most affected receivers:** Residential receivers which adjoin the north side of City West Link between Norton Street and Henry Street. **Worst case construction scenario:** Pavement and infrastructure works during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the night-time period as part of the pavement and infrastructure works.

NCA	Location
NCA12	**Most affected receivers:** Residential receivers which adjoin the south side of City West Link between Norton Street and Henry Street. **Worst case construction scenario:** Road adjustment works during the night-time period. **Highest construction noise impacts:** Use of a road profiler during the night-time period as part of the road adjustment works.
NCA13	**Most affected receivers:** Residential receivers which adjoin the Darley Road civil and tunnel site (C4) on Darley Road between Norton Street and Falls Street. The most noise affected receivers are located between Charles Street and Norton Street due to their proximity to the construction site. **Worst case construction scenario:** Pavement and infrastructure works and spoil handling works within the acoustic shed during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a rock-breaker during the night-time period as part of the pavement and infrastructure works
NCA14	**Most affected receivers:** Residential receivers and the St Columba Primary School located on William Street to the south of the construction site that have line of sight to the construction site down Charles Street, North Street and James Street. **Worst case construction scenario:** Minor impacts are predicted only during the night period.

Cumulative construction noise impacts

Given that concurrent activities may occur within Darley Road civil and tunnel site (C4) during any period, it is likely that receivers would, occasionally, be subject to cumulative noise impacts from construction ancillary facilities operating concurrently in the same area. Cumulative construction noise impacts may be apparent during out of hour's works periods where cumulative impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Darley Road and City West Link). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increased site hoarding to height of four metres around all construction ancillary facilities
- Upgrading the acoustic shed performance
- Limiting the total internal sound power level to 110 dBA within the acoustic shed.

Ground-borne noise and vibration Impacts

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

Based on the excavation of the access tunnel at this site, 10 residential receivers are predicted to exceed the night-time ground-borne NML for up to around 14 days. While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to five buildings in this area may be within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the Darley Road civil and tunnel site. Around 74 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. One heritage listed item has been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Management of ground-borne noise impacts

With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

Management of construction vibration impacts

The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

7.3.2 Operational impacts

The M4-M5 Link project is not proposing any additional surface infrastructure changes in this area. As such, no further consideration is required for the operational assessment.

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the, Darley Road study area.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.4 Rozelle

The Rozelle works area consists of three construction ancillary facilities; the Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and Victoria Road civil site (C7).

7.4.1 Construction summary

The highest noise levels and greatest impacts are associated with activities that utilise noise intensive plant items, including:

- Diamond/concrete saws
- Excavators with rock-breakers.

Short duration works (up to 4 weeks) which are required within this study area consist of:

- Demolition of existing structures
- Site clearing
- Installation of environmental controls
- Establishment of construction facilities and site remediation.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to construction ancillary facilities during the use of noise intensive plant items such as concrete saws.

Works undertaken outside of standard construction hours have the potential for greater noise impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent to the construction ancillary facilities.

Long term construction works (up to 192 weeks) required within this study area consists of:

- Utility works
- Establishment of construction facilities and drainage works
- Temporary and permanent roadworks and intersection modifications
- Tunnelling activities, including spoil handling and supporting activities
- Civil and mechanical works including earthworks, roadworks , and ventilation facility works
- General operations associated with construction compounds.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facilities during the operation of high noise construction plant such as graders and dozers.

During works outside of standard construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facilities. The highest NML exceedances predicted for long-term works outside of standard construction hours are representative of the operation of high noise construction plant such as graders and dozers in close proximity to sensitive receivers.

While construction works at long term construction ancillary facilities would be undertaken over a relatively longer percentage of the overall project duration, the noisy construction plant responsible for the worst case construction noise impacts would not be in continuous operation, nor would the works be undertaken in the same area for the full duration of the construction project. During periods where the noisy construction plant is either not in operation, or is not located immediately adjacent a sensitive receiver, the construction noise levels are anticipated to be significantly lower than the worst case predictions.

Table 7-4 provides a summary of the general locations of impacts associated works.

Table 7-4 Location summary of construction impacts – Rozelle

NCA	Location
NCA15	**Most affected receivers:** residential receivers located to the south of City West Link between Starling Street and Russell Street. **Worst case construction scenario:** Roadworks and utility adjustment and site establishment works within the Rozelle civil and tunnel site (C5) during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA16	**Most affected receivers:** Residential receivers which situated to the north of Lilyfield Road between Grove Street and Lamb Street. **Worst case construction scenario:** Roadworks and utility adjustment and site establishment works within the Rozelle civil and tunnel site (C5) during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA17	All receivers within this NCA are predicted to comply with the construction NMLs for all construction scenarios during all works periods.
NCA18	All receivers within this NCA are predicted to comply with the construction NMLs for all construction scenarios during all works periods.
NCA19	**Most affected receivers:** Residential receivers which are situated to the north of Lilyfield Road between Lamb Street and Foucart Street. **Worst case construction scenario:** Roadworks and utility adjustment, site establishment works and spoil handling activities within the Rozelle civil and tunnel site (C5) during out of hours works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA20	**Most affected receivers:** Residential receivers which are situated near Brenan Street between Starling Street and Railway Parade. **Worst case construction scenario:** Roadworks and utility adjustment, and activities within the Rozelle civil and tunnel site (C5) during out of hours works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA21	**Most affected receivers:** Residential receivers which are situated near Railway Parade and Bayview Crescent. **Worst case construction scenario:** Roadworks and utility adjustment and activities within the Rozelle civil and tunnel site (C5) and The Crescent civil site (C6) during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA22	All receivers within this NCA are predicted to comply with the construction NMLs for all construction scenarios during all works periods.

NCA	Location
NCA23	**Most affected receivers:** Residential receivers and an educational facility which are situated near The Crescent and Johnston Street intersection. **Worst case construction scenario:** Roadworks and utility adjustment and activities within The Crescent civil site (C6) during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA24	**Most affected receivers:** Residential receivers which are situated to the north of Lilyfield Road between Foucart Street and Gordon Street. **Worst case construction scenario:** Roadworks and utility adjustment, site establishment works and spoil handling activities within the Rozelle civil and tunnel site (C5) during all works periods. **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works.
NCA25	**Most affected receivers:** Residential receivers which are situated near Lilyfield Road between Gordon Street and Victoria Road. **Worst case construction scenario:** Roadworks and utility adjustment, site establishment works and spoil handling activities within the Rozelle civil and tunnel site (C5) and the Victoria Road civil site (C7) during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA26	**Most affected receivers:** Commercial receivers situated along James Craig Drive. **Worst case construction scenario:** Roadworks and utility adjustment during the daytime period. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA27	**Most affected receivers:** Residential receivers which front Rozelle Bay between Alexandra Road and Glebe Point Road. **Worst case construction scenario:** Roadworks and utility adjustment during all work periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA28	**Most affected receivers:** Residential receivers which front Rozelle Bay and Anzac Bridge. **Worst case construction scenario:** Roadworks and utility adjustment during all work periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period as part of roadworks.

NCA	Location
NCA29	**Most affected receivers:** Residential receivers which are situated near Victoria Road between Robert Street and Evans Street. **Worst case construction scenario:** Roadworks and utility adjustment and site establishment works located at the Victoria Road civil site (C7) during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a number of noise intensive items of plant during the night-time period as part of roadworks.
NCA30	**Most affected receivers:** Residential receivers which are situated near Victoria Road between Darling Street and Evans Street. **Worst case construction scenario:** Roadworks and utility adjustment and site establishment works located at the Victoria Road civil site (C7) during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a number of noise intensive items of plant during the night-time period as part of roadworks.

Cumulative construction noise impacts

Given that several tunnelling works activities may operate simultaneously during any period, it is likely that receivers would, occasionally, be subject to cumulative noise impacts from works activities operating concurrently in the same area (associated with both M4-M5 Link and the proposed future Western Harbour Tunnel and Beaches Link projects). Cumulative construction noise impacts may be apparent during out of hour's works periods where cumulative impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.

Consecutive construction noise impacts

The Rozelle study area would likely be subject to construction impacts from works associated with other infrastructure projects, including the approved and currently under construction CBD and South East Light Rail (CSELR) Rozelle maintenance depot. This combination of these projects may result in receivers being exposed to extended construction noise impacts, which may occur consecutively.

The receivers most likely to be affected by consecutive construction impacts are:

- Receivers adjoining Lilyfield Road between Justin Street and Ryan Street (NCA16 and NCA19).
- Receivers adjoining Brenan Street between Starling Street and White Street (NCA15).

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, once options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be considered when preparing the site specific CNVIS for this area.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (City West Link, Victoria Road and The Crescent). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increasing site hoarding to height of four metres in select areas
- Upgrading the acoustic shed performance.

Ground-borne noise and vibration Impacts

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

Based on the excavation of the ventilation tunnels at this site, 63 residential receivers are predicted to exceed the night-time ground-borne NML for up to a maximum of around 16 days for each road-header. While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

In the Rozelle area, there are several ventilation tunnels, mainline tunnels and access ramps which may be under construction simultaneously and/or consecutively. During simultaneous construction, ground-borne noise levels would be dominated by the closest road-header to the receiver, however, where multiple road-headers are operating at a similar distance from the receiver this may result in ground-borne noise impacts marginally higher than the predicted noise levels. Consecutive construction with road-headers would not increase the level of ground-borne noise but may increase the duration of impacts at any one receiver. Detailed scheduling of road-header works would be determined at a later design stage.

Up to 124 buildings in this area may be within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. Around 345 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration should a large rock-breaker be used at the outer extents of the site. 19 heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Management of ground-borne noise impacts

With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

At receivers predicted to exceed the night-time NMLs by more than 10 dB, the following mitigation measures should be considered in addition to those outlined above:

- Individual briefings to inform the residents about the impacts of the works and mitigation measures that will be implemented. Where the resident cannot be met with individually then an alternative form of engagement should be used
- Respite periods may be offered to the affected residents during works where noise levels are predicted to exceed the NML by 10 dBA or more
- Alternative accommodation options may be offered to the affected residents for the periods where noise levels are predicted to exceed the NML by 10 dBA or more.

Management of construction vibration impacts

The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

7.4.2 Operational impacts

NCA16, NCA19

These catchments are located to the north of Lilyfield Road. Existing noise levels are dominated by a combination of road traffic noise from Lilyfield Road and City West Link.

In the *No Build* scenario, the predicted noise levels at receivers adjacent to Lilyfield Road are typically in the order of 65 dBA and 60 dBA in the daytime and night-time, respectively.

The project would widen the City West Link in this area. Entry and exit ramps to the new tunnels are located in the south of former Rozelle Rail Yards.

Without mitigation 13 receivers qualify for consideration of additional noise mitigation in these catchments. These receivers are situated along Lilyfield Road.

A noise barrier has been considered on Lilyfield Road to mitigate noise levels. The barrier analysis however concluded that the barrier was not feasible or reasonable for the EIS design. A preferred noise mitigation option would be determined during detailed design and may include at-source control measures and/or at-property treatment.

NCA15, NCA17, NCA20, NCA21, NCA23 and NCA27

These catchments are located to the south of City West Link and The Crescent. Existing noise levels are dominated by road traffic noise from City West Link and The Crescent. An existing 3 metre noise barrier runs through NCA17, NCA20 and NCA21, on the southern side of City West Link.

In the *No Build* scenario, the predicted noise levels at receivers adjacent to City West Link and The Crescent are typically in the order of 60-65 dBA and 55-60 dBA in the daytime and night-time, respectively.

This area is located to the south of the proposed widening of City West Link and The Crescent. Entry and exit ramps to the Rozelle interchange would be located to the north, in the Rozelle Rail Yards. The widening of this intersection would remove the eastern section (around 90 metres in length) of the existing noise barrier on City West Link.

Without mitigation 46 receivers qualify for consideration of additional noise mitigation in these catchments. These receivers are situated along City West Link, The Crescent and Johnston Street.

Increasing the height of the existing noise barrier on City West Link has been considered. The barrier analysis however concluded that the barrier design was not feasible or reasonable for the EIS design. A preferred noise mitigation option would be determined during detailed design and may include at-source control measures and/or at-property treatment.

NCA25 and NCA26

These catchments are located to the immediate west and east of Victoria Road bridge and generally to the north of Lilyfield Road.

In the *No Build* scenario, the predicted noise levels at receivers adjacent to Victoria Road are typically in the order of 65 dBA and 60 dBA in the daytime and night-time, respectively.

The project would widen the current Victoria Road intersection with The Crescent (at Victoria Road bridge), with the existing westbound lane of Victoria Road moving closer to the receivers on the southern side. Property acquisitions are required in this area to allow the widening to occur and existing buildings on this side of Victoria Road which currently provide some shielding of noise would be removed. New access ramps to the new tunnels would be located to the south of this catchment in the former Rozelle Rail Yard, adjacent to residential properties along the south side of Lilyfield Road.

Without mitigation 157 receivers qualify for consideration of additional noise mitigation in these catchments. These receivers are located near to Victoria Road bridge.

Noise levels are predicted to increase by more than 2 dBA to the west of Victoria Road due to the widening works in combination with the removal of existing properties in this area.

Noise barriers have been considered on the western side of Victoria Road and to the northern side of The Crescent. The barrier analysis however concluded that no barriers were feasible or reasonable for the EIS design. A preferred noise mitigation option would be determined during detailed design and may include at-source control measures and/or at-property treatment.

NCA24, NCA29, NCA30, NCA31 and NCA32

These catchments are located along Victoria Road, between Victoria Road bridge and Iron Cove. Existing noise levels are dominated by road traffic noise from Victoria Road.

In the *No Build* scenario, the predicted noise levels at receivers adjacent to Victoria Road are typically in the order of 65 dBA and 60 dBA in the daytime and night-time, respectively.

There are no construction works in these catchments associated with the project. The project would result in surface traffic volumes reducing on this section of Victoria Road due to traffic being rerouted to the new tunnels.

Without mitigation 16 receivers qualify for consideration of additional noise mitigation in these catchments. These receivers are located near to Victoria Road bridge. These receivers are situated along Victoria Road, between Victoria Road bridge and Iron Cove.

As noise levels are predicted to generally reduce in this area, noise mitigation would likely be limited to architectural treatment of individual properties where exceedances are apparent

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the Rozelle study area.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.5 Iron Cove

The Iron Cove Link civil site (C8) would be located on the southern side of Victoria Road, east of the Iron Cove Bridge, between Byrnes Street and Springside Street. The site would support the construction of the Iron Cove tunnel connection and associated infrastructure.

7.5.1 Construction summary

The highest noise levels and greatest impacts are associated with activities that utilise noise intensive plant items, including:

- Diamond/concrete saws
- Excavators with rock-breakers.

Short duration works (up to two weeks) which are required within this study area consist of:

- Site clearing
- Installation of environmental controls

- Pavement and infrastructure works
- Establishment of construction facilities.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to construction ancillary facilities during the use of noise intensive plant items such as concrete saws.

Works undertaken outside of standard construction hours have the potential for greater noise impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent the works areas.

Long term construction works (up to 144 weeks) required within this study area consist of:

- Demolition of existing buildings
- Utility works
- General compound operations including car parking, deliveries, and supporting works
- Civil works including earthworks, bridge works, and roadworks
- Site rehabilitation.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facilities during the operation of high noise construction plant such as concrete saws, rock-breakers, and dozers.

During works outside of standard construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction ancillary facilities. The highest NML exceedances predicted for long-term works outside of standard construction hours are representative of the operation of high noise construction plant such as concrete saws in close proximity to sensitive receivers.

It is noted that while construction works at long term construction ancillary facilities would be undertaken over a relatively longer percentage of the overall project duration, the noisy construction plant responsible for the worst case construction noise impacts would not be in continuous operation, nor would the works be undertaken in the same area for the full duration of the construction project. During periods where the noisy construction plant is either not in operation, or is not located immediately adjacent a sensitive receiver, the construction noise levels are anticipated to be significantly lower than the worst case predictions.

Table 7-5 provides a summary of the general locations of impacts associated works.

Table 7-5 Location summary of construction impacts – Iron Cove

NCA	Location
NCA30	**Most affected receivers:** Residential receivers which front Victoria Road and Darling Street. **Worst case construction scenario:** Receivers within this NCA are generally predicted to comply with the construction NMLs for all construction scenarios during all works periods with the exception of minor exceedances during roadworks, utility works, and pavement and infrastructure works activities. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.

NCA	Location
NCA31	**Most affected receivers:** Residential, commercial and educational receivers fronting front Victoria Road, Darling Street, and Merton Street. **Worst case construction scenario:** Roadworks, utility works and pavement and infrastructure works during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.
NCA32	**Most affected receivers:** Residential and commercial receivers that front Victoria Road and Waterloo Street. **Worst case construction scenario:** Roadworks, utility works and pavement and infrastructure works during all works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.
NCA33	**Most affected receivers:** Residential receivers closest to Victoria Road. **Worst case construction scenario:** Demolition of existing buildings during the daytime, roadworks, utility works and pavement and infrastructure works during out of hour's works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.
NCA34	**Most affected receivers:** Commercial receivers fronting Victoria Road and residential receivers on Terry Street and Wellington Street. **Worst case construction scenario:** • For commercial receivers: demolition of existing buildings and earthworks during the daytime • For residential receivers: roadworks, utility works and pavement and infrastructure works during out of hours works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.
NCA35	**Most affected receivers:** Residential receivers fronting front Victoria Road and the construction site. **Worst case construction scenario:** roadworks, utility works and pavement and infrastructure works during out of hour's works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.
NCA36	**Most affected receivers:** Residential receivers at the eastern end of Byrnes Street, Clubb Street, and Toelle Street that are closest to the construction site. **Worst case construction scenario:** • Demolition of existing buildings during the daytime • Utility adjustments and pavement and infrastructure works during out of hours works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.

NCA	Location
NCA38	**Most affected receivers:** residential receivers fronting the Parramatta River with line of sight to the construction site. **Worst case construction scenario:** utility works and pavement and infrastructure works during out of hour's works periods. **Highest construction noise impacts:** Use of a number of noise intensive items of plant during the night-time period.

Cumulative construction noise impacts

Given that several compound related activities may operate simultaneously during any period, it is likely that receivers would, occasionally, be subject to cumulative noise impacts from works activities operating concurrently in the same area. Cumulative construction noise impacts are predicted to result in minor NML exceedances of up to 20 dBA during the daytime period.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Victoria Road). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increased site hoarding to a height of four metres around all construction ancillary facilities.

Ground-borne noise and vibration impacts

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

As such, airborne noise emissions from the Campbell Road civil and tunnel site are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

Up to 45 buildings in this area may be within the minimum cosmetic damage vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. Under this scenario, around 107 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration. No heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Management of construction vibration impacts

The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

7.5.2 Operational impacts

NCA33, NCA34, NCA35, NCA36 and NCA37

These catchments are to the immediate north and south of Iron Cove where existing noise levels are dominated by road traffic noise from Victoria Road. An existing 2.6 metre noise barrier is located in NCA35, to the north of Victoria Road.

In the *No Build* scenario, the predicted noise levels at receivers adjacent to Victoria Road are typically in the order of 65 dBA and 60 dBA in the daytime and night-time, respectively.

The project would split the current Victoria Road alignment, with the existing westbound lane moving closer to the receivers to the south of Victoria Road (in NCA33 and NCA36) to allow the new lanes in the middle to be constructed which enter the tunnel portals, heading east. Property acquisitions are required in NCA33 and NCA36 to allow the widening of the westbound lane to occur.

Without mitigation 205 receivers qualify for consideration of additional noise mitigation in these catchments. These receivers are located near to Victoria Road bridge.

Noise levels are predicted to increase by more than 2 dBA to the south of Victoria Road in NCA33 and NCA36. This is a result of the widening works in combination with the removal of existing properties in this area.

Noise barriers have been considered on both the northern and southern side of Victoria Road. The barrier analysis concluded that no barriers were feasible or reasonable for the EIS design. A preferred noise mitigation option would be determined during detailed design and may include at-source control measures and/or at-property treatment.

Noise emissions from fixed facilities in the Iron Cove area are predicted to exceed the criteria by up to 12 dBA at the most-affected receivers in NCA33, adjacent to the substation. This assumes the substation noise source is at the closest point to the nearest residence, with no shielding from a substation building or intervening walls.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.6 Pyrmont Bridge Road

The Pyrmont Bridge Road tunnel site (C9) would be located at the intersection of Pyrmont Bridge Road and Parramatta Road, between Gordon Street and Mallet Street. The Pyrmont Bridge Road tunnel site would be the main mid-tunnel construction site along the eastern section of the M4-M5 Link.

7.6.1 Construction summary

The highest noise levels and greatest impacts are associated with activities that utilise noise intensive plant items, including:

- Diamond/concrete saws
- Excavators with rock-breakers.

Short duration works (up to two weeks) which are required within this study area consist of:

- Site clearing
- Utility works
- Installation of environmental controls
- Pavement and infrastructure works.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with short term works are generally predicted to be at receivers immediately adjacent to the construction site during the use of noise intensive plant items such as rock-breakers.

Works undertaken outside of standard construction hours have the potential for greater impacts (greater than 20 dBA exceedance of NMLs) throughout the study area, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime. Impacts during this period are likely to extend beyond receivers immediately adjacent the works areas.

Long term construction works (up to 180 weeks) which are required within this study area consist of:

- Demolition of existing buildings
- Establishment of construction facilities
- Tunnelling activities, including the operation of laydown areas and car parking.
- Construction of access tunnel
- Site rehabilitation works.

During standard daytime construction hours, the highest impacts (greater than 20 dBA exceedance of NMLs) associated with long term works are generally predicted to be at receivers which are immediately adjacent to the construction site.

During works outside of standard construction hours, the highest impacts (up to 20 dBA exceedance of NMLs) associated with long term works are also generally predicted to be at receivers which are immediately adjacent to the construction site.

Table 7-6 provides a summary of the general locations of impacts associated works.

Table 7-6 Location summary of construction impacts – Pyrmont Bridge Road

NCA	Location
NCA40	**Most affected receivers:** Residential receivers which are situated on Susan Street and Nelson Street between Parramatta Road and Chester Street. **Worst case construction scenario:** Pavement and infrastructure work during all works periods. **Highest construction noise impacts:** Use of a concrete saw during the night-time period as part of pavement and infrastructure works.
NCA41	**Most affected receivers:** Residential receivers which front Pyrmont Bridge Road and adjoin the Pyrmont Bridge Road tunnelling site (C9) between Parramatta Road and Booth Street. **Worst case construction scenario:** Demolition of existing structures, construction site car parking and deliveries and pavement and infrastructure work during all works periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a concrete saw during the night-time period as part of the pavement and infrastructure works.

NCA	Location
NCA42	**Most affected receivers:** Residential receivers and an educational facility which front the southern side of Parramatta Road between Bridge Road and Mallet Street. **Worst case construction scenario:** Demolition of existing structures, construction site car parking, construction compound deliveries, and pavement and infrastructure works during all periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a concrete saw during the night-time period as part of the pavement and infrastructure works.
NCA43	**Most affected receivers:** Residential receivers which front the southern side of Parramatta Road between Mallet Street and Missenden Road. **Worst case construction scenario:** Demolition of existing structures, construction site car parking and deliveries and pavement and infrastructure works during all periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a concrete saw during the night-time period as part of the pavement and infrastructure works.
NCA44	**Most affected receivers:** Residential receivers which front the eastern side of Mallett Street between Parramatta Road and Alexandra Drive. **Worst case construction scenario:** demolition of existing structures, construction site car parking, construction compound deliveries, and pavement and infrastructure works during all periods. **Highest construction noise impacts:** • Use of a rock-breaker during the daytime period as part of the demolition works • Use of a concrete saw during the night-time period as part of the pavement and infrastructure works.

Cumulative construction noise impacts

Given that several tunnelling works activities may operate simultaneously during any period, it is likely that receivers would, occasionally, be subject to cumulative noise impacts from works activities operating concurrently in the same area. Cumulative construction noise impacts may be apparent during out of hour's works periods where cumulative impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Parramatta Road and Pyrmont Bridge Road). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Increasing site hoarding to four metres in select areas
- Upgrading the acoustic shed performance.

Ground-borne noise and vibration impacts

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

Based on the excavation of the access tunnel at this site, three residential receivers and two other sensitive receivers are predicted to exceed the night-time ground-borne NML for up to around 16 days. While most road-heading works are anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Up to 33 buildings in this area may be within the minimum vibration working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility. For this scenario, around 73 receivers in the vicinity of the site would fall within the nominated minimum working distance for human comfort vibration. Five heritage listed items have been identified as having the potential to be within the minimum safe working distances should a large rock-breaker be used at the outer extents of the construction ancillary facility.

Management of ground-borne noise impacts

With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

Management of construction vibration impacts

The following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted vibration levels at the nearest receiver buildings to the vibration intensive works
- Use of alternative method to de-couple load path / equipment that generates less vibration where feasible and reasonable
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Respite periods may be offered to the affected residents during works where vibration intensive plant levels are predicted to be operated within the safe working distance for human comfort for an extended period of time on any one day.

7.6.2 Operational impacts

The M4-M5 Link project is not proposing any additional surface infrastructure changes in this area. As such, no further consideration is required for the operational assessment.

7.7 St Peters

The Campbell Road civil and tunnel site (C10) would be located on the southern side of Albert Street and Campbell Lane in St Peters. The site is currently the Campbell Road construction compound for the New M5 project. The Campbell Road civil and tunnel site would be the main tunnel site at the southern end of the M4-M5 Link project.

7.7.1 Construction summary

During standard daytime construction hours, the proposed construction works at the Campbell Road civil and tunnel site are predicted to comply with the applicable NMLs in all NCAs.

The highest noise levels and greatest impacts are associated with activities that are performed during the more sensitive out of hour's periods, especially during the most sensitive night-time period. This is due to more stringent NMLs during these periods than during the daytime.

During works outside of standard construction hours, the highest impacts are generally predicted to be at receivers which are closest to tunnelling and supporting works. NML exceedances of less than 10 dBA are predicted at the potentially most affected receivers during the evening and night-time periods.

Table 7-7 provides a summary of the general locations of impacts associated works.

Table 7-7 Location summary of construction impacts – St Peters

NCA	Location
NCA48	**Most affected receivers:** Residential receivers situated on the southern side of Campbell Road between Woodley Street and Harber Street. **Worst case construction scenario:** Construction site deliveries and tunnelling operations inside the acoustic shed during the night-time period.
NCA49	**Most affected receivers:** Residential receivers situated on the northern side of Campbell Street between Crown Street and Barwon Park Road. **Worst case construction scenario:** construction site deliveries and tunnelling operations inside the acoustic shed during the night-time period.
NCA50	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA51	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA52	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA54	No impacts above the project NMLs are predicted within this NCA for all works activities.
NCA55	No impacts above the project NMLs are predicted within this NCA for all works activities.

Cumulative construction noise impacts

Given that several tunnelling works activities may operate simultaneously during any period, it is likely that receivers would, occasionally, be subject to cumulative noise impacts from works activities operating concurrently in the same area. Cumulative construction noise impacts may be apparent during out of hour's works periods where cumulative impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.

Consecutive construction noise impacts

The St Peters study area would likely be subject to construction impacts from works associated with other infrastructure projects, including the approved and currently under construction New-M5 project.

This combination of these projects may result in receivers being exposed to extended construction noise impacts, which may occur consecutively.

Excluding short-term works such as pavement and utility works, receivers located within NCA48 and NCA49, which front Campbell Road, are predicted to experience up to 10 dBA exceedances of the project NMLs (in the night-time period) during construction of the M4-M5 Link project. While the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers which would likely have been exposed to significant noise impacts from the New M5 project.

In situations where consecutive long term construction noise impacts occur, at-receiver noise mitigation may be considered where feasible and reasonable, once options for at source noise mitigation and management measures have been exhausted. The requirement for this should be evaluated in consultation with Roads and Maritime and the community during detailed design, and should be considered when preparing the site specific CNVIS for this area.

Construction road traffic noise impacts

The assessment indicates that construction traffic is unlikely to result in a noticeable increase in L_{Aeq} noise levels at receivers along the proposed construction traffic routes (Campbell Road). It is also important to note that no local roads would be used by heavy vehicles during works.

Management of construction noise impacts

The assessment of construction impacts identified the following in-situ mitigation measures that should be included for this study area:

- Upgrading the acoustic shed performance.

Ground-borne noise and vibration impacts

Works with the potential to cause ground-borne noise impacts in this area, such as excavation of the ventilation facility, ventilation tunnels, dive structures and tunnel stubs, are being undertaken as part of the New M5 project.

Ground-borne noise from tunnelling works associated with construction of the mainline tunnel alignment and access ramps is summarised in **section 7.8.1**.

As such, airborne noise emissions from the Campbell Road civil and tunnel site are predicted to be higher than the ground-borne noise levels. For this reason, ground-borne noise is not anticipated to be the controlling factor for these works.

No vibration intensive works are proposed from the Campbell Road civil and tunnel site as part of the M4-M5 Link project.

7.7.2 Operational impacts

In St Peters, the M4-M5 Link would tie into the New M5 project at St Peters interchange. The surrounding roads which may be affected by traffic associated with the M4-M5 Link are Campbell Road, Princess Highway and Euston Road. Refinements to the road design through detailed design by the New M5 project may also influence noise levels at surrounding receivers. Any changes in design as well as forecast traffic in the as-built noise model would be used to evaluate the adequacy of noise mitigation measures during preparation of the Operational Noise and Vibration Compliance Report for the New M5 project.

Operational noise emissions from the fixed facilities are predicted to comply with the relevant criteria during the more stringent night-time period in all NCAs in the St Peters area.

The selected mechanical equipment should be reviewed and assessed for conformance with the established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. Note that the cumulative noise emissions from all fixed facility noise sources should be considered when determining the appropriate mitigation options.

7.8 Additional construction works

7.8.1 Ground-borne noise – mainline tunnels

No surface works associated with the mainline tunnel alignment would occur outside of the areas discussed above and therefore the impacts at receivers for the construction of the mainline tunnel alignment would be limited to ground-borne noise and vibration.

At residential locations greater than a distance of 30 metres from the nearest tunnel (ie taking into account the tunnel depth and the horizontal offset distance), exceedances of the ground-borne NML of 35 dBA $L_{Aeq(15minute)}$ during night-time periods are unlikely.

Based on a progression rate of around 20 metres per week for the excavation using road-headers, potential ground-borne noise impacts are predicted at the following locations:

- In Haberfield (near Wattle Street, north of Martin Street), where the tunnel ramps climb to meet with the Wattle Street tunnel stubs, 46 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 44 dBA LAeq(15minute) are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In the vicinity of the Rozelle interchange (primarily to the north of Lilyfield Road and around Catherine Street), where the tunnel ramps climb to meet City West Link, 225 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 45 dBA $L_{Aeq(15minute)}$ are predicted when tunnelling equipment is located at the shortest distance to the receiver. Due to the number of tunnels being constructed in this area the duration of impacts may extend in these locations due to consecutive construction works, as discussed in **section 5.3.4**
- In the vicinity of the Iron Cove Link tunnel portals (south of Victoria Road between Toelle Street and Cambridge Street), where the tunnel ramps climb to meet Victoria Road, 29 receivers are predicted to experience noise levels above the criteria for up to around 17 days for each road-header. Ground-borne noise levels of up to around 42 dBA LAeq(15minute) are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In Annandale (between Moore Street, Catherine Street, Reserve Street and Annandale Street) where the tunnels veer north towards the Rozelle interchange, 48 receivers are predicted to experience noise levels above the criteria for up to around 12 days for each road-header. Ground-borne noise levels of up to around 37 dBA LAeq(15minute) are predicted when tunnelling equipment is located at the shortest distance to the receiver
- In the vicinity of the St Peters interchange (west of Sydney Park), where the tunnel ramps climb to meet St Peters tunnel stubs, 39 receivers are predicted to experience noise levels above the criteria for up to around 19 days for each road-header. Ground-borne noise levels of up to around 44 dBA LAeq(15minute) are predicted when tunnelling equipment is located at the shortest distance to the receiver.

While most road-heading works would be anticipated to progress at a consistent rate, there may be discreet locations which require a longer duration of tunnelling works due to site conditions.

Managing ground borne noise impacts

With reference to the CNVG ground-borne noise mitigation measures outlined in **Table 4-15**, the following mitigation measures should be considered where feasible and reasonable:

- Validation of predicted ground-borne noise levels (note that this may not be required where the ground-borne noise impacts would last less than three weeks at any one sensitive receiver and should be confirmed at a later design stage)
- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these will occur, impacts and mitigation measures
- Specific notifications provided to receivers where the ground-borne noise levels are predicted to exceed the night-time NML, providing additional information when relevant and more specific information than covered in general letterbox drops.

At receivers predicted to exceed the night-time NMLs by more than 10 dB, the following mitigation measures should be considered in addition to those outlined above:

- Individual briefings to inform the residents about the impacts of the works and mitigation measures that will be implemented. Where the resident cannot be met with individually then an alternative form of engagement should be used
- Respite periods may be offered to the affected residents during works where noise levels are predicted to exceed the NML by 10 dBA or more
- Alternative accommodation options may be offered to the affected residents for the periods where noise levels are predicted to exceed the NML by 10 dBA or more.

7.8.2 Utility works

Construction works associated with utility relocation and diversion works would likely be required at most compound sites. Works would also be required along various streets in the vicinity of the compound locations to allow access and modification to new and existing underground utilities. Where the utilities are within the road reserve, the work may be required outside standard daytime construction hours.

The exact location and equipment required to undertake utility works outside of compounds is being investigated and will be confirmed during the development of the detailed design and construction methodology. Utility works would require the use of noise intensive equipment such as excavators, concrete saws, rock-breakers, etc.

Noise impacts during these works would likely be relatively high when works are adjacent to receivers. However it is noted that the impacts would be of a temporary nature and would move progressively along the utility service corridor resulting in impacts at particular receivers for only a limited period of time. The potential noise impacts associated with utility works would be identified when the extent and locations of the works have been confirmed. Appropriate mitigation measures would be selected from the CNVG and implemented.

7.9 Environmental management measures

Mitigation and management measures for potential ambient noise and vibration impacts during construction and operation are shown in **Table 7-8**. Most of these measures are routinely employed as 'standard practice' on projects of this scale.

Table 7-8 Noise and vibration management measures to be implemented during construction and operation

Impact	No.	Environmental management measure	Timing
Construction			
Construction noise and vibration impacts	NV1	A suitably qualified and experienced acoustics advisor, who is independent of the design and construction personnel, will be engaged for the duration of construction of the project. The acoustics advisor will be responsible for: • Reviewing management plans related to noise and vibration and endorsing that they address all relevant conditions of approval and requirements of all applicable guidelines • Providing advice to the Proponent, the construction contractor(s) and the Secretary regarding the management of potential noise and vibration impacts associated with the project and compliance with relevant conditions of approval.	Construction

Impact	No.	Environmental management measure	Timing
	NV2	A Construction Noise and Vibration Management Plan will be prepared for the project. The plan will: • Identify relevant performance criteria in relation to noise and vibration • Identify noise and vibration sensitive receivers and features in the vicinity of the project • Include standard and additional mitigation measures from CNVG and details about when each will be applied • Describe the process(es) that will be adopted for carrying out location and activity specific noise and vibration impact assessments to assist with the selection of appropriate mitigation measures • Include protocols that will be adopted to manage works required outside standard construction hours in accordance with relevant guidelines • Detail monitoring that will be carried out to confirm project performance in relation to noise and vibration performance criteria. The CNVMP will be implemented for the duration of construction of the project.	Construction
	NV3	Detailed noise assessments will be carried out for all ancillary facilities required for construction of the project. The assessment will consider the proposed site layouts and noise generating activities that will occur at the facilities and assess predicted noise levels against the relevant noise management levels determined in accordance with the requirements of the ICNG. The assessments will be used to determine the appropriate heights and configurations of noise barriers, and other appropriate noise management measures, consistent with the requirements of the ICNG and the CNVG. Noise barriers, as confirmed through the noise assessments, will be installed as early as possible during site establishment and as a minimum prior to the commencement of excavation associated with tunnel access.	Construction
	NV4	As a minimum, location and activity specific noise and vibration impact assessments will be carried out prior to (as a minimum) activities: • With the potential to result in noise levels above 75 dBA at any receiver • Required outside standard construction hours likely to result in noise levels in greater than the relevant noise management levels • With the potential to exceed relevant performance criteria for vibration. The assessments will clarify predicted impacts at relevant receivers in the vicinity of the activities to assist with the selection of appropriate management measures, consistent with the requirements of ICNG and CNVG, that will be implemented during the works.	Construction

Impact	No.	Environmental management measure	Timing
Out-of-hours noise impacts	NV5	An out-of-hours works protocol will be developed for the construction of the project. The protocol will include: • Details of works required outside standard construction hours, including justification of why the activities are required outside standard construction hours • Measures that will be implemented to manage potential impacts associated with works outside standard construction hours • Location and activity specific noise and vibration impact assessment process(es) that will be followed to identify potentially affected receivers, clarify potential impacts and select appropriate management measures • Details of the approval process (internal and external) for works proposed outside standard construction hours. The protocol will be prepared in consultation with DP&E and the NSW EPA, endorsed by the acoustic advisor for the project and implemented during construction of the project.	Construction
Additional noise and vibration activity impacts	NV6	Monitoring will be carried out at the commencement of new noise and vibration intensive activities and works in new locations to confirm that actual noise and vibration levels are consistent with noise and vibration impact predictions and that the management measures that have been implemented are appropriate.	Construction
Acoustic sheds	NV7	Acoustic sheds will be designed within consideration of the activities that will occur within them and the relevant noise management levels in adjacent areas. Monitoring will be carried out to confirm that the actual acoustic performance of the sheds are consistent with predicted acoustic performance.	Construction
Vibration impacts	NV8	A Blast Management Strategy will be prepared and implemented for the project if blasting is proposed. The strategy will: • Identify relevant performance criteria in relation to potential noise and vibration impacts due to blasting with reference to (as a minimum) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZEC, 1990) and Australian Standard AS 2187.2-2006 *Explosives - Storage, transport and use, Part 2: Use of explosives* • Describe trials that will be carried out to confirm vibration levels from blasting and facilitate development of predictive tools to allow potential noise and vibration impacts to be identified • Include details of management measures that will be implemented to ensure compliance with relevant performance criteria. The Blast Management Strategy will be implemented for all blasting carried out as part of the project.	Construction

Impact	No.	Environmental management measure	Timing
Operational noise impacts	NV9	Receivers that qualify for assessment for at receiver treatment in relation to operational noise that are also predicted to experience significant exceedances of noise management levels due to construction will be given priority preference for assessment. When at receiver treatments are found to be appropriate, the application of the treatment will be expedited.	Construction
	NV10	Where reasonable and feasible, operational noise mitigation such as noise barriers, berms and at-property treatments identified during detailed design should be installed early in the project so as to provide a benefit to receivers during the construction phase of the project.	Construction
Road traffic noise	NV11	The use of low noise pavement to further reduce road traffic noise at the source will be investigated during detailed design taking into account whole-life engineering considerations and the overall social, economic and environmental effects. If low noise pavement is found to be appropriate, it would be considered as a management measure when assessing operation noise impacts based on the detailed design.	Construction
	NV12	The area in the vicinity of the western portal of the Iron Cove Link, Rozelle, will be assessed further during development of the detailed design to identify appropriate noise mitigation measures to address predicted increases in road traffic noise to the project. The measures that would be considered would include low road noise pavement, noise barriers, at-property treatments and the project design.	Construction
Operation			
Operational noise performance	N13	Potential operational noise performance of the project based on the detailed design would be assessed and appropriate management measures would be confirmed and implemented.	Construction
	NV14	Within 12 months of the commencement of the operation of the project, actual operational noise performance would be compared to predicted operational noise performance. The need for any additional management measures to address any identified operational performance issues and meet relevant operational noise criteria would be assessed and implemented where reasonable and feasible.	Operation

8 References

Assessing Vibration: A Technical Guideline (EPA, 2006)

Australian Acoustical Society Technical Meeting – Tunnelling Noise and Vibration Management (Wilkinson Murray, 2003)

Australian Standard AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors (Standards Australia, 2000)

Australian Standard AS 2187: Part 2-2006 Explosives - Storage and Use - Part 2: Use of Explosives (Standards Australia, 2006)

Australian Standard AS IEC 61672.1—2004 – Electroacoustics—Sound level meters, Part 1: Specifications (Standards Australia, 2004)

BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2 (British Standards Institution (BSI), 1993)

Calculation of Road Traffic Noise (CORTN) (UK Department of Transport, 1988)

Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime, 2016)

DIN 4150: Part 3-1999 Structural vibration - Effects of vibration on structures (Deutsches Institut für Normung (DIN), 1999)

Environmental Noise Management Manual (ENMM), Roads and Traffic Authority, 2001

Interim Construction Noise Guideline (ICNG) (EPA, 2009)

Internoise 96 Noise from Tunnel Openings – An Engineering Approach (Olafsen, 1996)

Model Validation Guideline (Roads and Maritime, draft document)

Noise Criteria Guideline (NCG) (Roads and Maritime, 2015)

Noise Criteria Guideline Application Notes (Roads and Maritime, 2016)

Noise Mitigation Guideline (NMG) (Roads and Maritime, 2015)

NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999)

NSW Industrial Noise Policy (INP) (EPA, 1999)

NSW Industrial Noise Policy Application Notes (EPA, 2010)

NSW Road Noise Policy (RNP) (NSW Environment Protection Agency (EPA), 2011)

Preparing an Operational Noise and Vibration Assessment (Roads and Maritime, 2011)

Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZECC 1990).

WestConnex M4 East EIS – Construction and Operational Noise and Vibration Impact Assessment

WestConnex New M5 EIS – Technical Working Paper: Noise and Vibration

Annexure A

Acoustic terminology

Acoustic terminology

1 Sound Level or Noise Level

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

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

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

2 'A' Weighted Sound Pressure Level

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

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

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

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

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

3 Sound Power Level

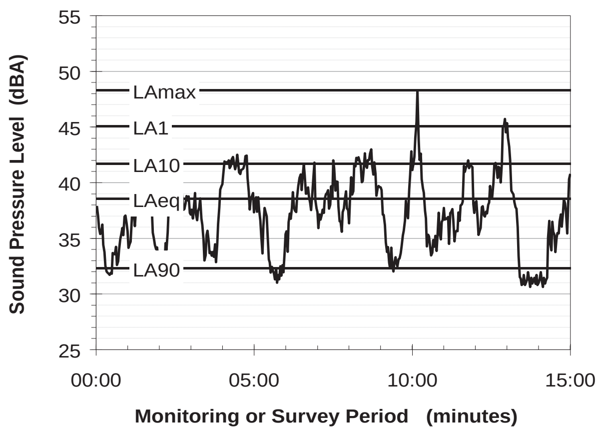
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

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

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

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

6 Impulsiveness

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

7 Frequency Analysis

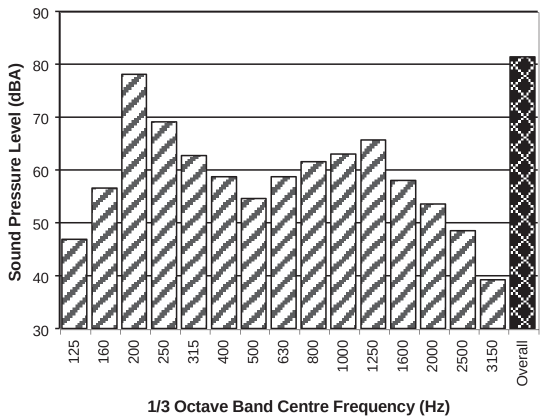
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

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

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

9 Human Perception of Vibration

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

10 Over-Pressure

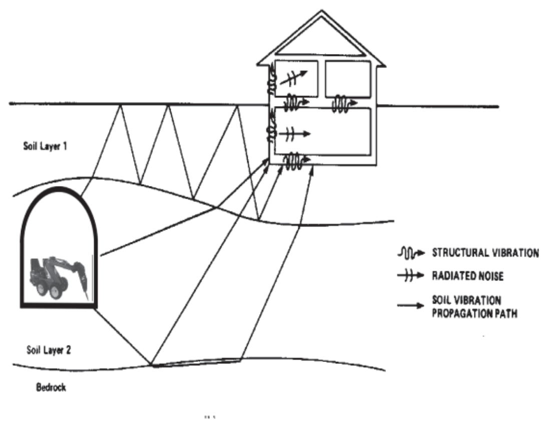
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

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

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

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



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

Annexure B-1

Site plan and noise catchment areas