Appendix

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Appendix G

Noise and vibration

Main document

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Roads and Maritime Services

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Noise and vibration

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Prepared for

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Prepared by

Renzo Tonin and Associates

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Executive summary

Introduction (section 1)

Renzo Tonin & Associates has been engaged by Roads and Maritime Services (Roads and Maritime) to assess potential noise and vibration impacts from the construction and operation of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the WestConnex M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including allowance for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

Existing noise environment (section 2)

The project extends from Rozelle at the southern extent, through to Naremburn at the most northern extent. Areas adjacent to the project alignment have been separated into 89 noise catchment areas (NCAs), which represent areas with similar acoustic environments.

The existing acoustic environment varies throughout the project alignment. Residents located along existing major road corridors, such as City West Link and Warringah Freeway, experience high levels of road traffic noise, while further away from these corridors other roads and noise sources influence the noise environment for receivers.

Long-term noise monitoring was carried out at 41 locations throughout the project extent, supplemented by data from the M4-M5 Link project, where required. The monitoring data was used to quantify the existing noise environment in areas where receivers may potentially be affected by construction noise, and to determine the existing levels of road traffic noise along the project corridor. Noise logging occurred for between seven days and 25 days at each location, except for one location where data was logged over five days, which was considered appropriate for this assessment.

Criteria and noise management levels (NMLs) for the assessment of operational and construction noise were derived with reference to the long-term noise monitoring. In addition, the operational road traffic noise models have been calibrated using the monitoring of existing road traffic noise levels.

Relevant guidelines and noise and vibration objectives (section 3)

Noise and vibration guidelines listed in the project Secretary's environmental assessment requirements have been considered in this assessment. Roads and Maritime's *Construction Noise and Vibration Guideline* (2016) (CNVG) provides guidance for the assessment and mitigation of construction noise and

vibration. The CNVG refers to the policies, guidelines and standards presented in Table 3-1, which have been adopted in the construction noise and vibration assessment for the project.

The operational noise guidelines and policies adopted for the operational noise assessment are presented in Table 3-18.

Noise and vibration assessment methodology (section 4)

Construction

Across the Western Harbour Tunnel and Warringah Freeway Upgrade project, the construction works with the potential for noise and vibration impacts have been separated into two major categories:

- **Construction support sites** are fixed construction support sites located along the project length and would be established for a large proportion of the project duration. Within these support sites, the louder construction activities occur predominantly during standard construction hours, with support for 24-hour tunnelling taking place within acoustic sheds. Access decline tunnel, shaft or ventilation tunnel construction is also assessed as part of construction support sites
- **Surface road upgrades** where construction locations vary along the corridor and where works occur at each location for shorter periods of time. For **surface road upgrades,** large portions of the construction work need to occur during road closures. As road closures for major arterial roads must occur outside the peak traffic period, a large amount of out of hours construction works (OOHW) would be needed during the evenings and nights.

Construction noise and vibration impacts have been assessed using three-dimensional models which include all noise sources, receiver locations, topographical and man-made features, and feasible and reasonable noise mitigation measures developed for this project. Models were developed for each of the major stages of construction across the project based on preliminary site layouts and reasonable worst case construction plant and equipment. Feasible and reasonable noise treatment measures and management methods have been identified and incorporated into the models to assist in attenuating and managing noise from construction activities as discussed in Section 4.1.

For **surface road upgrades**, additional assessment took place to look at both typical and reasonable worst case construction activities, both when works are in close proximity to receivers and further away within the construction works area. Predicted impacts for both these cases represent the highest noise levels that occur over an entire stage/works area and not an individual activity/night. The number of noise affected receivers on an individual night would be less than presented, and receivers impacted would also vary between nights as the location and type of activity change.

Both assessment approaches are conservative. Actual noise levels would vary greatly depending on a range of factors including the location of the construction works within each construction works area, the distance between noise sources and nearby receivers, the noise intensity of works taking place and the time of day specific activities take place. All construction works would be reviewed during detailed

design as part of the site-specific construction noise and vibration impact statement (CNVIS) to determine which works are required to occur outside standard construction hours and re-evaluate the proposed mitigation and management measures as required.

The potential ground-borne noise and vibration impacts from the construction of the mainline tunnels and ramps is assessed as a separate section.

Operation

Operational road traffic noise impacts were assessed for surface roads associated with the project. Noise modelling predictions were carried out for all noise-sensitive receiver locations. For multi-storey buildings, all floor levels which accommodate noise-sensitive receivers have been included in the road traffic noise assessment.

Various operational traffic noise scenarios were modelled; however, the identification of additional traffic noise mitigation (eg. noise barriers, at-property treatment) was based on the assessment between the 'without the project' (2037 'Do minimum') and the 'with the project-cumulative' (2037 'Do something cumulative') scenarios, where these scenarios represent the following:

- Without the project – **WITH** the full WestConnex (Stages 1, 2 and 3), **WITHOUT** the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension
- With the project cumulative – **WITH** the project, full WestConnex (Stages 1, 2 and 3), Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.

Construction noise and vibration assessment (section 5)

This section summaries the potential noise and vibration impacts, with the mitigation and management measures to control these impacts outlined in the following section.

Rozelle Rail Yards (section 5.2)

The Rozelle Rail Yards construction support site located on City West Link at Lilyfield would be located within the M4-M5 Link's Rozelle construction support site.

As an overview, works at this site would typically be carried out during standard construction hours only, except for tunnel fitout support deliveries. Noise mitigation measures outlined in the M4-M5 Link environmental impact statement have been identified and assumed for the noise impact assessment at this construction site, with no receivers are predicted to be highly noise affected (ie. >75 dB(A)). The highest predicted noise levels occur during early works in standard construction hours, where no receiver buildings (a receiver building represents an individual building such as house or apartment building) are expected to be noise affected (ie. > NML). No non-residential receiver buildings are expected to be noise affected.

Outside standard construction hours, tunnel fitout and finishing works (ROZ_03) would require deliveries to the tunnel during the night period; however, these activities would not result in any noise-affected

receivers. Maximum noise levels from delivery heavy vehicles are predicted to be above the sleep disturbance screening level at some receiver buildings; however, no receiver buildings are predicted to exceed the awakening reaction noise level.

The project timeline overlaps the adjacent WestConnex M4-M5 Link Rozelle Rail Yards construction support site. The proximity of these construction works could result in increases in construction noise levels, potentially exceeding the NML. However, noise impacts from the M4-M5 Link works are expected to dominate during all construction stages except the loudest early stage construction work, and during other stages cumulative construction noise levels are predicted to either remain below the NML or would be dominated by the M4-M5 Link construction work. As such, potential cumulative construction noise impacts are considered minor; however, there may be increases in the overall duration and frequency of construction noise impacts. These cumulative and consecutive project construction noise impacts would be managed, coordinated and mitigated at detailed design stage in the relevant CNVIS.

Road traffic noise levels at receivers directly exposed to traffic noise on construction haulage and traffic routes (City West Link/James Craig Road), including M4-M5 Link construction traffic and other project sites, are predicted to increase by less than 2 dB(A) during both day and night as a result of construction traffic, which represents a minor impact. Since the number of heavy vehicle movements generated by the site is not substantial compared to existing heavy vehicle numbers on the City West Link, sleep disturbance impacts are not likely increase.

A ventilation tunnel would be constructed from the mainline tunnel alignment to locations within the Rozelle Rail Yards with the potential for ground-borne noise impacts on sensitive receivers during roadheader construction of the ventilation tunnel.

No vibration-intensive work is proposed for the Rozelle Rail Yards construction support site, so vibration impacts have not been assessed for this site.

Victoria Road (section 5.3)

There would be a Victoria Road construction support site at Rozelle to support tunnelling works between Rozelle and Yurulbin Point.

The highest predicted noise levels occur during early works and site establishment, which is expected when carrying out rock hammering for the relocation of services and demolition of existing structures. During these stages, up to 27 residential receiver buildings are predicted to be highly noise affected (ie. >75 dB(A) and up to 208 residential receiver buildings are predicted to be noise affected (ie. > NML) during standard construction hours. During other stages, up to 138 residential receiver buildings are predicted to be noise affected during standard construction hours. Up to thirteen non-residential receivers would also be noise affected. It is noted that the longest duration works, being tunnel construction and tunnel fitout, would have the lowest potential noise impact, no more than 11 receiver buildings being noise affected during standard hours.

Outside standard construction hours, up to three residential receiver buildings are predicted to be noise affected by delivery activities at night. During longer-term tunnel fitout work, no receivers are expected to be noise affected. Maximum noise levels from delivery vehicles are predicted to be above the awakening reaction noise levels, however the number of heavy vehicle movements generated by the site are not substantial compared to existing traffic numbers on Victoria Road and so sleep disturbance impacts are not likely.

The project timeline overlaps the nearby M4-M5 Link Iron Cove construction support site. The proximity of these construction works could result in increases in construction noise levels, potentially exceeding the NML. Cumulative increases in construction noise levels are predicted to be up to 3 dB(A) above construction noise levels from an individual project.

Road traffic noise levels at receivers directly exposed to Victoria Road, including M4-M5 Link construction traffic, are predicted to increase by less than 2 dB(A) during both the day and night as a result of construction traffic, which represents a minor impact. Since the number of heavy vehicle movements generated by the site are not substantial compared to existing heavy vehicle numbers on Victoria Road, sleep disturbance impacts are not likely to occur.

Ground-borne noise impacts from the construction of the access decline tunnel between the Victoria Road construction support site and the mainline tunnel alignment would be managed where required by restricting working hours to ensure ground-borne noise levels at noise sensitive receiver buildings are below the appropriate ground-borne noise management level (GBNML).

When large rock hammers are used during early construction stages, up to thirty-eight receiver buildings are identified as within the sound structure cosmetic damage minimum working distance, one heritage item is located within the minimum working distance for unsound structures and occupants of 112 receiver buildings could potentially experience vibration levels above the human response level.

White Bay (section 5.4)

The White Bay construction support site would be used to cast tunnel elements, handle excavated spoil and handle dredge spoil from the water-based tunnelling sites in Sydney Harbour at Birchgrove and Berrys Bay.

During standard construction hours, for all construction work stages except for early works, a maximum of two receiver buildings are predicted to be noise affected. During utility connections as part of the early works, up to 90 residential receiver buildings are predicted to be noise affected; however, this would be for a relatively short duration at some point during the site establishment stage. No receivers are predicted to be highly noise affected (ie. >75 dB(A)) during any construction stage. Seven non-residential receiver buildings are also predicted to be noise affected.

Outside standard construction hours, construction works would not typically be carried out except for support for the Yurulbin construction site during tunnel construction. Concrete agitators would be transported by barge from White Bay to the Yurulbin construction support site. As the tunnel

construction works take place 24 hours a day, this support would be required to take place during the evening and night periods, with no nearby receivers predicted to be noise affected. Maximum noise levels are predicted to be above the sleep disturbance screening level at five residential receiver buildings, but do not exceed the awakening reaction noise level.

The project timeline overlaps the nearby M4-M5 Link construction support site, and could result in increased overall construction noise levels, potentially exceeding the NML. However, cumulative construction noise increases are unlikely, as they would only occur during the early works stage.

Road traffic noise levels at receivers directly exposed to traffic noise on construction haulage and traffic routes (The Crescent, City West Link and James Craig Road) are predicted to increase by less than 2 dB(A) during both day and night. This is due to the addition of construction traffic from the project and the M4-M5 Link, which represents a minor impact. Since the number of heavy vehicle movements generated by the site is not substantial compared to existing heavy vehicle numbers on The Crescent, City West Link and Victoria Road, sleep disturbance impacts are not likely to increase.

In the case that rock hammers are used during utility connection works one heritage item is located within the minimum working distance for unsound structures and occupants of five receiver buildings could potentially experience vibration levels above the human response level.

Yurulbin Point (section 5.5)

The Yurulbin Point construction support site would support mainline tunnelling and spoil removal by barge, eliminating spoil haulage by road along Louisa Road, Birchgrove.

During standard construction hours, no receivers are predicted to be highly noise affected except during site establishment utility works, when up to two residential receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) and up to 229 are predicted to be noise affected (ie. > NML) by rock hammering. One non-residential receiver is also predicted to be noise affected. During other stages, noise levels would be less, with up to 128 noise affected residential receiver buildings. The longest duration works, being tunnel construction and tunnel fitout, would have the lowest potential noise impact, with no noise affected receiver buildings during standard hours.

No receivers are predicted to be noise affected outside standard construction hours. However, maximum noise levels associated with barge deliveries during night time tunnel support and tunnel fitout are predicted to exceed sleep disturbance screening levels at up to 88 receiver buildings, with maximum noise levels potentially above awakening reaction levels at up to nine receiver buildings.

The Yurulbin Point construction support site timeline overlaps the timeline of nearby construction support sites at Berrys Bay and the Sydney Harbour Crossing. Cumulative impacts from Berrys Bay are unlikely, while cumulative noise level increases and consecutive noise impacts from the Sydney Harbour Crossing activities could affect receivers near the site.

Access and deliveries to and from the site would be via water by small boats or barges. No road traffic movements or associated noise would be generated at the site.

Ground-borne noise was predicted from the construction of the access shaft between the Yurulbin Point construction support site and the mainline tunnel alignment, with potential impacts managed by restricting construction hours to ensure ground-borne noise levels are below the appropriate GBNML.

When large rock hammers are used, four heritage items are located within the minimum working distance for unsound structures and the occupants of 21 receiver buildings could potentially experience vibration levels above the human response level. Vibration impacts would be managed through applying all feasible and reasonable vibration mitigation measures, including alternative equipment/techniques, vibration monitoring and respite where required.

Sydney Harbour Crossing (section 5.6)

The Sydney Harbour Crossing would be an immersed tube tunnel crossing Sydney Harbour, between Birchgrove and Waverton.

During standard construction hours, noise levels from cofferdam impact piling are predicted to exceed the NML at up to 545 receiver buildings, including six receiver buildings predicted to be highly noise affected (ie. >75 dB(A)) during piling of the Sydney Harbour south cofferdam on the southern side of Sydney Harbour. Other stages of the Sydney Harbour crossing would result in low noise impacts, with no more than six receiver buildings predicted to be noise affected and no highly noise affected (ie. >75 dB(A)) receiver buildings. The higher noise impacts during the building of the cofferdams are due to impact piling with large (23 tonne) hammers, which are difficult to physically mitigate. Impact piling would result in up to six non-residential receivers being noise affected.

To manage noise impacts, the impact piling works would be restricted to standard construction hours with respite periods provided to receivers for high noise work. The high noise generating activities from impact piling would likely only occur for part of the day. The associated setup and piling preparation works would occur during the rest of the day. Vibratory piling would occur throughout the day and noise impacts would be managed in a similar manner, with respite.

Up to six receiver buildings are predicted to be noise affected during excavation within the cofferdams. Excavation would only occur during standard construction hours. Due to the distance from the construction works, only one non-residential receiver, a recreation area, is predicted to be noise affected from the construction works.

Only dredging (trailer suction hopper dredging) and tunnel element immersion activities would be required outside standard construction hours, from which up to 53 nearby receiver buildings are predicted to be noise affected. However, trailer suction hopper dredging of the crossing would only occur around three times a night for around half an hour at a time, as most of the time the dredge would be travelling between the Sydney Harbour Crossing and the disposal site. Each tunnel element would take 24 to 48 hours to immerse, and for safety this would occur during harbour closures. Up to 138 residential receiver buildings are predicted to be noise affected during tunnel element immersions.

Maximum noise levels associated with dredging and tunnel element immersion activities during the night period are predicted to exceed the sleep disturbance screening level at up to 102 receiver buildings, while events related to crane/equipment/plant operation during tunnel element immersion are predicted to also exceed the awakening reaction level at seven receiver buildings.

The Sydney Harbour Crossing timeline overlaps the nearby project construction support sites at Berrys Bay and Yurulbin Point; however, cumulative increases in construction noise are not expected to be substantial.

During cofferdam construction activities 20 heritage items are within the unsound structure minimum working distance, which would be carefully managed, but no other buildings are within the minimum working distance. Site-specific buffer distances would be determined during detailed design to maintain compliance with relevant vibration limits for cosmetic damage. Where this cannot be achieved, alternative construction methodologies would be investigated. Due to the limited duration of piling or rock hammering activities, there is a low risk of human response to vibration; however, occupants of up to 72 buildings would potentially be exposed to vibration above the human response level.

Berrys Bay (section 5.7)

The Berrys Bay construction support site would be a tunnel support site on Balls Head Road at Waverton.

No receivers are predicted to be highly noise affected (ie. >75 dB(A)) during standard construction hours except for one building during early works. Up to 92 receiver buildings are predicted to be noise affected (ie. > NML) during site establishment, but once the site is established, no more than 32 residential receiver buildings would be noise affected. One non-residential receiver would be noise affected.

Outside standard construction hours, up to one residential receiver building is predicted to be noise affected by delivery truck activities. During longer-term tunnel fitout work, no receivers are expected to be noise affected.

Maximum noise levels from delivery truck arrivals or departures when on site may be above sleep disturbance screening levels at up to 25 receiver buildings and may be above the awakening reaction level at two receiver buildings. No more than three concrete truck deliveries are anticipated during a night period and these maximum noise events would be managed.

The project timeline overlaps the nearby construction support sites at Yurulbin Point and the Sydney Harbour Crossing. Cumulative impacts from Yurulbin Point are unlikely, while consecutive noise impacts from the Sydney Harbour Crossing could affect receivers near the site.

Total predicted road traffic noise levels at receivers along Balls Head Road and Bay Road exceed the *NSW Road Noise Policy* (RNP) (Department of Climate Change and Water, 2011) local road noise criteria by up to 6 dB(A) during the daytime period and up to 7 dB(A) in the night period during tunnel support and fitout. Maximum noise levels from these night heavy vehicle movements are predicted to exceed

the sleep disturbance screening level and awakening reaction levels at receivers along Balls Head Road and Bay Road. While the predicted noise levels exceed the RNP criteria, heavy vehicle movements would be infrequent.

Ground-borne noise was predicted from the construction of the access decline tunnel between the site and the mainline tunnel with potential impacts managed by restricting construction hours to ensure ground-borne noise levels experienced by noise sensitive receiver buildings are below the appropriate GBNML.

When large rock hammers are used during early construction stages, up to four receiver buildings are identified as within the sound structure cosmetic damage minimum working distance, one heritage item is located within the minimum working distance for unsound structures and occupants of 112 receiver buildings could potentially experience vibration levels above the human response level.

Cammeray Golf Course (section 5.8)

The construction support site at Cammeray Golf Course would be a tunnel support site, a support site for the Warringah Freeway Upgrade, and the site of operational facilities for the project including ventilation buildings.

Noise impacts from construction works at the Cammeray Golf Course construction support sites are mostly low impact. Receiver buildings are most noise affected during the early works and site establishment phases, which are short duration. Up to 12 receiver buildings may be highly noise affected (ie. >75 dB(A)) and up to 242 residential receiver buildings may be noise affected by these works during standard construction hours. Up to 14 non-residential receivers may be noise affected during the short duration early works and site establishment phases.

Once the site is established, no residential receiver buildings are predicted to be noise affected during standard construction hours until site rehabilitation, although up to three non-residential receivers may be noise affected (ie. > NML) during surface work support and acoustic shed construction. During site rehabilitation works, up to 17 residential receiver buildings, and four non-residential receivers, are predicted to be noise affected (ie. > NML). No receiver buildings are likely to be highly noise affected.

OOHW would be mitigated and managed to achieve the NMLs, with construction noise levels predicted to achieve the NML for all project stages. Maximum noise levels are predicted to exceed the sleep disturbance screening level during night time Warringah Freeway Upgrade surface road works support activities and concrete deliveries during longer-term tunnelling and tunnel fitout, with predicted noise levels from some activities also exceeding the awakening reaction levels.

The project timeline overlaps nearby construction support sites, specifically the Warringah Freeway Upgrade, and the Victoria Cross North construction support site for the Sydney Metro project. If works across these projects occur simultaneously there is potential for construction noise impacts at similar receivers. Consequently, there is potential for increased overall duration and frequency of construction noise impacts during both standard construction hours and outside standard construction hours.

The majority of heavy vehicle access to the Cammeray Golf Course construction support sites during tunnel construction and some Warringah Freeway Upgrade surface road works, would be directly to and from the Warringah Freeway. Light vehicle access to this site is expected to be to and from Ernest Street; however, some heavy vehicles would access the site via Ernest Street, particularly prior to construction of access points to the site via the Warringah Freeway during site establishment. Since the number of heavy vehicle movements generated by the site on the Warringah Freeway is not substantial compared to existing traffic volumes and heavy vehicle numbers, road traffic noise impacts are not expected, and sleep disturbance impacts are not likely to increase.

Ground-borne noise was predicted from the construction of the access shaft, decline and ventilation tunnels, with potential impacts managed by restricting construction hours to ensure ground-borne noise levels experienced by noise sensitive receiver buildings are below the appropriate GBNML.

If large rock hammers are used during site establishment, six buildings would be within the minimum working distance for cosmetic damage to sound structures, and one heritage item within the unsound structure minimum working distance. Due to the limited duration that rock hammers would operate at this site; the risk of annoyance is considered low. However, occupants at up to 41 receiver buildings may be exposed to vibration levels above the perception level during early works and site establishment.

Warringah Freeway Upgrade surface road works (section 5.9)

The Warringah Freeway Upgrade surface road works would involve surface road upgrade works that would extend from the northern end of the Sydney Harbour Bridge to Willoughby Road. The main construction activities include cut and cover portals to the Western Harbour Tunnel and the Beaches Link tunnel (not part of this project), and upgrades to surface roads in the Warringah Freeway corridor. Work would take place across 11 major works areas, supported by 11 minor construction support sites. In addition to those areas, some local road works, road surface and modification works, utility and sewerage modification works along the Warringah Freeway Upgrade surface road works would also be required at locations to be determined during detailed design.

To protect the safety of workers and road users, and minimise disruption to critical roads, certain works would need to occur outside standard construction hours, typically during road closures. The works would often move along the Warringah Freeway Upgrade surface road works, minimising the length of time specific areas are impacted by noise.

Noise levels were predicted for each of the key stages across all major works areas. Most work areas would require noisy activities such as rock hammering and road sawing; however, these activities would occur only for small periods of time and could be scheduled for less sensitive time periods such as before midnight. Predictions indicate that across the major works areas, receivers close to the works could experience noise levels that exceed the NML by more than 25 dB(A), which would be considered highly intrusive, and may exceed sleep disturbance and awakening reaction levels. However, when works occur further away in the works area, predicted noise levels are lower.

There are limited opportunities to install fixed noise mitigation (ie. acoustic sheds, acoustic enclosures, large temporary barriers) as the road needs to be fully open the next day. Receivers are predicted to be noise affected at different times during the construction works.

A range of options and methods have been identified and developed to mitigate the noise impacts as part of this assessment. The management of these noise impacts will be further considered in detailed design as part of the project construction noise and vibration management plan (CNVMP), out of hours work (OOHW) protocol and each site-specific CNVIS to refine the management measures outlined in this assessment. The following mitigation and management measures would be used across the works where feasible and reasonable to minimise construction noise and vibration impacts:

- Management and mitigation at the noise/vibration source (eg. acoustic screens, use of quieter plant and equipment)
- Community engagement to provide information about what are the most effective noise mitigation and management strategies and how they are being implemented on the project
- Construction programming to utilise the linear nature of the surface road works area and shifting the works along the extent of the works area to provide respite to receivers affected by different sections of works area
- Limiting timing of noise-intensive work to provide respite to highly noise affected receivers.

Following the incorporation of these mitigation and management measures, additional mitigation measures would be provided in accordance with the CNVG to manage residual impacts where receivers remain noise affected.

The Warringah Freeway Upgrade surface road works timeline overlaps nearby construction support sites associated with the project and construction sites associated with the Beaches Link and Gore Hill Freeway Connection project and the Sydney Metro project. Construction program planning and coordination would be implemented where feasible and reasonable to manage cumulative and consecutive impacts from these various construction activities. The site-specific CNVIS developed for the Warringah Freeway Upgrade surface road works would detail the programming, coordination and management where feasible and reasonable of concurrent and consecutive construction noise activities to minimise impacts and provide respite to noise affected receivers. Where required, additional mitigation measures would be adopted with consideration of cumulative and long-term noise impacts on the noise affected receiver buildings.

A relatively small number of construction vehicles are proposed to travel between the Warringah Freeway Upgrade surface road works major works areas, with most vehicles travelling directly to each area at the start of a shift during less sensitive times of day. Similarly, Warringah Freeway Upgrade surface road works are likely to decrease existing vehicle speeds on the Warringah Freeway, which would likely result in decreased road traffic noise levels during construction.

Site-specific CNVISs would be developed for the Warringah Freeway Upgrade surface road works construction support sites during detailed design to assist in reducing OOHW construction noise

impacts to receivers. This would include developing site layouts to reduce noise impacts such as placing site offices and fixed structures between the works area and the receivers to assist in reducing noise levels to nearby receivers. Where feasible and reasonable, louder support activities would be scheduled to standard construction hours.

Impacts from mainline tunnelling works (section 5.11)

Tunnelling activities associated with the construction of the project would include:

- Roadheader tunnelling
- Rock drilling tunnel support
- Excavation using rock hammers
- Blasting (section 5.12)
- Cross passage excavation.

Buildings potentially affected by ground-borne noise (ie. above the GBNML) from roadheader tunnelling are located across Waverton and North Sydney, and include:

- Twenty-three residential receiver buildings may be ground-borne noise affected during the night period (above 35 dB(A))
- One residential property may be ground-borne noise affected during the evening period (above 40 dB(A))
- No residential receiver buildings are predicted to be exposed to ground-borne noise levels above 45 dB(A)
- One other noise sensitive receiver building (theatre) in North Sydney is predicted to be ground-borne noise-affected
- Commercial/industrial premises and all other noise-sensitive receivers are not expected to be ground-borne noise affected during roadheader tunnelling.

Ground-borne noise affected properties would require, as a minimum, letterbox notification to advise that tunnelling works would be occurring and that noise levels are likely to be clearly audible during the works. Other mitigation and management measures would be put in place based on the level of ground-borne noise.

Typically, excavators with large rock hammer attachments would follow behind the roadheaders to remove the rock along the tunnel floor (the bench). There is potential that more receiver buildings would be affected by ground-borne noise from rock hammer tunnelling than during the roadheader operations, and these would be located along the length of the mainline tunnel. Where ground-borne noise levels are predicted to exceed NMLs outside standard construction hours, impacts would be managed by restricting rock hammer excavation to standard construction hours.

No buildings are identified within the cosmetic damage safe working distance for roadheader or rock hammer tunnelling. Five heritage items, as well as the Balls Head Coal Loader and associated wrecks, would be within the safe working distance for tunnelling, Additionally, vibration impacts from roadheader tunnelling are predicted to be below the vibration limit for human disturbance at all receivers, while occupants of up to 258 occupied receiver buildings fall within the minimum working distance for human response from vibration generated during rock hammer tunnelling. Additional mitigation measures would be provided for some receivers.

Construction noise and vibration mitigation (section 6)

Site-specific feasible and reasonable noise management, mitigation and treatment measures have been developed across the project and included in the assessment of the project's construction noise and vibration impacts. These include specifically designed measures such as construction noise barriers, acoustic sheds, acoustic enclosures, and limiting construction hours and activities.

Mitigation and management measures would be reviewed in accordance with the CNVG and project approval conditions when preparing site-specific CNVISs during detailed design to reflect the contractor's preferred construction approach. Detailed design refinements to construction work areas, locations, layouts, equipment, construction methods or construction hours may require other mitigation and management measures from those assumed.

A CNVMP would be prepared during detailed design to document, in more detail, how all mitigation measures would be implemented for the project. The CNVMP, OOHW protocol and the site-specific CNVIS would include detailed programming, coordination and management where feasible and reasonable of concurrent or consecutive construction noise and vibration impacts to minimise and provide respite to affected receivers considering all construction noise and vibration impacts and not projects individually. These would include:

- Management and mitigation at the source of noise or vibration, such as site design, acoustic screens, use of quieter plant and equipment
- Community consultation, engagement and notification to inform the most effective noise mitigation and management strategy
- Detailed programming and respite protocols
- OOHW protocols
- Limiting timing of noise-intensive work to provide respite to highly noise affected receivers
- Construction traffic management
- Maintaining minimum working distances from vibration intensive plant and equipment
- Vibration and blasting trials and/or monitoring along with building condition surveys.

Following these, additional mitigation measures would be provided to manage residual impacts in line with the CNVG, where receivers remain noise affected even after the incorporation of feasible and reasonable mitigation measures.

Where operational noise mitigation is found to be both feasible and reasonable at reducing construction noise impacts and likely to form part of the final design, then installation of operational noise mitigation would be targeted at an early stage in the project with the aim of assisting with the mitigation and management of construction noise impacts.

Operational noise assessment (section 7)

The project is predicted to typically decrease road traffic noise levels at most receiver locations, with additional noise mitigation requirements a result of the high existing road traffic noise levels resulting in exceedances of the cumulative limit criterion or traffic noise levels being acute.

A total of 478 receiver buildings have been identified as requiring additional noise mitigation, where 71 receiver buildings were identified in the area surrounding the surface connection to City West Link at Rozelle and 407 receiver buildings in the Warringah Freeway Upgrade area. It is noted that for the surface connection to City West Link at Rozelle, some receiver buildings may be provided with noise mitigation measures as part of the M4-M5 Link project.

Noise barriers have been considered at various locations in the area surrounding the surface connection to City West Link at Rozelle and the Warringah Freeway and surrounds including quieter pavement, noise barriers and at-property treatment. Design barrier heights were determined through the Roads and Maritime's *Noise Mitigation Guideline* (NMG) barrier analysis procedures. The reasonableness and feasibility of barrier heights were subject to urban design, visual amenity, landscape impacts, constructability, impacts on properties and other engineering constraints.

With the implementation of the reasonable and feasible noise barriers, residual receivers still exceeding the Roads and Maritime's *Noise Criteria Guideline* (NCG) project criteria were identified and triggered for eligible at-property treatment.

The project is predicted to increase maximum noise levels and the number of maximum noise events in the following areas:

- Receivers to the west of The Crescent and City West Link intersection may experience an increase in maximum noise levels and the number of events, due to the realignment of The Crescent closer to those receivers to allow the intersection to include roads leading to and from the portal of the Western Harbour Tunnel and increased traffic movements
- Receivers to the north of City West Link are predicted to experience an increase in maximum noise levels and the number of events due to the widening of City West Link moving traffic closer to those receivers and increased traffic movements due to the operation of the Western Harbour Tunnel portal

- Receivers to the east of Warringah Freeway are predicted to experience an increase in maximum noise levels and the number of events, due to the Warringah Freeway widening causing southbound traffic to move closer to receivers.

Given there are no major realignments or widening of the roads in the other areas besides those discussed above, maximum noise levels are not expected to increase as a result of the project.

Operational noise impacts from the proposed fixed facilities associated with the project have been assessed for receivers surrounding the facilities. Predicted noise levels from the proposed fixed facilities are predicted to comply with the relevant project noise levels.

Assessment of final noise predictions from the proposed fixed facilities and any required noise mitigation measures would occur during the project's detailed design, when actual types, makes and models of the plant and equipment are known.

1 Introduction

This chapter provides an overview of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), including its key features and location. It also outlines the Secretary's environmental assessment requirements addressed in this technical working paper.

1.1 Overview

The Greater Sydney Commission's Greater Sydney Region Plan – A Metropolis of Three Cities (Greater Sydney Commission, 2018) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth the NSW Government is implementing the Future Transport Strategy 2056 (Transport for NSW, 2018), a plan that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and to improve transport connectivity with Sydney's northern beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and south, west and north-west of Sydney Harbour. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested harbour crossings.

1.2 The project

Roads and Maritime Services (Roads and Maritime) is seeking approval under Division 5.2, Part 5 of the Environmental Planning and Assessment Act 1979 to construct and operate the Western Harbour Tunnel and Warringah Freeway Upgrade, which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)

- Upgrade and integration works along the existing Warringah Freeway, including infrastructure required for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

Key features of the Western Harbour Tunnel component of the project are shown in Figure 1-1 and would include:

- Twin mainline tunnels about 6.5 kilometres long and each accommodating three lanes of traffic in each direction, connecting the stub tunnels from the M4-M5 Link at Rozelle to the Warringah Freeway and to the Beaches Link mainline tunnels at Cammeray. The crossing of Sydney Harbour between Birchgrove and Waverton would involve a dual, three lane, immersed tube tunnel
- Connections to the stub tunnels at the M4-M5 Link project in Rozelle and to the mainline tunnels at Cammeray (for a future connection to the Beaches Link and Gore Hill Freeway Connection project)
- Surface connections at Rozelle, North Sydney and Cammeray, including direct connections to and from the Warringah Freeway (including integration with the Warringah Freeway Upgrade), an off ramp to Falcon Street and an on ramp from Berry Street at North Sydney
- A ventilation outlet and motorway facilities (fitout and commissioning only) at the Rozelle Interchange
- A ventilation outlet and motorway facilities at the Warringah Freeway in Cammeray
- Operational facilities including a motorway control centre at Waltham Street, within the Artarmon industrial area and tunnel support facilities at the Warringah Freeway in Cammeray
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, signage, tolling infrastructure, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure, CCTV and other traffic management systems.

Key features of the Warringah Freeway Upgrade component of the project are shown in Figure 1-2 and would include:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges at Falcon Street in Cammeray and High Street in North Sydney
- New and upgraded pedestrian and cyclist infrastructure
- New, modified and relocated road and shared user bridges across the Warringah Freeway
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels and the Beaches Link tunnels via on and off ramps, which would consist of a combination of trough and cut and cover structures

- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network
- Upgrades and modifications to bus infrastructure, including relocation of the existing bus layover along the Warringah Freeway
- Other operational infrastructure, including surface drainage and utility infrastructure, signage, tolling, lighting, CCTV and other traffic management systems.

A detailed description of the project is provided in Chapter 5 (Project description) and construction of the project is described in Chapter 6 (Construction work) of the environmental impact statement. The project alignment at the Rozelle Interchange shown in Figure 1-1 and Figure 1-3 reflects the arrangement presented in the environmental impact statement for the M4-M5 Link, and as amended by the proposed modifications, would be constructed in accordance with the now finalised M4-M5 Link detailed design. Refer to Section 2.1.1 of Chapter 2 (Assessment process) of the environmental impact statement for further details.

The project does not include ongoing motorway maintenance activities during operation or future use of residual land occupied or affected by project construction activities, but not required for operational infrastructure. These would be subject to separate planning and approval processes at the relevant times.

Subject to the project obtaining planning approval, construction is anticipated to commence in 2020 and is expected to take around six years to complete.

Figure 1-1 – Key features of the Western Harbour Tunnel component of the project

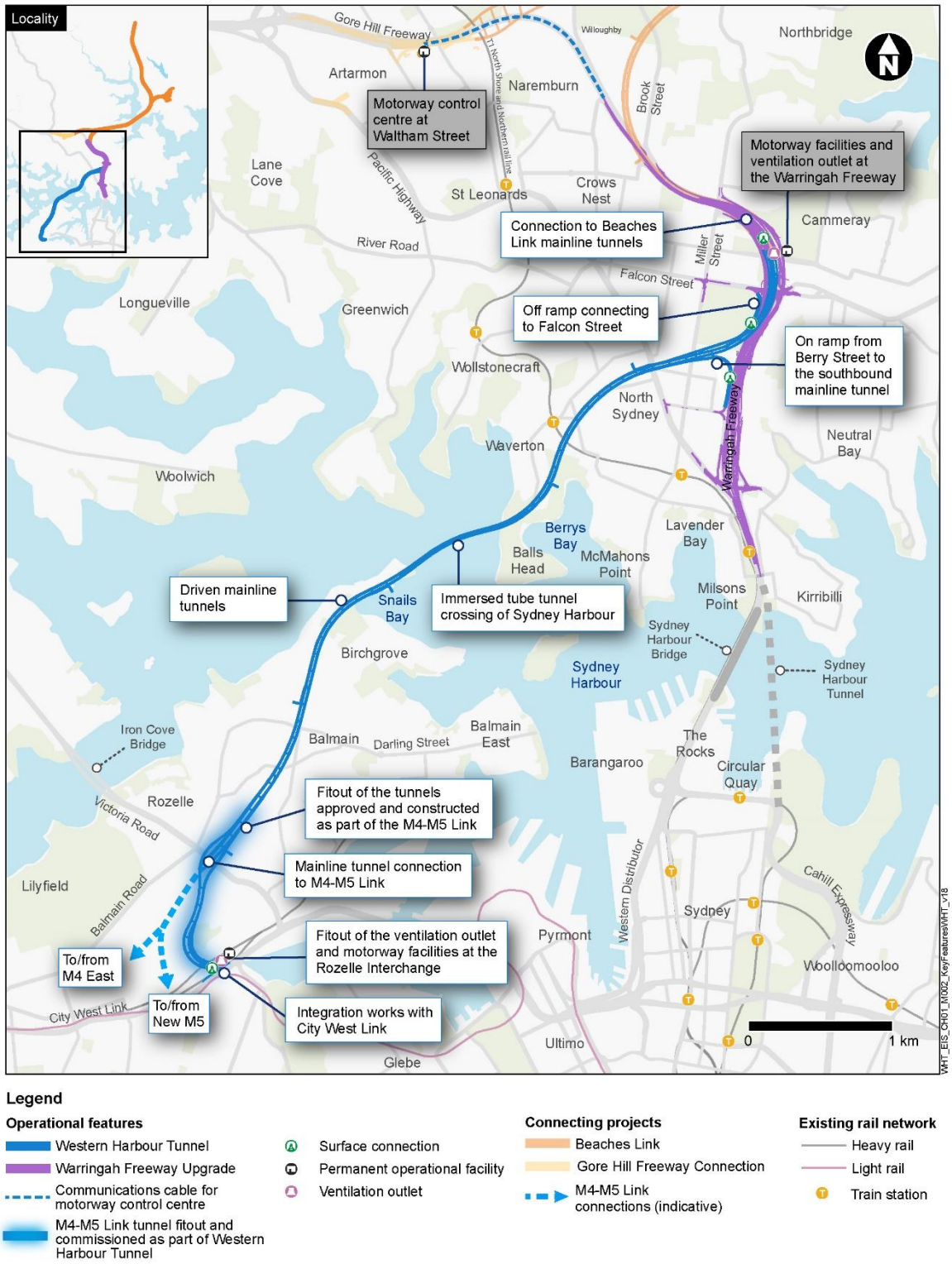
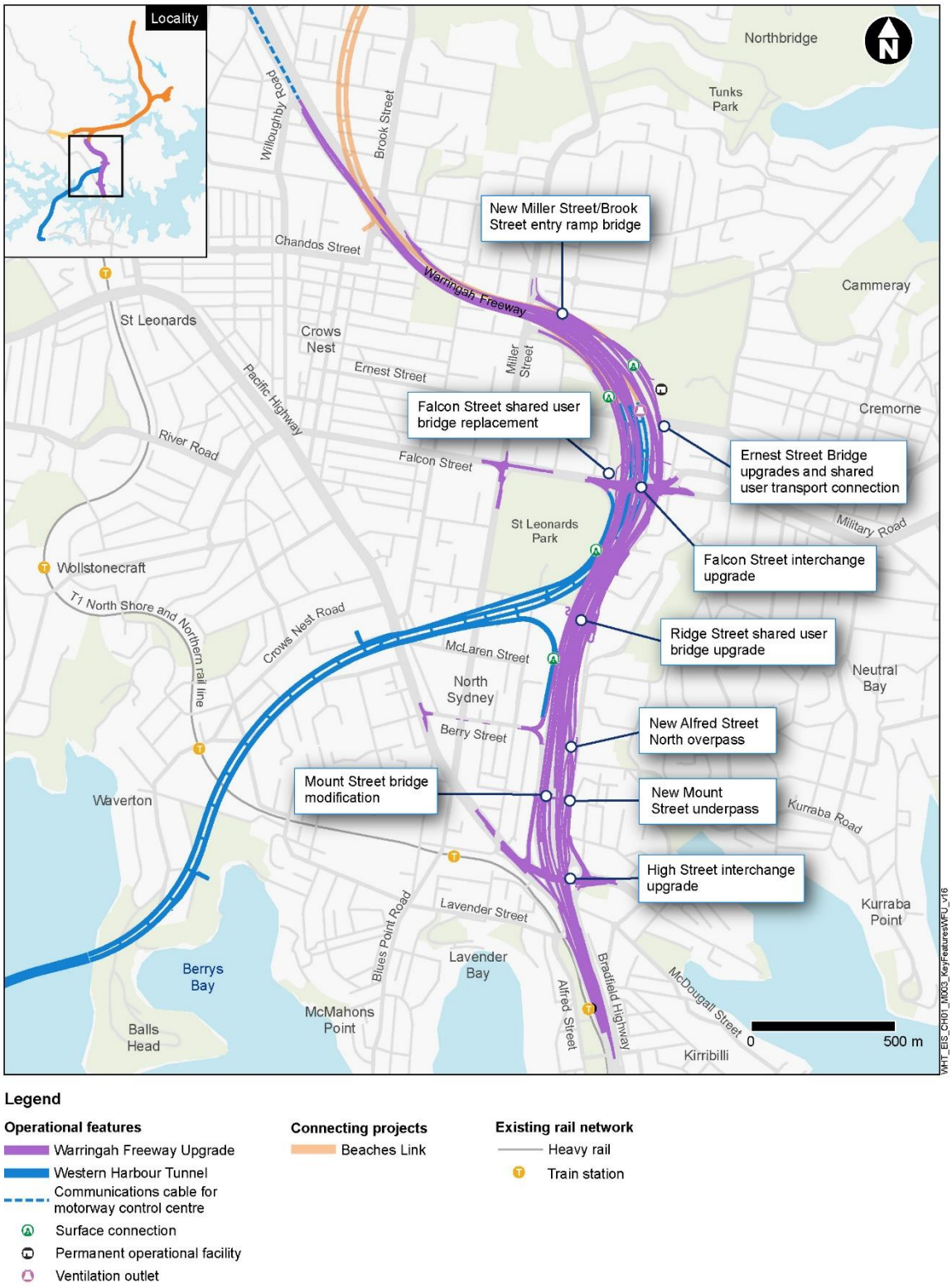


Figure 1-2 – Key features of the Warringah Freeway component of the project



1.3 Key construction activities

The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline tunnels. However, surface areas would be required to support tunnelling activities and to construct the tunnel connections, tunnel portals and operational ancillary facilities.

Key construction activities would include:

- Early works and site establishment, with typical activities being property acquisition and condition surveys, utilities installation, protection, adjustments and relocations, installation of site fencing, environmental controls (including noise attenuation and erosion and sediment control) and traffic management controls, vegetation clearing, earthworks and demolition of structures, establishment of construction support sites including acoustic sheds and associated access decline acoustic enclosures (where required), construction of minor access roads and the provision of property access, temporary relocation of pedestrian and cycle paths and bus stops, temporary relocation of swing moorings within Berrys Bay and relocation of the historic vessels
- Construction of Western Harbour Tunnel, with typical activities being excavation of tunnel construction accesses, construction of driven tunnels, cut and cover and trough structures and construction of cofferdams, dredging activities in preparation for the installation of immersed tube tunnels, casting and installation of immersed tube tunnels and civil finishing and tunnel fitout
- Construction of operational facilities comprising of a motorway control centre at Waltham Street in Artarmon, motorway and tunnel support facilities and ventilation outlets at the Warringah Freeway in Cammeray, construction and fitout of the project operational facilities that form part of the M4-M5 Link Rozelle East Motorway Operations Complex, a wastewater treatment plant at Rozelle and the installation of motorway tolling infrastructure
- Construction of the Warringah Freeway Upgrade, with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of road furniture, lighting, signage and noise barriers
- Testing of plant and equipment, and commissioning of the project, backfill of access declines, removal of construction support sites, landscaping and rehabilitation of disturbed areas and removal of environmental and traffic controls.

Temporary construction support sites would be required as part of the project (refer to Figure 1-3), and would include tunnelling and tunnel support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities. Construction support sites for Western Harbour Tunnel would include:

- Rozelle Rail Yards (WHT1)
- Victoria Road (WHT2)
- White Bay (WHT3)

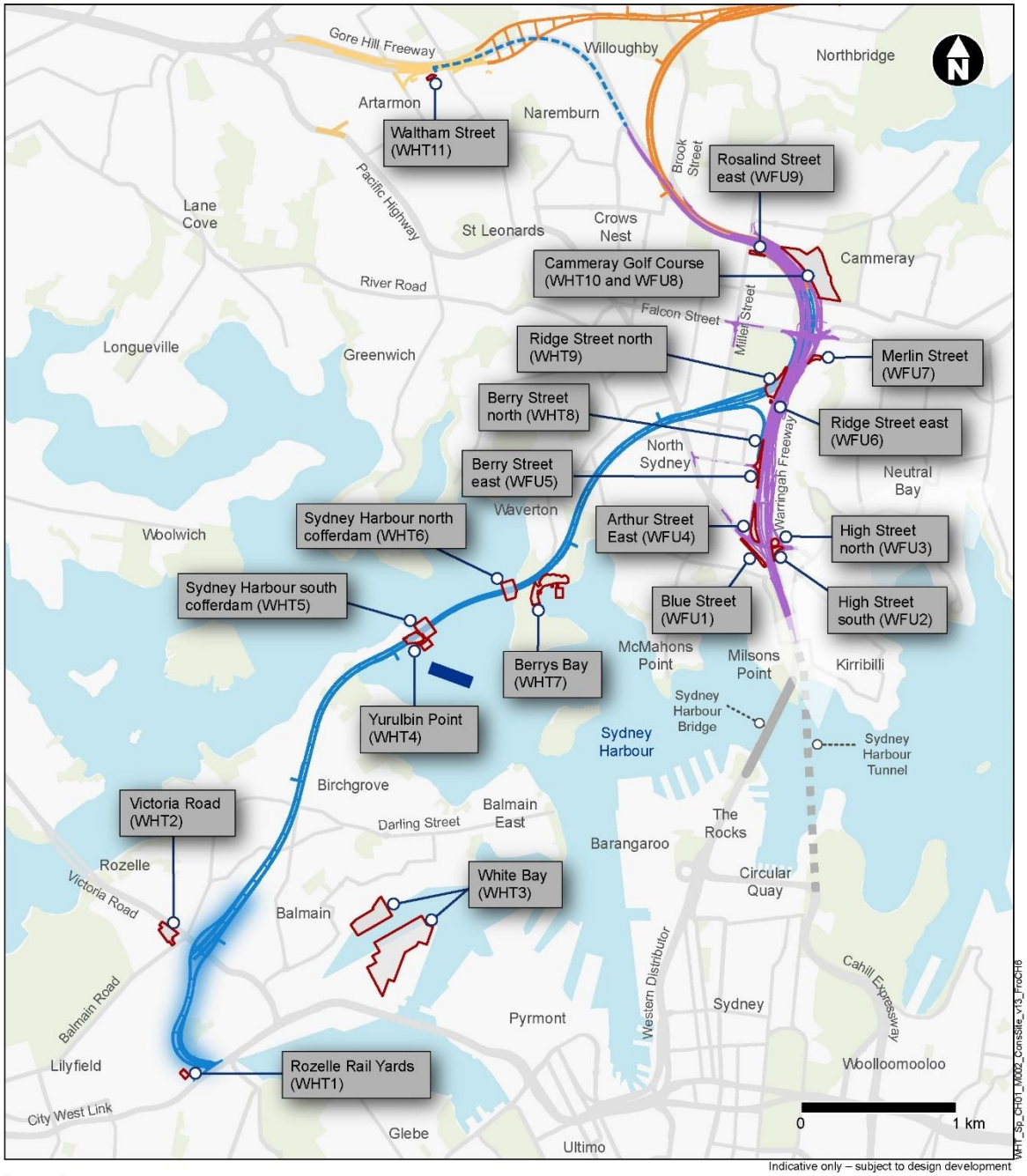
- Yurulbin Point (WHT4)
- Sydney Harbour south cofferdam (WHT5)
- Sydney Harbour north cofferdam (WHT6)
- Berrys Bay (WHT7)
- Berry Street north (WHT8)
- Ridge Street north (WHT9)
- Cammeray Golf Course (WHT10)
- Waltham Street (WHT11).

During the construction of the Warringah Freeway Upgrade, smaller construction support sites would be required to support the construction works (as shown on Figure 1-3). These include:

- Blue Street (WFU1)
- High Street south (WFU2)
- High Street north (WFU3)
- Arthur Street east (WFU4)
- Berry Street east (WFU5)
- Ridge Street east (WFU6)
- Merlin Street (WFU7)
- Cammeray Golf Course (WFU8)
- Rosalind Street east (WFU9).

A detailed description of construction works for the project is provided in Chapter 6 (Construction work) of the environmental impact statement.

Figure 1-3 – Overview of the construction support sites



1.4 Project location

The project would be located within the Inner West, North Sydney and Willoughby local government areas, connecting Rozelle in the south with Naremburn in the north.

Commencing at the Rozelle Interchange, the mainline tunnels would pass under Balmain and Birchgrove, then cross Sydney Harbour between Birchgrove and Balls Head. The tunnels would then continue under Waverton and North Sydney, linking directly to the Warringah Freeway to the north of the existing Ernest Street bridge.

The motorway control centre would be located at Waltham Street, Artarmon, with a trenched communications cable connecting the motorway control centre to the Western Harbour tunnel along the Gore Hill Freeway and Warringah Freeway road reserves.

The Warringah Freeway Upgrade would be carried out on the Warringah Freeway from around Fitzroy Street at Milsons Point to around Willoughby Road at Naremburn. Upgrade works would include improvements to bridges across the Warringah Freeway, and upgrades to surrounding roads.

1.5 Purpose of this report

This report has been prepared to support the environmental impact statement for the project and to address the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (formerly Department of Planning and Environment) ('the Secretary's environmental assessment requirements').

This report has been prepared to assess noise and vibration impacts during the construction and operational stages of the project, and propose mitigation measures to reduce the nature of particular impacts in construction and operation. The noise and vibration assessment has been carried out in accordance with the policies, guidelines and standards presented in sections 3.1 and 3.5.1 of this report for construction noise and vibration and operational noise, respectively.

1.6 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to the project, and where these requirements are addressed in this report, are outlined in Table 1-1.

Table 1-1 – Secretary's environmental assessment requirements – Noise and Vibration

Secretary's environmental assessment requirements	Where addressed
4. Noise and Vibration - Amenity	
1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must take into consideration and address the redistribution of traffic (including on local feeder roads) and operational plant and equipment and must include consideration of impacts to sensitive receivers and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	**Chapter 5** assesses construction noise and vibration impacts associated with the project **Section 7** assesses operational noise and vibration impacts from the project
2. An assessment of construction noise and vibration impacts must address:	**Section 5** assesses construction noise and vibration impacts addressing the requirements (a),(b),(d) to (j) **Section 6 and 8** address construction noise and vibration mitigation and management measures for the project addressing the requirements (e),(f),(i) and (j) **Section 2.2** and **Appendix B** identify the noise and vibration the sensitive receivers during the construction period as required by (c)
(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). This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	
(c) the identification of receivers, existing and likely, during the construction period;	
(d) the nature, sensitivity and impact to receivers;	
(e) 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);	
(f) the potential for works outside standard construction hours, including predicted levels, exceedances, number of potentially affected receivers, and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	
(g) a cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities);	
(h) a cumulative noise and vibration assessment of the impacts from the project and the construction of other relevant development in the vicinity of the proposal;	
(i) details and analysis of the effectiveness of mitigation measures to adequately manage identified impacts, including cumulative impacts as identified in (g) and (h) and a clear identification of residual noise and vibration following application of mitigation measures; and	
(j) a description of how community preferences have been taken into account in the design of mitigation measures and consider tailored mitigation, management and communication strategies for vulnerable community members.	
3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	**Section 5.12**
5. Noise and Vibration - Structural	
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) as well as property in general.	**Section 5** assesses construction noise and vibration impacts Relevant site assessments in **Section 5** **Section 5.11** – Tunnelling **Section 7.5** assesses operational ground-borne noise and tactile vibration impacts
2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	**Section 5.12**

1.7 Structure of this report

This noise and vibration technical working paper has been broken into the following structure:

Description	Report Section
Overview of the project key features, and construction activities, Secretary's environmental assessment requirements and structure of the report	Section 1
Overview of the existing noise environment and the results from the ambient noise monitoring surveys	Section 2
Assessment guidelines and objectives - Construction	Section 3.1 to 3.4.6
Assessment guidelines and objectives - Operational	Section 3.5
Assessment methodology - Construction	Section 4.1 to 4.5
Assessment methodology and mitigation options - Operational	Section 4.6 to 4.8
Assessment of potential noise and vibration impacts, along with mitigation and management measures during the construction stages of the project	Section 5
Overview of construction noise and vibration mitigation and management measures	Section 6
Assessment of potential noise and vibration impacts and the mitigation measures during the operational stages of the project	Section 7

This report has been structured so that it can be navigated by multiple methods, in addition to following the above report structure.

- In order to navigate the report via geographic locations, refer to Figure 1-4 to Figure 1-6
- In order to navigate the report via assessment types,
  - Construction airborne noise, refer to the flow chart in Figure 4-2
  - Construction-related road traffic noise, refer to Table 4-5
  - Construction ground-borne noise, refer to Table 4-10
  - Construction vibration, refer to Table 4-12
  - Mainline tunnelling construction noise and vibration, refer to section 5.11
  - Operational road traffic airborne noise, refer to section 7.1
  - Operational fixed facility noise, refer to section 7.4.

For the purposes of this report, in order to assist with referring to each site within this noise and vibration assessment, each construction site or construction works area is referenced with a unique acronym. These site reference acronyms are as presented in Table 1-2.

Table 1-2 – Site-specific construction noise and vibration assessment acronym reference

Location	Construction noise and vibration assessment acronym	Report section
Rozelle Rail Yards (WHT1)	ROZ	Section 5.2
Victoria Road (WHT2)	VIC	Section 5.3
White Bay (WHT3)	WHB	Section 5.4
Yurulbin Point (WHT4)	YRB	Section 5.5
Sydney Harbour south cofferdam (WHT5)	SHC (forms part of the Sydney Harbour Crossing)	Section 5.6
Sydney Harbour north cofferdam (WHT6)	SHC (forms part of the Sydney Harbour Crossing)	Section 5.6
Berrys Bay (WHT7)	BRY	Section 5.7
Cammeray Golf Course (WHT10)	CGC	Section 5.8
Warringah Freeway Upgrade[1]	WFU[1]	Section 5.9

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

Satellite imagery in this report was provided by Jacobs (Group) Australia Pty Ltd.

Figure 1-4 – Report navigation maps – southern section

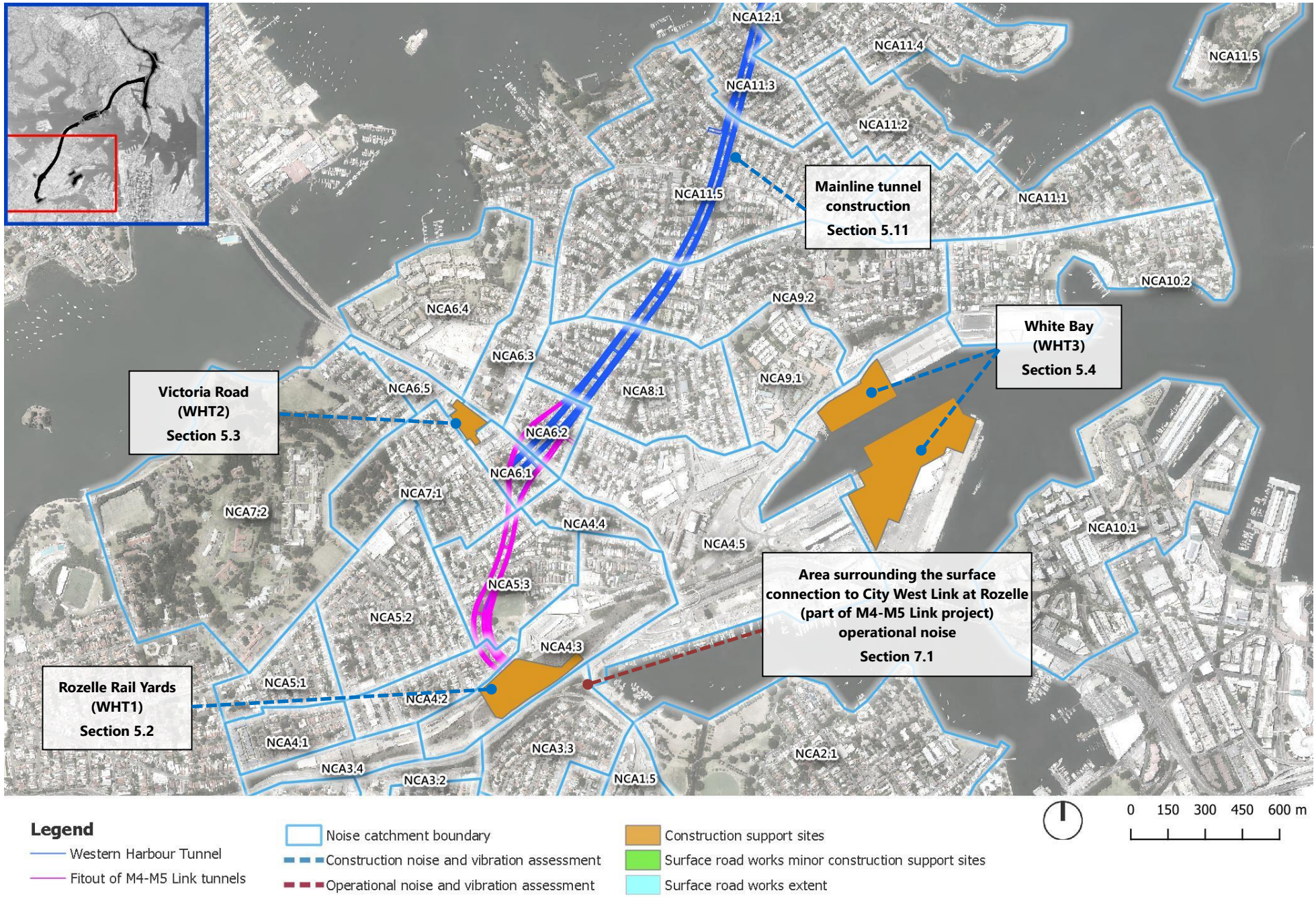


Figure 1-5 – Report navigation maps – Mid section

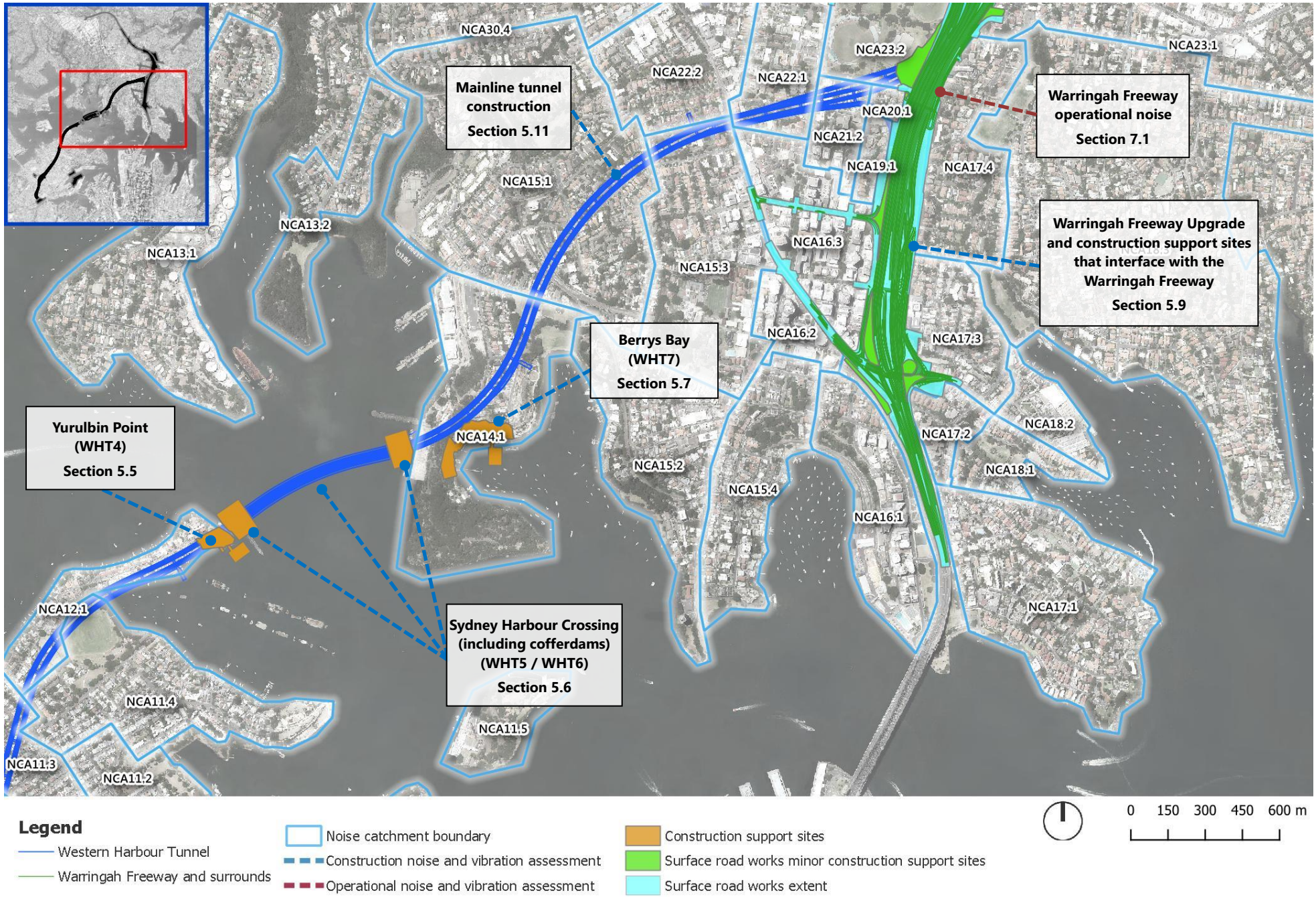
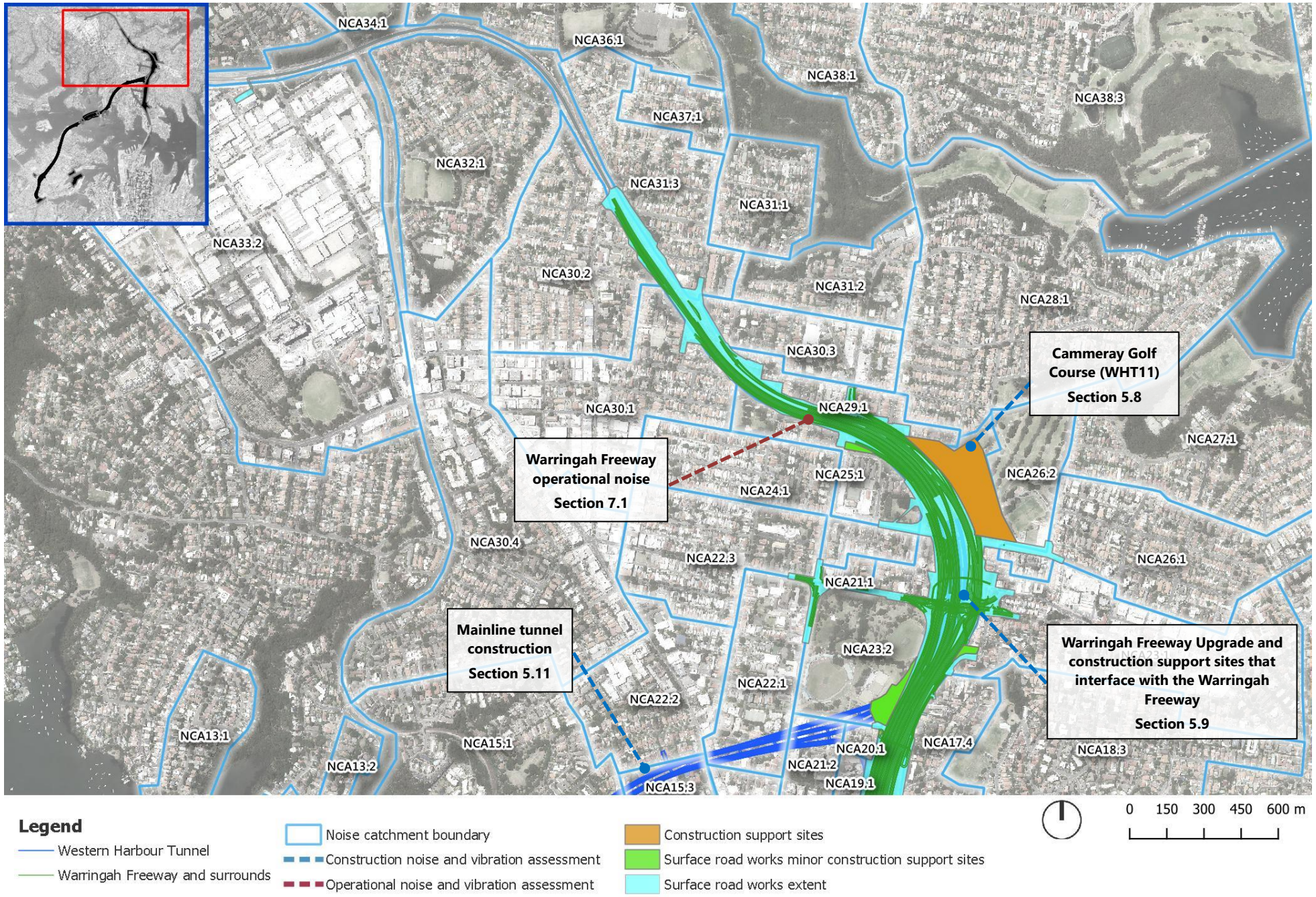


Figure 1-6 – Report navigation maps – Northern section



1.8 Terminology and acoustic concepts

This report is technical in nature and uses acoustic terminology throughout. A summary and explanation of the common acoustic terms that have been used in this report is presented in Appendix A, section A.1.

Some of the key acoustic concepts used in this report are outlined in Appendix A, section A.2.

2 Existing noise environment

2.1 Overview

The existing acoustic environment varies throughout the project extent. The areas surrounding the project alignment and construction support sites are mostly residential, except for clusters of commercial and industrial receivers around White Bay, Artarmon and the North Sydney central business district.

The acoustic environment in these residential areas is mostly influenced by noise from the major arterial roads such as City West Link, Victoria Road, Warringah Freeway, Gore Hill Freeway, Pacific Highway and Military Road, as well as local transport activities.

Traffic volumes on these main roads, and resulting noise levels, are generally highest in the morning between 7.00am and 9.00am, and lowest between 2.00am and 3.00am. Traffic noise on major arterial roads is more continuous, rather than intermittent.

Noise generated by shops, restaurants, employment and entertainment areas can influence the surrounding acoustic environment and may contribute to higher ambient noise levels which locally mask road traffic noise.

2.2 Noise and vibration-sensitive receivers

A land use survey was carried out to identify the receiver types and uses of buildings around the project that could potentially be impacted by noise or vibration from the project. The survey was carried out to assist with defining appropriate management objectives for the sensitive receivers.

Where future receivers were identified as likely to be in place during the construction period, these have been assessed as the likely future use. At detailed design a land use survey of current noise-sensitive receivers at the time of construction would be carried out to identify all potentially affected receivers.

The noise and vibration-sensitive receivers are generally separated into the following major categories, with further details of the breakdowns of categories and noise and vibration objectives presented in section 3:

- Residential receivers (including mixed use buildings and aged care facilities)
- Other noise and vibration-sensitive receivers, including:
  - Classrooms at schools and other educational institutions
  - Hospital wards and operating theatres
  - Places of worship
  - Childcare centres
  - Active recreation areas (eg. sports fields/activities which generate their own noise and are generally less sensitive to external noise)

  - Passive recreation areas (eg. areas used for low intensity and low noise producing activities which have the potential to be impacted by external noise such as reading or meditation)
  - Community centres
  - Special noise and/or vibration-sensitive receivers (eg. laboratories, recording studios)
- Commercial premises (including offices and retail outlets)
- Industrial premises.

All assessed noise and vibration-sensitive receiver types for the project are shown in Appendix B.

2.3 Noise catchment areas

As the existing acoustic environment along the length of the project varies, noise-sensitive receivers have been grouped into Noise Catchment Areas (NCAs) based on areas with similar acoustic environments. The project has been divided into 89 NCAs.

The NCAs also help to logically group all noise and vibration-sensitive receivers into groups to assist with the assessment of noise and vibration impacts from the project. Each NCA consists of a range of receiver types and land uses.

The noise monitoring, detailed in section 2.3 and section 2.4, along with the relative location of the NCAs to key environmental noise sources were used to define the NCA extents.

The locations of NCAs relative to the project are shown in Figure 2-1 to Figure 2-3. All NCAs and the key noise and vibration sensitive receiver types are described further in Appendix B.

2.4 Noise monitoring locations

Noise monitoring was carried out along the project extent to quantify the existing noise environment in areas where receivers may potentially be affected by construction noise, and to determine the existing levels of road traffic noise along the project. Criteria and noise management levels (NMLs) for the assessment of operational and construction noise are usually derived from measurements of existing noise levels in an area, excluding noise from the subject development.

The rating background level (RBL) (see section 2.5 for a description) is used to determine noise management and trigger levels at residential receiver locations:

- The NMLs described in the NSW *Interim Construction Noise Guideline* (Department of Environment and Conservation 2009), for construction noise
- The project noise trigger levels in the NSW *Noise Policy for Industry* (NPfI) (Environment Protection Authority 2017), for operational facility noise.

Fact Sheet A and Fact Sheet B of the NPfI outline the method for determining the RBL using long-term noise measurements. As stated in the NPfI, typically one week of valid data covering the days and times of operation of the project is required to meaningfully determine the existing noise environment. Noise

measurements are ideally carried out at the nearest or most potentially affected locations for either construction or traffic noise impacts along the extent of the project. The long-term noise monitoring locations are presented in Figure 2-1 to Figure 2-3, and details of the noise logging locations are outlined in Table 2-1.

In addition, existing traffic noise levels were measured at specific monitoring locations along the project extent. The road traffic noise models were then calibrated using existing measured road traffic noise levels.

Noise monitoring was not carried out within all NCAs across the project. The NCAs are established both as a logical grouping of receivers with similar acoustic environments and as a grouping for the purposes of assessing and reporting noise and vibration impacts. As such, some areas which have similar acoustic environments (eg. controlled by similar noise levels from a nearby major road), have been broken down into smaller NCAs.

Figure 2-1 – Long-term noise monitoring locations (south)

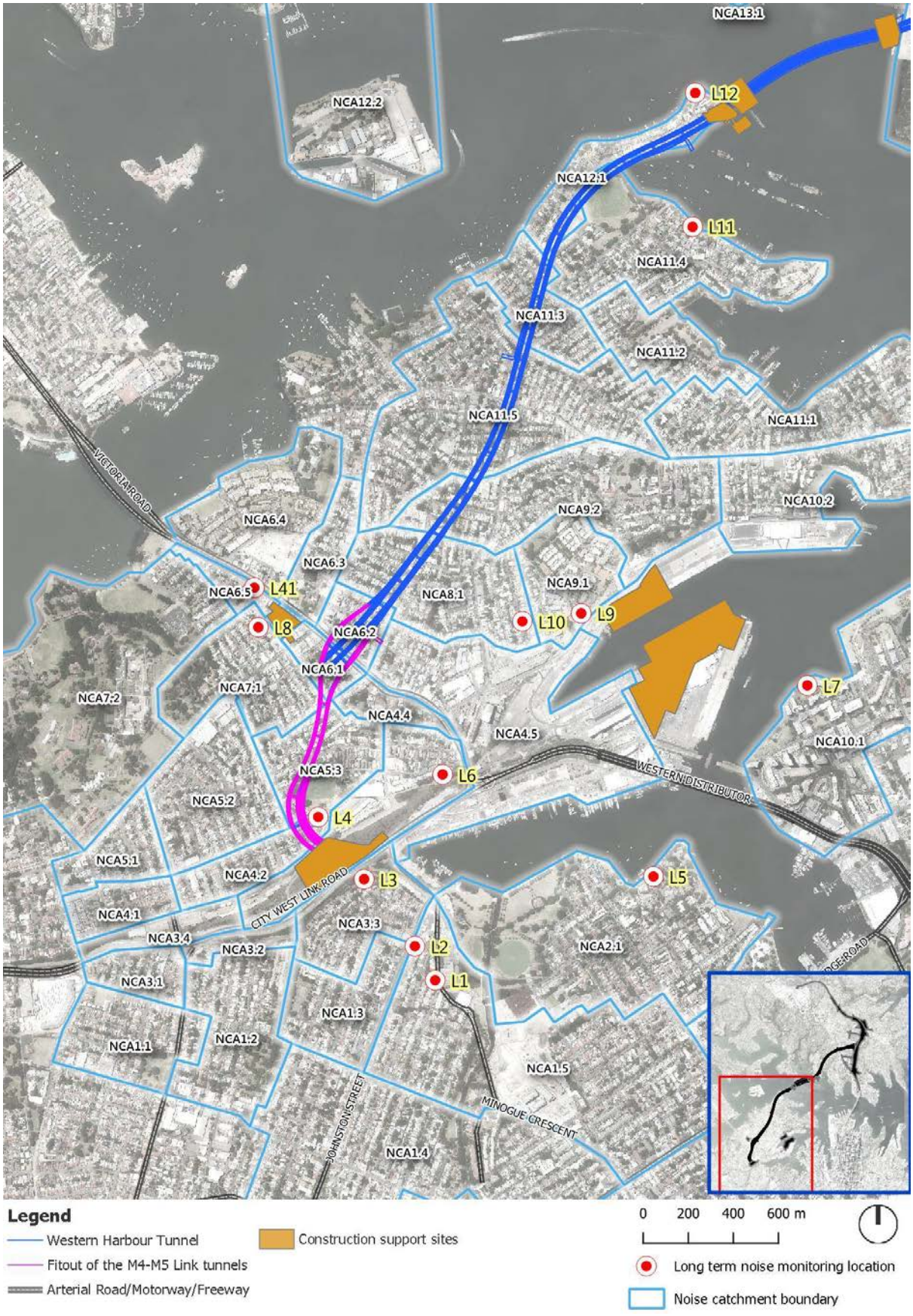


Figure 2-2 – Long-term noise monitoring locations (mid)

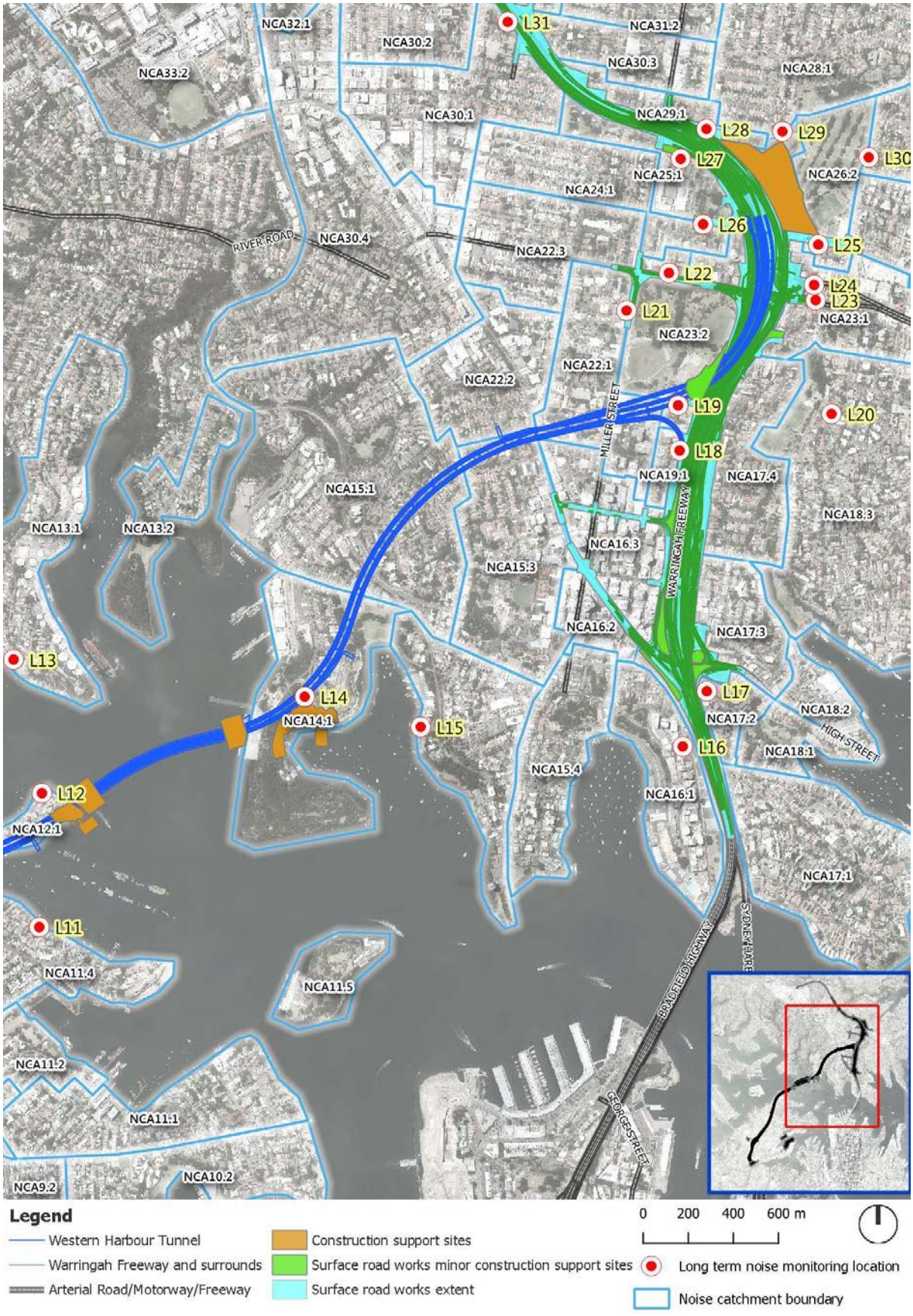


Figure 2-3 – Long-term noise monitoring locations (north)

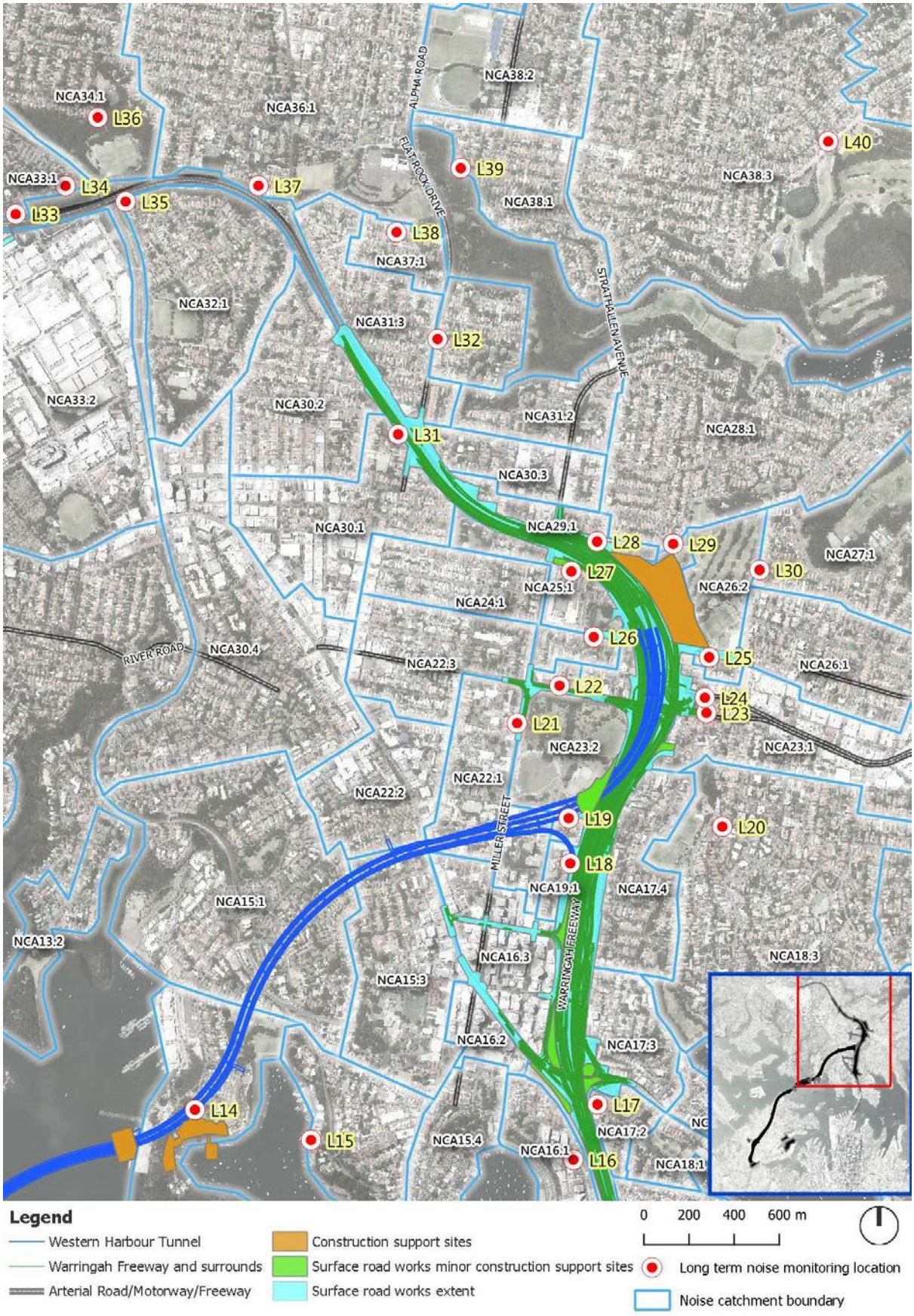


Table 2-1 – Long term noise monitoring locations

Monitoring location ID	Address	Monitoring period	Description
Location L1	22 The Crescent, Annandale	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment is dominated by traffic on The Crescent.
Location L2	2/277 Johnston Street, Annandale	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Johnston Street.
Location L3	16 Railway Parade, Annandale	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the City-West Link and rail noise from light rail pass-bys.
Location L4	109 Denison Street, Rozelle	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds and traffic on Lilyfield Road.
Location L5	14 Oxley Street, Glebe	19/07/2017 to 28/07/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds.
Location L6	28 Lilyfield Road, Rozelle	5/09/2017 to 15/09/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by traffic on The Crescent.
Location L7	203/38 Refinery Drive, Pyrmont	10/08/2017 to 15/08/2017	Noise monitor located on the northern facade of the second-floor balcony overlooking Jones Bay. Noise environment consists of natural sounds and motor boats from the bay.
Location L8	31 Cambridge Street, Rozelle	30/10/2017 to 14/11/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment consists of natural sounds.
Location L9	C13/1 Buchanan Street, Balmain	01/08/2017 to 11/08/2017	Noise monitor located on the south-eastern facade of the first floor balcony overlooking White Bay. Noise environment consists of natural sounds and some industrial noise from across the bay.
Location L10	23 Smith Street, Rozelle	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds. Traffic noise audible in the distance.
Location L11	31 Wharf Road, Birchgrove	19/07/2017 to 28/07/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds.
Location L12	9 Numa Street, Birchgrove	19/07/2017 to 28/07/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds and motor boat pass-bys.
Location L13	6 O'Connell Street, Greenwich	01/08/2017 to 09/08/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds.
Location L14	5 Balls Head Road, Waverton	05/09/2017 to 15/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by natural sounds.
Location L15	1/16 Munro Street, McMahons Point	01/08/2017 to 10/08/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds and occasional motor boat pass-bys.
Location L16	401/102 Alfred Street, Milsons Point	14/09/2017 to 24/09/2017	Noise monitor located on the eastern facade of the fourth-floor balcony. Noise environment dominated by traffic on the Warringah Freeway and Alfred Street, and rail noise.
Location L17	6 McDougall Street, Kirribilli	25/08/2017 to 05/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Cahill Expressway/Bradfield Highway and general neighbourhood and natural sounds.
Location L18	1/191-195 Walker Street, North Sydney	21/06/2017 to 01/07/2017	Noise monitor located on the eastern side of the property, on the ground floor and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Monitoring location ID	Address	Monitoring period	Description
Location L19	91 Ridge Street, North Sydney	21/06/2017 to 02/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L20	14 Montpellier Road, Neutral Bay	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.
Location L21	306 Miller Street, North Sydney	20/06/2017 to 03/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Miller Street.
Location L22	1/1 Bardsley Gardens, Crows Nest	21/06/2017 to 02/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Falcon Street.
Location L23	288 Falcon Street, Neutral Bay	25/08/2017 to 05/09/2017	Noise monitor located in the front yard and positioned approximately one metre away from the front facade. Noise environment dominated by traffic on Falcon Street.
Location L24	5 Military Road, Neutral Bay	25/08/2017 to 05/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Military Road.
Location L25	317 Ernest Street, Cammeray	25/08/2017 to 05/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Ernest Street.
Location L26	225 Ernest Street, Cammeray	25/08/2017 to 05/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Ernest Street.
Location L27	77 Rosalind Street, Cammeray	08/09/2017 to 20/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L28	53 Bellevue Street, Cammeray	08/09/2017 to 20/09/2017	Noise monitor located in the western side yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L29	12 Warringa Road, Cammeray	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.
Location L30	57 Park Avenue, Cremorne	19/07/2017 to 26/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.
Location L31	18/22-24 Donnelly Road, Crows Nest	08/09/2017 to 20/09/2017	Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L32	79 Brook Street, Naremburn	20/06/2017 to 03/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Brook Street.
Location L33	20/2 Parkes Road, Artarmon	07/09/2017 to 20/09/2017	Noise monitor located on the second-floor balcony in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L34	3/2 Cleland Road, Artarmon	08/09/2017 to 20/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L35	1 Chelmsford Avenue, Naremburn	08/09/2017 to 20/09/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L36	2 Burra Road, Artarmon	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by noise from nature.
Location L37	16 Walter Street, Willoughby	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Monitoring location ID	Address	Monitoring period	Description
Location L38	27 Garland Street, Naremburn	19/07/2017 to 28/07/2017	Noise monitor located on the rear balcony and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.
Location L39	2 Pyalla Street, Northbridge	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by noise from nature.
Location L40	375 Sailors Bay Road, Northbridge	19/07/2017 to 28/07/2017	Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Sailors Bay Road.
Location L41	198 Victoria Road, Rozelle	13/09/2016 to 4/10/2016	Noise monitor located in the front yard and positioned in the free-field. Carried out as part of the M4-M5 Link environmental impact statement. See Note 1.

Notes: 1. Logger has been adopted, from unattended noise monitoring carried out as part of the WestConnex – M4-M5 Link Technical paper: Noise and Vibration (SLR, 2015), logger reference I.02. The noise monitoring background noise levels in that project were relevant for the receivers in the identified NCA for this project.

2.5 Existing noise environment measurements

As detailed in Section 2.4, noise monitoring was carried out at locations along the project extent to quantify the existing noise environment in areas where receivers may potentially be affected by construction noise, and to determine the existing levels of road traffic noise along the project.

The equipment used for the long-term noise monitoring was RTA (Renzo Tonin & Associates) Technology RTA05/06/07 noise loggers which are based on the NTi Audio Type XL2 precision sound level analyser, a class 1 instrument with accuracy suitable for field and laboratory use.

A field calibration check of the instrument was carried out before and after measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

All instrumentation complies with IEC 61672 (parts 1-3) 'Electroacoustics - Sound Level Meters and IEC 60942 Electroacoustics - Sound calibrators' and has current NATA certification (or if less than two years old, manufacturer's certification).

Weather information was obtained from the Bureau of Meteorology for the most suitable weather station nearest to each monitoring location for the monitoring period and any data adversely affected by rain, wind (more than five metres per second as per NPfI) or extraneous noise were discarded.

Rating Background Level (RBL) is the background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night time periods and is used to set the $L_{Aeq(15\ minute)}$ noise management levels for residential receivers. RBLs for each monitoring location presented in Figure 2-1 to Figure 2-3 were determined in accordance with the NPfI and are presented in Table 2-2. The noise monitoring locations are also presented in the maps in Appendix B.1.

The RBL is defined in the NPfI as:

> *"Rating background level (RBL) - the overall single figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each*

24 hour period used for the assessment background level). The rating background level is the level used for assessment purposes. Where the rating background level is found to be less than 30 dB(A) for the evening and night periods, then it is set to 30 dB(A); where it is found to be less than 35 dB(A) for the daytime period, then it is set to 35 dB(A)."

The RBL is derived based on the measured time periods where the lowest 10th percentile background noise level occurs, representing the "quietest" period of the day, evening or night assessment period. During the more sensitive night time period for the types of urban and suburban receiver areas across the project, the RBL usually represents the period between 2.00am and 4.00am. For these areas, background L_{A90} noise levels typically decline with the reduction in traffic flow on nearby road corridors from around 11.00pm and onwards. When commuter traffic becomes more active again, background L_{A90} noise levels increases, typically reaching high points during the morning and afternoon traffic peak periods.

Ambient noise level represents all encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far. Figure 2-4 shows graphically how the ambient and background noise level varies over a typical week night, from 10.00pm to 7.00am, extracted from the data of a seven to 10 day monitoring period. This is contrasted with the RBL which is based on a single figure conservative representation of the background noise level over the total night period as described above. The NML sits at 5 dB(A) above the RBL during this time period. The graph represents a typical week night. Background and ambient noise levels start dropping off after 10.00pm, reaching the lowest level in the period between 2.00am and 3.00am. From 4.00am noise levels start to rise again towards the morning peak period. The graph shows clearly that the RBL is not based on the lowest background noise level, but the typical lowest. This time period may change from night to night. The figure also shows that the ambient noise level (or L_{Aeq}) is typically 5 dB(A) above the background noise level and there are several periods of the night where the existing ambient noise level is higher than the NML. Refer to Appendix A, section A.2 for some of the key acoustic concepts used in Figure 2-4.

Figure 2-4 – Typical ambient and background noise level variations compared with RBL and NML

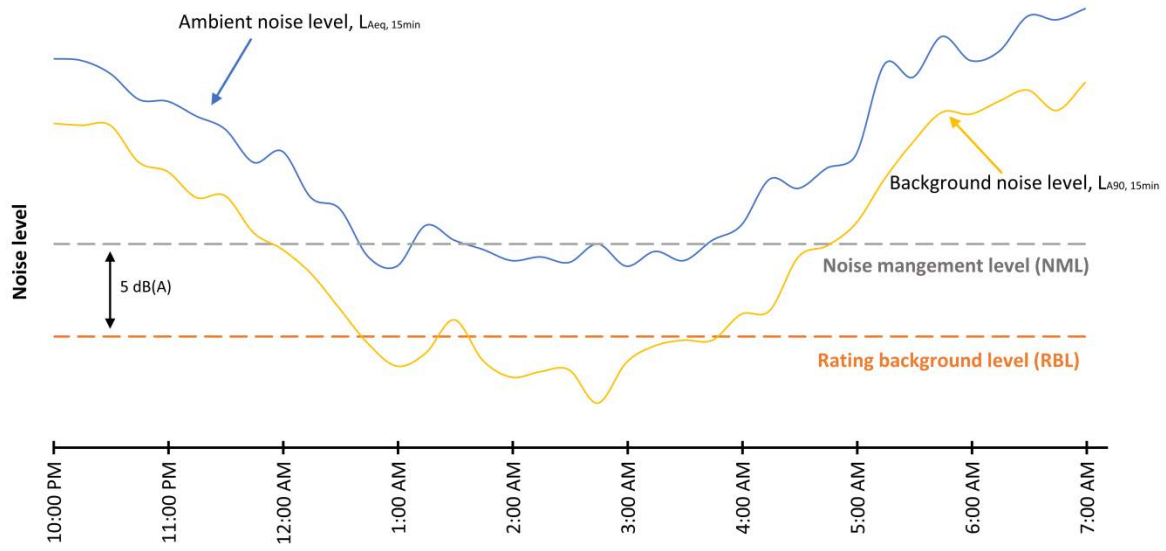


Table 2-2 also presents the existing L_{Aeq} ambient noise level for each of the day, evening and night periods in accordance with the NPfI. The L_{Aeq} level is the summation of all sound energy integrated over the sample period, encompassing all noise associated with the surrounding environment, from all sources near and far.

Any weather-affected data (due to wind or rain) was excluded from analysis in accordance with the NPfI exclusion procedures. The measured RBLs have been used to formulate noise objectives for the construction noise assessment and operational noise assessment of fixed facilities.

Table 2-2 – Long-term noise monitoring results

Monitoring location ID	Address	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise levels		
		Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Location L1	22 The Crescent, Annandale	51	45	33	66	65	60
Location L2	2/277 Johnston Street, Annandale	50	47	36	65	64	59
Location L3	16 Railway Parade, Annandale	50	51	44	58	58	53
Location L4	109 Denison Street, Rozelle	49	46	37	61	60	53
Location L5	14 Oxley Street, Glebe	51	52	45	57	55	52
Location L6	28 Lilyfield Road, Rozelle	52	52	45	58	58	55
Location L7	203/38 Refinery Drive, Pyrmont	48	45	44	52	49	48
Location L8	31 Cambridge Street, Rozelle	43	41	34	57	57	48
Location L9	C13/1 Buchanan Street, Balmain	49	49	46	54	51	49
Location L10	23 Smith Street, Rozelle	42	44	38	54	53	48
Location L11	31 Wharf Road, Birchgrove	40	42	37	52	48	43
Location L12	9 Numa Street, Birchgrove	46	45	40	58	56	53
Location L13	6 O'Connell Street, Greenwich	41	38	32	54	49	43
Location L14	5 Balls Head Road, Waverton	41	37	33	51	47	45
Location L15	1/16 Munro Street, McMahons Point	42	41	38	52	46	44
Location L16	401/102 Alfred Street, Milsons Point	60	60	50	63	62	58
Location L17	6 McDougall Street, Kirribilli	55	54	45	60	58	56
Location L18	1/191-195 Walker Street, North Sydney	73	71	55	76	75	72
Location L19	91 Ridge Street, North Sydney	52	52	45	57	57	52
Location L20	14 Montpellier Road, Neutral Bay	54	52	43	59	57	53
Location L21	306 Miller Street, North Sydney	52	47	36	65	63	58
Location L22	1/1 Bardsley Gardens, Crows Nest	53	49	41	68	67	63
Location L23	288 Falcon Street, Neutral Bay	61	54	44	69	68	65
Location L24	5 Military Road, Neutral Bay	58	54	44	72	71	67
Location L25	317 Ernest Street, Cammeray	58	54	41	69	66	62
Location L26	225 Ernest Street, Cammeray	56	52	37	68	66	61
Location L27	77 Rosalind Street, Cammeray	58	55	43	62	60	57
Location L28	53 Bellevue Street, Cammeray	64	63	47	67	67	64
Location L29	12 Warringa Road, Cammeray	47	45	37	54	51	48
Location L30	57 Park Avenue, Cremorne	49	48	39	59	57	54
Location L31	18/22-24 Donnelly Road, Crows Nest	58	56	38	62	61	58
Location L32	79 Brook Street, Naremburn	56	49	37	71	69	65

Monitoring location ID	Address	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise levels		
		Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Location L33	20/2 Parkes Road, Artarmon	67	63	46	72	70	67
Location L34	3/2 Cleland Road, Artarmon	55	53	40	59	58	55
Location L35	1 Chelmsford Avenue, Naremburn	59	55	40	63	61	58
Location L36	2 Burra Road, Artarmon	44	44	37	53	50	46
Location L37	16 Walter Street, Willoughby	50	48	38	55	52	49
Location L38	27 Garland Street, Naremburn	45	44	34	53	52	48
Location L39	2 Pyalla Street, Northbridge	52	48	37	60	56	57
Location L40	375 Sailors Bay Road, Northbridge	43	40	36	66	63	58
Location L41[5]	198 Victoria Road, Rozelle	63	58	43	74	73	69

Notes:
1. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
2. Evening: 6.00pm to 10.00pm Monday to Sunday & Public Holidays
3. Night: 10.00pm to 7.00am Monday to Saturday and 10.00pm to 8.00am Sundays & Public Holidays
4. As required by the NPfI, the external ambient noise levels presented are free-field noise levels. (ie. no facade reflection)
5. Logger has been adopted, from unattended noise monitoring carried out as part of the WestConnex – M4-M5 Link Technical paper: Noise and Vibration (SLR, 2015), logger reference I.02. The noise monitoring background noise levels in that project were relevant for the receivers in the identified NCA for this project.

The noise monitoring locations are presented in the maps in Appendix B.1 and in Figure 2-1 to Figure 2-3. The complete results from the noise monitoring are presented in Appendix C.

2.6 Measured road traffic noise levels

The existing traffic noise levels at the monitoring locations where road traffic was the dominating noise source are summarised in Table 2-3 below. The locations are presented in Figure 2-1 to Figure 2-3 and the maps in Appendix B.1. The complete results from the noise monitoring are presented in Appendix C.

Noise levels are described in accordance with the requirements of the NSW *Road Noise Policy* (RNP) (Department of Climate Change and Water, 2011). The relevant descriptors for traffic noise are $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$, which represent the existing day and night traffic noise levels, respectively.

At monitoring locations where the noise monitor was positioned in the free-field (ie away from buildings), a +2.5 dB(A) correction was added to the measured road traffic noise levels to represent an equivalent road traffic noise level at a distance of one metre from a building facade, in accordance with the requirements of the RNP.

Table 2-3 – Measured traffic noise levels

Monitoring location ID	Address	Measured road traffic noise level, dB(A)	
		$L_{Aeq,15hour}$ (7.00am to 10.00pm)	$L_{Aeq,9hour}$ (10.00pm to 7.00am)
Location L1	22 The Crescent, Annandale	68	63
Location L2	2/277 Johnston Street, Annandale	67	62
Location L3	16 Railway Parade, Annandale	61	56
Location L17	6 McDougall Street, Kirribilli	62	58
Location L18	1/191-195 Walker Street, North Sydney	79	74
Location L19	91 Ridge Street, North Sydney	60	54
Location L21	306 Miller Street, North Sydney	67	61
Location L22	1/1 Bardsley Gardens, Crows Nest	70	66
Location L23	288 Falcon Street, Neutral Bay	71	68
Location L24	5 Military Road, Neutral Bay	74	70
Location L25	317 Ernest Street, Cammeray	71	65
Location L26	225 Ernest Street, Cammeray	70	64
Location L27	77 Rosalind Street, Cammeray	64	59
Location L28	53 Bellevue Street, Cammeray	70	66
Location L31	18/22-24 Donnelly Road, Crows Nest	65	60
Location L32	79 Brook Street, Naremburn	73	67

Notes:
1. Noise levels presented are representative of road traffic noise level at one metre from a building facade, as per RNP.
2. Only noise monitoring locations that are applicable to the assessment of road traffic noise have been presented.

3 Assessment objectives

This section presents the guidelines and policies adopted to assess airborne and ground-borne construction and operational noise and vibration impacts.

3.1 Construction noise and vibration guidelines and policies

Roads and Maritime's *Construction Noise and Vibration Guideline* (CNVG) (Roads and Maritime, 2016) provides guidance for the assessment and mitigation of construction noise and vibration. The CNVG refers to the policies, guidelines and standards presented in Table 3-1, which have been adopted in the construction noise and vibration assessment for the project.

Table 3-1 – Construction noise and vibration policies, guidelines and standards

Guideline/policy document	Assessment aspect
Construction Noise and Vibration Guideline (Roads and Maritime, 2016)	Airborne noise, ground-borne noise and vibration impacts (including construction traffic within the construction support site boundary)
Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)	Airborne noise and ground-borne noise impacts (including construction traffic within the construction support site boundary)
Assessing Vibration: a technical guideline (Department of Environment and Climate Change, 2006)	Vibration amenity
British Standard BS 7385: Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration* (BSI 1993)	Vibration impacts to structures and blasting impacts
German Standard DIN 4150-3 (2016) *Structural vibration – Effects of vibration on structures* (Deutsches Institut für Normung, 1999)	Vibration impacts to structures and blasting impacts
Australian Standard AS 2187.2-2006 *Explosives - Storage and use - Part 2 Use of explosives*	Blasting impacts
NSW Road Noise Policy (Department of Environment, Climate Change and Water 2011)	Construction road traffic noise impacts (on public roads)
Noise Criteria Guideline (Roads and Maritime, 2015)	Construction road traffic noise impacts (on public roads)

For details addressing the *NSW Sustainable Design Guidelines Version 3.0 (Transport for NSW, 2013)* refer to Chapter 25 (Sustainability) of the environmental impact statement.

3.2 Assessment time periods

Noise management levels (NMLs) for the assessment of construction noise are usually derived from the existing noise environment of an area, excluding noise from the project which are detailed in Section 2.5.

As the noise environment of an area varies over time, background noise levels need to be determined for the purpose of determining construction noise goals. For example, in a suburban or urban area, the noise environment is typically at its minimum at 3.00am and at its maximum during the morning and afternoon traffic peak periods.

The NSW *Interim Construction Noise Guideline* (ICNG) refers to the NSW *Industrial Noise Policy*, which is superseded by the NSW NPfI for outlining the standard time periods over which the rating background levels (RBL) are to be determined and noise impacts assessed. These standard time periods are:

- **Day** is defined as 7.00am to 6.00pm, Monday to Saturday and 8.00am to 6.00pm Sundays and Public Holidays
- **Evening** is defined as 6.00pm to 10.00pm, Monday to Sunday and Public Holidays
- **Night** is defined as 10.00pm to 7.00am, Monday to Saturday and 10.00pm to 8.00am Sundays and Public Holidays.

3.3 Construction noise and vibration guideline (CNVG) construction hours

Construction hours defined in the CNVG are reproduced in Table 3-2. While the standard construction hours are not mandatory, limiting construction works to within standard construction hours as much as practicable assists in managing noise or vibration impacts and provides a lengthy respite period while people are most likely to be relaxing or sleeping.

Table 3-2 – Summary of CNVG construction hours

Construction hours	Monday to Friday	Saturday	Sunday/ Public holiday
Recommended standard construction hours			
Standard construction hours	7.00am to 6.00pm	8.00am to 1.00pm	No work
Construction activities with impulsive or tonal noise emissions	8.00am to 5.00pm[1]	9.00am to 1.00pm[1]	No work
Blasting	9.00am to 5.00pm	9.00am to 1.00pm	No blasting
Outside recommended standard construction hours			
Out-of-Hours Work (Day)	N/A	1.00pm to 6.00pm	8.00am to 6.00pm
Out-of-Hours Work (Evening)	7.00pm to 10.00pm	6.00pm to 10.00pm	6.00pm to 10.00pm
Out-of-Hours Work (Night)	10.00pm to 7.00am	10.00pm to 8.00am	10.00pm to 8.00am

Notes: 1. Works would be carried out in continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block. 'Continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work the subject of this condition.

3.4 Construction noise and vibration objectives

3.4.1 Construction airborne noise

The CNVG refers to the ICNG for the assessment of airborne noise impacts due to construction works and the establishment of NMLs.

The CNVG provides guidance for determining the type of construction noise assessment to be carried out for the project. There are two parts of the CNVG that are used to determine the type of assessment required to be carried out:

- Duration of the impact on affected receivers
- Number of affected receivers.

Based on the proposed duration of construction works and number of affected receivers, a quantitative assessment has been carried out in accordance with the CNVG.

Traffic noise on the major arterial roads is more continuous, rather than intermittent. Construction activities that generate sounds with similar characteristics to road traffic noise are likely to be less noticeable than sounds that are intermittent, impulsive or tonal.

The receivers most affected by construction noise are typically closest to the works, with direct line of sight. Further away, or at places that do not have line of sight, construction noise generally decreases faster with distance than road traffic noise.

3.4.1.1 Residential receivers

The CNVG intends to provide respite for residents exposed to excessive construction noise outside the recommended standard construction hours while allowing construction during the recommended standard construction hours without unnecessary restrictions.

Table 3-3, reproduced from the ICNG, sets out the NMLs and how they are applied at residential receivers.

NMLs are based on the RBL, the overall whole number background noise level measured in each assessment period (during or outside the recommended standard construction hours). It is derived from measurements of the existing noise environment of an area, excluding noise from the project. The project RBLs are detailed in Section 2.5. The RBL represents the lowest 10th percentile background noise levels over an assessment period, which is a conservative approach. Average noise levels are usually higher than the RBL, as suggested by the ambient L_{Aeq} noise measurements presented in Section 2.5.

To assess the extent of noise impact it is important to consider how often high noise events occur at night and the predicted maximum noise levels at night. The extent of noise emergence above the background noise and whether there are times when there is a clear change in the noise environment should also be considered.

Construction noise may be less distinguishable to a receiver when ambient noise levels are high. For example, during the day when existing road traffic noise is high, construction noise may be less noticeable than at night time when ambient noise levels are lower. At night, there are also times when ambient noise levels are typically higher, such as at the beginning of the night period between 10.00pm and 12.00am or at the end of the night period between 5.00am and 7.00am. Construction noise generated during these periods may be less noticeable than during the quietest period of the night, between 2.00am to 4.00am (see Figure 2-4).

To assess noise against the NMLs, the assessment adopts the equivalent sound pressure level indicator, L_{Aeq}, which is the energy average of noise over the 15 minute measurement period. For screening potential sleep disturbance at night, the assessment also uses the maximum noise level indicator, L_{Amax}, which accounts for instantaneous noise events. Refer to Appendix A, Section A.2 for an explanation of some of the key acoustic concepts used to assess construction noise.

The outcome of this approach coupled with worst case construction noise prediction is that the emergence of construction noise above background noise would usually be over-estimated compared with typical noise levels generated by construction activities. Assessment against the NML and sleep disturbance screening level can be used as effective ways to identify when noise impacts need to be further mitigated and managed in order to protect receivers from annoyance for at least 90 per cent of the time.

Table 3-3 – NMLs at residential receivers in accordance with the ICNG

Time of day	Management level $L_{Aeq\ (15min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7.00am to 6.00pm Saturday 8.00am to 1.00pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted 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 dB(A)	The highly noise affected (HNA) level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, 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.

Time of day	Management level $L_{Aeq\ (15min)}$ *	How to apply
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 (of the ICNG).

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence. As such, in this assessment all levels and facades of receiver buildings have been assessed.

Residential receivers are considered 'noise affected' where construction noise levels are greater than the NMLs. The noise affected level represents the point above which there may be some community reaction to noise. Where predicted and/or measured construction noise levels exceed NMLs, all feasible and reasonable work practices would be applied to meet the NMLs. If construction noise is above $L_{Aeq(15\ min)}$ 75 dB(A) at any residence at any time, that residential receiver is considered to be highly noise affected.

The construction NMLs for all residential receivers around the project are presented in Appendix B.2.

Long-term residential premises such as aged care facilities are considered residential receivers, while the NML for short-term accommodation receivers such as hotels is in Table 3-4. As outlined in the NPfI, a receiver where a person resides but which is associated with a commercial undertaking is not classified as a residential receiver, but as a commercial receiver. This includes receivers such as caretakers' quarters, hotels, motels, transient holiday accommodation and caravan parks.

For construction noise, where a building has multiple uses, the most stringent criteria has been adopted for the building. For example, where a building contains:

- Both commercial and residential units, the building is assessed against residential NMLs
- Commercial units and a childcare centre, the building is assessed against the childcare NML.

3.4.1.2 Other sensitive land uses

Table 3-4 sets out the NMLs for commercial, industrial and other noise-sensitive receiver (OSR) locations, including commercial and industrial premises in accordance with the ICNG.

Table 3-4 – Noise management levels at other noise-sensitive land uses

Land use[1]	Where objective applies	Noise management level $L_{Aeq\ (15\ min)}$[2]
Classrooms at schools, and other educational institutions	Internal noise level	45 dB(A)[3,9]
Hospital wards and operating theatres	Internal noise level	45 dB(A)[4]
Places of worship	Internal noise level	45 dB(A)[3]

Land use[1]	Where objective applies	Noise management level $L_{Aeq\ (15\ min)}$[2]
Childcare centre	External noise level	50 dB(A)[8]
Active recreation areas (eg. sports fields/activities which generate their own noise and are generally less sensitive to external noise)	External noise level	65 dB(A)
Passive recreation areas (eg. area used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation)	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.[5]	Refer to the 'maximum' internal levels in AS/NZS 2107 for specific uses.)[5]
Commercial premises (including offices and retail outlets) [5,6]	External noise level	70 dB(A)[6,7]
Industrial premises	External noise level	75 dB(A)[7]
Special noise and/or vibration-sensitive (eg. laboratories, recording studios)	Depends on the intended use	Refer to the 'maximum' internal levels in AS/NZS 2107 for specific uses.

Notes:
1. Where premises are noise-sensitive and cannot be suitably classified by the categories in this table, it is recommended that the recommended 'maximum' internal noise levels presented in AS/NZS 2107:2016 are adopted
2. NMLs apply when receiver areas are in use only
3. As per the ICNG and NPfI, it has been assumed that the difference between an internal noise level and the external noise level is 10 dB, assuming windows are open for adequate ventilation. An external NML has been defined on this basis.
4. Medical centres and similar are classified as commercial premises
5. Community centres have been assessed to an external noise level of 60 dB(A). Depending on the intended use of the centre, the noise management level may vary
6. Hotels and motels have been treated as commercial premises, except for during the night periods where they have been assessed for sleeping areas against a night time internal noise level of 40 dB(A) assuming closed windows with a 20 dB(A) outside to inside difference
7. The NML applies at the most affected occupied point on the premises
8. Refer to further details relating to childcare centres below
9. Refer to further to details relating to schools below.

As the majority of OSRs operate mostly during standard construction hours, predicted noise levels and affected receiver counts are presented based on noise levels during standard construction hours.

Internal noise management levels

The ICNG states that:

> *"As a guide, the difference between the internal noise level and the external noise level is typically 10 dB with windows open for adequate ventilation"*

On the basis of the above and the general acceptance that most buildings provide a noise reduction of at least 10 dB(A) when windows are left at least 20 per cent open, where windows are operable and without providing additional treatment, a conservative 10 dB(A) reduction from external noise levels to internal noise levels has been adopted to determine equivalent external NMLs.

The external to internal noise reductions can vary largely for different buildings and facade construction types as there are a number of physical factors that can influence the level of noise reduction actually achieved from outside to inside a dwelling. For receiver buildings that are exposed to existing high levels of traffic noise, the facades would typically be sealed and consist of thick glazing and heavy facade

construction materials. Sealed facades or facades with windows closed can provide external to internal noise reductions much greater than 10 dB(A). Noise reductions greater than 20–25 dB(A) are achievable where facades consist of standard to thick glazing and heavy facade construction (eg. brick construction). The NMLs will be refined following a detailed land use survey prior to the commencement of construction works.

Classrooms, hospital wards, operating theatres and places of worship would have the equivalent external NML of **55 dB(A)** (refer to Table 3-4). Where appropriate, this may also be applicable for OSRs where the NML defined by an internal noise level is in accordance with AS/NZS 2107:2016.

Childcare centres

The ICNG and AS/NZS 2107:2016 do not provide specific construction noise criteria for childcare centres. Typically, sensitive areas within childcare centres are external/internal play areas and sleeping areas.

The Association of Australian Acoustical Consultants (AAAC) *Guideline for Child Care Centre Acoustics Assessment* (2013) recommends noise levels from external noise sources such as road, rail traffic and industrial sources that would be suitable for the various childcare centre spaces.

More detailed analysis may be required during detailed design to determine appropriate criteria for childcare centres depending on which spaces are noise affected, and if sleeping areas are close to works activities.

Considering the above NMLs, an external screening level of $L_{Aeq\ (15\ min)}$ **50 dB(A)** has been adopted for assessing childcare centres.

Where a childcare centre is located within an existing commercial building, with no external play areas, they have been identified as commercial premises. This approach assumes the existing commercial facade would provide enough transmission loss to protect the amenity of the childcare centre.

Schools

Schools are also typically made up of both indoor and external receiver types (ie external active or passive recreation areas). As the internal NML presented in Table 3-4 is more stringent than other relevant external NMLs, this NML for educational receivers would typically sufficiently manage noise impacts for educational receivers.

3.4.1.3 Sleep disturbance

Maximum noise levels generated by construction activities have the potential to disturb sleep. Section 4.3 of the ICNG states:

> *"Where construction works are planned to extend over more than two consecutive nights, and a quantitative assessment method is used, the analysis should cover the maximum noise level, and the extent and the number of times that the maximum noise level exceeds the RBL. Some guidance indicating*

the potential for sleep disturbance is in the NSW Environmental Criteria for Road Traffic Noise (EPA 1999).

Factors that may be important in assessing the extent of impact on sleep include how often high noise events occur at night, the predicted maximum noise levels at night, whether there are times when there is a clear change in the noise environment (such as during early morning shoulder periods), and the degree of maximum noise levels above the background noise level at night."

The *NSW Environmental Criteria for Road Traffic Noise* (EPA, 1999) (ECRTN) has been superseded by the NSW RNP (Department of Climate Change and Water, 2011). Although noise goals are not specifically provided in the RNP, the RNP includes a review of internal sleep arousal research and concluded that:

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

As such, external noise levels below 65 dB(A) are unlikely to awaken people. A conservative 10 dB(A) reduction from external noise levels to internal noise levels has been assumed, which is not always the case and could be greater than this as further outlined in Section 3.4.1.2.

The RNP aims to limit the level of sleep disturbance due to environmental noise, noting there is not enough evidence to change previous guidance than the $L_{AF1,\ 1\ minute}$ level of any noise should not exceed the ambient L_{AF90} noise level by more than 15 dB(A). It also notes that the L_{Amax} is better linked to sleep disturbance than other descriptors. This guidance takes into account the emergence of noise events but does not directly limit the number of such events or their highest level, which are also found to affect sleep disturbance.

Considering the ICNG and RNP guidance, an L_{Amax} sleep disturbance screening level of RBL + 15 dB(A) has been adopted for the project. Where predicted maximum noise levels are above the screening level, more detailed analysis has been carried out to identify:

- The likely number of events that might occur where the maximum noise level (L_{Amax}) exceeds RBL + 15 dB(A)
- Whether events exceed an 'awakening reaction' level of L_{Amax} 65 dB(A), and the likely number of these events
- The likely nature, distribution and frequency of these maximum noise level events during the night time period
- Potential feasible and reasonable noise mitigation measures to assist in reducing the number of maximum noise events above the screening level.

3.4.2 Construction-related road traffic noise

3.4.2.1 Within the boundary of a construction support site

When heavy vehicles and other vehicles are operating within the boundary of a construction support site, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15\ minute)}$ construction support site noise emissions. These noise objectives are outlined in Section 3.4.1.

3.4.2.2 Outside the boundary of a construction support site

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 support site.

The CNVG requires an initial screening test to evaluate whether noise levels would increase by more than 2 dB(A) due to construction traffic or a temporary reroute due to a road closure. Where increases are 2 dB(A) or less then no further assessment is required. The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact. Where noise levels increase by more than 2 dB(A), then further assessment is required using the Roads and Maritime's *Noise Criteria Guideline* (NCG), and all feasible and reasonable noise mitigation and management measures would be implemented.

Consideration should be given, in considering feasible and reasonable mitigation measures, to the actual noise levels associated with construction traffic and whether these levels comply with the following road traffic noise criteria in the RNP:

- 60 dB(A) $L_{Aeq(15hour)}$ day and 55 dB(A) $L_{Aeq(9hour)}$ night for freeway/arterial/sub-arterial roads
- 55 dB(A) $L_{Aeq(1hour)}$ day and 50 dB(A) $L_{Aeq(1hour)}$ night for local roads.

For this assessment, it has been assumed that heavy vehicle movements occur generally during standard construction hours for construction support sites, where indicated. Where heavy vehicle movements are required outside recommended standard construction hours, this would be assessed further as required during detailed design.

3.4.3 Construction-related water traffic noise

There are no guidelines to assess noise from vessel movements in NSW. Nonetheless, an assessment of construction-related water traffic noise is provided in Section 4.2.7.

3.4.4 Ground-borne construction noise

Ground-borne or regenerated noise as a result of construction activities is usually associated with tunnelling projects when equipment such as roadheaders, rock hammers and drilling rigs are operated underground. Ground-borne noise is usually not a substantial disturbance to building occupants during daytime periods due to higher ambient noise levels which can mask the audibility of ground-borne noise

emissions. However, during the evening and night periods, ground-borne noise can be more prominent due to lower ambient noise levels and may result in adverse comments from building occupants. Table 3-5 summarises the CNVG ground-borne construction noise objectives for residential receivers, which are consistent with the ICNG.

Table 3-5 – Ground-borne noise objectives at residential premises

Period	Time	Internal $L_{Aeq(15minute)}$ Ground-borne Noise Management Level (GBNML), dB(A)
Daytime	7.00am to 6.00pm	N/A - Human comfort vibration objectives only
Evening	6.00pm to 10.00pm	40
Night	10.00pm to 6.00am	35

For OSRs and commercial receivers such as offices and retail areas, the ICNG and CNVG do not provide guidance in relation to acceptable ground-borne noise levels.

For commercial receivers, internal ground-borne noise management levels were derived from the airborne NML presented in the ICNG for commercial premises and assuming a 20 dB(A) noise reduction from outside to inside to determine a suitable internal construction noise level. For other noise-sensitive receivers, guidance has been taken from the recommended 'maximum' internal noise levels in Australian Standard AS/NZS 2107:2016 to determine suitable internal NMLs.

For the purpose of this assessment, ground-borne noise objectives for key 'other' noise-sensitive land uses are identified below in Table 3-6.

Table 3-6 – Ground-borne NMLs at other noise-sensitive land uses

Land Use	Internal $L_{Aeq(15minute)}$ Ground-borne NML, dB(A)[1]
Hospital wards and operating theatres	45
Childcare centres	40[2]
Classrooms at schools and other educational	45
Places of worship	45
Community centre	45
Commercial premises (including offices)	50
Commercial premises (including retail outlets)	55
Other noise-sensitive receivers	Refer to the 'maximum' internal levels in AS/NZS 2107 for specific uses

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

2. NML is based on the recommended internal level for indoor play or sleeping areas within childcare centres nominated in the AAAC Guideline (AAAC, 2013).

3.4.5 Construction vibration objectives

Construction vibration is associated with three main types of impact:

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

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

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

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

3.4.5.1 Human exposure to vibration

Tactile vibration potentially disturbing human occupants of buildings is managed by reference to *Assessing Vibration; a technical guideline* (DECC, 2006). This document provides criteria which are based on the British Standard BS 6472-2008 *Evaluation of human exposure to vibration in buildings (1-80Hz)*.

Vibration sources are defined as Continuous, Impulsive or Intermittent. Table 3-7 provides a definition and examples of each type of vibration.

Table 3-7 – Types of vibration

Type of vibration	Definition	Examples
Continuous	Continues uninterrupted for a defined period (usually throughout the day-time and/or night time)	Machinery, steady road traffic, continuous construction activity (such as roadheader excavation).
Impulsive	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing the duration is short (typically less than 2 seconds)	Infrequent: Activities that create up to three distinct vibration events in an assessment period, eg. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, they would be assessed against impulsive vibration criteria.

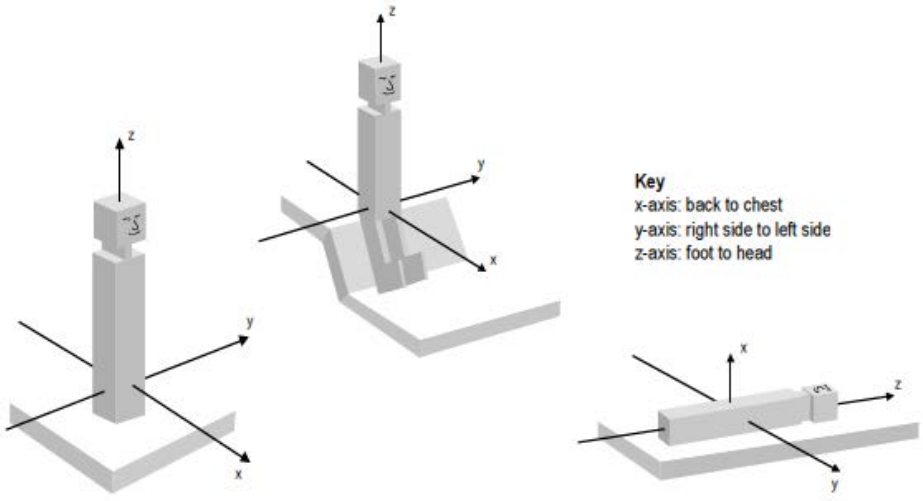
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change 2006.

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

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

When applying the criteria, it is important to note that vibration may enter the body along different orthogonal axes, ie. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). The three axes are referenced to the human body. Thus, vibration measured in the horizontal plane should be compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z-axis criteria if the concern is for people in the lateral position.

Figure 3-1 – Orthogonal axes for human exposure to vibration



Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change 2006 p4

Preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below.

Table 3-8 – Preferred and maximum levels for human comfort (continuous and impulsive vibration)

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration[3] (weighted rms Acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.04	0.029	0.080	0.058
Impulsive vibration[3] (Weighted rms Acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Offices, schools, educational institutions and places of worship	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7.00am to 10.00pm and night time is 10.00pm to 7.00am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (eg. relevant standards) and should be referred to. Source: BS 6472-2008

3. Source: Table 2.2, Assessing Vibration; a technical guideline, Department of Environment and Climate Change 2006.

Table 3-9 – Preferred and maximum levels for human comfort (intermittent vibration)

	Assessment period[1]	Preferred values	Maximum values
Intermittent vibration[3] (Vibration Dose Values, VDV, m/s1.75, 1-80Hz)			
Critical areas[2]	Day or night time	0.10	0.20
Residences	Daytime	0.20	0.40
	Night time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.80
Workshops	Day or night time	0.80	1.60

Notes: 1. Daytime is 7.00 am to 10.00 pm and night time is 10.00pm to 7.00 am

2. Examples include hospital operating theatres and precision laboratories where sensitive 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, as noted in BS 6472–1992

3. Source: Table 2.4, Assessing Vibration; a technical guideline, Department of Environment & Climate Change 2006.

3.4.5.2 Structural damage to buildings

Potential structural damage of buildings by vibration is typically managed by ensuring vibration impacting the structure does not exceed certain limits and standards, such as British Standard 7385: Part 2 and German Standard DIN 4150-3. As outlined in the Roads and Maritime's CNVG, guidance for cosmetic damage of structures is provided in the British Standard 7385: Part 2, while German Standard DIN 4150-3 has criteria of particular reference for heritage structures.

There is no current Australian Standard for assessing structural building damage caused by vibration.

British Standard BS 7385: Part 2 *Evaluation and measurement of vibration in buildings* can be used as a guide to assess the likelihood of building damage from ground vibration. The standard suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur. Damage consists of minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load-bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS 7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4 Hz to 250 Hz, being the range usually encountered in buildings. At frequencies below 4 Hz, a maximum

displacement value is recommended. The values set in the standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50 per cent. Table 3-10 sets out the BS 7385 safe limits for cosmetic damage.

Table 3-10 – BS 7385 cosmetic damage safe limits

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	Un-reinforced 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

For most construction activities involving intermittent vibration sources such as rock hammers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, the following vibration level (PPV) has been adopted as the assessment criteria for sound structures:

- Reinforced or framed structures – 25 mm/s
- Unreinforced or light framed structures – 7.5 mm/s.

For assessment purposes, a conservative vibration damage screening level of **7.5 mm/s** has been adopted for **sound structures** to identify where further investigation is required.

For structures where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be done during detailed design to determine the applicable safe vibration level and approach to construction near the structure.

3.4.5.3 Heritage items

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. It should be noted that British Standard BS 5228-2:2009 states that 'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive' (p.39) when compared to other structures.

Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for works to not further damage the structure. As stated previously, German Standard DIN 4150: Part 3 provides guidance for structures that are sensitive to vibration (eg. structurally unsound).

A conservative vibration damage screening level of 2.5 mm/s has been adopted for heritage structures. This does not necessarily reflect that there would be a vibration impact on the structure if this level is exceeded, instead it is a suitable vibration level that is used as part of the construction vibration management process to trigger further investigation.

Any heritage structure predicted to exceed the screening level would be further investigated during detailed design, and appropriate vibration criteria for the structure adopted. If a heritage building or structure is found to be structurally unsound (following inspection), the conservative cosmetic damage objective of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered, and appropriate protections put in place, as outlined in Section 6.8.

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Carry out a structural engineering report on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. Adopt the appropriate screening level from BS7385 Part 2 if the item was confirmed as 'structurally sound', or
4. Adopt the more conservative cosmetic damage level of 2.5 mm/s peak component particle velocity if the item was confirmed as 'structurally unsound'.

3.4.5.4 Damage to vibration-sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories use equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for sensitive equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment-specific data provided by manufacturers, there are generic vibration limits that can be used to assess the impact of vibration-generating activities on buildings housing vibration-sensitive equipment.

Vibration Criterion (VC) curves are often referred to as they are generic and apply to all tools/equipment types within each category. The VC curves are defined over the frequency range eight to 100Hz.

Table 3-11 summarises a range of suitable vibration limits that are applicable to buildings housing vibration-sensitive equipment which may potentially be affected by construction works associated with the project.

Table 3-11 – Acceptable vibration limits on building structure housing sensitive equipment

Equipment requirements	Vibration Limit[1] mm/s,		Description of Use
	rms	Peak [4]	
Computer areas[2]	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.
Medical[2, 3]	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A[3]	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc

Notes:
1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment
2. Based on AS 2834 Computer Accommodation
3. Gordon CG Generic Vibration Criteria for Vibration-sensitive Equipment
4. In the absence of Peak limits, rms limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414.

3.4.5.5 Existing rail tunnels

Any development that occurs within a distance of 25 metres horizontally from first reserve (dependent on tunnel dimensions), as defined in Asset Standards Authority (ASA) standard *Development Near Rail Tunnels* (ASA 2018), must consider vibration impacts on existing rail tunnels. The assessment requirement is a maximum peak particle velocity (PPV) of 15 mm/s at the tunnel lining for brick or mass concrete in good condition, or maximum PPV of 20 mm/s at the tunnel lining for cast iron, steel or concrete segment lining.

3.4.5.6 Damage to buried utilities

Section 5.3 of DIN 4150: Part 3 sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 3-12. As part of detailed design, these vibration limits would be considered to minimise the potential for damage to buried utilities from vibration impacts.

Table 3-12 – Acceptable vibration limits for effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note:
1. Consideration must also be given to pipe junctions within the building structure as potential substantial changes in mechanical loads on the pipe must be considered.

For long-term vibration, the vibration limits presented in Table 3-12 should be halved, as explained in Section 3.4.5.2.

Recommended vibration goals for electrical cables and telecommunication utilities such as fibre optic cables range from 50 mm/s to 100 mm/s. Although cables may sustain these vibration levels, the utilities they are connected to, such as transformers and switch blocks, may not. If such equipment is encountered

during the construction process, an individual vibration assessment would be carried out addressing impact on the utility, and consultation with the utility provider, to confirm specific vibration requirements.

3.4.6 Blasting noise and vibration management levels

Guidance in relation to acceptable overpressure and vibration from blasting is referenced 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* (ANZEC 1990). The CNVG refers to Australian Standard AS 2187.2-2006 *Explosives - Storage and use - Part 2 Use of explosives*.

The blast vibration criteria identified in ANZEC 1990 are considered too conservative and not practical for application to this project. The criteria in the ANZEC guideline do not take into account the timeframe of the blasting in terms of annoyance. That is, a short term project, eg. blasting for tunnel construction, is assessed with the same criteria as a long term project, eg. a mine site that may operate with blasting for several years. Table J4.5(A) and Table J5.4(A) of AS 2187.2-2006, reproduced in following sections, provide vibration and overpressure limits designed to safeguard human comfort from blasting, with consideration of the required duration of blasting for a project.

Table 3-13 and Table 3-15 show that the limits presented in AS 2187.2-2006 for long term projects (greater than 12 months) are similar to the ANZEC guideline. Further guidance is provided where only a small amount of blasting is required or where blasting may occur for less than 12 months. Australian Standard AS 2187.2-2006 *Explosives - Storage and use - Part 2 Use of explosives* has therefore been adopted for the project.

3.4.6.1 Airblast overpressure

Airblast overpressure generated by blasting associated with the project should be carried out so that the criteria specified in AS 2187.2-2006, reproduced in Table 3-13 and Table 3-14, is not be exceeded when measured at the most affected residence or other sensitive receiver.

Table 3-13 – Recommended airblast limits for human comfort (Table J5.4(A), AS 2187.2)

Category	Type of blasting operations	Peak sound pressure level (dBL)
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	115 dBL for 95 per cent blasts per year. 120 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	120 dBL for 95 per cent blasts. 125 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	125 dBL maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes: 1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people

2. The recommendations in Table J5.4(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

Table 3-14 – Recommended airblast limits for damage control (Table J5.4(B), AS 2187.2)[1]

Category	Type of blasting operations	Peak sound pressure level (dBL)
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All blasting	133 dBL maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables located above the ground	All blasting	Limit to be determined by structural design methodology

Notes: 1. The recommendations in Table J5.4(B) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

3.4.6.2 Blast vibration – human comfort

The human response to vibration from blasting is considered in terms of the likelihood of complaint, so that an appropriate community consultation program can be initiated to advise potentially affected receivers of the likely impacts from blasting. AS 2187.2-2006 suggests a limit of 10 mm/s PPV for human comfort for operations lasting less than 12 months, as shown in Table 3-15.

Table 3-15 – Ground vibration limits for human comfort (Table J4.5(A), AS 2187.2)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95 per cent blasts per year 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes: 1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people

2. The recommendations in Table J4.5(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions

3. The recommendations in Table J4.5(A) do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

3.4.6.3 Blast vibration – structural damage

Ground vibration limits for control of damage to structures (excluding heritage buildings) from blasting as required under AS2187.2-2006 is shown in Table 3-16.

Table 3-16 – Ground vibration limits for control of damage to structures (Table J4.5(B), AS 2187.2)[1]

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency-dependent damage limit criteria Tables J4.4.2.1

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Unoccupied structures of reinforced concrete or steel construction	All blasting	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

Notes: 1. The recommendations in Table J4.5(B) do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

Transient vibration guide values for cosmetic damage based on the British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', are presented in Table 3-17.

Table 3-17 – Transient vibration guide values for cosmetic damage (Table J4.4.2.1, AS 2187.2).

Group	Type of structure	Peak component particle velocity in frequency range of predominant pulse, mm/s	
		4Hz to 15Hz	15Hz and above
1	Reinforced or framed structures (industrial and heavy commercial buildings)	50	50
2	Un-reinforced or light framed structures (residential or light commercial type buildings)	15 (at 4Hz) to 20 (at 15 Hz)	20 (at 15 Hz) to 50 (above 15Hz)

Notes: 1. Values referred to are at the base of the building

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

To assess the likelihood of damage to heritage structures by blasting, and in the absence of specific unsound structure limits or limits for structures with particular sensitivity to vibration impacts, the structural damage screening level from general construction vibration impacts on heritage structures presented in Section 3.4.5.3 has been adopted for vibration impacts due to blasting. Blasting has been assessed against a vibration level no greater than **(PPV) 2.5 mm/s for structurally unsound heritage structures**. This is a conservative approach to identify heritage items that need further inspection. Heritage structures identified within this screening limit would require a structural inspection and following this, an appropriate limit would need to be adopted during detailed design in accordance with AS2187.2-2006 and/or BS7385.

3.4.6.4 Blasting operation hours

The recommended standard construction hours of blasting in accordance with Roads and Maritime's CNVG are as following:

- 9.00am to 5.00pm Monday to Friday
- 9.00am to 1.00pm Saturday
- No blasting on Sundays or public holidays.

3.5 Operational noise and vibration

3.5.1 Operational noise and vibration guidelines and policies

The operational noise guidelines and policies, which have been adopted in the operational noise assessment for the project, are presented in Table 3-18.

Table 3-18 – Operational noise guidelines and policies

Guideline/policy document	Assessment aspect	Relevant Section
Noise Model Validation Guideline (Roads and Maritime 2018)	Operational road traffic noise model validation	Section 4.6
NSW Road Noise Policy (Department of Environment, Climate Change and Water 2011)	Operational road traffic noise impacts	Section 7
Noise Criteria Guideline (Roads and Maritime 2015)	Operational road traffic noise criteria	Section 7
Application Notes – Noise Criteria Guideline (Roads and Maritime 2016)	Operational road traffic noise criteria	Section 7
Noise Mitigation Guideline (Roads and Maritime 2015)	Operational road traffic noise mitigation measures	Section 7
Noise Wall Design Guideline (Roads and Maritime 2016)	Operational road traffic noise mitigation measure	Section 7
At-Receiver Noise Treatment Guideline (Roads and Maritime 2017)	Operational road traffic noise mitigation measure	Section 7
Environmental Noise Management Manual (Roads and Traffic Authority 2001)	Operational road traffic noise impacts	Section 7
Development Near Rail Corridors and Busy Roads – Interim guideline (Department of Planning, 2008)	Operational road traffic noise impacts	Section 7
Noise Policy for Industry (Environment Protection Authority, 2017)	Fixed facilities noise impacts	Section 7.4

For details addressing the *NSW Sustainable Design Guidelines Version 3.0* (Transport for NSW, 2013) refer to Chapter 25 (Sustainability) of the environmental impact statement.

3.5.2 Operational road traffic noise criteria

Operational road traffic noise criteria are assigned to sensitive receivers using Roads and Maritime's NCG. The assessment timeframe criteria are for the year of opening of the project and 10 years after opening.

The project assessment area extends to where noise levels are dominated by other roads that are not being assessed as part of the project as defined in the NCG. This is typically up to a maximum distance of 600 metres from the project works.

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project would influence traffic noise levels. The most stringent applicable criteria would be used in the assessment for each facade of the residence.

Criteria are based on the type of road development a residence is affected by due to the road project. In some instances, residences may be exposed to noise from new and redeveloped roads or different

functional classes. In this instance, the proportion of noise from each road is used to establish transition zone criteria and provides a smooth change in noise criteria between adjacent residences. A further check would be made to prevent large increases in noise level, using the relative increase criteria.

The project involves the widening of the existing road corridors to accommodate portals to and from the tunnels and to increase the traffic-carrying capacities of the existing roads. Noise from traffic travelling through the tunnels would be contained within the tunnels and would not impact noise-sensitive areas on the surface.

The RNP and the NCG set road noise criteria based on the road's function in the road network and the type of road development.

The roads which form the project are classified as motorway or arterial roads because they handle through traffic bound for another locality and have characteristically heavy and continuous traffic flows. As such, the project contains the 'new road', 'redeveloped road' and 'transition zone' noise categories as described below:

New road

As per the NCG, a road is assessed as a 'new' road for any of the following cases:

- The project proposes road construction in an undeveloped corridor
- The road project changes the functional class of the road
- Widening, curve-straightening or adjustment of the corridor occurs where the upgrade road pavement has been substantially realigned
- Duplication of an existing road where the new lanes have been substantially realigned from the existing corridor
- A bypass road extends beyond the existing road corridor.

The NCG defines substantial realignment of an existing road as a distance beyond a tolerance band that is six times the existing road's total lane width.

Parts of the project may involve the acquisition and demolition of buildings to allow the road corridor to be widened. Where the project is substantially realigned outside the existing road corridor, the 'new' road criteria would be applicable to the impacted receivers.

Redeveloped road

As per the NCG, for a road to be considered 'redeveloped' rather than 'new', the existing road pavement should not be substantially realigned. Typical examples of road upgrades assessable under the 'redeveloped' noise criteria include:

- Widening/adjustment of the corridor where the road segment (including duplicated carriageway) has not been substantially realigned

- Duplication of a carriageway adjacent and parallel with the existing road corridor where the widened road has not been substantially realigned
- Duplication of a carriageway wholly within an existing corridor
- Introduction of on or off ramps to provide access through an intersection that was previously inaccessible for that direction.

The majority of surface roads associated with the project is an expansion of existing surface road corridors to increase the traffic-carrying capacity within the road alignment of the existing roads. The 'redeveloped' road noise criteria would be applicable to these receivers.

Transition zone

In the areas presented in Appendix M, receivers may be exposed to noise from a redeveloped road, new road and/or an existing road. For these areas, 'transition zones' have been established accordingly in accordance with the NCG, which provide a gradual change in noise criteria according to the road type (redeveloped or new) the receivers are most exposed to.

Relative increase criterion

A large increase in the existing level of traffic noise can cause a major change in the acoustic environment of a location. Under section 8 of the NCG and section 2.4 of the RNP, this is assessed using the 'Relative Increase Criterion' (RIC). The purpose of the RIC is to recognise the potential for such a change and provide a means to assess and mitigate for this type of noise impact.

Some receivers may not be currently impacted by traffic noise due to noise shielding provided by buildings located between the receiver and the road. Impacts would occur where the widened road corridor results in buildings being demolished, exposing receivers to traffic noise when they were previously well shielded. The traffic noise impact from the project would need to also comply with the RIC for these receivers.

The RIC is to be applied to the external areas of existing residential receivers impacted by the project. The RIC, as set out in the NCG and RNP applicable to this project, is reproduced as follows.

Table 3-19 – Relative increase criterion

Type of development	Total traffic noise level increase, dB(A)
Redevelopment of existing road	Existing traffic $L_{Aeq(period)}$ + 12 dB (external)

Notes: 1. 'Existing traffic' refers to the traffic noise levels for the relevant 'no build' scenario.

Importantly, the RIC should only be applied to receivers where the noise criteria are more stringent than the new or redeveloped road criteria. The RIC would only be applied for the project where existing traffic noise levels at the receiver are very low; for example:

- Day $L_{Aeq(15hour)}$ traffic noise ≤ 42 dB(A) for new and ≤ 47 dB(A) for redeveloped roads
- Night $L_{Aeq(9hour)}$ traffic noise ≤ 37 dB(A) for new and ≤ 42 dB(A) for redeveloped roads.

3.5.2.1 Operational road traffic noise criteria for residential receivers

A summary of the applicable traffic noise criteria in accordance with the NCG for residential receivers is presented in Table 3-20.

Table 3-20 – NCG criteria for residential receivers

Road category	Type of project/land use	Assessment criteria, dB(A)	
		Daytime (7.00am - 10.00pm)	Night time (10.00pm - 7.00am)
Freeway[4] / 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 dB(A) 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 dB(A) 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 applicable noise criteria for a particular receiver would be dependent on its location relative to where the new road joins the redeveloped road (transition zone). See section 7.1 and Table 1 of the Roads and Maritime Services' 'Noise Criteria Guideline' for further information
2. The criteria at each facade are determined from the existing traffic noise level plus 12 dB(A)
3. L_{Aeq} noise levels represent the equivalent average energy noise level of the corresponding period.
4. This covers motorways

3.5.2.2 Operational road traffic noise criteria for non-residential receivers

The NCG also set criteria for the assessment of traffic noise on non-residential sensitive land uses such as schools, hospitals, places of worship and recreation areas. Given that there are non-residential sensitive land uses that may be potentially impacted by traffic noise from the project, the following criteria are applicable.

Table 3-21 – NCG criteria for non-residential sensitive land uses

Existing sensitive land use	Assessment criteria, dB(A)		Additional considerations
	Day (7.00am-10.00pm)	Night (10.00pm-7.00am)	
School classrooms	$L_{Aeq,1hour}$ 40 (internal) when in use	–	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Hospital wards	$L_{Aeq,1\ hour}$ 35 (internal)	$L_{Aeq,1\ hour}$ 35 (internal)	
Places of worship	$L_{Aeq,1\ hour}$ 40 (internal)	$L_{Aeq,1\ hour}$ 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 what in these areas may be affected by road traffic noise. For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, there are areas between the church and the road where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the open space (passive use) criteria may be applied.
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. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, eg. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, eg. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Open space (passive use)	$L_{Aeq,15hour}$ 55 (external) when in use	–	
Childcare facilities	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, eg. 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

For non-residential receivers such as school classrooms, places of worship, childcare centres and hospitals, assessment criteria set out in the NSW *Road Noise Policy* (RNP) applies to the interior space during its use.

At this stage, since this assessment is only able to evaluate external noise exposure, internal criteria have been converted to the exterior of the building to facilitate the assessment of potential noise impact, assuming all classrooms, places of worship and hospital wards are located on the facade with the highest noise level and that windows are always open. When windows are open, it is generally accepted that the internal noise level is 10 dB(A) lower than the corresponding worst affected exterior location close to the facade. These non-residential receivers identified to exceed the external screening criterion in this assessment will require further investigation during detailed design to confirm the extent of noise impact and eligibility for consideration of noise mitigation since the difference in noise from outside to inside can increase to more than 30 dB(A) depending on the building type, location of the room within the building, window type and whether the use of the space requires the window to be fully opened, slightly opened or closed.

3.5.2.3 Road traffic noise impacts from existing roads

The NCG provides guidance for assessing traffic noise from existing roads not subject to any redevelopment but is predicted to increase traffic noise levels by more than 2 dB(A) as a result of the project. An example of this is when traffic from the project uses the existing road as a detour, resulting in an increase in traffic volumes on the existing road, which in turn increases the traffic noise levels at affected receivers by more than 2 dB(A).

For these scenarios, the NCG states that the existing road criteria presented in Table 3-22 would apply.

Table 3-22 – NCG criteria for existing roads not subject to redevelopment

Existing Road Category	Target Noise Level –dB(A)	
	Day (7.00am – 10.00pm)	Night (10.00pm – 7.00am)
Freeway/ motorway/ arterial/ sub-arterial road	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local road	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

3.5.2.4 Maximum road traffic noise levels

Maximum noise levels generated by road traffic noise have the potential to cause disturbance to sleep. Although noise goals are not provided in the RNP, the RNP includes a review of internal sleep arousal research. The RNP concludes that there appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. Nevertheless, Roads and Maritime recognises the potential impacts and requires an assessment of maximum noise levels be made where impacts may occur during the night.

Guidance for assessing maximum noise levels is provided in Practice Note iii of the *Environmental Noise Management Manual* (RTA, 2001) (ENMM). The maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies. It should not be used as a decisive criterion in itself and should not be used to aid in designing the degree of mitigation required.

The assessment considers the following:

- Calculation of maximum noise levels

- The extent to which the maximum noise levels for individual passing vehicles exceed the L_{Aeq} noise level for each hour of the night; ie. L_{Amax} noise levels greater than 65 dB(A) where $L_{Amax} - L_{Aeq(1hour)} \geq 15$ dB(A).

At locations where road traffic is continuous rather than intermittent, the $L_{Aeq(9hour)}$ criteria for operational noise assessment should sufficiently account for sleep disturbance impacts. However, where the emergence of L_{Amax} over the ambient L_{Aeq} is equal to or greater than 15 dB(A), the $L_{Aeq(9hour)}$ criteria may not sufficiently account for sleep disturbance impacts.

3.5.3 Operational vibration

Vibration from traffic travelling through the tunnels and the operations of the fixed facilities would be considered insignificant and would not impact sensitive areas on the surface. This is further addressed in Section 7.5.

3.5.4 Operational fixed facilities noise

Noise from the operation of the fixed facilities associated with the project may adversely impact nearby affected sensitive receivers. The principal elements of fixed facilities would include:

- Tunnel ventilation fans located within motorway facilities
- Jet fans located throughout the tunnels and ramps
- Egress passage ventilation fans
- Mechanical and electrical plant associated with substations, fire pump buildings, and wastewater treatment plant.

The above elements are considered industrial noise sources, as opposed to road traffic noise or construction noise sources.

3.5.4.1 Fixed facilities noise objectives

Noise impacts from the fixed facilities are to be assessed against the Environment Protection Authority's NPfI. The NPfI sets a project noise trigger level for industrial noise sources that if exceeded, would indicate a potential noise impact on the community, and would trigger a response of investigating feasible and reasonable noise mitigation and management measures. The project noise trigger level is the lowest value of the project intrusive noise level and the project amenity level. The project intrusiveness noise level aims to protect against substantial changes in noise levels, while the project amenity noise level seeks to protect against cumulative noise impacts from all industrial noise sources and maintain the amenity for a particular area of land use. The assessment is for total noise emissions from all noise sources associated with each fixed facility.

In addition to the project noise trigger levels, maximum noise levels are also assessed to determine the potential for sleep disturbance to residents as required in accordance with the NPfI.

Assessment time periods

Criteria for the assessment of operational fixed facility noise are usually derived from the existing noise environment of an area, excluding noise from the project.

As the noise environment of an area almost always varies over time, background noise levels need to be determined for the purpose of determining project noise trigger levels. The NSW NPfI outlines the standard time periods over which the background noise levels are to be determined:

- **Day** is defined as 7.00am to 6.00pm, Monday to Saturday and 8.00am to 6.00pm Sundays and Public Holidays
- **Evening** is defined as 6.00pm to 10.00pm, Monday to Sunday and Public Holidays
- **Night** is defined as 10.00pm to 7.00am, Monday to Saturday and 10.00pm to 8.00am Sundays and Public Holidays.

Project intrusiveness noise level

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15 minute period, does not exceed the background noise level measured in the absence of the source, by more than 5 dB(A). The intrusiveness noise level seeks to limit the degree of change the new source adds to an existing noise environment. The intrusiveness noise level is applicable to residential premises only.

The intrusiveness noise level is summarised as follows:

- **$L_{Aeq,15\ min}$ = Rating Background Level (RBL) plus 5 dB.**

Project amenity noise level

The recommended amenity noise levels presented in Table 2.2 of the NPfI represent the noise objectives for the total noise at a receiver location from industrial sources. The project amenity noise level represents the noise objective for a single industrial noise source at a receiver location.

To ensure total noise levels from industrial sources (existing and new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies as follows:

- **Project amenity noise level = Recommended amenity noise level minus 5 dB(A).**

Given that the intrusiveness noise level is based on a 15-minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15\ minute}$ level to standardise the time periods.

- **$L_{Aeq,15\ minute}$ = $L_{Aeq,period}$ + 3 dB.**

For this project, existing residential receivers that would be potentially affected by noise from the fixed facilities are considered to be 'urban residential' type receivers as the acoustical environment adjacent to all

the fixed facility locations has through traffic with characteristically heavy and continuous traffic flows during peak periods (as defined in Table 2.3 of the NPfI). Furthermore, other land use receivers may also be impacted by noise from the fixed facilities. The applicable project amenity noise levels, based on the NPfI, are presented in Table 3-23.

Table 3-23 – Project amenity noise levels

Receiver	Noise amenity area	Time of day	Amenity noise level $L_{Aeq(Period)}$,dB(A)	
			$L_{Aeq, Period}$	$L_{Aeq, 15min}$
Residence	Urban	Day	60 – 5 = 55	55 + 3 = **58**
		Evening	50 – 5 = 45	45 + 3 = **48**
		Night	45 – 5 = 40	40 + 3 = **43**
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day	
School classrooms - internal	All	Noisiest 1-hour period when in use	35 – 5 = 30	30 + 3 = **33**
Hospital ward	All	Noisiest 1-hour period		
- internal			35 – 5 = 30	30 + 3 = **33**
- external			50 – 5 = 45	45 + 3 = **48**
Place of worship - internal	All	When in use	40 – 5 = 35	35 + 3 = **38**
Area specifically reserved for passive recreation (eg. national park)	All	When in use	50 – 5 = 45	45 + 3 = **48**
Active recreation area (eg. school playground, golf course)	All	When in use	55 – 5 = 50	50 + 3 = **53**
Commercial premises	All	When in use	65 – 5 = 60	60 + 3 = **63**
Industrial premises	All	When in use	70 – 5 = 65	65 + 3 = **68**

In accordance with the NPfI, where existing transport noise (eg. traffic noise) is high enough to make noise from an industrial source effectively inaudible and the existing traffic noise level is 10 dB(A) higher than the applicable recommended amenity noise level for the area, then in such cases, the project amenity noise level would be derived as follows:

- **High traffic project amenity noise level = $L_{Aeq,period(traffic)}$ minus 15 dB(A).**

3.5.4.2 Annoying noise characteristics adjustments

Where the character of the industrial noise is assessed as particularly annoying (ie. if it has an inherently tonal, low frequency, is impulsive or is intermittent at night), then an adjustment would be added to penalise the noise for its potential increase in annoyance. The NPfI provides definitive procedures for determining whether a modifying factor should be applied. The definitions of the modifying factors applicable to the fixed facilities are presented in Table 3-24, reproduced from Fact Sheet C of the NPfI.

Table 3-24 – Modifying factor corrections

Factor	Assessment/ measurement	When to apply	Correction[1]	Comments
Tonal noise	One-third octave band analysis using objective method for assessing the audibility of tones in noise – simplified method (ISO1996.2-2007 – Annex D)	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500-10,000Hz • 8 dB or more if the centre frequency of the band containing the tone is 160-400 Hz inclusive • 15 dB or more if the centre frequency of the band containing the tone is in the range 25-125Hz	5 dB[2,3]	Third octave measurements should be carried out using unweighted or Z-weighted measurements. Note: Narrow-band analysis using the reference method in ISO1996-2:2007, Annex C may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, eg where it appears the tonal energy is at or close to the third octave band limits of contiguous bands.
Low frequency noise	Measurement of source contribution C-weighted and A-weighted level and on-third octave measurements in the range 10-160Hz	Measure/assess source contribution C- and A-weighted $L_{A,T}$ levels over same time period. Correction to be applied where the C minus A level is 15 dB or more and: • Where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated at 2 dB(A) positive adjustments to measures/predicted A-weighted levels applies for the evening/night period • Where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5 dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2 dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between the C- and A-weighted measurements identifies the potential for an unbalanced spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.

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, that is, at or below 160Hz
3. Where narrow band analysis using the reference method is required, as outlined in column 5, the correction would be determined by the ISO1996-2:2007 standard.

3.5.4.3 Sleep disturbance

For operational noise, guidance for the assessment of maximum noise levels leading to sleep disturbance is taken from the NPfI. The NPfI states:

> *"The potential for sleep disturbance from maximum noise level events from premises during the night time period needs to be considered. Sleep disturbance is considered to be both awakenings and disturbance to sleep stages.*
>
> *Where the subject development/premises night time noise levels at a residential location exceeds:*
>
> - *$L_{Aeq,\ 15\ min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is greater, and/or*

- *L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is greater.*

a detailed maximum noise level event assessment should be undertaken.

The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night time period. Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy.

Other factors that may be important in assessing the extent of impacts on sleep include:

- *How often high noise events will occur*
- *The distribution of likely events across the night time period and the existing ambient maximum events in the absence of the subject site*
- *Whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods).*

Maximum noise level event assessments should be based on the L_{AFmax} descriptor on an event basis under 'fast' time response.

The detailed assessment should consider all feasible and reasonable noise mitigation measures with a goal of achieving the above trigger levels."

For maximum noise level events, the NSW RNP identifies in its summary on sleep disturbance research to date that:

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

The above references identify that internal noise levels of 50-55 dB(A), are unlikely to cause awakenings. On the assumption that there is a 10 dB(A) outside-to-inside noise loss through an open window (see section 2.6 of the NPfI, p15), this indicates that external noise levels of L_{Amax} 55 to 65 dB(A) are unlikely to cause awakening reactions.

In summary, the sleep disturbance initial screening assessment in accordance with the NPfI has identified receivers that exceed:

- $L_{Amax} \geq L_{A90(15\ min)}$ + 15 dB(A), except in cases where the screening criterion is below 52 dB(A), then 52 dB(A)
- $L_{Aeq} \leq L_{A90(15\ min)}$ + 5 dB(A), except in cases where the screening criterion is below 40 dB(A), then 40 dB(A).

Where the L_{Aeq} and L_{Amax} levels exceed the screening criterion, further assessment would be carried out for possible sleep disturbance impacts.

4 Assessment methodology

This section presents the methodology and assumptions adopted for the assessment of both the construction and operational noise and vibration impacts of the project.

4.1 Overview of method for assessing construction noise and vibration

The process for assessing construction noise and vibration impacts is detailed on Figure 4-1.

Figure 4-1 – Process for assessing construction noise and vibration

1. Determine noise and vibration objectives

For each key construction area:

- Identify noise-sensitive receiver buildings (**individual receiver buildings are considered as a single receiver for the purposes of this assessment**)
- Determine relevant noise and vibration objectives, with reference to section 3.

2. Identify construction stages/scenarios

For each key construction area:

- Identify construction aspects or stages and key activities for each stage
- Including:
  - the site location
  - times of operation
  - processes involved
  - plant and equipment (including size and type).
- Identify other construction projects in the vicinity of the project to ensure cumulative noise and vibration impacts are managed, in particular in relation to out of hours work (OOHW).

3. Predict noise and vibration impacts

Airborne construction noise

- Determine $L_{Aeq(15\ minute)}$ sound power levels based on construction scenarios for input to noise model (see below)
- Establish noise model for construction activity/ component
- The noise model should include:
  - Height and location of sources and receivers,
  - Distance attenuation (incorporating noise reflections and ground absorption)
  - Effects of noise shielding (topography, buildings, boundary fences, noise barriers etc)
  - Effects of feasible and reasonable standard noise mitigation and management measures and any incorporated noise treatment measures
- Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction activities at each receiver and compare these with the construction noise objectives
- For night time activities, calculate the maximum (L_{Amax}) noise levels and compare with L_{Amax} sleep disturbance criterion.

3. Predict noise and vibration impacts (continued)	
Ground-borne construction noise	• Determine the reasonable worst-case location of each plant or equipment item in relation to each receiver • On the basis of ground-borne noise levels versus distance prediction curves for each plant item, determine the potential level of ground-borne noise at each building location.
Construction vibration	• Determine the reasonable worst-case location of each plant or equipment item in relation to each receiver • Determine the reasonable worst-case vibration-intensive plant that would operate within each construction support site, and the minimum working distances for this plant item that would achieve the vibration screening levels for sound and unsound structures, and for human response, as presented in Table 4-11 • Assess if vibration-intensive equipment could potentially be operating within the minimum working distances for nearby receivers or heritage items, and so potentially exceed recommended criteria. Note that minimum working distances may differ for heritage items.
4. Assess noise and vibration impacts	
Where predicted noise and vibration exceeds the objectives identified in Step 1:	• Identify appropriate reasonable/ feasible standard mitigation measures (see Appendix G) • Predict noise levels at receivers, incorporating further mitigation and management measures to minimise the number of receiver locations where noise exceeds the NMLs • Review vibration-intensive equipment and determine if and where vibration monitoring may be required during construction, as vibration-sensitive are within minimum working distances, and so may exceed recommended criteria • Identify additional potential mitigation measures for further consideration to manage residual impacts.

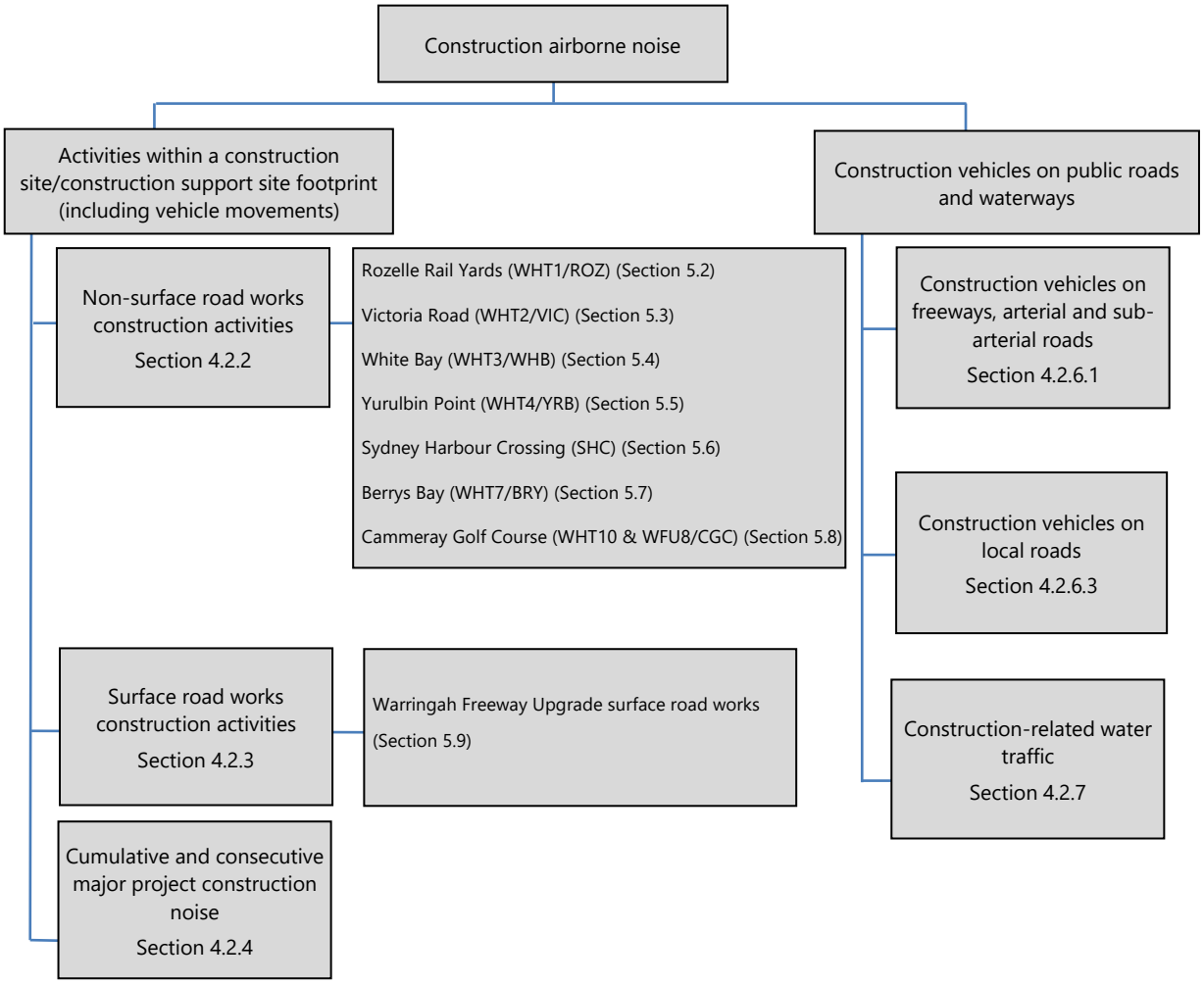
4.2 Airborne construction noise

An assessment of the potential level of construction noise impacts has been carried out to determine the degree of impacts and compliance with NMLs, whether noise mitigation measures would be required, and to determine appropriate management controls, based on proposed staging and activities.

Detailed specifications for required construction equipment would be determined during the detailed design stages. This may change or influence the mitigation and management measures required to manage noise and vibration impacts. The type and number of plant and equipment associated with each assessment stage for the proposed works have been developed based on experience with similar construction projects and input from Roads and Maritime.

Two different modelling approaches have been used in this assessment of construction airborne noise impacts. Presented in Figure 4-2 shows construction airborne noise methodologies used for the project construction sites and construction support sites, and the applicable report sections in which each item is addressed.

Figure 4-2 – Applicable construction airborne noise methodologies for construction works



4.2.1 Model development

Airborne noise impacts from activities associated with the construction works were assessed by modelling the noise sources, receiver building (a receiver building represents an individual building such as house or apartment building) locations, topographical features, and possible noise mitigation measures using a computer noise model developed for this project.

The model calculates the contribution of each noise source to each identified noise-sensitive receiver building location surrounding the work site, and allows for the prediction of the total noise from a works area or construction support site for the various stages of construction work.

The noise prediction model considers:

- Location of noise sources and sensitive receiver building locations
- Height of sources and receivers referenced to one-metre digital ground contours for the site and surrounding area
- Each noise-sensitive building in the project has been assessed separately, considering all facades, except educational institutions and similar with multiple buildings, which are considered as one noise-sensitive receiver
- Sound Power Levels (SWL) of plant and equipment likely to be used during the various construction activities
- Separation distances between sources and receivers
- Ground type between sources and receivers
- Attenuation from barriers and topography (natural and purpose built), including existing road noise barriers
- Noise propagation calculated on the implementation of the noise propagation algorithm ISO 9613-2 (1996), which incorporates moderately adverse meteorological conditions, implemented in accordance with ISO/TR 17534-3 (2015), based on a typical ground absorption of 0.5, and zero for hard/acoustically reflective areas such as water
- Feasible and reasonable noise mitigation/treatments and management measures that have been determined for the site (ie. acoustic sheds, other acoustic attenuation, on-site acoustic barriers).

Construction noise levels are assessed at the most noise affected facade and floor level of a receiver building. Construction noise levels experienced at other points on the building may be lower as demonstrated in the following figures, which show three typical scenarios where a receiver building is located 1) level with construction works, 2) at a lower ground level than the construction works and, 3) at a higher ground level than the construction works.

These figures help to demonstrate that for receivers that are further away from the construction works, or receivers that have increased acoustic shielding (ie. nearby tall buildings), the potential noise levels would be less than those presented compared with highest predicted noise level for an individual receiver building.

Figure 4-3 – Noise propagation and acoustic shielding – Receiver buildings at same ground level as construction works (construction noise level, dB(A))

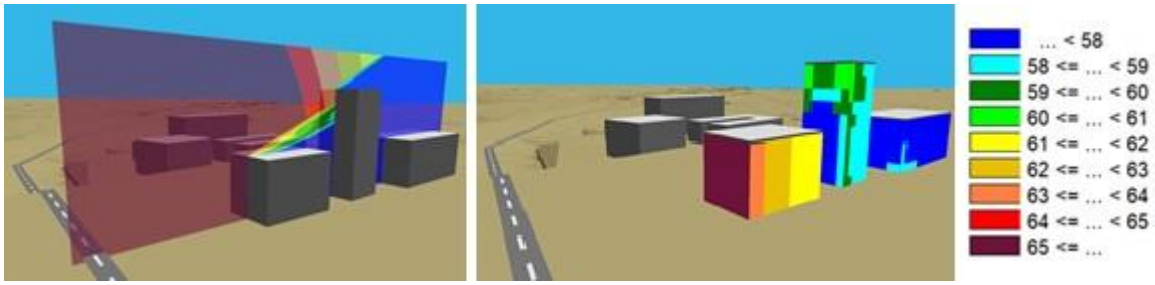
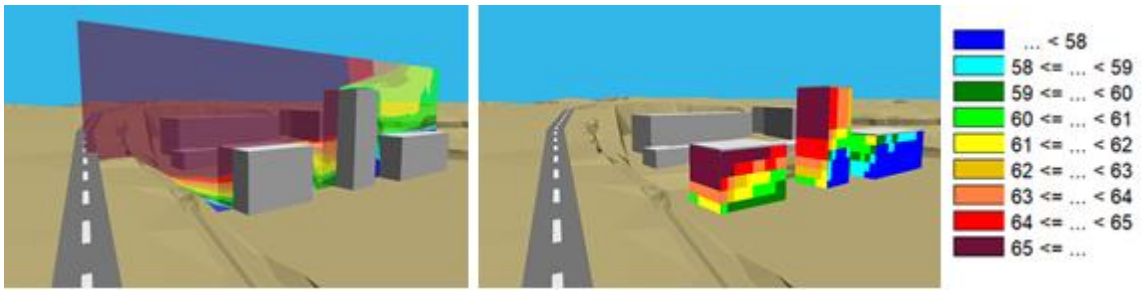


Figure 4-3 shows how noise from construction works located on a nearby road propagates away from the work site where the work site and the receiver buildings are at the same ground level (ie. flat ground). Receiver buildings at the nearest high-rise building would be exposed to similar construction noise across the entire exposed facade. The nearest buildings provide a noise barrier to the next row of buildings and the figure shows how lower floor levels would receive more substantial shielding from the building in front, reducing construction noise levels.

High-rise buildings may still be exposed to construction noise at the upper floor levels.

Receiver buildings further away from the construction work site, behind the nearest buildings would be exposed to substantially lower levels of construction noise (more than 15 dB(A) lower).

Figure 4-4 – Noise propagation and acoustic shielding – Receiver buildings at lower ground level than construction works (construction noise level, dB(A))



Construction noise propagating from a work site located on a nearby road at a higher ground level than the nearest receiver buildings (eg. on an embankment) is demonstrated on Figure 4-4. In this example, the edge of the embankment partially shields construction noise to the lower levels of the nearest high-rise building, while the upper levels of the building remain exposed to unshielded construction noise. Similarly, the noise barrier effect provided by the nearest buildings to those behind is also lessened, especially for high-rise buildings, where the upper floor levels may be directly exposed to the construction work site. Receiver buildings further away from the construction site, behind the nearest buildings would be exposed to lower levels of construction noise but are more exposed than in the case presented on Figure 4-3. This is because the buildings between this receiver and the construction work site have less of a barrier effect when the work site is elevated.

Figure 4-5 – Noise propagation and acoustic shielding – Receiver buildings at higher ground level than construction works (construction noise level, dB(A))

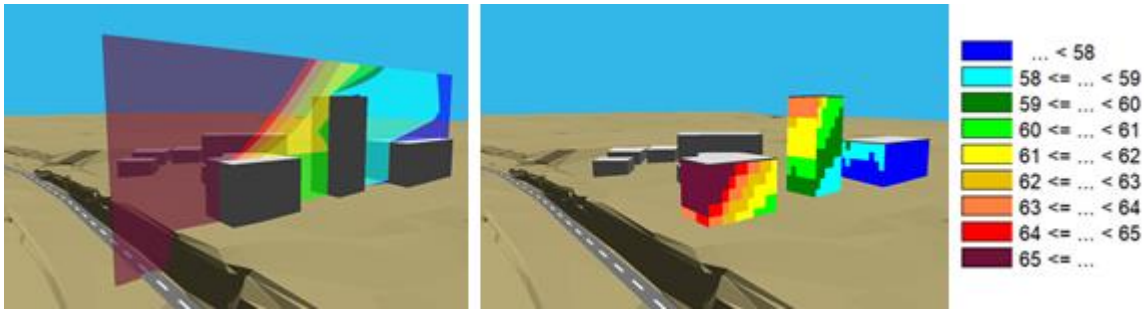


Figure 4-5 shows construction noise is propagating from a work site located on a nearby road at a lower ground level to the nearest receiver buildings (eg. in a cutting). In this example, the edge of the cutting partially shields construction noise to the lower levels of the nearest high-rise building, while the upper levels of the building remain exposed to construction noise. Further to this, the noise barrier effect provided by the nearest buildings to those behind is increased, even to high rise buildings, where the upper floor levels are not directly exposed to the construction work site.

4.2.2 Construction support sites modelling

4.2.2.1 Construction noise sources

The type, number and typical operational intensity of plant and equipment associated with each of the assessed 'reasonable worst case' construction works scenarios are based on experience with similar major transport infrastructure projects and inputs from the project team as well as from Roads and Maritime. These are detailed in Appendix E for each construction support site.

Sound power levels for the plant and equipment modelled in this project are based on maximum levels presented in each of the construction assessment sections. These are based on Table A1 of Australian Standard 2436 - 2010 *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, the CNVG, information from past projects, and information held in the Renzo Tonin & Associates (RT&A) library files from noise measurements and references.

Further details about the modelling assumptions for heavy vehicles operating within the construction support sites are detailed in Section 4.2.6.1.

4.2.2.2 Assessment scenarios

In developing a modelling scenario in accordance with the ICNG, the assessment assumes a 'reasonable worst case' set of operating plant and equipment that could occur during a 15 minute period. The assessment provides a typical representation of the potential construction noise levels for the project.

Each construction support site would be reviewed when more specific detail regarding construction activity is available during detailed design. This would be carried out as part of the preparation of a site-specific construction noise and vibration impact statement (CNVIS). Each site would be assessed in accordance with the requirements of the construction noise and vibration management plan (CNVMP) developed for the project, which implements project approval requirements.

The assessment scenarios were developed to review the potential reasonable worst case impacts and are conservative, in that they assume all the equipment identified within a scenario would:

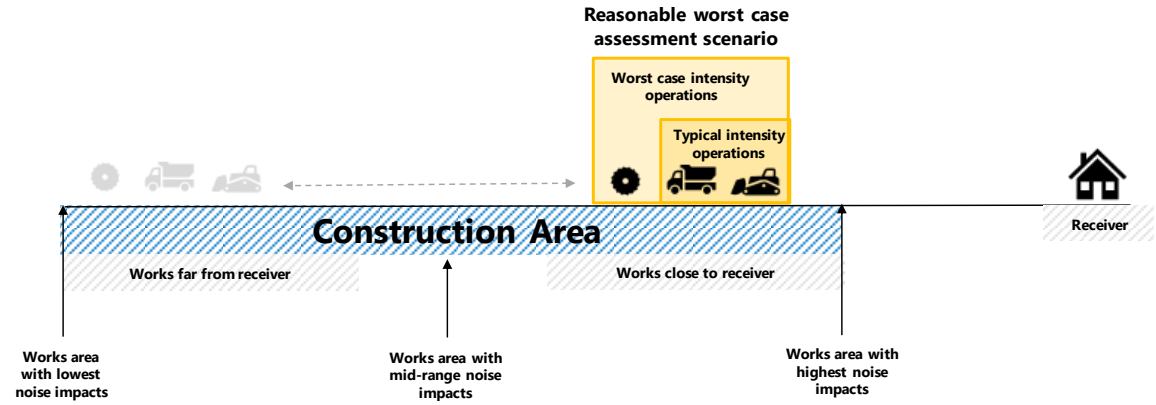
- Operate simultaneously
- Operate in a reasonable worst case condition (with mitigation or management included where noted) and in the worst case orientation, throughout a 15 minute period.

This is shown as the 'reasonable worst case assessment scenario' presented on Figure 4-6. This is conservative and unlikely to typically occur.

Noise levels are likely to be lower during actual construction works. The actual noise emissions from the works and resulting noise levels at nearby receiver buildings would be influenced by:

- The location/distance of the plant/equipment with respect to the receiver building (see Figure 4-6)
- The on/off time of the plant/equipment
- The intensity with which the plant/equipment is working.

Figure 4-6 – Basis of noise and vibration assessment scenarios



The modelling result tables presents the predicted noise levels for each NCA for each construction support site assessment and for each of the assessed 'reasonable worst case assessment scenarios'. These results present the range of predicted noise levels for residential receivers, commercial and other noise-sensitive receivers, unless no receivers of that type in that NCA are expected to exceed NMLs.

Noise contours for key stages of each construction support site are included Appendix H.1, representing the predicted construction noise levels at the ICNG assessment height of 1.5 metres above the local ground level.

4.2.2.3 Feasible and reasonable mitigation and management measures

Feasible and reasonable mitigation and management measures have been incorporated at the construction support sites as required by the Secretary's environmental assessment requirements (requirement 2(i)). Mitigation and management measures, including the indicative locations and heights of noise barriers and indicative acoustic performance requirements of site sheds and enclosures, have been identified in each construction support site assessment.

The indicative acoustic performance requirements have been identified for the site shed or enclosure construction and classified from low to very high, as presented in Table 4-1.

Table 4-1 – Indicative overall shed/enclosure element required acoustic performance

Shed/enclosure indicative acoustic performance	Indicative example constructions	Reference colour
Low	Single skin metal structure	
Medium	Double skin metal structure with air gap between skins	
High	Double skin structure with air gap, one skin metal/ one skin loaded vinyl or similar one side	
	Proprietary light-weight concrete sandwich panel	
Very High	Specialist acoustic wall	
	Double skin composite large air gap metal structure	
	Concrete panel / specialist acoustic construction	

Various building elements are further detailed in each construction support site assessment. Each shed design is indicative of what would be needed to sufficiently reduce noise impacts at nearby sensitive receivers. The acoustic performance recommended assumes that no gaps or openings would compromise the overall acoustic performance of the structure. Enclosures, sheds and any openings would be designed to achieve relevant noise requirements during detailed design.

Each construction support site would be reviewed during detailed design with all mitigation and management measures reviewed and updated as required. Revised mitigation and management measures would be included in site-specific CNVIS.

4.2.3 Surface road works modelling

4.2.3.1 Background

Project works that interface with the Warringah Freeway such as the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11) have a requirement to carry out the construction works within the live traffic corridor of the Warringah Freeway, which necessitates extensive night time road works. Work would need to take place under a Road Occupancy Licence (ROL) and outside standard construction hours to ensure:

- The safety of construction personnel working in the road alignment
- Minimised disruption to road users and traffic volumes during the work.

Due to the importance of these roads to the greater Sydney road network, and to minimise disruption to the road network, the project would seek ROLs for around five nights a week at various stages. While it is assumed that works can be progressed over five consecutive nights, works would be staged where feasible and reasonable along the road corridor to minimise impact on sensitive receivers at any one location.

A large part of night work would include noise-intensive activities such as concrete and rock hammering, concrete cutting and rock drilling. The temporary nature of works under an ROL means there are limited opportunities to install fixed noise mitigation (ie. acoustic sheds, acoustic enclosures, large temporary barriers) as the road needs to be fully operational the following day. Other feasible and reasonable noise

mitigation and management measures would be reviewed and implemented to minimise noise impacts on nearby noise-sensitive receivers.

An OOHW protocol would be developed during detailed design as part of the project CNVMP, which would provide more detailed justification, assessment and management of OOHW in accordance with the project approval (if issued).

Any out-of-hours work (OOHW) would require justification, assessment and detailed management. The OOHW protocol would be prepared as part of the detailed design for the project, in accordance with any approval conditions issued for the project, including allowable working hours and respite periods. The mitigation and management measures which would be put in place for surface road works are discussed in Section 6.4.

4.2.3.2 Construction noise sources

The type, number and typical operational intensity of plant and equipment associated with each of the assessed construction works scenarios are based on experience with similar major transport infrastructure projects and inputs from Roads and Maritime. For assessing surface road upgrade construction works, the equipment/plant listed in Appendix F represents the reasonable 'typical' and 'worst case' scenarios of equipment/plant operating simultaneously in any 15 minute period that has been assessed. Where plant items are not operating simultaneously, or for reduced times in a 15 minute period, noise impacts could be lower than predicted. Assumed sound power levels for the plant and equipment are outlined in Section 4.2.2.1.

4.2.3.3 Modelling approach and assessment scenarios

Due to the large number and size of work areas and the variability of the types of construction activities associated with the surface road works, a slightly modified modelling approach has been used to assess and present the construction noise impacts for the surface road works.

As outlined in Section 4.2.1, the ICNG and CNVG recommends the assessment of a 'reasonable worst case' construction scenario. However, the reality of construction noise impacts is that they would vary greatly depending on the location of the construction works within the major works area, the distance between the noise sources and the nearby receivers, the noise intensity of the works, the time of day these specific activities take place and the changing noise character with all these variables. To capture this, assessment scenarios were developed to review the potential 'typical' and 'worst case' impacts. Figure 4-6 aims to visually represent the differences between these two assessments, and the impacts of construction variables on noise impacts. The assessment scenarios are considered conservative, in that they assume:

- All the equipment identified within a scenario would operate simultaneously
- The equipment operates at its loudest, in its worst case orientation without consideration of directivity, for the specific usage factor period shown in Appendix F during the 15 minute period
- All plant is operating in one location, while plant may be scattered around the works area

- All plant is at the closest location to each receiver ('Near' level, see Section 4.2.3.3.3), while plant would move around the works area and noise levels would reduce as plant moves away from a receiver.

These assumptions are conservative and unlikely to typically occur all at the same time for any extended length of time during the construction works. During actual construction works, noise levels are likely to be lower. The actual noise emissions from the works and resulting noise levels at nearby receivers would be influenced by:

- The location/distance of the plant/equipment with respect to the receiver (see Figure 4-1)
- The on/off time of the plant/equipment
- The intensity with which the plant/equipment is working.

Only NCAs for surface road work assessments where an exceedance of the NMLs have been predicted at a stage during the works have been presented. NCAs where compliance is achieved during all stages of the assessed works have not presented in the assessment result tables.

To achieve the requirements of the CNVG, ICNG and the Secretary's environmental assessment requirements, the following sections outline the key concepts used to assess the potential noise impacts from the surface road works across the project.

There are also potentially a number of areas outside the major construction support sites and surface road upgrade areas where local area and utility adjustment works may be required. These works would be part of establishing construction support sites, such as utility identification works, electricity, sewerage, communications and other utility adjustments, and local road works to support increased heavy vehicle movements and project requirements, such as intersection adjustments. These works would be in isolated locations and occur for relatively short periods. The final location and extent of some of these works are still being investigated and would be determined during detailed design. As such, typical utility and local area work activities have been assessed to describe typical noise levels that would be associated with these works at the nearest sensitive receivers (see Section 5.10.1).

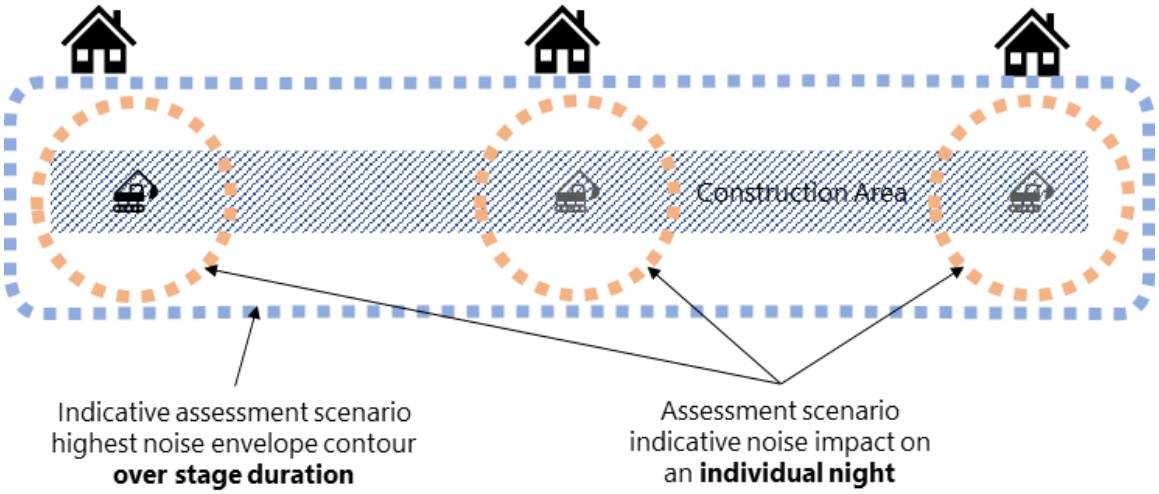
4.2.3.3.1 Highest noise level envelope

The noise impacts presented are the highest noise levels that could occur throughout a works stage. These noise levels assume that the assessed activities could occur anywhere within the assessed major works area, while in practice, the construction works would generally only occur at a single location at any one time.

This means that predicted noise levels are only likely to occur when works are at the closest point in the works area to each receiver. Due to the size and extent of many of the works areas, the noise impacts may be lower than predicted as the construction activities move around or progress along the works area extent, as indicated on Figure 4-7.

Noise results are presented in Appendix H.2 as noise contour envelopes, which are the reasonably highest noise levels that could result at the ICNG assessment height of 1.5 metres above ground level over the entire project, and do not show an individual 15 minute period during the day, evening or night.

Figure 4-7 – Indicative highest noise level envelope

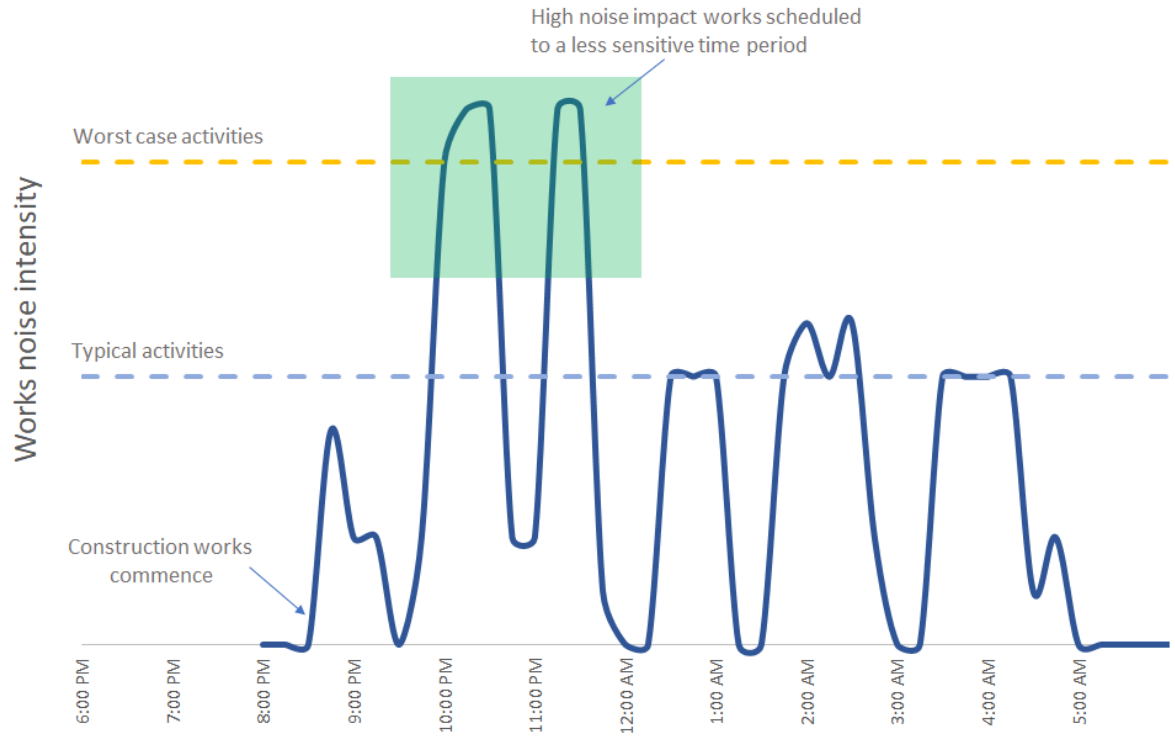


4.2.3.3.2 Typical and worst case noise impacts

For surface road works, an additional 'typical' scenario has been presented to represent the noise impacts when the loudest plant and equipment items (eg. rock hammers or road saws) are not being used, but the works are still noise-intensive. This is illustrated on Figure 4-6.

An indicative example of how noise-intensive works activities change and vary in time over an individual night is presented on Figure 4-8, showing how both 'typical' and 'worst case' impacts may only occur for a small proportion of the night period.

Figure 4-8 – Example of indicative night construction works noise-intensiveness – (eg. utility relocations)



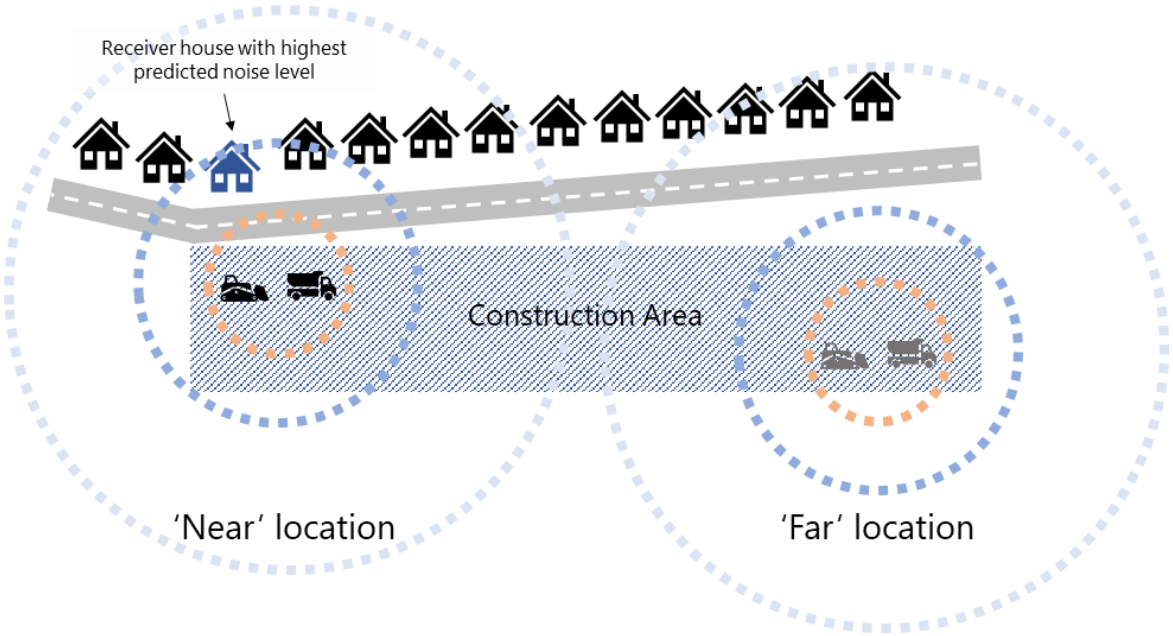
4.2.3.3.3 Near and far – variation in noise impacts due to location within works area

As discussed above, construction noise impacts vary based on the location of the noise-intensive activities. The highest predicted impacts would not occur throughout the operation of an individual site, rather they would vary as the works take place in specific locations within the site.

The highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver are shown in the assessment as the 'Near' level. When works take place at the furthest location in the assessed work area, the noise impacts on that same receiver are presented as the 'Far' noise level. This concept is presented on Figure 4-9.

'Near' and 'Far' noise impacts may occur for progressive works such as road re-surfacing activities, where the work moves along the road over the period of a night. For other work types, this may occur in various locations on various nights or periods in the construction stage. The 'Far' noise level has been estimated based on a correction applied to the predicted 'Near' noise level. This correction takes into consideration both the smallest distance to receivers from a point in each works area, and the relative size of the works area for the nearest receiver in each NCA.

Figure 4-9 – Variation in impacts with works location within a works area



4.2.3.3.4 Surface road upgrade assessment table presentation

Figure 4-10 presents an example from the assessment tables, to show how the assessment results from this modified approach are presented. It is important to note that the noise levels presented in these tables are for the receiver with the highest predicted noise level in each NCA. Predicted noise levels would be less than those presented where receivers:

- Are further away from the construction works
- Have increased acoustic shielding (ie from nearby tall buildings).

Figure 4-10 – Example predicted construction noise level table (surface road works)

Major works area/assessment reference		WFU1C_03			
Project stage duration				Typical	Worst-case
Typical/worst-case activity noise intensity				Far/Near	Far/Near
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ min)}$	
		HNA	NML		
Neutral Bay	17.4	75	65	64 / 71	**74 / 81**
	18.3	75	64	48 / 51	59 / 61
	23.1	75	71	44 / 46	54 / 56
Cremorne	26.1	75	68	< 35	49
	27.1	75	59	38 / 39	40 / 41

Noise impact during **typical noise intensive activities** (eg without high impact equipment such as rock hammers)

Noise impact during **worst-case noise intensive activities** (eg with high impact equipment such as rock hammers)

Noise level at closest / highest impacted receiver building when noise intensive works at the **closest point**.

Where the predicted noise level from activities at the other end of the works area from the receiver ("Far") is less than 35 dB(A) only "<" is presented. Where a "-" is presented then construction works are not proposed during that period.

Noise level at closest / highest impacted receiver building when noise intensive works at the **furthest point**.

4.2.4 Cumulative and consecutive major project construction noise impact assessment

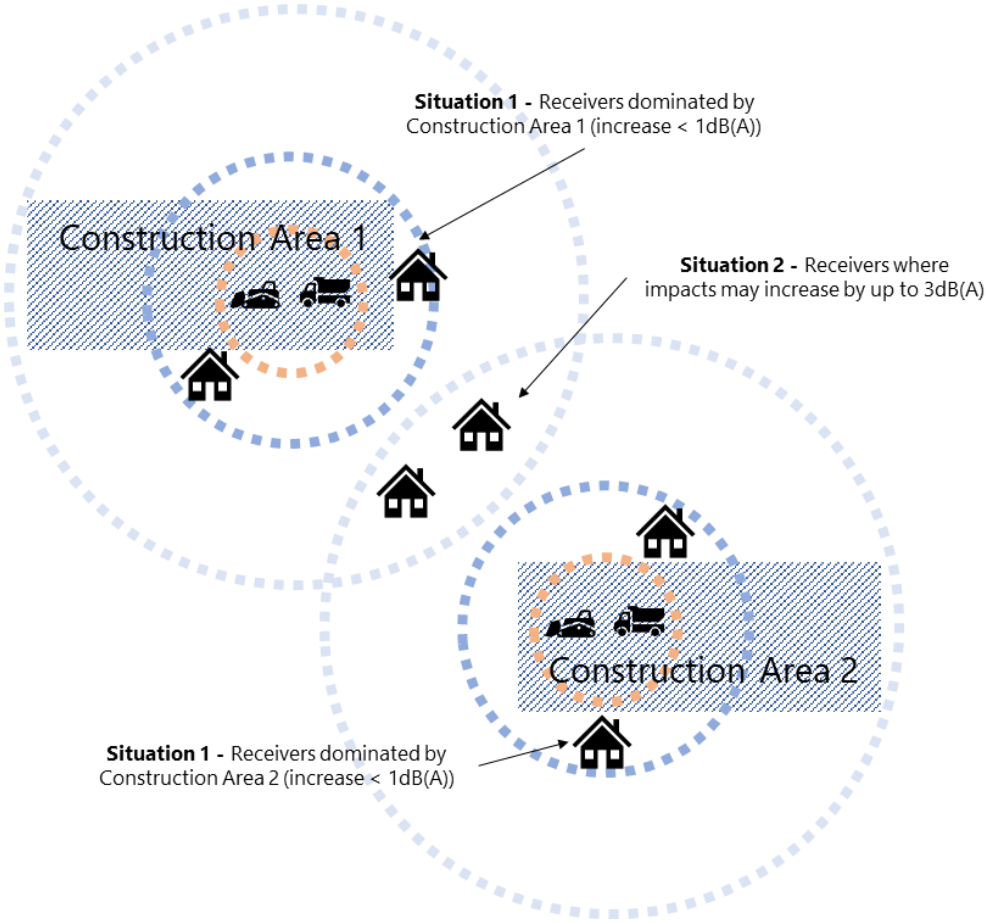
The CNVG identifies that for projects with long-term impacts, typically recommended additional mitigation measures become less effective. Subsequently, what are considered feasible and reasonable mitigation and management measures can vary based on the duration of construction noise impacts.

While impacts from one project or one construction site may be relatively short term, when viewed in the context of all other nearby major construction works (within the project and external to the project), the overall duration of construction noise impacting one receiver may be much longer. Typically, impacts from concurrent projects can impact nearby receiver locations in one of two ways, as also shown on Figure 4-11:

1. (Figure 4-11, Situation 1) – For receivers in close proximity to work areas, noise impacts would typically be dominated by the nearest construction work area. However, construction noise impacts at lower levels from the more distant work area can also impact these receivers, increasing the frequency and duration of total construction noise impacts

2. (Figure 4-11, Situation 2) – For receivers not in close proximity to the work areas, but between the two sets of noise generating work areas, the total construction noise level that they could be exposed to from cumulative construction noise may be slightly more than from a single work area, by up to 3 dB(A). They are also likely to be exposed to a greater frequency of construction noise impacts.

Figure 4-11 – Cumulative construction noise impacts



The following two assessment approaches have been used to assess the potential for cumulative or consecutive noise impacts from construction projects; one applicable for the construction support sites; and the second approach is for the surface road works. These are described in the following sections.

4.2.4.1 Construction support sites

The following have been identified and included in the assessment of cumulative and concurrent construction noise impacts at construction support sites:

1. Project program overlaps between construction support sites, surface road works and other major infrastructure projects (ie locations where nearby construction sites may be operating concurrently)
2. NCAs where there may be a greater frequency of noise impacts and slight increases in overall construction noise, typically for receivers not directly adjacent to the construction support site
3. Overlap of nearby major infrastructure projects with the construction support site being assessed, where there is potential impact on the same receivers both close to and further away from the construction support site.

This approach provides a full picture of potential construction noise impacts on these receivers to inform the development of feasible and reasonable mitigation and management.

4.2.4.2 Surface road works

As the surface road works can range over large works areas, and there are a range of construction activities that would take place in each work area, the level of concurrent or consecutive noise impact cannot be easily quantified. As such, the following methodology has been developed to identify the activities and locations where there is a greater potential for concurrent or consecutive construction noise impacts. The activities and locations would be further investigated during detailed design to determine if concurrent or consecutive construction noise impacts are likely, and if further mitigation or management is required.

To assess cumulative and consecutive construction noise impacts, NCAs where the 'typical' construction noise exceeds the NML, and where receivers within these NCAs could be considered 'noise affected', have been identified.

4.2.4.3 Cumulative assessment results

Site-specific cumulative and consecutive construction noise assessments have been carried out for each construction support site or major surface road upgrade area. Links to these site-specific assessments are included in Table 4-2.

Table 4-2 – Site-specific cumulative and consecutive construction noise assessments

Location	Assessment method	Report section
Rozelle Rail Yards (WHT1/ROZ)	Construction support site (See 4.2.4.1)	Section 5.2.3
Victoria Road (WHT2/VIC)	Construction support site (See 4.2.4.1)	Section 5.3.3
White Bay (WHT3/WHB)	Construction support site (See 4.2.4.1)	Section 5.4.3
Yurulbin Point (WHT4/YRB)	Construction support site (See 4.2.4.1)	Section 5.5.3
Sydney Harbour Crossing (SHC)	Construction support site (See 4.2.4.1)	Section 5.6.3
Berrys Bay (WHT7/BRY)	Construction support site (See 4.2.4.1)	Section 5.7.3
Cammeray Golf Course (WHT10/CGC)	Construction support site (See 4.2.4.1)	Section 5.8.3
Warringah Freeway Upgrade (WFU)[1]	Surface road upgrades (See 4.2.4.2)	Section 5.9.3

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

4.2.5 Construction work hours for specific activities

The project construction works would generally be carried out during the CNVG standard construction hours when above ground, while tunnelling activities would generally be carried out 24 hours a day, seven days per week. A summary of the various construction activities that would be carried out, and the proposed construction hours is presented in Table 4-3.

Table 4-3 – Overview of project construction works hours

Activity	Construction hours	Comment/exceptions
Tunnelling, tunnel support, excavation and haulage and underground activities		
Tunnelling, underground excavation and tunnel support	Up to 24 hours a day, seven days a week	Activities that support tunnelling works may need to occur 24 hours a day, up to seven days a week, including deliveries. Spoil handing outside standard construction hours would be carried out within an acoustic shed. Surface activities outside of an acoustic shed would typically be limited to standard construction hours unless they achieve the NMLs. Oversized deliveries would typically be carried out at night.
Underground construction and tunnel fitout	Up to 24 hours a day, seven days a week	Activities that support underground construction and tunnel fitout would occur 24 hours a day, up to seven days a week Deliveries for underground construction and tunnel fitout would occur 24 hours a day, up to seven days a week.
Dredging and excavation of the bed of the harbour, and barge movements for associated marine spoil transportation	Up to 24 hours a day, seven days a week	Backhoe dredging and gravel placement would occur during standard construction hours. Dredging (trailer suction hopper dredging) would be carried out on a 24 hour basis for the duration of dredging works.
Barge movements for transport of immersed tube tunnel elements	24 hours a day, for set periods	Ferry barges to transport immersed tube tunnel elements from the casting facility in White Bay to a temporary mooring location in Snails Bay.
Immersed tube tunnel construction	Standard construction hours	Large concrete pours may require occasional extended hours
Immersed tube tunnel installation	24 hours a day, for set periods	Carried out during closures of Sydney Harbour. About seven closures, each for a period of 48 hours.
Construction traffic for material supply and spoil removal		
Construction traffic for material supply and spoil removal	Standard construction hours, (occasional night works) OOH concrete deliveries	Spoil haulage and concrete deliveries would be carried out during standard construction hours. Some haulage/deliveries to and from the construction support sites would be required during the night time (up to 24 hours per day, seven days per week) to support construction activities, subject to the development and implementation of specific management measures, at: • Rozelle Rail Yards (WHT 1 / ROZ) • Victoria Road (WHT 2 / VIC) • Yurulbin Point (WHT 4 / YRB) • Berrys Bay (WHT 7 / BRY) • Cammeray Golf Course (WHT 8 / CGC)
Barge movements for terrestrial spoil transportation and disposal	Up to 24 hours a day, seven days a week	Loading of hopper barges within acoustic shed for the purpose of spoil transportation may be carried out at night.

Activity	Construction hours	Comment/exceptions
Surface road works activities (not specified elsewhere)		
Warringah Freeway Upgrade	Up to 24 hours a day, seven days a week	Works are required to be carried out up to five consecutive days per week along the length of the works
Demolition and surface construction activities	Standard construction hours	Aboveground work supporting underground construction activities (eg. concrete pumping, truck loading) expected to be required 24 hours a day, up to seven days a week where noise mitigation is in place. Non-disruptive preparatory work, repairs or maintenance may be carried out outside standard construction hours. Activities requiring the temporary closures of roads or to accommodate road network requirements may need to be carried out outside of standard construction hours.
Blasting and rock hammering		
Blasting	Standard construction blasting hours	Blasts would be limited to one single detonation in any one day per receiver group, unless otherwise agreed by the NSW EPA.
Rock hammering (with potential for impulsive or tonal noise impact at a sensitive receiver)	Standard construction hours	Respite periods would be provided and programmed to minimise the frequency and duration of extended rock hammering activities with the potential for impulsive or tonal noise emissions. Rock hammering and other high impact noise activities could also occur outside these standard daytime construction hours if authorised by an environmental protection licence.
Other activities		
Minor activities	At any time	Includes activities that do not lead to an exceedance of the applicable NML 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.
Out of hours works for safety and operational reasons	At any time, subject to individual requirements	Specific management measures would be developed for each relevant activity or group of activities to manage potential impacts on sensitive receivers. This would include use of respite periods where appropriate. Examples would be works operating under a road occupancy licence.
Emergency or directed activities	At any time	Activities carried out if required to prevent an imminent loss of life or environmental damage.

4.2.6 Construction-related road traffic noise prediction methodology

This assessment methodology covers construction related traffic operating on the public road network. The assessment of noise impacts from traffic movements within the construction support site boundary are included in the overall assessment of construction support site noise emissions as per Section 4.2.2 for construction support sites, Section 4.2.3 for major surface road upgrade works, and Section 4.2.4 for cumulative construction noise impacts.

Where feasible and reasonable, haulage routes would use arterial and sub-arterial roads.

Assessed heavy vehicle movements are based on the maximum projected number of movements during construction of the project, when construction works are well underway. During other stages of the project, there would be a reduced number of vehicles, and a corresponding reduction in noise levels.

Two methodologies for the assessment of construction road traffic noise have been used, depending on whether construction road traffic is travelling on motorways, arterial and sub-arterial roads or local roads. Where applicable, the issue of construction vehicles exiting/entering construction support sites from/to public roads is also addressed below.

4.2.6.1 Construction heavy vehicle assumptions

A large range of heavy vehicles would be used as part of the construction works. For assessment modelling purposes, these have been separated into two categories (Table 4-4):

- Smaller heavy vehicles such as medium rigid trucks, which would typically be used for activities such as site deliveries
- Larger heavy vehicles such as heavy rigid trucks with dog trailer combinations (mainly used for spoil haulage), prime movers with trailer (such as for concrete, aggregate and sand delivery or oversized deliveries), and concrete agitators.

Table 4-4 – Heavy vehicle noise modelling assumptions for movements within construction support sites, entering/exiting the site from public roads (< 50 km/h) or moving slowly on local roads

Heavy vehicle type	Example vehicles	Sound power levels, dB(A)	
		SWL[1]	L_{Amax}[2]
Small heavy vehicle	Medium rigid trucks, medium flatbed delivery trucks	103	120
Larger heavy vehicle	Heavy rigid trucks with dog trailer combinations, prime movers with trailer, concrete agitators	108	120

Notes:
1. The noise source power level has been based on pass-by noise measurements in the field of similar heavy vehicles. The modelled levels are assumed to be average heavy vehicles operating at slow speeds (<20km/h) so as to include engine noise with various loads. Sound power levels of the heavy vehicles used for the project may differ and would be reviewed at detailed design.
2. For maximum noise events from heavy vehicle movements both 117 dB(A) and 120 dB(A) are assessed to consider both the impacts from heavy vehicle air-brakes, or metal-on-metal bangs from heavy vehicle loads moving or shifting.

Typically, when within the boundary of a construction support site, heavy vehicles would not move faster than 10 kilometres per hour, so noise from the heavy vehicle would be dominated by engine noise. When heavy vehicles move off site, they would then accelerate away from the site at greater speeds. Noise source levels for heavy vehicles onsite, entering/exiting the site from public roads (less than 50 kilometres per hour) or moving slowly on local roads have been based on noise measurements in the field for similar heavy vehicles travelling at low speeds when accelerating/decelerating with and without loads.

4.2.6.2 Construction traffic vehicles on freeways, motorways, arterial and sub-arterial roads

A large number of heavy vehicles already use the motorways, arterial and sub-arterial roads that would be used as construction traffic routes with substantial levels of existing traffic. The traffic using these roads is relatively constant during critical periods (ie. night time). Noise levels for these roads have been calculated using the *Calculation of Road Traffic Noise (1988)* (CoRTN88) method to determine if the overall change in road traffic noise level caused by the project's construction vehicles could potentially be more than the 2 dB(A) initial screening test as per the CNVG.

4.2.6.3 Construction traffic on local roads

Existing road traffic noise levels from local roads is typically low. This assessment has assumed the project construction traffic noise from heavy vehicles would likely dominate the overall road traffic noise on these local roads. As such, the noise level from the project's heavy vehicles has been predicted and assessed directly against the RNP road traffic noise criteria.

Local roads are unlikely to have a substantial number of existing heavy vehicle movements and are likely to have intermittent traffic flows. A calculation method more suited to intermittent traffic acting like a moving point source at lower speeds (less than 50 kilometres per hour) has been used, with noise levels calculated based on the method presented in British Standard BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites*, section F.2.5 for moving vehicles using a regular well-defined route. Local road traffic noise level predictions assumed the following:

- Heavy vehicles would travel along local roads (eg. Balls Head Road, Waverton) at lower than the posted speed for safety or vehicle limitation reasons, which is conservative for the duration of traffic noise impacts
- The SWL of the vehicle assessed was that of the reasonable worst case construction vehicle proposed to use the route, with consideration of the above point
- Road traffic noise levels were predicted at the facade of the nearest residential receiver building to the road. Receiver buildings at further distances are expected to experience lower noise levels than those predicted
- The British Standard does not include corrections for road grade; so, the worst case gradient of the road was calculated, and a correction added to consider the sustained engine load at grade based on Table H-1 of Appendix H 'Grades' of the FHWA Traffic Noise Prediction Model Handbook (Ref: NCHRP Report 117 Method). This includes noise level adjustments for heavy vehicles on grades ranging from no correction up to a 5 dB(A) adjustment for gradients over seven per cent.

For both assessment approaches, where local road traffic noise levels are predicted to increase by more than 2 dB(A) and exceed the RNP road traffic noise criteria for the corresponding road classification, consideration would be given to applying feasible and reasonable noise mitigation and management measures to reduce potential noise impacts and preserve acoustic amenity at receivers near the road.

4.2.6.4 Construction vehicles exiting/entering construction support sites from/to public roads

Construction heavy vehicles either entering or exiting the construction support sites have the potential to add to the overall road traffic noise levels. A screening test has been carried out for the Cammeray Golf Course construction support site for the Ernest Street intersection to determine if additional heavy vehicles would exceed RNP requirements, should they be required to use this intersection during early stages in the project. It was determined that there would be less than a 2 dB(A) increase in road traffic noise, satisfying RNP requirements.

As the specific construction methodology is not yet known, construction road traffic noise impacts associated with construction support site enter/exit areas would be further refined during the detailed design phase.

4.2.6.5 Construction road traffic noise assessment results

Site-specific road traffic noise assessments have been carried out for each construction support site or major surface road upgrade area. Links to these site-specific assessments are included in Table 4-5.

Table 4-5 – Site-specific construction road traffic noise assessments

Location	Report section
Rozelle Rail Yards (WHT1/ROZ)	Section 5.2.3
Victoria Road (WHT2/VIC)	Section 5.3.3
White Bay (WHT3/WHB)	Section 5.4.3
Yurulbin Point (WHT4/YRB)	Section 5.5.3
Sydney Harbour Crossing (SHC)	Section 5.6.3
Berrys Bay (WHT7/BRY)	Section 5.7.3
Cammeray Golf Course (WHT10/CGC)	Section 5.8.3
Warringah Freeway Upgrade (WFU)[1]	Section 5.9.3

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

4.2.7 Construction-related water traffic noise

As there are no guidelines for the assessment of noise from vessel movements in NSW, measures to manage noise from barges would be included in the CNVMP developed during detailed design. Barges would be operated and maintained to comply with the Protection of the Environment Operations (Noise Control) Regulation 2017, particularly Clauses 37 and 38 of the regulation which require vessels to have properly maintained noise controls.

Operating from the White Bay construction support site, barge and boat movements would support the Yurulbin construction support site, the Berrys Bay construction support site, and the Sydney Harbour Crossing including the Sydney Harbour north and Sydney Harbour south cofferdams.

Up to 48 barge movements and 22 small boat movements are expected during the day either to or from White Bay, as well as five barge movements to dispose of dredged material. These would be made up of the indicative vessel movements presented in Table 4-6.

Table 4-6 – Indicative water based traffic movements operating

Site	Indicative vessel movements per day	Required movements outside of standard construction hours
To and from White Bay		
Yurulbin Point (WHT4)	• Eight boat movements for transporting the construction workforce • Four barge movements for spoil removal • Twelve barge movements for deliveries.	Deliveries of concrete for tunnel lining or justified activities to support tunnelling would be required during the tunnel construction stages (maximum four barge movements)
Sydney Harbour Crossing	• Eight boat movements for transporting the construction workforce • Sixteen barge movements for deliveries	No typical OOH movements
Berrys Bay (WHT7)	• Six boat movements for transporting the construction workforce • Six barge movements for spoil removal • Six barge movements for deliveries	No typical OOH movements
Spoil haulage for disposal		
Sydney Harbour Crossing	• Two barge movements for cofferdam spoil and four barge movements for dredge spoil would be required per day	Dredging (trailer suction hopper dredging) would be carried out on a 24 hour basis for the duration of dredging works.

Concrete delivery by barge may require up to eight additional barges during standard construction hours during the formation of concrete interface structures for the cofferdams. This is the peak number of barges that could occur and would last for around one week per cofferdam structure. As such, these movements would last for a total period of around two weeks.

Outside of standard construction hours, barge movements to and from project sites are expected to occur infrequently, generally up to two barges (four barge movements) during the night. A small number of movements would be required outside of standard construction hours for concrete deliveries to Yurulbin Point construction support site, and during dredging.

It is expected that noise from project barge movements would not cause substantial amenity or sleep disturbance impacts.

4.3 Ground-borne construction noise

4.3.1 Ground-borne noise from tunnelling

4.3.1.1 Tunnelling methodology

The stages/operations proposed to be carried out for the construction of the mainline tunnels and ramps, cross passages, access decline tunnels and ventilations tunnels are summarised below.

Noise generated from tunnelling activities associated with the project would vary depending on the excavation method used. Table 4-7 provides a summary of likely tunnelling methods, followed by a description of what is typically involved with these tunnelling activities.

Table 4-7 – Tunnelling methodologies

Construction scenarios	Assumed plant and equipment
Mainline tunnels: Heading	Roadheader/s per tunnel Rock drilling
Mainline tunnels: Benching	Roadheader/s per tunnel and/or Excavator with rock hammer attachment and/or Drill and blast (the adopted method would be confirmed before construction) (section 5.12)
Cross passages	Roadheader per cross passage and/or Excavator with rock hammer attachment and/or Drill and blast (the adopted method would be confirmed before construction) (section 5.12)
Access decline tunnels Ventilation tunnels	Roadheader

4.3.1.1.1 Roadheader tunnelling

Roadheaders would be launched from the tunnel support sites across the project to excavate the main road tunnels, ramps, cross passages, access declines, substations and ventilation tunnels.

Between two and four roadheaders would be typically used to excavate the tunnel headings (top section of the tunnel up to the tunnel crown) for the two mainline tunnels and where feasible and reasonable, the rock along the lower section of the tunnel to the tunnel floor (called the bench). Roadheaders would also be used to excavate headings for ramp tunnels (and where feasible and reasonable, the ramp tunnel bench), cross passages and ventilation tunnels. Individual roadheaders would be separated by some distance during tunnel excavation depending on ground conditions, tunnel support and contractor excavation methodology.

4.3.1.1.2 Rock drilling tunnel support – mainline tunnels and ramps

Ground support in the form of a canopy tube structure is required to be installed ahead of the excavation for the mainline tunnels and ramps for some sections of the alignment. A pilot bit and eccentric reamer would be employed to drill a hole large enough to accommodate a casing tube, which is driven in during the drilling process. When the end of the hole is reached, the direction of the rotation is reversed and the drill string can be retracted, leaving the casing tube behind.

4.3.1.1.3 Rock hammer tunnelling

One to two excavators with rock hammer attachments would be used to excavate the bench, cross passages and drainage areas. The rock hammers follow around 100 metres behind the tunnelling roadheaders to remove the bench on the tunnel floor. Only an individual excavator with rock hammer attachments would be undertaking excavation in any one area of the tunnel depending on ground conditions, tunnel support and contractor excavation methodology.

The bench is typically excavated out five metres below the tunnel crown level with an average advance rate of 20 to 30 metres per week. This can vary based on the rock type and the size of the tunnel.

4.3.1.1.4 Cross passage excavation

Cross passages between the two road tunnels would be required every 120 metres along the tunnel alignment and on ramps and off ramps. These can be excavated by either rock hammers or roadheaders.

4.3.1.2 Analysis methodology

Ground-borne noise impacts have been predicted based on calculation of the three-dimensional minimum slant distance from the tunnel alignment to the base of each receiver structure.

The empirical algorithms used in roadheader, rock hammer and rock drill ground-borne noise and vibration modelling were developed and established to suit Sydney's geology. The algorithms have been developed from measurement data obtained from various recent Sydney-based tunnelling projects and have subsequently been validated on the projects.

The predictions and subsequent assessment are based on typical geology for the area, comprising Sydney sandstone with a varying depth of shale above. However due to localised geological anomalies, foundation-to-footing interaction and the large range and variety of structures that exist (eg. construction type, dimensions, materials, quality of construction, footing conditions etc.), actual ground-borne noise and vibration levels may vary from what has been predicted. Verification measurements would be carried out at first opportunity following tunnelling commencement to check and verify the predictions.

Roadheader progress is estimated to be 20 to 30 metres a week depending on the type and size of the tunnel section. As such, the predicted noise levels are the peak noise levels that a receiver would be exposed to, and the noise is expected to drop away as the tunnelling moves further away from the receiver.

For rock hammer tunnelling works, the potential increased annoyance due to the percussive character associated with rock hammer excavation activities was accounted for by applying a +5 dB(A) correction to the predicted ground-borne noise levels. This approach is in accordance with the ICNG, and although any audible rock hammer ground-borne noise inside buildings is likely to be predominantly of low frequency character, rather than the more intrusive medium-to-high frequency airborne noise emitted from rock hammers, this approach is consistent with providing a conservative assessment.

As tunnelling progresses, the tunnelling equipment approaches or moves away from individual receiver locations. The predicted noise levels are the peak noise levels and the noise is expected to drop away as the tunnelling moves further away from the receiver, as shown on Figure 4-12 and Figure 4-13.

Figure 4-12 – Indicative ground-borne noise impacts as tunnelling progresses

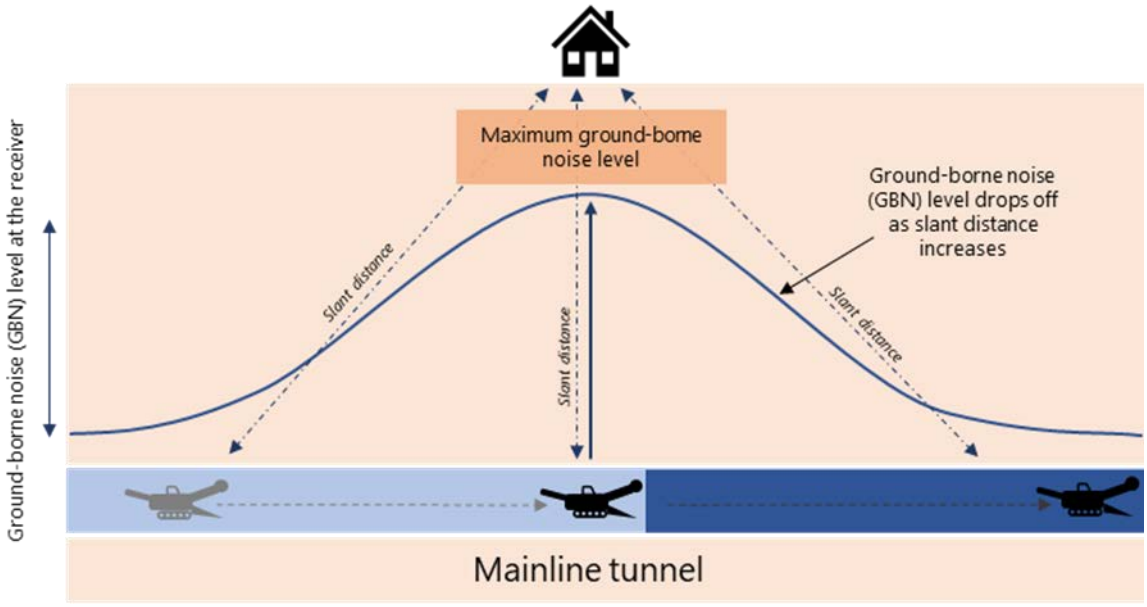
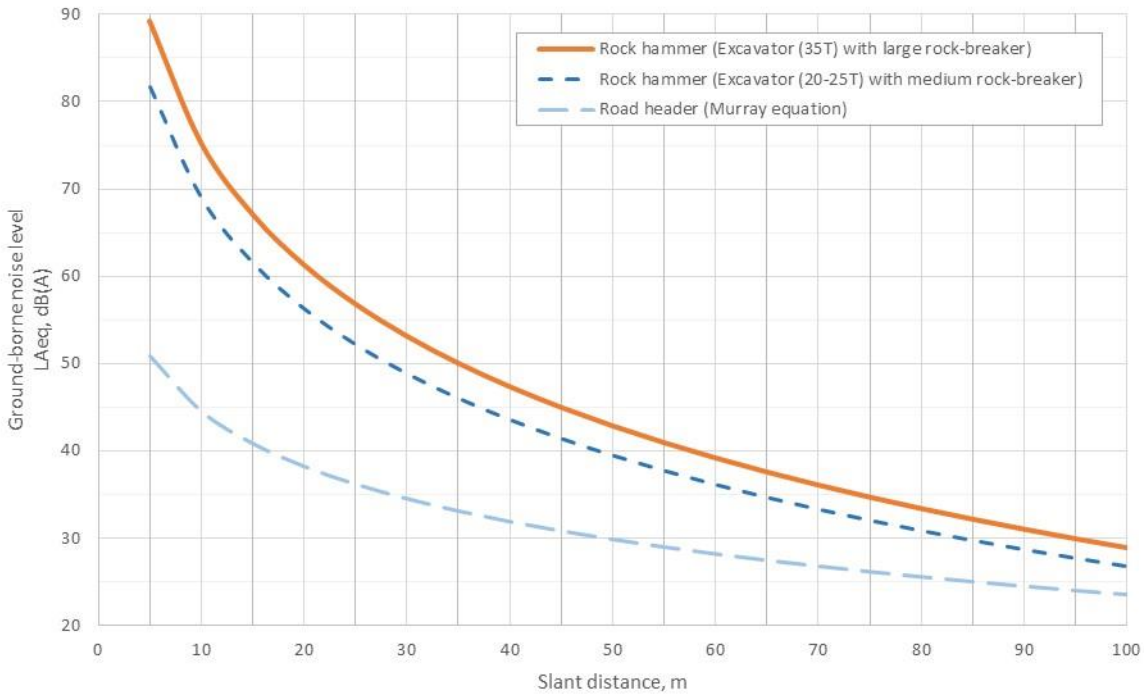


Figure 4-13 – Indicative ground-borne noise levels from tunnelling



Notes:
1. Rock hammer: Algorithms used in ground-borne noise modelling have been developed from measurement data obtained from various Sydney projects
2. Roadheader: SOURCE: Australian Acoustical Society technical meeting - Tunnelling noise and vibration management, Wilkinson Murray, December 2003

4.3.1.3 Modelling inputs and assumptions

Noise generated from tunnelling activities associated with the project would vary depending on the excavation method used. The predicted ground-borne noise and vibration levels are based on the noise modelling inputs and assumptions outlined in Table 4-8.

Table 4-8 – Construction ground-borne noise sources - tunnelling

Project component	Assessed plant and equipment
Mainline tunnels and ramps (including cross passages and substations)	Roadheader tunnelling
	Excavator with rock hammer attachment[1,2] (benching along tunnel floor)
Access decline tunnels Ventilation tunnels	Roadheader tunnelling

Note: 1. A 5 dB(A) penalty has been applied to predicted noise levels from 'particularly annoying' activities, namely rock hammering, in accordance with the ICNG

2. Assumed for the construction of access shaft at Yurulbin construction support site and Cammeray Golf Course construction support site

4.3.2 Ground-borne noise from surface construction activities

Ground-borne noise has the potential to be generated by vibration-intensive surface activities within a construction support site, which would usually be activities that involve equipment listed in Table 4-11. However, as noted in the ICNG, the ground-borne NMLs for residential receivers:

> *"…indicate when management actions should be implemented. These levels recognise the temporary nature of construction and are only applicable when ground-borne noise levels are higher than airborne noise levels."*

Once all reasonable and feasible mitigation and management measures have been applied, and the airborne noise levels at impacted receivers still exceed the NML, then the additional mitigation measures outlined in the CNVG would be applied (refer to Section 6.10.1). These include measures such as notifications, briefings, respite offers or provision of periods, or alternative accommodation depending on the degree of exceedance of the NML.

During standard construction hours, the CNVG ground-borne noise level objectives are the same as the human comfort vibration objectives. The potential for the human comfort vibration objectives to be exceeded is assessed in detail for each construction work site in the relevant assessment section, as described in Section 4.4.2.

Outside of standard construction hours:

- For the construction support sites across the project, no vibration-intensive works are proposed outside of standard construction hours except for associated intersection works, and local area and utility works

- For the surface road works, intersection, local area and utility works associated with construction support sites, vibration-intensive activities could take place outside standard construction hours. However, as limited fixed mitigation measures could be used for those works (see Section 4.2.3.1), it is likely that airborne noise levels would be higher than any ground-borne noise levels at all nearby sensitive receivers.

A screening test is presented in Table 4-9 for a typical vibration-intensive activity during surface road works. For surface road works, a five to 10 tonne excavator with small rock hammer attachment would typically be used. The ground-borne noise prediction equations are based on a 20 to 25 tonne excavator with a medium rock hammer for a conservative assessment.

Table 4-9 – Airborne noise impacts compared with ground-borne noise (GBN) impacts, for a typical surface road upgrade activity involving a rock hammer

Activity/ equipment	Assessment period	CNVG internal ground-borne NML, dB(A)	Distance, metres	Predicted GBN level, dB(A)[3,5]	Predicted airborne noise levels			Level by which internal airborne noise exceeds GBN, dB(A)
					$L_{Aeq\ 15\ minute}$ SWL, dB(A)	External airborne noise level, dB(A)	Internal airborne noise level[4]	
Excavator with medium rock hammer	Evening[1]	40	75	37	118	77	67 - 52	30 - 15
	Night[2]	35	100	32		75	65 - 50	33 - 18

Notes:
1. Evening is 6.00pm to 10.00pm Monday to Friday and 6.00pm to 10.00pm Saturday/Sunday/ Public holiday
2. Night is 10.00pm to 7.00am Monday to Friday and 10.00pm to 8.00am Saturday/ Sunday/ Public holiday
3. Includes a +5 dB(A) annoyance penalty
4. The range is based on an outside to inside noise reduction ranging from 10 dB(A) to 25 dB(A). Refer to section 3.4.1.2 for a discussion of receiver building envelope noise reductions
5. Typically, for surface road works a five to 10 tonne excavator with small rock hammer attachment would be used. The ground-borne noise (GBN) prediction equations are based on a medium rock hammer for a conservative assessment
6. Equations are based on propagation through Sydney sandstone, and assume no additional forms of attenuation or loss, as further explained in section 4.3.1.2, such as localised geological anomalies, discontinuities, basements, variations in ground type, foundation-to-footing interaction, services etc. The presence of any of these elements can result in greater attenuation, and lower ground-borne noise levels (GBN), than predicted.

Table 4-9 presents both predicted construction ground-borne noise levels and airborne noise levels from vibration-intensive construction activities at distances where ground-borne noise could potentially exceed the ground-borne noise management level. The results demonstrate that internal airborne noise levels from these activities, based on the most affected facade of the building, would likely be more than 10 dB(A) higher than the ground-borne noise level at the assessed distances. As the most affected facade of the building would be the trigger for applying additional mitigation measures for airborne noise, ground-borne noise impacts for that activity would also be managed.

Ground-borne noise impacts have not been assessed in detail for surface road works at construction support sites or surface road works areas, as airborne noise from these activities would likely dominate noise levels at nearby receivers.

Management measures to address airborne noise impacts at affected receivers are also likely to manage associated ground-borne noise impacts, as identified in Section 6.9. For example:

- Respite from construction activities that are both high noise and vibration-intensive, such as rock hammering, would provide respite from both high airborne noise levels and associated ground-borne noise
- Similarly, programming of noisy work can reduce ground-borne noise during sensitive times
- Quieter, less vibration emitting plant, and plant of the smallest necessary size or power rating would produce less airborne and ground-borne noise
- Alternative accommodation would remove building occupants from substantially ground-borne noise-affected buildings during night periods
- Effective community consultation and notification can educate receivers on what to expect so they are not alarmed if they notice ground-borne noise.

Additionally, if ground-borne noise is detected above the relevant NML, additional mitigation measures would be provided in line with the CNVG.

4.3.3 Site-specific ground-borne noise assessments

Site-specific ground-borne noise assessments have been carried out for each construction support site or major surface road upgrade area. Links to these site-specific assessments are included in Table 4-10. Specific assessments were not done where noise impacts would be controlled by airborne noise impacts, as explained above.

Table 4-10 – Site-specific ground-borne construction noise assessments

Location	Report section
Rozelle Rail Yards (WHT1/ROZ)	Airborne noise controlled
Victoria Road (WHT2/VIC)	Section 5.3.4
White Bay (WHT3/WHB)	Section 5.4.4
Yurulbin Point (WHT4/YRB)	Section 5.5.4
Sydney Harbour Crossing (SHC)	Section 5.6.4
Berrys Bay (WHT7/BRY)	Section 5.7.4
Cammeray Golf Course (WHT10/CGC)	Section 5.8.4
Warringah Freeway Upgrade (WFU)[1]	Airborne noise controlled

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number of Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

4.4 Construction vibration prediction methodology

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity. Unlike noise, it is difficult to 'predict' vibration. There are many variables from site to site, for example soil type and conditions; sub-surface rock; building types and foundations; and actual plant on-site.

The data relied on in this assessment are taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS 5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Potential vibration experienced by receivers for this project would be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

4.4.1 Minimum working distances

As a guide, indicative minimum working distances for typical items of vibration-intensive plant and equipment are provided in Table 4-11 below from the CNVG and other sources. The minimum working distances are quoted for the purpose of minimising:

- Cosmetic damage (referenced from British Standard BS 7385 Part 2-1993 and German Standard DIN 4150-2016)
- Human response (referenced from Assessing Vibration: a technical guideline (DEC, 2006)).

The minimum working distances for 'cosmetic' damage nominated in Table 4-11 have been derived based on the adopted screening levels and criteria presented in Section 3.4.5. These are to be complied with at all times, unless further monitoring and validation is used to determine different site-specific minimum working distances which achieve the criteria presented in section 3.4.5.

Table 4-11 – Recommended minimum working distances for vibration-intensive plant and equipment

Plant item	Rating /activity description	Recommended minimum working distance (metres)		
		Cosmetic damage		Human response[3]
		Structurally sound (eg. residential & light commercial[1])	Structurally unsound[2] (eg. unsound heritage structures)	
Vibratory roller	< 50 kN (typically 1-2 tonne)	5	11	15-20
	< 100 kN (typically 2-4 tonne)	6	13	20
	< 200 kN (typically 4-6 tonne)	12	15	40
	< 300 kN (typically 7-13 tonne)	15	31	100
	> 300 kN (typically 13-18 tonne)	20	40	100
	> 300 kN (typically > 18 tonne)	25	50	100
Compactor[4]	32 tonne (non-vibratory)	15	30	40
Bulldozer[4]	D10 with ripper	2	10	20
Excavators[4]	< 30t (travelling/digging)	10	15	15
Small hydraulic hammer	300 kg - 5 to 12 tonne excavator	2	5	7
Medium hydraulic hammer	900 kg - 12 to 18 tonne	7	15	23
Large hydraulic hammer	1600 kg - 18 to 34 tonne	22	30[4]	73
Vibratory pile driver	Sheet piles	2 – 20	5 - 30	20 - 50
Impact piling[5]	Typical driven pile[9]	20	30	110

Plant item	Rating /activity description	Recommended minimum working distance (metres)		
		Cosmetic damage		
		Structurally sound (eg. residential & light commercial[1])	Structurally unsound[2] (eg. unsound heritage structures)	Human response[3]
Impact piling[5, 7]	338kJ per stroke (23 tonne hammer with 1.5 metre stroke)	70	140[8]	330[10]
Pile boring	≤ 800 mm	2	5	5
Jackhammer	Handheld	1	3	5
Roadheader [4]	Tunnelling	5	5	10
Rock drilling [4]	Tunnelling	5	5	10
Hydraulic hammer [4]	Tunnelling (35 tonne excavator benching with large rock hammer)	10	20	50
Heavy vehicle traffic	On uneven construction haul roads	5	10	20
Blasting operations [6]		Based on charge size – see Note 6		

Notes:
1. Referenced from either the CNVG or against the criteria in the British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2
2. Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration (including heritage items)
3. Referenced from either the CNVG or the criteria referenced in the EPA's Assessing Vibration: a technical guideline (December 2006)
4. Measurement from RT&A database
5. Vibration levels from piling can be strongly dependent on site ground condition, and are influenced by variables such as pile diameter, hammer weight, stroke length, and rock types. Vibration levels for proposed piling operations must be verified at the proposed site prior to undertaking the required piling works to determine the suitable required minimum working distances. Approximate working distances based on US Department of Transportation Federal Transit Administration Noise and vibration manual vibration levels, and minimum working distances calculated using BS 5228-2:2009.
6. To be determined during test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions and confirmed, refer to section 6.11
7. Assuming ground is very stiff and cohesive, dense granular soil, or fill containing objects which are large relative to the pile cross-section. Based on 338kJ per stroke (23 tonne hammer with 1.5 metres stroke)
8. Minimum working distance is based on the DIN 4150 requirement for short-term vibration impacts of 3 mm/s PPV
9. Referenced to a 'typical' pile driver (impact) taken from US Department of Transportation Federal Transit Administration Noise and vibration manual.
10. Based on a pile driving duration of 1.5 hours per day.

4.4.2 Screening assessment

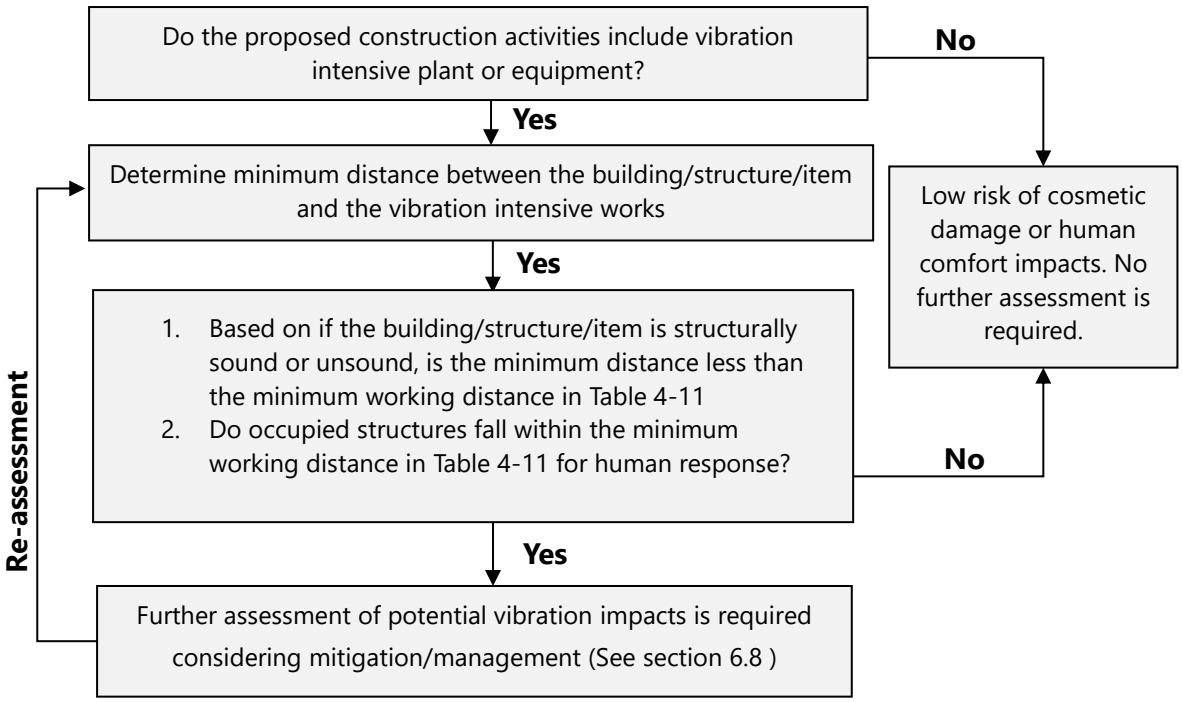
A screening assessment has been carried out across the construction work areas for the most vibration intensive works that could occur as part of the project. This assessment has assumed that the most vibration intensive works could occur anywhere across the construction areas. The purpose of this assessment is to act as a screening test to determine if further investigation is required during detailed design to review vibration impacts because of:

1. The types of vibration intensive works that could occur
2. The proximity of vibration sensitive item/building/structures.

If items or structures are within the screening test buffer distances, then the mitigation and management measures outlined in Section 6.8 would be reviewed and adopted where required. The process of this screening assessment is presented on Figure 4-14.

All AHIMS sites identified within the unsound structure minimum working distance were unable to be assessed during archaeological assessment of the study area due to property access constraints. As such the location and presence of items used in the screening assessments is assumed. Specific locations and the presence of sensitive items would be confirmed during detailed design and potential impacts would be managed in accordance with mitigation measures presented in Technical working paper: Cultural heritage assessment report.

Figure 4-14 – Vibration screening assessment procedure considering minimum working distances



4.4.3 Site-specific vibration assessments

Site-specific vibration assessments have been carried out for each construction support site, major surface road upgrade areas and the mainline tunnels and ramps, to determine how many vibration-sensitive receivers may be within the potential worst case minimum working distances, using the minimum working distances in Table 4-11. Links to the site-specific assessments are included in Table 4-12.

Table 4-12 – Site-specific vibration assessments

Location	Report section
Rozelle Rail Yards (WHT1/ROZ)	Section 5.2.5
Victoria Road (WHT2/VIC)	Section 5.3.5
White Bay (WHT3/WHB)	Section 5.4.5
Yurulbin Point (WHT4/YRB)	Section 5.5.5
Sydney Harbour Crossing (SHC)	Section 5.6.5
Berrys Bay (WHT7/BRY)	Section 5.7.5
Cammeray Golf Course (WHT10/CGC)	Section 5.8.5
Warringah Freeway Upgrade (WFU)[1]	Section 5.9.5
Mainline tunnels and ramps	Section 5.11.2

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number of Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

4.5 Construction blasting noise and vibration

Refer to Section 3.4.6 and 5.12 in regard to construction blasting noise and vibration that would occur across the project.

Blasting for tunnelling would be investigated during detailed design to determine if this is achievable during stages of the project within the noise and vibration requirements.

4.6 Operational traffic noise prediction methodology

4.6.1 Noise modelling scenarios

To conduct the noise assessment, a number of specific traffic scenarios were required to be modelled and compared. The assessment considers both the 'build' (with the project) and 'no build' (without the project) scenarios for the year of opening (assumed to be 2027) and 10 years after opening (2037). Table 4-13 summarises the scenarios that were modelled.

Table 4-13 – Noise modelling scenarios

Modelled Scenario	Description
2027 Opening year	
Do nothing (2027)	'No Build' opening year of the Western Harbour Tunnel and Warringah Freeway Upgrade project, **WITHOUT** the project, Beaches Link and Gore Hill Freeway Connection, WestConnex, Sydney Gateway and the F6 Extension. Only applicable for the area surrounding the surface connection to City West Link at Rozelle
Do minimum (2027)	'No Build' opening year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the full WestConnex (Stages 1, 2 and 3), **WITHOUT** the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension
Do something (2027)	'Build' opening year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the project and full WestConnex (Stages 1, 2 and 3), **WITHOUT** the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension
Do something - cumulative (2027)	'Build' opening year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the project, Beaches Link and Gore Hill Freeway Connection, full WestConnex (Stages 1, 2 and 3), Sydney Gateway and the F6 Extension (Stage 1)

Modelled Scenario	Description
2037 Design year (10 years after opening)	
Do nothing (2037)	'No Build' design year of the Western Harbour Tunnel and Warringah Freeway Upgrade project, **WITHOUT** the project, Beaches Link and Gore Hill Freeway Connection, WestConnex, Sydney Gateway and the F6 Extension. Only applicable for the area surrounding the surface connection to City West Link at Rozelle
Do minimum (2037)	'No Build' design year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the full WestConnex (Stages 1, 2 and 3), **WITHOUT** the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension
Do something (2037)	'Build' design year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the project and full WestConnex (Stages 1, 2 and 3), **WITHOUT** the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension
Do something - cumulative (2037)	'Build' design year of the Western Harbour Tunnel and Warringah Freeway Upgrade project **WITH** the project, Beaches Link and Gore Hill Freeway Connection, full WestConnex (Stages 1, 2 and 3), Sydney Gateway and the F6 Extension (all stages)

4.6.2 Noise modelling inputs

Building heights

Building height information in the study area based on LiDAR data was used for the assessment. Details of single and multi-storey buildings including building footprints were input to the noise model based on the supplied building height, supplemented by desktop and field surveys.

Road pavement

Road pavement information was sourced from the reference design. When pavement surfaces are not dense-graded asphalt or similar, corrections are included in the noise model, typically reflecting a noise increase for concrete pavements, and a noise decrease for quiet pavements. The road pavement surfaces for the project would consist of various types of wearing courses and appropriate noise corrections were used in the prediction of future traffic noise levels.

Traffic flow and composition summary

Traffic classification surveys were carried out by Matrix Traffic and Transport Data Pty Ltd (ref. N3227 – Sydney ATC) at numerous locations along the project route concurrently with the long-term traffic noise monitoring discussed in Section 2.6. In accordance with Roads and Maritime procedures, the traffic data obtained were used for the validation process of the traffic noise model. Results of the traffic classification surveys are presented in Appendix D.

The traffic volumes used for the traffic noise predictions and assessment have been based on traffic data provided by the project team.

4.6.3 Noise modelling methodology

Noise modelling was carried out using the Road Traffic Noise Module in the SoundPLAN (version 8.0) noise modelling software. This noise modelling software is recognised and accepted by both Roads and Maritime and the NSW EPA.

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

The method predicts the $L_{10\ (1\ hour)}$ noise levels, and a correction of -3 dB(A) is applied to obtain the $L_{Aeq(1hour)}$ noise levels. The $L_{Aeq\ (1\ hour)}$ noise levels for the daytime 15-hour period from 7.00am to 10.00pm are then determined to derive the daily $L_{Aeq\ (15\ hour)}$ noise level. Similarly, the $L_{Aeq\ (1\ hour)}$ noise levels for the night time nine hour period from 10.00pm to 7.00am are then determined to derive the night time $L_{Aeq\ (9\ hour)}$ noise level.

Parameters and assumptions used in the noise model are presented in Table 4-14.

Table 4-14 – Summary of noise modelling parameters and assumptions

Parameters	Inputs
Model geometry	
Source height	Three source heights: • 0.5 metres for car exhausts/engines and car/heavy vehicle tyre noise • 1.5 metres for heavy vehicle engines • 3.6 metres for heavy vehicle exhausts.
Ground topography at receiver and road	• Topographic contours presented in one metre intervals within road corridor • Topographic contours presented in two metre intervals outside road corridor and within 600 metres from the project.
Road geometry	Reference Design models.
Noise-sensitive receiver locations, building heights, angle of view	• Detailed building height surveys provided by project team • Other details from aerial and terrestrial photography, supplemented by limited site checks and survey.
Receiver heights	• 1.5 metres above ground level to represent 1.5 metres above ground floor level • 4.5 metres above ground level to represent 1.5 metres above first floor level for double-storey premises • 1.5 metres above floor level for all receiver floors of all multi-level dwellings including high rise apartment buildings.
Existing noise barriers	Existing noise barrier heights and locations based on aerial and terrestrial photography and site checks where necessary.
Road pavement surface	Road surfaces comprise the following: • Dense Graded Asphalt (DGA) • Continuously Reinforced Concrete Pavement (CRCP) • Crumb Rubber Asphalt (CRA10) • Stone Mastic Asphalt (SMA).
Reflections from existing barriers, structures and cuttings on opposite side of road	• Determined from review of design drawings and aerial photography complemented with site checks • Detailed within CoRTN algorithms.

Parameters	Inputs
Traffic parameters	
Traffic volumes and mix	Traffic volumes for daytime 15hr and night time 9hr and corresponding light and heavy vehicle mix provided by project team.
Vehicle speeds	Detailed posted speed data provided by project team.
Non-project arterial roads	Non-project arterial roads up to 600 metres from the project have been considered
Corrections to model	
L_{10} to L_{Aeq} correction	-3 dB
Road surface correction	Where applicable, the following corrections were applied relevant to standard DGA: • 0 dB(A) for DGA • 0 dB(A) for Low Noise Diamond Ground Concrete Pavement (LNDG) • 0 dB(A) for Stone Mastic Asphalt with 10mm aggregate (SMA10) • -2 dB(A) for Crumb Rubber Asphalt (CRA10) • +3 dB(A) for Concrete Pavement (CRCP or PCP).
Tunnel portal correction:	A correction is applied to the road noise source adjacent to the tunnel portals to provide a conservative estimate of the noise contribution from the portal.
Facade correction	+2.5 dB(A), when modelling to one metre from building facades (RNP Table 7 (p17)).
Traffic mix correction	Corrections to account for the composition of heavy vehicle types along the road are determined based on a method developed by Roads and Maritime and implemented on this project (J. Peng *et al*, 2017)
SoundPLAN Noise Model Settings	
Calculation method	Ray-tracing method
Ground absorption factor	0 for water surfaces and 0.5 for other areas
Maximal search radius	3000 metres for contours and 1000 metres for individual predictions
For noise contour maps	• Grid space = 50 metres • Height above ground =1.5 metres and 4.5 metres • Grid Interpolation = Not used

4.6.4 Noise model validation

The noise model validation process provides confidence that the noise model prepared for the existing situation represents the real world as accurately as possible within the limitations of the traffic noise prediction algorithms used in the computer noise modelling software. The validated noise model would be used to predict and assess the future traffic noise levels from the project and provide confidence in recommending applicable noise mitigation measures.

The noise model was validated using the long-term traffic noise monitoring results presented in Table 2-3 and the concurrent traffic classification counts. Table 4-15 and Table 4-16 summarise the results of the traffic noise model validation for the areas surrounding the surface connection to City West Link at Rozelle and the Warringah Freeway and surrounds, respectively, providing a comparison between the modelled traffic noise levels for existing conditions and the measured traffic noise levels during the daytime (7.00am to 10.00pm) and night time (10.00pm to 7.00am).

Table 4-15 – Noise model verification results for the area surrounding the surface connection to City West Link at Rozelle

Location	$L_{Aeq\ (15\ hour)}$ Daytime Noise Level			$L_{Aeq\ (9\ hour)}$ Night Time Noise Level		
	Measured	Modelled	Variation	Measured	Modelled	Variation
L1 – 22 The Crescent, Annandale	65.7	65.7	0.0	60.2	61.1	0.9
L2 – 2/277 Johnston Street, Annandale	65.1	65.0	-0.1	59.6	59.7	0.1
L3 – 16 Railway Parade, Annandale	57.9	55.5	-2.4[1]	53.1	52.4	-0.7
		Mean	**-0.8**			**0.1**

Notes: 1. Under-prediction due to measured noise levels influenced by operational noise from light rail during the daytime period
2. Free-field monitoring locations do not include +2.5 dB(A)) correction for facade reflections.

Table 4-16 – Noise model verification results for Warringah Freeway and surrounds

Location	$L_{Aeq\ (15\ hour)}$ Daytime Noise Level			$L_{Aeq\ (9\ hour)}$ Night Time Noise Level		
	Measured	Modelled	Variation	Measured	Modelled	Variation
L17 – 6 McDougall Street, Kirribilli	59.9	61.3	1.4	55.8	57.1	1.3
L18 – 1/191-195 Walker Street, North Sydney	76.1	76.6	0.5	71.3	72.5	1.2
L19 – 91 Ridge Street, North Sydney	57.3	57.8	0.5	52.0	53.6	1.6
L21 – 306 Miller Street, North Sydney	64.1	65.1	1.0	57.9	57.1	-0.8
L22 – 1/1 Bardsley Gardens, Crows Nest	67.9	68.6	0.7	62.9	62.6	-0.3
L23 – 288 Falcon Street, Neutral Bay	71.4	73.0	1.6	68.0	68.9	0.9
L24 – 5 Military Road, Neutral Bay	71.2	72.3	1.1	67.5	67.3	-0.2
L25 – 317 Ernest Street, Cammeray	68.5	69.4	0.9	62.6	62.1	-0.5
L26 – 225 Ernest Street, Cammeray	67.3	68.6	1.3	61.3	61.3	0.0
L27 – 77 Rosalind Street, Cammeray	61.6	62.8	1.2	56.7	57.3	0.6
L28 – 53 Bellevue Street, Cammeray	67.2	68.3	1.1	63.6	62.9	-0.7
L31 – 18/22-24 Donnelly Road, Crows Nest	62.0	63.6	1.6	57.7	58.4	0.7
L32 – 79 Brook Street, Naremburn	70.4	70.6	0.2	64.2	64.3	0.1
		Mean	**1.0**			**0.3**

Notes: 1. Free-field monitoring locations do not include +2.5 dB(A)) correction for facade reflections.

The noise model validation results presented in Table 4-15 and Table 4-16 above show that the noise model output results are generally in good agreement with noise monitoring for the daytime and night time periods, so a reasonable level of confidence can be placed on the noise model for predicting future traffic noise levels for the daytime and night time periods.

The exception is Location L3, where the daytime variation is -2.4 dB(A) indicating that the noise model predicts traffic noise levels less than actual noise levels measured at the monitoring location. A review of the monitoring data and site information suggests that noise from the operation of the light rail, which is located between the monitoring location and the road source, contributed to the measured traffic noise levels.

Overall, the mean variations between measured and modelled results for the daytime and night time periods are within the ±2 dB(A) allowance for traffic noise validation.

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

4.7 Operational road traffic noise mitigation

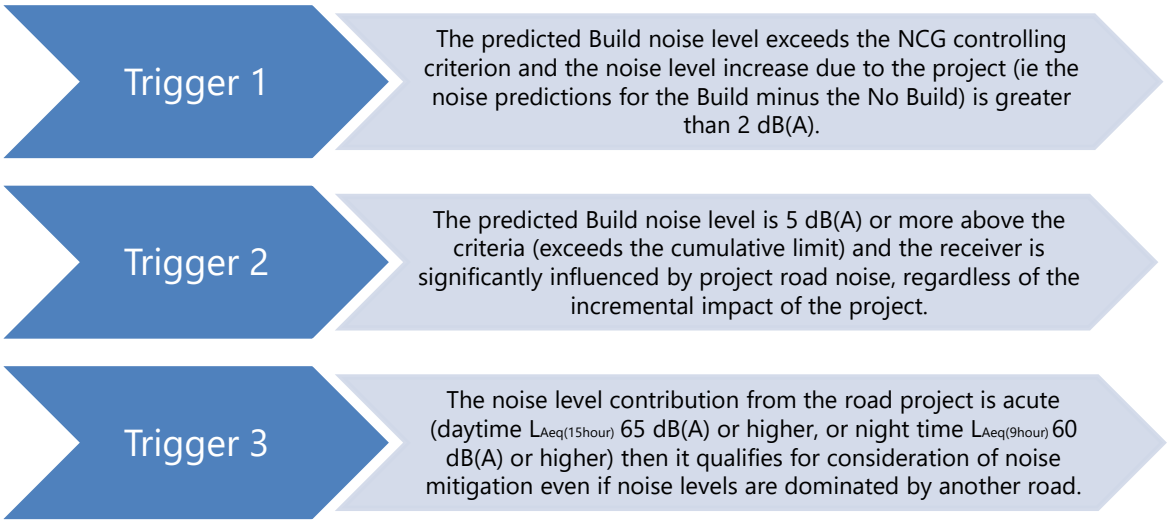
In determining the applicable road traffic noise mitigation measures for the project, the results of the assessment between the 'Do minimum' (without the project) and the 'Do something cumulative' (with the project) scenarios have been used for the affected receivers impacted by the project. Given that the 'Do something cumulative' (with project) scenario represents all the major road infrastructure projects being operational, the determination of the applicable road traffic noise mitigation measures for the project would be considered conservative, representing a worst case scenario.

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

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These triggers are shown on Figure 4-15.

Figure 4-15 – NMG noise mitigation triggers



The eligibility of receivers for consideration of additional noise mitigation is determined before the benefit of additional noise mitigation (quieter pavement and noise barriers) is included. The requirement for the proposal is to provide feasible and reasonable additional mitigation for these eligible receivers to meet the NCG controlling criterion.

The NMG provides a methodology in relation to determining and recommending acoustic treatments for road projects. In accordance with the NMG, once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages, receivers with residual exceedances of the NCG criteria are assessed to determine if these receivers qualify for consideration of additional noise mitigation.

Potential noise mitigation measures are identified for receivers that qualify for consideration of noise mitigation measures, in the order of preference as follows:

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

The priority of mitigation measures recognises the importance of providing protection to both external and internal areas of a receiver and also the degree of visual impact. For it to be considered reasonable to provide quieter pavement surfaces, noise mounds and/or noise walls, there needs to be four or more closely spaced receivers that would benefit from these mitigation measures. At-property noise mitigation may replace at-road mitigation, subject to a reasonable and feasible assessment, in the following circumstances:

- Isolated single residences or isolated groups of closely spaced residences
- Where the affected community expresses a preference for at-property treatment and the cost is less than a combination of a barrier and at-property treatment
- Where noise barriers cannot 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 facilities where play areas meet external criteria)
- Where other noise mitigation measures have been shown not to be feasible or reasonable.

A combination of at-road mitigation and at-property treatment can provide the most reasonable overall noise reduction for an affected community when consideration is given to cost, urban design, shadowing and engineering constraints with the maximum barrier. The process of deriving the most effective combination of noise barrier height and at-property treatment is described in detail in section 8 of the NMG.

4.7.1 Quieter pavements

With the general exception of motorcycles, for all vehicles in a reasonable state of maintenance, tyre/road interaction represents the main source of noise at constant speeds in excess of around 30–50 kilometres per hour for cars and 40–80 kilometres per hour for trucks (RTA, 2001). The type of road surface can have a substantial impact on traffic noise generated by pavement tyre/road interaction.

A quieter asphalt surface, such as Crumb Rubber Asphalt (CRA10) pavements could be used to aid in reducing tyre/road noise at the source and provide a reasonable noise reduction for large areas of receivers, where exceedance of the relevant traffic noise criteria is predicted.

4.7.2 Noise barriers

Following the adoption of a quieter pavement as the first method of noise mitigation, noise barriers are the next preferred form of mitigation in accordance with the NMG. The NMG states the following key points in relation to noise barriers:

"Noise barriers should be considered where there are four or more closely spaced receivers."

AND

"Barrier heights above 8 metres will not be considered"

AND

"As a guide noise walls or mounds are considered to be a reasonable noise mitigation option where they are capable of providing an insertion loss of:

- *5 dB(A) at representative receivers for heights up to 5 metres high*
- *10 dB(A) at representative receivers for heights above 5 metres and up to 8 metres high"*

Noise barrier effectiveness assessments are carried out where noise barriers are feasible options for reducing road traffic noise at affected receivers. Assessments are carried out in accordance with the process described in Section 8 of the NMG. The outcomes of the barrier assessment determines whether the barriers are reasonable to implement, and if so, the optimum barrier height.

4.7.3 Property treatments

At-property 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 with windows closed that are around 20 dB(A) less than the external noise criteria. In practice, there would be some variation in reduction due to the design of the existing building and other limitations such as building condition. A 20 dB(A) goal results in internal noise levels that are consistent with guidance in other policies and Standards. These include the State *Environmental Planning Policy (Infrastructure) 2007 (NSW)* and Australian Standard 2107. The 20 dB(A) goal also provides protection against a large increase in internal noise level in accordance with the NCG and RNP relative increase criterion.

For non-residential noise sensitive receivers such as schools, hospitals, places of worship and childcare centres, equivalent external noise goals are based on a 10 dB(A) reduction from external noise levels to internal noise levels when windows are left 20 per cent open, which has been conservatively adopted to allow external assessments. Architectural treatment for non-residential noise sensitive receivers have been based on this conservative assessment.

4.8 Operational fixed facilities

Fixed facilities associated with other major road infrastructure projects similar in design to this project typically incorporate the following types of plant and equipment:

- **Ventilation outlet** – ventilation fans located within the buildings to supply and exhaust air to and from the tunnels (including egress passages) would be the main source of noise from these facilities. The fans would generally consist of jet fans with attenuators incorporated. These facilities are anticipated to operate 24 hours per day, seven days a week
- **In-tunnel jet fans** – jet fans would typically be located throughout the tunnels. However, only jet fans located near the tunnel portals would potentially impact sensitive receivers as noise emanates out of the portal openings. Jet fans are anticipated to operate 24 hours per day, seven days a week
- **Substations** – substations would typically house transformers and mechanical plant to provide ventilation and cooling for the transformers. Substations are anticipated to operate 24 hours per day, seven days a week

- **Wastewater treatment plant and fire pump buildings** – pumps and blowers within the wastewater treatment plants and fire pump buildings would be the main source of noise from these buildings. Plant and equipment associated with the wastewater treatment plants are to be enclosed within buildings and are anticipated to operate 24 hours per day, seven days a week, while fire pump buildings would operate during emergencies and periodic maintenance.

Indicative SWL data for the typical plant and equipment associated with the fixed facilities for the project that have been used for modelling purposes are presented in Table 4-17. Type of plant and equipment to be used for the fixed facilities would be refined during detailed design.

Table 4-17 – Indicative sound power levels of fixed facility plant and equipment, dB re. 1pW

Plant item	Octave band centre frequency, Hz – dB(lin)								Overall dB(A)
	63	125	250	500	1k	2k	4k	8k	
Ventilation outlet[1]	105	88	62	50	45	54	65	68	105
Tunnel jet fan	108	100	64	87	95	91	87	87	109
Substation (4 x 3.15mVA transformers)	81	89	79	73	73	71	-	-	90
Wastewater treatment plant (blower and pump)	99	94	95	93	93	92	85	75	98

Notes: 1. Sound power level presented is at the outlet and assumes all appropriate attenuators (eg. circular silencers, rectangular silences, acoustic louvres and the like) are installed

2. Plant and equipment sound power levels are indicative and subject to final selection during detailed design

5 Construction noise and vibration assessment

This section documents the assessment of noise and vibration impacts resulting from the construction of the project.

5.1 Overview

5.1.1 Description of assessed works

Construction noise and vibration impacts from major construction support sites and the major surface road works areas (Warringah Freeway Upgrade) have each been assessed separately. Minor construction support sites supporting the Warringah Freeway Upgrade surface road works have also been assessed.

The assessment of the Warringah Freeway Upgrade also covers a number of Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

Potential noise and vibration impacts from the construction of the mainline tunnel have been assessed, including blasting. Other construction works required for the project outside of the major construction zones such as local area and utility adjustment works, and heavy vehicle marshalling areas, are reviewed.

An overview of the proposed construction support sites across the project is shown in Figure 1-3.

5.1.2 Overview of construction program

Subject to planning approval, construction of the project is planned to commence in 2020 and is expected to take around six years to complete, as presented in Table 5-1.

Table 5-1 –Western Harbour Tunnel and Warringah Freeway Upgrade project – indicative program and timeline

Construction activity	Indicative construction timeframe																			
	2020				2021				2022				2023				2024				2025				2026			
	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
Western Harbour Tunnel and Warringah Freeway Upgrade early works and site establishment																												
Construction of the Warringah Freeway Upgrade component																												
Construction of driven tunnels																												
Fabrication, preparation for and installation of immersed tube tunnels																												
Tunnel fitout and finishing																												
Construction of operational facilities																												
Testing and commissioning																												
Site clean-up and demobilisation																												

Table 5-2 summarises the construction activities and estimated timeframe for construction works that have been assessed. The likelihood for works to be completed during standard construction hours or as OOHW is also identified. Figure 1-3 shows the location of major works areas and construction support sites associated with the project.

Table 5-2 – Construction activities and indicative timeframes of activities/construction works

Location	Construction scenarios	Approx. duration of works at any locality	Construction hours of work standard/ OOHW
Tunnel construction support sites			
WHT1 - Rozelle Rail Yards (ROZ) WHT2 - Victoria Road (VIC) WHT3 - White Bay (WHB) WHT4 - Yurulbin Point (YRB) WHT7 - Berrys Bay BRY) WHT10 - Cammeray Golf Course (CGC)	Early works and site establishment	18 months	Standard & OOHW where works are required within public road corridor
	Decline / shaft excavation and support	Up to 6 months	Standard
	Tunnel construction support	Up to 24 months	Standard and OOHW to support 24 hour tunnelling
	Tunnel mechanical and electrical fitout	Up to 30 months	Standard
	Tunnel commissioning and site rehabilitation	Up to 24 months	Standard
	Construction of permanent operational facilities	Up to 24 months	Standard

Location	Construction scenarios	Approx. duration of works at any locality	Construction hours of work standard/ OOHW
Surface road works in the Warringah Freeway and surrounds			
Warringah Freeway Upgrade Construction support sites • WFU1 - Blue Street • WFU2 - High Street south • WFU3 - High Street north • WFU4 - Arthur Street east • WFU5 - Berry Street east • WFU6 - Ridge Street east • WFU7 - Merlin Street • WFU8 - Cammeray Golf Course (CGC) • WFU9 - Rosalind Street east Western Harbour Tunnel Construction support sites • WHT8 - Berry Street north (WFU1B) • WHT9 - Ridge Street north (WFU3J) • WHT11 - Waltham Street (WFU3K) Road work in the local road network	Early works	4 to 5 months	Standard and OOHW
	Utilities, sewerage and local area upgrade works	Up to 30 months	Standard and OOHW
	Road work	Up to 42 months	Standard and OOHW for road tie ins
	Bridge and concrete works (cut and cover, ramp pavements, bridge demolition / construction) Motorway facilities construction (WHT11)	Up to 24 months	Standard and OOHW
Mainline tunnelling			
Rozelle to Birchgrove Berrys Bay to North Sydney	Mainline tunnels: Heading	Up to 24 months	24 hours
	Mainline tunnels: Benching		Up to 24 hours
	Cross passages		Up to 24 hours
	Mechanical and electrical fitout		24 hours
White Bay construction support site			
WHT3 - White Bay (WHB)	Early works, site establishment and wharf construction	9 months	Standard
	Cast of immersed tube tunnel elements	Up to 6 months	Standard
	Spoil handling and treatment, and tunnelling support deliveries	Up to 33 months	Standard and OOHW to support 24 hour tunnelling
Sydney Harbour Crossing			
Sydney Harbour Crossing WHT5 - Sydney Harbour south cofferdam (SHC(S)) WHT6 - Sydney Harbour north cofferdam (SHC(N)) Snails Bay temporary mooring site	Immersed tube tunnel immersion	12 to 15 months	Standard and OOHW
	Dredging	12 months	Standard and OOHW
	Coffer dam construction	Up to 18 months	Standard

5.1.3 Required tunnel construction and fitout work outside of standard construction hours

Work in tunnels, and other underground activities, would occur 24 hours per day, seven days a week. On-site acoustic treatment such as site hoarding and acoustic sheds are proposed to control noise emitted by tunnelling and tunnel support activities outside standard construction hours. 24 hour spoil handling would be required to support tunnelling works.

Tunnelling using roadheaders would occur 24 hours per day, seven days a week, due to each excavation cycle taking around eight to 10 hours. Once complete, it would be supported immediately to ensure the tunnel is stable and minimise any potential ground movement where required.

This ground support for tunnelling would include shotcrete and rock bolts where required. For sections of the alignment, not installing ground support immediately could result in settlement in the tunnel and create an unsafe working environment. Where required, the concrete deliveries for this ground support may also be required outside standard construction hours to enable concreting works to be completed safely.

During the tunnel fitout stage, deliveries of mechanical and utilities services would be required. In order to support the installation of these components within the tunnel 24 hours per day, seven days a week, which would shorten the overall duration of the project, deliveries outside of standard hours may be required. These deliveries are relatively low noise impact, and delivery trucks would move directly into the tunnel minimising noise emissions within the construction site footprint.

5.1.4 Other work outside standard construction hours

There are five categories of work (other than tunnelling) that typically may be required to be carried out outside the standard construction hours:

- The **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
- **Emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
- **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard construction hours
- **Public infrastructure works** that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies **a need to operate outside the recommended standard construction hours**.

The above categories would apply to specific stages of the construction of the project works for various reasons. For example, the works within the existing road network would need to be carried out outside standard construction hours in order to limit impacts on the traffic network during peak periods and for both worker and road user safety. This would also likely be the case where a Road Occupancy Licence is

required to undertake the construction works on major roads. This would apply extensively as part of the Warringah Freeway Upgrade surface road works due to the critical nature of these roads to the Sydney road networks.

Any out of hours work would require justification, assessment and more detailed management. This would be completed in accordance with the CNVMP developed for the project during detailed design.

5.1.5 Surface road upgrades and road interface works

As part of the project construction works, surface upgrades of interfacing roads are required along the Warringah Freeway.

These surface road upgrades and road interface works would be required for the following major sets of works:

- New tunnel dive structures at the Warringah Freeway
- Upgrade and reconfiguration works along about four kilometres of the Warringah Freeway
- New and adjusted bridge structures across the Warringah Freeway
- Modifications to local roads and intersections to accommodate changes in traffic conditions
- Upgrades and amendments to bus infrastructure
- Noise attenuation, including noise barriers
- Other ancillary works, including drainage and utility works, roadside furniture and lighting installation and pavement works.

Where feasible and reasonable, works would be programmed during standard construction hours; however, large sections of works across the project, particularly on the Warringah Freeway, would be required to take place outside of standard construction hours due to the requirement for a Road Occupancy Licence (ROL).

5.2 Rozelle Rail Yards construction support site

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the Rozelle Rail Yards construction support site.

5.2.1 Construction support site overview

5.2.1.1 Construction support site description

The site is located on City West Link, Lilyfield. It is bounded by Lilyfield Road to the north and City West Link to the south. The site would be within the M4-M5 Link's Rozelle Interchange construction footprint. Works at the site are proposed to occur in stages as presented in Table 5-3. Utility works and onsite vehicle access road at this site would be completed and supported as part of the M4-M5 Link project prior to the operation of the site.

Table 5-3 – Rozelle Rail Yards construction support site – major stage activities overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Establish site	Install environmental controls
	2. Establishment of construction facilities	Establish site offices and workshops
Tunnel fitout and finishing	3. Tunnel fitout and finishing	Tunnel spoil handling from the fitout works only (benching, conduit trenching and installation, etc) Install mechanical and utilities infrastructure to the tunnel and within the ventilation outlet building
Integration road works	4. Surface road works	Connection of the portals to the Rozelle Interchange
Tunnel commission and site rehabilitation	5. Restore site	Commission tunnel, decommission site and restore site

The tunnels connecting the Rozelle Rail Yards and the mainline Western Harbour Tunnel are part of the M4-M5 Link. As such, portions of the tunnelling are to be carried out as part of the M4-M5 Link project, also operating out of the Rozelle Rail Yards construction support site.

A ventilation tunnel would be constructed from the mainline tunnel alignment to locations within the Rozelle Rail Yards to connect to ventilation outlet buildings constructed by the M4-M5 Link. The fitout from within the tunnel would take place during the tunnel fitout and finishing stage (Stage 3). Potential ground-borne noise impacts from the construction of this tunnel are assessed in section 5.2.4.

5.2.1.2 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-4, subject to project approval. This site is planned to operate from Q2 2023 until Q1 2026. The construction support site would support mechanical and electrical fitout of the mainline tunnels. The site would also support construction and fitout of the ventilation outlet and motorway facilities, as well as surface roads connecting the ramp tunnels to City West Link. The longest duration activities at this construction support site would be tunnelling and tunnel fitout works.

Table 5-4 – Rozelle Rail Yards construction support site – indicative program and timeline

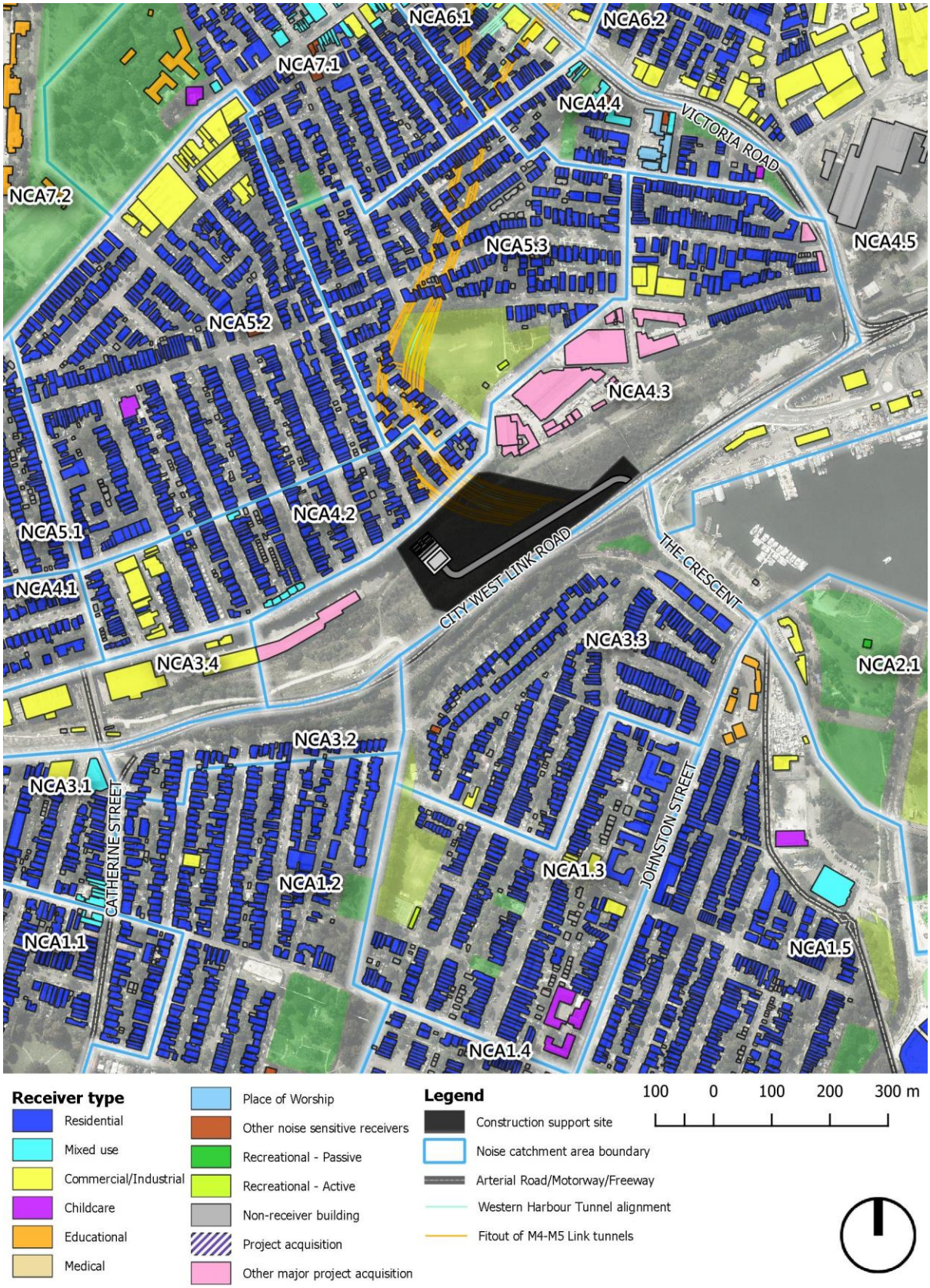
Stage	Representative activity	Reference	Indicative construction timeframe															
			2023				2024				2025				2026			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1. Establish the site	ROZ_01		■	■	■												
	2. Establish the construction facilities	ROZ_02		■	■	■												
Tunnel fitout and finishing	3. Tunnel fitout and finishing	ROZ_03			■	■	■	■	■	■	■	■	■	■	■			
Integration road works	4. Surface road woks	ROZ_04										■	■	■	■			
Tunnel commission and site rehabilitation	5. Restore site	ROZ_05												■	■			

5.2.1.3 Nearby noise and vibration-sensitive receivers

The site is located on the City West Link in Lilyfield. It is mostly surrounded by residential receivers with a number of recreational receivers and industrial receivers to the east in Rozelle.

The location of the site, tunnel alignment, nearby NCAs and receiver locations are shown in Figure 5-1.

Figure 5-1 – Location of Rozelle Rail Yards construction support site



5.2.1.4 Construction duration and working hours

Table 5-5 presents each of the major stages and each of the assessed activities for the Rozelle Rail Yards construction support site, along with the proposed time periods for each activity.

During operation of the Rozelle Rail Yards construction support site, work would typically take place during the ICNG standard construction hours as presented in Table 3-2. However, some out-of-hours works (OOHW) would take place outside standard construction hours, as presented in Table 5-5. Further justification for OOHW is provided in section 5.1.3.

Table 5-5 – Rozelle Rail Yards construction support site – construction hours

Stage	Representative activity	Reference	Assessed activities[1]	Work hours[2]			
				Day (Standard)	Day (OOHW)	Evening	Night
Site establishment	1. Establish site	ROZ_01	Install environmental controls	♦			
	2. Establishment of construction facilities	ROZ_02	Establish site offices and workshops	♦			
Tunnel fitout and finishing	3. Tunnelling support fitout	ROZ_03	General site activities	♦			
			Deliveries to site	♦			
			Tunnelling support[3]	♦			
			Spoil handling[3]	♦			
			Deliveries to tunnel	♦	♦[4]	♦[4]	♦[4]
			Laydown areas	♦			
Integration road works	4. Surface road works	ROZ_04	Line marking and road pavement	♦			
Tunnel commission and site rehabilitation	5. Restore site	ROZ_05	Decommission site	♦			

Notes:
1. Appendix E describes the modelled plant for each activity
2. Day Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
   Day Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
   Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
   Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday
3. Tunnel fitout and finishing activities that take place sufficiently within the tunnel so that noise emissions achieve the NML would take place outside of standard construction hours.
4. Heavy vehicle deliveries would move directly into the tunnel, and not move within the site for an extended period.

5.2.1.5 Concurrent and consecutive construction projects

The nearest other construction support sites associated with the project are the White Bay construction support site, around 1.5 kilometres north-east of this site, and the Victoria Road construction support site, about 1 kilometre north of this site.

The nearest construction support sites with another major infrastructure project that would be taking place concurrently is the M4-M5 Link Rozelle works area which consists of three construction sites, including the Rozelle civil and tunnel site (C5) (within the boundary of which the Rozelle Rail Yards construction support

site is located), the Crescent civil site (C6), the Victoria Road civil site (C7), in addition to a construction support site located at White Bay (C11), as identified in the M4-M5 Link environmental impact statement documentation.

Other additional construction sites associated with major infrastructure projects which are likely to be undertaking construction activities during similar time periods as the construction works associated with the project, include the Sydney Metro City & Southwest for which construction activities at White Bay are to end in 2020, and Sydney Metro West for which additional project information is not currently available.

Due to the distance to the Victoria Road construction support site and the construction activities in White Bay associated with the project, the M4-M5 Link, Sydney Metro City & Southwest and the level of noise emissions expected from these construction activities, consecutive noise impacts on receivers nearby to the Rozelle Rail Yards is unlikely from these construction activities.

5.2.1.6 Construction assessment scenarios

The airborne noise assessment of the Rozelle Rail Yards construction support site has been separated into five stages. Each stage has been assessed against the works periods presented in Table 5-5.

The equipment/plant listed in Appendix E represents the reasonable worst-case equipment/plant assumed to be operating during the stage. It is assumed that all equipment/plant operate simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

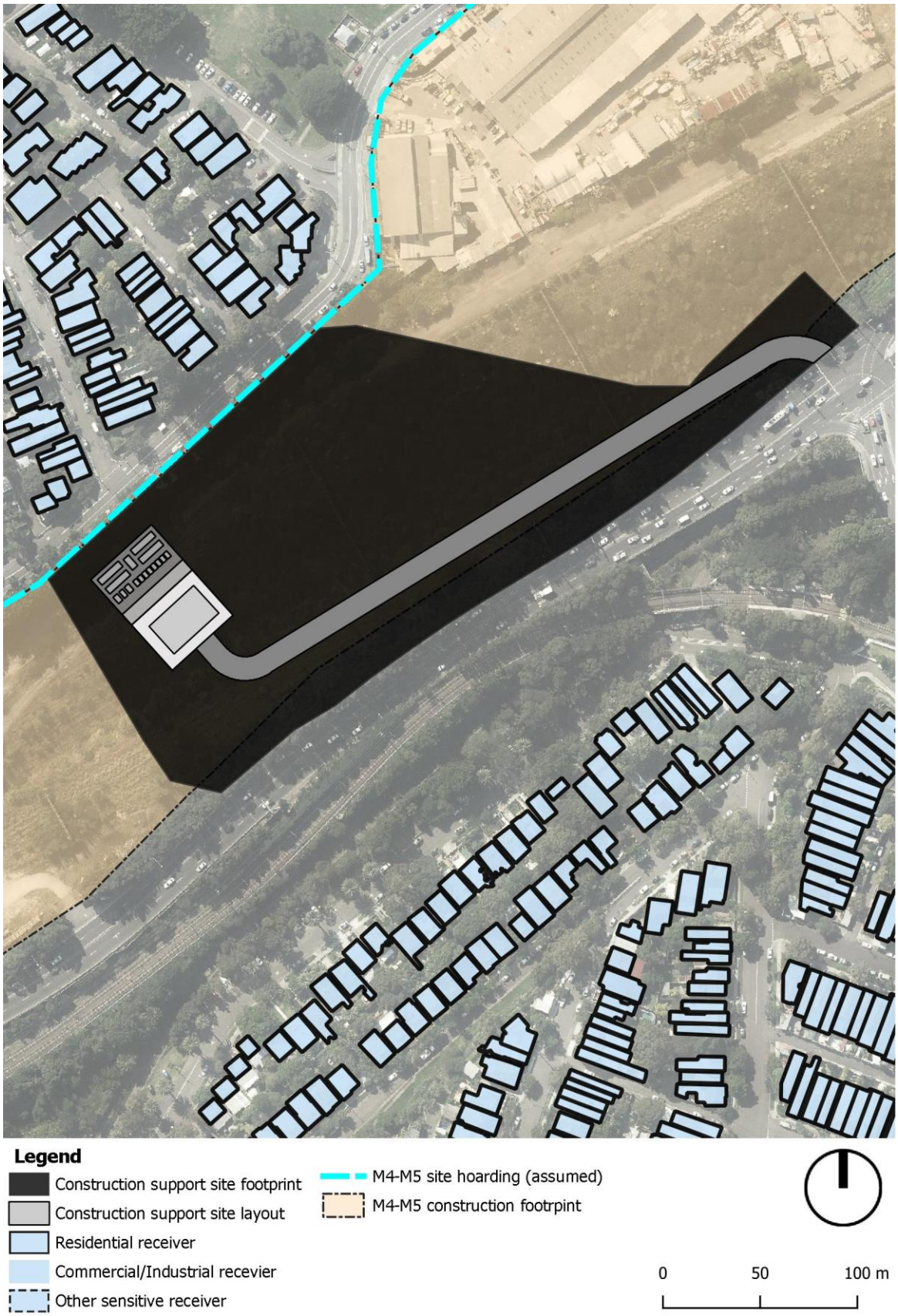
Multiple activities would sometimes occur concurrently within the one construction support site and where this would reasonably occur it has been captured in the assessment as shown in Table 5-5.

5.2.1.7 Summary of assumed noise treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating, to assist in attenuating and managing noise emissions from the construction activities.

Noise mitigation measures outlined in the M4-M5 Link environmental impact statement have been identified and included in the noise modelling. The M4-M5 Link is programmed to have completed construction works by this stage, and so it is assumed that these mitigation measures, or noise mitigation measures providing similar noise reduction benefits, are either left or partially left in place to manage noise emissions from these assessed construction activities. The locations of the assumed physical noise treatment measures are shown on Figure 5-2. Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

Figure 5-2 – Construction support site layout with indicative/assumed noise treatment measures at the Rozelle Rail Yards



5.2.2 Construction airborne noise

5.2.2.1 Nearby receiver summary and objectives

Table 5-6 presents NMLs and screening levels for assessing sleep disturbance for the nearest residential receivers surrounding the Rozelle Rail Yards construction support site. For all other NMLs refer to Appendix B.1. Other non-residential noise-sensitive receivers are presented in section 3.4.1.

Table 5-6 – Construction noise management levels at residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
1.2	60	55	52	41	51
1.3	60	55	52	41	51
3.2	60	55	55	49	59
3.3	60	55	55	49	59
4.2	62	57	57	50	60
4.3	62	57	57	50	60
5.2	59	54	51	42	52
5.3	59	54	51	42	52
7.1	53	48	46	39	49

5.2.2.2 Predicted noise impacts

Table 5-7 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-7 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

Model results present the range of the highest predicted noise levels for each NCA for residential receivers, commercial and OSRs, unless no receivers of that type in that NCA are expected to exceed NMLs.

The range is of noise levels throughout all receivers in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented. The noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest and longer-term tunnel fitout and finishing stage is shown in Appendix H.

5.2.2.3 Residential

The predicted noise levels for residential receivers are presented in the following table:

- Table 5-8: for standard hours
- Table 5-9: for works outside of standard construction hours.

The number of receivers predicted to exceed the NMLs during each stage and time period are summarised in Table 5-10. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-8 – Predicted construction noise levels – standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Rozelle Rail Yards construction support site

NCA	Noise Management Level		Predicted noise level at each construction stage[2]				
	HNA	NML	ROZ_01	ROZ_02	ROZ_03	ROZ_04	ROZ_05
1.2	75	60	≤ 44	≤ 48	≤ 49	≤ 42	≤ 45
1.3	75	60	≤ 42	≤ 45	≤ 47	≤ 43	≤ 43
3.2	75	60	≤ 46	≤ 49	≤ 50	≤ 43	≤ 47
3.3	75	60	≤ 49	≤ 54	≤ 56	≤ 54	≤ 52
4.2	75	62	≤ 55	≤ 61	≤ 61	≤ 58	≤ 58
4.3	75	62	≤ 43	≤ 46	≤ 49	≤ 48	≤ 44
5.2	75	59	≤ 46	≤ 49	≤ 51	≤ 46	≤ 47
5.3	75	59	≤ 39	≤ 44	≤ 45	≤ 49	≤ 41
7.1	75	53	< 35	≤ 37	≤ 40	≤ 40	< 35

Notes:
1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-9 – Predicted construction noise levels – outside standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Rozelle Rail Yards construction support site

NCA	Noise Management Level				Predicted noise level at each construction stage[3]				
	HNA	Day (O)	Eve	Night	ROZ_01[1]	ROZ_02[1]	ROZ_03	ROZ_04[1]	ROZ_05[1]
1.2	75	55	52	41	-	-	< 35	-	-
1.3	75	55	52	41	-	-	< 35	-	-
3.2	75	55	55	49	-	-	< 35	-	-
3.3	75	55	55	49	-	-	< 41	-	-
4.2	75	57	57	50	-	-	< 40	-	-
4.3	75	57	57	50	-	-	< 35	-	-
5.2	75	54	51	42	-	-	< 35	-	-
5.3	75	54	51	42	-	-	< 35	-	-
7.1	75	48	46	39	-	-	< 35	-	-

Notes:
1. No typical work is proposed outside standard hours.
2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-10 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – Rozelle Rail Yards construction support site

Stage activity	Assessment reference	Highly noise affected: Standard hours L_{Aeq}	Highly noise affected: Outside standard hours L_{Aeq}	Day (standard hours) L_{Aeq}			Day (outside standard hours) L_{Aeq}				Evening L_{Aeq}				Night L_{Aeq}				Sleep Disturbance L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Establish site	**ROZ_01**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Establishment of construction facilities	**ROZ_02**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Tunnel fitout and finishing	**ROZ_03**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0
4. Integration road works	**ROZ_05**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Restore site	**ROZ_06**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-7

5.2.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted noise levels occur during tunnelling support and fitout (ROZ_03); however, no receivers are predicted to be noise affected (ie. > NML) during standard construction hours. No receivers are predicted to be highly noise affected (ie. >75 dB(A)).

Work outside of standard construction hours

During tunnel fitout and finishing works (ROZ_03) at the Rozelle Rail Yards construction support site, deliveries to the tunnel at night are required, as presented in Table 5-5. During OOHW delivery operations (ROZ_03), compliance with the night period NMLs is predicted. Therefore, no further mitigation measures beyond the on-site noise treatment and management measures, heavy vehicle code of conduct, and CNVMP requirements are needed.

Sleep disturbance

At the Rozelle Rail Yards construction support site, the OOHW stage which potentially include activities with maximum noise levels (L_{Amax}) is:

- Stage 3 (ROZ_03): Tunnel fitout and finishing – night time concrete agitator delivery.

During tunnel fitout and finishing works (ROZ_03), the following results are predicted:

- Concrete or delivery heavy vehicles are predicted to result in high maximum noise levels when arriving or departing the site. Up to 36 receivers would potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 64 dB(A)). However, no receivers are predicted to exceed the awakening reaction level.
- Since the number of heavy vehicle movements generated by the site is not substantial compared to existing traffic numbers on the City West Link, sleep disturbance impacts are not likely to occur from heavy vehicle movements to and from the site at night.

5.2.2.5 Non-residential

The predicted noise levels for non-residential receivers are presented in Table 5-11. The receivers predicted to exceed the NMLs are summarised in Table 5-12. The predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-11 – Predicted noise levels at other sensitive receivers, dB(A) – Rozelle Rail Yards construction support site

Receiver type	NCA	Noise Management Level		Predicted noise level at each construction stage[2]				
		HNA	NML	ROZ_01	ROZ_02	ROZ_03	ROZ_04	ROZ_05
Commercial	1.2	75	70	≤ 35	≤ 40	≤ 41	≤ 35	≤ 38
	1.3	75	70	< 35	≤ 36	≤ 38	< 35	< 35
	3.3	75	70	≤ 40	≤ 44	≤ 46	≤ 38	≤ 42
	3.4	75	75	≤ 42	38 - 46	39 - 46	≤ 41	35 - 43
	4.2	75	75	< 35	≤ 38	≤ 38	< 35	< 35
	4.3	75	70	36 - 40	41 - 43	43 - 46	41 - 44	39 - 41
	5.2	75	70	< 35	≤ 35	≤ 38	≤ 38	< 35
Childcare	1.3	75	50	< 35	37 - 38	≤ 39	< 35	35 - 36
	5.2	75	50	< 35	< 35	< 35	< 35	< 35
Other sensitive receiver	1.2	75	60	< 35	36 - 37	≤ 38	< 35	< 35
	3.3	75	70	≤ 43	≤ 48	≤ 49	≤ 42	≤ 46
	5.2	75	60	< 35	< 35	< 35	< 35	< 35
Recreational	1.3	75	60	≤ 36	≤ 40	≤ 41	≤ 35	≤ 38
	5.3	75	60	≤ 40	≤ 43	≤ 46	≤ 41	≤ 40

Notes:
1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: **Light blue** is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.
2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-12 – Number of other sensitive receivers over the noise management levels (all NCAs) - $L_{Aeq(15\ min)}$ – Rozelle Rail Yards construction support site

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1,2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Establish site	**ROZ_01**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Establishment of construction facilities	**ROZ_02**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Tunnel fitout and finishing	**ROZ_03**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Integration road works	**ROZ_05**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Restore site	**ROZ_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.

2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

No other sensitive receivers are predicted to exceed the NMLs during work at the Rozelle Rail Yards construction support site.

5.2.2.6 Summary of residual impacts and additional mitigation measures

Table 5-10 indicates the no residential receiver buildings are predicted to exceed the NMLs after the implementation of the noise treatments outlined in the M4-M5 Link environmental impact statement. Therefore, no additional mitigation measures are required at this site.

5.2.2.7 Cumulative and consecutive project airborne construction noise

Construction works at the Rozelle Rail Yards construction support site may overlap with construction of the approved M4-M5 Link, which has multiple construction sites nearby. As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the Rozelle Rail Yards construction support site are considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-13. Timelines have been based on the relevant environmental impact statement documentation.

Table 5-13 – Concurrent construction works near the Rozelle Rail Yards construction support site

Project	2019	2020	2021	2022	2023	2024	2025	2026
Rozelle Rail Yards construction support site (ROZ)								
Other major infrastructure projects								
Rozelle works area (M4-M5 Link)								

Proposed staging of concurrent work and noise impacts at the closest receivers to the Rozelle Rail Yards have been reviewed. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

In the case where noise from one site dominates noise levels at the receiver (ie > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

However, where noise levels from each site are similar at a receiver, total construction noise levels are predicted to increase by up to 3 dB(A). Two representative NCAs near the site have been assessed in Table 5-14.

Table 5-14 – Potential cumulative noise impacts from construction projects near Rozelle Rail Yards

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 4.2[4]	Standard hours NML 62 dB(A)	ROZ	2. Establish the construction facilities	≤ 61	For both site establishment (Stage 2) and tunnel fitout and finishing (Stage 3) there could be up to 2 dB(A) increase at some receivers in the case that establishment construction facilities at Rozelle Rail Yards (ROZ) occur concurrently with site rehabilitation for the M4-M5 Link Rozelle civil and tunnel site rehabilitation activities as they could contribute a similar noise levels. Which could result in a combined construction noise level marginally above the NML by 1 dB.
			3. Tunnel fitout and finishing	≤ 61	
		M4-M5 Link	Site rehabilitation[1,2]	≤ 63[1,2]	
	OOHW NML D/E/N 57/57/50 dB(A)	ROZ	3. Tunnel fitout and finishing	<40	Negligible cumulative increase are expected as M4-M5 Link would likely dominate during the activity and the Rozelle Rail Yards (ROZ) construction noise levels are predicted under the NML.
		M4-M5 Link	General construction activities (roadworks and utility works)[1,3]	57 to 59[1]	
NCA 3.3[5]	Standard hours NML 60 dB(A)	ROZ	2. Establish site	≤ 54	For both site establishment (Stage 2) and tunnel fitout and finishing (Stage 3) there could be up to 2 dB(A) increase at some receivers in the case that construction facilities at Rozelle Rail Yards (ROZ) occur concurrently with site rehabilitation for the M4-M5 Link Rozelle civil and tunnel site rehabilitation activities as they could contribute a similar noise levels. However the combined construction noise level remains below the NML.
			3. Tunnel fitout and finishing	≤ 56[1]	
		M4-M5 Link	Site rehabilitation[1,2]	52[1,3]	
	OOHW NML D/E/N 55/55/49 dB(A)	ROZ	3. Tunnel fitout and finishing	<41	Negligible cumulative increase as M4-M5 Link would likely dominate during the activity and the Rozelle Rail Yards (ROZ) construction noise levels are predicted under the NML.
		M4-M5 Link	General construction activities (roadworks and utility works)[1,3]	64 to 75[1]	

Notes:
1. Noise levels based on the M4-M5 Link environmental impact statement documentation
2. Rozelle civil and tunnel site (C5) (ROZ-19)
3. General construction activities (ROZ-26 to ROZ-28)
4. Equivalent NCA assessed is NCA24 in the M4-M5 Link environmental impact statement documentation
5. Equivalent NCA assessed is NCA21 in the M4-M5 Link environmental impact statement documentation

At the receiver buildings most affected by noise from the construction support site in NCAs 3.3 and 4.2, during stages when there is a program overlap with the M4-M5 Link there is a potential for construction noise levels to increase if construction activities occur concurrently during standard construction hours. These predicted cumulative noise levels are higher than the NML. However, outside of standard construction hours, due to the minimal construction noise generated by the Rozelle Railway Yards

construction support site activities, construction noise levels would likely be dominated by the M4-M5 Link construction work.

However, changes in potential construction noise levels as a result of cumulative and consecutive projects compared with those for the individual project are expected to be minor considering that cumulative construction noise increases are likely to occur rarely at these receiver buildings, as noise generating activities would need to occur simultaneously, and in reasonable worst case locations relative to the receiver.

For noise affected receiver buildings, the key difference in construction noise impacts could be an increased overall duration and frequency of construction noise impacts, even if they are at the same noise level. This would be considered by both projects when reviewing and incorporating feasible and reasonable noise mitigation measures.

Receiver buildings located at more distant locations in Rozelle, Lilyfield and Annandale and not directly adjacent to the Rozelle Rail Yards construction support site (and M4-M5 Link works) may find that no individual construction support site dominates construction noise levels (ie. noise generated by each site is within 5 dB(A) of other sites). Cumulative construction noise levels at these receiver buildings may be up to 3 dB(A) higher than the noise levels predicted for any one construction support site.

Some receiver buildings adjacent to the Rozelle Rail Yards construction support site would have already been exposed to multiple years of construction works associated with the M4-M5 Link project and other major infrastructure projects as detailed in section 5.2.1.5. Therefore, construction fatigue impacts may be expected for some nearby noise sensitive receivers. Development of mitigation and management measures would consider these potential consecutive construction noise impacts.

Potential cumulative and consecutive construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. These mitigation measures would be included in the site's detailed design and site specific CNVIS, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures and would be carried out in coordination with the construction contractors of the approved M4-M5 Link where required to ensure all interfaces are effectively managed.

5.2.3 Construction road traffic noise assessment

Vehicle access to the site within the Rozelle Rail Yards would be directly to and from the City West Link.

Table 5-15 presents the forecasted vehicle numbers for the peak construction period at this construction support site. Up to seven trucks would access the site per hour during the daytime period (7.00am to 10.00pm) and a maximum of one truck per hour (no more than four trucks in total) in the night time period (10.00pm to 7.00am) which would typically be deliveries to support fitout.

Predicted road traffic noise level increases from traffic accessing the site are presented in Table 5-16.

Table 5-15 – Number of construction vehicles accessing the Rozelle Rail Yards construction support site

Type of vehicle	Day[1] over 15 hours[4,5]	Night[2] over nine hours[4,5]
Heavy vehicle (deliveries, spoil haulage and concrete deliveries)	79	4
Light vehicle	101	52[3]

Notes:
1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am.
3. The majority of these vehicle movements would occur in the early morning peak period between 6.00am to 7.00am.
4. Numbers presented are individual vehicles, not vehicle movements
5. Vehicle numbers have been distributed onto the local road network based on the proposed access roads. Where a vehicle accesses the site by one road and leaves by another, one vehicle movement is counted along each road once. Where a vehicle accesses and leaves the site by the same road, two vehicle movements are counted on that road.

Table 5-16 – Road traffic noise impacts from the Rozelle Rail Yards construction support site

Construction vehicle access road	Road type	Time of day	Predicted road traffic noise increase, dB(A)[1, 2]	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level
City West Link	Arterial	Day $L_{Aeq(15hr)}$	<0.5	No	N/A
		Night $L_{Aeq(9hr)}$	<0.5	No	Yes

Notes:
1. Predicted road traffic noise levels are based on a loudest heavy vehicle
2. Predicted road traffic noise levels are based on the nearest residential receiver to the road.

Road traffic noise levels at receiver buildings directly exposed to traffic noise from City West Link may increase slightly (approximately 0.5 dB(A)) as a result of traffic accessing the construction support site. The highest increase is predicted to occur during the tunnel fitout and finishing stage (ROZ-03). However, road traffic noise levels are not predicted to increase by more than 2 dB(A) during any construction stage at this site, which represents a minor impact.

Maximum noise levels (L_{Amax}) from night time heavy vehicle movements have been predicted to exceed both the sleep disturbance screening level and the adopted awakening reaction level at receiver buildings along the City West Link. Since night time heavy vehicle movements from this site would be limited to one vehicle per hour and the City West Link has relatively high existing night time heavy vehicle movements, it is unlikely that there would be a substantial increase in the number of maximum noise events at nearby receiver buildings.

Mitigation and management

To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the CNVIS and CNVMP would implement, where required, the following:

- Where feasible and reasonable, heavy vehicle movements would occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive periods and limited to one heavy vehicle per hour during the night period
- All drivers would be trained in the project's Heavy Vehicle Code of Conduct, including noise management methods such as limiting compression braking.

5.2.3.1 Total increase in traffic noise levels on City West Link (considering all known major infrastructure projects in the area)

As well as the Rozelle Rail Yards construction support site, other major infrastructure construction works would result in traffic movements on the City West Link. As per Table 5-13 no overlap with the M4-M5 Link is expected, and so cumulative construction traffic noise impacts are not expected. However, in the case that there are program changes, and that there are overlaps, the potential for cumulative traffic noise impacts are assessed. Those works include:

- For this project:
  - The Victoria Road construction support site
  - The White Bay construction support site
- For the M4-M5 Link:
  - Rozelle civil and tunnel site (C5)
  - The Crescent civil site (C6)
  - Victoria Road civil site (C7)
  - White Bay civil site (C11).

Table 5-17 presents the forecasted vehicle numbers during the peak construction periods at each site. Up to 78 heavy vehicles per hour in the daytime period and up to 38 heavy vehicles per hour outside of these hours would access City West Link from construction support sites.

Predicted road traffic noise level increases from traffic accessing the site are presented in Table 5-18.

Table 5-17 – Number of construction vehicles generated onto City West Link

Construction support site	Day[1] over 15 hours		Night[2] over nine hours	
	Heavy vehicle	Light vehicle	Heavy vehicle	Light vehicle
Western Harbour Tunnel				
Rozelle Rail Yards construction support site	79	101	4	52
Victoria Road construction support site	205	91	5	24
White Bay construction support site	348	186	4	81
M4-M5 Link[3]				
Rozelle civil and tunnel site (C5)	323	219	194	131
The Crescent civil site (C6)	6	13	4	8
Victoria Road civil site (C7)	26	88	16	53
White Bay civil site (C11)	172	50	112	50

Notes:
1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am
3. Vehicle numbers are from the M4-M5 Link environmental impact statement, except for the White Bay civil site (C11) numbers which are from the M4-M5 Link response to submissions.

Table 5-18 – Total construction road traffic noise increase along City West Link

Construction Vehicle Access Road	Road Type	Time of day	Predicted road traffic noise increase, dB(A)[1, 2]	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level
City West Link	Arterial	Day $L_{Aeq(15hr)}$	1.0	No	Yes
		Night $L_{Aeq(9hr)}$	1.2	No	Yes

Notes: 1. Predicted road traffic noise levels are based on the loudest heavy vehicle

2. Predicted road traffic noise levels are based on the nearest residential receiver to the road. Receiver buildings further distances are expected to experience lower noise levels than those predicted.

The total increase in traffic noise level from all identified construction support sites at receiver buildings directly exposed to traffic noise from the City West Link is predicted to be less than 2 dB(A) which represents a minor impact.

The actual increase in traffic noise level at any one stage is likely to be less than predicted here, as it is unlikely that all sites would contribute their highest numbers of vehicles at the same time.

Whilst there would be an increase in the total number of heavy vehicle movements along the City West Link as a result of the combined heavy vehicle movements from the M4-M5 Link and this project, the alignment of the City West Link remains substantially unchanged. Consequently, the maximum noise levels (L_{Amax}) from night time heavy vehicle movements are unlikely to change in terms of noise levels compared with existing L_{Amax} noise levels at receiver buildings along the City West Link. The increased number of heavy vehicles may potentially cause an increase in the number of L_{Amax} events at residential receiver buildings along the heavy vehicle route; however, it is noted that night time heavy vehicle movements generated by this project are minimal (on average less than four heavy vehicles over the nine hour night period). Furthermore, heavy vehicles are directed onto major arterial roads in order to minimise impacts on local and sub-arterial roads.

5.2.3.2 Mitigation and management

Mitigation and management measures for construction related traffic noise impacts are outlined in section 6.7. To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the site specific CNVIS and project CNVMP would include the following:

- Where feasible and reasonable, heavy vehicle movements would occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive periods and limited to one heavy vehicle per hour during the night
- All drivers would be trained in the Heavy Vehicle Code of Conduct, including noise management methods such as limiting of compression braking.

5.2.4 Ground-borne construction noise

No access decline tunnel forms part of the construction activities at the Rozelle Rail Yards construction support site.

A ventilation tunnel would be constructed from the mainline tunnel alignment to locations within the Rozelle Rail Yards. The ventilation tunnel would be constructed by roadheader. However, the tunnel is generally deeper than 30 metres below nearby receiver buildings in Rozelle along the ventilation tunnel alignment. As such, the ground-borne noise levels are predicted to remain below the strictest ground-borne NML (ie. Night period 35 dB(A)). If required, potential noise impacts would be managed by restricting construction hours away from the evening and night periods, or if justified, in accordance with section 6.10.2. One receiver building is predicted to be potentially impacted by ground-borne noise above the strictest NML (ie. night time 35 dB(A)), as presented in Table 5-19. The location of this receiver building is presented in Appendix J.3. As such, ground-borne noise impacts from the construction of the ventilation tunnel are expected to be minor.

Table 5-19 – Number of receiver buildings affected by ground-borne noise from the construction of the Rozelle ventilation tunnel

NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML[1,2])				
	Residential			Other sensitive receivers	Commercial/ industrial receivers
	> 35[1] to ≤ 40 dB(A)	> 40[2] to ≤ 45 dB(A)	>45 dB(A)		
4.2	1	-	-	-	-

Notes: 1. Night ground-borne noise management level (GBNML)
2. Evening ground-borne noise management level (GBNML).

Tunnel construction may be extended outside standard hours if verification monitoring conducted during tunnelling work determines that ground-borne noise levels inside residential receiver buildings are below the predicted noise levels and comply with ground-borne noise management levels. Detailed noise mitigation and management measures would to be reviewed during detailed design.

Ground-borne noise and vibration impacts from mainline tunnel construction are presented in section 5.11.

Ground-borne noise levels could be generated by vibration-intensive works as part of the Rozelle Rail Yard construction support site. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

5.2.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out. For the Rozelle Rail Yards construction support site, no vibration-intensive work is proposed, so vibration impacts have not been assessed further for this site.

For the ventilation tunnel construction, due to the tunnel depth there are no structures that are identified within the minimum working distances presented in section 4.4.1 for roadheader tunnelling for either cosmetic damage or human response screening levels. As such, vibration impacts above the screening levels from the ventilation tunnel construction works are unlikely, but would be reviewed during detailed design considering final ventilation tunnel design and construction methodology.

5.3 Victoria Road construction support site

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receiver buildings near the Victoria Road construction support site.

5.3.1 Construction support site overview

5.3.1.1 Construction support site description

The site is located on Victoria Road at Rozelle. Work at the site would occur in stages as presented in Table 5-20.

Table 5-20 – Victoria Road construction support site – major stage activities overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Early works	Connect and relocate services at the site such as electricity, sewerage and water
	2. Establish the site	Install environmental controls and demolish existing structures
	3. Establishment of construction facilities	Establish site offices and workshops
Acoustic shed and surface level tunnel access construction	4. Piling for decline and acoustic shed	Pilling for the decline and acoustic shed foundations
	5. Surface level decline construction	Surface level decline excavation and construction
	6. Acoustic shed construction	Erect acoustic shed elements
Tunnel construction (access decline and mainline tunnels)	7. Tunnelling	Tunnel spoil handling and haulage, tunnel support, tunnel lining and associated deliveries
Tunnel fitout	8. Tunnel fitout	Install mechanical and utilities services to the tunnel
Tunnel commissioning and site rehabilitation	9. Restore site	Commissioning tunnel, decommission site and restore sports field

In addition to the major activities presented above, the Victoria Road construction support site would support up to three roadheaders excavating the mainline tunnels.

5.3.1.2 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-21, subject to project approval. This site would operate from the middle of 2021 until late 2025. The longest duration activity at this construction support site would be tunnelling works.

Table 5-21 – Victoria Road construction support site – indicative program and timeline

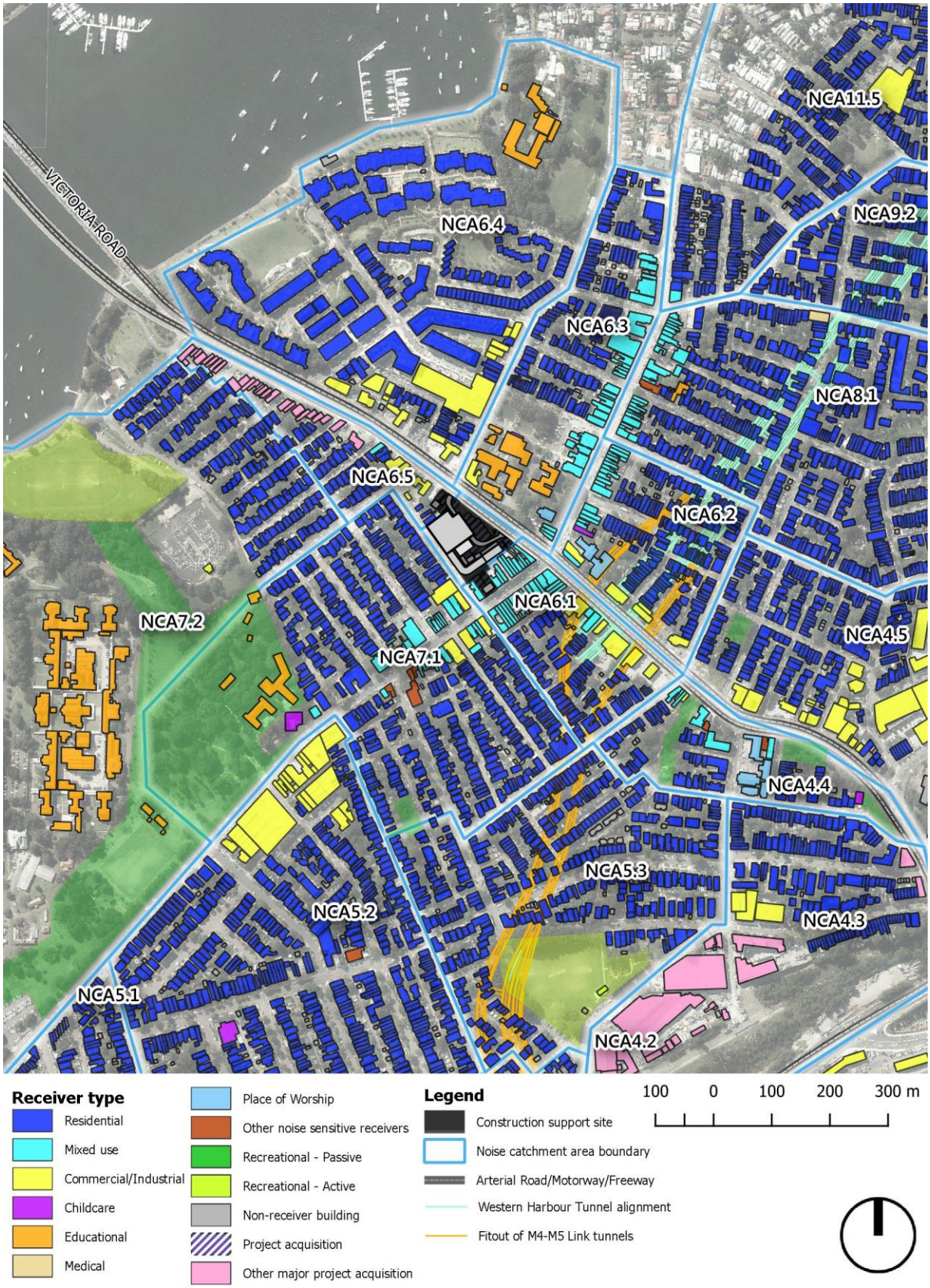
Stage	Construction activity	Reference	Indicative construction timeframe																	
			2021				2022				2023				2024				2025			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1. Early works	VIC_01																				
	2. Establish the site	VIC_02																				
	3. Establishment of construction facilities	VIC_03																				
Acoustic shed and surface level tunnel access construction	4. Piling for acoustic shed	VIC_04																				
	5. Surface level decline construction	VIC_05																				
	6. Acoustic shed construction	VIC_06																				
Tunnel construction (access decline and mainline tunnels)	7. Tunnelling	VIC_07																				
Tunnel fitout	8. Tunnel fitout	VIC_08																				
Tunnel commissioning and site rehabilitation	9. Restore site	VIC_09																				

5.3.1.3 Nearby noise and vibration-sensitive receivers

The site is located on Victoria Road at Rozelle. It is surrounded by a mix of commercial, industrial, educational, mixed use and residential receivers.

The location of the site, tunnel alignment, nearby NCAs and receiver locations are shown in Figure 5-3.

Figure 5-3 – Location of Victoria Road construction support site



5.3.1.4 Construction duration and working hours

Table 5-22 presents each of the major stages that have been assessed along with the representative activities that would take place during the stage for the Victoria Road construction support site, along with the proposed time periods.

During operation of the Victoria Road construction support site, work would typically take place during the ICNG standard construction hours as presented in Table 3-2. However, some OOHW would take place outside standard construction hours, as presented in Table 5-22. Further justification for OOHW is provided in section 5.1.3.

Table 5-22 – Victoria Road construction support site – construction hours

Stage	Representative activity	Reference	Assessed activities[1]	Work hours[2]			
				Day (Standard)	Day (OOHW)	Evening	Night
Site establishment	1. Early works	VIC_01	Utility works	♦			
	2. Establish site	VIC_02	Install environmental controls	♦			
			Demolish existing structures.	♦			
	3. Establishment of construction facilities	VIC_03	Establish construction facilities (site offices and workshops)	♦			
Acoustic shed and surface level tunnel access construction	4. Piling for decline and acoustic shed	VIC_04	Piling for decline and acoustic shed	♦			
	5. Surface level decline construction	VIC_05	Surface level decline excavation and construction	♦			
	6. Acoustic shed construction	VIC_06	Spoil shed construction	♦			
Tunnel construction (access decline and mainline tunnels)	7. Tunnelling	VIC_07	General site activities	♦	♦	♦	♦
			Deliveries	♦			
			Tunnelling and support	♦	♦	♦	♦
			Tunnelling lining (concreting) deliveries	♦	♦	♦	♦
			Spoil handling in an acoustic shed	♦	♦[3]	♦[3]	♦[3]
			Spoil haulage	♦			
Tunnel fitout	8. Tunnel fitout	VIC_08	Deliveries	♦	♦	♦	♦
			Laydown areas	♦			
Tunnel commission and site rehabilitation	9. Restore site	VIC_09	Decommission site	♦			

Notes:
1. Appendix E describes the modelled plant for each activity
2. Day Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
   Day Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
   Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
   Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday
3. Spoil haulage off the construction support site would occur during standard construction hours. OOHW spoil handling would occur inside acoustic shed.

5.3.1.5 Concurrent and consecutive construction projects

The nearest construction works associated with this project are the Rozelle Rail Yards construction support site, about one kilometre south of this site, and the White Bay construction support site, around 1.3 kilometres east of this site.

The nearest construction support sites associated with another major infrastructure project is the Iron Cove construction site for the M4-M5 Link, about 200 metres north-west of this site. Additionally, the M4-M5 Link Rozelle works area is located about 900 metres south-east of this site, and the M4-M5 Link construction support site at White Bay is located about 1 kilometre south-east of this site.

Due to the distance to the Rozelle Rail Yards construction support site, the M4-M5 Link Rozelle works area, and the construction activities in White Bay associated with the project, the M4-M5 Link and the Sydney Metro City & Southwest along with the level of noise emissions expected from these construction activities, concurrent and consecutive noise impacts on receivers nearby to the Victoria Road construction support site is unlikely from these construction activities.

5.3.1.6 Construction assessment scenarios

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant assumed to be operating during the stage. It is assumed that all the equipment/plant operate simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

Multiple activities would occasionally occur concurrently within the one construction support site and where this could reasonably occur it has been captured in the assessment as shown in Appendix E.

5.3.1.7 Summary of assumed noise treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods in accordance with the standard measures outlined in the CNVG (Appendix G) have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating to assist in attenuating and managing noise emissions from the construction activities.

Identified feasible and reasonable noise treatment measures have been included in the noise modelling and are presented in Table 5-23. The results presented in this assessment are based on these noise treatments and management measures being implemented. The locations of physical noise treatment measures are shown on Figure 5-4.

Table 5-23 – Assumed noise treatment and management measures – Victoria Road construction support site

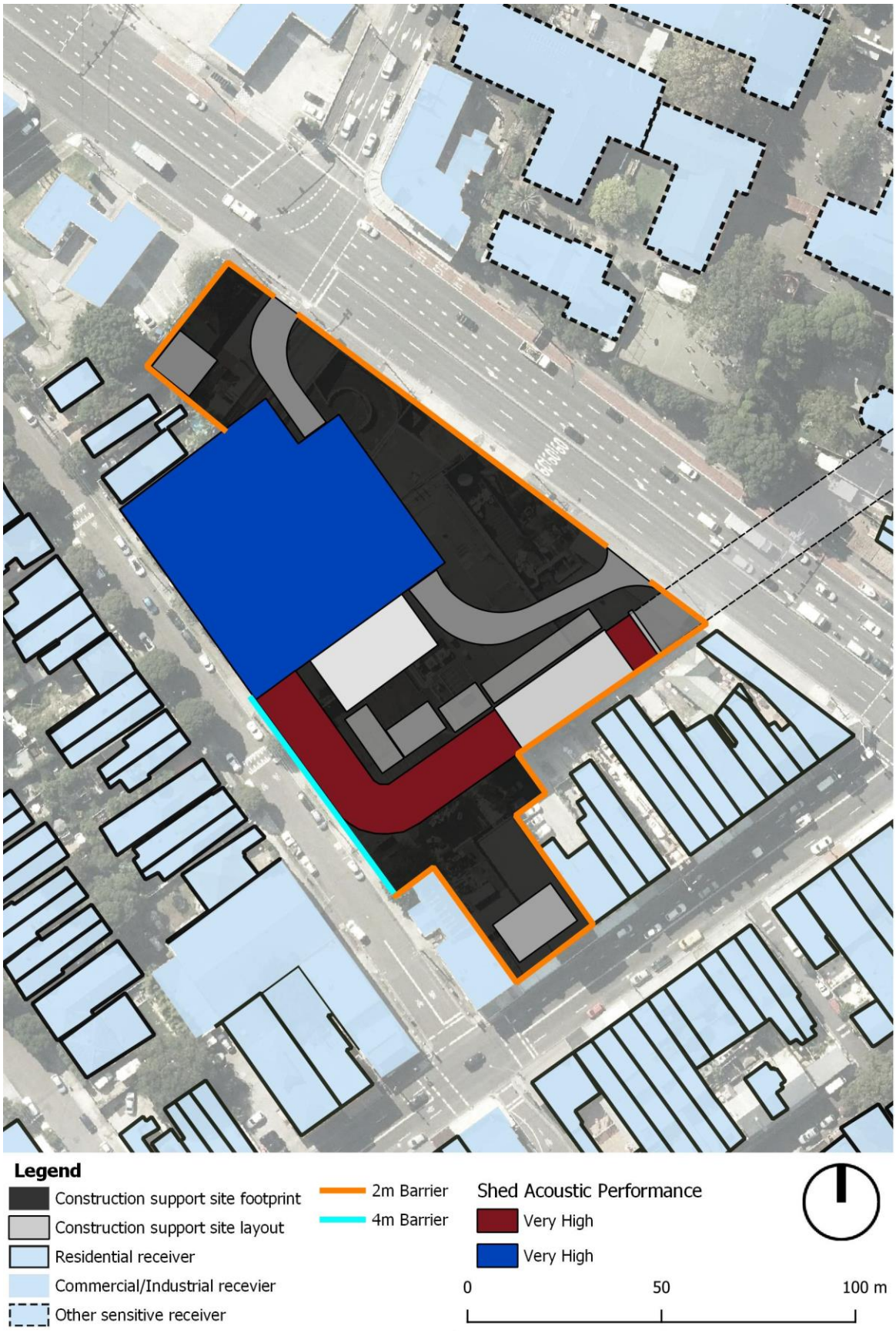
Activity or plant/equipment	Management and noise treatment measures applied
Tunnelling, support and fitout: acoustic shed	A very high performance acoustic shed would be built to reduce noise from tunnelling, support and fitout works outside standard construction hours. Performance requirements for individual elements of the acoustic shed are presented in Table 5-24.
Tunnelling, support and fitout: covered decline	The decline would be covered with very high performance acoustic cover to reduce noise from tunnelling, support and fitout works outside standard construction hours. Performance requirements for individual elements of the acoustic shed are presented in Table 5-24.
Wastewater treatment plant	The wastewater treatment plant would be acoustically treated or placed in an acoustic enclosure to achieve a total sound power level of 85 dB(A).
Substation	The substation is to achieve a total sound power level of 80 dB(A), which may require acoustic treatment or the use of an acoustic enclosure.
Ventilation plant	Plant items would be selected or acoustically treated to achieve a maximum combined sound power level of 82 dB(A). Three ventilation plant were assumed in the model.
Work outside standard hours	Work would only occur outside standard hours where it: • Meets the relevant NMLs • Occurs in an acoustic enclosure • Is required for safety reasons, or • Needs to occur outside standard construction hours to maintain the operational integrity of the road network.
Noise barriers	Noise barriers with various heights (two to four metres) would be installed around the site to reduce noise levels at sensitive receivers. Indicative locations and heights of barriers are shown in Figure 5-4.

Table 5-24 – Indicative acoustic shed construction and acoustic performance – Victoria Road construction support site

Shed / decline element (Indicative example constructions are shown in Table 4-1)	Octave band frequency transmission loss, dB						
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Acoustic shed (very high performance)							
North/west walls – Very high performance	35	36	41	49	55	63	72
South/east walls – Very high performance	25	31	40	49	61	69	75
Roof – Very high performance	23	31	40	49	56	58	63
Decline cover (very high performance)							
Walls – High performance	10	29	35	42	46	51	57
Roof – Very high performance	25	31	40	49	61	69	75

Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

Figure 5-4 – Construction support site layout with indicative noise treatment measures at Victoria Road



5.3.2 Construction airborne noise

5.3.2.1 Nearby receiver summary and objectives

Table 5-25 presents NMLs and screening levels for assessing sleep disturbance impacts, for the nearest residential receivers around the Victoria Road construction support site. Noise management levels for other (non-residential) noise-sensitive receivers are presented in section 3.4.1.

Table 5-25 – Construction noise management levels and screening levels at residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
4.4	62	57	57	50	60
4.5	62	57	57	50	60
5.2	59	54	51	42	52
5.3	59	54	51	42	52
6.1	73	68	63	48	58
6.2	73	68	63	48	58
6.3	73	68	63	48	58
6.4	73	68	63	48	58
6.5	73	68	63	48	58
7.1	53	48	46	39	49
7.2	53	48	46	39	49
8.1	52	47	47	43	53
9.2	59	54	54	51	61
11.5	50	45	45	42	52

5.3.2.2 Predicted noise impacts

Table 5-26 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-26 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

Model results present the range of the highest predicted noise levels for each NCA for residential receiver buildings, commercial and OSRs, unless no receiver buildings of that type in that NCA are expected to exceed NMLs. The range is of noise impacts throughout all receiver buildings in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented. The noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest early works, site establishment and longer-term tunnelling stages are shown in Appendix H.

5.3.2.3 Residential

Predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-27: for standard construction hours
- Table 5-28: for works outside of standard construction hours.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-29. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-27 – Predicted construction noise levels – standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Victoria Road construction support site

NCA	Noise Management Level		Predicted noise level at each construction stage[2]								
	HNA	NML	VIC_01	VIC_02	VIC_03	VIC_04	VIC_05	VIC_06	VIC_07	VIC_08	VIC_09
4.4	75	62	≤ 41	38 - 45	< 35	≤ 40	37 - 43	< 35	< 35	< 35	35 - 41
4.5	75	62	≤ 43	37 - 43	< 35	≤ 37	≤ 40	< 35	< 35	< 35	≤ 43
5.2	75	59	≤ 50	≤ 52	≤ 39	≤ 42	≤ 41	≤ 35	≤ 36	< 35	≤ 50
5.3	75	59	≤ 42	35 - 46	≤ 37	≤ 44	≤ 45	< 35	< 35	< 35	≤ 43
6.1	75	73	39 - **80**	43 - **93**	≤ 72	37 - 72	40 - **86**	≤ 64	≤ 66	≤ 66	39 - **78**
6.2	75	73	37 - 70	40 - 67	≤ 55	≤ 58	36 - 66	≤ 53	≤ 50	≤ 51	37 - 68
6.3	75	73	≤ **76**	38 - **79**	≤ 63	≤ 64	35 - 72	≤ 58	≤ 62	≤ 59	≤ 74
6.4	75	73	≤ 73	35 - 73	≤ 58	≤ 62	≤ 63	≤ 58	≤ 54	≤ 47	≤ 66
6.5	75	73	48 - **80**	51 - 73	39 - 59	46 - **78**	45 - 64	37 - 64	≤ 53	≤ 46	46 - 74
7.1	75	53	36 - **77**	40 - **83**	≤ 67	≤ **76**	37 - 74	≤ 70	≤ 59	≤ 55	36 - 69
7.2	75	53	41 - 61	44 - 61	≤ 48	40 - 53	38 - 51	≤ 47	≤ 37	< 35	39 - 61
8.1	75	52	≤ 47	≤ 54	≤ 43	≤ 48	≤ 53	≤ 39	≤ 39	≤ 37	≤ 45
9.2	75	59	≤ 37	36 - 42	< 35	≤ 38	≤ 45	< 35	< 35	< 35	≤ 36
11.5	75	50	≤ 41	≤ 50	≤ 43	≤ 46	≤ 53	≤ 36	≤ 36	< 35	≤ 42

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: **Light blue** is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-28 – Predicted construction noise levels – outside standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Victoria Road construction support site

NCA	Noise Management Level				Predicted noise level at each construction stage[3]								
	HNA	Day (O)	Eve	Night	VIC_01[1]	VIC_02[1]	VIC_03[1]	VIC_04[1]	VIC_05[1]	VIC_06[1]	VIC_07	VIC_08	VIC_09[1]
4.4	75	57	57	50	-	-	-	-	-	-	< 35	< 35	-
4.5	75	57	57	50	-	-	-	-	-	-	< 35	< 35	-
5.2	75	54	51	42	-	-	-	-	-	-	< 35	< 35	-
5.3	75	54	51	42	-	-	-	-	-	-	< 35	< 35	-
6.1	75	68	63	48	-	-	-	-	-	-	≤ 46	≤ 40	-
6.2	75	68	63	48	-	-	-	-	-	-	< 35	< 35	-
6.3	75	68	63	48	-	-	-	-	-	-	≤ 35	< 35	-
6.4	75	68	63	48	-	-	-	-	-	-	< 35	< 35	-
6.5	75	68	63	48	-	-	-	-	-	-	≤ 44	≤ 43	-
7.1	75	48	46	39	-	-	-	-	-	-	≤ 42	< 35	-
7.2	75	48	46	39	-	-	-	-	-	-	< 35	< 35	-
8.1	75	47	47	43	-	-	-	-	-	-	< 35	< 35	-
9.2	75	54	54	51	-	-	-	-	-	-	< 35	< 35	-
11.5	75	45	45	42	-	-	-	-	-	-	< 35	< 35	-

Notes:
1. No work is proposed outside standard construction hours.
2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-29 – Number of receiver buildings over the NML (all NCAs) – residential receivers – Victoria Road construction support site

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours	Outside standard hours																	
		L_{Aeq}	L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Early works	VIC_01[1]	27	-	109	14	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Site establishment	VIC_02[1]	22	-	163	33	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Establishment of construction facilities	VIC_03[1]	0	-	21	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Piling for decline and acoustic shed	VIC_04[1]	3	-	40	14	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Surface level decline construction	VIC_05[1]	10	-	41	23	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Acoustic shed construction	VIC_06[1]	0	-	17	8	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Tunnel construction	VIC_07	0	0	11	0	0	0	0	0	0	0	0	0	0	3	0	0	0	142	26
8. Tunnel fitout	VIC_08	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	210	21
9. Tunnel commission and site rehabilitation	VIC_09[1]	5	-	101	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-26

5.3.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted levels occur during early works and site establishment works (VIC_01 and VIC_02). During these stages up to 27 receiver buildings, which are located in NCAs 6.3, 6.5 and 7.1, are expected to be highly noise affected (ie. >75 dB(A)) and up to 208 residential receiver buildings are predicted to be noise affected (ie. > NML). This is due to the use of excavators with rock hammers required during the site establishment stage. When rock hammers are not in use, noise impacts are predicted to reduce by up to 8 dB(A).

During other stages, up to 138 receiver buildings in NCAs 6.1, 6.3, 6.5, 7.1,7.2, 8.1 and 11.5 are predicted to potentially be noise affected (ie. > NML). The highest number of noise affected receiver buildings during standard construction hours result from demolition works as part of early works (VIC_01). It is noted that the longest duration works, being tunnel construction and tunnel fitout are predicted to have low noise impact, with minimal noise affected receiver buildings (up to 11).

Work outside of standard construction hours

Due to 24 hour tunnelling requirements, some works are likely to be completed outside of standard construction hours. At the Victoria Road construction support site, key stages requiring OOHW are:

- Stage 7 (VIC_07): Tunnelling – tunnel construction
- Stage 8 (VIC_08): Tunnelling – tunnel fitout.

Night time tunnel construction (VIC_07) works are expected to result in residual noise impacts at the three residential receiver buildings in NCA 7.1, where noise is predicted to exceed the night NML by 1-3 dB(A).

These residual impacts are due to delivery activities. The predicted noise levels are based on all plant operating simultaneously and continuously during each assessment activity.

During the longer-term tunnel fitout night works (VIC_08) no residential receiver buildings would be noise affected during OOHW.

The predicted noise levels are based on all plant operating simultaneously and continuously during each assessment activity. However, in practice not all plant would typically operate all the time, meaning that for a substantial part of the time actual noise levels would likely be less than predicted.

Sleep disturbance

At the Victoria Road construction support site, key OOHW stages which potentially include activities with maximum noise levels (L_{Amax}) are:

- Stage 7 (VIC_07): Tunnel construction – night time concrete agitator delivery
- Stage 8 (VIC_08): Tunnel fitout – night time heavy vehicle deliveries.

During tunnelling (VIC_07) works, the following results are predicted:

- Concrete or delivery heavy vehicles are predicted to result in high maximum noise levels when arriving or departing the site. Up to 142 receiver buildings would potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 81 dB(A)). Of those, maximum noise levels at 26 receiver buildings are predicted to exceed the awakening reaction level
- Since the number of heavy vehicle movements generated by the site is not substantial compared to existing traffic numbers on Victoria Road, sleep disturbance impacts are not likely to occur from heavy vehicle movements to and from the site at night.

During tunnel fitout works (VIC_08) the following results are predicted:

- Delivery heavy vehicles are predicted to result in high maximum noise levels. Up to 210 receiver buildings would potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 73 dB(A)). Of those, maximum noise levels at 21 receiver buildings are predicted to exceed the awakening reactions noise levels
- Only one delivery heavy vehicle per hour is expected to deliver materials during tunnel fitout works. While predicted L_{Amax}, noise levels are greater than the screening levels, substantial sleep disturbance impacts are not likely to occur from the limited number of deliveries at night.

5.3.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-30. The receiver buildings predicted to exceed the NMLs are summarised in Table 5-31. The predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-30 – Predicted construction noise levels – other sensitive receivers, dB(A) – Victoria Road construction support site

Receiver type	NCA	Noise management level		Predicted noise levels at each construction stage[2]								
		HNA	NML	VIC_01	VIC_02	VIC_03	VIC_04	VIC_05	VIC_06	VIC_07	VIC_08	VIC_09
Commercial	4.4	75	70	≤ 40	≤ 40	< 35	≤ 36	≤ 39	< 35	< 35	< 35	≤ 40
	4.5	75	70	36 - 45	40 - 42	< 35	35 - 37	36 - 40	< 35	< 35	< 35	37 - 45
	5.2	75	70	36 - 53	39 - 52	≤ 40	37 - 44	35 - 43	≤ 36	≤ 39	< 35	37 - 50
	6.1	75	70	42 - 50	43 - 54	≤ 42	38 - 48	42 - 51	≤ 38	≤ 39	≤ 36	42 - 50
	6.2	75	70	42 - 72	44 - 70	≤ 52	37 - 60	41 - 54	≤ 54	≤ 51	≤ 46	42 - 67
	6.3	75	70	≤ 82	≤ 79	≤ 64	≤ 69	≤ 63	≤ 63	≤ 61	≤ 54	≤ 77
	6.4	75	70	45 - 72	47 - 74	37 - 58	43 - 64	43 - 64	≤ 60	≤ 53	≤ 46	45 - 67
	6.5	75	70	63 - 77	60 - 79	52 - 63	61 - 66	57 - 72	49 - 61	42 - 54	37 - 48	63 - 76
	7.2	75	75	≤ 44	≤ 48	≤ 36	≤ 42	≤ 40	< 35	< 35	< 35	≤ 41
Childcare	5.2	75	50	42 - 45	45 - 46	< 35	37 - 37	< 35	< 35	< 35	< 35	39 - 41
	6.2	75	50	≤ 61	≤ 57	≤ 46	≤ 52	≤ 51	≤ 44	≤ 44	≤ 40	≤ 52
	6.3	75	50	≤ 48	≤ 57	≤ 37	≤ 53	≤ 44	≤ 45	≤ 35	< 35	≤ 49
	7.1	75	50	≤ 47	≤ 50	≤ 39	≤ 43	≤ 42	< 35	≤ 36	< 35	≤ 42
Educational	6.3	75	55	≤ 83	≤ 80	≤ 65	≤ 69	≤ 71	≤ 63	≤ 63	≤ 57	≤ 81
	6.4	75	55	≤ 43	≤ 47	≤ 37	≤ 42	≤ 40	< 35	< 35	< 35	≤ 40
Other sensitive receiver	7.1	75	60	43 - 49	47 - 52	36 - 41	45 - 47	≤ 39	≤ 36	≤ 35	43 - 48	43 - 49
	8.1	75	60	≤ 42	≤ 48	≤ 38	≤ 47	≤ 35	< 35	< 35	≤ 43	≤ 42
Recreational	7.1	75	65	43 - 54	47 - 57	35 - 42	41 - 44	≤ 39	≤ 40	≤ 36	41 - 50	43 - 54
	7.2	75	65	46 - 48	46 - 51	≤ 38	≤ 38	≤ 35	< 35	< 35	37 - 45	46 - 48
Place of worship	4.4	75	55	38 - 40	41 - 42	< 35	42 - 44	< 35	< 35	< 35	38 - 40	38 - 40
	6.2	75	55	54 - 64	52 - 55	40 - 43	46 - 49	39 - 39	39 - 41	36 - 38	50 - 64	54 - 64
	6.3	75	55	≤ 76	≤ 77	≤ 63	≤ 72	≤ 59	≤ 62	≤ 59	≤ 71	≤ 76

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-31 – Number of other sensitive receivers over the noise management levels (all NCAs) – Victoria Road construction support site

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1,2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Early works	**VIC_01**	5	1	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0
2. Site establishment	**VIC_02**	7	0	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0	0
3. Establishment of construction facilities	**VIC_03**	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
4. Piling for decline and acoustic shed	**VIC_04**	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0
5. Surface level decline construction	**VIC_05**	2	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0
6. Acoustic shed construction	**VIC_06**	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
7. Tunnel construction	**VIC_07**	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
8. Tunnel fitout	**VIC_08**	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
9. Tunnel commission and site rehabilitation	**VIC_09**	2	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receiver buildings have been assessed against the respective NMLs, and exceedances have been presented in the count table.

2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

The highest predicted noise levels for non-residential receiver buildings occur during early works, site establishment and site rehabilitation (VIC_01, VIC_02 and VIC_09) works. During all stages, up to thirteen non-residential receiver buildings in NCAs 6.2, 6.3, 6.4 and 6.5 are predicted to be potentially noise affected (ie. > NML). The highest number of noise affected non-residential receiver buildings result from site establishment demolition works.

The predicted noise levels at these non-residential receiver buildings are based on a reasonable worst-case where all activities in each stage are occurring concurrently. However, actual noise levels would typically vary and be less than those predicted for most of the time in each stage.

Construction noise impacts to non-residential receiver buildings would be managed through the CNVMP prepared as part of detailed design.

5.3.2.6 Summary of residual impacts and additional mitigation measures

Table 5-29 indicates the number of residential buildings where noise impacts are expected to exceed the NMLs after the implementation of noise treatments and management measures.

Further acoustic mitigation and management measures, as outlined in the standard ICNG mitigation measures included in Appendix G, would be confirmed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures in accordance with the CNVG and presented in section 6.10.1 are to be provided to manage construction noise impacts.

5.3.2.7 Cumulative and consecutive construction noise impacts

Construction works at the Victoria Road construction support site may overlap with construction site at Iron Cove for the approved M4-M5 Link. As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the Victoria Road construction support site would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-32. Timelines have been based on the relevant environmental impact statement documentation.

Table 5-32 – Concurrent construction works near the Victoria Road construction support site

Project	2019	2020	2021	2022	2023	2024	2025
Victoria Road construction support site (VIC)							
Other major infrastructure projects							
Iron Cove (M4-M5 Link)							

Proposed staging of concurrent work and noise impacts at the closest receiver buildings to the Victoria Road construction support site have been reviewed. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

If noise from one site dominates noise levels at the receiver (ie. > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

If noise levels from each site are similar at a receiver, a total construction noise increase of up to 3 dB(A) is expected. Two representative NCAs adjacent to the works have been assessed in Table 5-33.

Table 5-33 – Potential cumulative noise impacts from construction projects near Victoria Road

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 6.5	Standard hours NML73 dB(A)	VIC	1) Early works	48-80	For both early works (Stage 1) and piling (Stage 2) there could be up to 3 dB(A) increase at some nearby receivers in the case that M4-M5 Link cover / portals construction activities occur concurrently.
			2) Piling	46-78	
		M4-M5 Link[1]	Cut and cover / portals	≤77	
	OOHW NML D/E/N 68/63/48	VIC	1) Tunnelling	≤44	If construction works occur concurrently then M4-M5 Link construction noise levels would likely dominate during the activity. During the activity construction noise levels from the Victoria Road construction support site (VIC) are predicted to achieve the NML.
			2) Tunnel fitout	≤43	
		M4-M5 Link[1]	Cut and cover / portals	≤77	
NCA 7.1	Standard hours NML 53 dB(A)	VIC	1) Establish site	40-83	For both early works (Stage 1) and piling (Stage 2) the Victoria Road construction support site, the M4-M5 Link construction noise levels would likely dominate at nearby receivers. However, both sets of works are predicted to be above the NML at some receivers.
			2) Piling	≤76	
		M4-M5 Link[1]	Cut and cover / portals	≤82	
	OOHW NML D/E/N 48/46/39	VIC	1) Tunnelling	≤42	If construction works occur concurrently then M4-M5 Link construction noise levels would likely dominate during the activity. Construction noise from the Victoria Road construction support site are predicted to achieve the NML.
			2) Tunnel fitout	<35	
		M4-M5 Link[1]	Cut and cover / portals	≤82	

Notes: 1. Refer to M4-M5 Link environmental impact statement documentation.

At receiver buildings not directly adjacent to the Victoria Road construction support site, there is potential for cumulative increases of construction noise from concurrent works with the M4-M5 Link Iron Cove site.

At some receiver locations, when an individual site does not dominate construction noise levels at the receiver (ie. it does not contribute more than 5 dB(A) more noise than other sites), cumulative construction noise levels are predicted to be up to 3 dB(A) higher than the noise levels predicted for any one activity.

Any increase due to cumulative noise is unlikely as noise generating activities would need to occur simultaneously. However, even where a cumulative construction noise increase is predicted, the total construction noise level at that receiver is expected to be below the NML. As such, mitigation and management of construction noise at the Victoria Road construction support site is expected to sufficiently manage cumulative impacts at nearby receiver buildings.

Potential cumulative and consecutive construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. These mitigation measures would be included in the site's detailed design and site specific CNVIS, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures and would be carried out in coordination with the construction contractors of the approved M4-M5 Link where required to ensure all interfaces are effectively managed.

5.3.3 Construction-related road traffic noise assessment

Vehicle access to the Victoria Road construction support site would be directly from the northbound lanes of Victoria Road. To exit, heavy vehicles would turn right out of the site and travel south along Victoria Road before heading west along the City West Link.

Table 5-34 presents the forecasted vehicle numbers during the peak construction period at this construction support site. Up to 18 trucks would access the site per hour during the daytime period (7.00am to 10.00pm) and a maximum of one truck per hour (no more than 5 trucks in total) in the night time period (10.00pm to 7.00am) which would typically be concrete deliveries to support tunnelling.

Table 5-34 – Number of construction vehicles accessing the Victoria Road construction support site

Type of vehicle	Day[1] over 15 hours[3,4]	Night[2] over nine hours[3,4]
Heavy vehicle (deliveries, spoil haulage and concrete deliveries)	205	5
Light vehicle	91	24

Notes:
1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am
3. Numbers presented are individual vehicles, not vehicle movements
4. Vehicle numbers have been distributed onto the local road network based on the proposed access roads. Where a vehicle accesses the site by one road and leaves by another, one vehicle movement is counted along each road once. Where a vehicle accesses and leaves the site by the same road, two vehicle movements are counted on that road.

Table 5-35 – Road traffic noise impacts from the Victoria Road construction support site

Construction vehicle access road	Road type	Time of day	Predicted road traffic noise increase, dB(A)[1, 2]	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level
Victoria Road	Arterial	Day $L_{Aeq(15hr)}$	<0.5	No	N/A
		Night $L_{Aeq(9hr)}$	<0.5	No	Yes

Notes: 1. Predicted road traffic noise levels are based on the loudest heavy vehicle

2. Predicted road traffic noise levels are based on the nearest residential receiver to the road. Receiver buildings further distances are expected to experience lower noise levels than those predicted.

Road traffic noise levels at receiver buildings directly exposed to traffic noise from Victoria Road are predicted to potentially increase by less than 0.5 dB(A) during day and night periods as a result of the site's construction traffic. The highest increase is predicted to occur during tunnelling works (VIC_07). Therefore, road traffic noise levels are not predicted to increase by more than 2 dB(A) and so is considered a minor impact.

Maximum noise levels (L_{Amax}) from night period heavy vehicle movements have been predicted to exceed both the sleep disturbance screening level and the adopted awakening reaction level at receiver buildings along Victoria Road. Since the night time heavy vehicle movements from this site would be limited to one vehicle per hour, and Victoria Road has relatively high existing night time heavy vehicle movements, it is unlikely there would be a substantial increase in the number of maximum noise events at nearby receiver buildings.

5.3.3.1 Total increase in traffic noise levels on Victoria Road

The M4-M5 Link environmental impact statement identifies for both the Iron Cove construction site (C8) and the Victoria Road civil site (C7) that the maximum daily construction vehicles at each site during construction works would be 42 heavy vehicles and 140 light vehicles.

Combining these with the traffic movements assessed in Table 5-35 results, the predicted traffic noise level increase remains less than 0.5 dB(A) during day and night periods on Victoria Road.

Assessment of this traffic cumulatively with other nearby major infrastructure projects once it moves onto City West Link at Rozelle is presented in section 5.2.3.1.

5.3.3.2 Mitigation and management

Mitigation and management measures for construction related traffic noise impacts are outlined in section 6.7. To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the site specific CNVIS and project CNVMP would include the following:

- Where feasible and reasonable, heavy vehicle movements would occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive periods and limited to one heavy vehicle per hour during the night

- All drivers would be trained in the Heavy Vehicle Code of Conduct, including noise management methods such as limiting of compression braking.

5.3.4 Ground-borne construction noise

Ground-borne noise impacts could result from the construction of the access decline tunnel between the Victoria Road construction support site and the mainline tunnel alignment. The numbers of receiver buildings predicted to be potentially impacted by ground-borne noise are presented in Table 5-36.

Table 5-36 – Number of receiver buildings affected by ground-borne noise from Victoria Road construction support site access decline tunnel

NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML[1,2])				
	Residential			Other sensitive receivers	Commercial/ industrial receivers
	> 35[1] to ≤ 40 dB(A)	> 40[2] to ≤ 45 dB(A)	>45 dB(A)		
6.1	4	3	1	-	-
6.2	2	-	-	-	-
6.3	-	3	-	-	-

Notes: 1. Night ground-borne noise management level (GBNML)
2. Evening ground-borne noise management level (GBNML).

Table 5-36 indicates that 13 residential receiver buildings are identified as potentially being impacted by ground-borne noise levels above the strictest NML (ie. night time 35 dB(A)). Locations of receiver buildings that are predicted to be affected by ground-borne noise are presented in Appendix J.3. As such, the access decline tunnel construction would be managed by restricting the construction hours that tunnelling could be carried out to minimise impacts during more sensitive periods (eg. night), or if justified, in accordance with section 6.10.2. The extent of mitigation and management required to limit potential ground-borne noise impacts to receiver buildings would be determined by looking not only at the level of noise impact, but also the duration that receiver buildings are likely to be exposed to ground-borne noise levels above the NML.

If verification monitoring conducted during tunnelling determines that ground-borne noise levels inside residential receiver buildings are below the predicted noise levels and comply with ground-borne noise management levels, tunnel construction may be extended outside standard hours. Detailed noise mitigation and management measures would be reviewed during detailed design.

Ground-borne noise levels could be generated by vibration-intensive works as part of the construction support site. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts of ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

5.3.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity. The major stages that would include vibration-intensive works would be:

- Stage 1 (VIC_01): Early works
- Stage 3 (VIC_03): Establishment of construction facilities
- Stage 4 (VIC_04): Piling acoustic shed
- Stage 5 (VIC_05): Decline excavation and construction.

The proposed vibration-intensive plant items are identified in Appendix E, with the minimum working distances for a range of plant presented in Table 4-11. Presented in Appendix L are the estimated minimum working distances from the works construction support site for both cosmetic damage and human response to vibration, for the most vibration-intensive activity proposed for the construction support site, which is likely to be the use of a large rock hammer during the site establishment stages (VIC_01, VIC_03 and VIC_05). This is the basis of the assessment and receiver building counts presented in Table 5-37.

Potential vibration from this project, experienced by receivers, would be dependent on vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. The assessment presented in this study considers a worst-case scenario where the proposed vibration-intensive plant items could be used anywhere within the boundaries of the site. However, this is unlikely to occur, and the location of vibration-intensive equipment would be confirmed during detailed design.

Table 5-37 – Number of receiver buildings within nominated minimum working distance for vibration impacts – Victoria Road construction support site

NCA	Number of structures within minimum working distances		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Access decline tunnel			
6.1	0	0	1
Construction support site			
6.1	-	19	34
6.2	-	-	2
6.3	-	-	8
6.4	-	-	3
6.5	-	3	6
7.1	1	16	59

For the access decline construction, due to the tunnel depth there are no structures that are identified within the minimum working distances presented in section 4.4.1 for roadheader tunnelling for either cosmetic damage or human response screening levels. As such, vibration impacts above the screening

levels from the access decline tunnel construction works are unlikely, but would be reviewed during detailed design considering final tunnel design and construction methodology.

5.3.5.1 Cosmetic damage

The most vibration affected NCA is predicted to be NCA 6.1. In this NCA 19 buildings have been identified within the minimum working distances for cosmetic damage, as presented in Table 4-11.

Site-specific buffer distances for vibration-intensive activities (eg. compaction, rock hammering) would be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see Table 4-11). Site-specific buffer distances would then be maintained in order to comply with relevant vibration limits for cosmetic damage.

5.3.5.2 Heritage listed structures

One heritage item has been identified within the unsound structure cosmetic damage minimum working distance as shown in Appendix L, and is identified in Table 5-38.

Refer to the Technical working paper: Cultural heritage assessment report and Technical working paper: Non-Aboriginal heritage for the assessment of impacts to heritage items.

Table 5-38 – Heritage receivers within the cosmetic damage minimum working distance – Victoria Road

Name	Significance	Type/Classification	Site Heritage ID
Former police station, including interiors	Local	Item – General	I747

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.3.5.3 Human response

Due to the limited duration that the rock hammer would be operating at this site; the risk of annoyance is considered low. However, occupants of up to 59 receiver buildings in NCA 7.1 are predicted to be exposed to vibration levels above the human response level, as presented in Table 4-11.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures would be provided (see section 6.10.3).

5.4 White Bay construction support site

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the White Bay construction support site.

5.4.1 Construction support site overview

5.4.1.1 Construction support site description

The site is located on White Bay at Rozelle. Works at the site are proposed to occur in the stages presented in Table 5-39.

Table 5-39 – White Bay construction support site – major stage activities overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Early works	Connect services at the site such as electricity, sewerage and water
	2. Establish site	Install environmental controls
	3. Establishment of construction facilities	Establish site offices and workshops
Construction of wharf structure	4. Piling for the wharf structure	Piling for the wharf structure
Casting of immersed tube tunnel elements	5. Substructure - construction and placement	Immersed tube tunnel precast facility - concrete pours, deliveries to site
	6. Substructure - immersed tube tunnel production	Assemble and fitout immersed tube tunnel
Spoil handling and treatment	7. Spoil handling	Tunnel and dredged spoil handling and associated deliveries
Site rehabilitation	8. Restore site	Commission tunnel, decommission site and restore site

5.4.1.2 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-40, subject to project approval. This construction support site would operate from mid 2021 until late 2025. The longest duration activities at this construction support site would be spoil handling and treatment.

Table 5-40 – White Bay construction support site – indicative program and timeline

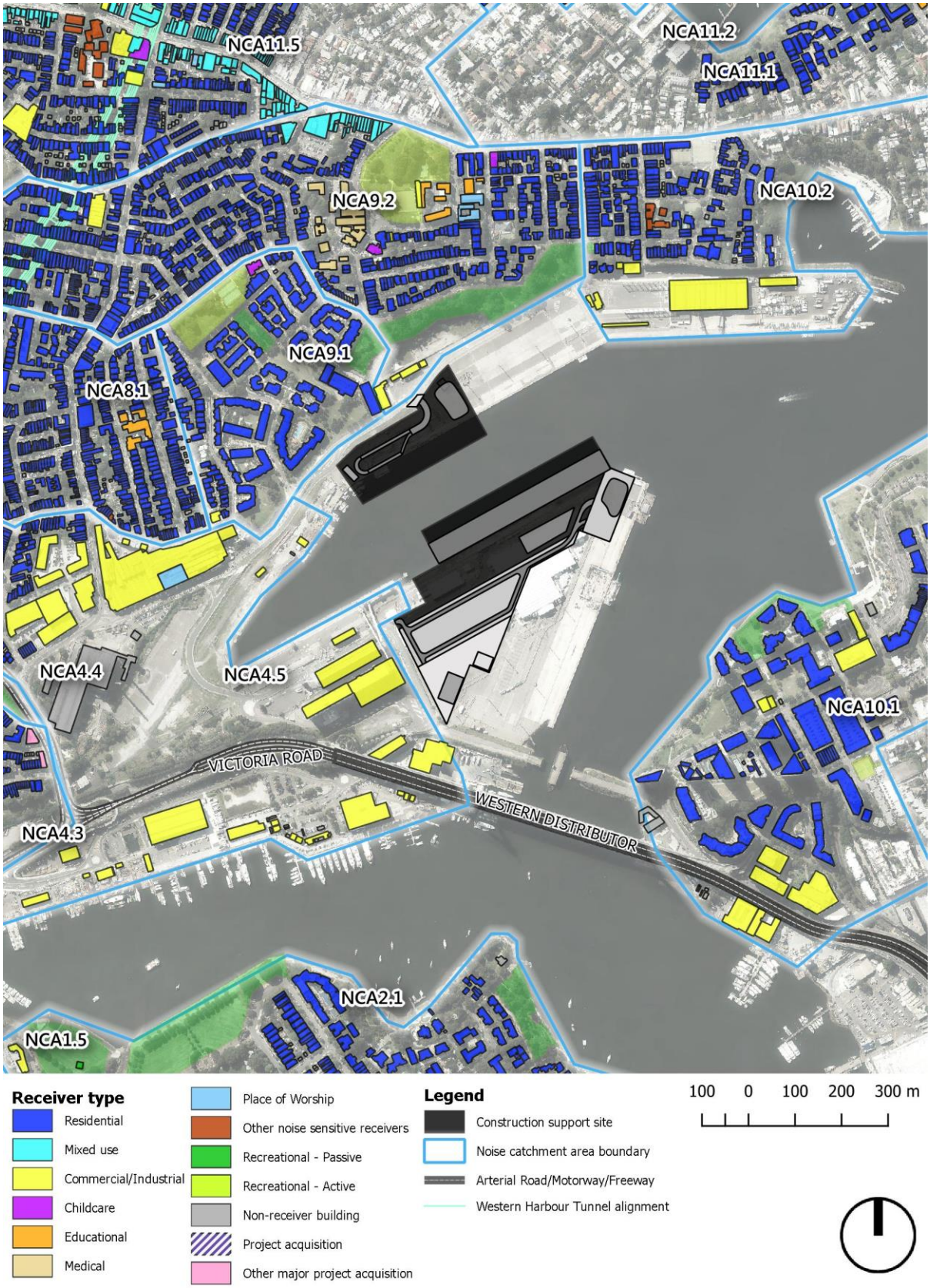
Stage	Construction activity	Reference	Indicative construction timeframe																	
			2021				2022				2023				2024				2025			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1. Early works	WHB_01																				
	2. Establish site	WHB_02																				
	3. Establishment of construction facilities	WHB_03																				
Construction of wharf structure	4. Piling for the wharf structure	WHB_04																				
Casting of immersed tube tunnel units	5. Substructure - construction and placement	WHB_05																				
	6. Substructure - immersed tube tunnel production	WHB_06																				
Spoil handling and treatment, and support deliveries	7. Spoil handling	WHB_07																				
Site rehabilitation	8. Restore site	WHB_08																				

5.4.1.3 Nearby noise and vibration-sensitive receivers

The site is located on White Bay at Rozelle. It is surrounded by a mix of commercial, industrial and residential receivers.

The location of the site, nearby NCAs and receiver locations are shown in Figure 5-5.

Figure 5-5 – Location of White Bay construction support site



5.4.1.4 Construction duration and working hours

Table 5-41 presents each of the major stages that have been assessed along with the representative activities that would take place during the stage for the White Bay construction support site, along with the proposed time periods for each activity.

During the operation of the White Bay construction support site, work would typically take place during standard construction hours, as presented in Table 3-2. However, some OOHW would take place outside standard construction hours, as presented in Table 5-41.

In particular, support of Yurulbin and Berrys Bay construction support sites would be required to occur 24 hours per day, seven days per week. Further justification for out of hours work is provided in section 5.1.3.

Table 5-41 – White Bay construction support site – construction hours

Stage	Representative activity		Reference	Assessed activities[1]	Work hours[2]			
					Day (Standard)	Day (OOHW)	Evening	Night
Site establishment	1.	Early works	WHB_01	Utility works	♦			
	2.	Establish site	WHB_02	Install environmental controls	♦			
	3.	Establishment of construction facilities	WHB_03	Establish construction facilities (site offices and workshops)	♦			
Construction of wharf structure	4.	Piling for wharf structure	WHB_04	Piling for wharf structure	♦			
Casting of immersed tube tunnel elements	5.	Tunnel element production	WHB_05a	Concrete pours, bulkheads/ballast production	♦			
			WHB_05b	Material deliveries	♦			
	6.	Tunnel element fitout	WHB_06	Assemble and fitout immersed tube tunnel	♦			
Spoil handling and treatment; and support deliveries	7.	Spoil handling and treatment	WHB_07a	Dredged spoil handling (White Bay north)	♦			
				Tunnel spoil handling (Glebe Island)	♦			
			WHB_07b	Deliveries	♦			
	8.	Construction site deliveries	WHB_07c	Support Berrys Bay and Yurulbin construction support sites	♦	♦[3]	♦[3]	♦[3]
Site rehabilitation	9.	Restore site	WHB_08	Commission tunnel, decommission site and restore site	♦			

Notes: 1. Appendix E describes the modelled plant for each activity

2. Day Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday,
Day Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday.

3. Deliveries by barge to Yurulbin construction support site during this period

5.4.1.5 Concurrent and consecutive construction projects

The nearest construction support sites associated with this project the Rozelle Rail Yards construction support site, around 1 kilometre south-west of this site and the Victoria Road construction support site, around 1.3 kilometres west of this site.

The nearest construction support sites associated with another major infrastructure project are the construction support sites for the M4-M5 Link, with a construction support site located at White Bay adjacent to Port Access Road and other construction sites associated with the M4-M5 Link Rozelle works area, between 500 m to 1 kilometre south-west of this site.

Work at the site is expected to overlap with nearby M4-M5 Link construction support site at White Bay (C11). The M4-M5 Link project proposed to use part of the eastern end of White Bay as a construction site primarily to support heavy vehicle marshalling and construction workforce parking.

The other additional construction sites associated with major infrastructure projects that are likely to be carried out construction activities during similar time periods as the construction works associated with the project in the White Bay area include Sydney Metro City & Southwest for which construction activities at White Bay are to end in 2020, and Sydney Metro West for which additional project information is not currently available. Due to the distance to the Victoria Road construction support site and the construction activities for the M4-M5 Link at the Rozelle civil and tunnel site (C5), the Crescent civil site (C6) and the Victoria Road civil site (C7), and the level of noise emissions expected from these construction activities, consecutive noise impacts on noise sensitive receivers nearby to the White Bay construction support site is unlikely from these construction activities.

5.4.1.6 Construction assessment scenarios

The airborne noise assessment of the White Bay construction support site has been separated into eight stages. Each stage has been assessed against the work periods.

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant assumed to be operating during each stage. It is assumed that all equipment/plant operates simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

Multiple activities would occasionally occur concurrently within the one construction support site, and where this could reasonably occur it has been captured in the assessment as shown in Table 5-41.

5.4.1.7 Summary of assumed noise treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods in accordance with the standard measures outlined in the CNVG (Appendix G) were incorporated to assist in attenuating and managing noise emissions from construction activities. These feasible and reasonable noise treatment measures have been included in the noise model, based on the preliminary site layout and the reasonable worst-case plant/equipment operating.

No further physical noise treatment measures were identified to assist in reducing noise impacts below the NMLs at this site.

Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

5.4.2 Construction airborne noise

5.4.2.1 Nearby receiver summary and objectives

Table 5-42 presents NMLs and the screening levels for the assessment of sleep disturbance for the nearest residential receivers surrounding the White Bay construction support site. Noise management levels for other (non-residential) noise-sensitive receivers are presented in section 3.4.1.

Table 5-42 – Construction NMLs at residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance Screening levels
	Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work(OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
2.1	61	56	56	50	60
3.3	60	55	55	49	59
4.5	62	57	57	50	60
6.2	73	68	63	48	58
8.1	52	47	47	43	53
9.1	59	54	54	51	61
9.2	59	54	54	51	61
10.1	58	53	50	49	59
10.2	58	53	50	49	59
11.1	50	45	45	42	52
11.5	50	45	45	42	52

5.4.2.2 Predicted noise impacts

Table 5-43 provides a key to the cell shading and text formatting used to explain results in the following tables. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-43 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

Modelling results present the range of the highest predicted noise levels for each NCA for residential receiver buildings, commercial and OSRs, unless no receiver buildings of that type in that NCA are expected to exceed NMLs.

The range presented is of noise impacts throughout all receiver buildings in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented. The noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest early works and site establishment stages; and longer-term spoil handling and treatment stages are shown in Appendix H.

5.4.2.3 Residential

Predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-44: for standard construction hours
- Table 5-45: for works outside of standard construction hours.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-46. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-44 – Predicted construction noise levels – standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$ – White Bay construction support site

NCA	Noise Management Level		Predicted noise level at each construction stage[2]							
	HNA	NML	WHB_01	WHB_02	WHB_03	WHB_04	WHB_05	WHB_06	WHB_07	WHB_08
10.1	75	58	≤ 54	≤ 49	≤ 51	≤ 45	≤ 50	≤ 49	≤ 52	≤ 49
10.2	75	58	≤ 60	≤ 46	≤ 46	≤ 43	≤ 46	≤ 47	≤ 51	≤ 43
11.1	75	50	≤ 40	< 35	< 35	< 35	< 35	< 35	≤ 35	< 35
11.5	75	50	≤ 45	< 35	≤ 40	≤ 39	< 35	≤ 36	≤ 40	≤ 36
2.1	75	61	≤ 47	≤ 38	≤ 41	≤ 36	≤ 40	≤ 41	≤ 43	≤ 38
3.3	75	60	≤ 44	< 35	≤ 35	≤ 39	< 35	< 35	≤ 36	< 35
4.5	75	62	≤ 43	< 35	≤ 36	≤ 36	≤ 38	< 35	≤ 41	< 35
6.2	75	73	≤ 42	< 35	≤ 35	< 35	< 35	< 35≤ 39	≤ 37	< 35
8.1	75	52	≤ 55	≤ 42	≤ 47	≤ 47	≤ 43	≤ 38	≤ 47	≤ 43
9.1	75	59	36 - 75	≤ 66	≤ 62	≤ 59	≤ 50	≤ 40	≤ 62	≤ 57
9.2	75	59	≤ 67	≤ 51	≤ 51	≤ 47	≤ 47	< 35	≤ 54	≤ 46

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-45 – Predicted construction noise levels – outside standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$ – White Bay construction support site

NCA	Noise Management Level				Predicted noise level at each construction stage[3]							
	HNA	Day (O)	Eve	Night	WHB_01[1]	WHB_02[1]	WHB_03[1]	WHB_04[1]	WHB_05[1]	WHB_06	WHB_07[1]	WHB_08[1]
10.1	75	53	50	49	-	-	-	-	-	-	≤ 44	-
10.2	75	53	50	49	-	-	-	-	-	-	≤ 44	-
11.1	75	45	45	42	-	-	-	-	-	-	< 35	-
11.5	75	45	45	42	-	-	-	-	-	-	< 35	-
2.1	75	56	56	50	-	-	-	-	-	-	< 35	-
3.3	75	55	55	49	-	-	-	-	-	-	< 35	-
4.5	75	57	57	50	-	-	-	-	-	-	< 35	-
6.2	75	68	63	48	-	-	-	-	-	-	< 35	-
8.1	75	47	47	43	-	-	-	-	-	-	< 35	-
9.1	75	54	54	51	-	-	-	-	-	-	≤ 43	-
9.2	75	54	54	51	-	-	-	-	-	-	≤ 44	-

Notes:
1. No work is proposed outside standard construction hours
2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-46 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – White Bay construction support site

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours L_{Aeq}	Outside standard hours L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Early works	**WHB_01**[1]	0	-	88	2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Installation of environmental controls	**WHB_02**[1]	0	-	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Establishment of construction facilities	**WHB_03**[1]	0	-	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Piling for wharf structure	**WHB_04**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Immersed tube tunnel production	**WHB_05**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Immersed tube tunnel fitout	**WHB_06**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Spoil handling and treatment	**WHB_07**	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
8. Site rehabilitation/landscaping	**WHB_08**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-43Table 5-7

5.4.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted levels occur during the early works (WHB_01) stage for a relatively short period of time. During this stage, while no receiver is expected to be highly noise affected (ie. >75 dB(A)), up to 90 residential receiver buildings, which are located in NCAs 8.1, 9.1, 9.2 and 10.2, are expected to be noise affected (ie. > NML). These noise levels are expected to occur when an excavator with rock hammers are in operation as part of the utility modification works.

During other stages noise impacts would be less, with potentially up to two noise affected receiver buildings.

Work outside of standard construction hours

Outside standard construction hours, construction works would not typically be carried out except for support for the Yurulbin during tunnel construction. Concrete agitators would be transported by barge from White Bay to the Yurulbin construction support site. As the tunnel construction works take place 24 hours a day, this support would be required to take place during the evening and night periods. These out of hours deliveries are only proposed to occur on Glebe Island on the southern side of the White Bay construction support site, maximising the distance from the nearest residential receiver buildings in NCAs 9.1 and 9.2.

Predicted noise levels from this tunnel support activities stage (WHB_07) are presented in Table 5-41. During the OOHW delivery operations (WHB_07), compliance with the night period NMLs is predicted. No further mitigation measures beyond the on-site noise treatment and management measures, heavy vehicle code of conduct, and CNVMP requirements are needed.

Predicted noise levels are based on all plant operating simultaneously and continuously during each assessment activity. However, in practice not all plant would typically operate all the same time, so for a substantial part of the time actual noise levels would likely be less than predicted noise levels. As part of developing a site-specific CNVIS during detailed design, further analysis would be carried out to confirm impacts during OOHW and whether further mitigation and management measures are needed.

Sleep disturbance

At the White Bay construction support site, the key OOHW which potentially includes activities with maximum noise levels (L_{Amax}), are during stage 7 (WHB_07). Maximum noise impacts from the concrete agitators and barge activities have been predicted. The predicted noise levels exceed the sleep disturbance screening level (up to L_{Amax} 59 dB(A)) and five receiver buildings in NCA10.1 however no receiver buildings are predicted to be affected by noise above the awakening level.

5.4.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-47. The non-residential receiver buildings predicted to exceed the NMLs are summarised in Table 5-48. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-47 – Predicted construction noise levels – other sensitive receivers – White Bay construction support site

Receiver type	NCA	Noise Management Level		Predicted noise level at each construction stage[2]							
		HNA	NML	WHB_01	WHB_02	WHB_03	WHB_04	WHB_05	WHB_06	WHB_07	WHB_08
Commercial	10.1	75	70	≤ 51	≤ 46	≤ 40	≤ 42	≤ 45	≤ 44	≤ 49	≤ 37
	10.2	75	75	43 - 61	40 - 49	41 - 48	37 - 47	44 - 49	40 - 49	48 - 55	38 - 44
	4.5	75	70	≤ 61	≤ 49	≤ 63	≤ 56	≤ 52	≤ 53	≤ 59	≤ 58
	9.2	75	75	60 - 80	44 - 60	46 - 57	44 - 49	43 - 50	42 - 50	39 - 62	41 - 52
Childcare	9.1	75	50	≤ 38	< 35	≤ 41	≤ 41	≤ 35	≤ 39	≤ 40	≤ 36
	9.2	75	50	≤ 52	≤ 44	35 - 44	≤ 44	≤ 42	≤ 41	36 - 46	≤ 39
Educational	8.1	75	55	43 - 54	≤ 40	≤ 43	≤ 46	≤ 40	≤ 40	37 - 44	≤ 37
	9.2	75	55	≤ 60	≤ 44	≤ 46	≤ 43	≤ 42	≤ 43	≤ 49	≤ 42
Other sensitive receiver	10.2	75	60	40 - 50	≤ 41	≤ 40	≤ 38	≤ 41	≤ 41	36 - 46	≤ 37
	9.2	75	55	37 - 56	≤ 46	37 - 46	≤ 45	≤ 42	≤ 43	38 - 47	≤ 42
Recreational	10.1	75	60	≤ 35	≤ 44	< 35	< 35	< 35	< 35	37 - 46	< 35
	9.2	75	60	≤ 44	< 35	≤ 40	≤ 38	≤ 38	≤ 40	≤ 42	≤ 37
Place of worship	9.2	75	55	54 - 59	41 - 44	43 - 45	42 - 43	43 - 44	43 - 44	47 - 49	40 - 42

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-48 – Number of other sensitive receivers over the noise management level (all NCAs) – White Bay construction support site

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1,2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Early works	**WHB_01**	3	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0
2. Installation of environmental controls	**WHB_02**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Establishment of construction facilities	**WHB_03**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Piling for wharf structure	**WHB_04**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Substructure - Construction and placement	**WHB_05**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Substructure - immersed tube tunnel production	**WHB_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Spoil handling and treatment	**WHB_07**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Site rehabilitation/landscaping	**WHB_08**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receiver buildings have been assessed against the respective NMLs, and exceedances have been presented in the count table.

2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

The highest predicted noise levels are expected to occur during the early works (WHB_01) for a relatively short period of time. During this stage:

- Three commercial receiver buildings in NCA 9.2 are predicted to be noise affected (up to 5 dB(A) above NML)
- One childcare receiver in NCA 9.2 is predicted to be noise affected (up to 2 dB(A) above NML)
- One educational receiver in NCA 9.2 is predicted to be noise affected (up to 5 dB(A) above NML)
- One place of worship in NCA 9.2 is predicted to be noise affected (up to 4 dB(A) above NML)
- One other sensitive receiver in NCA 9.2 is predicted to be noise affected (up to 4 dB(A) above NML).

This is due to the use of excavators with rock hammers during the early works. These impacts would be managed through a CNVMP.

5.4.2.6 Summary of residual impacts and additional mitigation measures

Table 5-46 indicates the number of residential buildings where noise impacts are expected to exceed the NMLs after the implementation of noise treatments and management measures.

Further acoustic mitigation and management measures, as outlined in the standard ICNG mitigation measures included in Appendix G, would be reviewed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures in accordance with the CNVG and presented in section 6.10.1 are to be provided to manage construction noise impacts.

5.4.2.7 Cumulative and consecutive construction noise impacts

As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the White Bay construction support site would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Work at the site is expected to overlap with nearby M4-M5 Link construction support site within the White Bay construction support site. The M4-M5 Link project proposed to use part of the eastern end of White Bay as a civil site primarily to support heavy vehicle marshalling and construction workforce parking. Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-49, based on their corresponding project environmental impact statement documentation.

Table 5-49 – Concurrent construction works near the White Bay construction support site

Project	2019	2020	2021	2022	2023	2024	2025
White Bay construction support site (WHB)							
Other major infrastructure projects							
White Bay construction support site (M4-M5 Link)							

Proposed staging of concurrent work and noise impacts at the closest receiver buildings to the White Bay construction support site have been reviewed. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

If noise from one site dominates noise levels at the receiver (ie. > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

However, where noise levels from each of two sites are similar at a receiver, an increase of a total construction noise of up to 3 dB(A) is predicted. Two representative NCAs to the north and south of the White Bay construction support site have been reviewed in Table 5-50.

Table 5-50 – Potential cumulative noise impacts from construction projects

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$ dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 9.1	Standard hours NML 59 dB(A)	WHB	Early works	36 - 75	If construction works occur concurrently then construction noise levels for the early works at the White Bay construction support site (WHB) would likely dominate at nearby receivers. However, both sets of works are predicted to be above the NML at some nearby receivers.
		M4-M5 Link[1]	Site operations - Peak	55	
	OOHW NML D/E/N 54/54/51 dB(A)	WHB	Spoil handling and treatment	≤ 43	If construction works for both projects occur concurrently then the cumulative noise level is predicted to achieve the NML.
		M4-M5 Link[1]	Site operations - Night	49	
NCA 10.1	Standard hours NML 58 dB(A)	WHB	Early works	≤ 60	If construction works occur concurrently then construction noise levels for the early works at the White Bay construction support site (WHB) would likely dominate at nearby receivers. Construction noise from the M4-M5 Link construction activities are predicted to achieve the NML.
		M4-M5 Link[1]	Site operations - Peak	41	
NCA 10.1	OOHW NML D/E/N 53/50/49 dB(A)	WHB	Spoil handling and treatment	≤ 44	If construction works for both projects occur concurrently then the cumulative noise level is predicted to achieve the NML.

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$ dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
		M4-M5 Link[1]	Site operations - Night	35	

Notes: 1. Refer to M4-M5 Link, submissions and preferred infrastructure report documentation. Reference NCA 29 on the north side of White Bay and NCA 28 on the south side of White Bay.

At the receiver buildings most affected by noise from the White Bay (WHB) construction support site in NCA 9.1, there is a potential for residential receiver buildings to be construction noise affected from the M4-M5 Link project combined with early works at the White Bay site during standard construction hours. If construction activities occur concurrently outside of standard construction hours, overall construction noise levels could increase, however the cumulative noise levels are predicted to achieve the NML. The following points should be noted for the cumulative and consecutive noise impacts:

- For noise affected receiver buildings, the key difference in construction noise impacts could be an increased overall duration and frequency of construction noise impacts, even if they are at the same noise level. This would be considered by both projects when reviewing and incorporating feasible and reasonable noise mitigation measures
- The key noise-generating activities during early works such as the connection and relocation of services such as electricity, sewerage and water at the White Bay site, are typically intermittent in nature. Therefore, cumulative construction noise increases would occur rarely at these nearby receiver buildings, because for these construction noise increases to result, noise-generating activities would need to occur simultaneously in both projects at the reasonable worst-case locations to the receiver buildings. As such, management measures for each set of works individually are likely sufficient, if coordination takes place.

Receiver buildings located at more distant locations in Rozelle and Balmain and not directly adjacent to the White Bay construction sites may find that no individual construction support site dominates construction noise levels (ie. noise generated by each site is within 5 dB(A) of other sites). Cumulative construction noise levels at these receiver buildings may be up to 3 dB(A) higher than the noise levels predicted for any one construction support site.

Some receiver buildings adjacent to White Bay would have already been exposed to multiple years of construction works associated with major infrastructure projects as detailed in section 5.4.1.5. Therefore, construction fatigue impacts may be expected for some nearby noise sensitive receivers. Development of mitigation and management measures would consider these potential consecutive construction noise impacts.

Potential cumulative and consecutive construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. These mitigation measures would be included in the site's detailed design and site specific CNVIS, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures and would be

carried out in coordination with the construction contractors of the approved M4-M5 Link and any other required organisations where required to ensure all interfaces are effectively managed.

5.4.3 Construction-related road traffic noise assessment

Vehicle access to the White Bay construction support site would be via James Craig Road off The Crescent and City West Link. Vehicles that would be operating to and from the northern portion of the site would then continue onto Port Access Road within the Port Authority of NSW controlled area.

Table 5-51 presents forecast vehicle numbers during the peak construction period at this site. Up to 32 trucks would access the site per hour during the daytime period (7.00am to 10.00pm) and a maximum of one truck per hour (no more than four trucks in total) in the night time period (10.00pm to 7.00am) which would typically be concrete deliveries to support tunnelling at Yurulbin Point construction support site.

Table 5-51 – Number of construction vehicles accessing the White Bay construction support site

Type of vehicle	Day[1] over 15 hours[3,4]	Night[2] over nine hours[3,4]
Heavy vehicle (deliveries, spoil haulage and concrete deliveries)	348	4
Light vehicle	186	81

Notes:
1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am.
3. Numbers presented are individual vehicles, not vehicle movements
4. Vehicle numbers have been distributed onto the local road network based on the proposed access roads. Where a vehicle accesses the site by one road and leaves by another, one vehicle movement is counted along each road once. Where a vehicle accesses and leaves the site by the same road, two vehicle movements are counted on that road.

Table 5-52 presents the predicted increase in road traffic noise levels (L_{Aeq}) and the predicted maximum noise levels, L_{Amax}, from the White Bay construction support site.

Table 5-52 – Road traffic noise impacts from the White Bay construction support site

Construction vehicle access road	Road type	Time of day	Predicted road traffic noise increase, dB(A)[1, 3, 4]	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level[3]
The Crescent /City West Link / James Craig Road[4]	Arterial	Day $L_{Aeq(15hr)}$	<0.5	No	N/A
		Night $L_{Aeq(9hr)}$	<0.5	No	Yes
Port Access Road	Note 2	Day $L_{Aeq(15hr)}$	N/A[2]		
		Night $L_{Aeq(9hr)}$			

Notes:
1. Predicted road traffic noise levels are based on the loudest heavy vehicle
2. This is within the White Bay/Glebe island precinct port controlled area and so covered in the airborne. In the section 5.4.2.
3. Predicted road traffic noise levels are based on the nearest residential receiver to the road. Receiver buildings at further distances are expected to experience lower noise levels than those predicted.
4. As there are no residential receivers along James Craig Road, and the nearest residential receivers are located 150 metres to the north on Lilyfield Road, construction traffic along James Craig Road has been included in the assessment of construction traffic noise impacts from The Crescent /City West Link.

Road traffic noise levels at receiver buildings directly exposed to traffic noise on The Crescent, City West Link and James Craig Road are predicted to increase by less than 0.5 dB(A) during the day and night as a result of the addition of the site's construction traffic, which represents a minor impact.

Maximum noise levels (L_{Amax}) from night time heavy vehicle movements have been predicted and exceed both the sleep disturbance screening level and the adopted awakening reaction level at receiver buildings along Victoria Road.

Since night time heavy vehicle movements from this site would be limited to one vehicle per hour, and The Crescent and City West Link has relatively high existing night time heavy vehicle movements, a substantial increase in the number of maximum noise events is unlikely.

5.4.3.1 Total increase in traffic noise levels considering construction traffic at White Bay

The potential for cumulative road traffic noise impacts from other major construction works in the area around the White Bay construction support site has been considered. Vehicle movements during work at this site are expected to overlap with the nearby M4-M5 Link White Bay civil site (C11). The White Bay civil site (M4-M5 Link) would be used primarily for heavy vehicle marshalling and construction workforce parking.

Vehicle access to the White Bay civil site (M4-M5 Link) would be by the City West Link/The Crescent, and James Craig Road. The forecast maximum daily heavy and light vehicle numbers from construction at the White Bay civil site (M4-M5 Link) are presented in Table 5-53. During site operations vehicles associated with both sites would access James Craig Road concurrently.

Table 5-53 – Road traffic generation of the M4-M5 Link White Bay civil site

Type of vehicle	Day[1] over 15 hours	Night[2] over nine hours
Heavy vehicle	172	112
Light vehicle	50	50

Notes: 1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am

The nearest residential receiver buildings which could experience cumulative impacts are located on Lilyfield Road. These receiver buildings have line of sight to James Craig Road, but are more than 150 metres away. Moreover, the noise environment for these residential receiver buildings is dominated by traffic noise from The Crescent, City West Link and Victoria Road.

Assessment of this traffic cumulatively with all other nearby major infrastructure project construction sites on the City West Link at Rozelle is presented in section 5.2.3.1.

Therefore, given the projected relatively low relative increase in volume of combined construction traffic associated with both sites, any increase in traffic noise would be considered minor, and a noticeable increase in the number of maximum noise events is also unlikely.

5.4.3.2 Mitigation and management

Mitigation and management measures for construction related traffic noise impacts are outlined in section 6.7. To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the site specific CNVIS and project CNVMP would include the following:

- Where feasible and reasonable, heavy vehicle movements would occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive periods and limited to one heavy vehicle per hour during the night
- All drivers would be trained in the Project Heavy Vehicle Code of Conduct, including noise management methods such as limiting compression braking.

5.4.4 Ground-borne construction noise

Vibration-intensive works during site establishment at the construction support site have the potential to generate ground-borne noise at nearby receiver buildings. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

No tunnelling activities are proposed for this site. Ground-borne vibration impacts due to mainline tunnel construction are presented in section 5.11.1.

5.4.5 Construction vibration

Vibration generated from construction works would vary depending on the level and type of activity carried out at the site during each activity. The major stages that would include vibration-intensive works would be:

- Stage 1 (WHB_01): Early Works.

Proposed vibration-intensive plant items are identified in Appendix E, with the minimum working distances for a range of plant presented in Table 4-11. Minimum working distances from the works construction support site for both cosmetic damage and human response to vibration are presented in Appendix L for the most vibration-intensive activity proposed for the site, which is likely to be the use of a large rock hammer during the site establishment stages of the construction works (WHB_01). This is the basis of the vibration assessment and receiver building counts presented in Table 5-54.

Potential vibration generated to receiver buildings for this project would depend on vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

The assessment presented in this study considers a worst-case scenario that the proposed vibration-intensive plant items could be used anywhere within the boundaries of the site. However, this is unlikely to occur, and the location of the vibration-intensive equipment would be confirmed during detailed design.

Table 5-54 – Number of receivers within the minimum working distances for potential vibration impacts

NCA	Number of structures within minimum working distances		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Construction support site (Early works)			
9.1	1	-	3
9.2	-	-	2

5.4.5.1 Cosmetic damage

One heritage item has been identified within the minimum working distances for cosmetic damage, as presented in Table 5-55. Site-specific buffer distances for vibration-intensive activities (eg. compaction, rock hammering) must be measured on site where plant and equipment are likely to operate close to or within the typical minimum working distances (see Table 4-11). Site-specific buffer distances would then be maintained to comply with relevant vibration limits for cosmetic damage.

5.4.5.2 Heritage listed structures

One heritage item has been identified within the unsound structure cosmetic damage minimum working distance, as shown in Appendix L. This item is identified in Table 5-55.

Refer to the Technical working paper: Cultural heritage assessment report, Technical working paper: Non-Aboriginal heritage and Technical working paper: Maritime heritage for the assessment of impacts to heritage items.

Table 5-55 – Heritage receivers within the cosmetic damage minimum working distance – White Bay

Name	Significance	Type/Classification	Site Heritage ID
Former Unilever copra store, including interiors	Local	Item - General	I306

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.4.5.3 Human response

Due to the limited duration that the rock hammer would be operating at this site; the risk of annoyance is considered low. However, occupants of five buildings in NCA 9.1 and 9.2 are predicted to be exposed to vibration above the human response level, as presented in Table 5-54. After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration

levels exceed the perception level, appropriate additional mitigation measures would be provided (see section 6.10.3).

5.5 Yurulbin Point construction support site

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the Yurulbin Point construction support site.

5.5.1 Construction support site overview

5.5.1.1 Construction support site description

The site is located on Louisa Road in Birchgrove. Work at the site is proposed to occur in the stages as presented in Table 5-56.

Table 5-56 – Yurulbin Point construction support site – major stage activities overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Early works	Connect and relocate services at the site such as electricity, sewerage and water
	2. Establish site	Install environmental controls, clearing and grubbing the site.
	3. Establishment of construction facilities	Establish site offices and workshops
	4. Piling for acoustic sheds	Pilling for the on-shore shed foundations and piling for the barge shed.
	5. Acoustic shed construction	Erect on-shore and water-based acoustic shed elements.
Shaft construction	6. Shaft construction at surface level	Shaft excavation and construction
Tunnel construction (shaft and mainline tunnels)	7. Tunnelling	Tunnel spoil handling and transfer to barge, tunnel support, tunnel lining and associated deliveries
Tunnel fitout	8. Tunnel fitout	Install mechanical and utilities services to the tunnel
Tunnel commission and site rehabilitation	9. Restore site	Commission tunnel, decommission and restore site

In addition to the major activities presented above, the Yurulbin Point construction support site would also support the following construction activities:

- Three roadheaders excavating the mainline tunnels
- A gantry crane to allow for spoil removal and supply of materials to the mainline tunnels
- Spoil transferred by barge to the White Bay construction support site
- Deliveries to the Yurulbin Point construction support site from the White Bay construction support site.

5.5.1.2 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-57, subject to project approval. This site is planned to operate from early 2021 until late 2025. The longest duration activities at this site would be tunnelling and tunnel fitout works.

Table 5-57 – Yurulbin Point construction support site – indicative program and timeline

Stage	Construction activity	Reference	Indicative construction timeframe																	
			2021				2022				2023				2024				2025			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1. Early works	YRB_01																				
	2. Establish site	YRB_02																				
	3. Establishment of construction facilities	YRB_03																				
	4. Piling for acoustic sheds	YRB_04																				
	5. Acoustic shed construction	YRB_05																				
Shaft construction	6. Shaft construction at surface level	YRB_06																				
Tunnel construction (shaft and mainline tunnels)	7. Tunnelling	YRB_07																				
Tunnel fitout	8. Tunnel fitout	YRB_08																				
Tunnel commission and site restoration	9. Restore site	YRB_09																				

5.5.1.3 Nearby noise and vibration-sensitive receivers

The site is located on Louisa Road in Birchgrove and is mostly surrounded by residential receivers located to the west and various land uses to the north and east across Sydney Harbour. The location of the site, tunnel alignment, nearby NCAs and receiver locations are shown in Figure 5-6.

Figure 5-6 – Location of Yurulbin Point construction support site



5.5.1.4 Construction duration and working hours

Table 5-58 presents each of the major stages that have been assessed along with the representative activities that would take place during the stage for the Yurulbin Point construction support site, and the proposed time periods when each activity is proposed to occur.

During the operation of the Yurulbin Point construction support site, work would typically take place during standard construction hours, presented in Table 3-2. However, some OOHW would take place outside standard construction hours, as presented in Table 5-58.

In particular, tunnelling would be required 24 hours per day, seven days a week. Further justification for out of hours work is provided in section 5.1.3.

Table 5-58 – Yurulbin Point construction support site – construction hours

Stage	Representative activity		Reference	Assessed activities[1]	Work hours[2]			
					Day (Std)	Day (OOHW)	Evening	Night
Site establishment	1.	Early works	YRB_01	Utility works	♦			
	2.	Establish site	YRB_02	Install environmental controls	♦			
				Clearing and grubbing	♦			
	3.	Establishment of construction facilities	YRB_03	Establishment of construction facilities	♦			
	4.	Piling for acoustic sheds	YRB_04	Piling for excavation shaft and onshore acoustic shed	♦			
				Piling for water-based shed	♦			
	5.	Acoustic shed	YRB_05	Acoustic shed construction	♦			
				Water-based acoustic shed construction	♦			
Shaft construction	6.	Shaft construction at surface level	YRB_06	Shaft excavation and construction	♦			
Tunnel construction (shaft and mainline tunnels)	7.	Tunnelling	YRB_07	General site activities	♦	♦	♦	♦
				Deliveries	♦			
				Tunnelling and support	♦	♦	♦	♦
				Tunnelling lining (concreting) deliveries	♦	♦	♦	♦
				Spoil handling in acoustic shed	♦	♦[3]	♦[3]	♦[3]
				Barge spoil haulage	♦			
Tunnel fitout	8.	Tunnel fitout	YRB_08	Deliveries	♦	♦	♦	♦
				Laydown areas	♦			
Tunnel commission and site rehabilitation	9.	Restore site	YRB_09	Decommission site	♦			

Notes: 1. Appendix E describes the modelled plant for each activity

2. Day Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
Day Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday

3. Spoil haulage by barge off the construction support site would occur during standard construction hours. OOHW spoil handling would occur inside acoustic shed.

5.5.1.5 Concurrent and consecutive construction projects

The nearest construction support sites associated with this project are the Sydney Harbour Crossing and the Berrys Bay construction support site. The Sydney Harbour Crossing includes the Sydney Harbour south cofferdam located about 40 metres north of this site and the Sydney Harbour north cofferdam located on the north side of Sydney Harbour about 600 metres north-east of this site. The Berrys Bay construction support site is located about 900 metres north -east of this construction support site.

The nearest construction works associated with another major construction project are the Sydney Metro City & Southwest construction support sites at Barangaroo and Blues Point. However due to the distance to these construction sites and the level of noise emissions expected from these construction activities and the Yurulbin Point construction support site, consecutive noise impacts on receivers nearby to the Yurulbin Point construction support site is unlikely from these construction activities.

5.5.1.6 Construction assessment scenarios

The airborne noise assessment of the Yurulbin Point construction support site has been separated into nine stages. Each stage has been assessed against the work periods presented in Table 5-58.

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant assumed to be operating during the stage. It is assumed that all equipment/plant operate simultaneously in any 15 minute period (refer to section 4.2 for further explanation of assessment scenarios).

Multiple activities would occasionally occur concurrently within the one construction support site and where this could reasonably occur this has been captured in the assessment as shown in Table 5-58.

5.5.1.7 Summary of assumed noise treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating to assist in attenuating and managing noise emissions from the construction activities.

Identified feasible and reasonable noise treatment measures have been included in the noise modelling and are presented in Table 5-59. The results presented in this assessment are based on these noise treatments and management measures being implemented. The locations of physical noise treatment measures are shown in Figure 5-7.

Table 5-59 – Assumed noise treatment and management measures – Yurulbin Point site

Activity or plant/equipment	Management and noise treatment measures applied
Tunnelling, support and fitout: acoustic shed and conveyor	A very high performance acoustic shed would be built on shore to reduce noise from tunnelling works and a high performance acoustic shed would be built to reduce noise from loading spoil on barges, support and fitout works outside standard construction hours. Performance requirements for individual elements of the acoustic shed are presented in Table 5-60. A conveyor rain hood would be built to achieve a total sound power level of 75 dB(A) per metre.
Wastewater treatment plant	The wastewater treatment plant would be acoustically treated or placed in an acoustic enclosure to achieve a total sound power level of 86 dB(A).
Substation	The substation would achieve a total sound power level of 75 dB(A), which may require acoustic treatment or the use of an acoustic enclosure.
Work outside standard hours	Work would only occur outside standard hours where it: ▪ Meets the relevant NMLs ▪ Occurs in an acoustic enclosure ▪ Is required for safety reasons ▪ Barge idling would be minimised so that idling would not occur throughout deliveries ▪ At night, noise generating delivery activities would occur within the acoustic shed and any associated activities outside of the shed would be minimised.
Noise barriers	Noise barriers would be installed around the northern and western side of the construction support site and on the western side of the temporary wharf to provide noise attenuation for ground level receivers near the site.

Table 5-60 – Indicative acoustic shed construction and acoustic performance – Yurulbin Point site

Shed/conveyor element (Indicative example constructions are shown in Table 4-1)	Octave band frequency transmission loss, dB						
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Onshore acoustic shed and decline cover (very high performance)							
Walls – Very high performance	25	31	40	49	61	69	75
Roof – High performance	20	27	36	45	51	56	62
Water-based acoustic shed and conveyor cover (high performance)							
Walls – High performance	10	29	35	42	46	51	57
Roof – High performance	10	29	35	42	46	51	57

Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

Figure 5-7 – Construction support site layout with indicative noise treatment measures at Yurulbin Point



5.5.2 Construction airborne noise

5.5.2.1 Nearby receiver summary and objectives

Table 5-61 presents NMLs and the screening levels for the assessment of sleep disturbance for the nearest residential receivers surrounding the Yurulbin Point construction support site. Noise management levels for other (non-residential) noise-sensitive receivers are presented in section 3.4.1.

Table 5-61 – Construction noise management levels and screening levels at residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
11.2	50	45	45	42	52
11.3	50	45	45	42	52
11.4	50	45	45	42	52
12.1	56	51	50	45	55
13.1	51	46	43	37	47
13.2	51	46	43	37	47
14.1	51	46	42	38	48
15.1	52	47	46	43	53

5.5.2.2 Predicted noise impacts

Table 5-62 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-62 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

Modelling results presented are the range of the highest predicted noise levels for each NCA for residential receiver buildings, commercial and OSRs, unless no receiver buildings of that type in that NCA are expected to exceed NMLs.

The presented range is of noise impacts throughout all receiver buildings in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented. The noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest early works and site establishment stages, and longer-term tunnelling stages are shown in Appendix H.

5.5.2.3 Residential

The predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-63: for standard construction hours
- Table 5-64: for works outside of standard construction hours.

The numbers of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-65. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-63 – Predicted construction noise levels – standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Yurulbin Point construction support site

NCA	Noise Management Level		Predicted noise level at each construction stage[2]								
	HNA	NML	YRB_01	YRB_02	YRB_03	YRB_04	YRB_05	YRB_06	YRB_07	YRB_08	YRB_09
11.2	75	50	≤ 46	≤ 41	≤ 35	≤ 40	≤ 37	≤ 40	< 35	< 35	< 35
11.3	75	50	41 - 50	40 - 46	≤ 40	37 - 44	≤ 41	37 - 41	≤ 35	< 35	≤ 37
11.4	75	50	≤ 60	≤ 59	≤ 52	≤ 57	≤ 53	≤ 47	≤ 46	≤ 45	≤ 46
12.1	75	56	**≤ 81**	≤ 72	≤ 63	≤ 68	≤ 65	35 - 61	≤ 56	≤ 55	≤ 63
13.1	75	51	≤ 59	≤ 49	≤ 42	≤ 47	≤ 47	≤ 45	< 35	< 35	≤ 44
13.2	75	51	49 - 49	42 - 43	36 - 36	42 - 42	41 - 41	≤ 35	< 35	< 35	36 - 36
14.1	75	51	≤ 49	≤ 45	≤ 39	≤ 46	≤ 44	≤ 40	≤ 35	< 35	≤ 37
15.1	75	52	36 - 50	≤ 43	≤ 37	≤ 45	≤ 42	≤ 35	< 35	< 35	≤ 37

Notes:
1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-64 – Predicted construction noise levels – outside standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Yurulbin Point construction support site

NCA	Noise Management Level				Predicted noise level at each construction stage								
	HNA	Day (O)	Eve	Night	YRB_01[1]	YRB_02[1]	YRB_03[1]	YRB_04[1]	YRB_05[1]	YRB_06[1]	YRB_07	YRB_08	YRB_09[1]
11.2	75	45	45	42	-	-	-	-	-	-	< 35	< 35	-
11.3	75	45	45	42	-	-	-	-	-	-	< 35	< 35	-
11.4	75	45	45	42	-	-	-	-	-	-	≤ 38	≤ 38	-
12.1	75	51	50	45	-	-	-	-	-	-	≤ 45	≤ 45	-
13.1	75	46	43	37	-	-	-	-	-	-	< 35	< 35	-
13.2	75	46	43	37	-	-	-	-	-	-	< 35	< 35	-
14.1	75	46	42	38	-	-	-	-	-	-	< 35	< 35	-
15.1	75	47	46	43	-	-	-	-	-	-	< 35	< 35	-

Notes:
1. No work is proposed outside standard construction hours.
2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-65 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – Yurulbin Point construction support site

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours	Outside standard hours																	
		L_{Aeq}	L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Early works	YRB_01[1]	2	-	212	12	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Establish site	YRB_02[1]	0	-	113	15	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Establishment of construction facilities	YRB_03[1]	0	-	28	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Piling for acoustic sheds	YRB_04[1]	0	-	103	4	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Acoustic shed construction	YRB_05[1]	0	-	40	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Shaft construction at surface level	YRB_06[1]	0	-	11	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Tunnelling	YRB_07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	9
8. Tunnel fitout	YRB_08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	9
9. Restore site	YRB_09[1]	0	-	8	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-62Table 5-43Table 5-7

5.5.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted levels occur during utility works (YRB_01). During this stage, up to two receiver buildings which are located in NCA 12.1 are predicted to be highly noise affected (ie. >75 dB(A)), due to the use of excavators with rock hammers. When rock hammers are not used, noise levels are predicted to reduce by up to 8 dB(A).

Up to 229 receiver buildings across NCAs 11.4, 12.1 and 13.1 are expected to be noise affected (ie. > NML) during utility works (YRB_01) during standard construction hours. These impacts would be managed through a CNVMP.

During other stages noise impacts would be less. Up to 128 receiver buildings are predicted to be noise affected during any stage. These standard construction hours noise impacts would be managed through the CNVMP developed during detailed design. It is noted that during the longest duration works, being tunnel construction and tunnel fitout, no receiver buildings are predicted to be noise affected during standard construction hours.

Work outside of standard construction hours

At the Yurulbin Point construction support site the adopted feasible and reasonable noise treatment measures allow the site to meet NMLs outside standard construction hours. Therefore, no residential receiver buildings are expected to be noise affected during OOHW.

The predicted noise levels are based on all plant operating simultaneously during each assessment activity. However, in practice not all plant would typically operate all the time, meaning that for a substantial part of the time actual noise levels would likely be less than predicted.

Sleep disturbance

During night time tunnel construction and tunnel fitout works (YRB_07 and YRB_08), up to 79 receiver buildings are predicted to be exposed to maximum noise levels above the sleep disturbance screening levels (up to L_{Amax} 69 dB(A)).

Up to nine receiver buildings are predicted to be exposed to maximum noise levels above the awakening reaction level. This is due to night time general site operations near the laydown area where cranes would be used to unload delivery barges.

Since only up to two barges (four barge movements) are expected for tunnel support works, site operations near the laydown area are expected to be insignificant during night. While predicted L_{Amax}, noise levels are greater than the screening level, sleep disturbance impacts are unlikely to occur as:

- The limited number of delivery barge movements (typically up to two barge deliveries which equates to four barge movements) during the night would result in minimal L_{Amax} noise events,

which are in line with the number of maximum noise events that already occur as shown in the noise logger graphs in Appendix C

- L_{Amax} noise events would be from metal-on-metal bangs during the barge deliveries, which can be mitigated and managed through both work practice and physical mitigation (eg. belt fasteners instead of chains).

During detailed design, all feasible and reasonable mitigation as outlined in section 6 and the standard ICNG mitigation measures included in Appendix G would be confirmed and incorporated to minimise residual noise impacts.

5.5.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-66. The receiver buildings predicted to exceed the NMLs are summarised in Table 5-67. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-66 – Predicted construction noise levels – other sensitive receivers – Yurulbin Point construction support site

Receiver type	NCA	Noise Management Level		Predicted noise level at each construction stage[2]								
		HNA	NML	YRB_01	YRB_02	YRB_03	YRB_04	YRB_05	YRB_06	YRB_07	YRB_08	YRB_09
Commercial	13.1	75	70	36 - 48	≤ 42	≤ 37	≤ 42	≤ 39	38 - 40	≤ 38	≤ 37	≤ 36
	14.1	75	70	≤ 51	≤ 48	≤ 42	≤ 49	≤ 46	≤ 42	≤ 43	≤ 42	≤ 40
Recreational	11.4	75	65	≤ 55	≤ 53	≤ 46	≤ 52	≤ 48	≤ 44	35 - 41	35 - 40	≤ 42
	12.1	75	60	48 - 51	45 - 51	40 - 45	46 - 50	43 - 46	40 - 43	< 35	< 35	38 - 39
	13.1	75	60	49 - 62	43 - 47	37 - 41	42 - 47	40 - 48	39 - 42	≤ 38	≤ 37	39 - 45

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-67 – Number of other sensitive receivers over the noise management levels (all NCAs) – Yurulbin Point construction support site

Stage activity	Assessment reference	Commercial[1]			Recreational[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Early works	YRB_01	0	0	0	1	0	0
2. Establish site	YRB_02	0	0	0	0	0	0
3. Establishment of construction facilities	YRB_03	0	0	0	0	0	0
4. Piling for acoustic sheds	YRB_04	0	0	0	0	0	0
5. Acoustic shed construction	YRB_05	0	0	0	0	0	0
6. Shaft construction at surface level	YRB_06	0	0	0	0	0	0
7. Tunnelling	YRB_07	0	0	0	0	0	0
8. Tunnel fitout	YRB_08	0	0	0	0	0	0
9. Restore site	YRB_09	0	0	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receiver buildings have been assessed against the respective NMLs, and exceedances have been presented in the count table.

One recreational receiver in NCA 13.1 is predicted to exceed the NML (by up to 2 dB(A)) during early works (YRB_01) at the Yurulbin Point construction support site.

5.5.2.6 Summary of residual impacts and additional mitigation measures

No sensitive receiver buildings are expected to be impacted by noise from this site above the NMLs.

Further acoustic mitigation and management measures, as outlined in the standard ICNG mitigation measures included in Appendix G would be confirmed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures in accordance with the CNVG and presented in section 6.10.1 would be provided to manage construction noise impacts.

5.5.2.7 Cumulative and consecutive construction noise impacts

As outlined in section 4.2.4, the potential for cumulative and consecutive noise impacts from other major construction projects in the area around the Yurulbin Point construction support site would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-68.

Table 5-68 – Concurrent construction works near the Yurulbin Point construction support site

Project	2021	2022	2023	2024	2025
Sydney Harbour Crossing					
Berrys Bay construction support site					
Yurulbin Point construction support site					

Proposed staging of concurrent work and noise impacts at the closest receiver buildings to the Yurulbin Point construction support site have been reviewed. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

If noise from one site dominates noise levels at the receiver (ie. > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

However, where noise levels from each of two sites are similar at a receiver, an increase of a total construction noise of up to 3 dB(A) is predicted. One representative NCA adjacent to the works has been assessed in Table 5-69.

Table 5-69 – Potential cumulative noise impacts from construction projects near Yurulbin Point construction support site

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$ dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 12.1	Standard hours NML 56 dB(A)	YRB	Tunnelling	≤ 56	If construction works at the Yurulbin Point construction support site (YRB) occur concurrently with the Berrys Bay construction support site (BRY) then construction noise levels from the Yurulbin Point construction support site would likely dominate at nearby receivers. Additionally, the cumulative noise level is predicted to achieve the NML.
		BRY	Tunnelling	<35	
		SHC	Build Sydney Harbour south cofferdam	≤ 81	If construction works at the Yurulbin Point construction support site (YRB) occur concurrently with cofferdam construction activities at the Sydney Harbour Crossing, the noise levels from piling are likely to dominate at nearby receivers. Construction noise from the Yurulbin Point construction support site is predicted to achieve the NML.
	OOHW NML D/E/N 51/50/45	YRB	Tunnelling	≤ 45	If construction works at the Yurulbin Point construction support site (YRB) occur concurrently with the Berrys Bay construction support site (BRY) then construction noise levels from the Yurulbin Point construction support site would likely dominate at nearby receivers. Nonetheless, the cumulative noise level is predicted to achieve the NML.
		BRY	Tunnelling	<35	
		SHC	Immerse elements	≤ 57	If construction works at the Yurulbin Point construction support site (YRB) occur concurrently with tunnel element immersion activities outside of standard construction hours at the Sydney Harbour Crossing, then the noise from tunnel element immersion activities is likely to dominate at nearby receivers. Construction noise from the Yurulbin Point construction support site is predicted to achieve the NML.

At the most affected receiver buildings in NCA 12.1, concurrent works are unlikely to increase construction noise levels above the NML more than for any one project. However, for noise affected receiver buildings, the key difference in construction noise impacts could be an increase in overall duration and frequency of impacts, even if they are at the same noise level. This increased frequency would be considered by the other construction support sites during detailed design when reviewing and incorporating feasible and reasonable noise mitigation measures.

Although the noise levels at the affected receiver buildings in NCA 12.1 are predicted to be above NML outside standard construction hours, the contribution from the Yurulbin Point construction support site is less than the NML. Noise levels from the tunnel element immersion activities at the Sydney Harbour Crossing would likely dominate construction noise when it occurs nearby to receivers. However, construction noise impact from tunnel element immersion activities at the Sydney Harbour Crossing would be short in duration and intermittent (refer to section 5.6.1).

Potential consecutive or cumulative construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. The CNVMP prepared as part of the detailed design would include these mitigation measures and cumulative noise impacts and would be considered further during detailed design where feasible and reasonable. These mitigation measures would be included in the site's detailed design and site specific CNVIS where feasible and reasonable, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures.

5.5.3 Construction-related road traffic noise assessment

Access and deliveries to and from the site would be via water with a delivery wharf constructed on the site to accommodate barges. No heavy vehicle road access to Yurulbin Point construction support site (WHT4) is proposed during peak construction, however there may be a requirement for some heavy vehicle movements during the early works and site establishment phase. An access route to Louisa Road has been provided for emergency use only.

5.5.4 Ground-borne construction noise

Ground-borne noise impacts could result from the construction of the access shaft between the Yurulbin Point construction support site and the mainline tunnel alignment underneath the acoustic shed. It has been assumed that this would be constructed using a large excavator with rock hammer attachment; however, alternative excavation techniques could result in lower ground-borne noise levels. The number of receiver buildings predicted to be potentially impacted by ground-borne noise are presented in Table 5-74.

Table 5-70 – Number of receiver buildings affected by ground-borne noise from Yurulbin Point construction support site access shaft construction

NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML[1,2])				
	Residential			Other sensitive receivers	Commercial/ industrial receivers
	> 35[1] to ≤ 40 dB(A)	> 40[2] to ≤ 45 dB(A)	>45 dB(A)		
12.1	6	2	1	-	-

Notes: 1. Night ground-borne noise management level (GBNML)
2. Evening ground-borne noise management level (GBNML).

Table 5-74 indicates that nine residential receiver buildings are identified as potentially being impacted by ground-borne noise levels above the strictest NML (ie. night time 35 dB(A)). Locations of receiver buildings that are predicted to be affected by ground-borne noise are presented in Appendix J.3. As such, the shaft construction would be managed by restricting the construction hours to minimise impacts during more sensitive periods (eg. evening and night), adopting alternative excavation techniques, or if justified, in accordance with section 6.10.2. The extent of mitigation and management required to limit potential ground-borne noise impacts to receiver buildings would be determined by looking not only at the level of noise impact, but also the duration that receiver buildings are likely to be exposed to ground-borne noise levels above the NML.

If verification monitoring conducted during the shaft construction determines that ground-borne noise levels inside residential receiver buildings are below the predicted noise levels and comply with ground-borne noise management levels, shaft construction may be extended outside standard hours. Detailed noise mitigation and management measures would to be reviewed during detailed design.

Ground-borne noise levels could be generated by vibration-intensive works as part of the construction support site. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

Ground-borne noise impacts from the mainline tunnel construction are presented in section 5.11.1.

5.5.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity. The major stages that would include vibration-intensive works would be:

- Stage 1 (YRB_01): Early works
- Stage 3 (YRB_03): Establishment of construction facilities
- Stage 4 (YRB_04): Piling for acoustic shed
- Stage 6 (YRB_06): Shaft construction.

Use of rock hammers for excavation would occur as part of the above works. The range of proposed vibration-intensive plant items are identified in Appendix E, with the minimum working distances for a range of plant presented in Table 4-11. Presented in Appendix L are the estimated minimum working distances from the works construction support site for both cosmetic damage and human response to vibration for the most vibration-intensive activity proposed for the construction support site, which is likely to be the use of a large rock hammer during the site establishment stages of the construction works (YRB_01). This is the basis of the assessment and receiver building counts presented in Table 5-71.

Potential vibration generated to receivers for this project depends on vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

The assessment presented in this study considers a worst-case scenario where proposed vibration-intensive plant items could be used anywhere within the boundaries of the site. However, this is unlikely to occur, and the location of the vibration-intensive equipment would be confirmed during detailed design.

Table 5-71 – Number of affected receiver buildings within minimum working distances – Yurulbin Point construction support site

NCA	Number of receiver buildings within minimum working distances		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Construction support site			
12.1	3	0	21

5.5.5.1 Cosmetic damage

Three heritage items in NCA 12.1 have been identified within the minimum working distances for cosmetic damage, as presented in Table 5-71.

Site-specific buffer distances for vibration-intensive activities (eg. compaction, rock hammering) would be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see Table 4-11). Site-specific buffer distances would then be maintained in order to comply with relevant vibration limits for cosmetic damage.

5.5.5.2 Heritage listed structures

Four heritage items were identified within the unsound structure cosmetic damage minimum working distances. Nearby heritage items are shown in Appendix L. These items are identified and described in Table 5-72.

Refer to the Technical working paper: Cultural heritage assessment report, Technical working paper: Non-Aboriginal heritage and Technical working paper: Maritime heritage for the assessment of impacts to heritage items.

Table 5-72 – Heritage items within the cosmetic damage minimum working distance – Yurulbin Point

Name	Significance	Type/Classification	Site Heritage ID
Yurulbin Park	Local	Item - General	I555
Railway electricity tunnel under Sydney Harbour;	State	State Heritage Act	01231
Balmain to Greenwich Electric Cable Tunnel, including interiors		RailCorp Section 170 and conservation register	5062542
Long Noise Point (Birchgrove) Wharf site and shelter	Maritime	-	-
Shed Cave - Birchgrove	AHIMS registered site[2]	-	A4 45-6-2672

Notes: 1. Conservation areas have not been considered as they do not form a structure that would be impacted by vibration.
2. National Parks and Wildlife Act (AHIMS registered site).

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.5.5.3 Human response

Due to the excavation works required at the Yurulbin Point construction support site, and the proximity of the nearby sensitive receivers, there is a risk of annoyance at nearby sensitive receivers. Occupants of up to 21 receiver buildings in NCA 12.1 are identified as within the minimum working distance for excavation works using a large rock hammer. These receiver buildings could potentially be exposed to vibration levels above the human response level, as presented in Table 5-71.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures, including alternative equipment/techniques and respite, would be provided (see section 6.10.3).

5.6 Sydney Harbour Crossing

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the Sydney Harbour Crossing.

5.6.1 Construction support site overview

5.6.1.1 Construction support site description

Work at the site would occur in stages as presented in Table 5-73.

Table 5-73 – Sydney Harbour Crossing - Major stage activities overview

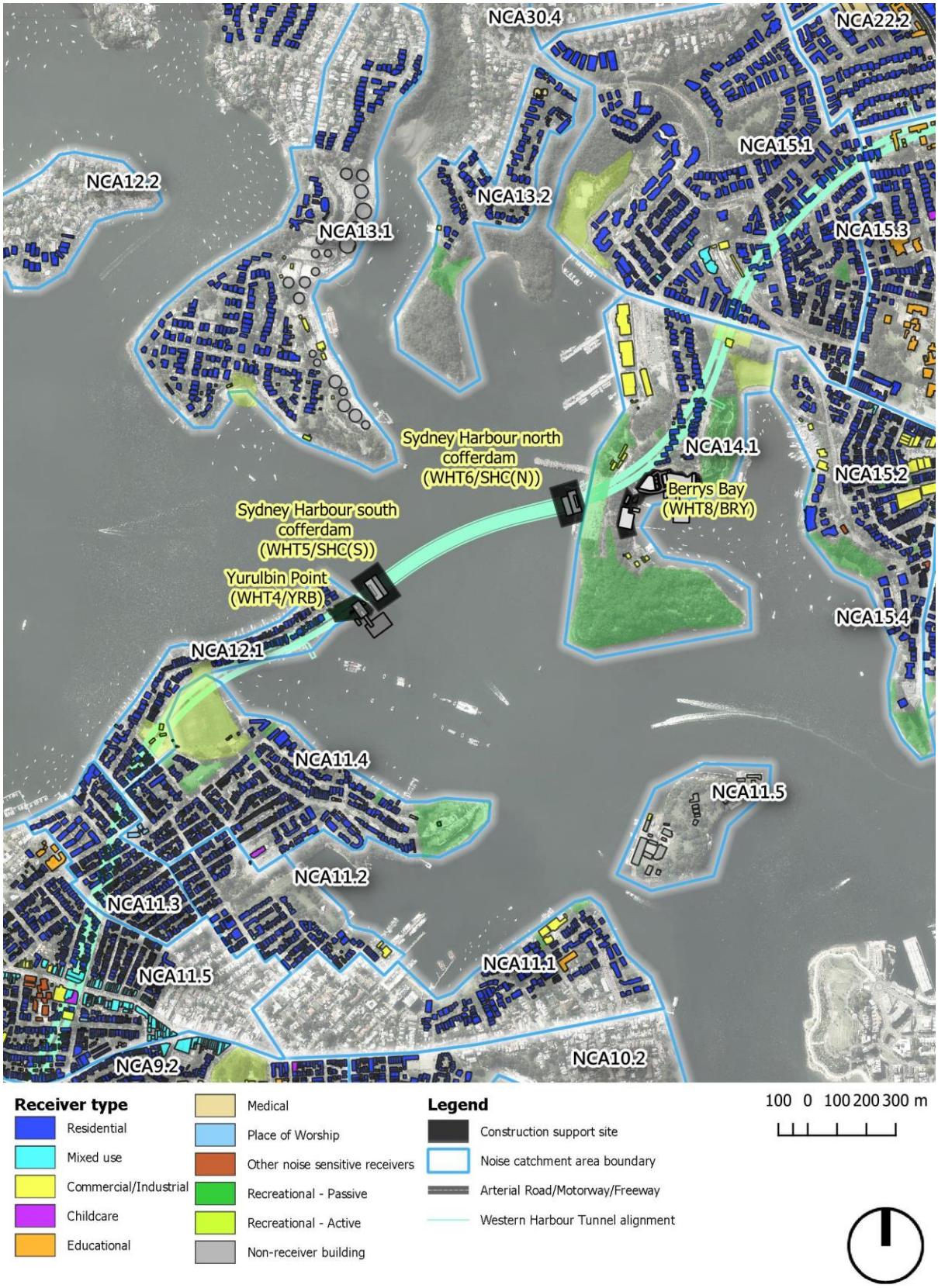
Stage	Representative activity	Major stage activities/description
Installation of temporary cofferdam structure	1. Build Sydney Harbour north cofferdam 2. Build Sydney Harbour south cofferdam	Build cofferdams by: • Vibratory piling through sediment • Impact piling into rock
	3. Dewater cofferdams	Pump water out to allow work in the cofferdams
Excavation of rock within cofferdam and trench	4. Excavate cofferdams	Remove soil and rock to make space for the transition structures
Construction of interface structure	5. Cast transition structures	Cast concrete transition structures to allow the driven tunnel to connect to the immersed tube tunnel
Removal of cofferdam structure and site rehabilitation	6. Remove cofferdams	Inundate then remove cofferdams

Stage	Representative activity	Major stage activities/description
Dredging and gravel placement	7. Prepare foundations	Dredge space for immersed tube tunnel, and place gravel foundations
Tunnel element immersion	8. Immerse elements	Immerse and connect tube tunnel elements

5.6.1.2 Nearby noise and vibration-sensitive receivers

The site is in Sydney Harbour between Birchgrove and Waverton. It is mostly surrounded by residential, recreational and commercial type receivers. The locations of the site, nearby NCAs and receiver locations are shown in Figure 5-8.

Figure 5-8 – Location of the Sydney Harbour Crossing



5.6.1.3 Construction works program

The indicative program and timeline for the site is presented in Table 5-74, subject to project approval. This construction support site is planned to operate from late 2021 until the end of 2025.

The longest duration activity at this construction support site would be the installation of temporary cofferdam structures.

Table 5-74 – Sydney Harbour Crossing – indicative construction program and timeline

Stage	Representative activity		Reference	Indicative construction timeframe															
				2021				2022				2023				2024				2025			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Installation of temporary cofferdam structure	1.	Build Sydney Harbour north cofferdam	SHC_01																				
	2.	Build Sydney Harbour south cofferdam	SHC_02																				
	3.	Dewater cofferdams	SHC_03																				
Excavation of rock within cofferdam and trench	4.	Excavate cofferdams	SHC_04																				
Construction of interface structure	5.	Cast transition structures	SHC_05																				
Removal of cofferdam structure and site rehabilitation	6.	Remove cofferdams	SHC_06																				
Dredging and gravel placement	7.	Prepare foundations	SHC_07																				
Tunnel element immersion	8.	Immerse elements	SHC_08																				

5.6.1.4 Construction duration and working hours

Table 5-74 presents each of the major stages and each of the assessed activities for the Sydney Harbour Crossing, along with the duration and proposed periods of work for each activity.

During building of the Sydney Harbour Crossing, work would typically take place during the ICNG standard construction hours as presented in Table 3-2. As the crossing needs to be completed before the driven tunnels can connect, some OOHW would take place outside standard construction hours:

- Dewatering and inundation of cofferdams would occur 24 hours a day, seven days a week
- Trailer suction hopper dredging would occur 24 hours a day and up to seven days a week. Gravel foundations would be built during standard construction hours
- Tunnel element immersion would occur 24 hours a day during harbour closures, to allow work to take place safely without impacting normal harbour traffic. It would typically take between 24 and 48 hours to safely sink each of the five tunnel elements.

Table 5-75 – Sydney Harbour Crossing – construction hours

Stage	Representative activity		Reference	Assessed activities[1]	Work hours[2]			
					Day (Standard)	Day (OOHW)	Evening	Night
Installation of temporary cofferdam structure	1.	Build Sydney Harbour north cofferdam	SHC_01	Piling for cofferdams	♦			
	2.	Build Sydney Harbour south cofferdam	SHC_02					
	3.	Dewater cofferdams	SHC_03	Pump water out of cofferdams	♦	♦[3]	♦[3]	♦[3]
Excavation of rock within cofferdam and trench	4.	Excavate cofferdams	SHC_04	Remove soil and rock from cofferdams	♦			
Construction of interface structure	5.	Cast transition structures	SHC_05	Cast concrete transition structures	♦			
Removal of cofferdam structure and site rehabilitation	6.	Remove cofferdams	SHC_06	Inundate and remove cofferdams	♦	♦[3]	♦[3]	♦[3]
Dredging and gravel placement	7.	Prepare foundations	SHC_07	Dredge and place gravel foundations	♦	♦	♦	♦
Tunnel element immersion	8.	Immerse elements	SHC_08	Immerse and connect tube tunnel elements	♦	♦	♦	♦

Notes: 1. Appendix E describes the modelled plant for each activity

2. Day Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
Day Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday

3. Pumps are to remain operating, no other activities proposed.

5.6.1.5 Concurrent and consecutive construction projects

The nearest construction works associated with this project are Yurulbin Point construction support site, about 40 metres south of the Sydney Harbour south cofferdam and Berrys Bay construction support site, about 150 metres east of the Sydney Harbour north cofferdam.

The nearest construction works associated with another major construction project are the Sydney Metro City & Southwest construction support sites at Barangaroo and Blues Point, and Sydney Harbour ground improvement works. Based on the Sydney Metro City & Southwest environmental impact statement, work at Blues Point and ground improvement works are expected to be complete before work starts on the Sydney Harbour Crossing for the project, and rail tunnel and station fitout works would be taking place at the Barangaroo construction support site. As such, for these Sydney Metro City & Southwest construction sites, due to distance, terrain and nearby acoustic shielding increases in construction noise levels from cumulative noise impacts are not expected. However, some receivers in Balmain (NCA 11.1) may have already been exposed to multiple years of construction works, from the construction works at Barangaroo which should be taken into consideration.

5.6.1.6 Construction assessment scenarios

The airborne noise assessment of the Sydney Harbour Crossing was separated into eight stages. Each stage was assessed against the works periods proposed in Table 5-75. The details of modelled construction plant items and corresponding sound power levels are presented in Appendix E.

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant operating simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

Multiple activities would occasionally occur concurrently within the one construction support site and were captured in the assessment as shown in Appendix E.

5.6.1.7 Summary of assumed noise treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating, to assist in attenuating and managing noise emissions from the construction activities.

Identified feasible and reasonable noise treatment measures have been included in the noise modelling and are presented in Table 5-76. The results presented in this assessment are based on these noise treatments and management measures being implemented.

Table 5-76 – Assumed noise treatment and management measures – Sydney Harbour Crossing

Activity or plant/equipment	Management and noise treatment measures applied
Water pumps	Pumps would be selected or acoustically treated (ie. placed in an acoustic enclosure) to achieve a maximum sound power level of 82 dB(A).
Respite for high noise impact work	Respite would be provided from piling works (impact and vibratory) where required by the ICNG. Respite would be provided where required by the ICNG, from rock hammering works and any activity which emits impulsive or tonal noise and any activity which exceeds the 'highly noise affected' management level.

Detailed design refinements to the construction support site layout, the location of cofferdams or other Sydney Harbour Crossing design elements, required plant or equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

5.6.2 Construction airborne noise

The methodology used for assessing airborne noise impacts from construction support sites is outlined in section 4.2.2.

5.6.2.1 Nearby receiver summary and objectives

Table 5-77 presents NMLs and the screening levels for the assessment of sleep disturbance for the nearest residential receivers surrounding the Sydney Harbour Crossing. Noise management levels for other (non-residential) noise-sensitive receivers are presented in section 3.4.1.

Table 5-77 – Construction noise management levels and screening levels for residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
11.1	50	45	45	42	52
11.2	50	45	45	42	52
11.3	50	45	45	42	52
11.4	50	45	45	42	52
12.1	56	51	50	45	55
12.2	56	51	50	45	55
13.1	51	46	43	37	47
13.2	51	46	43	37	47
14.1	51	46	42	38	48
15.1	52	47	46	43	53

5.6.2.2 Predicted noise impacts

Table 5-78 provides a key to the cell shading and text formatting used to explain results in the following tables. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-78 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

The modelling results present the range of the highest predicted noise levels for each NCA for residential receivers, commercial and OSRs, unless no receivers of that type in that NCA are expected to exceed NMLs.

The range is of noise impacts throughout all receivers in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented.

Noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest stages (piling during Stage 1 and excavation during Stage 3) and for dredging (Stage 6) at night, are shown in Appendix H.

5.6.2.3 Residential

The predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-79 for standard construction hours
- Table 5-80 for works outside of standard construction hours.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-81. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-79 – Predicted construction noise levels – standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$ dB(A) – Sydney Harbour Crossing

NCA	Noise Management Level		Predicted noise level at each construction stage							
	HNA	NML	SHC_01	SHC_02	SHC_03	SHC_04	SHC_05	SHC_06	SHC_07	SHC_08
11.1	75	50	40 - 57	36 - 58	< 35	≤ 39	≤ 42	< 35	≤ 42	≤ 41
11.2	75	50	≤ 46	36 - 51	< 35	< 35	< 35	< 35	< 35	< 35
11.3	75	50	≤ 48	≤ 51	< 35	≤ 37	< 35	< 35	≤ 36	≤ 35
11.4	75	50	≤ 60	36 - 65	< 35	≤ 46	≤ 45	< 35	≤ 48	≤ 47
12.1	75	56	≤ 63	36 - **81**	< 35	≤ 63	≤ 64	< 35	≤ 59	≤ 57
12.2	75	56	≤ 50	≤ 56	< 35	< 35	≤ 37	< 35	≤ 37	≤ 37
13.1	75	51	≤ 61	≤ 66	< 35	≤ 49	≤ 47	< 35	≤ 47	≤ 44
13.2	75	51	40 - 62	38 - 58	< 35	≤ 48	≤ 44	< 35	≤ 44	≤ 43
14.1	75	51	39 - 59	≤ 55	< 35	37 - 46	≤ 40	< 35	≤ 43	≤ 42
15.1	75	52	≤ 64	≤ 58	< 35	≤ 46	≤ 45	< 35	≤ 45	≤ 44

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-80 – Predicted construction noise levels – outside standard construction hours (residential receivers) – $L_{Aeq\ 15\ minute}$ dB(A) – Sydney Harbour Crossing

NCA	Noise Management Level				Predicted noise level at each construction stage[3]							
	HNA	Day (O)	Eve	Night	SHC_01[1]	SHC_02[1]	SHC_03	SHC_04[1]	SHC_05[1]	SHC_06	SHC_07	SHC_08
11.1	75	45	45	42	-	-	< 35	-	-	< 35	≤ 38	≤ 41
11.2	75	45	45	42	-	-	< 35	-	-	< 35	< 35	< 35
11.3	75	45	45	42	-	-	< 35	-	-	< 35	< 35	≤ 35
11.4	75	45	45	42	-	-	< 35	-	-	< 35	≤ 44	≤ 47
12.1	75	51	50	45	-	-	< 35	-	-	< 35	≤ 55	≤ 57
12.2	75	51	50	45	-	-	< 35	-	-	< 35	< 35	≤ 37
13.1	75	46	43	37	-	-	< 35	-	-	< 35	≤ 43	≤ 44
13.2	75	46	43	37	-	-	< 35	-	-	< 35	≤ 40	≤ 43
14.1	75	46	42	38	-	-	< 35	-	-	< 35	≤ 39	≤ 42
15.1	75	47	46	43	-	-	< 35	-	-	< 35	≤ 41	≤ 44

Notes: 1. No typical work is proposed outside standard hours.

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML, Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).

3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-81 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – Sydney Harbour Crossing

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours) L_{Aeq}	Outside standard hours L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Build Sydney Harbour north cofferdam	**SHC_01**[1]	0	-	416	4	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Build Sydney Harbour south cofferdam	**SHC_02**[1]	6	-	505	34	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Dewater cofferdams	**SHC_03**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Excavate cofferdams	**SHC_04**[1]	0	-	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Cast transition structures	**SHC_05**[1]	0	-	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Remove cofferdams	**SHC_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Prepare foundations	**SHC_07**	0	0	6	0	0	6	0	0	0	6	0	0	0	46	7	0	0	6	0
8. Immerse elements	**SHC_08**	0	0	1	0	0	18	1	0	0	22	3	0	0	119	19	0	0	102	7

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-78 Table 5-7

5.6.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted levels would occur during piling for cofferdams (Stages 1 and 2). During these stages:

- Six receiver buildings located in NCA 12.1 are expected to be highly noise affected (ie. >75 dB(A)) when piling occurs at the Sydney Harbour south cofferdam
- Up to a total of 545 receiver buildings in NCAs 11.1, 11.2, 11.3, 11.4, 12.1, 13.1, 13.2, 14.1 and 15.1 are expected to be noise affected (ie. > NML) at any one time.

The above impacts are due to impact piling with large (23 tonne) hammers, which are difficult to mitigate using physical noise mitigation measures. It is recommended that alternative piling methods are investigated during detailed design. Alternative piling methods would reduce the airborne noise impacts on the surrounding receiver buildings in addition to minimising the vibration impacts (see section 5.6.5).

Impacts would be managed through a CNVMP, which would include respite periods. It is worth noting that:

- Impact piling would take place only during standard construction hours
- Impact piling high noise generating activities would typically only occur for part of the day, with setup activities, piling preparation and vibratory piling occurring during other parts of the day
- The piling preparation and setup activities associated with the impact piling would provide receivers with longer respite periods than those typically required by the Environment Protection Authority for high noise work
- When vibratory piling takes place, it would occur throughout the day but would contribute lower noise levels than impact piling. These works would be limited to standard construction hours, and respite would still be provided where required.

During other stages at the Sydney Harbour Crossing, noise impacts would be less, with up to six noise affected receiver buildings. These standard construction hours noise impacts would be managed through the CNVMP developed during detailed design.

Work outside of standard construction hours

Due to harbour navigation and safety requirements and lengthy vessel turnaround times, some works are likely to be completed outside of standard construction hours, as presented in Table 5-75. At the Sydney Harbour Crossing, the key stages requiring OOHW are:

- Stage 3 (SHC_03): Dewater cofferdams
- Stage 6 (SHC_06): Remove cofferdams
- Stage 7 (SHC_07): Prepare foundations
- Stage 8 (SHC_08): Immerse elements.

During Stages 3 and 6 (SHC_03 and SHC_06), the only work which may occur outside standard construction hours is pumping water into or out of the cofferdams. If this work is needed, pumps would be enclosed or otherwise treated so that NMLs are not exceeded.

During trailer suction hopper dredging at night (SHC_07), up to 46 residential receiver buildings are expected to be noise affected by 1 to 5 dB(A) and seven residential receiver buildings are expected to be noise affected by 6 to 15 dB(A).

Backhoe dredging, and gravel placement would only occur during standard construction hours. The only plant which would operate during foundation preparation outside standard construction hours is the trailer suction hopper dredge.

Dredging (trailer suction hopper dredging) of the Sydney Harbour Crossing would occur three times a night for only 25 minutes at a time. This represents about 10 per cent of the night time. Most of the time the dredge would be travelling between the Sydney Harbour Crossing and the disposal site.

During tunnel element immersion (SHC_08), up to 119 residential receiver buildings are expected to be noise affected by 1 to 5 dB(A) and 19 residential receiver buildings are expected to be noise affected by 6 to 15 dB(A).

Each of the five tunnel elements would take between 24 and 48 hours to immerse, and for safety reasons this would occur during harbour closures. These impacts would be managed through a CNVMP, and it is likely that additional mitigation measures would need to be offered in accordance with the CNVG.

The predicted noise levels are based on all plant operating simultaneously and continuously during each assessment activity. However, in practice not all plant would typically operate all the time, meaning that for a significant part of the time actual noise levels would be less than the predicted noise levels.

Sleep disturbance

At the Sydney Harbour Crossing, the key OOHW stages which potentially include activities with maximum noise levels (L_{Amax}) are:

- Stage 7 (SHC_07): Prepare foundations
- Stage 8 (SHC_08): Immerse elements.

Foundation preparation works (SHC_07) would require dredging at night to minimise disruption to vessel movements and manage lengthy vessel turnaround times. During this stage:

- Up to six receiver buildings in NCA 12.1 are predicted to potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 59 dB(A)); however, no receiver buildings are expected to be affected by noise above the awakening level
- Due to the nature of the trailer suction hopper dredge and the expected duration of use (25 minutes a time, up to three times a night) substantial sleep disturbance impacts are not likely to occur.

Immersion of tunnel elements (SHC_08) would be carried out at night during harbour closures, to minimise risks from interactions with other vessels. During this stage:

- Up to 102 receiver buildings in NCAs 11.4, 12.1, 13.1, 13.2, 14.1 and 15.1 are predicted to potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 70 dB(A)), including seven receiver buildings where predicted noise levels are above the awakening level
- Maximum noise level events may occur occasionally during crane/plant/equipment operation, for example if chains are dropped on to the barge deck. These events would be minimised as far as practicable, by programming each immersion to start and end outside the night time period and adopting quiet work practices through the CNVMP.

5.6.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-82.

The number of non-residential receiver buildings predicted to exceed the NMLs are summarised in Table 5-83. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Predicted noise levels from piling for cofferdams (Stage 1 and Stage 2) would result in a total of six non-residential receiver buildings being noise affected:

- One recreational receiver in NCA 15.1 would be noise affected by up to 3 dB(A) during Stage 1 (construction of Sydney Harbour north cofferdam)
- During Stage 2 (construction of Sydney Harbour south cofferdam), two recreational receiver buildings in NCAs 11.4 and 13.1 would be noise affected by up to 10 dB(A) and one in NCA 12.1 would be noise affected by up to 20 dB(A)
- Two other sensitive receiver buildings in NCA 13.2 would also be noise affected by up to 10 dB(A) during Stage 1 works (construction of Sydney Harbour north cofferdam).

Table 5-82 – Predicted construction noise levels at other sensitive receivers – $L_{Aeq(15min)}$, dB(A) – Sydney Harbour Crossing

Receiver type	NCA	NML	Predicted noise levels at each construction stage[2]							
			SHC_01	SHC_02	SHC_03	SHC_04	SHC_05	SHC_06	SHC_07	SHC_08
Commercial	11.1	70	52 - 58	50 - 59	< 35	36 - 40	37 - 43	< 35	37 - 43	36 - 42
	11.2	75	≤ 46	≤ 49	< 35	< 35	< 35	< 35	< 35	< 35
	13.1	75	41 - 64	39 - 55	< 35	≤ 46	≤ 45	< 35	≤ 46	≤ 47
	14.1	75	42 - 70	37 - 62	< 35	36 - 55	≤ 48	< 35	≤ 50	≤ 51
	15.1	70	46 - 52	46 - 46	< 35	≤ 35	< 35	< 35	< 35	< 35
Childcare	15.1	50	≤ 38	≤ 44	< 35	< 35	< 35	< 35	< 35	< 35
Recreational	11.1	60	43 - 48	48 - 59	< 35	≤ 38	≤ 40	< 35	≤ 43	36 - 42
	11.4	60	≤ 59	≤ 63	< 35	≤ 48	≤ 46	< 35	≤ 46	≤ 45
	12.1	60 - 65	46 - 62	46 - 80	< 35	38 - 63	37 - 62	< 35	38 - 58	36 - 56
	13.1	65	43 - 46	62 - 68	< 35	48 - 50	43 - 49	< 35	43 - 49	40 - 48
	13.2	65	≤ 64	≤ 47	< 35	≤ 46	≤ 45	< 35	≤ 45	≤ 42
	14.1	65	38 - 58	40 - 50	< 35	35 - 54	≤ 38	< 35	≤ 40	≤ 38
	15.1	60	38 - 63	44 - 57	< 35	≤ 46	≤ 45	< 35	≤ 45	≤ 43
Place of worship	11.4	55	44 - 54	49 - 51	< 35	≤ 37	< 35	< 35	≤ 37	≤ 35
Other sensitive receiver	13.2	55	36 - 61	≤ 50	< 35	≤ 45	≤ 42	< 35	≤ 43	≤ 42

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-83 – Number of other sensitive receivers over the noise management level (all NCAs) – $L_{Aeq(15min)}$ – Sydney Harbour Crossing

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1,2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Build Sydney Harbour north cofferdam	**SHC_01**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
2. Build Sydney Harbour south cofferdam	**SHC_02**	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
3. Dewater cofferdams	**SHC_03**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Excavate cofferdams	**SHC_04**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
5. Cast transition structures	**SHC_05**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
6. Remove cofferdams	**SHC_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Prepare foundations	**SHC_07**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Immerse elements	**SHC_08**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.

2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

5.6.2.6 Summary of residual impacts and additional mitigation measures

Table 5-81 indicates the number of residential buildings where noise impacts are expected to exceed the NMLs after the implementation of noise treatments and management measures.

Further acoustic mitigation and management measures, as outlined in Appendix G, would be confirmed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures, in accordance with the CNVG and presented in section 6.10.1, would be provided to manage construction noise impacts.

5.6.2.7 Cumulative and consecutive construction noise impacts

As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the Sydney Harbour Crossing would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Proposed staging of concurrent construction works associated with the project that are considered for cumulative or concurrent construction noise assessment are presented in Table 5-84.

Table 5-84 – Concurrent construction works near the Sydney Harbour Crossing

Project	2019	2020	2021	2022	2023	2024	2025
Sydney Harbour Crossing							
Berrys Bay construction support site							
Yurulbin Point construction support site							

Proposed staging of concurrent work has been reviewed for the closest receiver buildings to the Sydney Harbour Crossing. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

If noise from one site dominates noise levels at the receiver (ie. > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

If noise levels from each site are similar at a receiver, a total construction noise increase of up to 3 dB(A) is expected. Two representative NCAs nearby to the works have been assessed in Table 5-85, one adjacent to the Sydney Harbour south cofferdam and one adjacent to the Sydney Harbour north cofferdam.

Table 5-85 – Potential cumulative noise impacts from construction near the Sydney Harbour Crossing

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 12.1	Standard hours NML 56 dB(A)	SHC	Build Sydney Harbour south cofferdam	81	If cofferdam construction activities at the Sydney Harbour Crossing (SHC) occur concurrently with tunnelling at the Berrys Bay (BRY) and Yurulbin Point (YRB) construction support sites, then the noise levels from cofferdam construction activities are likely to dominate at nearby receivers. During the activity, construction noise levels from the Berrys Bay and Yurulbin Point construction support site are predicted to achieve the NML.
		BRY	Tunnelling	<35	
		YRB	Tunnelling	49	
	OOHW NML D/E/N 51/50/45 dB(A)	SHC	Immerse elements	57	If tunnel element immersion activities at the Sydney Harbour Crossing occur concurrently with tunnelling at the Berrys Bay and Yurulbin Point construction support sites, then the noise levels from tunnel element immersion activities are likely to dominate at nearby to receivers. During the activity construction noise levels from both the Berrys Bay and the Yurulbin Point construction support sites are predicted to achieve the NML.
		BRY	Tunnelling	<35	
		YRB	Tunnelling	43	
NCA 14.1	Standard hours NML 51 dB(A)	SHC	Build Sydney Harbour north cofferdam	59	If cofferdam construction activities at the Sydney Harbour Crossing occur concurrently with tunnelling at the Berrys Bay construction support site, then the cumulative construction noise level could increase by up to 3 dB(A) as both sites contribute a similar noise level. Both the individual construction support sites and the cumulative construction noise level are above the standard construction hours NML. Construction noise from Yurulbin Point construction support site activities is predicted to be below the NML.
		BRY	Tunnelling	59	
		YRB	Tunnelling	<35	
	OOHW NML D/E/N 46/42/38 dB(A)	SHC	Immerse elements	42	If tunnel element immersion activities at the Sydney Harbour Crossing occur concurrently with tunnelling at the Berrys Bay construction support site, then the cumulative construction noise level could increase by up to 1 dB(A), slightly increasing construction noise above the NML. Tunnelling at the Berrys Bay construction support site by itself achieves the night NML, however cumulatively the construction noise level may be higher than the NML. Construction noise from Yurulbin Point construction support site activities is predicted below the NML.
		BRY	Tunnelling	38	
		YRB	Tunnelling	<35	

At the receiver buildings in NCA 14.1 most affected by the Sydney Harbour Crossing, there is the potential for NMLs to be exceeded by cumulative increases of construction noise from concurrent work at the Berrys Bay construction support site. However, cumulative noise impacts are not expected to be substantial as:

- Piling and tunnel element immersion would be relatively short in duration for the noise intensive activities
- The cumulative increase in construction noise level is not likely to substantially increase the number of receiver buildings where total construction noise is above the NML.

Potential consecutive or cumulative construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. The CNVMP prepared as part of the detailed design would include these mitigation measures and cumulative noise impacts would be considered further during detailed design where feasible and reasonable. These mitigation measures would be included in the site's detailed design and site specific CNVIS where feasible and reasonable, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures.

5.6.3 Construction-related traffic noise assessment

The Sydney Harbour Crossing would be accessed by barges, usually from the White Bay construction support site. Construction-related water traffic is discussed in section 4.2.7.

Construction-related road traffic noise impacts are therefore addressed in the assessment for the site at White Bay as detailed in section 5.4.3.

5.6.4 Ground-borne construction noise

Airborne noise is expected to dominate noise emitted from this site, even though ground-borne noise levels could be generated by piling activities. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. As with the case study impacts presented in section 4.3.2, airborne noise is expected to exceed ground-borne noise levels. As such, the management measures to address airborne noise impacts at these receiver buildings are also likely to manage associated ground-borne noise impacts.

Ground-borne noise impacts from the construction of the mainline tunnel are assessed through ground-borne vibration impacts presented in section 5.11.1.

5.6.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out. For the Sydney Harbour Crossing, the major stages which may include vibration-intensive works are:

- Stage 1 (SHC_01) build Sydney Harbour north cofferdam
- Stage 2 (SHC_02) build Sydney Harbour south cofferdam
- Stage 4 (SHC_04) excavate cofferdams.

Proposed vibration-intensive plant items are identified in Appendix E. Minimum working distances for a range of plant are presented in Table 4-11. Presented in Appendix L are the estimated minimum working distances from the works construction support site for both structural damage and human response to vibration for the most vibration-intensive activity proposed for the construction support site.

The most vibration-intensive activity at this site is likely to be impact piling with a large (23 tonne) hammer for cofferdam construction (SHC_01 and SHC_02). The number of receiver buildings within the minimum working distances for this activity is presented in Table 5-86.

Potential vibration generated to receivers depends on the vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. This assessment considers a worst-case scenario that the proposed vibration-intensive plant items could be used anywhere with the boundaries of the cofferdams and crossing work areas. However, vibration-intensive activities are unlikely to occur across the entirety of these areas, and the location of the vibration-intensive equipment would be confirmed during detailed design.

Table 5-86 – Potential vibration impacts – Sydney Harbour Crossing

NCA	Number of structures within minimum working distances		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Build or excavate cofferdams			
12.1	7	-	50
14.1	8	-	22

Due to the proximity of vibration sensitive structures and the levels of vibration generated by the piling activities as part of the Sydney Harbour Crossing specific mitigation and management measures are detailed in section 5.6.5.4.

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate limits.

Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.6.5.1 Cosmetic damage

This assessment considers a worst-case scenario that the proposed vibration-intensive plant items could occur at all locations across the cofferdams work areas. However, the vibration-intensive activities would not occur across the entirety of the works areas, as the required equipment would vary for different locations across the construction area, and the sensitivity of the potentially impacted structures would vary. The specific vibration-intensive equipment and where it would occur would be reviewed during detailed design.

Site-specific minimum working distances for vibration-intensive activities (such as compaction, rock hammering and piling) would be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see Table 4-11). Site-specific buffer distances would be maintained in order to comply with relevant vibration limits for cosmetic damage.

Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.6.5.2 Heritage listed structures

Twenty heritage items were identified within the unsound structure cosmetic damage minimum working distance, 14 nearby to the Sydney Harbour north cofferdam and six nearby to the Sydney Harbour south cofferdam. Nearby heritage items are shown in Appendix L and identified in Table 5-87. Refer to the Technical working paper: Cultural heritage assessment report, Technical working paper: Non-Aboriginal heritage and Technical working paper: Maritime heritage for the assessment of impacts to heritage items.

Table 5-87 – Heritage receivers within the cosmetic damage minimum working distance – Sydney Harbour Crossing

Name	Significance	Type	Site Heritage ID
Sydney Harbour south cofferdam			
Yurulbin Park	Local	Item - General	I555
Aboriginal middens and rock shelter Yerroulbin Cave	Local AHIMS site[2]	Item - Archaeological	A6 45-6-2287
Aboriginal middens and rock shelter 5 Hands Shelter B NSC-074	Local AHIMS site[2]	Item - Archaeological	A8 45-6-2967
Railway electricity tunnel under Sydney Harbour; Balmain to Greenwich Electric Cable Tunnel, including interiors	State	State Heritage Act RailCorp Section 170 and conservation register	01231 5062542
Long Nose Point (Birchgrove) Wharf site and shelter (remnant maritime infrastructure and associated archaeological deposits)	Maritime	-	-
Shed Cave - Birchgrove	AHIMS site[2]	-	A4 45-6-2672

Name	Significance	Type	Site Heritage ID
Sydney Harbour north cofferdam			
Former coal loader (including wharf and seawall)	Local	Item - General	I1040
Balls Head Foreshore Relics Group 'Uncle Tom's Cabin	Local	Item - Landscape	I1048
Balls Head Foreshore Relics Group, ring bolt and iron screen	Local	Item - Landscape	I1045
Balls Head Foreshore Relics Group, remains of windlass spindle	Local	Item - Landscape	I1044
Balls Head Foreshore Relics Group, ring bolt	Local	Item - Landscape	I1046
Balls Head Foreshore Relics Group - steps to former harbour pool	Local	Item - Landscape	I1047
Woodleys Shipyard	Local	Item – General Item – Landscape Roads and Maritime Section 170 Heritage and Conservation Registers	I1038 4920101
Balls Head Reserve	Local	Item - Landscape	I1041
Unidentified Balls Head Bay 1	Maritime	-	-
Unidentified Balls Head Bay 2	Maritime	-	-
Magnetic Anomaly No. 1	Maritime	-	-
SSS Anomaly No. 1	Maritime	-	-
SSS Anomaly No. 2	Maritime	-	-
SSS Anomaly No. 3	Maritime	-	-

Notes: 1. Conservation areas and the heritage ships of M.V. Baragoola and M.V. Cape Don that are moored at adjacent to the Former Coal Loader have not been considered as they do not form a structure that would be impacted by vibration.

2. National Parks and Wildlife Act (AHIMS registered site).

Before starting work with the potential to impact on heritage items, all nearby heritage items would be confirmed, structural surveys carried out where required and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate limits.

Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.6.5.3 Human response

Piling or rock hammering would only occur for a limited duration at this site; therefore, the risk of annoyance is low. However, residents of up to 72 buildings are predicted to be exposed to vibration levels above the perception level (ie. residents may feel vibration from piling or rock hammering), as presented in Table 5-86.

Mainline tunnel construction ground-borne vibration impacts are presented in Section 5.11.1.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures would be provided (see section 6.10.3).

5.6.5.4 Specific mitigation and management of cofferdam construction

Due to the proximity of vibration sensitive structures, including heritage items such as the former Coal Loader to the cofferdam construction work area, there is the potential for cosmetic damage to these structures/items if mitigation and management measures are not implemented.

This is of importance when considering the use of impact piling, which can generate high levels of vibration. Ground resistance varies as the pile is driven into the ground, causing vibration from impact piling to change over the course of the piling driving. Considering this, it is important that the potential worst-case vibration impacts are used when reviewing the piling methodology and potential vibration levels, and why continuous vibration monitoring is crucial to ensure that vibration limits are maintained.

The management of vibration impacts from cofferdam piling (impact and sheet) would require specific reviews of the methodology during detailed design to be used by the construction contractor to minimise impacts from vibration. Where vibration levels are likely to be higher than the acceptable limits, alternative piling techniques are to be considered. These piling methods would also assist in reducing the airborne noise impacts on the surrounding receivers.

Once the vibration intensive works methodologies are determined, site-specific minimum working distances for all vibration-intensive activities (eg. compaction, rock hammering, piling) that may impact vibration sensitive structures/items must be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see Table 4-11) prior to the vibration intensive construction works commencing. Site-specific buffer distances would be maintained to comply with relevant vibration limits for cosmetic damage for each vibration sensitive structure/item.

5.7 Berrys Bay construction support site

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the Berrys Bay construction support site.

5.7.1 Construction support site overview

5.7.1.1 Construction support site description

The Berrys Bay construction support site is located on Balls Head Road at Waverton. Work at the site would occur in stages as presented in Table 5-88.

Table 5-88 –Berrys Bay construction support site – major stage activities overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Early works	Connect and relocate services at the site such as electricity, sewerage and water
	2. Establish site	Install environmental controls
	3. Establishment of construction facilities	Establish site offices and workshops
Acoustic shed and surface level tunnel access construction	4. Piling for acoustic sheds	Pilling for the shed foundations and piling for the barge shed.
	5. Surface level decline construction	Surface level decline excavation and construction works
	6. Acoustic shed construction	Erect on-shore and water-based shed elements.
Tunnel construction (access decline and mainline tunnels)	7. Tunnelling	Tunnel spoil handling and transfer to barge, tunnel support, tunnel lining and associated deliveries
Tunnel fitout	8. Tunnel fitout	Install mechanical and utilities services to the tunnel
Tunnel commission and site rehabilitation	9. Restore site	Commission tunnel, decommission site

In addition to the major activities presented above, the Berrys Bay construction support site would also support up to four roadheaders operating as follows:

- Three excavating the mainline tunnels north to the Warringah Freeway and south to Birchgrove
- One excavating the cross passages between the mainline tunnels
- Spoil would also be transferred to White Bay construction support site by barge.

5.7.1.2 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-89, subject to project approval. This construction support site would operate from mid 2021 until late 2025. The longest duration activity at this construction support site would be tunnelling and tunnel fitout works.

Table 5-89 – Berrys Bay construction support site – indicative program and timeline

Stage	Construction activity	Reference	Indicative construction timeframe																	
			2021				2022				2023				2024				2025			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1. Early works	BRY_01																				
	2. Establish site	BRY_02																				
	3. Establishment of construction facilities	BRY_03																				
Acoustic shed and surface level tunnel access construction	4. Piling for acoustic sheds	BRY_04																				
	5. Surface level decline construction	BRY_05																				
	6. Acoustic shed construction	BRY_06																				
Tunnel construction (access decline and mainline tunnels)	7. Tunnelling	BRY_07																				
Tunnel fitout	8. Tunnel fitout	BRY_08																				
Tunnel commission and site rehabilitation	9. Restore site	BRY_09																				

5.7.1.3 Nearby noise and vibration-sensitive receivers

The site is located on Balls Head Road in Waverton and is surrounded by a mix of commercial, industrial, recreational and residential receivers.

Residential receivers are located to the north and east, passive recreation areas are adjacent to the south and west and commercial/industrial receivers are located to the south, north-east and north-west of the construction support site. The location of the site, tunnel alignment, nearby NCAs and receiver locations are shown in Figure 5-9.

Figure 5-9 – Location of Berrys Bay construction support site



5.7.1.4 Construction duration and working hours

Table 5-90 presents each of the major stages that have been assessed along with the representative activities that would take place during each stage for the Berrys Bay construction support site, along with the proposed time periods each activity is proposed to occur.

During the operation of the Berrys Bay construction support site, work would typically take place during the ICNG standard construction hours as presented in Table 3-2. However, some OOHW would take place outside standard construction hours as presented in Table 5-90. Tunnelling works in particular would be required to occur 24 hours per day, seven days per week. Further justification for OOHW is provided in section 5.1.3.

Table 5-90 – Berrys Bay construction support site – construction hours

Stage	Representative activity		Reference	Assessed activities[1]	Work hours[2]			
					Day (Std)	Day (OOHW)	Evening	Night
Site establishment	1.	Early works	BRY_01	Utility works	♦			
	2.	Establish site	BRY_02	Install environmental controls	♦			
				Clearing and grubbing	♦			
	3.	Establishment of construction facilities	BRY_03	Establishment of construction facilities	♦			
Acoustic shed and surface level tunnel access construction	4.	Piling for acoustic sheds	BRY_04	Piling for onshore acoustic shed	♦			
				Piling for water-based shed	♦			
	5.	Surface level decline construction	BRY_05	Surface level decline excavation and construction works.	♦			
				Laydown areas	♦			
	6.	Acoustic shed construction	BRY_06	Acoustic shed construction	♦			
				Barge shed construction	♦			
Tunnel construction (access decline and mainline tunnels)	7.	Tunnelling	BRY_07	General site activities	♦	♦	♦	♦
				Deliveries	♦			
				Tunnelling and support	♦	♦	♦	♦
				Tunnel lining (concreting)	♦	♦	♦	♦
				Deliveries by barge	♦			
				Barge spoil handling	♦	♦[3]	♦[3]	♦[3]
Tunnel fitout	8.	Tunnel fitout	BRY_08	Deliveries	♦	♦	♦	♦
				Laydown areas	♦			
Tunnel commission and site rehabilitation	9.	Restore site	BRY_09	Decommission site	♦			

Notes: 1. Appendix E describes the modelled plant for each activity

2. Day (S) Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
Day (O) Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday

3. Spoil haulage by barge off the construction support site would occur during standard construction hours. OOHW spoil handling would occur inside acoustic shed.

5.7.1.5 Concurrent and consecutive construction projects

The nearest construction support sites associated with this project are the Sydney Harbour Crossing, about 200 metres west of this site, and the Yurulbin Point construction support site, about 1 kilometre south-west of this site.

The nearest construction works associated with another major construction project are the Sydney Metro City & Southwest construction support sites at Barangaroo and Blues Point. However due to the separation distance between the construction sites and the level of noise emissions expected from construction activities at the Yurulbin Point construction support site, consecutive noise impacts on receivers nearby to the Yurulbin Point construction support site is unlikely from these construction activities.

5.7.1.6 Construction assessment scenarios

The airborne noise assessment of the Berrys Bay construction support site has been separated into nine stages. Each stage has been assessed against the work periods presented in Table 5-90.

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant assumed to be operating during the stage. It is assumed the all equipment/plant operate simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

Multiple activities would occasionally occur concurrently within the one construction support site and where this could reasonably occur it has been captured in the assessment as shown in Appendix E.

5.7.1.7 Summary of assumed mitigation and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating, to assist in attenuating and managing noise emissions from the construction activities.

Identified feasible and reasonable noise treatment measures have been included in the noise modelling and are presented in Table 5-91. The results presented in this assessment are based on these noise treatments and management measures being implemented. The locations of physical noise treatment measures are shown on Figure 5-10.

Table 5-91 – Assumed noise treatment and management measures – Berrys Bay construction support site

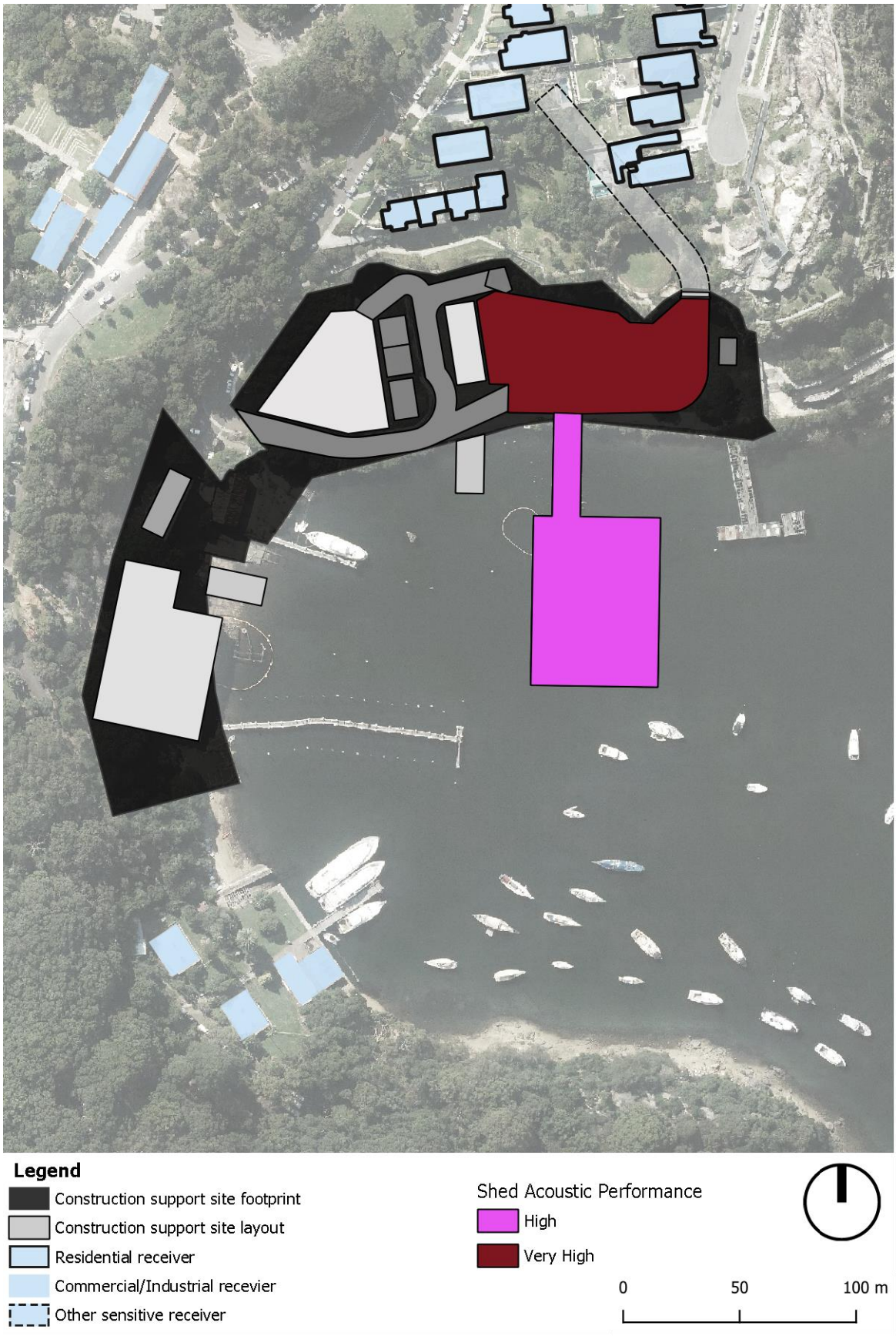
Activity or plant/equipment	Management and noise treatment measures applied
Tunnelling, support and fitout: acoustic shed, decline and conveyor	A very high performance on-shore acoustic shed and decline cover, and a high performance on-water acoustic shed with conveyor would be built to reduce noise from tunnelling, tunnel support and fitout works outside standard construction hours. The performance requirements for individual elements of the acoustic shed are presented in Table 5-92. A conveyor rain hood would be built to achieve a total sound power level of 75 dB(A) per metre.
Ventilation plant	Plant items would be selected or acoustically treated to achieve a maximum combined sound power level of 86 dB(A). Three ventilation plant were assumed in the model.
Wastewater treatment plant	The wastewater treatment plant would be acoustically treated or placed in an acoustic enclosure to achieve a total sound power level of 74 dB(A).
Substation	The substation would be built to achieve a total sound power level of 73 dB(A), which may require acoustic treatment or the use of an acoustic enclosure.
Work outside standard hours	Work would only occur outside standard hours where it: ▪ Meets the relevant NMLs ▪ Occurs in an acoustic enclosure ▪ Is required for safety reasons ▪ At night, noise generating delivery activities would occur within the acoustic shed and any associated activities outside of the shed would be minimised.

Table 5-92 – Indicative acoustic shed construction and acoustic performance – Berrys Bay construction support site

Shed/conveyor element (Indicative example constructions are shown in Table 4-1)	Octave band frequency transmission loss, dB						
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Onshore spoil shed and decline cover (very high performance)							
Walls – Very high performance	25	31	40	49	61	69	75
Roof – Very high performance	23	31	40	49	56	58	63
Offshore spoil shed and conveyor cover (high performance)							
Walls – High performance	10	29	35	42	46	51	57
Roof – High performance	10	29	35	42	46	51	57

Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

Figure 5-10 – Construction support site layout with indicative noise treatment measures at Berrys Bay



5.7.2 Construction airborne noise

5.7.2.1 Nearby receiver summary and objectives

Table 5-93 presents NMLs and the screening levels for the assessment of sleep disturbance for the nearest residential receivers surrounding the Berrys Bay construction support site. Noise management levels for other (non-residential) noise-sensitive receivers are presented in Section 3.4.1.

Table 5-93 – Construction noise management levels and screening levels at residential receivers

NCA ID	Noise management level (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
14.1	51	46	42	38	48
15.1	52	47	46	43	53
15.2	52	47	46	43	53
15.3	52	47	46	43	53

5.7.2.2 Predicted noise impacts

Table 5-94 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-94 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

The modelling results presented are the range of the highest predicted noise levels for each NCA for residential receiver buildings, commercial and OSRs, unless no receiver buildings of that type in that NCA are expected to exceed NMLs.

The range is of noise impacts throughout all receiver buildings in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented. The noise predictions include adjustments for impulsive, tonal and other annoying noise characteristics in accordance with the ICNG.

Noise contours for the loudest early works and site establishment stages, and longer-term tunnelling stages are shown in Appendix H.

5.7.2.3 Residential

The predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-95: for standard construction hours
- Table 5-96: for works outside of standard construction hours.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-97. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-95 – Predicted construction noise levels – standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Berrys Bay construction support site

NCA	Noise Management Levels		Predicted noise levels at each construction stage[2]								
	HNA	NML	BRY_01	BRY_02	BRY_03	BRY_04	BRY_05	BRY_06	BRY_07	BRY_08	BRY_09
14.1	75	51	38 - **76**	≤ 65	≤ 69	≤ 70	37 - **76**	≤ 68	≤ 59	≤ 59	≤ 63
15.1	75	52	40 - 49	≤ 40	≤ 36	36 - 46	≤ 36	37 - 42	< 35	< 35	< 35
15.2	75	52	≤ 58	≤ 53	≤ 50	≤ 56	≤ 56	≤ 52	≤ 42	≤ 43	≤ 49
15.3	75	52	36 - 49	≤ 41	≤ 37	37 - 46	≤ 37	≤ 42	≤ 36	≤ 36	≤ 36

Notes:
1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-96 – Predicted construction noise levels – outside standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$, dB(A) – Berrys Bay construction support site

NCA	Noise Management Level				Predicted noise levels at each construction stage[3]								
	HNA	Day (O)	Eve	Night	BRY_01[1]	BRY_02[1]	BRY_03[1]	BRY_04[1]	BRY_05[1]	BRY_06[1]	BRY_07	BRY_08	BRY_09[1]
14.1	75	46	42	38	-	-	-	-	-	-	≤ 40	≤ 38	-
15.1	75	47	46	43	-	-	-	-	-	-	< 35	< 35	-
15.2	75	47	46	43	-	-	-	-	-	-	< 35	< 35	-
15.3	75	47	46	43	-	-	-	-	-	-	< 35	< 35	-

Notes:
1. No work is proposed outside standard construction hours.
2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).
3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-97 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – Berrys Bay construction support site

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours	Outside standard hours																	
		L_{Aeq}	L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
1. Early works	BRY_01[1]	1	-	74	14	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Establish site	BRY_02[1]	0	-	18	5	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Establishment of construction facilities	BRY_03[1]	0	-	10	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Piling for acoustic sheds	BRY_04[1]	0	-	23	9	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Surface level decline construction	BRY_05[1]	1	-	7	7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Acoustic shed construction	BRY_06[1]	0	-	11	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Tunnelling	BRY_07	0	0	4	0	0	-	0	0	0	0	0	0	0	1	0	0	0	25	2
8. Tunnel fitout	BRY_08	0	0	4	0	0	-	0	0	0	0	0	0	0	0	0	0	0	25	2
9. Restore site	BRY_09[1]	0	-	5	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-94Table 5-78Table 5-7

5.7.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted noise levels would occur during early works and decline construction (BRY_01 and BRY_05). During these stages, one receiver building in NCA 14.1 is expected to be highly noise affected (ie. >75 dB(A)). Up to 92 receiver buildings in NCAs 14.1 and 15.2 are predicted to be noise affected (ie. > NML) during Stage 1.

These noise levels are expected to occur when excavators with rock hammers are used. When rock hammers are not used, noise impacts are predicted to reduce by up to 8 dB(A).

During other stages, noise impacts would be less, with the number of noise affected receiver buildings ranging from four to 27.

Work outside of standard construction hours

Due to 24 hour tunnelling requirements, some works are likely to be completed outside of standard construction hours, as presented in Table 5-58. At the Berrys Bay construction support site, the key stages requiring OOHW are:

- Stage 7 (BRY_07): Tunnelling – tunnel construction
- Stage 8 (BRY_07): Tunnelling – tunnel fitout.

Night time tunnel construction (BRY_07) works are expected to result in residual noise impacts at one residential receiver building in NCA 14.1, where noise is predicted to exceed the night NML by 2 dB(A). This is a result of concrete agitator deliveries. When concrete agitator deliveries do not occur at night, the predicted noise levels from the construction support site are within the NML at all residential receivers. As detailed in section 5.7.3 impacts from deliveries would be reviewed during detailed design, when actual heavy vehicle noise source levels and impacts can be measured, and feasible and reasonable mitigation and management methods would be implemented considering the actual noise levels.

During the longer-term tunnel fitout night works (BRY_08), additional mitigation measures are not required as no residential receiver buildings are expected to be noise affected during OOHW.

Predicted noise levels are based on all plant operating simultaneously and continuously during each assessment activity. However, in practice, not all plant would typically operate all the time, meaning that for a substantial part of the time actual noise levels would likely be less than predicted.

Sleep disturbance

During night time tunnelling and tunnel support works, concrete/delivery heavy vehicles are predicted to occasionally result in high maximum noise levels during arrival at or departure from the site. Up to 25 receiver buildings are predicted to potentially be exposed to maximum noise levels above the sleep

disturbance screening level (up to L_{Amax} 71 dB(A)). Two receiver buildings are predicted to potentially experience noise levels above the awakening reaction noise level.

Typically, up to three to four concrete heavy vehicles per night are expected to provide shotcrete for ground support work during tunnelling, with only a few isolated occasions during the project when more heavy vehicles are required. While predicted L_{Amax}, noise levels are greater than the screening levels, potential sleep disturbance impacts can be managed due to the limited number of heavy vehicle movements.

5.7.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-98. The receiver buildings predicted to exceed the NMLs are summarised in Table 5-99. The predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

After all feasible and reasonable noise treatment measures are applied, one recreational receiver in NCA 14.1 is predicted to exceed the NML (by up to 4 dB(A)) during early works (BRY_01) and surface level decline construction (BRY_05) at the Berrys Bay construction support site.

Table 5-98 – Predicted noise levels at other sensitive receivers, dB(A) – Berrys Bay construction support site

Receiver type	NCA	Noise Management Level		Predicted noise level at each construction stage[2]								
		HNA	NML	BRY_01	BRY_02	BRY_03	BRY_04	BRY_05	BRY_06	BRY_07	BRY_08	BRY_09
Commercial	14.1	75	75	37 - 69	≤ 56	≤ 57	≤ 64	37 - 69	≤ 60	≤ 56	≤ 56	≤ 56
	15.2	75	75	40 - 57	36 - 52	≤ 44	53 - 55	39 - 45	47 - 50	≤ 41	≤ 43	38 - 43
Other sensitive receivers	15.2	75	60	≤ 48	≤ 40	≤ 38	≤ 41	≤ 42	≤ 40	< 35	< 35	≤ 37
Recreational	14.1	75	60	≤ 64	≤ 52	≤ 53	≤ 57	≤ 63	≤ 55	≤ 56	≤ 55	≤ 51

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-99 – Number of other sensitive receivers over the noise management level (all NCAs) – $L_{Aeq(15min)}$ – Berrys Bay construction support site

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
1. Early works	BRY_01	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2. Establish site	BRY_02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Establishment of construction facilities	BRY_03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Piling for acoustic sheds	BRY_04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Surface level decline construction	BRY_05	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
6. Acoustic shed construction	BRY_06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Tunnelling	BRY_07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Tunnel fitout	BRY_08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. Restore site	BRY_09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: 1. Commercial, industrial, recreational active and passive, and other sensitive receiver buildings have been assessed against the respective NMLs, and exceedances have been presented in the count table.

2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

5.7.2.6 Summary of residual impacts and additional mitigation measures

Table 5-97 indicates the number of residential buildings where noise impacts are expected to exceed the NMLs after the implementation of noise treatments and management measures.

Further acoustic mitigation and management measures, as outlined in the standard ICNG mitigation measures included in Appendix G would be confirmed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures in accordance with the CNVG and presented in section 6.10.1 would be provided to manage construction noise impacts.

5.7.2.7 Cumulative and consecutive construction noise impacts

As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the Berrys Bay construction support site would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-100.

Table 5-100 – Concurrent construction works near the Berrys Bay construction support site

Project	2021	2022	2023	2024	2025
Sydney Harbour Crossing					
Berrys Bay construction support site					
Yurulbin Point construction support site					

Proposed staging of concurrent work and noise impacts at the closest receiver buildings to the site at Berrys Bay have been reviewed. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

In the case where noise from one site dominates noise levels at the receiver (ie. > 5-10 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

However, where noise levels from each site are similar at a receiver, an increase of a total construction noise of up to 3 dB(A) is predicted. One representative NCA adjacent to the works has been assessed in Table 5-101.

Table 5-101 – Potential cumulative noise impacts from construction projects – Berrys Bay site

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 14.1	Standard hours NML 51 dB(A)	BRY	Tunnelling	59	If tunnelling at the Berrys Bay construction support site (BRY) occurs concurrently with cofferdam construction activities at Sydney Harbour Crossing (SHC), then the cumulative construction noise level could increase by up to 3 dB(A) as both sites contribute a similar noise level. Both Berrys Bay and Western Harbour Crossing construction support sites and the cumulative construction noise level are above the standard construction hours NML. Construction noise from activities at the Yurulbin Point construction support site is predicted to be below the NML.
		SHC	Build Sydney Harbour north cofferdam	59	
		YRB	Tunnelling	<35	
	OOHW NML D/E/N 46/42/38	BRY	Tunnelling	38	If tunnelling at the Berrys Bay construction support site (BRY) occurs concurrently with tunnel element immersion activities at the Sydney Harbour Crossing (SHC), then the cumulative construction noise level could increase by up to 1 dB(A), slightly increasing the construction noise level above the NML. Tunnelling at the Berrys Bay construction support site by itself achieves the night NML, however cumulatively the construction noise level may be higher than the NML. Construction noise from Yurulbin Point construction support site activities is predicted below the NML.
		SHC	Immerse elements	42	
		YRB	Tunnelling	<35	

At the receiver buildings most affected by the site at Berrys Bay in NCA 14.1, there is potential for NMLs to be exceeded by cumulative increases of construction noise from concurrent work with the Sydney Harbour Crossing during standard construction hours.

For noise affected receiver buildings, the key difference in construction noise impacts could be an increased overall duration and frequency of construction noise impacts, even if they are at the same noise level. This increased frequency would be considered by the other construction support sites during detailed design when reviewing and incorporating feasible and reasonable noise mitigation measures.

However, cumulative noise impacts are expected to be minor as:

- Noise impacts from piling and tunnel element immersion at the Sydney Harbour Crossing relatively short in duration for the noise intensive activities
- Only four receiver buildings are predicted to exceed the NML during standard construction hours during tunnelling, where cumulative impacts may increase the overall construction noise level.

Potential consecutive or cumulative construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. The CNVMP prepared as part of the detailed design would include these mitigation measures and cumulative noise impacts would be considered further during detailed design where feasible and reasonable. These mitigation measures would

be included in the site's detailed design and site specific CNVIS where feasible and reasonable, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures.

5.7.3 Construction-related road traffic noise assessment

Based on the location of the Berrys Bay construction support site in Waverton, limited vehicle access to and from the site is proposed during construction works. Although major deliveries to and from the site would typically be via a barge accessing a delivery wharf, a limited number of road deliveries would access the site via Balls Head Road.

Table 5-102 presents the maximum number forecasted vehicle numbers during the peak construction period at this construction support site.

Table 5-102 – Number of construction vehicles accessing the Berrys Bay construction support site

Type of vehicle	Activity period	Day[2] maximum per hour	Night[3] maximum per hour
Heavy vehicle (deliveries, and concrete deliveries)	Entire period	4	1
Light vehicle	Shift change over	62[4]	35[5]
	Other periods	2	0

Notes:
1. Numbers presented are individual vehicles as a vehicle accesses and leaves the site by the same road, two vehicle movements are counted on that road
2. Day is 7.00am to 10.00pm
3. Night is 10.00pm to 7.00am
4. Period typically 7.00am to 8.00am
5. Period typically 5/6.00am to 7.00am

This assessment considers road traffic noise impacts generated by the site on Balls Head Road and Bay Road.

Table 5-103 – Road traffic noise impacts from the Berrys Bay construction support site

Construction vehicle access road	Road type	Time of day	Base criteria, dB(A)	Activity period	Predicted road traffic noise level [1 - 4], dB(A)	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level
Balls Head Road and Bay Road	Local	Day $L_{Aeq(1hr)}$	55	Shift change over	62	Yes	N/A
				Other periods	61	Yes	
		Night $L_{Aeq(1hr)}$	50	Shift change over	56	Yes	Yes
				Other periods	55	Yes	Yes

Notes:
1. Predicted road traffic noise levels are based on the loudest heavy vehicle to be used (ie. concrete agitator). A +5 dB(A) correction is added to the predicted noise levels to account for the road gradient, as the gradient ranges up to 9-10 degrees in the worst-case, and appropriate vehicle speeds on the road.
2. Gradient correction applied in accordance with NCHRP Report 117 (Table H-1). Predicted road traffic noise levels are also based on the previously measured noise levels for light vehicles traveling uphill on a local road with the gradient of 9-10 degrees
3. Noise levels are predicted at one metre from a facade as per RNP
4. Predicted road traffic noise levels are based on the nearest residential receiver to the road. Receiver buildings at further distances are expected to experience lower noise levels than those predicted

Total predicted traffic noise levels at receiver buildings along Balls Head Road and Bay Road are predicted to potentially exceed the RNP local road noise criteria by up to 7 dB(A) during the daytime period and up to 6 dB(A) for the night time period during the tunnelling and fitout stages (BRY_07 and BRY_08). Further assessment show that road traffic noise levels generated by heavy vehicle movements alone on Balls Head Road and Bay Road would exceed the RNP criteria during both the day and night periods. Therefore, mitigation and management measures should be considered to minimise noise impacts from construction vehicles on receiver buildings adjacent to these roads. Impacts would be reviewed during detailed design, when actual heavy vehicle noise source levels and impacts can be measured, and feasible and reasonable mitigation and management methods would be implemented considering the actual noise levels.

Maximum noise levels (L_{Amax}) from night time heavy vehicle movements are predicted to exceed both the sleep disturbance screening level and the adopted awakening reaction level at receiver buildings along Balls Head Road and Bay Road.

5.7.3.1 Mitigation and management

Mitigation and management measures for construction related traffic noise impacts are outlined in section 6.7. To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the site specific CNVIS and project CNVMP would review and implement, where required, the following measures for the Berrys Bay construction support site where feasible and reasonable:

General site vehicles

- Arrangements for on-site parking to prevent worker/contractor vehicles from parking in the surrounding streets (ie. Balls Head Road and Bay Road), where feasible and reasonable
- Investigate during detailed design feasible and reasonable arrangements to minimise the number of vehicles accessing/exiting the site outside of standard construction hours.

Heavy vehicles

- Where feasible and reasonable, heavy vehicle movements would occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive time periods and limited to no more than one heavy vehicle per hour during the night period
- Transportation of tunnel spoil from this site by barge, rather than road
- All drivers would be trained in the Project Heavy Vehicle Code of Conduct, including noise management methods such as limiting compression braking.

5.7.4 Ground-borne construction noise

Ground-borne noise impacts could result from the construction of the access decline tunnel between the Berrys Bay construction support site and the mainline tunnel alignment. The number of receiver buildings that could potentially be impacted by ground-borne noise levels are presented in Table 5-104.

Table 5-104 – Number of receiver buildings affected by ground-borne noise from Berrys Bay construction support site access decline tunnel

NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML[1,2])				
	Residential			Other sensitive receivers	Commercial/ industrial receivers
	> 35[1] to ≤ 40 dB(A)	> 40[2] to ≤ 45 dB(A)	>45 dB(A)		
NCA 14.1	2	-	-	-	-

Notes: 1. Night ground-borne noise management level (GBNML)
2. Evening ground-borne noise management level (GBNML).

Table 5-104 indicates that two residential receiver buildings are identified as potentially being impacted by ground-borne noise levels above the strictest NML (ie. night time 35 dB(A)). Locations where receiver buildings may be impacted by ground-borne noise are presented in Appendix J.3.

As such, access decline tunnel construction would be managed by restricting the construction hours that tunnelling could be carried out to minimise impacts during more sensitive periods (eg. night), or if justified, in accordance with section 6.10.2. The extent of mitigation and management measures required to limit potential ground-borne noise impacts to receiver buildings would be determined by reviewing both the level of noise impact and the duration that receiver buildings are likely to be exposed to ground-borne noise levels above the NML.

If verification monitoring conducted during tunnelling determines that ground-borne noise levels inside residential receiver buildings are below the predicted noise levels and complies with the ground-borne noise NMLs, work may be extended into the OOHW period. Detailed noise mitigation and management measures for ground-borne noise would be reviewed during detailed design.

Ground-borne noise levels could be generated by vibration-intensive works as part of the construction support site. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

5.7.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity. The major stages that would include vibration-intensive works would be:

- Stage 1 (BRY_01): Early Works
- Stage 3 (BRY_03): Establishment of construction facilities
- Stage 4 (BRY_04): Piling for acoustic shed
- Stage 5 (BRY_05): Decline construction.

The proposed vibration-intensive plant items are identified in Appendix E, with the minimum working distances for a range of vibration-intensive plant presented in Table 4-11. Presented in Appendix L are the

estimated minimum working distances from the works construction support site for both cosmetic damage and human response to vibration for the most vibration-intensive activity proposed for the construction support site, which is likely to be use of a large rock hammer during the site establishment stages of the construction works (BRY_01 to BRY_05). This is the basis of the assessment and receiver building counts presented in Table 5-105.

Potential vibration generated to receivers for this project would depend on vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

This assessment considers a worst-case scenario that the proposed vibration-intensive plant items could be used anywhere with the boundaries of the site. However, this is unlikely to occur, and the location of the vibration-intensive equipment would be reviewed during detailed design.

Table 5-105 – Number of receiver buildings within nominated minimum working distance for vibration impacts – Berrys Bay construction support site

NCA	Number of receiver buildings		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Site construction			
14.1	9	4	18
Access decline tunnel			
14.1	-	-	-

For the access decline construction, due to the tunnel depth there are no structures that are identified within the minimum working distances presented in section 4.4.1 for roadheader tunnelling for either cosmetic damage or human response screening levels. As such, vibration impacts above the screening levels from the access decline tunnel construction works are unlikely but would be reviewed during detailed design considering final tunnel design and construction methodology.

5.7.5.1 Cosmetic damage

Fourteen buildings in NCA 14.1 have been identified within the minimum working distances for cosmetic damage, as presented in Table 5-105. Site-specific buffer distances for vibration-intensive activities (eg. compaction, rock hammering) would be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see in Table 4-11). Site-specific buffer distances would be maintained in order to comply with relevant vibration limits for cosmetic damage.

5.7.5.2 Heritage listed structures

Nine heritage items have been identified within the unsound structure cosmetic damage minimum working distance and are shown in Appendix L. These items are identified in Table 5-106.

Refer to the Technical working paper: Cultural heritage assessment report, Technical working paper: Non-Aboriginal heritage and Technical working paper: Maritime heritage for the assessment of impacts to heritage items.

Table 5-106 – Heritage receivers within the cosmetic damage minimum working distance – Berrys Bay

Name	Significance	Type/Classification	Site Heritage ID
Balls Head Foreshore Relics Group, ring bolt	Local	Item - Landscape	I1046
Woodleys Shipyard	Local	Item – Landscape Item - General	I1038
Balls Head Foreshore Relics Group 'Uncle Tom's Cabin	Local	Item - Landscape	I1048
Balls Head Foreshore Relics Group, ring bolt and iron screen	Local	Item - Landscape	I1045
Balls Head Foreshore Relics Group, remains of windlass spindle	Local	Item - Landscape	I1044
BP site	Local	Item - General	I1036
Balls Head Foreshore Relics Group - steps to former harbour pool	Local	Item - Landscape	I1047
BP site	Local	Item - General	I1036
Balls Head Reserve	Local	Item - Landscape	I1041

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.7.5.3 Human response

Due to the limited duration that the rock hammer would operate at this site; the risk of annoyance is considered low. However, occupants of up to 18 receiver buildings in NCA 14.1 are predicted to be exposed to vibration levels above the human response level, as presented in Table 5-105.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures would be provided (see section 6.10.3).

5.8 Cammeray Golf Course construction support sites

Two construction support sites would be operating within Cammeray Golf Course:

- Cammeray Golf Course (WHT10), which would be used to support construction activities associated with the Western Harbour Tunnel
- Cammeray Golf Course (WFU8), which would be used to support construction activities associated with the Warringah Freeway Upgrade.

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration-sensitive receivers near the Cammeray Golf Course construction support sites. For the purposes of assessing noise and vibration impacts from these two construction support sites the sites have been assessed as a consolidated construction site. It is appropriate to consider these sites as consolidated as nearby receivers would perceive construction noise and/or vibration would be coming from the one construction site.

5.8.1 Construction support site overview

5.8.1.1 Construction support site description

Work at the site would occur in stages as presented in Table 5-107.

Table 5-107 – Cammeray Golf Course construction support sites – major stage overview

Stage	Representative activity	Major stage activities/description
Site establishment	1. Early works	Connect and relocate services at the site such as electricity, sewerage and water
	2. Establish site	Install environmental controls Construction of vehicle access points Demolish existing structures, clear vegetation and level site Install site offices, store rooms and workshops
Acoustic shed and surface level shaft and tunnel excavation	3. Acoustic shed and surface level shaft and tunnel excavation	Pile shed footings at surface level Surface level excavation for access and ventilation shafts and tunnels Acoustic shed construction
Surface work support	4. Support Warringah Freeway Upgrade	Deliveries and laydown activities
Tunnel construction (decline, ventilation and mainline tunnels) and rock crushing	5. Tunnelling	Tunnelling using roadheaders and including Tunnel support (including spoil handling) and tunnel lining Rock crushing within the acoustic shed
Tunnel fitout	6. Tunnel fitout	Install services to tunnel
Permanent motorway facilities construction	7. Remove spoil shed, construct motorway facilities building	Demolish spoil shed Build operational tunnel motorway facilities building
Fitout of motorway facilities and ventilation outlet	8. Motorway facilities building fitout and ventilation outlet	Install electrical and mechanical infrastructure to the motorway facilities building and within the ventilation outlet
Tunnel commission and site rehabilitation	9. Restore site	Commission tunnel Decommission and rehabilitate site

As well as the major activities presented above, the Cammeray Golf Course construction support sites would support up to five roadheaders operating as follows:

- Two digging mainline tunnels towards Waverton
- Two digging ramps to North Sydney and ventilation tunnels
- One digging cross passages.

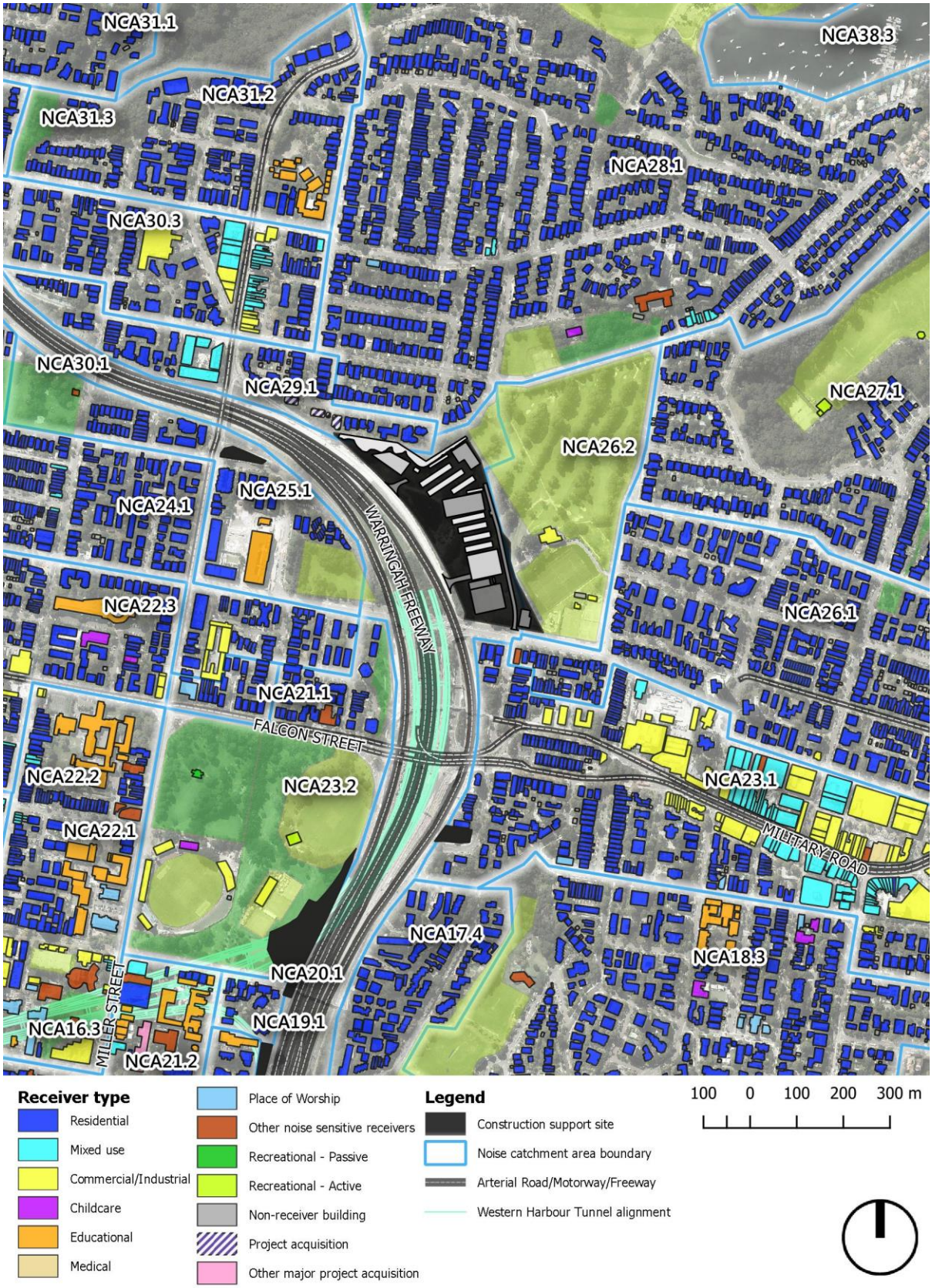
The site would also be used by the Beaches Link and Gore Hill Freeway Connection; however, this assessment only relates to the use of the construction support sites for the project.

5.8.1.2 Nearby noise and vibration-sensitive receivers

The site would be located at Ernest Street in Cammeray, adjacent to the Warringah Freeway, mostly surrounded by residential and recreational receivers.

The location of the site, nearby NCAs and receiver locations are shown in Figure 5-11.

Figure 5-11 – Location of the Cammeray Golf Course construction support sites



5.8.1.3 Construction works program

The indicative program and timeline for the construction support site is presented in Table 5-108, subject to project approval. This site is planned to operate from the start of 2021 until late 2025. The longest duration activities at this construction support site would be surface work support and tunnelling.

Table 5-108 – Cammeray Golf Course construction support sites – indicative program and timeline

Stage	Representative activity		Reference	Indicative construction timeframe															
				2021				2022				2023				2024				2025			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site establishment	1.	Early works	CGC_01																				
	2.	Establish site	CGC_02																				
Acoustic shed and surface level shaft and tunnel excavation	3.	Acoustic shed and surface level shaft and tunnel excavation	CGC_03																				
Surface work support	4.	Support Warringah Freeway Upgrade	CGC_04																				
Tunnel construction (decline, ventilation and mainline tunnels) and rock crushing	5.	Tunnelling	CGC_05																				
Tunnel fitout	6.	Tunnel fitout	CGC_06																				
Permanent motorway facilities construction	7.	Remove spoil shed, construct motorway facilities building	CGC_07																				
Fitout of motorway facilities and ventilation outlet	8.	Motorway facilities building fitout and ventilation outlet	CGC_08																				
Tunnel commission and site rehabilitation	9.	Restore site	CGC_09																				

5.8.1.4 Construction duration and working hours

Table 5-108 presents each of the major stages and each of the assessed activities for the Cammeray Golf Course construction support sites, along with the proposed periods of works for each activity.

During the operation of the Cammeray Golf Course construction support sites, work would typically take place during the ICNG standard construction hours, presented in Table 3-2. However, some OOHW would take place outside standard construction hours, as presented in Table 5-109. Further justification for OOHW is provided in section 5.1.3.

Table 5-109 – Cammeray Golf Course construction support sites – construction hours

Stage	Representative activity	Reference	Assessed activities[1]	Work hours[2]			
				Day (Std)	Day (OOHW)	Evening	Night
Site establishment	1. Early works	CGC_01	Utility works	♦			
	2. Establish site	CGC_02	Install environmental controls	♦			
			Construction of vehicle access points via the Warringah Freeway	♦			
			Demolition	♦			
			Clearing and grubbing	♦			
			Bulk earthwork	♦			
			Establish construction facilities	♦			
Acoustic shed and surface level shaft and tunnel excavation	3. Acoustic shed and surface level shaft and tunnel excavation	CGC_03	Piling shed and motorway facility building, and hammering for shaft construction	♦			
			Surface level access and ventilation shaft and tunnel construction	♦			
			Acoustic shed construction	♦			
Surface work support	4. Support Warringah Freeway Upgrade	CGC_04	General support site activities	♦	♦	♦	♦
			Deliveries to site	♦[5]			
			Surface work support - hardstand areas	♦[5]			
Tunnel construction (decline, ventilation and mainline tunnels) and rock crushing	5. Tunnelling	CGC_05	General site activities	♦	♦	♦	♦
			Tunnel support - deliveries	♦	♦[3]	♦[3]	♦[3]
			Tunnelling and support	♦	♦	♦	♦
			Tunnel lining (concreting)	♦	♦	♦	♦
			Rock crushing in an acoustic shed	♦			
			Spoil handling in an acoustic shed	♦	♦[4]	♦[4]	♦[4]
			Spoil haulage	♦			
Tunnel fitout	6. Tunnel fitout	CGC_06	Tunnel fitout - deliveries	♦	♦[3]	♦[3]	♦[3]
			Tunnel fitout – laydown areas	♦			
Permanent motorway facilities construction	7. Remove spoil shed, construct motorway facilities building	CGC_07	Motorway facilities structure construction	♦			
			Demolition of structures (no rock hammer)	♦			
Fitout of motorway facilities and ventilation outlet	8. Motorway facilities building fitout and ventilation outlet	CGC_08	Deliveries to site	♦			

Stage	Representative activity	Reference	Assessed activities[1]	Work hours[2]			
				Day (Std)	Day (OOHW)	Evening	Night
Tunnel commission and site rehabilitation	9. Restore site	CGC_09	Decommission and restore site	♦			

Notes:
1. Appendix E describes the modelled plant for each activity
2. Day (S) Standard is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
   Day (O) Out-of-Hours Work is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
   Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
   Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday
3. Laydown activities would occur inside acoustic shed.
4. Spoil haulage off the construction support site would occur during standard construction hours. OOHW spoil handling would occur inside acoustic shed.
5. It is assumed that deliveries to the Warringah Freeway Upgrade construction works areas within the Warringah Freeway road corridor would either be carried out directly to the construction works areas or deliveries to and from hardstand areas within the Cammeray construction support site would occur during standard construction hours, moving equipment and materials to locations near to the construction work areas within the Warringah Freeway road corridor.

5.8.1.5 Concurrent and consecutive construction projects

The nearest construction work associated with this project would be the Warringah Freeway Upgrade surface road works immediately west of this site. There is also potential for overlaps with construction works for Western Harbour Tunnel construction support sites at Ridge Street north (WHT9), Waltham Street (WHT11) and Berry Street north (WHT8).

The nearest construction support sites associated with other major infrastructure projects would be:

- The Cammeray Golf Course construction support sites, for the Beaches Link and Gore Hill Freeway Connection project. This site is also located at the Cammeray Golf Course and would have some overlap with Cammeray Golf Course construction support site for the project
- The Victoria Cross North construction support site would be finishing the later stages of the project, located about 1 kilometre south-west of this site, for Sydney Metro City & Southwest, however due to distance, terrain and nearby acoustic shielding from buildings cumulative noise impacts are not expected.

5.8.1.6 Construction assessment scenarios

The airborne noise assessment of the Cammeray Golf Course construction support sites was separated into nine stages. Each stage was assessed against the work periods proposed in Table 5-109. The details of modelled construction plant items and corresponding sound power levels are presented in Appendix E.

The equipment/plant listed in Appendix E represent the reasonable worst-case equipment/plant operating simultaneously in any 15 minute period (refer to section 4 for further explanation of assessment scenarios).

Multiple activities would at times occur concurrently within the one construction support site and were captured in the assessment as shown in Table 5-109.

5.8.1.7 Summary of assumed treatment and management measures

As part of the assessment process, feasible and reasonable noise treatment measures and management methods have been identified based on the preliminary site layout and the reasonable worst-case plant/equipment operating, to assist in attenuating and managing noise emissions from the construction activities.

Identified feasible and reasonable noise treatment measures have been included in the noise modelling and are presented in Table 5-110. The results presented in this assessment are based on these noise treatments and management measures being implemented. The locations of physical noise treatment measures are shown on Figure 5-12.

Table 5-110 – Assumed noise treatment and management measures – Cammeray Golf Course construction support sites

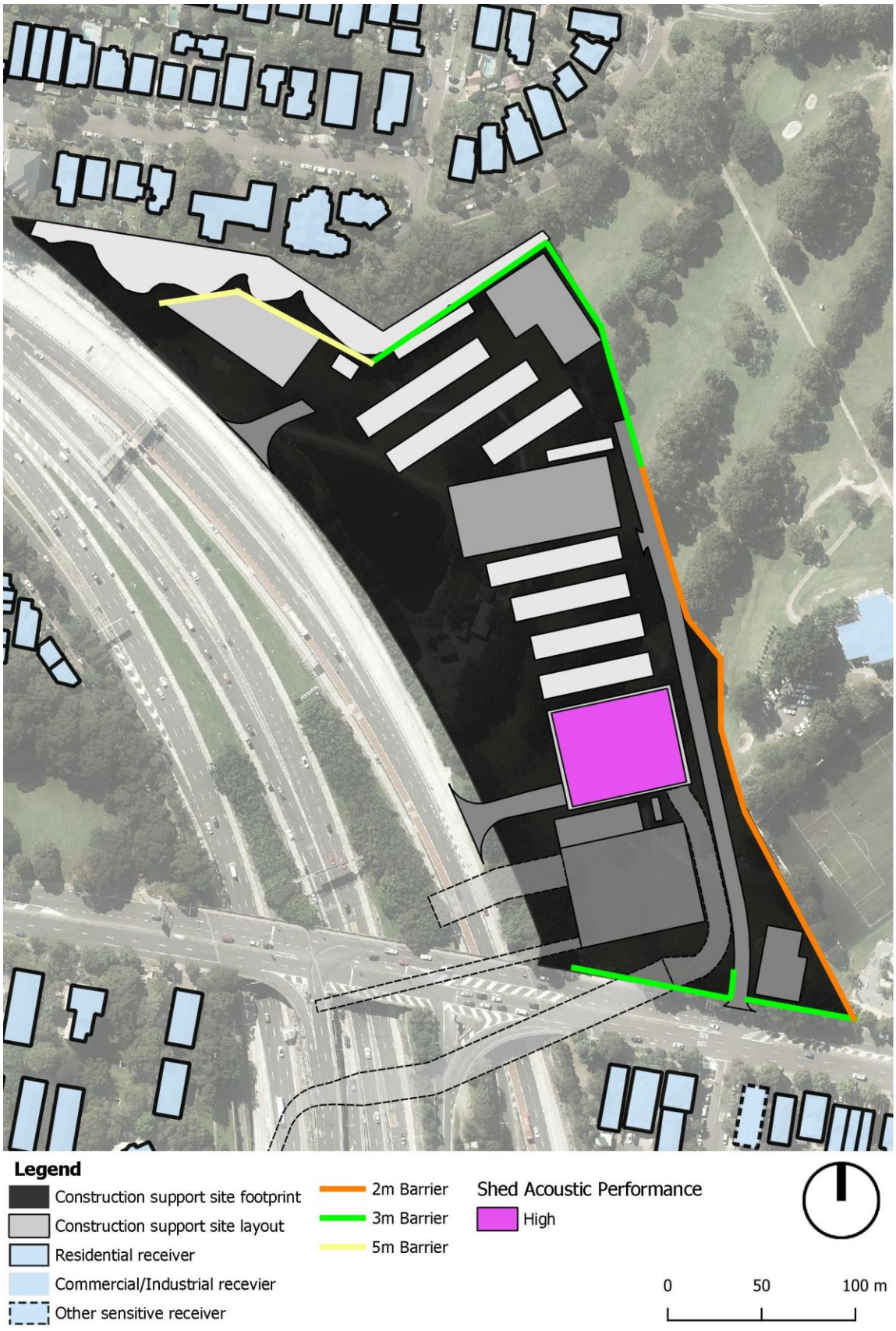
Activity or plant/equipment	Management and noise treatment measures applied
Work outside standard construction hours	Work would only occur outside standard hours where it: • Meets the relevant NMLs • Occurs in an acoustic enclosure • Is required for safety reasons or • Needs to occur outside standard hours to maintain the operational integrity of the road network. The following noise barriers would be installed around the site to manage noise outside standard hours: • Three to five metre high barriers to the north and eastern boundaries of the Warringah Freeway Upgrade surface road works area (WFU8) • Two meter high barrier along an extent of the eastern boundary of the Western Harbour Tunnel Cammeray Golf Course construction support site (WHT10) • Three metre high barrier on the site boundary along Ernest Street
Heavy vehicle access outside standard hours	All heavy vehicles accessing the site outside standard hours would enter and exit directly from and to the Warringah Freeway.
Tunnelling, support and fitout: acoustic shed	**An acoustic shed would be built to reduce noise from tunnelling, support and fitout works for Western Harbour Tunnel activities outside standard construction hours. Indicative elements and performance requirements are in** Table 5-111.
Wastewater treatment plant	The wastewater treatment plant would be placed in an acoustic enclosure to achieve a total sound power level of 85 dB(A).
Substation	The substation would be placed in an acoustic enclosure to achieve a total sound power level of 85 dB(A).
Ventilation plant	Plant would be acoustically treated to achieve a maximum total sound power level of 85 dB(A). Five ventilation plant were included in the model.

Table 5-111 – Indicative acoustic shed construction and acoustic performance – Cammeray Golf Course construction support sites

Shed element (Indicative example constructions are shown in Table 4-1)	Octave band frequency transmission loss, dB						
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Acoustic shed (high performance)							
Walls – High performance	10	29	35	42	46	51	57
Roof – High performance	10	29	35	42	46	51	57

Detailed design refinements to construction support site layouts, equipment, construction methods or construction hours may require specific mitigation and management measures that are different from those outlined in this section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design to determine what is feasible and reasonable, with consideration of cumulative and consecutive construction impacts.

Figure 5-12 – Site layout with indicative noise treatment for the Cammeray Golf Course construction support sites



5.8.2 Construction airborne noise

5.8.2.1 Nearby receiver summary and objectives

Table 5-112 presents NMLs and the screening levels for the assessment of sleep disturbance for the nearest residential receivers surrounding the Cammeray Golf Course construction support sites. Noise management levels for other (non-residential) noise-sensitive receivers are presented in section 3.4.1.

Table 5-112 – Construction noise management levels and screening levels for residential receivers

NCA ID	Noise management levels (NML) $L_{Aeq(15min)}$				Sleep disturbance screening levels
	Standard hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
	Day	Day	Evening	Night	Night
16.3	70	65	65	55	65
18.3	64	59	57	48	58
21.2	63	58	54	46	56
22.2	62	57	52	41	51
22.3	62	57	52	41	51
23.1	71	66	59	49	59
23.2	71	66	59	49	59
24.1	66	61	57	42	52
25.1	68	63	60	48	58
26.1	68	63	59	46	56
26.2	68	63	59	46	56
27.1	59	54	53	44	54
28.1	57	52	50	42	52
29.1	74	69	68	52	62
30.3	68	63	61	43	53

5.8.2.2 Predicted noise impacts

Table 5-113 provides a key to the cell shading and text formatting used to explain results in the following tables. Colours and formatting are based on the highest predicted value, with ranges to show variations across the NCA.

Table 5-113 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue)	11-20 dB(A) over NML (mid blue)	>20 dB(A) above NML (dark blue)	
	Outside standard hours	1-5 dB(A) above NML (green)	6-15 dB(A) above NML (yellow)	16-25 dB(A) above NML (orange)	>25 dB(A) above NML (purple)
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receivers
2. Highly noise affected (HNA) applies to residential receivers only.

The modelling results present the range of the highest predicted noise levels for each NCA for residential receiver buildings, commercial and OSRs, unless no receiver buildings of that type in that NCA are expected to exceed NMLs. The range is of noise impacts throughout all receiver buildings in the NCA. If the lower noise level of the range is below the NML, only the upper noise level is presented.

It is noted that the noise predictions include adjustments for impulsive, tonal and other more annoying activities, in accordance with the ICNG.

Noise contours for the loudest early works, site establishment, and longer-term tunnelling stages are shown in Appendix H.

5.8.2.3 Residential

The predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-114: for standard hours
- Table 5-115: for works outside of standard construction hours.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-116. Predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

Table 5-114 – Predicted construction noise levels – standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$ dB(A) – Cammeray Golf Course construction support sites

NCA	Noise Management Level		Predicted levels at each construction stage[2]							
	HNA	NML	CGC_01	CGC_02	CGC_03+ CGC_04	CGC_04+CGC_05	CGC_04+CGC_06	CGC_04+CGC_07	CGC_08	CGC_09
16.3	75	70	≤ 39	37 - 47	≤ 38	< 35	< 35	< 35	< 35	≤ 39
18.3	75	64	≤ 44	≤ 54	≤ 46	< 35	≤ 36	≤ 40	< 35	≤ 45
21.2	75	63	39 - 42	45 - 50	41 - 42	< 35	≤ 35	≤ 37	< 35	40 - 42
22.2	75	62	≤ 40	≤ 50	≤ 41	< 35	< 35	≤ 36	< 35	≤ 41
22.3	75	62	≤ 49	≤ 61	≤ 53	≤ 40	≤ 42	≤ 47	≤ 35	≤ 51
23.1	75	71	≤ 69	**≤ 77**	≤ 66	≤ 50	≤ 50	≤ 64	≤ 53	≤ 70
23.2	75	71	38 - 59	45 - 72	≤ 63	≤ 49	≤ 51	≤ 57	≤ 43	39 - 61
24.1	75	66	≤ 58	≤ 70	≤ 61	≤ 49	≤ 51	≤ 55	≤ 44	≤ 60
25.1	75	68	≤ 60	42 - 73	≤ 61	≤ 52	≤ 53	≤ 56	≤ 42	35 - 60
26.1	75	68	≤ 68	**≤ 82**	≤ 64	≤ 50	≤ 53	≤ 60	≤ 50	≤ 68
27.1	75	59	≤ 52	≤ 62	≤ 48	≤ 41	≤ 44	≤ 42	< 35	≤ 52
28.1	75	57	≤ 69	≤ 74	≤ 59	≤ 49	≤ 51	≤ 53	≤ 39	≤ 69
29.1	75	74	≤ 69	**≤ 79**	≤ 62	≤ 59	≤ 59	≤ 60	≤ 39	≤ 72
30.3	75	68	≤ 50	≤ 61	≤ 51	≤ 40	≤ 42	≤ 45	< 35	≤ 50

Notes: 1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)).

2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-115 – Predicted construction noise levels – outside standard hours (residential receivers) – $L_{Aeq\ 15\ minute}$ dB(A) – Cammeray Golf Course construction support sites

NCA	Noise Management Level				Predicted noise level at each construction stage[3]							
	HNA	Day (O)	Eve (O)	Night	CGC_01[1]	CGC_02[1]	CGC_03+CGC_04	CGC_04+CGC_05	CGC_04+CGC_06	CGC_04+CGC_07	CGC_08[1]	CGC_09[1]
16.3	75	65	65	55	-	-	< 35	< 35	< 35	< 35	-	-
18.3	75	59	57	48	-	-	< 35	< 35	< 35	< 35	-	-
21.2	75	58	54	46	-	-	< 35	< 35	< 35	< 35	-	-
22.2	75	57	52	41	-	-	< 35	< 35	< 35	< 35	-	-
22.3	75	57	52	41	-	-	< 35	< 35	< 35	< 35	-	-
23.1	75	66	59	49	-	-	≤ 37	≤ 45	≤ 45	≤ 42	-	-
23.2	75	66	59	49	-	-	< 35	≤ 43	≤ 42	≤ 37	-	-
24.1	75	61	57	42	-	-	< 35	≤ 41	≤ 40	≤ 35	-	-
25.1	75	63	60	48	-	-	< 35	≤ 42	≤ 41	≤ 38	-	-
26.1	75	63	59	46	-	-	≤ 35	≤ 42	≤ 42	≤ 39	-	-
27.1	75	54	53	44	-	-	< 35	< 35	< 35	< 35	-	-
28.1	75	52	50	42	-	-	≤ 40	≤ 41	≤ 41	≤ 41	-	-
29.1	75	69	68	52	-	-	≤ 41	≤ 43	≤ 42	≤ 42	-	-
30.3	75	63	61	43	-	-	< 35	< 35	< 35	< 35	-	-

Notes: 1. No work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and bold text is highly noise affected (HNA) (>75 dB(A)).

3. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-116 – Number of receiver buildings over the noise management level (all NCAs) – residential receivers – Cammeray Golf Course construction support sites

Stage activity	Assessment reference	Highly noise affected		Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		Standard hours	Outside standard hours																	
		L_{Aeq}	L_{Aeq}	L_{Aeq}			L_{Aeq}				L_{Aeq}				L_{Aeq}				L_{Amax}	
		> 75 dB(A)	> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening	Awakening
Early works (Stage 1)	**CGC_01**[1]	0	-	15	2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Establish site (Stage 2)	**CGC_02**[1]	12	-	231	11	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acoustic shed and surface level shaft/tunnel construction (Stage 3) + Surface work support (Stage 4)	**CGC_03+CGC_04**	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	2
Surface work support (Stage 4)+ Tunnelling (Stage 5)	**CGC_04+CGC_05**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	2
Surface work support (Stage 4) + Tunnel fitout (Stage 6)	**CGC_04+CGC_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	2
Surface work support (Stage 3) + Remove spoil shed, construct motorway facilities building (Stage 7)	**CGC_04+CGC_07**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	2
Motorway facilities building fitout and ventilation outlet (Stage 8)	**CGC_08**[1]	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Restore site (Stage 9)	**CGC_09**[1]	0	-	14	3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. No typical work is proposed outside standard construction hours

2. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 5-113

5.8.2.4 Residential – summary of airborne noise assessment

Standard construction hours

The highest predicted levels would occur during early works (Stage 1), site establishment (Stage 2) and site restoration (Stage 8):

- Up to 12 receiver buildings in NCA 26.1 are predicted to be highly noise affected (>75 dB(A)) during the short period of site establishment (CGC_02) works which would occur during standard construction hours only. This would be caused by construction of vehicle access points to the site and vegetation clearing near Ernest Street
- Up to 17 receiver buildings in NCA 28.1 are predicted to be noise affected (ie. > NML) during early works (CGC_01) such as utility modifications/relocations
- Up to 242 receiver buildings in NCAs 23.1, 23.2, 24.1, 25.1, 26.1, 27.1, 28.1 and 29.1 are predicted to be noise affected (above NML) during site establishment (CGC_02) works which would occur during standard construction hours. This is largely caused by vegetation clearing, earthworks, and demolition with rock hammers
- Up to 17 receiver buildings in NCA 28.1 are predicted to be noise affected (ie. > NML) during site restoration (CGC_09) works during standard construction hours. This would be largely caused by rehabilitation works near Warringa Road.

During other stages noise impacts would be low, with no noise affected receiver buildings. Standard construction hours construction noise impacts would be managed through the CNVMP developed during detailed design.

Work outside of standard construction hours

Due to Warringah Freeway Upgrade surface road works, worker safety and 24 hour tunnelling requirements, some works are likely to be completed outside of standard construction hours as presented in Table 5-109. At the Cammeray Golf Course construction support sites, the key stages requiring OOHW are during:

- Stage 3 and Stage 4 (CGC_03 + CGC_04): Surface work support and acoustic shed and shaft construction
- Stage 4 and Stage 5 (CGC_04 + CGC_05): Surface work support and tunnelling
- Stage 4 and Stage 6 (CGC_04 + CGC_06): Surface work support and tunnel fitout
- Stage 4 and Stage 7 (CGC_04 + CGC_07): Surface work support and permanent facilities construction.

Construction noise levels ls during these stages are predicted to achieve the night period NMLs. The predicted noise levels are based on all plant operating simultaneously and continuously during each assessed activity. However, in practice not all plant would typically operate all the time, meaning that for a substantial part of the time actual noise levels would be less than the predicted noise levels.

Sleep disturbance

At the Cammeray Golf Course construction support sites, the key OOHW stages which potentially include activities with maximum noise levels (L_{Amax}) are:

- Stage 3 and Stage 4 (CGC_03 + CGC_04): Surface work support and acoustic shed and shaft construction
- Stage 4 and Stage 5 (CGC_04 + CGC_05): Surface work support and tunnelling
- Stage 4 and Stage 6 (CGC_04 + CGC_06): Surface work support and tunnel fitout
- Stage 4 and Stage 7 (CGC_04 + CGC_07): Surface work support and permanent facilities construction.

During surface work support and acoustic shed construction (CGC_03+CGC_04) works, and surface work support and permanent facilities construction (CGC_04+CGC_07), occasional clangs and bangs may occur from general site activities in laydown areas, and maximum noise level events could occur from occasional heavy vehicle movements into and out of the site from the Warringah Freeway. Up to 32 receiver buildings are predicted to be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 70 dB(A)). Two receiver buildings are predicted to potentially experience noise levels above the awakening reaction noise level.

During surface work support and tunnelling (CGC_04+CGC_05), concrete delivery heavy vehicles occasionally accessing the site could result in high instantaneous noise impacts during arrival or departure. Up to 95 receiver buildings are predicted to potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 70 dB(A)). Two receiver buildings could potentially receive noise levels above the awakening reaction noise level.

During surface work support and tunnel fitout (CGC_04+CGC_06), heavy vehicle movements occasionally accessing the site could result in high instantaneous noise impacts during arrival or departure. Moreover, occasional clangs and bangs may occur from general site activities in laydown areas, and maximum noise level events could occur from occasional heavy vehicle movements into and out of the site from the Warringah Freeway. Up to 57 receiver buildings are predicted to potentially be exposed to maximum noise levels above the sleep disturbance screening level (up to L_{Amax} 70 dB(A)). Two receiver buildings could potentially experience noise levels above the awakening reaction noise level.

Potential maximum noise events from clangs and bangs would be minimised by adopting quiet work practices through the CNVMP.

Potential sleep disturbance impacts from night time heavy vehicle movements would be mitigated by limiting night time heavy vehicle access to the site to occur from the Warringah Freeway. Since the number of heavy vehicle movements generated by the site is insignificant compared to existing traffic numbers on the Warringah Freeway, sleep disturbance impacts are not likely to occur from heavy vehicles accessing the site at night.

5.8.2.5 Non-residential

The predicted noise levels for non-residential receiver buildings are presented in Table 5-117. The receiver buildings predicted to exceed the NMLs are summarised in Table 5-118. The predicted noise levels are intended to be conservative and represent reasonable worst-case impacts during the project.

After all feasible and reasonable mitigation measures are applied, the greatest number of noise affected other sensitive receiver buildings impacted would be during site establishment works (Stage 2) at the Cammeray Golf Course construction support sites. The other sensitive receiver buildings identified to be noise affected are as follows:

- One childcare receiver building in NCA 22.3 would be noise affected by up to 2 dB(A)
- One childcare receiver building in NCA 23.2 would be noise affected by up to 3 dB(A)
- One childcare receiver building in NCA 28.1 would be noise affected by up to 14 dB(A)
- One educational receiver building in NCA 22.1 would be noise affected by up to 1 dB(A)
- One educational receiver building in NCA 22.3 would be noise affected by up to 1 dB(A)
- One educational receiver building in NCA 25.1 would be noise affected by up to 2 dB(A)
- One educational receiver building in NCA 25.1 would be noise affected by up to 12 dB(A)
- Up to four recreational receivers in NCAs 25.1, 26.2 and 28.1 are predicted to be noise affected by up to 10 dB(A), including Cammeray Park, tennis courts and Cammeray Golf Club
- One recreational receiver in NCA 26.2 is predicted to be noise affected by up to 18 dB(A) in Cammeray Park
- One place of worship in NCA 28.1 would be noise affected by up to 5 dB(A)
- One other sensitive receiver building (hotel) in NCA 26.1 would be noise affected by up to 2 dB(A).

Table 5-117 – Predicted noise levels at other sensitive receiver locations dB(A) – Cammeray Golf Course construction support sites

Receiver type	NCA	Noise Management Level		Predicted noise levels at each construction stage[2]							
		HNA	NML	CGC_01	CGC_02	CGC_03+CGC_04	CGC_04+CGC_05	CGC_04+CGC_06	CGC_04+CGC_07	CGC_08	CGC_09
Commercial	22.1	75	70	≤ 42	38 - 52	≤ 43	< 35	< 35	≤ 38	< 35	≤ 43
	22.3	75	70	≤ 45	≤ 56	≤ 46	≤ 35	≤ 35	≤ 40	< 35	≤ 46
	23.1	75	75	≤ 52	≤ 62	≤ 54	≤ 40	≤ 39	≤ 49	< 35	≤ 53
	23.2	75	70	39 - 44	46 - 53	36 - 45	≤ 35	≤ 35	≤ 40	< 35	39 - 45
	24.1	75	75	36 - 48	43 - 60	36 - 52	≤ 39	≤ 38	≤ 45	< 35	37 - 49
Childcare	18.3	75	50	< 35	42 - 43	< 35	< 35	< 35	< 35	< 35	< 35
	22.3	75	50	38 - 41	49 - 52	41 - 44	< 35	< 35	35 - 38	< 35	40 - 43
	23.2	75	50	≤ 43	≤ 53	≤ 44	< 35	< 35	≤ 39	< 35	≤ 43
	26.1	75	50	40 - 40	47 - 47	< 35	< 35	< 35	< 35	< 35	≤ 40
	28.1	75	50	≤ 56	≤ 64	≤ 50	≤ 40	≤ 40	≤ 45	< 35	≤ 56
Educational	18.3	75	55	≤ 36	≤ 47	≤ 36	< 35	< 35	< 35	< 35	≤ 37
	22.1	75	55	≤ 45	38 - 56	≤ 46	≤ 36	≤ 35	≤ 40	< 35	≤ 46
	22.3	75	55	≤ 45	≤ 56	≤ 47	≤ 35	< 35	≤ 43	< 35	≤ 47
	23.1	75	55	≤ 39	≤ 48	≤ 37	< 35	< 35	≤ 35	< 35	≤ 40
	25.1	75	55	≤ 52	57 - 67	43 - 57	≤ 42	41 - 42	48 - 51	< 35	51 - 55
Other sensitive receivers	22.1	75	55	≤ 44	≤ 54	≤ 44	< 35	< 35	≤ 40	< 35	≤ 45
	23.1	75	60	≤ 43	≤ 53	≤ 40	< 35	< 35	≤ 39	< 35	≤ 45
	24.1	75	60	≤ 38	≤ 48	≤ 39	< 35	< 35	< 35	< 35	≤ 39
	26.1	75	70	≤ 70	≤ 80	≤ 65	≤ 49	≤ 47	≤ 62	≤ 41	≤ 70
	28.1	75	60	≤ 53	≤ 61	≤ 51	≤ 38	≤ 38	≤ 44	< 35	≤ 54
Place of worship	18.3	75	55	< 35	42 - 42	< 35	< 35	< 35	< 35	< 35	< 35
	21.1	75	55	≤ 42	≤ 49	≤ 36	< 35	< 35	< 35	< 35	≤ 38
	23.1	75	55	< 35	39 - 39	< 35	< 35	< 35	< 35	< 35	< 35
	24.1	75	55	36 - 38	47 - 48	39 - 39	< 35	< 35	< 35	< 35	37 - 39
	26.1	75	55	≤ 39	39 - 47	≤ 35	< 35	< 35	< 35	< 35	≤ 40
	28.1	75	55	≤ 52	≤ 62	≤ 52	≤ 40	≤ 39	≤ 46	< 35	≤ 52

Receiver type	NCA	Noise Management Level		Predicted noise levels at each construction stage[2]							
		HNA	NML	CGC_01	CGC_02	CGC_03+CGC_04	CGC_04+CGC_05	CGC_04+CGC_06	CGC_04+CGC_07	CGC_08	CGC_09
Recreational	22.1	75	65	≤ 35	38 - 44	≤ 39	< 35	< 35	< 35	< 35	< 35
	22.2	75	65	≤ 35	≤ 44	< 35	< 35	< 35	< 35	< 35	≤ 36
	23.2	75	65	38 - 56	45 - 65	39 - 55	≤ 43	≤ 42	≤ 51	< 35	38 - 57
	25.1	75	65	43 - 55	53 - 66	43 - 56	≤ 44	≤ 44	38 - 50	< 35	43 - 55
	26.1	75	65	< 35	38 - 38	< 35	< 35	< 35	< 35	< 35	< 35
	26.2	75	60	55 - 64	67 - 81	51 - 66	44 - 50	43 - 50	53 - 61	≤ 41	56 - 66
	27.1	75	60	≤ 38	37 - 44	< 35	< 35	< 35	< 35	< 35	≤ 39
	28.1	75	60	≤ 57	≤ 66	≤ 52	≤ 41	≤ 41	≤ 46	< 35	≤ 57

Notes:
1. Construction noise level cells are shaded based on the predicted worst case NML exceedance of the controlling time period as follows: **Light blue** is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML.
2. Predicted noise levels for each stage are based on the reasonable worst-case 15 minute construction works scenario as described in section 4.2.2.

Table 5-118 – Number of other sensitive receivers over the NMLs (all NCAs) - $L_{Aeq(15min)}$ – Cammeray Golf Course construction support sites

Stage activity	Assessment reference	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1,2]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
Early works (Stage 1)	**CGC_01**	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Establish site (Stage 2)	**CGC_02**	0	0	0	2	1	0	3	1	0	3	1	0	1	0	0	1	0	0
Surface work support (Stage 4) + Acoustic shed and surface level shaft/tunnel construction (Stage 3)	**CGC_03+CGC_04**	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
Surface work support (Stage 4)+ Tunnelling (Stage 5)	**CGC_04+CGC_05**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface work support (Stage 4) + Tunnel fitout (Stage 6)	**CGC_04+CGC_06**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface work support (Stage 4) + Remove spoil shed, construct motorway facilities building (Stage 7)	**CGC_04+CGC_07**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Motorway facilities building fitout and ventilation outlet (Stage 8)	**CGC_08**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Restore site (Stage 9)	**CGC_09**	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0

Notes:
1. Commercial, industrial, recreational active and passive, and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. There is a range of NML for other sensitive receiver buildings, which are defined in section 3.4.1. Each nearby other sensitive receiver has been assessed against the applicable NML.

5.8.2.6 Summary of residual impacts and additional mitigation measures

Table 5-116 indicates the number of residential buildings where noise impacts are expected to exceed the NMLs after the implementation of noise treatment and management measures.

Further acoustic mitigation and management measures, as outlined in the standard ICNG mitigation measures included in Appendix G, would be confirmed and adopted where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design when the specific construction works details are known.

Where residual noise impacts still exceed the NMLs, additional mitigation measures in accordance with the CNVG and presented in section 6.10.1 would be provided to manage construction noise impacts.

5.8.2.7 Cumulative and consecutive construction noise impacts

As outlined in section 4.2.4, the potential for cumulative noise impacts from other major construction projects in the area around the Cammeray Golf Course construction support sites would be considered when assessing the site and determining feasible and reasonable mitigation and management measures.

For a more detailed overview of the potential cumulative and concurrent impacts from the Warringah Freeway Upgrade surface road works and Western Harbour Tunnel construction works that interface with the Warringah Freeway in combination with the Cammeray Golf Course construction support site, refer to section 5.9.2.14.

Proposed staging of concurrent construction works associated with the project and other nearby major infrastructure projects that are considered for cumulative or concurrent construction noise are presented in Table 5-119, based on the relevant project's environmental impact statement documentation.

Table 5-119 – Concurrent construction works near the Cammeray Golf Course construction support sites

Project	2019	2020	2021	2022	2023	2024	2025
Cammeray Golf Course construction support sites (CGC)							
Warringah Freeway Upgrade surface road works (WFU)							
Other major infrastructure projects							
Cammeray Golf Course construction support site as part of the Beaches Link and Gore Hill Freeway Connection project (CGC-BL)[1]							
Warringah Freeway surface road works (WFU2H) as part of the Beaches Link and Gore Hill Freeway Connection project (WFU2H-BL)[1]							

Notes: 1. Indicative programs have been assumed for the Beaches Link and Gore Hill Freeway Connection project

For other potential consecutive or cumulative impacts from construction works for the Warringah Freeway Upgrade or the associated Western Harbour Tunnel construction support sites that interface

with the Warringah Freeway at Ridge Street north (WHT9), Waltham Street (WHT11) and Berry Street north (WHT8) refer to section 5.9.2.14.

Use of the Cammeray Golf Course construction support sites for the Beaches Link and Gore Hill Freeway Connection project would overlap with the construction support site use for this project. There is potential for concurrent works generally during the permanent facility construction and fitout work, tunnel fitout, commissioning and site rehabilitation work and Warringah Freeway Upgrade support works stages. This project would construct the motorway facilities for the Beaches Link and Gore Hill Freeway Connection project. Even though there could be overlaps of the construction works programs, due to the Beaches Link and Gore Hill Freeway Connection project using the same site it is unlikely that there would be concurrent construction activities for key sets of construction works.

Proposed staging of concurrent work has been reviewed for the closest receiver buildings to the site. For each construction support site, the stages with the highest chance of concurrent construction activities for both standard construction hours and out-of-hours works have been reviewed for potential cumulative noise impacts at the nearest receiver buildings.

If noise from one site dominates noise levels at the receiver (ie. more than 5 dB(A) above noise from other sites), that site would typically control construction noise levels at the receiver. As such, it is not likely to increase the overall $L_{Aeq,\ 15\ min}$ construction noise level at these receiver buildings.

If noise levels from each site are similar at a receiver, a total construction noise increase of up to 3 dB(A) is expected. Two representative NCAs adjacent to the works have been assessed in Table 5-13.

Table 5-120 – Potential cumulative noise impacts from construction projects near Cammeray Golf Course

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 24.1	Standard hours NML 66 dB(A)	CGC	Surface work support and tunnelling	≤ 49	Construction noise levels from other construction support sites could result in similar construction noise levels at nearby receivers and so cumulative increases could result. All construction support site noise levels are below the NML. Construction noise from the Warringah Freeway Upgrade surface road works are above the NML and may dominate over noise from the construction support sites. Cumulative construction noise levels would likely remain below the NML at nearby receivers, except for when the Warringah Freeway Upgrade surface road works occur near to receivers.
			Surface work support and permanent facilities construction	≤ 55	
		WFU[3]	Zone 2 (Falcon Street to Miller Street)	49 - 69	
		CGC-BL	Civil works + Tunnelling	≤ 49	
		WFU2H-BL[3]	Demolition works	≤ 57	

NCA	Construction period (NML)	Construction work area	Works stage	Predicted construction noise level $L_{Aeq\ 15\ min}$, dB(A)	Potential change in construction noise impacts due to concurrent activities during stage
NCA 24.1	OOHW NML D/E/N 61/57/42 dB(A)	CGC	Surface work support and tunnelling	≤ 41	Other construction support sites would generate construction noise similar to the Cammeray Golf Course construction support site. This could result in cumulative increases in noise. Even though the project contribution is predicted to achieve the NML, if other construction activities are occurring concurrently, then cumulatively there could be slightly higher construction noise levels (up to 2 dB(A)) at some receivers. Warringah Freeway Upgrade surface road works and Warringah Freeway surface road works as part of the Beaches Link and Gore Hill Freeway Connection project would likely generate construction noise that dominates over Cammeray Golf Course noise levels if close to receivers.
			Surface work support and permanent facilities construction	≤ 35	
		WFU[3]	Zone 2 (Falcon Street to Miller Street)	53 - 69	
		CGC-BL	Civil works + Tunnelling	≤ 44	
		WFU2H-BL[3]	Demolition works	≤ 57	
NCA 28.1	Standard hours NML 57 dB(A)	CGC	Surface work support and tunnelling	≤ 49	Construction noise from other construction support sites could result in similar construction noise levels to the Cammeray Golf Course construction support site at nearby receivers. This may result in cumulative increases in construction noise, all of which are below the NML. Warringah Freeway Upgrade surface road works would dominate over construction noise from the construction support sites. Cumulative construction noise levels would likely remain below the NML at nearby receivers, except for when the Warringah Freeway Upgrade surface road works occur near to receivers.
			Surface work support and permanent facilities construction	≤ 53	
		WFU[3]	Zone 2 (Falcon Street to Miller Street)	46 - 66	
		CGC-BL	Civil works + Tunnelling	≤ 49	
		WFU2H-BL[3]	Piling works	≤ 50	
	OOHW NML D/E/N 52/50/42 dB(A)	CGC	Surface work support and tunnelling	≤ 41	Construction noise levels from other construction support sites could result in similar construction noise levels to the Cammeray Golf Course construction support site at nearby receivers. This may result in cumulative increases in construction noise. The individual construction support sites achieve the NML, however cumulatively noise levels could increase by up to 3 dB(A) which would be just above the NML. Warringah Freeway Upgrade surface road works and Warringah Freeway surface road works as part of the Beaches Link and Gore Hill Freeway Connection project would likely dominate over noise generated by the Cammeray Golf Course construction support site where works are near to receivers.
			Surface work support and permanent facilities construction	≤ 41	
		WFU[3]	Zone 2 (Falcon Street to Miller Street)	47 - 52	
		CGC-BL	Civil works + Tunnelling	≤ 44	
		WFU2H-BL[3]	Piling works	≤ 48	

Notes:
1. Indicative construction programs and noise levels have been assumed for the Beaches Link and Gore Hill Freeway Connection project
2. No typical construction works outside of standard construction hours.
3. Based on the range of noise levels for typical construction works considering the nearest impacted receiver.

At some receivers close to the Cammeray Golf Course construction support sites there is potential for cumulative construction noise levels to exceed the NML, when each individual project may achieve the NML separately. As such, cumulative construction noise levels for separate projects would require mitigation and management where feasible and reasonable.

At receiver buildings not directly adjacent to the Cammeray Golf Course construction support sites, there is potential for cumulative increases of construction noise from concurrent works with the Cammeray Golf Course construction support site as part of the Beaches Link and Gore Hill Freeway Connection project and construction works for the Warringah Freeway Upgrade and Western Harbour Tunnel construction support sites that interface with the Warringah Freeway.

At some receiver locations, when an individual site does not dominate construction noise levels at the receiver (ie. it does not contribute more than 5 dB(A) more noise than other sites), cumulative construction noise levels are predicted to be up to 3 dB(A) higher than the noise levels predicted for any one activity.

Any increase due to cumulative noise is unlikely as noise generating activities would need to occur simultaneously. However, even where a cumulative construction noise increase is predicted, the total construction noise level at that receiver is expected to be below the NML.

Potential consecutive or cumulative construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. The CNVMP prepared as part of the detailed design would include these mitigation measures and cumulative noise impacts would be considered further during detailed design where feasible and reasonable. These mitigation measures would be included in the site's detailed design and site specific CNVIS where feasible and reasonable, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures.

5.8.3 Construction-related road traffic noise assessment

The Warringah Freeway would be the primary access for construction heavy vehicles for the Cammeray Golf Course construction support sites. However, some heavy vehicles would access the site via Ernest Street particularly during site establishment. The assessment has considered heavy vehicles accessing the Cammeray Golf Course construction support sites during tunnel construction and some Warringah Freeway Upgrade surface road works, directly to and from the Warringah Freeway. Access for light vehicle to this site is expected to be to and from Ernest Street. It was assumed that four heavy vehicles per hour would access the site via Ernest Street during the daytime period, which will be verified at detailed design. This may particularly occur when access from the Warringah Freeway has not been constructed during the establishment works stages (eg. Stage 1 (CGC_01) and Stage 2 (CGC_02)).

Table 5-121 presents forecasted vehicle numbers during peak construction periods at this site. During this period up to 22 trucks would access the site per hour from the Warringah Freeway during the daytime period (7.00am to 10.00pm) and a maximum of one truck per hour (no more than four trucks in

total over the night period) in the night time period (10.00pm to 7.00am) which would typically be concrete deliveries to support tunnelling or to support surface road works.

Table 5-121 – Number of construction vehicles accessing the Cammeray Golf Course construction support sites

Type of vehicle	Day[1] over 15 hours[3,4]	Night[2] over nine hours[3,4]
Heavy vehicle (deliveries, spoil haulage and concrete deliveries)	238	4
Light vehicle	161	80

Notes:
1. Day is 7.00am to 10.00pm
2. Night is 10.00pm to 7.00am
3. Numbers presented are individual vehicles, not vehicle movements
4. Vehicle numbers have been distributed onto the local road network based on the proposed access roads. Where a vehicle accesses the site by one road and leaves by another, one vehicle movement is counted along each road once. Where a vehicle accesses and leaves the site by the same road, two vehicle movements are counted on that road.

The existing traffic volumes on the Warringah Freeway are around 100,000 vehicles per day, with greater than 8 per cent heavy vehicles. Because of the relatively small number of construction vehicles associated with this site, the added traffic on Warringah Freeway is unlikely to noticeably increase L_{Aeq} road traffic noise levels at receiver buildings along the freeway.

The potential for increased traffic noise levels from the additional construction traffic on Ernest Street has been assessed, considering that Ernest Street is used as a secondary access, and up to four heavy vehicles per hour would access the site during the daytime period. This assessment is based on the predicted non-project existing traffic volumes during the construction period. Table 5-122 presents the predicted increase in road traffic noise from additional construction traffic.

Table 5-122 – Road traffic noise impacts from the Cammeray Golf Course construction support sites

Construction vehicle access road	Road type	Time of day	Predicted road traffic noise increase, dB(A)[1, 2]	Exceedance of the RNP criteria	Exceedance of sleep disturbance screening level
Ernest Street	Sub-arterial	Day $L_{Aeq(15hr)}$	<0.5	No	N/A
		Night $L_{Aeq(9hr)}$	<0.5	No	No

Notes:
1. Predicted road traffic noise levels are based on the loudest heavy vehicle
2. Predicted road traffic noise levels are based on the nearest residential receiver to the road. Receiver buildings at further distances are expected to experience lower noise levels than those predicted

The predicted road traffic noise increase due to the Cammeray Golf Course construction support sites is less than 2 dB(A) during day and night time periods on Ernest Street. Therefore, predicted noise levels on those roads comply with the RNP criteria identified in section 3.4.2.

Maximum noise levels (L_{Amax}) from night period heavy vehicle movements are predicted to exceed both the sleep disturbance screening level and the adopted awakening reaction level. Since night time heavy vehicle movements from this site would be around nine heavy vehicles per night, they are not likely to

noticeably increase the number of maximum noise events experienced by nearby receiver buildings compared with existing vehicle movements on the Warringah Freeway. This is due to the number of heavy vehicle movements generated by the site being insignificant when compared to existing traffic.

No heavy vehicle movements would access this site via Ernest Street during night time period.

5.8.3.1 Mitigation and management

Mitigation and management measures for construction related traffic noise impacts are outlined in section 6.7. To minimise noise impacts from construction vehicles on surrounding streets, during detailed design the site specific CNVIS and project CNVMP would review and implement the following mitigation measures:

- Where feasible and reasonable, programming heavy vehicle movements to occur during standard construction hours. Out of hours heavy vehicle movements would be programmed to occur during less sensitive time periods and limited to no more than one heavy vehicle per hour
- Requiring all drivers to comply with a Heavy Vehicle Code of Conduct, including noise management methods such as limiting idling and compression braking.

5.8.4 Ground-borne construction noise

Ground-borne noise could result from the construction of the ventilation shaft and access decline tunnel, which would also become a ventilation tunnel between the Cammeray Golf Course construction support sites and the main road tunnels. The access decline tunnel crown at Cammeray Golf Course construction support site would start around 10 metres below ground level. As such a vertical shaft would be constructed within the acoustic shed prior to the horizontal access decline tunnel construction.

There are three ventilation tunnels that would be constructed from Cammeray Golf Course construction support site as presented in Figure 5-12. The southern most tunnel is the closest to the nearest sensitive receivers. All other access decline tunnels are at further distances away, and as such it is unlikely during the construction of these other tunnels that any receivers would be affected by ground-borne noise.

The number of receiver buildings that could potentially be impacted by the highest predicted ground-borne noise levels considering both shaft and tunnel construction are presented in Table 5-123.

Table 5-123 – Number of receiver buildings affected by ground-borne noise from ventilation shaft, decline and ventilation tunnel construction

NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML[1,2])				
	Residential			Other sensitive receivers	Commercial/ industrial receivers
	> 35[1] to ≤ 40 dB(A)	> 40[2] to ≤ 45 dB(A)	>45 dB(A)		
NCA 23.1	2	-	-	-	-
NCA 23.2	-	1	-	-	-
NCA 26.1	-	-	-	-	-

Notes: 1. Night ground-borne noise management level (GBNML)
2. Evening ground-borne noise management level (GBNML).

Table 5-123 indicates that three residential receiver buildings are predicted to be impacted by ground-borne noise levels above the strictest NML (ie. night time 35 dB(A)). Predicted ground-borne noise levels are presented in Appendix J.3.

Ground-borne noise from the construction of the ventilation shaft, decline and ventilation tunnels would be managed by potentially restricting the construction hours that tunnelling could be carried out to minimise impacts during more sensitive periods (eg. night), or if justified, in accordance with section 6.10.2. The extent of mitigation and management required to limit potential impacts to receiver buildings would be determined by considering not only the level of noise impact, but also the duration that receiver buildings are likely to be exposed to ground-borne noise levels above the NML.

Furthermore, if verification monitoring conducted during the tunnelling works determines that ground-borne noise levels inside residential receiver buildings are below the predicted noise levels and comply with the ground-borne noise NMLs, tunnel construction may be extended outside standard hours. Detailed noise mitigation and management measures would be confirmed during detailed design.

Ground-borne noise levels could be generated by vibration-intensive works as part of works within the construction support site. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receiver buildings. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

5.8.5 Construction vibration

The vibration generated from construction works would vary depending on the level and type of activity carried out. For the Cammeray Golf Course construction support sites, the major stages which may include vibration-intensive works are:

- Stage 1 (CGC_01): early works
- Stage 2 (CGC_02): establishment of construction facilities
- Stage 3 (CGC_03): build shaft, shed and vent tunnels

- Stage 5 (CGC_05): tunnelling.

Proposed vibration-intensive plant items are identified in Appendix E. Minimum working distances for a range of construction plant items are presented in Table 4-11. Presented in Appendix L are the estimated minimum working distances from the works construction support site for both structural damage and human response to vibration for the most vibration-intensive activity proposed for the construction support site.

The most vibration-intensive activity at this site is likely to be the use of rock hammers for utility relocation during early works (CGC_01), for demolition during site establishment (CGC_02) works, or for the construction of the ventilation shaft.

Access decline tunnel and ventilation tunnel construction during tunnelling (CGC_05) works may also cause vibration impacts, as the access decline tunnel passes under receiver buildings. The locations of all other ventilation tunnels to be constructed are further than the minimum working distances presented in section 4.4.1 for roadheader tunnelling.

The number of receiver buildings within the minimum working distances for substantial vibration-generating activities is presented in Table 5-124. Access decline and ventilation tunnel construction using roadheaders at the site are not expected to result in vibration impacts.

Potential vibration generated to receivers depends on the vibration source levels, separation distance, intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. This assessment considers a worst-case scenario that the proposed vibration-intensive plant items could be used anywhere within the boundaries of the site. However, this is unlikely to occur, and the location of the vibration-intensive equipment would be confirmed during detailed design.

Table 5-124 – Number of receivers within minimum working distances for vibration impact

NCA	Number of structures within minimum working distances		
	Cosmetic damage		Human response
	Heritage item	Sound structure	
Early works and site establishment			
23.1	-	-	5
26.1	-	-	9
26.2	1	-	-
28.1	-	-	18
29.1	-	6	9

5.8.5.1 Cosmetic damage

Six buildings in NCA 29.1 have been identified within the minimum working distances for cosmetic damage, as presented in Table 5-124.

Site-specific buffer distances for vibration-intensive activities (eg. compaction, rock hammering) would be measured on site where plant and equipment are likely to operate close to or within the minimum working distances (see Table 4-11). Site-specific buffer distances would be maintained in order to comply with relevant vibration limits for cosmetic damage.

5.8.5.2 Heritage listed structures

One heritage item has been identified within the unsound structure cosmetic damage minimum working distance. The item is shown in Appendix L and identified and described in Table 5-125.

Refer to the Technical working paper: Cultural heritage assessment report and Technical working paper: Non-Aboriginal heritage for the assessment of impacts to heritage items.

Table 5-125 – Heritage receivers within the cosmetic damage minimum working distance – Cammeray Golf Course

Name	Significance	Type	Site Heritage ID
Cammeray Park (including golf course)	Local	Item - Landscape	I0024

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.8.5.3 Human response

Rock hammering would occur for limited duration only at this site; therefore, the risk of annoyance is low. However, occupants at up to 41 receiver buildings are predicted to be exposed to vibration levels above the perception level during early works and site establishment, as presented in Table 5-124.

The extent of mitigation and management required to limit potential impacts to receivers would be determined by looking not only at the level of vibration, but also the duration that receiver buildings are likely to be exposed to vibration above the perception level.

No receivers are expected to be exposed to vibration from access decline tunnel construction above the perception level. Mainline tunnel construction ground-borne vibration impacts are presented in section 5.11.1.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures would be provided (see section 6.10.3).

5.9 Warringah Freeway Upgrade surface road works

This Warringah Freeway Upgrade surface road works assessment section assesses both the Warringah Freeway Upgrade construction works and Western Harbour Tunnel construction works that interface with the Warringah Freeway such as the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

As part of the Western Harbour Tunnel (WHT) and Warringah Freeway Upgrade (WFU) project (the project), connections would be provided to and from the project at the existing Warringah Freeway at North Sydney (the northern end of the project). This includes on and off ramps to North Sydney off Berry Street and Falcon Street and connections with the Warringah Freeway. Additionally, a motorway control centre would be constructed at Waltham Street, Artarmon and then connected to the Western Harbour Tunnel. These works associated with the Western Harbour Tunnel that interface with the Warringah Freeway have been assessed as part of this section.

5.9.1 Construction works overview

To accommodate these connections, key functional changes would be made to the Warringah Freeway to improve local and arterial road connections.

The Warringah Freeway Upgrade would:

- Connect and integrate with the Western Harbour Tunnel and Beaches Link and Gore Hill Freeway Connection project and with the existing motorway and arterial road network
- Improve wayfinding and separate traffic on the freeway depending on different trip functions (through traffic, traffic for arterial distribution and traffic for local destinations).

The upgrade would provide:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges
- New and upgraded pedestrian and cyclist infrastructure
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels
- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network
- Upgrades and modifications to bus infrastructure
- Bridgeworks, pavement and linemarking, and construction of retaining walls

- Other operational ancillary facilities and infrastructure, including, stormwater and cross drainage installations, utilities installations and relocations, tolling gantries and associated infrastructure, installation of road furniture, lighting and signage and noise barriers, and landscaping.

The Western Harbour Tunnel interface construction works provide:

- A motorway control centre at Artarmon
- Portals and on and off ramps for the Western Harbour Tunnel mainline tunnels and integration with the Warringah Freeway.

This section assesses the potential construction noise and vibration impacts, and the reasonable and feasible mitigation measures that would be considered to control impacts on noise and vibration sensitive receivers near the Warringah Freeway upgrade surface road works.

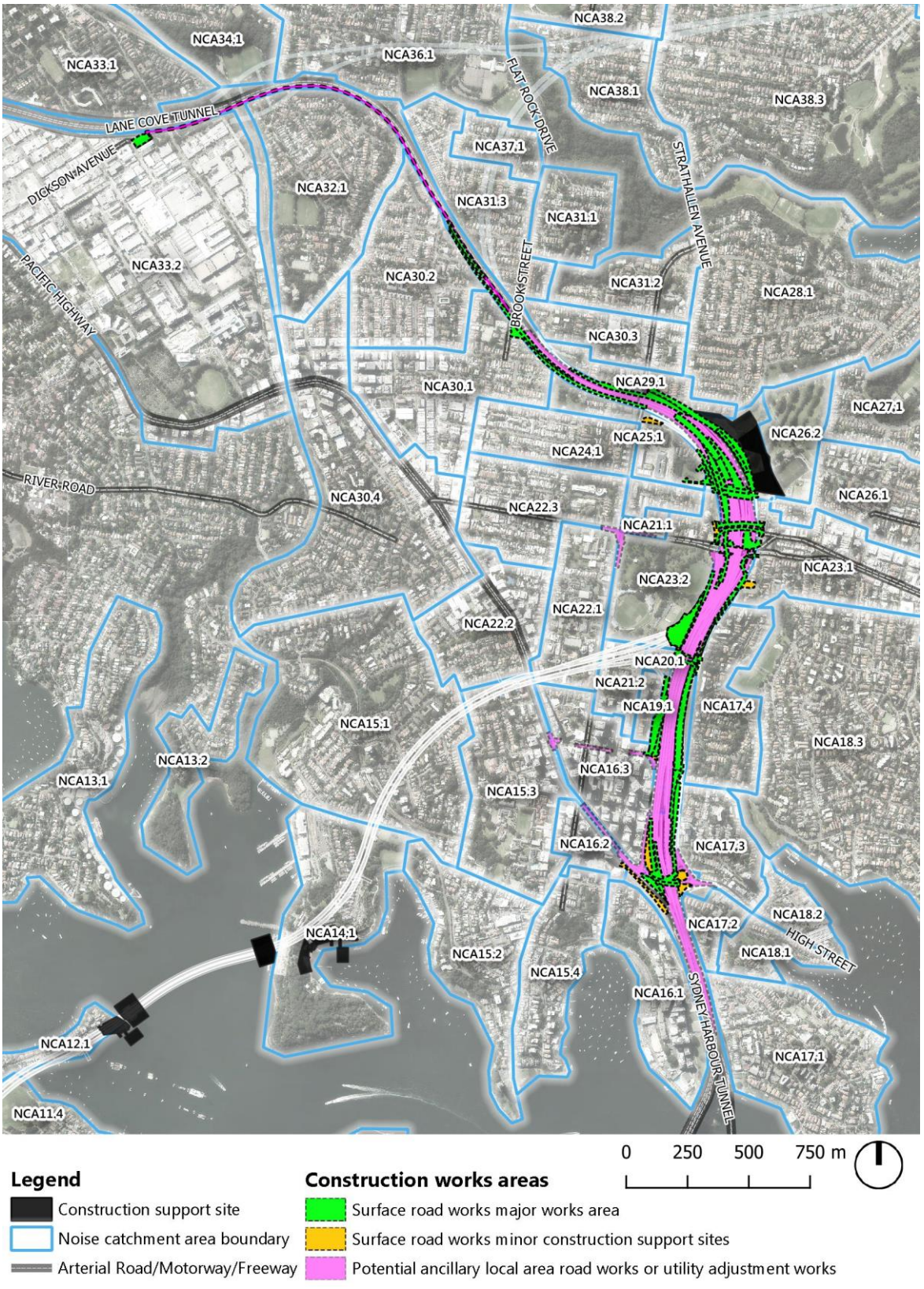
Warringah Freeway Upgrade surface road works would extend from the northern end of the Sydney Harbour Bridge to Willoughby Road. The main construction activities include cut and cover portal structures, surface earthworks, new and modified bridge structures, drainage and water quality management infrastructure and pavement works.

The construction works have been grouped into 11 sets of construction work areas, classified for the purposes of the assessment as major works areas. These major work areas are supported by minor construction support sites located adjacent to the Warringah Freeway corridor. The locations of these major work areas and minor construction support sites is presented in Figure 5-13.

Noise and vibration impact from the Cammeray Golf Course construction support site (WFU8) supporting the Warringah Freeway Upgrade surface road works has been assessed in section 5.8, and has been assessed operating concurrently with the adjacent Cammeray Golf Course construction support site (WHT10) supporting the Western Harbour Tunnel construction.

Additional ancillary local area road works or utility adjustment works may also be required along the extent of the Warringah Freeway Upgrade project. The extent of where these construction works as part of the Warringah Freeway Upgrade surface road works may be required is presented in Figure 5-13.

Figure 5-13 – Warringah Freeway Upgrade surface road works extent - major works areas, construction support sites and additional ancillary construction works extent



5.9.1.1 Nearby noise and vibration-sensitive receivers

Figure 5-14 presents the upgrade location, nearby noise-sensitive receivers and the NCA boundaries.

The NCAs that are in proximity to the Warringah Freeway Upgrade surface road works are NCA 13.1 through to NCA 38.2. Refer to Appendix B.1 for more detailed information on the nearby noise-sensitive receivers and the NCA boundaries.

Figure 5-14 – Warringah Freeway Upgrade surface road works - major works areas, construction support sites, nearby noise-sensitive receivers and NCA boundaries



5.9.1.2 Assessed construction works

As shown in Figure 5-15 to Figure 5-17 there are 11 major works areas that have been assessed as part of the Warringah Freeway Upgrade surface road works. These are made up of the major components of Warringah Freeway Upgrade surface road works or Western Harbour Tunnel construction works that interface with the Warringah Freeway such as the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

In addition, 12 minor construction support sites have been identified for assessment due to their potential use during the construction works. These include eight sites that support the Warringah Freeway Upgrade surface road works in addition to support activities within the Western Harbour Tunnel construction support sites of Berry Street north (WHT8) and Ridge Street north (WHT9). The construction activities at Jeaffreson Jackson Reserve and Merlin Street, north of Falcon Street, to support construction work at the Falcon Street shared user bridge have also been included in the assessment of minor construction support sites, even though construction support sites would not be fully established at these locations.

A summary of the major works areas that have been assessed, as well as the range of proposed noise-generating construction activities, is presented in Table 5-127. Construction noise from these major works areas are assessed in detail in section 5.9.2.2 through to section 5.9.2.13. Furthermore, at various locations within the Warringah Freeway Upgrade surface road works, the following additional general works would occur within the construction footprint. The exact locations have not been finalised at this stage and would be assessed during detailed design when the locations are known.

- Local road works
- Utility and sewerage modifications
- Relocation of traffic controls and barriers
- Milling of pavement
- Asphalt
- Line marking
- Signposting
- Utilities
- Stormwater drainage
- Demolition of medians, barriers and pavement.

Additionally, there are some ancillary local area road works or utility adjustment works that would be required for relatively short term periods (less than one month) such as intersection modification works, however, these are likely required OOH due to road congestion and road safety issues. An assessment for these works is presented in section 5.10.1.

Figure 5-15 – Warringah Freeway Upgrade surface road works – major works areas (south section)



Figure 5-16 – Warringah Freeway Upgrade surface road works – major works areas (north section)



Figure 5-17 – Western Harbour Tunnel motorway control centre (Western Harbour Tunnel) – major works areas (Artarmon)



5.9.1.3 Construction works program

The proposed approximate timeframe for the Warringah Freeway Upgrade is presented in Table 5-126 subject to project approval. Work would occur from late 2020 to 2025. This timeframe is indicative and subject to refinement during construction planning.

Table 5-126 – Warringah Freeway Upgrade surface road works – indicative program and timeline

Zone	Major works areas	Reference (Figure 5-15-Figure 5-17)	Indicative construction timeframe																							
			2020				2021				2022				2023				2024				2025			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Minor construction support sites		WFU0A				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Zone 1	Ridge Street shared user bridge	WFU1A									■	■	■	■												
	Berry Street entry on ramp works	WFU1B										■	■	■												
	Alfred Street north and Mount Street interchange modification and grade separation works	WFU1C									■	■	■	■	■	■	■	■	■	■						
	Warringah Freeway northbound widening	WFU1D													■	■										
	Falcon Street interchange upgrade	WFU1E										■	■	■	■	■	■									
	High Street interchange upgrade	WFU1F													■	■	■	■	■	■						
	Warringah Freeway southbound widening	WFU1G													■	■	■	■								
	Western Harbour Tunnel Falcon Street off ramp cut and cover	WFU3J										■	■	■	■											
Zone 2	Falcon Street to Miller Street construction works	WFU2H									■	■	■	■	■	■										
Zone 3	Miller Street to Willoughby Road construction works	WFU3I										■	■													
	Western Harbour Tunnel motorway control centre	WFU3K																■	■	■	■	■	■	■	■	■

5.9.1.4 Construction hours, durations and required out of hours work

5.9.1.4.1 Construction hours and programming

A number of construction activities for the Warringah Freeway Upgrade road surface works would occur outside of standard construction hours, typically commencing in the evening period and continuing into the night period.

Construction support sites required for the Warringah Freeway Upgrade surface road works would operate up to 24 hours per day, seven days per week. Where feasible and reasonable, works would be programmed to occur during standard construction hours; as outlined in section 5.1.4.

A large amount of road work would be carried out during night time road closures as well as weekend closures during non-peak periods. This is predominantly to protect the safety of workers and road users and to minimise traffic disruptions to critical parts of the Sydney road network.

Noisy activities such as rock hammering and road sawing would be programmed for periods before midnight, where feasible and reasonable. Where unavoidable or in unforeseen circumstances, these noisy activities may be required to be carried out after midnight. Further consultation with the community would take place if these works were required after midnight.

5.9.1.4.2 Required out of hours works (OOHW)

Subject to approval, the programming, durations and required OOHW would be refined during detailed design. During detailed design the contractor would review proposed OOHW and as a result, the amount of OOHW may increase or decrease. Increased OOHW could potentially reduce the overall duration of construction works, or further improvements to the efficiency of construction activities may reduce the amount of OOHW. All OOHW would be carried out subject to an OOHW protocol, as outlined in section 6.4.4.

Proposed OOHW are outlined in each assessment section, including a description of the works and justifications why they need to take place outside of standard construction hours. Due to the importance of Warringah Freeway to the greater Sydney road network:

- Access to the work area may not be allowed before the evening or night periods, and so construction work would need to happen in the night time
- Work would need to occur around five nights a week to minimise disruption to the network. While work could progress over five consecutive nights where feasible, it would be staged along the road corridor to manage impacts on sensitive receivers at any one location.

The following key sets of construction works for the Warringah Freeway Upgrade surface road works would need to be carried out outside standard construction hours and around five nights a week at various stages. The works would include:

- Utility relocations or replacements
- Stormwater works
- Pavement widening works and tie-ins
- Bridge and large road structure demolition works
- Concrete median demolition, removal and construction.

The major activities where bridge works would need to occur during closures of the entire Warringah Freeway carriageways, for safety reasons, include:

- Ridge Street shared user bridge replacement
- High Street bridge southern widening
- Falcon Street shared user bridge replacement
- Ernest Street active transport bridge modifications.

Other OOHW may be required within consideration of:

- The physical constraints and impacts of the various activities
- Certain construction activity may involve periods of continuous work over several days under extended lane closures
- Minimisation of impacts on traffic or impact on noise-sensitive receivers
- The balance between the type of activity and the impact on traffic flow immediately prior to, during or after the works
- The traffic management strategies and the required complexity of implementation
- The potential to isolate construction areas from the live traffic corridor. This would be investigated, where feasible and reasonable, to allow more activities to occur during standard construction hours.

The temporary nature of works carried out under an ROL means that there are limited opportunities to install fixed noise mitigation (ie. acoustic sheds, acoustic enclosures, large temporary barriers) as the road needs to be fully open the next day.

Other feasible and reasonable noise mitigation and management measures would be reviewed and implemented to minimise noise impacts on nearby noise-sensitive receivers. The mitigation and management measures which would be put in place for surface road works are discussed in section 6.4.

5.9.1.5 Concurrent and consecutive construction projects

The nearest construction support site to the construction activities assessed in this section associated with the project is the Cammeray Golf Course construction support sites (WHT10 and WFU8) which

would support the Warringah Freeway Upgrade surface road works and Western Harbour Tunnel tunnelling works.

The nearest construction works associated with other major infrastructure projects are:

- As part of the Beaches Link and Gore Hill Freeway Connection project, the construction works areas nearby are:
  - The Cammeray Golf Course would also be used as a construction support site for this project, located on the eastern side of the Warringah Freeway at Cammeray, once the Warringah Freeway Upgrade is complete
  - Warringah Freeway surface road works for this project to construct the Beaches Link portal structures and associated ramps and road-tie ins would take place within the Warringah Freeway corridor at Cammeray, adjacent to the Cammeray Golf Course construction support site
  - The Gore Hill Freeway Connection surface road works at Artarmon, which are located around 1.5 kilometres north-west of the Warringah Freeway Upgrade surface road works
  - The Punch Street construction support site at Artarmon, around 1.5 kilometres north-west of this Warringah Freeway Upgrade surface road works.
- As part of the Sydney Metro City & Southwest project, construction support sites are located at:
  - North Sydney for Victoria Cross Station on Miller Street, North Sydney
  - Crows Nest for Crows Nest Station on the Pacific Highway, Crows Nest
  - Artarmon for Artarmon Substation on Reserve Road, Artarmon.

5.9.1.6 Construction activities, assessed scenarios and noise sources

Construction noise sources and activities

Noise impacts have been assessed for the reasonably worst-case noise-intensive works that would occur in each Warringah Freeway Upgrade surface road works major works area. This assessment aims to predict the potential extent of noise impacts for construction works proposed to take place within each major works area.

At this stage of the project, specific items of plant and equipment are not known in detail. For the assessment of surface road works noise impacts, a range of typical construction activities and associated plant and equipment that have been developed to assess the potential noise impacts from surface road works in this environmental impact statement, which are listed in Appendix F. These were developed based on other major road and tunnelling projects in Sydney.

During construction work, the number of plant items operating at any one time may change on site. The assumed number of plant modelled are based on a conservative, but realistic, estimate of the likely number of units operating concurrently for each activity.

Each activity specifies the number of plant items assumed to operate during either the 'typical' and/or 'worst-case' scenarios for each activity, shown by the 'Assumed No. of units' in Appendix F, with the corresponding sound power levels. The total noise level for each activity was determined by combining the noise levels of all identified construction plant and equipment.

Range of noise levels from construction activities

A range of construction activities are to be carried out within each major works area. Presented in Table 5-127 is the range of potential types of construction activities along with the associated assessment SWLs that may occur as part of the surface road upgrades, and an indication of whether these are to occur in each major works area. Works that could occur during standard construction hours are indicated as 'D'; works modelled during OOHW periods are indicated as 'O'; and where the activity may occur during both periods it is indicated as 'DO'.

For assessment purposes, not all activities could be modelled, and so only the most noise-intensive activities have been modelled. These are highlighted in Table 5-127, with **blue** shading where the activity has been modelled during standard construction hours, and **orange** shading where the activity has been modelled outside of standard construction hours. However, the other noted activities may also occur as part of the construction works. Works modelled during standard construction hours are shaded blue and works modelled during OOHW periods are shaded orange. As presented, the noise impacts would vary as the construction activities vary.

Table 5-127 – Proposed key construction activities and construction hours across the works areas and assessed works activities – Warringah Freeway Upgrade surface road works

Zone/ Works Area / Assessment Scenario Reference ACTIVITY KEY Standard construction hours = 'D' OOHW = 'O' Standard construction hours & OOHW = 'DO' MODELLED SCENARIOS Shaded blue = standard construction hours Shaded orange = OOHW			Number of assessed works areas	Road work	Concrete barriers and traffic controls	Demolition (rock hammering)	Pavement/road modification works	Paving/asphalting/road works (inc. road saws)	Resurfacing works	Road furniture installation/modification	Earthworks	Clearing & grubbing works	Earthwork	Pile breaking	Piling – Bored	Rock drilling	Rock trimming	Shotcrete	Structures	Concrete formwork and reinforcement	Concrete pours	Erection of structural steelwork	Erection/removal of large items	Noise barrier installations	Services/Utilities	Utilities modification works	Support Activities	Deliveries	Deliveries (oversized)	Mobilisation/demobilisation & site setup	Spoil handling	Support site general activities
Worst-case SWL[1]					105	121	120	120	118	114		116	119	122	117	117	121	112		113	116	117	111	118		120		104	111	110	106	105
Typical case SWL[1]					99	109	110	109	112	107		112	116	113	108	95	116	109		104	112	111	110	111		110		98	110	108	104	100
	Minor construction support sites	WFU0A	12																									D		D		DO
Zone 1	Ridge Street shared user bridge	WFU1A	2		O	O			D			D			O		D				O	O	O						O	D	O	
	Berry Street entry on ramp works	WFU1B	3		D	DO	D			D		D	DO		D								D			D		O		D	O	
	Alfred St Nth to Mount Street interchange	WFU1C	6		O		DO	DO		D		DO	D		D						O		DO			DO		DO	O	D		
	Warringah Freeway northbound widening	WFU1D	1		O		D		DO	D		D	D													D				D		
	Falcon Street Interchange	WFU1E	6		O	O	DO	D	DO	O			DO							DO	O		O			DO		O	O	D	O	
	High Street Interchange	WFU1F	4		DO		D	D	D	O		D			DO					DO	O	D	DO			D		D	O	D		
	Warringah Freeway southbound widening	WFU1G	5		DO	D	O	O	DO	D		O	D		D	D		D		D	O		D			D		O	O	D	O	
	Western Harbour Tunnel Falcon Street off ramp cut and cover	WFU3J	2			D	DO	O	DO	DO		D	D		D					D			D			D		D	DO	D	D	
Zone 2	Tunnel structure works	WFU2H	9		O	D		D	O	D		D	D		D		D			D	O					D			O	D		
	Ernest Street bridge	WFU2H	2		DO	D		O	D	D			D		D					D	O		O			D		O	O	D		
Zone 3	Miller Street to Willoughby Road construction works	WFU3I	5		O	DO		D	D	DO		O	DO							D	O		D			D		O	O	D	DO	
	Western Harbour Tunnel motorway control centre	WFU3K	1																	D	D	D	D			DO		D	DO	D	D	

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2 Construction airborne noise

The following sections summarise the predicted $L_{Aeq(15minute)}$ and L_{Amax} noise levels from Warringah Freeway Upgrade surface road works. The predicted noise level range presented in the summary tables is explained further in section 4.2.3.3. The presented noise levels are based on the worst affected receiver building/s within an NCA, and the 'typical' and 'worst-case' construction noise levels that may affect these receivers.

Additionally, predicted noise levels are presented to show how noise impacts from these activities would change when the activity is located at the 'far' end of the major works area compared with the 'near' location closest to the receiver. If the 'far' noise level of the range is below the NML or there is a less than 1 dB(A) range, only the upper noise level is presented.

The worst affected receivers for each NCA are typically in the first row of buildings with direct line of sight to the work area. Receivers in the next row of houses back from the project, or receivers without direct line of sight to the construction area would typically be exposed to construction noise levels 5 to 10 dB(A) lower than the levels predicted for the most affected receivers.

The highest 'typical' noise levels predicted for all stages of major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels from the various major works areas that make up the Warringah Freeway Upgrade.

It is important to note that the noise contours represent the highest 'typical' noise levels that occur over an entire stage/works area and not an individual activity/night. As such, the number of noise affected receivers (ie. greater than NML) during individual works/activities or on an individual night would be less than those presented, and receivers impacted would also vary between nights as the location and type of activity changes.

5.9.2.1 Predicted noise impacts presentation

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

The colours in the table indicate whether or not noise levels at receiver buildings in the NCA comply with the NML, where exceedance of the NML occurs, and how construction noise may be perceived based on the CNVG. Refer to section 4.2.3 for the airborne noise prediction methodology.

Table 5-128 – Key to the results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue) Clearly audible	11-20 dB(A) over NML (mid blue) Moderately intrusive	>20 dB(A) above NML (dark blue) Highly intrusive	
	Outside standard hours	1-5 dB(A) above NML (green) Noticeable	6-15 dB(A) above NML (yellow) Clearly audible	16-25 dB(A) above NML (orange) Moderately intrusive	>25 dB(A) above NML (purple) Highly intrusive
	Any time	**Highly noise affected (>75 dB(A), bold)**[2]			
Sleep Disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		**L_{Amax} above awakening level (>65 dB(A), bold and purple)**	

Notes: 1. Standard construction hours shading is applied for non-residential receiver buildings
2. Highly noise affected (HNA) applies to residential receiver buildings only.

It is important to note that all results presented in this section represent the noise levels that occur over an entire stage/works area and not an individual activity/night. As such, the number of noise affected receiver buildings (ie. > NML) during individual works/activities or on an individual night would be less than those presented, and receiver buildings impacted would also vary between nights as the location and type of activity changes.

5.9.2.2 Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites (WFU0A)

To support the Warringah Freeway Upgrade surface road works and works that interface with the Warringah Freeway, 12 minor construction support sites have been identified for assessment due to their potential use during the construction works.

There are eight minor construction support sites associated with the Warringah Freeway Upgrade surface road works, in addition to the major support site at Cammeray Golf Course construction support site (section 5.8). Two Western Harbour Tunnel construction sites adjacent to the Warringah Freeway identified as Ridge Street north (WHT9) and Berry Street north (WHT8) would also undertake support activities which have also been assessed in this section for the noise emissions from activities supporting the Warringah Freeway Upgrade surface road works. The construction activities at Jeaffreson Jackson Reserve and Merlin Street, north of Falcon Street, to support construction work at the Falcon Street shared user bridge have also been included in the assessment of minor construction support sites, even though construction support sites would not be fully established at these locations.

The locations of the assessed minor construction support sites are presented in Figure 5-18. These sites would support the various major work areas assessed throughout the rest of this section. Noise impacts from Warringah Freeway Upgrade surface road works at the Cammeray Golf Course construction support site {WHT10(CGC)/WFU8} are covered in the individual site assessment in section 5.8.

In order to assess the noise impacts from the minor construction support sites, typical construction activities for standard construction hours and outside of standard construction hours have been assessed. The activities presented in Table 5-129 represents the reasonable most noise-intensive

activities that would operate at each of the support sites. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-129 – Assessed construction activities – Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites

Assessment scenario reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
All minor construction support sites	Mobilisation/demobilisation and site setup	108	110	Support site general activities	100	105

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

Presented in Table 5-130 are the highest predicted noise levels at the nearest residential receiver buildings to each minor construction support site. In addition, the number of residential receiver buildings predicted to potentially experience noise levels above the NML are also presented.

Figure 5-18 – Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support site locations

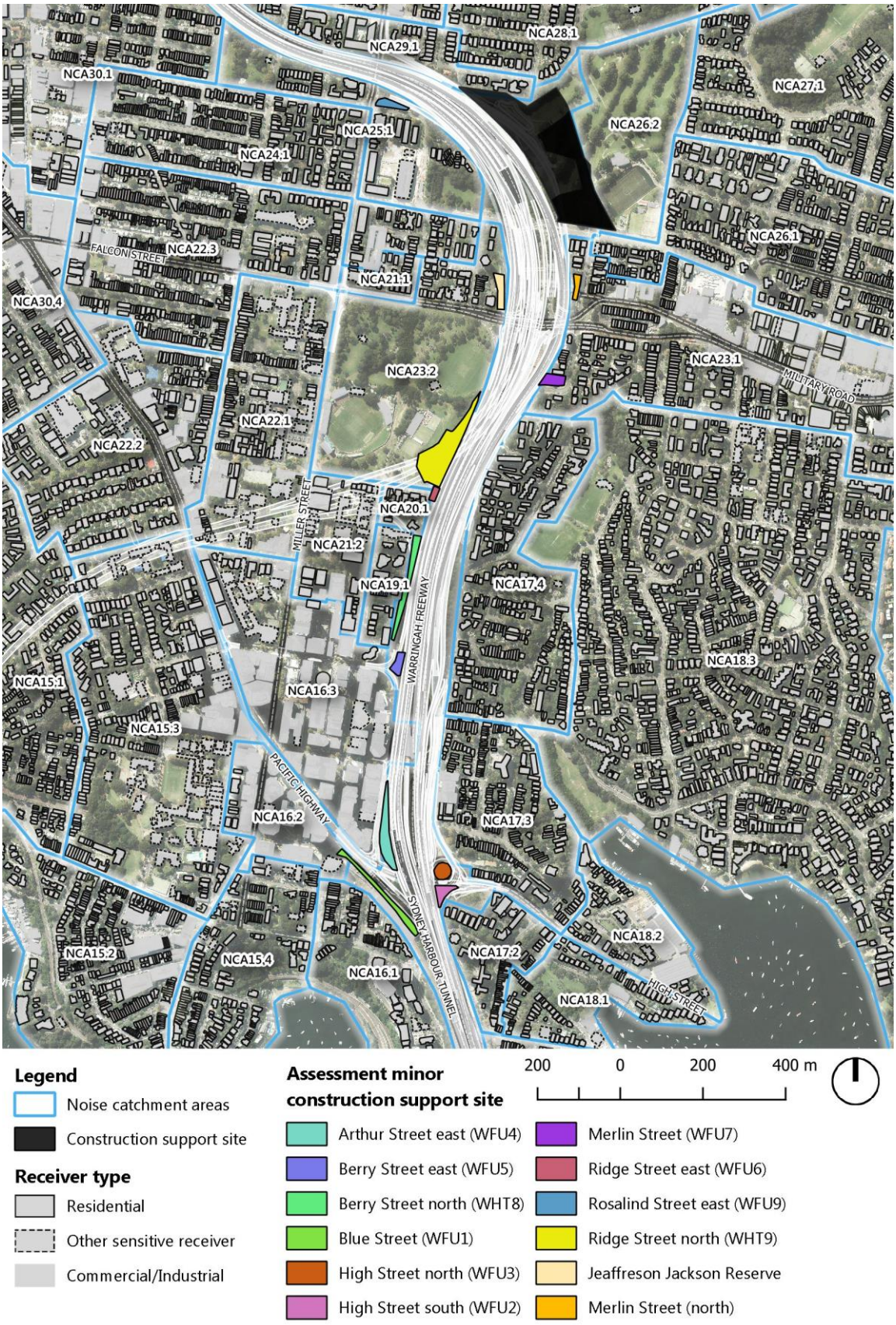


Table 5-130 – Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites – construction noise assessment

Minor construction support site	Typical / worst-case activity noise intensity	Predicted construction noise level at nearest receiver building, dB(A)		Number of residential receiver buildings predicted over the noise management level for all NCAs[1]					Indicative noise mitigation measures assumed for the assessment
		Standard hours	OOHW (Night)	Day (standard hours)	Day (outside standard hours)	Evening	Night	Sleep disturbance - Awakening (L_{Amax})	
Blue Street (WFU1)	Typical	62	54	6	0	6	6	0	-
	Worst-case	64	59	6	6	6	9	6	
High Street south (WFU2)	Typical	60	51	0	0	0	1	5	Temporary noise barrier along the south-west boundary
	Worst-case	61	56	0	0	0	20	21	
High Street north (WFU3)	Typical	68	60	6	0	1	35	39	Temporary noise barrier north and west boundary
	Worst-case	70	65	14	14	22	57	51	
Arthur Street east (WFU4)	Typical	72	64	0	0	0	1	2	-
	Worst-case	74	69	1	1	3	13	9	
Berry Street east (WFU5)	Typical	66	57	0	0	0	1	3	-
	Worst-case	67	62	0	0	0	10	7	
Berry Street north (WHT8)	Typical	74	66	15	6	6	24	25	-
	Worst-case	76	71	18	18	22	31	28	
Ridge Street east (WFU6)	Typical	75	67	4	3	3	5	8	-
	Worst-case	77	72	4	4	4	15	13	
Ridge Street north (WHT9)	Typical	63	55	1	0	0	3	5	As shown in Figure 5-28. Minimum five metres temporary noise barrier along southern boundary, and three metres temporary noise barrier along western boundary.
	Worst-case	65	60	3	3	3	18	15	
Merlin Street (WFU7)	Typical	75	67	1	1	1	17	19	Temporary noise barrier along the southern and eastern boundary
	Worst-case	77	71	1	1	5	34	33	
Jeaffreson Jackson Reserve construction area[2]	Typical	73	65	1	0	5	29	27	Temporary noise barrier along the western and northern boundary
	Worst-case	75	70	3	3	10	72	44	
Merlin Street (north) construction area[2]	Typical	75	67	1	1	2	23	17	Temporary noise barrier along the northern and eastern boundary
	Worst-case	77	72	1	2	10	59	24	
Rosalind Street east (WFU9)	Typical	69	60	1	0	0	25	17	Temporary noise barrier along the southern boundary
	Worst-case	70	65	2	1	7	96	25	

Notes: 1. Figure 5-18 presents the locations of all support locations, and locations of the surrounding NCAs. The NMLs for these NCAs are included in Appendix B.2.

2. The construction activities at Jeaffreson Jackson Reserve and Merlin Street, north of Falcon Street, to support construction work at the Falcon Street shared user bridge have also been included in the assessment of minor construction support sites, even though construction support sites would not be fully established at these locations.

5.9.2.2.1 Indicative noise mitigation measures

As the support sites are fixed locations, there are opportunities to install temporary noise mitigation where it can be beneficial for nearby receiver buildings. However, as the layout and activities at each of these support sites are being refined at this stage, they are to be assessed during detailed design to determine further feasible and reasonable mitigation. Indicative site boundary noise barriers have been included in the assessments for modelling purposes to determine the extent of potential noise impacts. These are identified in Table 5-130.

5.9.2.2.2 Discussion of noise impacts from Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites

Table 5-130 shows that for all minor construction support sites, during standard construction hours worst-case noise-intensive activities, the noise impacts are predicted to exceed the NMLs at the nearest residential receiver buildings, but when typical noise-intensive activities are taking place, the predicted impacts comply with the NML or exceed at only one or two nearby receiver buildings, except for Blue Street (WFU1), High Street north (WFU3), Berry Street north (WHT8) and Ridge Street east (WFU6).

During the OOHW night period both typical and worst-case noise-intensive activities generally could exceed the NMLs at the nearest residential receiver buildings, and exceed sleep disturbance screening levels, including the level where there is the potential for an awakening reaction.

However, the minor construction support sites would typically operate in conjunction with the Warringah Freeway Upgrade surface road works in the nearby major works areas, which are often impacting the same receiver buildings. As such, the mitigation and management measures that have been implemented for the surface road works would assist to manage construction noise impacts on these receiver locations, and further on-site mitigation in and around the minor construction support sites would typically not assist in reducing the overall construction noise levels at these receiver buildings. Noise impacts from the minor construction support sites would be considered cumulatively with other Warringah Freeway Upgrade surface road works.

5.9.2.2.3 Summary of residual impacts and additional mitigation and management measures

As there is potential for exceedance of the NMLs for all minor construction support sites, during detailed design of the support sites further noise mitigation and management measures are to be developed. This includes developing the site layout with consideration of noise, including the positioning of the site offices and fixed structures in between noise generating activities and nearby receiver buildings to assist in mitigating construction noise impacts. This would be beneficial for multi-storey residential receiver buildings.

Careful use of close-proximity temporary noise barriers near designated areas where noise generating activities can occur can assist in mitigating noise impacts at the nearby receiver buildings.

Where feasible and reasonable, it would be effective to reduce noise impacts by programming louder surface work minor construction support site activities to standard construction hours or shifted to less sensitive OOH periods (ie. evening), so that noise generating activities and associated noise impacts outside standard construction hours are minimised.

The construction mitigation and management measures outlined in section 6.2 would be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receiver buildings.

Additional mitigation measures would be provided to manage residual impacts where receiver buildings are still over the NMLs with the incorporation of feasible and reasonable mitigation measures, in accordance with the CNVG.

Additional mitigation measures would be adopted with consideration of cumulative and long-term noise impacts on receivers, specifically noting the Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations.

5.9.2.3 Ridge Street shared user bridge (WFU1A)

The Ridge Street shared user bridge site is located over the Warringah Freeway, directly south-east of St Leonards Park, North Sydney, as shown in Figure 5-19, and is located within Zone 1. The location of the works area and surrounding noise-sensitive receivers is presented in Figure 5-19.

The key activities of the proposed construction work includes:

- Demolition of the existing Ridge Street shared user bridge
- Construction of a new replacement shared user bridge south of the existing Ridge Street shared user bridge.

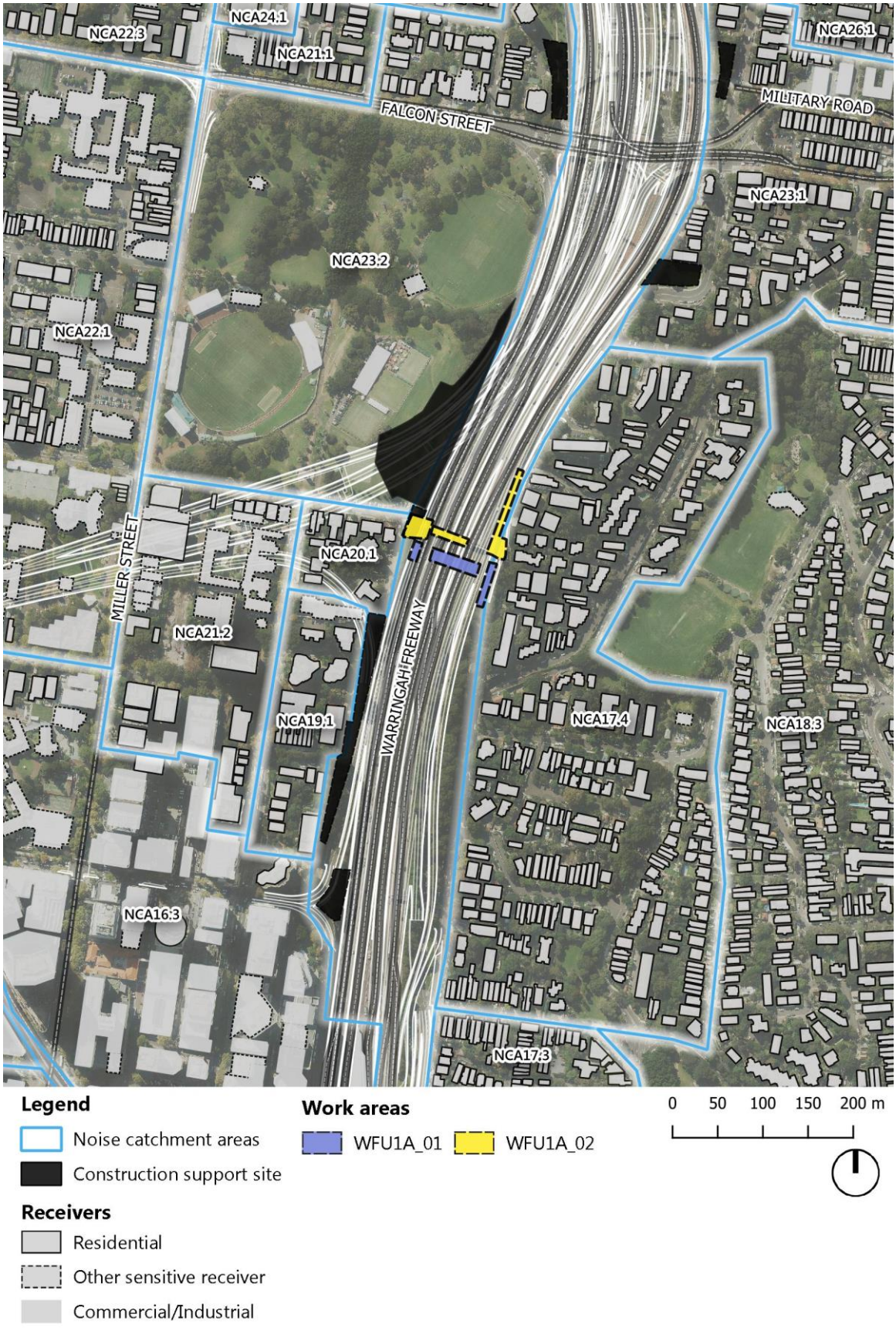
Construction support would generally be provided by minor construction support sites located at the eastern end of Ridge Street (supporting work at the western end of the bridge), at St Leonards Park, and at Merlin Street (supporting work on the eastern end of the bridge and Alfred Street North).

The approximate durations for the key construction activities within the major works area are outlined in Table 5-131. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-131 – Ridge Street shared user bridge (WFU1A) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1A_01	Construction of new Ridge Street shared user bridge	12 months
WFU1A_02	Demolition of Ridge Street shared user bridge	6 months

Figure 5-19 – Ridge Street shared user bridge (WFU1A) - assessment work areas



5.9.2.3.1 Construction hours and durations

Certain construction works would occur during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways. Specifically, bridge demolition work (WFU1A_02) would not occur during standard construction hours as the Warringah Freeway carriageways would need to be closed to work safely. Bridge construction work (WFU1A_01) would also have to take place outside of standard construction hours.

OOHW would only be required for a smaller portion of the overall allocated construction stage timeframes presented in the table above. The estimated period of required OOHW over the total construction timeframe, and justifications for the OOHW are presented in Table 5-132.

Table 5-132 – Required out of hours work – Ridge Street shared user bridge (WFU1A)

Works area reference	Required OOHW	Percentage of program days OOHW is required[1]	Justification
WFU1A_01	Bridge modification/construction within traffic corridor	30	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads
WFU1A_02	1. Bridge demolition over live traffic corridor 2. Delivery and installation of oversized plant/structures/bridge elements	20	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically address the OOHW noise impacts.

5.9.2.3.2 Construction assessment scenarios

The airborne noise assessment of the Ridge Street shared user bridge works was separated into two work areas. Each work area was assessed against, for works during both standard construction hours and OOHW.

Presented in Table 5-133 are the assessed activities for each works area, which represent the reasonable most noise-intensive activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant modelled are listed in Appendix F and represent the reasonable 'typical' and 'worst-case' equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3

for further explanation of assessment scenarios). Where plant items do not operate simultaneously or operate for less than a 15 minute period, noise impacts would be lower than predicted.

Table 5-133 – Assessed construction activities – Ridge Street shared user bridge (WFU1A)

Works area reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)[1]		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)[1]	
	Assessed activity	Typical	Worst-case	Assessed activity	Typical	Worst-case
WFU1A_01	Rock trimming	111	120	Demolition (rock hammering)	109	121
WFU1A_02	-	-	-	Demolition (rock hammering)	109	121

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.3.3 Construction noise prediction summary

Table 5-134, Table 5-135 and Table 5-137 present the predicted noise levels from construction activities and compare them with the NMLs for standard construction hours and outside standard hours. Table 5-136 and Table 5-138 present the indicative number of receiver buildings that exceed the NMLs in each NCA, and the number of receiver buildings that are potentially highly noise affected.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

During standard construction hours, predicted noise levels do not exceed NMLs, except for some receiver buildings in NCAs 17.4, 19.1, and 20.1 which are located either side of the Warringah Freeway adjacent to the works area:

- The highest predicted noise levels would occur in NCAs 17.4 and 20.1, when rock trimming or rock hammering is needed near Alfred Street north or the western end of the bridge. This includes rock hammering during bridge demolition
- Over the entire works stage, during typical activities impacts would exceed the NML by up to 8 dB(A) but are unlikely to result in receiver buildings to be highly noise affected (ie. >75 dB(A)) noise levels
- Over the entire works stage, during worst-case activities up to nine receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when works are in close proximity.

The key activity that has been assessed is demolition using a rock hammer which would be required as OOHW during both bridge demolition (WFU1A_02) and construction works (WFU1A_01):

- For all works areas that have been assessed considering the stage with the highest number of noise affected receiver buildings, during the night period, up to 55 receiver buildings are predicted to exceed NMLs during typical works. This is predicted to increase to 1700 receiver buildings during the worst-case activities
- For all works areas that have been assessed considering the stage with the highest number of noise affected receiver buildings, during typical activities with the highest predicted noise levels at night (WFU1A_02) up to four receiver buildings are predicted to exceed the NMLs by more than 25 dB(A) which could be considered highly intrusive. This is predicted to increase to 17 receiver buildings during the worst-case activities.

Non-residential receivers

During standard construction hours, construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Two childcare centres located in NCA 16.3, both of which are predicted to comply during typical works, however, they are predicted to exceed the NML by more than 6 dB(A) during the worst-case works
- One school which has buildings located in NCA 19.1 and 21.2, is predicted to exceed the NML by up to 5 dB(A) during typical works. This is predicted to increase by up to 14 dB(A) during the most noise-intensive works
- An exceedance of up to 6 dB(A) is predicted at a theatre receiver in NCA 21.2 during OOHW.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from night construction works would be from rock hammering during bridge demolition. Maximum noise levels have been predicted to the nearest affected residential receivers to allow the potential for sleep disturbance to be assessed, with results indicating the following:

- Predicted noise levels show exceedances of the sleep disturbance screening levels for both sets of works are required to operate during the night period
- During typical construction activities, air-brakes or metal-on-metal bangs of other equipment have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 19 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction level at up to 27 receiver buildings, mostly in NCAs 17.4 and 20.1
- During worst-case construction activities such as rock hammering, up to 356 receiver buildings exceed the L_{Amax} sleep disturbance screening level. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 54 receiver buildings.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the demolition works there are limited available noise source and noise path mitigation measures. Construction mitigation and management measures outlined in section 6.2 would be included, where feasible and reasonable, in a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, would be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.3.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-134 for residential receivers during standard construction hours
- Table 5-135 for residential receivers during works outside of standard construction hours
- Table 5-137 for non-residential receivers.

Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts that could occur during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2, and for all other non-residential receivers in section 3.4.1.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-136 and Table 5-138.

The highest 'typical' noise levels predicted for all stages of major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-134 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1A_01		WFU1A_02
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$		
		HNA	NML			
Wollstonecraft	22.2	75	62	36 / 37	45 / 46	Standard hours work not proposed
	30.4	75	68	< 35	43	
North Sydney - south west	15.3	75	52	36 / 37	45 / 46	
	16.3	75	70	50	59	
North Sydney - north west	19.1	75	62	57 / 59	66 / 68	
	20.1	75	62	62 / 68	71 / **77**	
	21.1	75	63	37	46 / 47	
	21.2	75	63	50 / 51	59 / 60	
	22.1	75	62	38	47	
	23.2	75	71	41 / 42	50 / 51	
North Sydney - east	17.3	75	65	47 / 48	56 / 57	
	18.2	75	64	42	51	
Neutral Bay	17.4	75	65	67 / 73	**76 / 82**	
	18.3	75	64	50 / 51	59 / 60	
	23.1	75	71	47	56	
Crows Nest	22.3	75	62	36	45	
	24.1	75	66	40	49	
Cammeray	28.1	75	57	< 35	43	
	30.3	75	68	< 35	42	
Cremorne	26.1	75	68	39 / 40	48 / 49	

Notes

1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-135 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference						WFU1A_01		WFU1A_02	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	Day (O)	Eve	Night				
Wollstonecraft	22.2	75	57	52	41	< 35	46	38	50 / 51
	30.4	75	63	61	43	< 35	44	35	47 / 48
North Sydney - south west	15.3	75	47	46	43	< 35	46	< 35	43
	16.3	75	65	65	55	47 / 48	60	45 / 46	57 / 58
North Sydney - north west	19.1	75	57	57	50	54 / 56	67 / 68	51 / 53	64 / 66
	20.1	75	57	57	50	59 / 65	72 / **78**	65 / 74	**77** / **87**
	21.1	75	58	54	46	34 / 35	47	37 / 38	50
	21.2	75	58	54	46	47 / 48	60 / 61	47 / 49	59 / 61
	22.1	75	57	52	41	35 / 36	48	41 / 42	54
	23.2	75	66	59	49	39 / 40	51 / 52	39 / 40	51 / 53
North Sydney - east	17.3	75	60	59	50	45	57 / 58	43 / 44	56
	18.2	75	59	57	48	39	52	39	51 / 52
Neutral Bay	17.4	75	60	59	50	64 / 71	**77** / **83**	66 / **79**	**78** / **91**
	18.3	75	59	57	48	47 / 48	60 / 61	47 / 48	59 / 60
	23.1	75	66	59	49	44 / 45	57	45 / 46	58 / 59
Crows Nest	22.3	75	57	52	41	< 35	46	36 / 37	49
	24.1	75	61	57	42	37 / 38	50	37 / 38	50
Cammeray	28.1	75	52	50	42	< 35	44	< 35	44 / 45
	30.3	75	63	61	43	< 35	43	< 35	44
Cremorne	26.1	75	63	59	46	37	49 / 50	36 / 37	49

Notes

1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-136 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1A_01	Typical	0	13	0	0	4	10	0	0	4	10	0	0	27	19	7	0	25	**19**
	Worst-case	**9**	31	1	0	47	31	13	0	111	33	14	0	892	364	28	13	324	**71**
WFU1A_02	Typical	-	-	-	-	7	10	5	0	6	11	6	0	24	17	10	4	19	**27**
	Worst-case	-	-	-	-	22	25	12	6	77	27	14	6	1232	429	22	17	356	**54**

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-137 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1A_01		WFU1A_02
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	
Receiver type	**NCA**	**NML[6]**	**Predicted noise levels, $L_{Aeq\ (15\ minutes)}$**		
Childcare	16.3	50	47	56	Standard hours work not proposed
	18.3	50	40 / 41	49 / 50	
Educational	23.2	50	38 / 39	48 / 49	
	18.3	55	41	50 / 51	
	19.1	55	58 / 60	68 / 69	
	21.2	55	50 / 52	59 / 61	
	22.1	55	36	45	
Other sensitive receiver	16.3	55	40 / 41	50	
	18.3	60	47 / 48	56 / 57	
	21.2	50	51 / 52	60 / 62	
	22.1	55	40 / 41	49 / 50	
	22.2	55	38	47	
Place of worship	22.1	55	39	48	
Recreational	17.4	60	44 / 51	53 / 60	
	18.3	60	51	60	
	23.2	60	49 / 50	58 / 59	

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg. rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-138 – Number of non-residential receivers over the noise management level

All NCAs	Assessment Reference	Typical/worst-case activity noise intensity	Commercial[2]			Childcare			Educational			Recreational[2]			Places of worship			Other sensitive receivers[2]		
			1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
Construction of new Ridge Street shared user bridge	WFU1A_01	Typical	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
		Worst-case	0	0	0	2	0	0		1	0	0	0	0	0	0	0	0	1	0
Demolition of Ridge Street shared user bridge	WFU1A_02[1]	Typical	-	-	-	-[1]	-[1]	-[1]	-[1]	-[1]	-[1]	-	-	-	-	-	-	-[1]	-[1]	-[1]
		Worst-case	-	-	-	-[1]	-[1]	-[1]	-[1]	-[1]	-[1]	-	-	-	-	-	-	-[1]	-[1]	-[1]

Notes:
1. Standard construction hours works not proposed, during which the childcare and educational receivers would not be in use. For the theatre receiver in NCA 21.2, noise impacts would be similar to WFU1A_01, and would be managed in a similar manner.
2. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
3. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
4. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
5. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.4 Berry Street entry on ramp works (WFU1B)

The Berry Street entry on ramp works are to be located at the Berry Street north construction support site (WHT8), directly adjacent to the Warringah Freeway at North Sydney, as shown in Figure 5-20. The location of the works area, and the surrounding noise-sensitive receivers is presented in Figure 5-20.

Key activities of the proposed construction works for the Berry Street on ramp works and Berry Street north construction support site (WHT8) include:

- Realignment and pavement works
- Building the trough and portal structure for southbound entry to the Western Harbour Tunnel.

Berry Street east (WFU5) and Berry Street north (WHT8) would be the main support sites for these construction works.

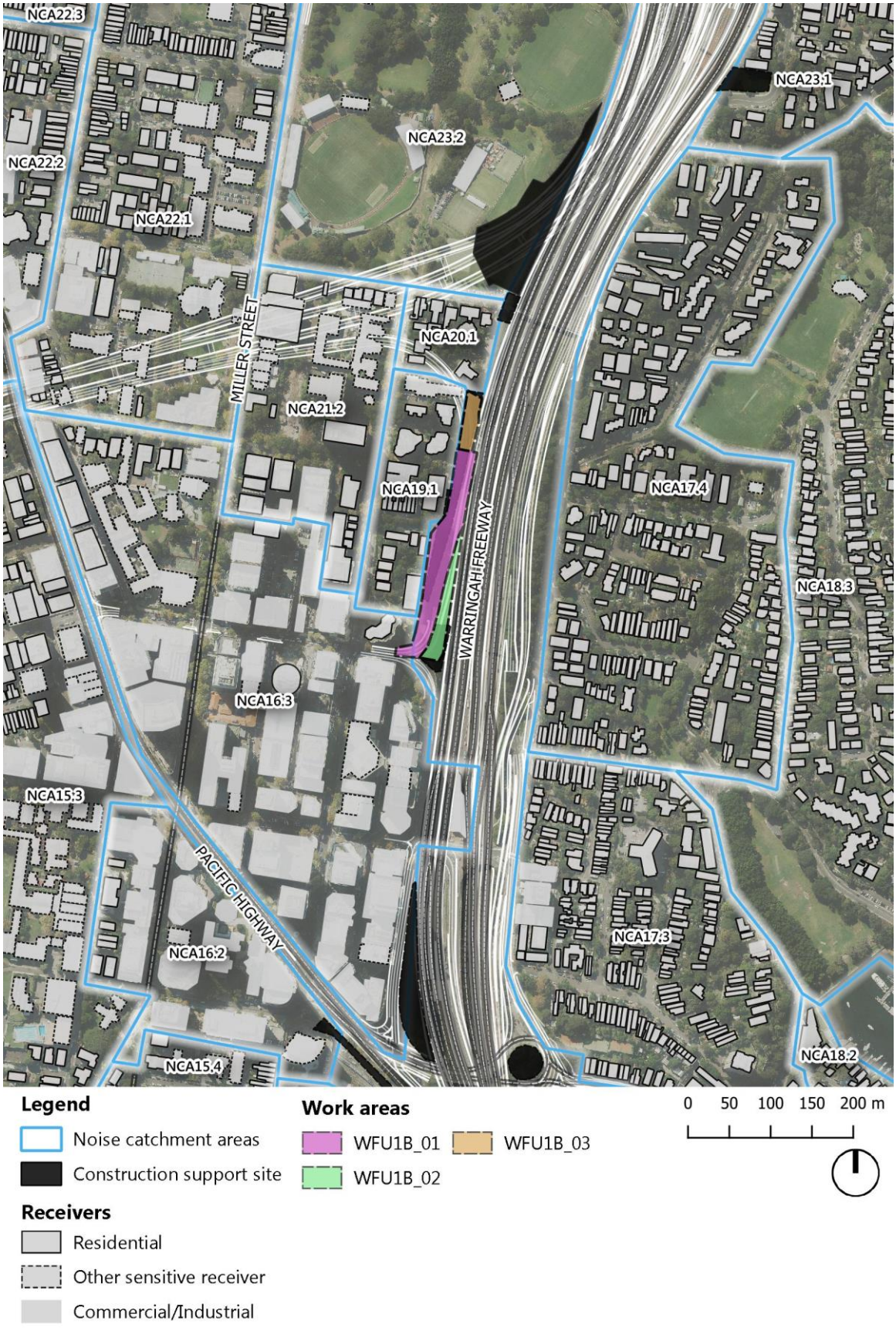
In addition to the above works, modification works at the intersection of Berry Street and the Pacific Highway are proposed. These works would include adjustment to signals, pavement works and road modifications of the Pacific Highway, line marking and median removal. As these works are minor, relatively short term, and would predominately occur during standard construction hours with a few periods of OOHW during road closures, refer to section 5.10.1 for indicative noise impacts from these activities.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-139. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-139 – Berry Street on ramp works (WFU1B) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1B_01	Ramp realignment and pavement works	6 months
WFU1B_02	Ramp realignment and pavement works	
WFU1B_03	Construction of Western Harbour Tunnel trough and portal structure	9 months

Figure 5-20 – Berry Street on ramp works (WFU1B) - assessment work areas



5.9.2.4.1 Construction hours and durations

As the major works areas are located off the Warringah Freeway, substantial portions of works would be carried out during standard construction hours. However, some of the proposed works would occur during night time road closures, as the works need to occupy part of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-140.

Table 5-140 – Required out of hours work – Berry Street on ramp works (WFU1B)

Works area reference	Required OOHW	Percentage of program days OOHW is required[1]	Justification
WFU1B_01	Road interface and ties ins, oversized item delivery and installation	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of portal elements, or road interface works. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU1B_02	Road interface and ties ins, oversized item delivery and installation	10	
WFU1B_03	Road interface and ties ins, oversized item delivery and installation	20	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically address expected OOHW noise impacts.

5.9.2.4.2 Construction assessment scenarios

The airborne noise assessment of the Berry Street on ramp works was separated into three works areas. Each work area was assessed against NMLs for work during both standard construction hours and OOHW.

Presented in Table 5-141 are the assessed activities for each works area, which represent the reasonable most intensive noise activities needed as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the activities being carried out.

Table 5-141 summarises the range of noise generating activities that are proposed for the works area. Details of the modelled construction plant items and corresponding sound power levels that make up these activities are presented in Appendix F.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for less than the 15 minute period, noise impacts could be lower than predicted.

Table 5-141 – Assessed construction activities – Berry Street on ramp works (WFU1B)

Assessment scenario reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)[1]		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A) [1]	
	Assessed activity	Typical	Worst-case	Assessed activity	Typical	Worst-case
WFU1B_01	Pavement/road modification works	110	120	Bulk earthwork	116	119
WFU1B_02	Demolition (rock hammering)	109	121	Demolition (rock hammering)	109	121
WFU1B_03	Utilities modification works	110	120	Demolition (rock hammering)	109	121

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.4.3 Construction noise prediction summary

Table 5-142, Table 5-143 and Table 5-145 present the predicted noise levels from construction activities and compare them with the NMLs for during the proposed works. Table 5-144 and Table 5-146 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receiver buildings that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels do not exceed the NMLs for standard construction hours, except for NCAs 15.3, 16.3, 17.4, 19.1, 20.1, and 21.2 which are located either side of the Warringah Freeway in North Sydney and Neutral Bay:

- The highest predicted noise levels occur for receiver buildings in NCA 16.3, 19.1 and 20.1 which are directly adjacent to the works area, when earthworks or rock hammering is required near receiver buildings

- Over the entire works stage, during typical activities these receiver buildings would not be highly noise affected except during earthworks, where four receiver buildings are predicted to remain highly noise affected. When worst-case activities occur, there is the potential for up to 18 different receiver buildings to be highly noise affected (ie. >75 dB(A)) when works are nearby
- Over the entire works stage, the highest noise levels during typical activities are predicted to exceed the NML by up to 20 dB(A) at the closest receiver buildings. However, during worst-case works, exceedances of the NML could increase to greater than 20 dB(A), which could be considered highly intrusive for up to six of the closest receiver buildings in NCA 19.1 and up to 36 other receiver buildings exceeding the NML.

During OOHW, the key activity that has been assessed is demolition using a rock hammer which would be required during both ramp construction (WFU1B_02) and portal construction (WFU1B_03):

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, up to 50 receiver buildings are predicted to exceed the night period NMLs during the typical construction activities. This is predicted to increase to 1324 receiver buildings during the worst-case construction activities
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during the typical construction activities the highest predicted noise levels at night (WFU1B_03) are predicted to exceed the NMLs by more than 25 dB(A) at up to three receiver buildings, which could be considered highly intrusive. During worst-case activities this number of receiver buildings is predicted to increase to 21.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Up to three childcare centre receiver buildings located in NCA 16.3 and 18.3. Two of these are predicted to exceed the screening NML by up to 7-10 dB(A) during typical works, which is predicted to increase to 18-20 dB(A) during the worst-case works
- Up to one school receiver, which has buildings located in both NCA 19.1 and 21.2, is predicted to exceed the NML by more than 20 dB(A) during both the typical and worst-case works, as the closest school building overlooks the major works area
- Up to 10 dB(A) exceedance at two hotels in NCA 21.2 during the worst-case works and during all stages, but compliance is predicted during typical works
- Up to 6 dB(A) exceedance during typical works at a recreational receiver on Walker Street, North Sydney, which is predicted to increase to 20 dB(A) during worst-case works.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from night time construction works would be from the use of rock hammers during road tie-ins or road excavation/trenching works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow potential sleep disturbance from OOHW to be assessed.

- The predicted noise levels show exceedances of the sleep disturbance screening levels for both sets of works during the night period
- During typical construction activities, air-brakes or metal-on-metal bangs of other equipment have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 11 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 35 receiver buildings mostly in NCA 19.1
- During worst-case construction activities such as rock hammering, up to 532 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 73 receiver buildings.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the excavation and earthworks construction stages there are limited effective noise source and noise path mitigation measures available.

While there is opportunity for permanent noise mitigation along the western boundary of the site; the effectiveness of any fixed mitigation on-site would be limited for the residential receiver buildings overlooking the site from multi-storey dwellings and therefore has not been included in the modelling.

During detailed design, the effectiveness of correct site planning and on-site mitigation measures would be reviewed. The construction mitigation and management measures outlined in section 6.2 would be incorporated, where feasible and reasonable, in a site-specific CNVIS to assist in reducing OOHW construction noise impacts.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.4.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-142 for residential receivers during standard construction hours
- Table 5-143 for residential receivers outside of standard construction hours
- Table 5-145 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2 and for all other non-residential receivers see section 3.4.1.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-144 and Table 5-146. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-142 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1B_01		WFU1B_02		WFU1B_03	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minute)}$					
		HNA	NML						
Wollstonecraft	22.2	75	62	35 / 39	45 / 49	32 / 35	44 / 48	32 / 37	42 / 47
Waverton	15.1	75	52	< 35	42 / 45	< 35	43 / 45	< 35	32 / 36
North Sydney - south west	15.3	75	52	39 / 44	50 / 54	37 / 42	49 / 54	< 35	39 / 44
	16.3	75	70	46 / 75	56 / **85**	65 / 68	**78** / **81**	49 / 69	60 / **80**
North Sydney - north west	19.1	75	62	46 / **81**	57 / **91**	60 / 74	73 / **86**	61 / **78**	71 / **89**
	20.1	75	62	52 / 63	62 / 73	51 / 61	64 / 74	49 / **77**	59 / **87**
	21.2	75	63	60 / 62	70 / 72	60	72	60 / 62	70 / 73
	22.1	75	62	32 / 39	42 / 49	31 / 37	44 / 50	32 / 40	42 / 50
	23.2	75	71	33 / 38	43 / 48	32 / 37	45 / 49	32 / 39	43 / 49
North Sydney - east	17.3	75	65	45 / 53	55 / 63	43 / 52	55 / 64	44 / 52	54 / 62
	18.2	75	64	40 / 43	50 / 53	37 / 41	50 / 53	39 / 43	50 / 53
Kirribilli	17.1	75	65	39 / 41	49 / 51	37 / 39	50 / 52	35 / 37	45 / 48
	17.2	75	65	41 / 44	51 / 54	38 / 42	51 / 54	39 / 42	50 / 53
	18.1	75	64	37 / 40	47 / 50	35 / 38	48 / 50	34 / 37	44 / 47
Neutral Bay	17.4	75	65	36 / 56	47 / 66	32 / 54	44 / 66	< 59	< 70
	18.3	75	64	44 / 49	54 / 59	42 / 47	54 / 60	43 / 49	53 / 59
	23.1	75	71	39 / 42	49 / 53	37 / 40	49 / 53	41 / 45	51 / 55
Crows Nest	22.3	75	62	< 35	41 / 43	< 35	40 / 43	< 35	40 / 43
	24.1	75	66	< 35	42 / 45	< 35	42 / 45	32 / 35	42 / 46
Cammeray	28.1	75	57	< 35	41 / 42	< 35	41 / 43	< 35	41 / 43
Cremorne	26.1	75	68	36 / 38	46 / 48	33 / 36	46 / 48	35 / 38	45 / 48

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-143 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference						WFU1B_01		WFU1B_02		WFU1B_03	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minute)}$					
		HNA	Day (O)	Eve	Ngt						
Wollstonecraft	22.2	75	57	52	41	41 / 45	44 / 48	31 / 35	44 / 48	30 / 35	43 / 48
Waverton	15.1	75	47	46	43	38 / 41	40 / 43	< 35	42 / 45	< 35	33 / 36
North Sydney - south west	15.3	75	47	46	43	46 / 51	48 / 53	37 / 42	49 / 54	< 35	40 / 45
	16.3	75	65	65	55	53 / **82**	55 / **84**	65 / 68	**78** / **81**	48 / 68	60 / **80**
North Sydney - north west	19.1	75	57	57	50	53 / **87**	56 / **90**	61 / 74	73 / **86**	60 / **77**	72 / **89**
	20.1	75	57	57	50	59 / 70	61 / 72	51 / 61	64 / 74	47 / 75	60 / **88**
	21.2	75	58	54	46	67 / 69	69 / 71	60	72	59 / 61	71 / 73
	22.1	75	57	52	41	38 / 45	41 / 48	31 / 37	44 / 50	30 / 38	43 / 51
	23.2	75	66	59	49	39 / 45	42 / 47	32 / 37	45 / 49	31 / 37	43 / 50
North Sydney - east	17.3	75	60	59	50	52 / 60	54 / 62	43 / 52	55 / 64	42 / 50	55 / 63
	18.2	75	59	57	48	47 / 50	49 / 52	38 / 41	50 / 53	38 / 41	51 / 54
Kirribilli	17.1	75	60	59	50	46 / 48	48 / 50	37 / 39	50 / 52	34 / 36	46 / 48
	17.2	75	60	59	50	48 / 51	50 / 53	39 / 42	51 / 54	38 / 41	50 / 53
	18.1	75	59	57	48	43 / 46	46 / 49	35 / 38	47 / 50	32 / 35	45 / 48
Neutral Bay	17.4	75	60	59	50	43 / 63	45 / 65	32 / 54	44 / 66	< 58	30 / 70
	18.3	75	59	57	48	51 / 56	53 / 58	42 / 47	55 / 60	41 / 47	54 / 60
	23.1	75	66	59	49	45 / 49	48 / 52	37 / 40	49 / 53	39 / 44	52 / 56
Crows Nest	22.3	75	57	52	41	37 / 40	39 / 42	< 35	40 / 43	< 35	41 / 44
	24.1	75	61	57	42	39 / 41	41 / 44	< 35	42 / 45	< 35	43 / 46
Cammeray	28.1	75	52	50	42	37 / 39	40 / 41	< 35	41 / 43	< 35	41 / 43
Cremorne	26.1	75	63	59	46	42 / 45	45 / 47	33 / 36	46 / 48	33 / 36	46 / 49

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-144 – Highest noise level envelope – Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1B_01	Typical	**4**	19	4	0	9	14	13	3	10	16	13	3	536	98	21	9	6	**30**
	Worst-case	**17**	13	19	4	16	12	17	4	21	13	21	4	590	379	16	16	21	**31**
WFU1B_02	Typical	0	15	1	0	12	15	1	0	13	16	1	0	7	25	7	0	6	**30**
	Worst-case	**16**	16	19	4	33	16	19	4	103	9	26	4	667	523	19	17	495	**63**
WFU1B_03	Typical	**5**	18	6	0	9	14	6	0	12	15	6	0	12	25	10	3	11	**35**
	Worst-case	**18**	18	18	6	30	21	18	6	113	15	25	6	717	563	23	21	532	**73**

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-145 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1B_01		WFU1B_02		WFU1B_03	
Typical/worst-case activity noise intensity			Typical	Worst-case	Typical	Worst-case	Typical	Worst-case
Location of noise-generating works within works area relative to receiver			Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$					
Childcare	16.3	50	31 / 60	41 / 70	55 / 58	67 / 70	37 / 57	47 / 68
	18.3	50	34 / 39	44 / 49	32 / 37	44 / 49	34 / 40	45 / 51
Commercial	16.3	70	44 / 73	54 / 83	67 / 70	79 / 82	44 / 64	54 / 74
Educational	19.1	55	< 63	39 / 73	48 / 61	60 / 74	65 / 83	76 / 93
	21.2	55	47 / 49	57 / 59	47	59	56 / 59	67 / 69
Other sensitive receivers	16.3	55	≤ 55	36 / 65	45 / 48	57 / 60	< 49	39 / 59
	21.2	70	57 / 59	67 / 69	57	69	57 / 59	67 / 69
Recreational	16.3	65	42 / 71	52 / 81	67 / 70	79 / 82	40 / 60	50 / 71

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128 further in section 4.2.3.3
5. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-146 – Number of non-residential receivers over the noise management level

All NCAs	Assessment Reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
			1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
Widen Berry St N/B on ramp to the west	**WFU1B_01**	Typical	1	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0
		Worst-case	5	1	0	0	2	0	0	1	0	0	1	0	0	0	0	1	0	0
Widen Berry St N/B on ramp to the east	**WFU1B_02**	Typical	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0
		Worst-case	5	1	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	0
Construction of the trough and portal structure for the southbound entry to the Western Harbour Tunnel	**WFU1B_03**	Typical	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Worst-case	4	0	0	1	2	0	0	0	1	1	0	0	0	0	0	1	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.5 Alfred Street north and Mount Street interchange modification and grade separation works (WFU1C)

The key activities of the proposed construction works include:

- Realignment of Alfred Street North between Merlin Street and Ridge Street shared user bridge
- Widening of the Warringah Freeway to the east
- Construction of a new Alfred Street north off ramp bridge
- Modifications to Mount Street interchange
- Construction of new Mount Street underpass.

During the works the Cammeray Golf Course construction support site would be used. However, there would also be a minor construction support site established within the works area for laydown, offices and toilets that would shift as the works progress.

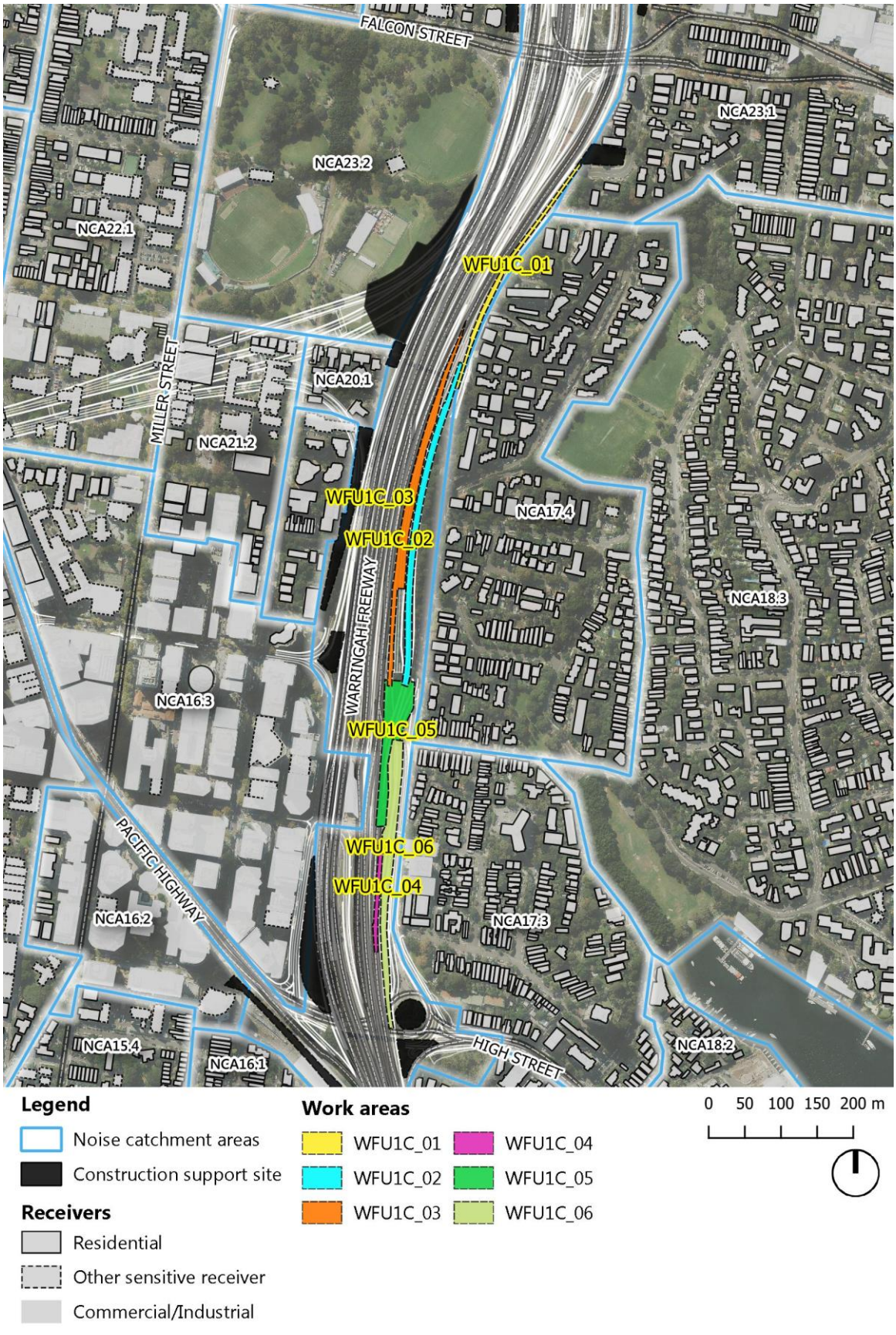
The location of the works area and the surrounding noise-sensitive receivers is presented in Figure 5-21.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-147. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-147 – Alfred Street North and Mount Street interchange modification and grade separation works (WFU1C) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1C_01	Realignment of Alfred Street north between Merlin Street and Ridge Street	9 months
WFU1C_02	Widening of the Warringah Freeway to the east	6 months
WFU1C_03	Widening of the Warringah Freeway to the east	
WFU1C_04	Modifications to Mount Street Interchange	24 months
WFU1C_05	New Alfred Street North off ramp bridge	9 months
WFU1C_06	New Mount Street underpass	9 months

Figure 5-21 – Alfred Street north and Mount Street interchange modification and grade separation works (WFU1C) - assessment work areas



5.9.2.5.1 Construction hours and durations

A portion of the proposed works would be carried out during night time road closures, as the works would require road occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-148.

Table 5-148 – Required out of hours work - Alfred Street north and Mount Street interchange modification and grade separation works (WFU1C)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU1C_01	1. Utilities modification 2. Pavement/road modification works, large item delivery and installation	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads
WFU1C_02		10	
WFU1C_03	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor	10	
WFU1C_04	Concrete pours	10	
WFU1C_05	Pavement/road modification works, large item delivery and installation	10	
WFU1C_06	Oversized item delivery and installation	10	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically approach the OOHW noise impacts.

5.9.2.5.2 Construction assessment scenarios

The airborne noise assessment of the Alfred Street North and Mount Street Interchange works was separated into six works areas. Each work area was assessed for works during both standard construction hours and OOHW.

Presented in Table 5-149 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period noise impacts could be lower than predicted.

Table 5-149 – Assessed construction activities - Alfred Street north and Mount Street interchange modification and grade separation works (WFU1C)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU1C_01	Utilities modification works	110	120	Utilities modification works	110	120
WFU1C_02	Pavement/road modification works	110	120	Pavement/road modification works	110	120
WFU1C_03	Pavement/road modification works	109	120	Concrete pours	110	114
WFU1C_04	Utilities modification works	110	120	Clearing and grubbing works	112	116
WFU1C_05	Paving/asphalting/road surface works (including concrete sawing)	109	120	Paving/asphalting/road surface works (including concrete sawing)	109	120
WFU1C_06	Paving/asphalting/road surface works (including concrete sawing)	109	120	Clearing and grubbing works	112	116

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.5.3 Construction noise prediction summary

Table 5-150, Table 5-151 and Table 5-153 present the predicted noise levels from construction activities and compares them to the established NMLs. Table 5-152 and Table 5-154 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receiver buildings that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels generally comply with the NMLs for standard construction hours, except for NCAs 15.4, 17.3, 17.3, 17.4, 19.1, 20.1, 21.2 and 23.1, which are located either side of the Warringah Freeway in North Sydney and Neutral Bay. Results of the noise predictions for standard construction hours works are as follows:

- The highest predicted noise levels vary for each works area due to the lengths of the areas and their extent along various sections of the eastern side of the Warringah Freeway. Receiver buildings in NCA 17.4 and 17.3, which are directly adjacent to the works areas, exceed the NMLs when earthworks or the use of rock hammers are required in close proximity to the receiver buildings directly to the west of the major works area
- Over the entire works stage, during typical activities no receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when the construction works are in close proximity to the nearest affected receiver buildings, except during utilities modification works, where five receiver buildings are predicted to remain highly noise affected. When worst-case activities occur, there is the potential for up to 26 different receiver buildings to be highly noise affected
- Across all the works areas, the highest noise level during typical construction activities is predicted to exceed the NML by up to 10 dB(A), which could be considered clearly audible, except for five receiver buildings in NCA 17.4 during WFU1C_01, where construction noise levels are predicted to be 11-20 dB(A) above the NML, which could be considered moderately intrusive
- Across all the works areas, during worst-case construction activities noise levels are predicted to be greater than 20 dB(A) above the NML for up to five of the closest receiver buildings in NCA 17.4 during WFU1C_01, and one receiver building in WFU1C_06, which could be considered highly intrusive. Generally worst-case construction activities in other works area are predicted to exceed the NML by up to 11-20 dB(A). These exceedances are predicted for up to 26 of the closest receiver buildings, while up to 120 other receiver buildings are predicted to exceed the NMLs by up to 10 dB(A). The highest number is during pavement and road modification works in WFU1C_03.

During OOHW, the key activities that have been assessed are utilities modification, pavement and road modification works or clearing and grubbing. Results of the assessment of OOHW noise impacts are as follows:

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical night period construction works, up to 315 receiver buildings are predicted to exceed the NMLs. During the worst-case construction works stage, up to 2569 receiver buildings are predicted to exceed the night NMLs. The highest number is predicted during WFU1C_01 when a rock hammer or road saws are being used
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical night period construction works, up to five receiver buildings are predicted to exceed the NML by more than 25 dB(A) which would be considered highly intrusive. During worst-case construction works this number is predicted to increase to 26 receiver buildings.

Non-residential receivers

Construction noise levels at non-residential receiver buildings are generally predicted to meet the NMLs, except for the following key receivers:

- Up to eight childcare centre receivers located in NCA 16.2, 16.3,18.3, 22.3, and 23.2. Of these, two are predicted to exceed the NMLs by up to 5-9 dB(A) during typical works, which are predicted to increase to 15-20 dB(A) during the worst-case works
- Up to two school receivers, where one has buildings located in NCA 19.1 and 21.2 and could exceed the NML by up to 15 dB(A) during the worst-case works; the second school receiver is in NCA 15.3 and has a marginal exceedance of 1 dB(A)
- An exceedance of up to 7 dB(A) is predicted at a theatre receiver in NCA 21.2, and up to 13 dB(A) at a library in NCA 16.3
- A marginal exceedance of up to 2 dB(A) at a place of worship in NCA 16.1
- Up to 4 dB(A) exceedance at a recreational receiver in NCA 17.3
- Up to 11 dB(A) exceedance at six commercial buildings in NCA 16.3 and 17.3 for WFU1C_04, WFU1C_05 and WFU1C_06 works.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night construction works would be from the use of rock hammer/s during road tie-ins or road excavation/trenching works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow for an assessment of the potential for sleep disturbance from OOHW. Results of the predictions are:

- The predicted noise levels show exceedances of the sleep disturbance screening levels during typical and worst-case activities
- During typical construction activities, air-brakes or metal-on-metal bangs of other equipment have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 108 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 68 receiver buildings during the stage with the highest number of exceedances mostly in NCA 17.3 and 17.4
- During worst-case construction activities such as rock hammering, up to 878 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening levels. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 111 receiver buildings.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the road works requiring utilities relocation, clearing and grubbing and road construction works adjacent to and within live traffic corridors under an ROL, there are limited available noise source and noise path mitigation measures available during OOHW.

Careful use of close-proximity temporary noise barriers along the eastern boundary could provide some noise reduction to close receivers; however, for receivers further away, any fixed mitigation on-site would be very limited and so have not been included in the modelling. The effectiveness of programming of noise-intensive activities, along with correct site planning and any potential temporary mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.5.4 Construction noise prediction tables

The predicted noise levels for residential receiver buildings are presented in the following tables:

- Table 5-150 for residential receiver buildings during standard construction hours
- Table 5-151 for residential receiver buildings during works outside of standard construction hours
- Table 5-153 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2, and for all other non-residential receivers see section 3.4.1.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-152 and Table 5-154. Predicted noise levels are intended to be conservative and

represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-150 – Predicted construction noise levels – standard hours (residential receivers)

Major works area/assessment reference				WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	NML												
Wollstonecraft	22.2	75	62	37 / 40	47 / 51	32 / 38	42 / 48	31 / 38	41 / 49	< 35	36 / 38	< 35	38 / 40	< 35	37 / 41
	30.4	75	68	36 / 39	46 / 49	31 / 35	42 / 46	31 / 36	42 / 46	< 35	< 35	< 35	35 / 36	< 35	< 35
Waverton	15.1	75	52	33 / 35	43 / 46	< 35	35 / 40	< 35	37 / 42	< 35	42 / 44	< 35	36 / 38	< 35	40 / 45
McMahons Point	15.2	75	52	< 35	36 / 38	< 35	33 / 37	< 35	31 / 35	35 / 37	46 / 48	< 35	< 35	33 / 39	44 / 50
Lavender Bay	15.4	75	52	< 35	39 / 41	< 35	36 / 42	< 35	35 / 41	43 / 47	53 / 58	32 / 36	44 / 47	38 / 49	49 / 60
Milsons Point	16.1	75	70	36 / 38	46 / 49	35 / 40	45 / 50	36 / 42	47 / 52	45 / 50	56 / 61	42 / 46	53 / 57	38 / 51	49 / 62
North Sydney - south west	15.3	75	52	34 / 38	45 / 48	≤ 36	39 / 46	32 / 40	42 / 50	37 / 40	48 / 51	33 / 37	44 / 48	31 / 39	42 / 50
	16.3	75	70	42 / 47	52 / 58	≤ 55	36 / 65	58	69	39 / 50	49 / 61	55 / 57	66 / 68	45 / 54	57 / 65
North Sydney - north west	19.1	75	62	45 / 54	55 / 64	50 / 58	60 / 68	52 / 63	63 / 73	45 / 48	56 / 59	47 / 56	59 / 67	42 / 52	53 / 63
	20.1	75	62	44 / 60	54 / 70	58 / 61	68 / 71	55 / 62	66 / 73	42 / 44	53 / 55	45 / 49	56 / 60	41 / 47	52 / 58
	21.1	75	63	37 / 43	47 / 53	33 / 39	44 / 49	33 / 39	43 / 49	< 35	41 / 42	< 35	41 / 42	< 35	39 / 42
	21.2	75	63	39 / 49	49 / 59	46 / 52	56 / 62	53 / 56	64 / 66	41 / 43	51 / 54	45 / 51	56 / 62	35 / 44	47 / 55
	22.1	75	62	37 / 43	48 / 54	31 / 41	41 / 51	≤ 41	39 / 52	< 35	43 / 45	< 35	42 / 45	< 35	41 / 46
	23.2	75	71	34 / 51	45 / 62	32 / 42	42 / 52	32 / 46	43 / 56	33 / 35	44 / 45	32 / 35	44 / 46	31 / 35	42 / 46
North Sydney - east	17.3	75	65	42 / 46	52 / 56	44 / 60	55 / 70	43 / 59	54 / 70	61 / 69	72 / **79**	59 / 70	70 / **81**	46 / 75	57 / **86**
	18.2	75	64	38 / 40	48 / 51	38 / 43	48 / 54	37 / 43	48 / 54	33 / 36	43 / 46	37 / 40	48 / 52	34 / 44	46 / 55
Kirribilli	17.2	75	65	36 / 39	46 / 49	34 / 40	45 / 50	35 / 41	46 / 52	46 / 51	57 / 62	40 / 44	51 / 55	43 / 57	55 / 68
	18.1	75	64	33 / 36	44 / 46	31 / 36	42 / 46	32 / 37	42 / 47	37 / 40	48 / 51	< 35	43 / 46	34 / 42	46 / 53
Neutral Bay	17.4	75	65	50 / **83**	60 / **93**	47 / 72	57 / **82**	54 / 71	64 / **81**	46 / 51	56 / 61	51 / 73	63 / **84**	70 / 71	**81** / **82**
	18.3	75	64	41 / 52	52 / 63	36 / 51	47 / 61	34 / 51	44 / 61	42 / 46	53 / 56	45 / 50	56 / 61	39 / 49	50 / 61
	23.1	75	71	40 / 70	51 / **80**	36 / 44	46 / 55	36 / 46	46 / 56	38 / 40	49 / 50	39 / 41	50 / 53	37 / 41	48 / 52
Crows Nest	22.3	75	62	37 / 42	48 / 53	32 / 37	43 / 47	32 / 38	43 / 48	< 35	41 / 42	< 35	41 / 43	< 35	40 / 43
	24.1	75	66	39 / 45	49 / 55	35 / 40	45 / 50	35 / 41	45 / 51	< 35	41 / 42	< 35	44 / 45	< 35	42 / 44
	30.1	75	68	32 / 35	43 / 45	< 35	36 / 39	< 35	38 / 42	< 35	35 / 36	< 35	35 / 36	< 35	35 / 37

Major works area/assessment reference				WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	NML												
Cammeray	25.1	75	68	36 / 40	47 / 51	33 / 37	44 / 48	32 / 37	42 / 47	< 35	41 / 42	< 35	41 / 42	< 35	40 / 42
	28.1	75	57	37 / 40	48 / 51	< 35	40 / 43	< 35	40 / 44	< 35	38 / 39	< 35	39 / 40	< 35	38 / 40
	30.3	75	68	35 / 37	45 / 48	< 35	40 / 43	< 35	40 / 43	< 35	38	< 35	39 / 40	< 35	37 / 39
	31.2	75	66	< 35	43 / 45	< 35	38 / 41	< 35	38 / 41	< 35	< 35	< 35	37 / 38	< 35	36 / 37
Cremorne	26.1	75	68	40 / 46	51 / 56	33 / 38	44 / 48	34 / 39	44 / 49	< 35	42 / 43	< 35	44 / 45	< 35	42 / 44
	27.1	75	59	32 / 35	43 / 46	< 35	36 / 39	< 35	38 / 41	< 35	37 / 38	< 35	37 / 38	< 35	36 / 38

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in Section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-151 – Predicted construction noise levels – outside standard hours (residential receivers)

Major works area/assessment reference						WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day (O)	Eve	Ngt												
Wollstonecraft	22.2	75	57	52	41	37 / 40	47 / 51	32 / 38	42 / 48	31 / 38	35 / 42	< 35	< 35	< 35	38 / 40	< 35	33 / 37
	30.4	75	63	61	43	36 / 39	46 / 49	31 / 35	42 / 46	32 / 36	35 / 40	< 35	< 35	< 35	35 / 36	< 35	< 35
Waverton	15.1	75	47	46	43	33 / 35	43 / 46	< 35	35 / 40	< 35	30 / 35	34 / 35	38 / 40	< 35	36 / 38	32 / 36	36 / 40
McMahons Point	15.2	75	47	46	43	< 35	36 / 38	< 35	33 / 37	< 35	< 35	37 / 39	41 / 43	< 35	< 35	36 / 41	40 / 46
Lavender Bay	15.4	75	47	46	43	< 35	39 / 41	< 35	36 / 42	< 35	< 35	44 / 49	49 / 53	32 / 36	44 / 47	40 / 51	45 / 56
Milsons Point	16.1	75	65	65	55	36 / 38	46 / 49	35 / 40	45 / 50	36 / 42	40 / 46	47 / 52	51 / 56	42 / 46	53 / 57	40 / 53	45 / 58
North Sydney - south west	15.3	75	47	46	43	34 / 38	45 / 48	≤ 36	39 / 46	32 / 40	36 / 44	39 / 42	44 / 46	33 / 37	44 / 48	33 / 42	38 / 46
	16.3	75	65	65	55	42 / 47	52 / 58	≤ 55	36 / 65	58 / 59	62	40 / 52	45 / 56	55 / 57	66 / 68	48 / 56	53 / 61
North Sydney - north west	19.1	75	57	57	50	45 / 54	55 / 64	50 / 58	60 / 68	52 / 63	56 / 67	47 / 50	51 / 55	47 / 56	59 / 67	44 / 55	49 / 59
	20.1	75	57	57	50	44 / 60	54 / 70	58 / 61	68 / 71	55 / 62	59 / 66	44 / 46	49 / 50	45 / 49	56 / 60	43 / 49	48 / 54
	21.1	75	58	54	46	37 / 43	47 / 53	33 / 39	44 / 49	33 / 39	36 / 43	< 35	37 / 38	< 35	41 / 42	< 35	35 / 38
	21.2	75	58	54	46	39 / 49	49 / 59	46 / 52	56 / 62	53 / 56	57 / 60	42 / 45	47 / 50	45 / 51	56 / 62	38 / 46	42 / 51
	22.1	75	57	52	41	37 / 43	48 / 54	31 / 41	41 / 51	≤ 42	33 / 45	34 / 36	39 / 40	< 35	42 / 45	32 / 37	36 / 42
	23.2	75	66	59	49	34 / 51	45 / 62	32 / 42	42 / 52	32 / 46	36 / 50	35 / 36	40 / 41	32 / 35	44 / 46	33 / 37	38 / 42
North Sydney - east	17.3	75	60	59	50	42 / 46	52 / 56	44 / 60	55 / 70	43 / 60	47 / 63	63 / 71	67 / 75	59 / 70	70 / **81**	48 / **77**	53 / **82**
	18.2	75	59	57	48	38 / 40	48 / 51	38 / 43	48 / 54	37 / 43	41 / 47	34 / 37	39 / 42	37 / 40	48 / 52	37 / 46	42 / 51
Kirribilli	17.2	75	60	59	50	36 / 39	46 / 49	34 / 40	45 / 50	36 / 41	39 / 45	48 / 53	52 / 57	40 / 44	51 / 55	46 / 59	51 / 64
	18.1	75	59	57	48	33 / 36	44 / 46	31 / 36	42 / 46	32 / 37	36 / 41	39 / 42	44 / 46	< 35	43 / 46	37 / 44	42 / 49
Neutral Bay	17.4	75	60	59	50	50 / **83**	60 / **93**	47 / 72	57 / **82**	54 / 71	58 / 75	47 / 53	52 / 57	51 / 73	63 / **84**	72 / 73	**77** / **78**
	18.3	75	59	57	48	41 / 52	52 / 63	36 / 51	47 / 61	34 / 51	37 / 55	44 / 47	49 / 52	45 / 50	56 / 61	42 / 52	46 / 57
	23.1	75	66	59	49	40 / 70	51 / **80**	36 / 44	46 / 55	36 / 46	40 / 50	40 / 41	44 / 46	39 / 41	50 / 53	39 / 43	44 / 48
Crows Nest	22.3	75	57	52	41	37 / 42	48 / 53	32 / 37	43 / 47	32 / 38	36 / 42	< 35	37 / 38	< 35	41 / 43	< 35	36 / 39
	24.1	75	61	57	42	39 / 45	49 / 55	35 / 40	45 / 50	35 / 41	39 / 44	< 35	37 / 38	< 35	44 / 45	33 / 36	37 / 40
	30.1	75	63	61	43	32 / 35	43 / 45	< 35	36 / 39	< 35	32 / 35	< 35	< 35	< 35	35 / 36	< 35	< 35

Major works area/assessment reference						WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day (O)	Eve	Ngt												
Cammeray	25.1	75	63	60	48	36 / 40	47 / 51	33 / 37	44 / 48	32 / 37	36 / 41	< 35	37	< 35	41 / 42	< 35	36 / 38
	28.1	75	52	50	42	37 / 40	48 / 51	< 35	40 / 43	< 35	34 / 38	< 35	34 / 35	< 35	39 / 40	< 35	34 / 36
	30.3	75	63	61	43	35 / 37	45 / 48	< 35	40 / 43	< 35	34 / 37	< 35	< 35	< 35	39 / 40	< 35	33 / 35
	31.2	75	61	54	42	< 35	43 / 45	< 35	38 / 41	< 35	32 / 35	< 35	< 35	< 35	37 / 38	< 35	< 35
Cremorne	26.1	75	63	59	46	40 / 46	51 / 56	33 / 38	44 / 48	34 / 39	38 / 43	< 35	38	< 35	44 / 45	33 / 36	38 / 40
	27.1	75	54	53	44	32 / 35	43 / 46	< 35	36 / 39	< 35	31 / 35	< 35	< 35	< 35	37 / 38	< 35	< 35

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-152 – Highest noise level envelope – Number of residential buildings over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1C_01	Typical	5	14	5	0	12	14	5	0	17	18	5	0	86	38	17	5	29	42
	Worst-case	22	32	14	5	43	32	14	5	144	47	17	6	1625	884	38	22	878	95
WFU1C_02	Typical	0	25	0	0	34	25	0	0	35	29	0	0	183	87	25	0	84	68
	Worst-case	26	97	26	0	159	97	26	0	263	109	32	0	755	534	91	26	184	111
WFU1C_03	Typical	0	7	0	0	45	7	0	0	49	16	0	0	195	114	6	0	108	66
	Worst-case	7	120	9	0	64	41	0	0	72	48	1	0	362	206	33	0	195	115
WFU1C_04	Typical	0	2	0	0	9	3	0	0	11	5	0	0	38	17	3	0	14	9
	Worst-case	2	24	2	0	19	12	0	0	24	14	1	0	252	44	8	0	29	15
WFU1C_05	Typical	0	16	0	0	15	16	0	0	19	16	0	0	76	47	16	0	52	46
	Worst-case	18	61	18	0	110	61	18	0	181	68	23	0	551	457	61	18	104	73
WFU1C_06	Typical	0	18	0	0	35	26	1	0	44	29	2	0	153	91	26	1	68	58
	Worst-case	23	95	22	1	70	47	14	0	76	59	14	0	495	212	38	14	103	95

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-153 – Predicted construction noise levels – standard hours (non-residential receivers)

Major works area/assessment reference			WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
Commercial	16.3	70	42 / 47	52 / 57	≤ 51	32 / 61	58 / 59	69	53 / 64	63 / 74	68 / 70	80 / 81	58 / 67	70 / 78
	17.3	70	38 / 42	48 / 53	37 / 52	47 / 63	36 / 52	46 / 63	63 / 71	73 / 81	55 / 66	67 / 78	47 / 76	58 / 87
Childcare	16.2	50	< 35	40 / 43	< 35	36 / 43	< 35	35 / 43	36 / 41	47 / 52	< 35	34 / 39	≤ 39	36 / 50
	16.3	50	40 / 45	50 / 55	≤ 55	36 / 65	57 / 58	68	46 / 57	56 / 67	57 / 59	68 / 70	49 / 58	60 / 69
	18.3	50	≤ 40	39 / 50	≤ 40	36 / 50	≤ 40	33 / 50	< 35	40 / 44	30 / 35	41 / 47	< 35	34 / 44
	22.3	50	35 / 40	45 / 50	< 35	36 / 40	< 35	36 / 42	< 35	35 / 36	< 35	34 / 36	< 35	34 / 37
	23.2	50	≤ 45	38 / 55	≤ 39	39 / 49	≤ 41	38 / 51	< 35	43 / 44	< 35	41 / 44	< 35	40 / 45
Educational	15.3	55	< 35	37 / 41	< 35	33 / 40	< 35	35 / 43	40 / 43	50 / 53	38 / 42	50 / 54	37 / 45	48 / 56
	18.3	55	32 / 44	43 / 54	≤ 41	36 / 51	≤ 40	34 / 51	< 35	41 / 44	30 / 35	41 / 46	< 35	35 / 45
	19.1	55	45 / 54	55 / 65	50 / 58	60 / 68	50 / 60	60 / 70	40 / 43	50 / 53	39 / 47	50 / 58	34 / 45	46 / 56
	21.2	55	39 / 49	50 / 59	45 / 51	56 / 62	50 / 52	60 / 63	39 / 42	49 / 52	37 / 43	48 / 54	33 / 41	44 / 53
	22.1	55	37 / 43	48 / 54	≤ 39	39 / 49	≤ 39	37 / 50	< 35	37 / 39	< 35	39 / 42	< 35	37 / 43
	22.2	55	36 / 40	46 / 50	< 35	39 / 45	< 35	37 / 44	< 35	< 35	< 35	< 35	< 35	< 35
	22.3	55	36 / 41	46 / 51	31 / 36	41 / 46	33 / 39	44 / 49	< 35	41 / 42	< 35	39 / 41	< 35	39 / 42
	25.1	55	36 / 40	46 / 50	31 / 35	41 / 45	31 / 35	41 / 45	< 35	38 / 39	< 35	40 / 41	< 35	39 / 41
Other sensitive receiver[6]	16.3	55	36 / 41	46 / 51	≤ 46	≤ 56	48	58	47 / 59	58 / 69	54 / 56	65 / 67	49 / 58	61 / 69
	18.3	60	36 / 48	47 / 58	32 / 47	42 / 57	≤ 47	40 / 57	35 / 38	45 / 48	38 / 43	49 / 54	31 / 41	42 / 53
	21.2	50	37 / 46	47 / 57	34 / 40	44 / 50	41 / 44	52 / 54	< 35	32 / 35	< 35	36 / 42	< 35	28 / 37
	22.1	55	38 / 44	48 / 54	30 / 40	40 / 50	≤ 42	40 / 52	< 35	36 / 38	34 / 37	45 / 48	30 / 36	42 / 47
	22.2	55	37 / 41	48 / 52	32 / 38	42 / 48	31 / 38	41 / 49	< 35	< 35	< 35	34 / 36	< 35	33 / 37
Place of worship	16.1	55	< 35	42 / 44	33 / 38	43 / 48	34 / 40	44 / 50	40 / 45	50 / 55	37 / 41	48 / 52	33 / 46	44 / 57
	21.1	55	35 / 41	45 / 51	30 / 35	40 / 46	31 / 37	41 / 47	< 35	41 / 42	< 35	40 / 41	< 35	39 / 42
	22.1	55	38 / 44	49 / 55	31 / 41	41 / 51	29 / 41	39 / 51	< 35	36 / 37	< 35	42 / 45	< 35	33 / 38

Major works area/assessment reference			WFU1C_01		WFU1C_02		WFU1C_03		WFU1C_04		WFU1C_05		WFU1C_06	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
Recreational	17.3	60	< 35	39 / 43	< 35	≤ 44	< 35	≤ 45	44 / 52	54 / 62	< 35	35 / 47	≤ 58	40 / 69
	17.4	60	≤ 47	≤ 58	≤ 50	35 / 60	32 / 50	42 / 60	37 / 43	48 / 53	≤ 46	35 / 57	43 / 44	54 / 55
	18.3	60	35 / 46	45 / 57	37 / 52	47 / 62	34 / 51	44 / 61	38 / 41	48 / 51	37 / 43	49 / 54	32 / 42	43 / 54
	23.2	60	39 / 56	50 / 66	40 / 50	50 / 60	38 / 52	48 / 62	34 / 36	45 / 46	35 / 38	47 / 49	32 / 37	44 / 48

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML. The predicted noise levels are for the OSR with the highest predicted noise level.

Table 5-154 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU1C_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	3	0	0	1	0	0	2	0	0	0	0	0	1	0	0
WFU1C_02	Typical	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	2	0	0
WFU1C_03	Typical	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	2	0	0	1	0	2	0	0	0	0	0	2	0	0
WFU1C_04	Typical	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Worst-case	2	0	0	1	2	0	0	0	0	1	0	0	0	0	0	0	1	0
WFU1C_05	Typical	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Worst-case	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0
WFU1C_06	Typical	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Worst-case	1	0	0	0	2	0	2	0	0	2	0	0	1	0	0	0	1	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.6 Warringah Freeway northbound widening (WFU1D)

The key activities of the proposed construction works include construction of a new northbound lane on the Warringah Freeway.

During the construction works, the Blue Street (WFU1) and Arthur Street east (WFU4) would be the key minor construction support site for these construction works.

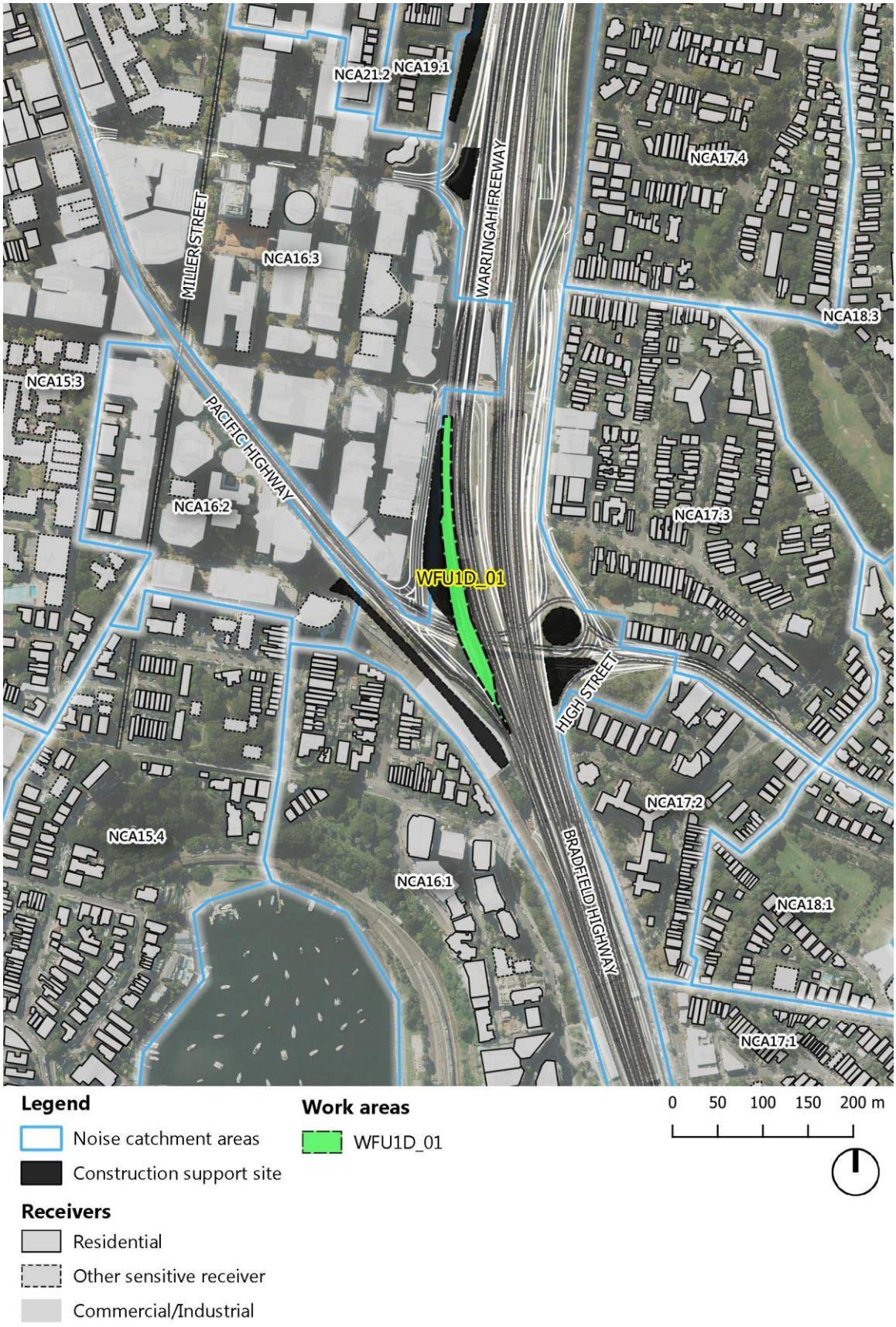
The location of the works area and the surrounding noise-sensitive receivers is presented in Figure 5-22.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-155. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-155 – Warringah Freeway northbound widening (WFU1D) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1D_01	New northbound lane on Warringah Freeway	6 months

Figure 5-22 – Warringah Freeway northbound widening (WFU1D) - assessment work areas



5.9.2.6.1 Construction hours and durations

A portion of the proposed works would be carried out during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways.

Out of hours works (OOHW) would only be required for a smaller portion of the overall allocated construction stage timeframes presented in the table above. The estimated period of required OOHW over the total construction timeframe and justifications for the OOHW are presented in Table 5-156.

Table 5-156 – Required out of hours work – Warringah Freeway northbound widening (WFU1D)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU1D_01	Resurfacing works	10	ROL required, impact on road network performance, safety for workers and road users within carriageway

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically approach the OOHW noise impacts.

5.9.2.6.2 Construction assessment scenarios

The airborne noise assessment of the Warringah Freeway northbound widening works was modelled as a single works area and assessed for works during both standard construction hours and OOHW.

Presented in Table 5-157 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-157 – Assessed construction activities – Warringah Freeway northbound widening (WFU1D)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU1D_01	Utilities modification works	110	120	Resurfacing works	108	117

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.6.3 Construction noise prediction summary

Table 5-158, Table 5-159 and Table 5-161 present the predicted noise levels from construction activities and compares them with the NMLs. Table 5-160 and Table 5-162 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels do not exceed the NMLs during standard construction hours, except for some receiver buildings in NCAs 15.3, 15.4, 17.2 and 17.3, which are located either side of the Warringah Freeway in North Sydney and Neutral Bay. Results of the predicted construction Nosie levels are as follows:

- The highest predicted noise levels occur for receiver buildings in NCA 17.1, 17.2 and 17.3 to the east of the works. However, the highest exceedances are in NCA 15.4, which are west of the works area, when rock hammers or road saws are required as part of utility modification works
- During both typical and worst-case activities no receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)). The highest predicted noise level during worst-case activities is 75 dB(A)
- During standard construction hours, the highest noise impacts are predicted to be moderately intrusive (up to 12 dB(A) exceedance) for four receiver buildings in NCA 15.4 and up to 46 other receiver buildings exceed the NMLs.

During OOHW, the key activity that has been assessed is road resurfacing works, which would require the use of pavement profilers and pavement laying machines, and results are as follows:

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, up to 67 receiver buildings are predicted to exceed the NMLs

during typical construction activities. During worst-case construction activities, this number of receiver buildings is predicted to increase to 511

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, in the worst-case, up to 11 receiver buildings are predicted to exceed the NML by 16-18 dB(A), which would be considered moderately intrusive.

Non-residential receivers

Directly west of the works area is the North Sydney CBD which covers primarily NCA 16.2 and 16.3. Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Up to three childcare centre receivers located in NCA 16.3 and 17.1. Two of the receivers in NCA 16.3 are predicted to exceed the screening NML by up to 4-8 dB(A) during typical works, which are predicted to increase to 14-19 dB(A) during the worst-case activities. However, as these childcare centres are located within existing commercial buildings, the noise impacts would be sufficiently managed by the construction of the building's external facade
- Up 10 dB(A) exceedance at one hotel and library in NCA 16.3 and one theatre in NCA 18.1. At the hotel receiver the predicted noise levels achieves the NML during typical daytime works, but can exceed the night NML by up to 8 dB(A). During worst-case construction activities, these exceedances are predicted to increase to 10 dB(A) during the daytime and up to 17 dB(A) during the night time
- An exceedance of up to 3 dB(A) at two places of worship in NCA 15.4 and 16.1
- A marginal exceedance of 1 dB(A) at a recreational receiver in NCA 17.3
- Up to 12 dB(A) exceedance at 10 commercial buildings in NCA 16.3.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night time construction works would be from air-brakes or metal-on-metal bangs during road tie-in and resurfacing works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow potential sleep disturbance from OOHW to be assessed. Results indicate the following:

- The predicted noise levels show exceedances of the sleep disturbance screening levels for the works
- During typical works, operations such as using air-brakes have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 47 residential receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to six residential receiver buildings across the works area

- During the worst-case individual stage up to 67 residential receiver buildings exceed the L_{Amax} sleep disturbance screening level. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 23 receiver buildings, with the greatest number being in NCAs 17.2 and 17.3.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the resurfacing works taking place within the Warringah Freeway carriageway there are limited physical noise source and noise path mitigation measures that can be installed during the works. As the hotel and residential receiver buildings are located in multi-storey buildings, they would overlook the site and any fixed mitigation on-site would be very limited. Furthermore, due to the transient nature of resurfacing works, fixed mitigation measures would be of limited effectiveness and so have not been included in the modelling.

The effectiveness of programming of noise-intensive activities, correct site planning, combined with on-site mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receiver buildings.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.6.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-158 for residential receivers during standard construction hours
- Table 5-159 for residential receivers during works outside standard construction hours
- Table 5-161 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2, and for all other non-residential receivers see section 3.4.1.

The number of receiver buildings predicted to exceed the NMLs during each stage and time period are summarised in Table 5-160 and Table 5-162. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-158 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1D_01	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$	
		HNA	NML		
Waverton	14.1	75	51	< 35	40 / 43
McMahons Point	15.2	75	52	34 / 40	45 / 51
Lavender Bay	15.4	75	52	32 / 54	42 / 64
Milsons Point	16.1	75	70	54 / 57	64 / 67
North Sydney - south west	15.3	75	52	36 / 43	47 / 53
North Sydney - north west	19.1	75	62	40 / 46	50 / 57
	20.1	75	62	39 / 43	50 / 54
North Sydney - east	17.3	75	65	55 / 60	66 / 71
	18.2	75	64	40 / 47	50 / 58
Kirribilli	17.1	75	65	38 / 44	48 / 54
	17.2	75	65	41 / 64	52 / 75
	18.1	75	64	39 / 46	49 / 57
Neutral Bay	17.4	75	65	36 / 46	47 / 56
	18.3	75	64	39 / 45	49 / 55

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-159 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference		WFU1D_01					
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$	
		HNA	Day (O)	Eve	Night		
Waverton	14.1	75	46	42	38	< 35	37 / 40
McMahons Point	15.2	75	47	46	43	33 / 39	41 / 47
Lavender Bay	15.4	75	47	46	43	30 / 52	39 / 61
Milsons Point	16.1	75	65	65	55	52 / 55	61 / 64
North Sydney - south west	15.3	75	47	46	43	35 / 41	43 / 50
North Sydney - north west	19.1	75	57	57	50	38 / 45	47 / 54
	20.1	75	57	57	50	38 / 42	47 / 51
North Sydney - east	17.3	75	60	59	50	54 / 58	62 / 67
	18.2	75	59	57	48	38 / 45	47 / 54
Kirribilli	17.1	75	60	59	50	36 / 42	45 / 51
	17.2	75	60	59	50	39 / 63	48 / 72
	18.1	75	59	57	48	37 / 45	46 / 54
Neutral Bay	17.4	75	60	59	50	35 / 44	44 / 53
	18.3	75	59	57	48	37 / 43	46 / 52

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-160 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1D_01	Typical	0	4	0	0	9	0	0	0	11	2	0	0	52	15	0	0	47	6
	Worst-case	0	46	4	0	70	20	0	0	110	27	0	0	382	118	11	0	67	23

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-161 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1D_01	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$	
Commercial	16.3	70	53 / 71	63 / 82
Childcare	16.3	50	40 / 58	50 / 69
	17.1	50	36 / 42	46 / 52
Other sensitive receiver	16.2	70	57 / 58	67 / 69
	16.3	55	51 / 69	61 / 80
	18.1	50	33 / 40	43 / 51
Place of worship	15.4	55	≤ 48	37 / 58
	16.1	55	45 / 48	56 / 58
Recreational	17.3	65	51 / 56	61 / 66

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-162 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU1D_01	Typical	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Worst-case	7	3	0	1	2	0	0	0	0	1	0	0	2	0	0	2	0	1

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.7 Falcon Street Interchange upgrade (WFU1E)

The key activities of the proposed construction works include:

- Widening of the existing eastern bridge on the northern side
- Ramp reconfiguration works
- Structure-upgrade works for existing main bridge and ramp structures
- Demolition of the existing shared user bridge and construction of a new shared user bridge over the Warringah Freeway between Jeaffreson Jackson Reserve and Merlin Street.

During the works the Cammeray Golf Course construction support site would be used. However, there would also be an area established within the works area for laydown, offices and toilets that would shift as the works progress.

For the replacement of Falcon Street shared user bridge there would be support work areas located at Jeaffreson Jackson Reserve on the western side and Merlin Street on the eastern side.

The location of the works area and the surrounding noise-sensitive receivers is presented in Figure 5-23.

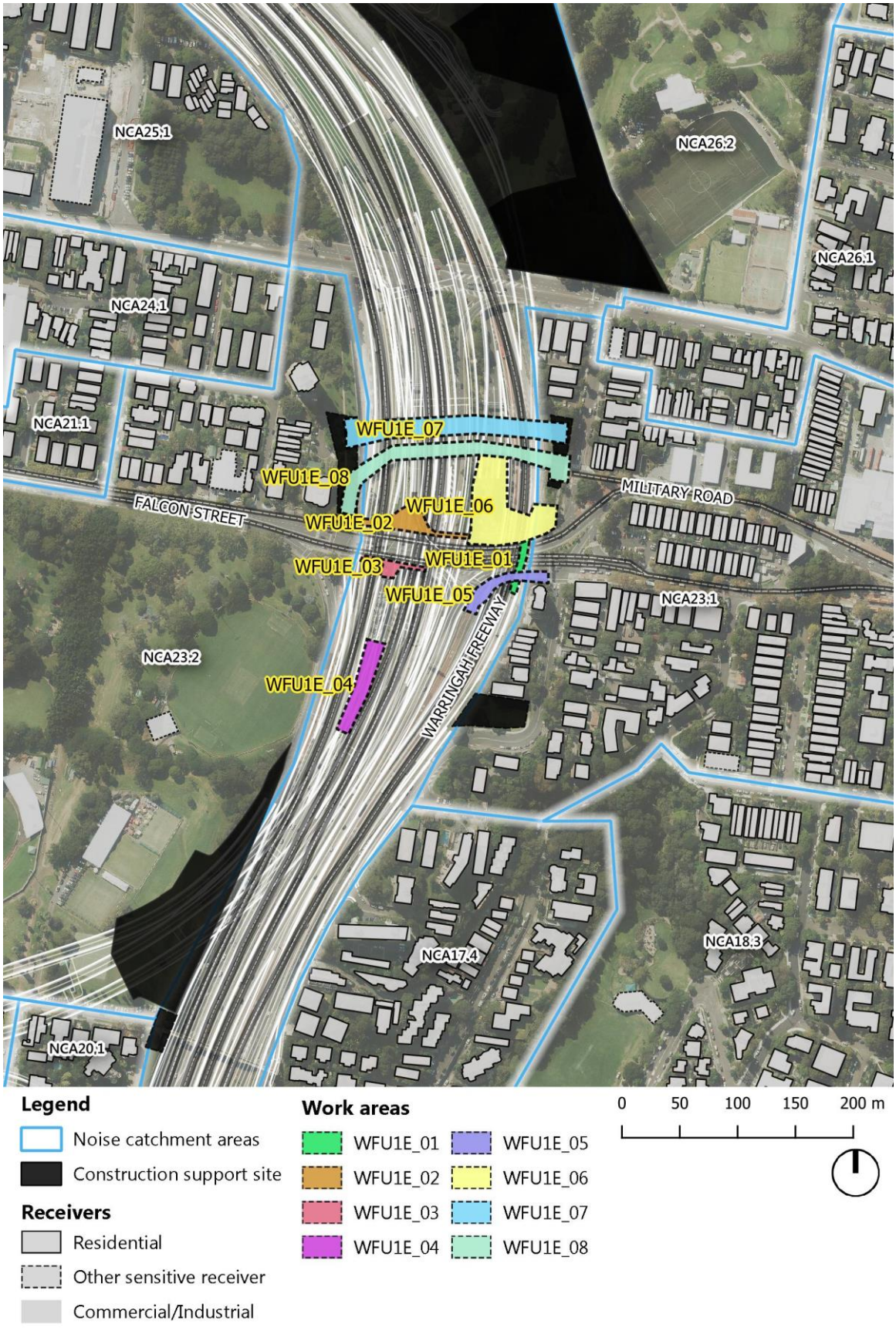
In addition to the above works, modification works at the intersection of Falcon and Miller Street are proposed. As these works are minor, relatively short term, and would mostly occur during standard construction hours, refer to section 5.10.1 for indicative noise impacts.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-163. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-163 – Falcon Street Interchange upgrade (WFU1E) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1E_01	Modifications to existing Falcon Street bridge	3 months
WFU1E_02	Modifications to existing Falcon Street bridge	6 months
WFU1E_03	Widening of existing Falcon Street bridge	9 months
WFU1E_04	Ramp modification works	6 months
WFU1E_05	Widening of existing Falcon Street bridge	6 months
WFU1E_06	Ramp modification works	18 months
WFU1E_07	Construction of new Falcon Street shared user bridge	12 months
WFU1E_08	Demolition of existing Falcon Street shared user bridge	3 months

Figure 5-23 – Falcon Street Interchange upgrade (WFU1E) - assessment work areas



5.9.2.7.1 Construction hours and durations

A large portion of the proposed works would be carried out during night time road closures, as the works would require road occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-164.

Table 5-164 – Required out of hours work – Falcon Street Interchange upgrade (WFU1E)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU1E_01	1. Road/bridge demolition/construction works in major traffic corridor 2. Oversized item delivery and installation	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads
WFU1E_02		10	
WFU1E_03		10	
WFU1E_04		10	
WFU1E_05		10	
WFU1E_06		10	
WFU1E_07	1. Bridge modification/construction within traffic corridor 2. Delivery and installation of oversized plant/structures/bridge elements	30	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads
WFU1E_08	1. Bridge demolition over live traffic corridor 2. Delivery and installation of oversized plant/structures/bridge elements	30	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically approach the OOHW noise impacts.

5.9.2.7.2 Construction assessment scenarios

The airborne noise assessment of the Falcon Street Interchange upgrade was separated into six works areas. Each work area was assessed for works during both standard construction hours and OOHW.

Presented in Table 5-165 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

Table 5-165 summarises the range of noise generating activities that are proposed for the works area. The details of the modelled plant items and relevant sound power levels that make up these activities are presented in Appendix F.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-165 – Assessed construction activities - Falcon Street Interchange upgrade (WFU1E)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU1E_01	Utilities modification works	110	120	Spoil handling	104	106
WFU1E_02	Utilities modification works	110	120	Pavement/road modification works	110	120
WFU1E_03	Utilities modification works	110	120	Demolition (rock hammering)	109	121
WFU1E_04	Demolition (rock hammering)	109	121	Pavement/road modification works	110	120
WFU1E_05	Demolition (rock hammering)	109	121	Resurfacing works	108	117
WFU1E_06	Utilities modification works	110	120	Demolition (rock hammering)	109	121
WFU1E_07	Rock trimming	111	120	Demolition (rock hammering)	109	121
WFU1E_08	Demolition (rock hammering)	109	121	Demolition (rock hammering)	109	121

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.7.3 Construction noise prediction summary

Table 5-166, Table 5-168 and Table 5-171 present the predicted noise levels from construction activities and compares them to the NMLs. Table 4-168 and Table 4-170 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each

receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels generally comply with the NMLs for standard construction hours, except for some receiver buildings in NCAs 17.4, 23.1 and 23.2, which are located either side of the Warringah Freeway in North Sydney and Neutral Bay. Results of the noise predictions are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 23.1 and 23.2 directly to the east and west of the works, when rock hammers or road saws are required as part of pavement/road modification works or bridge/road demolition works
- Over the entire works stage, during typical activities up to two receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when the construction works are in close proximity to nearby receiver buildings. When worst-case activities occur, there is the potential for up to 18 receiver buildings to be highly noise affected
- During standard construction hours, during typical construction activities compliance with the NML is generally predicted, except for one receiver building in NCA 23.1 which are predicted to exceed by up to 11 dB(A). During worst-case construction activities, the highest noise impacts are predicted to be >20 dB(A) above the NML during WFU1E_02 and WFU1E_05 (22-23 dB(A)) exceedance above NML) for up to one receiver building in each NCA 23.1 and 23.2 which could be considered highly intrusive. During other stages and up to 34 other receiver buildings are predicted to exceed the NML in any one stage.

During OOHW, the key activity that has been assessed is road resurfacing works and results of the assessment are as follows:

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical construction activities during the night period up to 227 receiver buildings are predicted to exceed the night period NMLs. This number is predicted to extend up to 2389 receiver buildings for worst-case construction activities. The highest impact works are demolition (rock hammering) works in WFU1E_06
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical works, up to one receiver building is predicted to exceed the night period NML by > 25 dB(A) which would be considered highly intrusive. This is predicted to increase to 24 receiver buildings during the worst-case works.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Up to three childcare centre receivers located in NCA 22.3 and 23.2. The highest predicted noise levels during typical construction activities achieve the NML at all childcare centres. However, during worst-case construction activities the predicted levels are up to 59 dB(A), 9 dB(A) above the screening NML
- Up to two educational receivers in NCA 22.1 and 25.1 are predicted to exceed the NML by up to 4 dB(A)
- Up 6 dB(A) exceedance during worst-case works at one theatre in NCA 21.2, while compliance is achieved during typical works
- Up to 12 dB(A) exceedances at a hotel receiver during the night period, and up to 9 dB(A) exceedances at a community centre in NCA 23.2
- Up to 2 dB(A) exceedance at two places of worship in NCA 21.1 and 22.1
- Exceedances at four recreational receiver locations in NCA 23.2 and 26.2, up to 16 dB(A).

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from night time construction works would be from the use of rock hammers during bridge demolition/modification or road excavation/trenching works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow for potential sleep disturbance from OOHW to be assessed. Results of the assessment are as follows:

- The predicted noise levels show exceedances of the sleep disturbance screening levels for both sets of works during the night time period
- During typical activities, high noise events such as heavy vehicle air-brakes or metal-on-metal bangs, have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 167 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 38 receiver buildings, mostly in NCA 23.1 and 23.2
- During worst-case construction activities such as rock hammering, up to 905 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 153 receiver buildings.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the resurfacing works taking place as part of the Falcon Street Interchange upgrade there is limited available noise source and noise path mitigation measures available that can be

installed. As the residential receiver buildings overlook the site from multi-storey buildings and due to the transient nature of the road works, the effectiveness of any fixed mitigation on-site would be very limited and so have not been included in the modelling.

The effectiveness of programming of noise-intensive activities, correct site planning, combined with on-site mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.7.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-166 for residential receivers during standard construction hours
- Table 5-168 for residential receivers during works outside of standard construction hours
- Table 5-171 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2, and for all other non-residential receivers see section 3.4.1.

The number of receivers predicted to exceed NMLs during each stage and time period are summarised in Table 5-170 and Table 5-173.

Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-166 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1E_01		WFU1E_02		WFU1E_03		WFU1E_04		WFU1E_05		WFU1E_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	NML												
Wollstonecraft	22.2	75	62	38 / 39	49 / 50	42 / 44	52 / 54	40 / 41	50 / 51	37 / 38	49 / 50	39 / 40	52 / 53	39 / 40	49 / 50
	30.4	75	68	35 / 36	46	38 / 39	49 / 50	37	47	< 35	46	36 / 37	49	36 / 37	47
Waverton	14.1	75	51	< 35	37	< 35	41 / 42	< 35	39	< 35	38 / 39	< 35	40	< 35	38
	15.1	75	52	< 35	42	35 / 36	46 / 47	< 35	43	< 35	43	< 35	44 / 45	< 35	43
North Sydney – SW	15.3	75	52	< 35	43 / 44	37 / 38	47 / 48	35 / 36	46	< 35	46	34 / 35	47	35 / 36	46
North Sydney - north west	19.1	75	62	38 / 39	48 / 49	40 / 42	50 / 52	41	51 / 52	40 / 42	53 / 54	40 / 41	52 / 53	40 / 41	50 / 51
	20.1	75	62	40 / 41	50 / 52	42 / 44	52 / 55	44 / 45	54 / 55	45 / 47	58 / 59	42 / 43	55 / 56	43 / 44	53 / 54
	21.1	75	63	42 / 44	52 / 54	47 / 51	57 / 62	49 / 51	59 / 61	40 / 42	52 / 55	44 / 46	57 / 59	44 / 46	54 / 57
	21.2	75	63	39 / 40	49 / 50	43 / 45	53 / 55	43 / 44	53 / 54	40 / 41	52 / 54	40 / 41	52 / 53	40 / 42	51 / 52
	22.1	75	62	41 / 42	52 / 53	48 / 50	58 / 61	46 / 47	57 / 58	41 / 42	53 / 55	43 / 45	56 / 57	44 / 46	55 / 56
	23.2	75	71	48 / 52	58 / 62	55 / **82**	66 / **93**	60 / 66	70 / **76**	51 / 55	64 / 68	51 / 55	64 / 68	53 / 58	63 / 68
Neutral Bay	17.4	75	65	51 / 54	61 / 64	49 / 53	59 / 64	52 / 54	62 / 64	53 / 58	66 / 71	50 / 53	63 / 65	50 / 52	60 / 63
	18.3	75	64	36 / 38	46 / 49	41 / 44	51 / 54	41 / 43	52 / 53	42 / 44	54 / 56	40 / 42	53 / 55	41 / 44	52 / 54
	23.1	75	71	69 / 71	79 / **81**	54 / 64	65 / 75	57 / 60	67 / 71	51 / 57	64 / 69	58 / **82**	70 / **94**	58 / 68	69 / **78**
Crows Nest	22.3	75	62	40 / 42	51 / 52	45 / 47	55 / 58	45 / 46	56 / 57	39 / 41	52 / 53	42 / 44	55 / 56	43 / 45	54 / 55
	24.1	75	66	46 / 49	56 / 59	52 / 55	62 / 66	51 / 53	61 / 64	45 / 47	57 / 60	46 / 49	59 / 61	49 / 52	59 / 62
	30.1	75	68	< 35	44 / 45	35 / 36	46 / 47	35 / 36	46	< 35	45	35	47 / 48	36 / 37	47 / 48
Cammeray	25.1	75	68	41 / 43	51 / 53	43 / 46	53 / 57	45 / 46	55 / 56	38 / 40	51 / 52	43 / 45	56 / 57	47 / 49	57 / 59
	28.1	75	57	40 / 41	50 / 51	42 / 44	52 / 54	42 / 43	52 / 53	38 / 39	50 / 51	39 / 40	52 / 53	42 / 43	52 / 53
	29.1	75	74	40 / 41	51 / 52	44 / 46	54 / 56	44 / 45	54 / 55	39 / 40	52 / 53	40 / 41	53 / 54	43 / 45	54 / 55
	30.3	75	68	36 / 37	46 / 47	40 / 41	50 / 52	39	49 / 50	34 / 35	47	39 / 40	51 / 52	40 / 41	51 / 52
	31.2	75	66	< 35	40 / 41	35 / 37	46 / 47	37	47	< 35	44	35 / 36	47 / 48	37 / 38	48 / 49
Cremorne	26.1	75	68	40 / 44	51 / 55	43 / 48	54 / 59	45 / 46	55 / 57	41 / 43	53 / 55	48 / 51	61 / 64	48 / 51	58 / 62
	27.1	75	59	34 / 35	44 / 46	37 / 39	47 / 49	36 / 37	46 / 47	< 35	45 / 46	34 / 36	47 / 48	35 / 37	46 / 47

Major works area/assessment reference				WFU1E_01		WFU1E_02		WFU1E_03		WFU1E_04		WFU1E_05		WFU1E_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	NML												
Naremburn	30.2	75	68	< 35	42 / 43	< 35	44	< 35	43 / 44	< 35	43	< 35	44 / 45	< 35	43 / 44
	31.1	75	66	< 35	41	< 35	43 / 44	< 35	44	< 35	43	< 35	45	< 35	43 / 44
	31.3	75	66	< 35	41 / 42	< 35	43 / 44	< 35	43 / 44	< 35	42	< 35	44	< 35	43 / 44
	37.1	75	55	< 35	37 / 38	< 35	40	< 35	40	< 35	39	< 35	41 / 42	< 35	40
Northbridge	38.3	75	62	< 35	41	34 / 35	44 / 45	< 35	44	< 35	43	< 35	44 / 45	< 35	44

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-167 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1E_07		WFU1E_08	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	NML				
Wollstonecraft	22.2	75	62	37 / 40	46 / 49	35 / 38	47 / 50
	30.4	75	68	36 / 38	45 / 47	34 / 36	46 / 48
North Sydney – SW	15.3	75	52	34 / 36	43 / 45	< 35	44 / 46
North Sydney - north west	19.1	75	62	37 / 40	46 / 49	36 / 39	48 / 51
	20.1	75	62	39 / 43	48 / 52	37 / 41	49 / 53
	21.1	75	63	39 / 49	48 / 58	37 / 46	49 / 58
	21.2	75	63	38 / 41	47 / 50	36 / 39	48 / 51
	22.1	75	62	40 / 44	49 / 53	38 / 43	50 / 55
	23.2	75	71	52 / 70	61 / **79**	65 / 74	**77** / **86**
Neutral Bay	17.4	75	65	44 / 49	53 / 58	41 / 48	53 / 60
	18.3	75	64	37 / 44	46 / 53	35 / 43	47 / 55
	23.1	75	71	54 / 74	63 / **83**	50 / 72	62 / **84**
Crows Nest	22.3	75	62	42 / 46	51 / 55	39 / 43	51 / 55
	24.1	75	66	50 / 61	59 / 70	56	68
	30.1	75	68	36 / 38	45 / 47	34 / 36	46 / 48
Cammeray	25.1	75	68	36 / 51	45 / 60	37 / 48	49 / 60
	28.1	75	57	42 / 46	51 / 55	40 / 43	52 / 55
	29.1	75	74	44 / 48	53 / 57	41 / 45	53 / 57
	30.3	75	68	40 / 43	49 / 52	38 / 40	50 / 52
	31.2	75	66	37 / 39	46 / 48	35 / 37	47 / 49
Cremorne	26.1	75	68	43 / 54	52 / 63	42 / 49	54 / 61
	27.1	75	59	35 / 39	44 / 48	33 / 37	45 / 49
Naremburn	30.2	75	68	33 / 35	42 / 44	< 35	43 / 45
	31.1	75	66	34 / 35	43 / 44	< 35	44 / 45
	31.3	75	66	33 / 35	42 / 44	< 35	43 / 45

Major works area/assessment reference				WFU1E_07		WFU1E_08	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	NML				
Naremburn	37.1	75	55	< 35	39 / 40	< 35	41 / 42
Northbridge	38.3	75	62	34 / 36	43 / 45	< 35	44 / 46

Notes

1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-168 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference						WFU1E_01		WFU1E_02		WFU1E_03		WFU1E_04		WFU1E_05		WFU1E_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day(O)	Eve	Ngt												
Wollstonecraft	22.2	75	57	52	41	< 35	< 35	42 / 44	52 / 54	38 / 39	51 / 52	38 / 39	49 / 50	39 / 40	48 / 49	37 / 38	50 / 51
	30.4	75	63	61	43	< 35	< 35	38 / 39	48 / 50	35 / 36	48	34 / 35	45	36 / 37	45	35	47 / 48
Waverton	14.1	75	46	42	38	< 35	< 35	< 35	41	< 35	40	< 35	38	< 35	36 / 37	< 35	38 / 39
	15.1	75	47	46	43	< 35	< 35	35 / 36	46 / 47	< 35	43 / 44	< 35	42 / 43	< 35	41	< 35	43 / 44
North Sydney – SW	15.3	75	47	46	43	< 35	< 35	37 / 38	47 / 48	< 35	46 / 47	35	45 / 46	< 35	43	< 35	46 / 47
North Sydney - north west	19.1	75	57	57	50	< 35	< 35	40 / 41	50 / 52	39 / 40	52	42 / 43	52 / 53	39 / 40	48 / 49	38 / 39	51 / 52
	20.1	75	57	57	50	< 35	35 / 36	42 / 44	52 / 55	42 / 44	55 / 56	46 / 48	57 / 59	42 / 43	51 / 52	41 / 43	54 / 55
	21.1	75	58	54	46	< 35	37 / 39	47 / 51	57 / 61	47 / 49	60 / 62	41 / 44	52 / 54	44 / 46	53 / 55	42 / 45	55 / 57
	21.2	75	58	54	46	< 35	34 / 35	42 / 45	53 / 55	41 / 42	54 / 55	41 / 43	52 / 53	39 / 40	48 / 49	39 / 40	51 / 53
	22.1	75	57	52	41	< 35	36 / 37	48 / 50	58 / 60	45 / 46	57 / 58	42 / 44	52 / 54	43 / 44	52 / 53	43 / 44	55 / 57
	23.2	75	66	59	49	38 / 42	43 / 47	55 / **82**	66 / **92**	58 / 64	71 / **77**	53 / 57	63 / 67	51 / 55	60 / 64	51 / 56	64 / 69
Neutral Bay	17.4	75	60	59	50	41 / 44	46 / 49	49 / 53	59 / 63	50 / 52	63 / 65	55 / 60	65 / 70	50 / 53	59 / 62	48 / 51	61 / 63
	18.3	75	59	57	48	< 35	< 35	40 / 44	51 / 54	40 / 41	52 / 54	43 / 45	53 / 55	40 / 42	49 / 51	40 / 42	52 / 55
	23.1	75	66	59	49	59 / 61	64 / 66	54 / 64	65 / 74	55 / 59	68 / 71	53 / 58	63 / 69	58 / **82**	67 / **91**	57 / 66	69 / **79**
Crows Nest	22.3	75	57	52	41	< 35	35 / 37	45 / 47	55 / 58	44 / 45	56 / 57	40 / 42	51 / 52	42 / 43	51 / 52	42 / 43	54 / 56
	24.1	75	61	57	42	36 / 39	41 / 44	52 / 55	62 / 66	49 / 52	62 / 64	46 / 48	56 / 59	46 / 48	55 / 57	47 / 50	60 / 63
	30.1	75	63	61	43	< 35	< 35	35 / 36	45 / 47	< 35	46 / 47	< 35	44 / 45	34 / 35	43 / 44	35 / 36	47 / 48
Cammeray	25.1	75	63	60	48	< 35	36 / 38	43 / 46	53 / 56	43 / 44	56 / 57	40 / 41	50 / 51	43 / 44	52 / 53	45 / 47	58 / 60
	28.1	75	52	50	42	< 35	35 / 36	42 / 44	52 / 54	41	53 / 54	39 / 40	49 / 50	39 / 40	48 / 49	40 / 42	53 / 54
	29.1	75	69	68	52	< 35	35 / 36	43 / 46	54 / 56	42 / 43	55 / 56	40 / 41	51 / 52	40 / 41	49 / 50	42 / 43	54 / 56
	30.3	75	63	61	43	< 35	< 35	40 / 41	50 / 51	37 / 38	50	35 / 36	46 / 47	39	47 / 48	39 / 40	51 / 52
	31.2	75	61	54	42	< 35	< 35	35 / 37	46 / 47	35	47 / 48	< 35	43 / 44	35	44	36 / 37	48 / 49
Cremorne	26.1	75	63	59	46	< 35	35 / 39	43 / 48	53 / 59	43 / 45	56 / 57	42 / 44	53 / 55	48 / 51	57 / 60	46 / 50	59 / 62
	27.1	75	54	53	44	< 35	< 35	37 / 39	47 / 49	34 / 35	47 / 48	< 35	44 / 45	34 / 35	43 / 44	34 / 35	46 / 48

Major works area/assessment reference						WFU1E_01		WFU1E_02		WFU1E_03		WFU1E_04		WFU1E_05		WFU1E_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day(O)	Eve	Ngt												
Naremburn	30.2	75	63	61	43	< 35	< 35	< 35	43 / 44	< 35	44	< 35	42	< 35	40 / 41	< 35	44 / 45
	31.1	75	61	54	42	< 35	< 35	< 35	43 / 44	< 35	44 / 45	< 35	42	< 35	41	< 35	44 / 45
	31.3	75	61	54	42	< 35	< 35	< 35	43 / 44	< 35	44	< 35	41	< 35	40	< 35	44 / 45
	37.1	75	50	49	39	< 35	< 35	< 35	39 / 40	< 35	40 / 41	< 35	38	< 35	37 / 38	< 35	41
Northbridge	38.3	75	57	53	42	< 35	< 35	34 / 35	44 / 45	< 35	44 / 45	< 35	42	< 35	41	< 35	44 / 45

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-169 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference						WFU1E_07		WFU1E_08	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	Day (O)	Eve	Night				
Wollstonecraft	22.2	75	57	52	41	35 / 38	47 / 50	35 / 38	47 / 50
	30.4	75	63	61	43	34 / 36	46 / 48	34 / 36	46 / 48
North Sydney – SW	15.3	75	47	46	43	< 35	44 / 46	< 35	44 / 46
North Sydney - north west	19.1	75	57	57	50	35 / 38	47 / 50	36 / 39	48 / 51
	20.1	75	57	57	50	37 / 41	49 / 53	37 / 41	49 / 53
	21.1	75	58	54	46	37 / 47	49 / 59	37 / 46	49 / 58
	21.2	75	58	54	46	36 / 39	48 / 51	36 / 39	48 / 51
	22.1	75	57	52	41	38 / 42	50 / 54	38 / 43	50 / 55
	23.2	75	66	59	49	50 / 68	62 / **80**	65 / 74	**77** / **86**
Neutral Bay	17.4	75	60	59	50	42 / 47	54 / 59	41 / 48	53 / 60
	18.3	75	59	57	48	35 / 42	47 / 54	35 / 43	47 / 55
	23.1	75	66	59	49	52 / 72	64 / **84**	50 / 72	62 / **84**
Crows Nest	22.3	75	57	52	41	40 / 44	52 / 56	39 / 43	51 / 55
	24.1	75	61	57	42	48 / 59	60 / 71	56	68
	30.1	75	63	61	43	34 / 36	46 / 48	34 / 36	46 / 48
Cammeray	25.1	75	63	60	48	34 / 49	46 / 61	37 / 48	49 / 60
	28.1	75	52	50	42	40 / 44	52 / 56	40 / 43	52 / 55
	29.1	75	69	68	52	42 / 46	54 / 58	41 / 45	53 / 57
	30.3	75	63	61	43	38 / 41	50 / 53	38 / 40	50 / 52
	31.2	75	61	54	42	35 / 37	47 / 49	35 / 37	47 / 49
Cremorne	26.1	75	63	59	46	41 / 52	53 / 64	42 / 49	54 / 61
	27.1	75	54	53	44	33 / 37	45 / 49	33 / 37	45 / 49

Major works area/assessment reference						WFU1E_07		WFU1E_08	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Naremburn	30.2	75	63	61	43	< 35	43 / 45	< 35	43 / 45
	31.1	75	61	54	42	< 35	44 / 45	< 35	44 / 45
	31.3	75	61	54	42	< 35	43 / 45	< 35	43 / 45
	37.1	75	50	49	39	< 35	40 / 41	< 35	41 / 42
Northbridge	38.3	75	57	53	42	< 35	44 / 46	< 35	44 / 46

Notes

1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-170 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1E_01	Typical	0	0	0	0	0	0	0	0	1	0	0	0	6	1	0	0	17	**9**
	Worst-case	**1**	5	0	0	0	0	0	0	0	1	0	0	11	6	1	0	328	**42**
WFU1E_02	Typical	**2**	0	1	0	1	0	1	0	11	2	1	0	165	59	2	1	87	**18**
	Worst-case	**6**	12	0	1	48	7	0	1	200	56	3	1	1176	1034	61	4	1155	**104**
WFU1E_03	Typical	0	0	0	0	0	0	0	0	1	0	0	0	54	15	0	0	40	**5**
	Worst-case	**1**	1	0	0	32	3	0	0	156	33	1	0	1102	1056	33	1	1011	**58**
WFU1E_04	Typical	0	0	0	0	0	0	0	0	1	0	0	0	29	15	0	0	19	**3**
	Worst-case	0	5	0	0	8	5	0	0	22	17	0	0	1202	392	18	0	533	**31**
WFU1E_05	Typical	**2**	0	1	0	3	0	1	0	13	4	1	0	63	41	4	1	53	**32**
	Worst-case	**18**	33	1	1	20	8	1	0	39	33	4	1	1032	303	33	5	730	**105**
WFU1E_06	Typical	0	0	0	0	0	0	0	0	15	2	0	0	96	51	2	0	84	**28**
	Worst-case	**4**	16	0	0	70	21	0	0	260	71	9	0	1110	1157	85	9	1116	**114**
WFU1E_07	Typical	0	2	0	0	8	1	0	0	13	16	0	0	95	41	18	0	70	**30**
	Worst-case	**16**	27	1	0	79	28	2	0	309	32	21	0	1062	1083	57	24	938	**101**
WFU1E_08	Typical	0	2	0	0	3	2	0	0	23	6	0	0	89	53	6	0	58	**36**
	Worst-case	**8**	29	3	0	51	29	3	0	260	53	12	1	1215	1095	65	14	940	**106**

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-171 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1E_01		WFU1E_02		WFU1E_03		WFU1E_04		WFU1E_05		WFU1E_06	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
Childcare	22.3	50	37 / 38	47 / 49	38 / 41	49 / 51	40 / 41	51 / 52	37 / 38	49 / 51	37 / 38	50 / 51	41 / 42	51 / 53
	23.2	50	37 / 42	48 / 52	< 49	32 / 59	39 / 45	50 / 55	38 / 42	51 / 55	39 / 43	52 / 56	39 / 43	49 / 54
Educational	22.1	55	41 / 42	51 / 53	46 / 48	56 / 59	45 / 46	55 / 56	39 / 41	52 / 54	42 / 43	54 / 56	43 / 44	53 / 55
	25.1	55	40 / 41	50 / 52	42 / 45	52 / 55	42 / 43	52 / 53	38 / 39	50 / 52	39 / 41	52 / 53	43 / 45	54 / 56
Other sensitive receiver	21.2	50	40 / 41	50 / 51	43 / 46	54 / 56	42 / 43	53 / 54	40 / 42	53 / 54	40 / 42	53 / 54	41 / 42	51 / 52
	23.2	60	44 / 48	54 / 59	34 / 61	45 / 72	52 / 58	63 / 68	46 / 50	58 / 63	47 / 50	59 / 63	48 / 52	58 / 63
Place of worship	21.1	55	39 / 41	50 / 52	42 / 47	53 / 57	44 / 46	54 / 56	37 / 39	50 / 52	41 / 42	53 / 55	41 / 43	51 / 54
	22.1	55	38 / 39	49 / 50	43 / 45	53 / 56	42 / 43	52 / 53	39 / 41	52 / 53	39 / 40	52 / 53	40 / 41	50 / 51
Recreational	23.2	60	46 / 51	57 / 61	33 / 60	43 / 70	50 / 56	61 / 66	57 / 61	69 / 73	48 / 51	60 / 64	51 / 56	61 / 66

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-172 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1E_07		WFU1E_08	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
Childcare	22.3	50	39 / 44	48 / 53	36 / 41	48 / 53
	28.1	50	37 / 41	46 / 50	34 / 38	46 / 50
Educational	25.1	55	32 / 47	41 / 56	33 / 44	45 / 56
Other sensitive receiver	21.2	50	40 / 43	49 / 52	37 / 41	49 / 53
	23.2	60	40 / 59	49 / 68	48 / 57	60 / 69
	26.1	60	51 / 63	60 / 72	51 / 58	63 / 70
Recreational	23.2	65	54 / 72	63 / 81	51 / 61	63 / 73
	26.2	60	40 / 52	49 / 61	43 / 50	55 / 62

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-173 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU1E_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
WFU1E_02	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Worst-case	0	0	0	2	0	0	2	0	0	2	0	0	2	0	0	1	1	0
WFU1E_03	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	2	0	0	1	0	0	1	0	0	1	0	0	2	0	0
WFU1E_04	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0
WFU1E_05	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	3	0	0	1	0	0	1	0	0	0	0	0	2	0	0
WFU1E_06	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	3	0	0	1	0	0	1	0	0	0	0	0	2	0	0
WFU1E_07	Typical	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
	Worst-case	0	0	0	2	0	0	1	0	0	1	1	0	0	0	0	2	1	0
WFU1E_08	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	2	0	0	2	0	0	3	0	0	0	0	0	3	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.8 High Street Interchange upgrade (WFU1F)

The key activities of the proposed construction works include:

- Widening of the existing bridge on the southern side
- The construction of a new northbound on ramp.

During the works, the Blue Street (WFU1) would be the key minor construction support site. There would also be a minor construction support site established adjacent to Arthur Street (WFU4) and High Street south (WFU2) for laydown, offices and toilets.

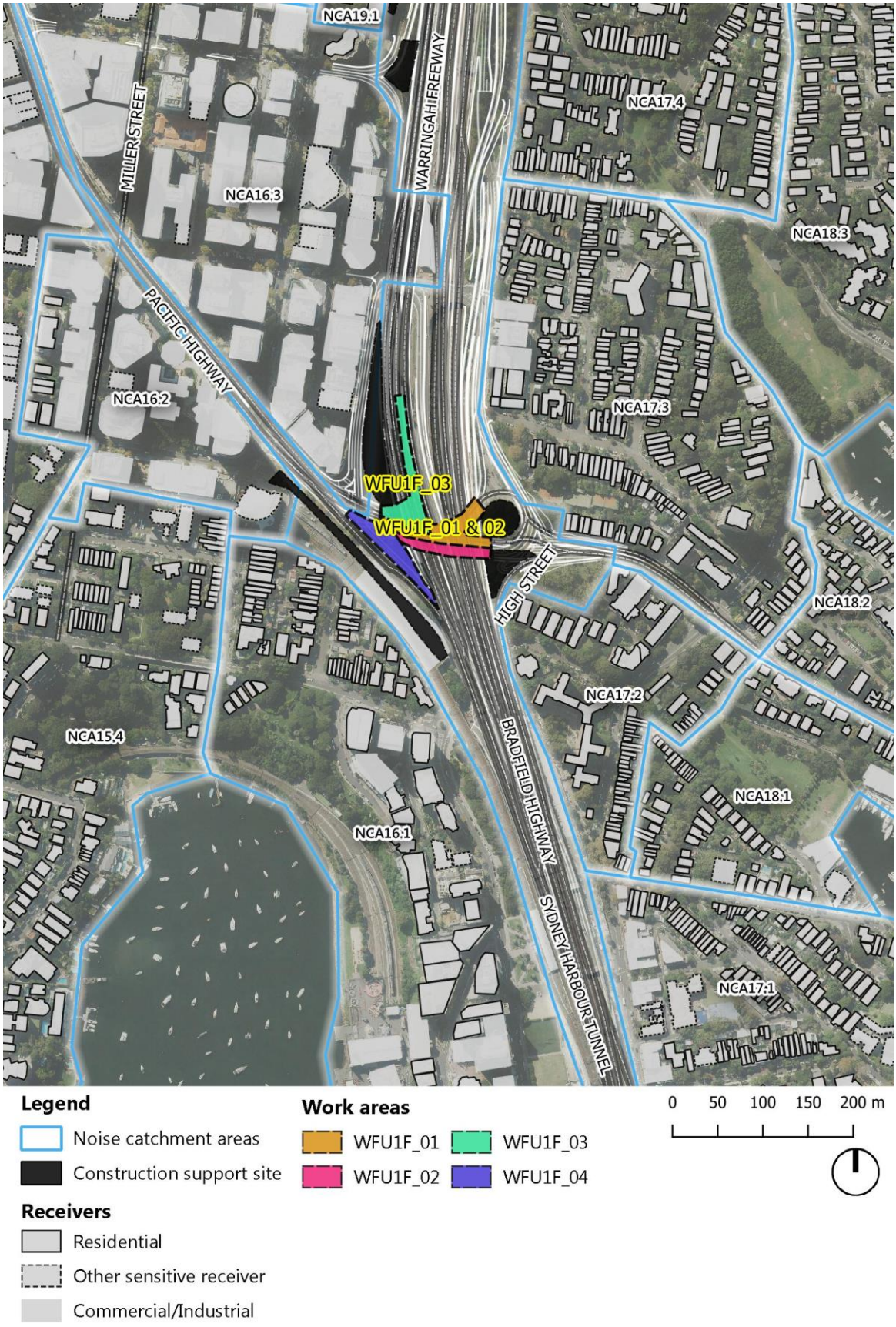
The location of the works area and the surrounding noise-sensitive receivers is presented in Figure 5-24.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-174. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-174 – High Street Interchange upgrade (WFU1F) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1F_01	Widening of High Street bridge	18 months
WFU1F_02	Widening of High Street bridge	
WFU1F_03	Construction of the new northbound on ramp	9 months
WFU1F_04	Ramp modification works	6 months

Figure 5-24 – High Street Interchange upgrade (WFU1F) - assessment work areas



5.9.2.8.1 Construction hours and durations

Certain construction works would be carried out during night time road closures, as the works would require occupancy of High Street and the Warringah Freeway carriageways when work is carried out over them.

OOHW would only be required for a smaller portion of the overall allocated construction stage timeframes presented in the table above. The estimated period of required OOHW over the total construction timeframe, and justifications for the OOHW are presented in Table 5-175.

Table 5-175 – Required out of hours work - High Street Interchange upgrade (WFU1F)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU1F_01	1. Oversized item delivery and installation, and	10	ROL required, impact on road network performance, safety for workers and road users within carriageway
WFU1F_02	2. Concrete pours in/adjacent to road corridor	20	
WFU1F_03	Oversized item delivery and installation of large items	10	
WFU1F_04		10	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the specific mitigation and management measures recommended to approach the OOHW noise impacts.

5.9.2.8.2 Construction assessment scenarios

The airborne noise assessment of the High Street Interchange upgrade was separated into four works areas. Each work area was assessed for works during both standard construction hours and OOHW.

Presented in Table 5-176 are the assessed activities for each works area, which represent the most reasonable intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable ‘typical’ and ‘worst’ case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-176 – Assessed construction activities

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU1F_01	Pavement/road modification works	110	120	Concrete formwork and reinforcement	104	113
WFU1F_02	Pavement/road modification works	110	120	Concrete formwork and reinforcement	104	113
WFU1F_03	Utilities modification works	110	120	Piling - Bored	108	116
WFU1F_04	Utilities modification works	110	120	Road furniture installation/modification	107	114

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.8.3 Construction noise prediction summary

Table 5-177, Table 5-178 and Table 5-180 present the predicted noise levels from construction activities and compares them with the NMLs. Table 5-179 and Table 5-181 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels generally do not exceed the NMLs for standard construction hours, except for NCAs 15.3, 15.4, 16.1, 17.2 and 17.3, which are located either side of the Warringah Freeway in North Sydney and Kirribilli. Results of the predictions are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 17.2 and 17.3, which are directly adjacent to the works area, when pavement/road modification works or utility modification works require the use of concrete saws or rock hammers in close proximity to the nearby affected receiver buildings
- During both typical and worst-case activities, no receiver buildings are predicted to be highly noise affected (ie. >75 dB(A))
- During standard construction hours, for typical construction activities the highest exceedances of the NMLs are predicted to be up to 5 dB(A) for receiver buildings in NCA 15.4. During worst-case construction activities, the exceedances are predicted to increase to 15 dB(A), which could be considered moderately intrusive. Receiver buildings in other NCAs, including 17.2 and 17.3,

are predicted to experience exceedances no greater than 10 dB(A), due to the existing high ambient noise levels controlled by the Warringah Freeway.

During OOHW, the key activities that have been assessed are concrete formwork construction, bored piling and road furniture installation activities. Results of the assessment of OOHW are as follows:

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical construction activities construction noise levels are predicted to exceed the night NML at up to 49 receiver buildings. This is predicted to increase to up to 247 receiver buildings when worst-case construction works associated with bored piling activities are carried out as part of the WFU1F_03 works
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical works the highest impacts are predicted to be up to 10 dB(A) above the night NML, which could be considered clearly audible. During worst-case construction activities, up to six receiver buildings are predicted to exceed the night NML by up to 18 dB(A), which could be considered moderately intrusive.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Up to four childcare centre receivers located in NCAs 15.3, 16.3 and 17.1. Exceedances up to 3 dB(A) are predicted during typical construction activities, however this could increase to 13 dB(A) during the worst-case works
- A marginal exceedance of 1 dB(A) at one school receiver in NCA 15.3
- An exceedance of up to 6 dB(A) at two hotel receivers in NCAs 16.2 and 16.3
- A marginal 1 dB(A) exceedance is predicted at a theatre receiver in NCA 18.1 and up to 5 dB(A) exceedance at a library in NCA 16.3
- Exceedances of up to 5 dB(A) at two places of worship in NCA 15.4
- Up to 8 dB(A) exceedance at two recreational receivers in NCA 17.3
- Up to 7 dB(A) exceedance at six commercial buildings in NCA 16.3.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night construction works would be from air-brakes or metal-on-metal bangs. Maximum noise levels have been predicted to the nearest affected residential receivers to allow potential sleep disturbance from OOHW to be assessed; results are as follows:

- The predicted noise levels exceed the sleep disturbance screening levels for the works
- During typical works, operations such as air-brakes have the potential to exceed the L_{Amax} sleep disturbance screening level at up to 43 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 26 receiver buildings across the works areas
- During the worst-case individual stage, up to 63 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 49 receiver buildings mostly located in NCA 17.2 and 17.3.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the construction works at the High Street Interchange upgrade there is limited available noise source and noise path mitigation measures available that can be installed during the works. As many of the hotel and nearby residential receiver buildings overlook the site from multi-storey buildings and due to the transient nature of the road works, the effectiveness of any fixed mitigation on-site would be very limited, so this has not been included in the modelling.

The effectiveness of programming of noise-intensive activities, correct site planning, combined with on-site mitigation measures would be reviewed during detailed design. There is opportunity during detailed design to investigate barriers, as some residential receiver buildings in NCAs 17.2 and 17.3 are at or below the level of the High Street bridge. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receiver buildings.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.8.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-177 for residential receivers during standard construction hours
- Table 5-178 for residential receivers during works outside of standard construction hours
- Table 5-180 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2; for all other non-residential receivers see section 3.4.1.

The number of receivers predicted to exceed noise management NMLs during each stage and time period are summarised in Table 5-179 and Table 5-181. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-177 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU1F_01		WFU1F_02		WFU1F_03		WFU1F_04	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$							
		HNA	NML								
McMahons Point	15.2	75	52	39 / 40	49 / 51	38 / 40	48 / 50	37 / 39	47 / 49	38 / 40	49 / 51
Lavender Bay	15.4	75	52	51 / 55	61 / 66	51 / 56	61 / 66	48 / 55	59 / 65	52 / 57	62 / 67
Milsons Point	16.1	75	70	50 / 59	61 / 69	50 / 59	60 / 69	48 / 59	59 / 70	46 / 63	57 / 73
North Sydney – south west	15.3	75	52	40 / 43	51 / 53	40 / 43	51 / 53	38 / 41	48 / 52	41 / 43	51 / 53
North Sydney - north west	19.1	75	62	42 / 44	52 / 54	42 / 44	52 / 54	43 / 45	53 / 56	42 / 43	52 / 54
North Sydney - east	17.3	75	65	54 / 63	65 / 73	54 / 63	65 / 73	50 / 61	60 / 72	52 / 57	62 / 67
	18.2	75	64	45 / 48	56 / 58	45 / 48	56 / 58	42 / 45	52 / 55	45 / 47	56 / 58
Kirribilli	17.2	75	65	53 / 63	64 / 73	54 / 65	65 / 75	47 / 55	58 / 66	54 / 61	65 / 71
	18.1	75	64	44 / 47	55 / 58	45 / 48	55 / 59	42 / 45	52 / 55	43 / 45	53 / 56
Neutral Bay	17.4	75	65	40 / 42	50 / 53	40 / 43	50 / 53	41 / 45	52 / 55	41 / 43	51 / 53

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-178 – Predicted construction noise levels – outside standard hours (residential receivers), dB(A)

Major works area/assessment reference						WFU1F_01		WFU1F_02		WFU1F_03		WFU1F_04	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$							
		HNA	Day (O)	Eve	Ngt								
McMahons Point	15.2	75	47	46	43	33 / 35	41 / 43	< 35	41 / 43	35 / 37	42 / 45	35 / 37	42 / 44
Lavender Bay	15.4	75	47	46	43	45 / 50	54 / 58	45 / 50	54 / 58	47 / 53	54 / 61	49 / 54	56 / 61
Milsons Point	16.1	75	65	65	55	45 / 54	53 / 62	44 / 54	52 / 62	47 / 58	54 / 65	43 / 59	50 / 66
North Sydney – south west	15.3	75	47	46	43	35 / 37	43 / 46	35 / 37	43 / 46	36 / 40	44 / 47	37 / 40	44 / 47
North Sydney – north west	19.1	75	57	57	50	37 / 38	45 / 47	36 / 38	45 / 47	41 / 44	49 / 51	38 / 40	45 / 47
North Sydney - east	17.3	75	60	59	50	49 / 57	57 / 66	49 / 57	57 / 66	48 / 60	56 / 67	49 / 54	55 / 60
	18.2	75	59	57	48	40 / 42	48 / 51	40 / 43	48 / 51	40 / 43	48 / 51	42 / 44	49 / 51
Kirribilli	17.2	75	60	59	50	48 / 58	56 / 66	49 / 60	57 / 68	46 / 54	53 / 61	51 / 58	58 / 65
	18.1	75	59	57	48	39 / 42	47 / 50	39 / 43	48 / 51	40 / 43	47 / 51	40 / 42	46 / 49
Neutral Bay	17.4	75	60	59	50	34 / 37	43 / 45	34 / 37	43 / 45	40 / 43	47 / 51	38 / 40	44 / 47

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-179 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1F_01	Typical	0	6	0	0	4	0	0	0	6	0	0	0	40	8	0	0	40	23
	Worst-case	0	59	6	0	38	8	0	0	43	13	0	0	89	71	2	0	52	45
WFU1F_02	Typical	0	6	0	0	4	0	0	0	7	0	0	0	41	8	0	0	43	26
	Worst-case	0	61	6	0	41	9	0	0	45	14	0	0	86	75	3	0	51	49
WFU1F_03	Typical	0	6	0	0	5	3	0	0	9	4	0	0	37	12	0	0	33	5
	Worst-case	0	29	6	0	27	14	0	0	34	18	0	0	168	73	6	0	47	13
WFU1F_04	Typical	0	6	0	0	6	3	0	0	9	4	0	0	44	9	0	0	47	7
	Worst-case	0	47	6	0	14	13	0	0	25	14	0	0	111	69	4	0	63	34

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-180 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU1F_01		WFU1F_02		WFU1F_03		WFU1F_04	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$							
Commercial	16.3	70	56 / 63	66 / 74	56 / 63	66 / 74	44 / 66	55 / 76	59 / 66	69 / 77
Childcare	15.3	50	< 35	35 / 37	< 35	38 / 40	< 35	33 / 37	40 / 43	50 / 53
	16.3	50	41 / 49	52 / 59	41 / 49	51 / 59	31 / 53	41 / 63	41 / 48	51 / 59
	17.1	50	39 / 41	49 / 51	39 / 41	49 / 52	34 / 37	44 / 47	40 / 42	50 / 52
Educational	15.3	55	43 / 46	53 / 56	43 / 45	53 / 56	39 / 42	49 / 52	37 / 39	47 / 50
Other sensitive receiver	16.2	70	53 / 59	64 / 69	53 / 59	64 / 69	50 / 59	61 / 69	56 / 62	66 / 72
	16.3	-[1]	51 / 58	61 / 68	50 / 58	61 / 68	44 / 66	54 / 76	50 / 58	60 / 68
	18.1	50	37 / 41	48 / 51	37 / 41	48 / 51	35 / 39	46 / 49	34 / 37	44 / 47
Place of worship	15.4	55	44 / 48	54 / 59	44 / 49	55 / 59	40 / 46	50 / 57	44 / 49	55 / 60
	16.1	55	38 / 47	49 / 58	38 / 47	48 / 58	35 / 46	45 / 56	28 / 44	38 / 55
Recreational	17.3	65	54 / 63	65 / 73	55 / 63	65 / 73	42 / 53	52 / 64	50 / 55	61 / 66

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-181 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU1F_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	1	0	0	3	0	0	1	0	0	2	0	0	2	0	0	2	0	0
WFU1F_02	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	1	0	0	3	0	0	1	0	0	2	0	0	2	0	0	2	0	0
WFU1F_03	Typical	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	6	0	0	1	1	0	0	0	0	0	0	0	2	0	0	2	0	
WFU1F_04	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	2	0	0	4	0	0	0	0	0	1	0	0	1	0	0	1	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.9 Warringah Freeway southbound widening (WFU1G)

The key activities of the proposed construction works include:

- Construction of a new southbound bus lane from Falcon Street
- Widening of Warringah Freeway to the east
- Construction of retaining walls.

The location of the works area and the surrounding noise-sensitive receivers is presented in Figure 5-25.

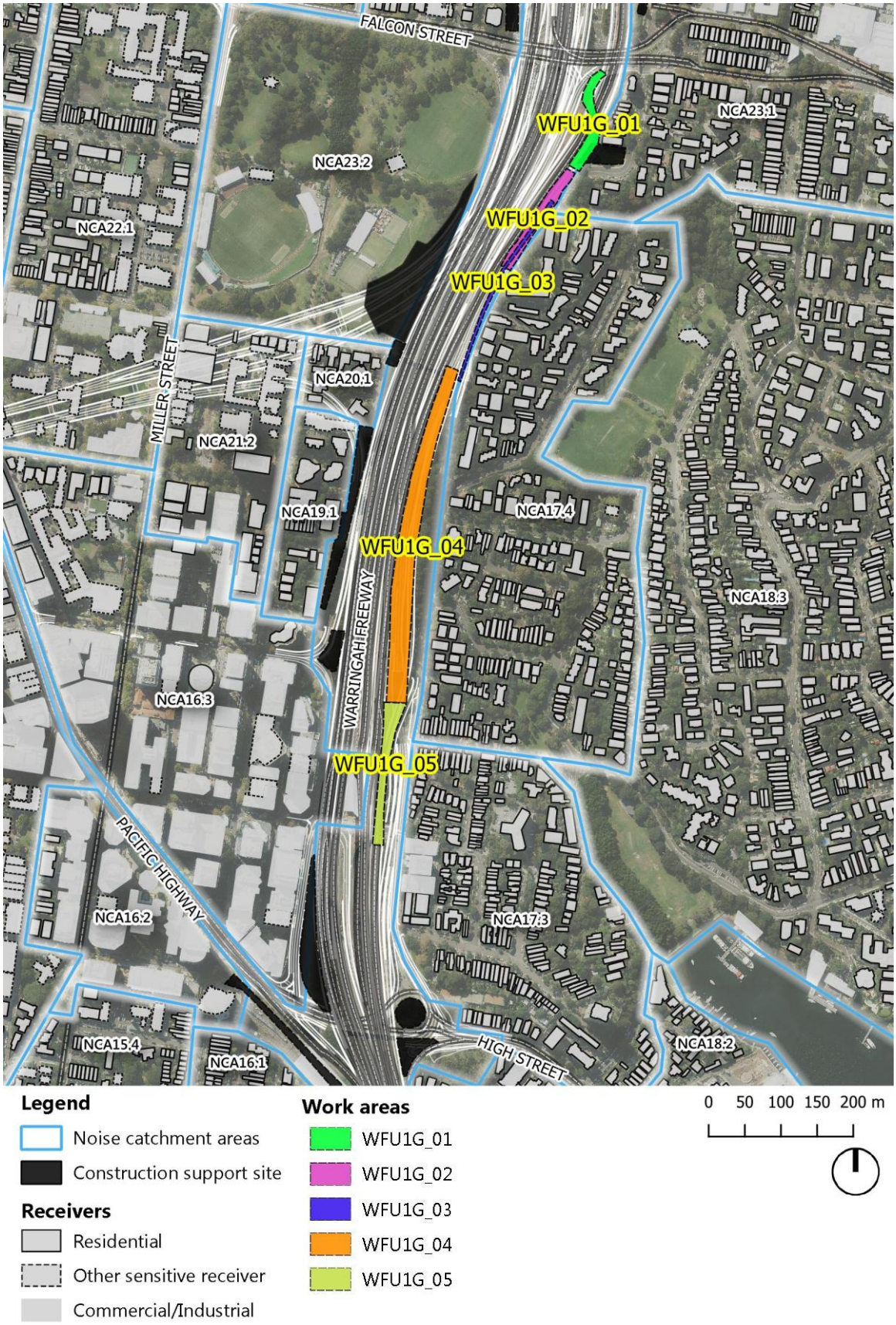
The approximate durations for the key construction activities within the major works area are outlined in Table 5-182. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-182 – Warringah Freeway southbound (WFU1G) – indicative duration of construction work

Works area reference	Stage	Duration
WFU1G_01	Construction of new bus lane bridge	12 months
WFU1G_02	Widening Warringah Freeway southbound	12 months
WFU1G_03	Widening Warringah Freeway southbound	9 months[1]
WFU1G_04	Widening Warringah Freeway southbound	6 months[1]
WFU1G_05	Retaining wall construction	9 months[1]

Notes: 1. WFU1G_03, WFU1G_04 and WFU1G_05 would likely be incorporated into the WFU1C construction work.

Figure 5-25 – Warringah Freeway southbound (WFU1G) - assessment work areas



5.9.2.9.1 Construction hours and durations

A portion of the proposed works would be carried out during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-183.

Table 5-183 – Required out of hours work - Warringah Freeway southbound (WFU1G)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU1G_01	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor 3. Completion of tie-ins at the extents of the road construction 4. Completion of temporary diversions and traffic switches	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU1G_02	Completion of tie-ins at the extents of the road construction	10	ROL required, impact on road network performance, safety for workers and road users within carriageway
WFU1G_03	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU1G_04	Completion of tie-ins at the extents of the road construction	10	ROL required, impact on road network performance, safety for workers and road users within carriageway
WFU1G_05	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically mitigate the OOHW noise impacts.

5.9.2.9.2 Construction assessment scenarios

The airborne noise assessment of the Warringah Freeway southbound works was separated into six work areas. Each work area was assessed against both standard construction hours and OOHW.

Presented in Table 5-184 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period noise impacts could be lower than predicted.

Table 5-184 – Assessed construction activities – Warringah Freeway southbound (WFU1G)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU1G_01	Clearing and grubbing works	112	116	Paving/asphalting/road surface works (including concrete sawing)	109	120
WFU1G_02	Demolition (rock hammering)	109	121	Pavement/road modification works	110	120
WFU1G_03	Demolition (rock hammering)	109	121	Concrete pours	110	114
WFU1G_04	Demolition (rock hammering)	109	121	Resurfacing works	108	117
WFU1G_05	Bulk earthwork	116	119	Resurfacing works	108	117

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.9.3 Construction noise prediction summary

Table 5-185, Table 5-186 and Table 5-188 present the predicted noise levels from construction activities and compares them with the NMLs. Table 5-187 and Table 5-189 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

The predicted noise levels generally do not exceed the NMLs for standard construction hours, except for NCAs 17.3, 17.4, 19.1, 20.1, 21.2 and 23.1, which are located either side of the Warringah Freeway in North Sydney and Neutral Bay. Results of the noise predictions are as follows:

- The highest predicted noise levels vary for each works area as the work areas are long and extend down various sections of the eastern side of the Warringah Freeway. Receiver buildings in NCAs 17.3, 17.4 and 23.1 which are directly east adjacent to the works areas, are impacted when demolition/excavation of the existing road require the use of rock hammers
- During typical activities up to four receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when works are in close proximity. However, as the works areas are over a large area, when worst-case activities occur there is the potential for up to 53 different receiver buildings to be highly noise affected across the various works areas. Of these 53 receiver buildings, between six and 28 are predicted to be highly noise affected in any one stage when construction activities are being carried out in close proximity to these receiver buildings
- During typical activities the highest noise impacts are not predicted to exceed the daytime NML by more than 16 dB(A). However, during worst-case activities, noise is predicted to increase to > 20 dB(A), which could be considered highly intrusive. This is predicted for up to five of the closest receiver buildings in NCA 17.4 during rock hammer activities for road demolition/excavation works (WFU1G_03).

During OOHW, the key activities that have been assessed are utilities modification, pavement and road modification works or clearing and grubbing. Results of the assessment are as follows:

- Over the entire works stage, during the night period up to 239 receiver buildings are predicted to exceed the night period NMLs during the typical construction activities. This number is predicted to increase to 2262 receiver buildings during the worst-case activities when a rock hammer or road saw is used as part of the WFU1G_03 works
- Over the entire works stage, both typical and worst-case construction activities have the potential to exceed the NML by more than 25 dB(A) at the nearest receiver buildings, which would be considered highly intrusive. This is predicted to occur for a range of up to two to five receiver buildings during typical works, and up to three to 11 receiver buildings during worst-case works.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Up to six childcare centre receivers located in NCAs 16.3,18.3, 22.3, and 23.2 of which only two are predicted to exceed the NML by up to 5-9 dB(A) during typical works, and 15-20 dB(A) during the worst-case works

- Up to two school receivers, where one has buildings located in NCAs 19.1 and 21.2, predicted to exceed the NML by up to 15 dB(A) during the worst-case works; while a second in NCA 15.3 has a marginal exceedance of 1 dB(A)
- An exceedance of up to 7 dB(A) is predicted at a theatre receiver in NCA 21.2 and up to 13 dB(A) at a library in NCA 16.3
- An exceedance of 8 dB(A) at a place of worship in each of NCA 22.1 and 23.1.
- Up to 4 dB(A) exceedance at three recreational receivers in NCA 16.3, 17.4 and 23.2
- Up to 11 dB(A) exceedance at three commercial buildings in NCA 16.3 and 17.3 for WFU1G_04 to WFU1G_05 works.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night construction works would be from air-brakes or metal-on-metal bangs during road tie-in and resurfacing works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow potential sleep disturbance from OOHW to be assessed and results are as follows:

- The predicted noise levels show exceedances of the sleep disturbance screening levels for the works
- During typical works, operations such as air-brakes are predicted to exceed the L_{Amax} sleep disturbance screening level at up to 124 receiver buildings. In addition, the L_{Amax} noise levels are predicted to exceed the awakening reaction levels at up to 80 receiver buildings across the works area
- During the worst-case construction activities, up to 1076 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level during the stage with the highest predicted noise levels. The L_{Amax} noise levels are predicted to exceed the awakening reaction level at up to 137 receiver buildings, with the greatest number of exceedances occurring in NCAs 17.3, 17.4 and 23.1.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the road works requiring road paving and surfacing works, in addition to concrete pours adjacent to and within live traffic corridors under an ROL, there are limited available noise source and noise path mitigation measures available during OOHW.

Careful use of close-proximity temporary noise barriers along the eastern boundary could provide some noise reduction to close receivers; however, for receivers further away any fixed mitigation on-site would provide limited noise reduction and so this has not been included in the modelling. The effectiveness of programming of noise-intensive activities, along with correct site planning and any potential temporary

mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated where feasible and reasonable as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.9.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-185 for residential receivers during standard construction hours
- Table 5-186 for residential receivers outside of standard construction hours
- Table 5-188 for non-residential receivers.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2; for all other non-residential receivers see section 3.4.1.

The number of receivers predicted to exceed NMLs during each stage and time period are summarised in Table 5-187 and Table 5-189. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest ‘typical’ noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-185 – Predicted construction noise levels – standard hours (residential receivers)

Major works area/assessment reference				WFU1G_01		WFU1G_02		WFU1G_03		WFU1G_04		WFU1G_05	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	NML										
Wollstonecraft	22.2	75	62	42 / 43	47 / 48	37 / 39	50 / 51	36 / 39	48 / 51	31 / 37	43 / 49	35 / 37	37 / 39
	30.4	75	68	39 / 40	43 / 44	36 / 37	49 / 50	34 / 36	47 / 49	< 35	41 / 45	< 35	< 35
Waverton	15.1	75	52	35 / 36	40 / 41	< 35	45 / 46	< 35	44 / 46	< 35	35 / 40	< 35	33 / 35
Lavender Bay	15.4	75	52	< 35	< 35	< 35	40 / 41	< 35	40 / 42	< 35	35 / 41	40 / 44	43 / 47
North Sydney - south west	15.3	75	52	37 / 38	42 / 43	35 / 36	47 / 49	33 / 36	46 / 49	30 / 38	43 / 50	< 35	< 35
	16.3	75	70	42 / 44	47 / 49	42 / 44	55 / 57	41 / 45	54 / 58	56 / 57	68 / 70	44 / 63	46 / 66
North Sydney - north west	19.1	75	62	44 / 46	48 / 51	44 / 47	56 / 59	43 / 51	56 / 63	52 / 61	65 / 74	55 / 62	57 / 65
	20.1	75	62	48 / 50	52 / 55	48 / 52	60 / 64	45 / 57	57 / 70	59 / 61	71 / 73	52 / 56	55 / 58
	21.1	75	63	45 / 48	49 / 53	39 / 42	51 / 55	37 / 42	49 / 54	30 / 35	42 / 48	37 / 39	40 / 41
	21.2	75	63	43 / 45	48 / 50	41 / 45	54 / 57	39 / 47	52 / 59	53 / 54	65 / 67	52 / 58	55 / 60
	22.1	75	62	44 / 47	49 / 51	40 / 43	53 / 55	37 / 42	50 / 54	28 / 39	41 / 52	39 / 42	41 / 44
	23.2	75	71	52 / 58	57 / 63	45 / 50	57 / 62	37 / 49	49 / 61	30 / 41	43 / 53	39 / 41	42 / 44
North Sydney - east	17.3	75	65	38 / 40	43 / 44	37 / 39	50 / 51	40 / 44	53 / 56	42 / 62	55 / 74	65 / 75	67 / **77**
	18.2	75	64	36 / 37	41 / 42	< 35	45 / 47	36 / 38	48 / 51	36 / 42	48 / 54	44 / 48	47 / 50
Kirribilli	17.2	75	65	36 / 37	41 / 42	34 / 35	46 / 47	35 / 37	48 / 50	34 / 40	47 / 53	46 / 50	49 / 53
Neutral Bay	17.4	75	65	56 / 64	61 / 69	51 / **76**	63 / **88**	51 / **81**	63 / **94**	46 / 69	58 / **81**	72 / **77**	75 / **80**
	18.3	75	64	47 / 52	52 / 57	46 / 51	59 / 64	42 / 50	54 / 63	35 / 50	47 / 62	52 / 57	54 / 59
	23.1	75	71	61 / **83**	65 / **88**	48 / 69	60 / **81**	48 / 64	61 / **77**	34 / 42	47 / 55	46 / 48	49 / 51
Crows Nest	22.3	75	62	43 / 46	48 / 50	39 / 41	51 / 53	37 / 41	49 / 53	< 35	42 / 47	37 / 39	40 / 41
	24.1	75	66	48 / 52	53 / 56	41 / 44	53 / 56	38 / 43	51 / 56	33 / 38	46 / 51	39 / 41	42 / 43
	30.1	75	68	37 / 38	42 / 43	< 35	45 / 46	< 35	44 / 45	< 35	36 / 39	< 35	35 / 36
Cammeray	25.1	75	68	43 / 46	48 / 50	38 / 40	50 / 52	34 / 38	47 / 50	< 35	42 / 46	37 / 39	40 / 41
	28.1	75	57	42 / 44	47 / 48	37 / 39	50 / 51	36 / 38	48 / 51	< 35	41 / 44	35 / 36	38 / 39
	29.1	75	74	43 / 44	47 / 49	37 / 38	49 / 51	36 / 38	48 / 51	< 35	40 / 43	35 / 36	37 / 39
	30.3	75	68	41 / 42	45 / 47	34 / 36	47 / 48	33 / 35	46 / 48	< 35	41 / 44	35 / 36	37 / 38
	31.2	75	66	37 / 38	42 / 43	< 35	45 / 46	< 35	43 / 45	< 35	39 / 41	< 35	35 / 36

Major works area/assessment reference				WFU1G_01		WFU1G_02		WFU1G_03		WFU1G_04		WFU1G_05	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	NML										
Cremorne	26.1	75	68	46 / 51	51 / 55	39 / 42	51 / 54	37 / 41	49 / 54	32 / 36	44 / 49	39 / 41	42 / 43
	27.1	75	59	36 / 37	40 / 42	< 35	45 / 46	< 35	44 / 46	< 35	38 / 42	< 35	36 / 37
Naremburn	31.1	75	66	34 / 35	39 / 40	< 35	42 / 43	< 35	41 / 42	< 35	38 / 40	< 35	< 35
	31.3	75	66	34 / 35	39	< 35	42 / 43	< 35	40 / 42	< 35	35 / 37	< 35	< 35

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-186 – Predicted construction noise levels – outside standard hours (residential receivers)

Major works area/assessment reference						WFU1G_01		WFU1G_02		WFU1G_03		WFU1G_04		WFU1G_05	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Wollstonecraft	22.2	75	57	52	41	39 / 41	51 / 52	39 / 40	49 / 51	37 / 40	41 / 44	30 / 37	39 / 46	< 35	35 / 38
	30.4	75	63	61	43	36 / 37	47 / 49	38 / 39	48 / 49	36 / 38	40 / 42	< 35	37 / 41	< 35	< 35
Waverton	15.1	75	47	46	43	< 35	44 / 45	34 / 35	44 / 46	33 / 35	37 / 39	< 35	31 / 36	< 35	< 35
Lavender Bay	15.4	75	47	46	43	< 35	38	< 35	40 / 41	< 35	33 / 35	< 35	31 / 37	32 / 36	41 / 45
North Sydney – south west	15.3	75	47	46	43	34 / 36	46 / 47	36 / 37	46 / 48	35 / 38	39 / 41	30 / 38	39 / 47	< 35	< 35
	16.3	75	65	65	55	40 / 41	51 / 53	44 / 46	54 / 56	43 / 47	47 / 51	55 / 57	64 / 66	36 / 55	44 / 64
North Sydney – north west	19.1	75	57	57	50	41 / 43	52 / 55	45 / 48	56 / 59	45 / 52	49 / 56	52 / 61	61 / 70	46 / 54	55 / 63
	20.1	75	57	57	50	45 / 48	56 / 59	49 / 53	59 / 63	46 / 59	50 / 62	59 / 61	67 / 70	44 / 47	53 / 56
	21.1	75	58	54	46	42 / 46	54 / 57	40 / 43	51 / 54	38 / 43	42 / 47	≤ 35	38 / 44	< 35	38 / 39
	21.2	75	58	54	46	40 / 43	52 / 54	43 / 46	53 / 56	41 / 48	45 / 52	53 / 54	62 / 63	44 / 49	53 / 58
	22.1	75	57	52	41	42 / 44	53 / 56	42 / 44	52 / 54	39 / 43	42 / 47	≤ 39	37 / 48	< 35	39 / 42
	23.2	75	66	59	49	49 / 56	61 / 67	46 / 51	56 / 61	38 / 50	42 / 54	30 / 40	39 / 49	< 35	40 / 42
North Sydney - east	17.3	75	60	59	50	36 / 37	47 / 49	39 / 40	49 / 51	42 / 45	46 / 49	42 / 61	51 / 70	57 / 66	66 / 75
	18.2	75	59	57	48	33 / 35	45 / 46	34 / 35	45 / 46	37 / 40	41 / 43	36 / 42	45 / 51	36 / 40	45 / 48
Kirribilli	17.2	75	60	59	50	< 35	45 / 46	35 / 36	45 / 46	37 / 39	41 / 43	34 / 40	43 / 49	38 / 42	47 / 51
Neutral Bay	17.4	75	60	59	50	54 / 62	65 / 73	52 / **77**	62 / **88**	52 / **83**	56 / **87**	46 / 69	54 / **78**	64 / 69	73 / **78**
	18.3	75	59	57	48	45 / 50	56 / 61	48 / 53	58 / 63	43 / 52	47 / 56	35 / 50	44 / 59	44 / 49	53 / 58
	23.1	75	66	59	49	58 / **80**	69 / **92**	49 / 70	59 / **80**	50 / 66	54 / 69	34 / 42	43 / 51	38 / 40	47 / 49
Crows Nest	22.3	75	57	52	41	41 / 43	52 / 54	40 / 42	50 / 53	38 / 42	42 / 46	< 35	38 / 43	< 35	38 / 39
	24.1	75	61	57	42	45 / 49	57 / 60	42 / 45	53 / 56	40 / 45	44 / 48	33 / 38	42 / 47	< 35	40 / 41
	30.1	75	63	61	43	34 / 36	46 / 47	34 / 35	44 / 45	< 35	36 / 38	< 35	32 / 35	< 35	33 / 35
Cammeray	25.1	75	63	60	48	41 / 43	52 / 55	39 / 41	49 / 51	36 / 39	40 / 43	< 35	39 / 43	< 35	38 / 39
	28.1	75	52	50	42	39 / 41	51 / 52	39 / 40	49 / 50	37 / 40	41 / 43	< 35	37 / 40	< 35	36 / 37
	29.1	75	69	68	52	40 / 42	51 / 53	38 / 40	48 / 50	37 / 40	41 / 44	< 35	36 / 39	< 35	36 / 37
	30.3	75	63	61	43	38 / 40	49 / 51	36 / 37	46 / 47	35 / 37	39 / 41	< 35	37 / 40	< 35	35 / 36
	31.2	75	61	54	42	35 / 36	46 / 47	34 / 35	44 / 45	< 35	36 / 38	< 35	35 / 38	< 35	< 35

Major works area/assessment reference						WFU1G_01		WFU1G_02		WFU1G_03		WFU1G_04		WFU1G_05	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Cremorne	26.1	75	63	59	46	44 / 48	55 / 59	40 / 43	51 / 54	38 / 43	42 / 46	31 / 36	40 / 45	< 35	40 / 42
	27.1	75	54	53	44	33 / 35	44 / 46	34 / 35	44 / 45	33 / 35	37 / 39	< 35	35 / 38	< 35	34 / 35
Naremburn	31.1	75	61	54	42	< 35	43 / 44	< 35	41 / 42	< 35	34 / 35	< 35	34 / 37	< 35	< 35
	31.3	75	61	54	42	< 35	43 / 44	< 35	41 / 42	< 35	< 35	< 35	< 35	< 35	< 35

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-187 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU1G_01	Typical	3	5	1	0	8	4	0	0	9	8	2	0	79	25	8	2	34	23
	Worst-case	8	12	2	0	24	18	3	1	126	30	8	3	1188	1031	32	11	1076	99
WFU1G_02	Typical	1	3	1	0	4	4	1	0	7	6	1	0	68	23	6	1	18	18
	Worst-case	7	15	4	1	41	13	4	1	87	26	7	1	1301	771	22	8	794	65
WFU1G_03	Typical	4	12	4	0	9	13	5	0	10	15	5	0	73	33	14	5	30	32
	Worst-case	20	26	14	5	14	15	5	2	20	20	5	2	439	63	17	7	59	46
WFU1G_04	Typical	0	20	0	0	29	19	0	0	35	21	0	0	136	84	19	0	124	80
	Worst-case	28	147	30	0	113	85	11	0	127	95	17	0	349	409	77	11	199	137
WFU1G_05	Typical	2	33	2	0	15	6	0	0	18	6	0	0	55	40	6	0	49	39
	Worst-case	6	48	6	0	47	38	3	0	53	41	6	0	381	224	37	3	81	66

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-188 – Predicted construction noise levels – standard hours (non-residential receivers)

Major works area/assessment reference			WFU1G_01		WFU1G_02		WFU1G_03		WFU1G_04		WFU1G_05	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
Commercial	16.3	70	36 / 37	40 / 42	37 / 39	50 / 52	40 / 45	53 / 57	57 / 59	70 / 71	59 / 78	62 / 81
	17.3	70	38 / 40	43 / 45	< 35	45 / 47	37 / 41	50 / 53	33 / 52	45 / 64	60 / 70	63 / 73
Childcare	16.3	50	38 / 40	43 / 45	39 / 41	51 / 53	38 / 43	51 / 55	56 / 57	68 / 70	47 / 66	49 / 69
	18.3	50	36 / 41	41 / 46	36 / 41	49 / 53	30 / 38	42 / 51	≤ 38	36 / 51	37 / 42	39 / 44
	22.3	50	40 / 43	45 / 47	36 / 38	48 / 51	34 / 38	47 / 51	< 35	36 / 41	< 35	< 35
	23.2	50	41 / 48	46 / 52	39 / 44	51 / 57	31 / 44	44 / 56	27 / 37	39 / 50	38 / 40	40 / 43
Educational	19.1	55	42 / 45	47 / 49	46 / 49	58 / 61	44 / 52	57 / 64	50 / 59	62 / 71	47 / 54	49 / 56
	21.2	55	43 / 45	48 / 50	42 / 45	54 / 58	38 / 46	51 / 58	49 / 51	62 / 64	44 / 50	47 / 52
Other sensitive receiver	16.3	55	36 / 37	41 / 42	34 / 36	47 / 49	35 / 39	47 / 51	45 / 47	58 / 59	43 / 63	46 / 65
	21.2	50	44 / 46	49 / 51	42 / 45	55 / 58	37 / 45	50 / 58	37 / 39	50 / 51	< 35	30 / 36
Place of worship	22.1	55	42 / 44	47 / 49	40 / 43	53 / 55	39 / 44	51 / 56	≤ 38	40 / 51	38 / 41	40 / 43
	23.1	55	25 / 48	30 / 52	30 / 51	42 / 63	31 / 47	44 / 60	34 / 42	46 / 54	43 / 45	46 / 48
Recreational	16.3	60	37 / 39	42 / 44	39 / 41	52 / 54	38 / 42	51 / 55	51 / 53	64 / 65	41 / 61	44 / 63
	17.4	60	< 35	29 / 37	≤ 37	≤ 50	≤ 40	≤ 53	≤ 51	41 / 64	51 / 56	54 / 58
	23.2	60	50 / 57	55 / 62	49 / 55	62 / 67	42 / 54	54 / 67	39 / 49	51 / 62	41 / 43	43 / 45

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-189 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU1G_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
WFU1G_02	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	6	0	0	2	0	0	2	0	0	1	0	0	1	0	0
WFU1G_03	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	5	0	0	2	0	0	2	0	0	2	0	0	1	0	0
WFU1G_04	Typical	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	1	0	0	1	2	0	1	1	0	3	0	0	0	0	0	2	0	0
WFU1G_05	Typical	1	0	0	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0
	Worst-case	2	1	0	0	2	0	1	0	0	1	0	0	0	0	0	1	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.10 Zone 2 (Falcon Street to Miller Street) construction works (WFU2H)

The key activities of the proposed construction works include:

- Realignment of Miller Street interchange ramps
- Construction of Western Harbour Tunnel tunnel structures
- Modification works to Ernest Street bridge.
- Cut and cover and trough structures
- Construction of New Brook / Miller Street on ramp bridge
- Stormwater works through ANZAC Park.
- Construction of the ventilation outlets within the Warringah Freeway corridor will also be carried out as part of the Western Harbour Tunnel, within the major works area WFU2H_06.

The location of the works area, and the surrounding noise-sensitive receivers is presented in Figure 5-26.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-190. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-190 – Zone 2 construction works (WFU2H) – indicative duration of construction work

Works area	Works area reference	Stage	Duration
Ernest Street bridge	WFU2H_01	Ernest Street underpass	18 months
	WFU2H_02	Ernest Street bridge widening	9 months
Tunnel structure works	WFU2H_03	Warringah Freeway southbound widening	3 months
	WFU2H_04	Warringah Freeway reconfiguration works	3 months
	WFU2H_05	Warringah Freeway reconfiguration works	3 months
	WFU2H_06	Warringah Freeway reconfiguration works	3 months
	WFU2H_07	Western Harbour Tunnel structure works	9 months
	WFU2H_08	Excavation works	6 months
	WFU2H_09	ANZAC Park stormwater works	6 months
	WFU2H_10	Cut and cover and trough structures	9 months
	WFU2H_11	Cut and cover and trough structures	9 months

Figure 5-26 – Zone 2 construction works (WFU2H) - assessment work areas



5.9.2.10.1 Construction hours and durations

A large portion of the proposed works would be carried out during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-191.

Table 5-191 – Required out of hours work – Zone 2 construction works (WFU2H)

Works area reference	Required OOHW	Percentage of program days OOHW is required[1]	Justification
WFU2H_01	1. Works adjacent to/within live traffic corridor 2. Oversized item delivery and installation 3. Concrete pours in/adjacent to road corridor	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU2H_02		20	
WFU2H_03	No typical OOH required	-	Standard construction hours, OOH not typically required.
WFU2H_04	1. Works adjacent to/within live traffic corridor	20	ROL required, impact on road network performance, safety for workers and road users within carriageway
WFU2H_05		20	
WFU2H_06		20	
WFU2H_07	1. Works adjacent to/within live traffic corridor 2. Oversized item delivery and installation 3. Concrete pours in/adjacent to road corridor	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU2H_08	1. Works adjacent to/within live traffic corridor 2. Concrete pours in/adjacent to road corridor	10	ROL required, impact on road network performance, safety for workers and road users within carriageway
WFU2H_09	1. Works adjacent to/within live traffic corridor	10	
WFU2H_10	No typical OOH required, except oversized deliveries	10	
WFU2H_11		10	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically mitigate the OOHW noise impacts.

5.9.2.10.2 Construction assessment scenarios

The airborne noise assessment of the WFU2H works was separated into 14 works areas. Each work area was assessed against both standard construction hours and OOHW.

Presented in Table 5-192 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-192 – Assessed construction activities – Zone 2 construction works (WFU2H)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU2H_01	Demolition (rock hammering)	109	121	Resurfacing works	112	118
WFU2H_02	Demolition (rock hammering)	109	121	Concrete pours	112	116
WFU2H_03	Bulk earthwork	116	120	-	-	-
WFU2H_04	Paving/asphalting/road surface works (including concrete sawing)	109	121	Resurfacing works	112	118
WFU2H_05	Demolition (rock hammering)	109	121	Demolition (rock hammering)	109	121
WFU2H_06	Demolition (rock hammering)	109	121	Demolition (rock hammering)	109	121
WFU2H_07	Demolition (rock hammering)	109	121	Concrete pours	112	116
WFU2H_08	Demolition (rock hammering)	109	121	Concrete pours	112	116
WFU2H_09	Utilities modification works	110	120	Utilities modification works	110	120
WFU2H_10	Demolition (rock hammering)	109	121	Paving/asphalting/road works (including road saws)	109	121
WFU2H_11	Piling	108	117	-	-	-

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.10.3 Construction noise prediction summary

Table 5-166 to Table 5-196 (for residential receivers) and Table 5-198 and Table 5-199 (non-residential) present the predicted noise levels from construction activities and compares them to the NMLs. Table 5-197 (residential) and Table 5-200 (non-residential) present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

The construction noise assessment has been broken into the following main sets of construction works:

- Ernest Street bridge modification work (WFU2H_01 and 02)
- Cut and cover portals, troughs and ramp works and ANZAC Park (WFU2H_03 to 11).

Residential receivers

The predicted noise levels do not exceed the NMLs for standard construction hours, except for some receivers in the following NCAs:

- Ernest Street bridge modification work – NCAs 23.1, 23.2, 24.1, 25.1, 26.1, 28.1
- Cut and cover portals, troughs and ramp works and ANZAC Park – NCAs 17.4, 23.2, 24.1, 25.1, 28.1, 29.1.

The above NCAs are located either side of the Warringah Freeway in North Sydney, Cammeray, Crows Nest and Neutral Bay.

Ernest Street bridge modification work (WFU2H_01 to 02)

During standard construction hours, the key activity that has been assessed is road modification works including the use of rock hammering activities The predicted results are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 23.1, 23.2 and 24.1, either side of the Ernest Street bridge, when rock hammers are required as part of demolition/rock -breaking activities.
- Over the entire works stage, no receiver buildings would be highly noise affected (ie. >75 dB(A)) during typical activities. However, there is the potential for up to three receiver buildings to be highly noise affected during periods of worst-case construction activities in close proximity and direct line of sight to nearby receiver buildings.

- During standard construction hours, the highest noise impacts could be moderately intrusive (greater than 11 dB(A) exceedance) from demolition activities for up to two receiver buildings mostly in NCA 23.1 during periods of worst-case construction activities.

During OOHW, the key activity that has been assessed is road resurfacing works and results are as follows:

- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during the night period up to 280 to 460 receiver buildings are predicted to exceed the NMLs during typical road resurfacing works. However, during periods of worst-case construction activities around 1050 to 1230 receiver buildings are predicted to exceed NMLs
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, in the worst-case, up to three receiver buildings are predicted to exceed the NML by more than 25 dB(A) which would be considered highly intrusive.

Cut and cover portals, troughs and ramp works and ANZAC Park (WFU2H_03 to 11)

During standard construction hours, the key activity that has been assessed is rock hammering and results are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 23.2 and 25.1 either side of the Warringah Freeway, when rock hammers are required for demolition and road modification work
- Over the entire works stage, up to two receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) during typical works, only when works are in very close proximity to receiver buildings. However, during periods of worst-case construction activities, it is predicted that up to 10 receiver buildings would be highly noise affected
- During standard construction hours, the highest noise impacts are predicted to be moderately intrusive (greater than 10 dB(A) exceedance) at 12 receiver buildings in NCA 29.1, due to worst-case earthworks construction in WFU2H_03.

During OOHW, the key activities that have been assessed are road demolition works, utility modification works, piling and concrete pours. Results of the assessment are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 23.2, 24.1 and 25.1
- For all works areas that have been assessed considering the one with the highest number of noise affected receiver buildings, during typical activities up to 120 to 380 receiver buildings are predicted to exceed the night NMLs. However when worst-case concrete saw rock hammering operations are required, this could increase to around 2100 receiver buildings above the NML
- When noise-intensive night concrete pour works are required (WFU2H_07/08), during typical work around 200-300 receiver buildings are predicted to exceed the NML which is predicted to increase to around 800 receiver buildings during periods of worst-case construction activities.

- In the stage with the highest predicted impacts (WFU2H_09 – ANZAC Park sewer works), up to 25 receiver buildings are predicted to exceed the NML by more than 25 dB(A), which would be considered highly intrusive.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Over the course of the Western Harbour Tunnel cut and cover portals and Ernest Street bridge work, the maximum numbers of other sensitive receivers that are predicted to exceed the NML for any one works area are:
  - one childcare centre receiver by up to 2 dB(A)
  - one educational receiver by up to 15 dB(A)
  - three recreational receivers by up to 14 dB(A).

Sleep disturbance

The most likely source of potential sleep disturbance from the night construction works would be from the use of rock hammer/s during road tie-in works or from air-brakes or metal-on-metal bangs. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow an assessment of the potential for sleep disturbance from OOHW. Results of the assessment are as follows:

- The predicted noise levels exceed the sleep disturbance screening level during worst-case and typical activities
- During typical activities across all the individual stages, air-brakes or metal-on-metal bangs of other equipment are predicted to exceed the awakening reaction levels at five to 33 receiver buildings
- During the worst-case activities across all the individual stages the maximum number of receiver buildings exceeding the L_{Amax} sleep disturbance screening level during worst-case works ranges from 116 to 827 receiver buildings; however, between only seven to 88 are predicted to exceed awakening reaction levels.

Summary of residual impacts and additional mitigation and management measures

Due to some works associated with the Western Harbour Tunnel cut and cover portals and Ernest Street bridge modification works required to be carried out under an ROL, there is limited opportunity for noise source and noise path mitigation measures to be available during OOHW.

Careful use of close-proximity temporary noise barriers during bridge works could provide some noise reduction to close receivers; however, for receivers further away any fixed mitigation on-site would be very limited and so has not been included in the modelling. The effectiveness of programming of noise-

intensive activities, along with correct site planning, and any potential temporary mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.10.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-193 and Table 5-194 for residential receivers during standard construction hours
- Table 5-195 and Table 5-196 for residential receivers during works outside of standard construction hours
- Table 5-198 and Table 5-199 for non-residential receivers.

The construction NMLs for all the nearest affected residential receivers are presented in Appendix B.1, and for all other non-residential receivers see section 3.4.1.

The number of receivers predicted to exceed NMLs during each stage and time period are summarised in:

- Table 5-197 for residential receivers
- Table 5-200 for non-residential receivers.

Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-193 – Predicted construction noise levels – standard hours (residential receivers) – Ernest Street bridge and cut and cover portals (WFU2H_01-06), dB(A)

Major works area/assessment reference				WFU2H_01		WFU2H_02		WFU2H_03		WFU2H_04		WFU2H_05		WFU2H_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	NML												
Wollstonecraft	22.2	75	62	35	47	33 / 35	45 / 47	39 / 44	43 / 48	30 / 36	42 / 48	33 / 35	45 / 47	33 / 36	45 / 48
	30.4	75	68	< 35	45 / 46	34 / 36	46 / 48	37 / 41	41 / 45	< 35	41 / 45	< 35	44 / 45	< 35	44 / 46
North Sydney – NW	20.1	75	62	36 / 37	48 / 49	35 / 37	47 / 49	38 / 44	42 / 48	≤ 44	41 / 56	< 35	44 / 46	33 / 36	45 / 48
	21.1	75	63	43 / 44	55 / 56	41 / 48	53 / 60	39 / 52	43 / 56	42 / 43	54 / 55	37 / 44	49 / 56	39 / 46	51 / 58
	21.2	75	63	37	49	35 / 37	47 / 49	38 / 44	42 / 48	≤ 41	41 / 53	33 / 35	45 / 47	33 / 36	45 / 48
	22.1	75	62	39	51	38 / 42	50 / 54	41 / 48	45 / 52	30 / 40	42 / 52	37 / 40	49 / 52	38 / 42	50 / 54
	23.2	75	71	50 / 53	62 / 65	48 / 69	60 / **81**	53 / 60	57 / 64	45 / 68	57 / **80**	46 / 60	58 / 72	51 / 57	63 / 69
Neutral Bay	17.4	75	65	40 / 41	52 / 53	40 / 43	52 / 55	37 / 46	41 / 50	42 / 56	54 / 68	37 / 40	49 / 52	36 / 40	48 / 52
	18.3	75	64	< 35	41 / 42	32 / 36	44 / 48	30 / 40	34 / 44	32 / 40	44 / 52	< 35	41 / 44	< 35	41 / 46
	23.1	75	71	60 / 75	72 / **87**	50 / 63	62 / 75	41 / 63	45 / 67	40 / 55	52 / 67	34 / 50	46 / 62	45 / 55	57 / 67
Crows Nest	22.3	75	62	36 / 42	48 / 54	42 / 47	54 / 59	40 / 53	44 / 57	≤ 43	41 / 55	39 / 44	51 / 56	38 / 43	50 / 55
	24.1	75	66	30 / 50	42 / 62	50 / 64	62 / **76**	47 / 59	51 / 63	42 / 59	54 / 71	52 / 58	64 / 70	≤ 54	39 / 66
	30.1	75	68	35	47	34 / 36	46 / 48	40 / 51	44 / 55	30 / 35	42 / 47	34 / 36	46 / 48	34 / 37	46 / 49
Cammeray	25.1	75	68	< 48	30 / 60	42 / 59	54 / 71	48 / 64	52 / 68	30 / 54	42 / 66	46 / 64	58 / **76**	52 / 59	64 / 71
	28.1	75	57	45 / 46	57 / 58	≤ 49	41 / 61	46 / 66	50 / 70	< 46	35 / 58	38 / 48	50 / 60	33 / 50	45 / 62
	29.1	75	74	46 / 47	58 / 59	< 50	23 / 62	49 / **88**	53 / **92**	47	59	32 / 51	44 / 63	51 / 55	63 / 67
	30.3	75	68	40 / 41	52 / 53	< 42	37 / 54	47 / 65	51 / 69	30 / 41	42 / 53	36 / 42	48 / 54	37 / 44	49 / 56
	31.2	75	66	36	48	36 / 38	48 / 50	43 / 51	47 / 55	30 / 37	42 / 49	33 / 37	45 / 49	34 / 38	46 / 50
Cremorne	26.1	75	68	58 / 59	70 / 71	34 / 56	46 / 68	50 / 58	54 / 62	41 / 46	53 / 58	38 / 47	50 / 59	< 49	30 / 61
	27.1	75	59	38 / 39	50 / 51	36 / 40	48 / 52	43 / 51	47 / 55	≤ 38	40 / 50	36 / 40	48 / 52	35 / 40	47 / 52
Naremburn	30.2	75	68	< 35	43	< 35	44 / 45	36 / 41	40 / 45	< 35	40 / 44	< 35	43 / 45	< 35	43 / 45
	31.1	75	66	< 35	44 / 45	< 35	45 / 46	36 / 44	40 / 48	< 35	41 / 45	< 35	44 / 46	< 35	44 / 46
	31.3	75	66	< 35	43 / 44	< 35	43 / 45	33 / 40	37 / 44	< 35	39 / 43	< 35	42 / 44	< 35	42 / 45
	37.1	75	55	< 35	41	< 35	41 / 42	34 / 39	38 / 43	< 35	38 / 41	< 35	40 / 42	< 35	41 / 43

Major works area/assessment reference				WFU2H_01		WFU2H_02		WFU2H_03		WFU2H_04		WFU2H_05		WFU2H_06	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level HNA	NML	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
Northbridge	38.1	75	62	< 35	42	< 35	43 / 44	35 / 40	39 / 44	< 35	39 / 43	< 35	42 / 43	< 35	42 / 43
	38.3	75	62	< 35	44 / 45	34 / 35	46 / 47	37 / 42	41 / 46	< 35	42 / 46	< 35	43 / 44	< 35	44 / 46
	39.1	75	47	< 35	< 35	< 35	< 35	35 / 37	39 / 41	< 35	< 35	< 35	37	< 35	37 / 38
	40.1	75	47	< 35	40	< 35	40 / 41	34 / 36	38 / 40	< 35	37 / 39	< 35	37 / 38	< 35	39 / 40

Notes:

1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-194 – Predicted construction noise levels – standard hours (residential receivers) – Cut and cover portal works and ANZAC Park (WFU2H_07-11), dB(A)

Major works area/assessment reference				WFU2H_07		WFU2H_08		WFU2H_09		WFU2H_10		WFU2H_11	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	NML										
Wollstonecraft	22.2	75	62	35 / 36	47 / 48	33 / 35	45 / 47	36 / 37	46 / 47	< 35	44 / 46	< 35	40 / 42
	30.4	75	68	34 / 35	46 / 47	< 35	42 / 44	34 / 36	44 / 46	< 35	41 / 43	< 35	39 / 41
North Sydney – north west	21.1	75	63	43 / 47	55 / 59	38 / 45	50 / 57	45 / 51	55 / 61	36 / 45	48 / 57	37 / 42	46 / 51
	21.2	75	63	35 / 36	47 / 48	33 / 35	45 / 47	37 / 38	47 / 48	< 35	43 / 45	< 35	40 / 42
	22.1	75	62	40 / 42	52 / 54	37 / 41	49 / 53	41 / 44	51 / 54	36 / 40	48 / 52	36 / 39	45 / 48
	23.2	75	71	35 / 59	47 / 71	33 / 51	45 / 63	55 / 61	65 / 71	39 / 68	51 / **80**	38 / 51	47 / 60
Neutral Bay	17.4	75	65	38 / 40	50 / 52	36 / 39	48 / 51	36 / 38	46 / 48	38 / 41	50 / 53	34 / 37	43 / 46
	23.1	75	71	44 / 51	56 / 63	38 / 46	50 / 58	43 / 49	53 / 59	≤ 50	39 / 62	33 / 52	42 / 61
Crows Nest	22.3	75	62	43 / 45	55 / 57	37 / 43	49 / 55	47 / 51	57 / 61	39 / 44	51 / 56	36 / 40	45 / 49
	24.1	75	66	46 / 56	58 / 68	39 / 51	51 / 63	54 / 69	64 / **79**	41 / 57	53 / 69	39 / 49	48 / 58
	30.1	75	68	35 / 36	47 / 48	37 / 40	49 / 52	36 / 37	46 / 47	33 / 35	45 / 47	34 / 36	43 / 45
Cammeray	25.1	75	68	57 / 60	69 / 72	48 / 60	60 / 72	68 / 75	**78** / **85**	41 / 67	53 / **79**	34 / 53	43 / 62
	28.1	75	57	43 / 47	55 / 59	45 / 48	57 / 60	43 / 47	53 / 57	39 / 48	51 / 60	≤ 50	37 / 59
	29.1	75	74	46 / 51	58 / 63	40 / 56	52 / 68	43 / 48	53 / 58	38 / 51	50 / 63	49 / 57	58 / 66
	30.3	75	68	40 / 43	52 / 55	30 / 43	42 / 55	40 / 43	50 / 53	37 / 43	49 / 55	37 / 43	46 / 52
	31.2	75	66	36 / 37	48 / 49	30 / 35	42 / 47	36 / 38	46 / 48	33 / 36	45 / 48	34 / 38	43 / 47
Cremorne	26.1	75	68	43 / 48	55 / 60	38 / 45	50 / 57	42 / 46	52 / 56	35 / 46	47 / 58	36 / 49	45 / 58
	27.1	75	59	38 / 40	50 / 52	35 / 39	47 / 51	37 / 39	47 / 49	37 / 40	49 / 52	36 / 41	45 / 50
Naremburn	30.2	75	68	< 35	44	33 / 35	45 / 47	< 35	43 / 44	< 35	43 / 45	< 35	40 / 41
	31.1	75	66	< 35	45 / 46	< 35	43 / 45	33 / 35	43 / 45	< 35	44 / 46	< 35	40 / 42
	31.3	75	66	< 35	43 / 44	< 35	42 / 45	< 35	42 / 43	< 35	42 / 44	< 35	39 / 41
	37.1	75	55	< 35	41	< 35	39 / 41	< 35	39 / 40	< 35	40 / 41	< 35	38 / 39
Northbridge	38.1	75	62	< 35	42 / 43	< 35	41 / 43	< 35	41 / 42	< 35	43 / 44	< 35	37 / 39
	38.3	75	62	< 35	44 / 45	< 35	41 / 43	< 35	42 / 43	< 35	43 / 45	< 35	40 / 42
	39.1	75	47	< 35	37	< 35	36 / 37	< 35	< 35	< 35	37 / 38	< 35	< 35
	40.1	75	47	< 35	39	< 35	37 / 38	< 35	37 / 38	< 35	39 / 40	< 35	35 / 36

Notes 1. As per Table 5-193.

Table 5-195 – Predicted construction noise levels – outside standard hours (residential receivers) – Ernest Street bridge and cut and cover portals (WFU2H_01-06), dB(A)

Major works area/assessment reference						WFU2H_01		WFU2H_02		WFU2H_03[6]		WFU2H_04		WFU2H_05		WFU2H_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day (O)	Eve	Ngt												
Wollstonecraft	22.2	75	57	52	41	38	44	36 / 38	40 / 42	-	-	33 / 39	39 / 45	33 / 35	45 / 47	33 / 36	45 / 48
	30.4	75	63	61	43	36 / 37	42 / 43	37 / 39	41 / 43	-	-	32 / 36	38 / 42	< 35	44 / 45	< 35	44 / 46
North Sydney – north west	20.1	75	57	57	50	39 / 40	45 / 46	38 / 40	42 / 44	-	-	32 / 47	38 / 53	< 35	44 / 46	33 / 36	45 / 48
	21.1	75	58	54	46	46 / 47	52 / 53	44 / 51	48 / 55	-	-	45 / 46	51 / 52	37 / 44	49 / 56	39 / 46	51 / 58
	21.2	75	58	54	46	40	46	38 / 40	42 / 44	-	-	32 / 44	38 / 50	33 / 35	45 / 47	33 / 36	45 / 48
	22.1	75	57	52	41	42	48	41 / 45	45 / 49	-	-	33 / 43	39 / 49	37 / 40	49 / 52	38 / 42	50 / 54
	23.2	75	66	59	49	53 / 56	59 / 62	51 / 72	55 / **76**	-	-	48 / 71	54 / **77**	46 / 60	58 / 72	51 / 57	63 / 69
Neutral Bay	17.4	75	60	59	50	43 / 44	49 / 50	43 / 46	47 / 50	-	-	45 / 59	51 / 65	37 / 40	49 / 52	36 / 40	48 / 52
	18.3	75	59	57	48	< 35	38 / 39	35 / 39	39 / 43	-	-	35 / 43	41 / 49	< 35	41 / 44	< 35	41 / 46
	23.1	75	66	59	49	63 / **78**	69 / **84**	53 / 66	57 / 70	-	-	43 / 58	49 / 64	34 / 50	46 / 62	45 / 55	57 / 67
Crows Nest	22.3	75	57	52	41	39 / 45	45 / 51	45 / 50	49 / 54	-	-	32 / 46	38 / 52	39 / 44	51 / 56	38 / 43	50 / 55
	24.1	75	61	57	42	33 / 53	39 / 59	53 / 67	57 / 71	-	-	45 / 62	51 / 68	52 / 58	64 / 70	≤ 54	39 / 66
	30.1	75	63	61	43	38	44	37 / 39	41 / 43	-	-	33 / 38	39 / 44	34 / 36	46 / 48	34 / 37	46 / 49
Cammeray	25.1	75	63	60	48	≤ 51	≤ 57	45 / 62	49 / 66	-	-	33 / 57	39 / 63	46 / 64	58 / **76**	52 / 59	64 / 71
	28.1	75	52	50	42	48 / 49	54 / 55	32 / 52	36 / 56	-	-	≤ 49	32 / 55	38 / 48	50 / 60	33 / 50	45 / 62
	29.1	75	69	68	52	49 / 50	55 / 56	≤ 53	25 / 57	-	-	50	56	32 / 51	44 / 63	51 / 55	63 / 67
	30.3	75	63	61	43	43 / 44	49 / 50	≤ 45	32 / 49	-	-	33 / 44	39 / 50	36 / 42	48 / 54	37 / 44	49 / 56
	31.2	75	61	54	42	39	45	39 / 41	43 / 45	-	-	33 / 40	39 / 46	33 / 37	45 / 49	34 / 38	46 / 50
Cremorne	26.1	75	63	59	46	61 / 62	67 / 68	37 / 59	41 / 63	-	-	44 / 49	50 / 55	38 / 47	50 / 59	25 / 49	30 / 61
	27.1	75	54	53	44	41 / 42	47 / 48	39 / 43	43 / 47	-	-	31 / 41	37 / 47	36 / 40	48 / 52	35 / 40	47 / 52
Naremburn	30.2	75	63	61	43	< 35	40	35 / 36	39 / 40	-	-	31 / 35	37 / 41	< 35	43 / 45	< 35	43 / 45
	31.1	75	61	54	42	35 / 36	41 / 42	36 / 37	40 / 41	-	-	32 / 36	38 / 42	< 35	44 / 46	< 35	44 / 46
	31.3	75	61	54	42	34 / 35	40 / 41	34 / 36	38 / 40	-	-	< 35	36 / 40	< 35	42 / 44	< 35	42 / 45
	37.1	75	50	49	39	< 35	38	< 35	36 / 37	-	-	< 35	35 / 38	< 35	40 / 42	< 35	41 / 43

Major works area/assessment reference						WFU2H_01		WFU2H_02		WFU2H_03[6]		WFU2H_04		WFU2H_05		WFU2H_06	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
		HNA	Day (O)	Eve	Ngt												
Northbridge	38.1	75	57	53	42	< 35	39	34 / 35	38 / 39	-	-	< 35	36 / 40	< 35	42 / 43	< 35	42 / 43
	38.3	75	57	53	42	35 / 36	41 / 42	37 / 38	41 / 42	-	-	33 / 37	39 / 43	< 35	43 / 44	< 35	44 / 46
	39.1	75	42	39	35	< 35	< 35	< 35	< 35	-	-	< 35	< 35	< 35	37	< 35	37 / 38
	40.1	75	42	42	38	< 35	37	< 35	35 / 36	-	-	< 35	34 / 36	< 35	37 / 38	< 35	39 / 40

Notes:
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.
6. No typical work is proposed outside standard construction hours

Table 5-196 – Predicted construction noise levels – outside standard hours (residential receivers) – Cut and cover portal works and ANZAC Park (WFU2H_07-11), dB(A)

Major works area/assessment reference						WFU2H_07		WFU2H_08		WFU2H_09		WFU2H_10		WFU2H_11[6]	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Wollstonecraft	22.2	75	57	52	41	38 / 39	42 / 43	36 / 38	40 / 42	36 / 37	46 / 47	< 35	44 / 46	-	-
	30.4	75	63	61	43	37 / 38	41 / 42	33 / 35	37 / 39	34 / 36	44 / 46	< 35	41 / 43	-	-
North Sydney – north west	21.1	75	58	54	46	46 / 50	50 / 54	41 / 48	45 / 52	45 / 51	55 / 61	36 / 45	48 / 57	-	-
	21.2	75	58	54	46	38 / 39	42 / 43	36 / 38	40 / 42	37 / 38	47 / 48	< 35	43 / 45	-	-
	22.1	75	57	52	41	43 / 45	47 / 49	40 / 44	44 / 48	41 / 44	51 / 54	36 / 40	48 / 52	-	-
	23.2	75	66	59	49	38 / 62	42 / 66	36 / 54	40 / 58	55 / 61	65 / 71	39 / 68	51 / **80**	-	-
Neutral Bay	17.4	75	60	59	50	41 / 43	45 / 47	39 / 42	43 / 46	36 / 38	46 / 48	38 / 41	50 / 53	-	-
	23.1	75	66	59	49	47 / 54	51 / 58	41 / 49	45 / 53	43 / 49	53 / 59	27 / 50	39 / 62	-	-
Crows Nest	22.3	75	57	52	41	46 / 48	50 / 52	40 / 46	44 / 50	47 / 51	57 / 61	39 / 44	51 / 56	-	-
	24.1	75	61	57	42	49 / 59	53 / 63	42 / 54	46 / 58	54 / 69	64 / **79**	41 / 57	53 / 69	-	-
	30.1	75	63	61	43	38 / 39	42 / 43	40 / 43	44 / 47	36 / 37	46 / 47	33 / 35	45 / 47	-	-
Cammeray	25.1	75	63	60	48	60 / 63	64 / 67	51 / 63	55 / 67	68 / 75	78 / **85**	41 / 67	53 / **79**	-	-
	28.1	75	52	50	42	46 / 50	50 / 54	48 / 51	52 / 55	43 / 47	53 / 57	39 / 48	51 / 60	-	-
	29.1	75	69	68	52	49 / 54	53 / 58	43 / 59	47 / 63	43 / 48	53 / 58	38 / 51	50 / 63	-	-
	30.3	75	63	61	43	43 / 46	47 / 50	33 / 46	37 / 50	40 / 43	50 / 53	37 / 43	49 / 55	-	-
	31.2	75	61	54	42	39 / 40	43 / 44	33 / 38	37 / 42	36 / 38	46 / 48	33 / 36	45 / 48	-	-
Cremorne	26.1	75	63	59	46	46 / 51	50 / 55	41 / 48	45 / 52	42 / 46	52 / 56	35 / 46	47 / 58	-	-
	27.1	75	54	53	44	41 / 43	45 / 47	38 / 42	42 / 46	37 / 39	47 / 49	37 / 40	49 / 52	-	-
Naremburn	30.2	75	63	61	43	35	39	36 / 38	40 / 42	< 35	43 / 44	< 35	43 / 45	-	-
	31.1	75	61	54	42	36 / 37	40 / 41	34 / 36	38 / 40	33 / 35	43 / 45	< 35	44 / 46	-	-
	31.3	75	61	54	42	34 / 35	38 / 39	33 / 36	37 / 40	< 35	42 / 43	< 35	42 / 44	-	-
	37.1	75	50	49	39	< 35	36	< 35	34 / 36	< 35	39 / 40	< 35	40 / 41	-	-

Major works area/assessment reference						WFU2H_07		WFU2H_08		WFU2H_09		WFU2H_10		WFU2H_11[6]	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Northbridge	38.1	75	57	53	42	< 35	37 / 38	< 35	36 / 38	< 35	41 / 42	< 35	43 / 44	-	-
	38.3	75	57	53	42	35 / 36	39 / 40	< 35	36 / 38	< 35	42 / 43	< 35	43 / 45	-	-
	39.1	75	42	39	35	< 35	< 35	< 35	< 35	< 35	< 35	< 35	37 / 38	-	-
	40.1	75	42	42	38	< 35	< 35	< 35	< 35	< 35	37 / 38	< 35	39 / 40	-	-

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.
6. No typical work is proposed outside standard construction hours

Table 5-197 – Highest noise level envelope – Number of residential buildings over the noise management level – Cut and cover portals and Ernest Street bridge work

Assessment reference	Typical / worst-case activity noise intensity	HNA	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU2H_01	Typical	0	1	0	0	1	2	0	0	3	3	1	0	237	39	5	1	38	**7**
	Worst-case	**3**	5	2	0	12	2	1	0	60	4	3	0	859	352	13	3	120	**8**
WFU2H_02	Typical	0	0	0	0	4	2	0	0	15	7	0	0	346	106	12	0	98	**17**
	Worst-case	**2**	23	0	0	18	5	0	0	81	17	1	0	671	354	24	3	297	**26**
WFU2H_03[4]	Typical	**2**	43	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Worst-case	**3**	108	12	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WFU2H_04	Typical	0	0	0	0	4	0	0	0	1	4	0	0	274	44	5	0	44	**5**
	Worst-case	**3**	9	0	0	12	4	0	0	60	5	1	0	698	434	8	2	117	**13**
WFU2H_05	Typical	0	0	0	0	1	0	0	0	7	0	0	0	89	37	2	0	59	**10**
	Worst-case	**1**	17	0	0	163	17	0	0	262	38	1	0	1085	713	51	6	678	**45**
WFU2H_06	Typical	0	0	0	0	0	0	0	0	0	0	0	0	171	43	0	0	96	**4**
	Worst-case	0	25	0	0	194	25	0	0	260	92	0	0	1225	885	72	0	827	**62**
WFU2H_07	Typical	0	0	0	0	0	0	0	0	5	0	0	0	307	75	1	0	70	**4**
	Worst-case	0	10	0	0	10	0	0	0	37	4	0	0	570	292	9	0	212	**7**
WFU2H_08	Typical	0	0	0	0	0	0	0	0	9	0	0	0	207	75	0	0	69	**6**
	Worst-case	0	17	0	0	17	0	0	0	33	3	0	0	515	187	12	0	116	**21**
WFU2H_09	Typical	0	4	0	0	10	4	0	0	21	11	0	0	101	52	21	4	64	**33**
	Worst-case	**10**	33	4	0	53	33	4	0	198	50	11	0	884	612	52	25	694	**88**
WFU2H_10	Typical	0	0	0	0	6	0	0	0	2	4	0	0	101	28	6	0	61	**8**
	Worst-case	**6**	15	2	0	175	15	2	0	251	40	6	0	858	618	50	7	617	**45**
WFU2H_11[4]	Typical	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Worst-case	0	10	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.
4. No typical work is proposed outside standard construction hours

Table 5-198 – Predicted construction noise levels – standard hours (non-residential receivers) – Cut and cover and Ernest Street bridge work (WFU2H_01-06), dB(A)

Major works area/assessment reference			WFU2H_01		WFU2H_02		WFU2H_03		WFU2H_04		WFU2H_05		WFU2H_06	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$											
Commercial	26.2	70	51 / 55	63 / 67	38 / 54	50 / 66	48 / 61	52 / 65	44 / 46	56 / 58	39 / 47	51 / 59	≤ 50	39 / 62
	30.3	70	38 / 39	50 / 51	≤ 42	37 / 54	50 / 67	54 / 71	30 / 40	42 / 52	36 / 42	48 / 54	34 / 42	46 / 54
Childcare	28.1	50	38 / 39	50 / 51	≤ 42	34 / 54	33 / 53	37 / 57	≤ 39	≤ 51	30 / 40	42 / 52	≤ 40	35 / 52
Educational	25.1	55	≤ 45	≤ 57	35 / 52	47 / 64	43 / 58	47 / 62	23 / 47	35 / 59	32 / 50	44 / 62	42 / 50	54 / 62
	31.2	55	37	49	37 / 39	49 / 51	46 / 54	50 / 58	32 / 39	44 / 51	37 / 40	49 / 52	37 / 41	49 / 53
Other sensitive receiver	21.2	50	38	50	35 / 37	47 / 49	38 / 44	42 / 48	≤ 40	40 / 52	34 / 36	46 / 48	34 / 36	46 / 48
	26.1	70	61 / 62	73 / 74	34 / 56	46 / 68	51 / 59	55 / 63	43 / 48	55 / 60	37 / 46	49 / 58	≤ 50	31 / 62
Place of worship	28.1	55	39 / 40	51 / 52	≤ 42	35 / 54	33 / 54	37 / 58	≤ 40	≤ 52	31 / 41	43 / 53	≤ 42	37 / 54
Recreational	23.2	65	49 / 51	61 / 63	33 / 54	45 / 66	49 / 56	53 / 60	37 / 60	49 / 72	38 / 52	50 / 64	45 / 51	57 / 63
	25.1	60	≤ 46	≤ 58	40 / 57	52 / 69	41 / 57	45 / 61	≤ 49	37 / 61	33 / 51	45 / 63	42 / 49	54 / 61
	26.2	60	52 / 57	64 / 69	38 / 54	50 / 66	48 / 61	52 / 65	44 / 46	56 / 58	39 / 48	51 / 60	≤ 50	40 / 62

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-199 – Predicted construction noise levels – standard hours (non-residential receivers) – Cut and cover and Ernest Street bridge work (WFU2H_07-09), dB(A)

Major works area/assessment reference			WFU2H_07		WFU2H_08		WFU2H_09		WFU2H_10		WFU2H_11	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
Commercial	26.2	70	43 / 49	55 / 61	35 / 45	47 / 57	41 / 45	51 / 55	39 / 47	51 / 59	≤ 48	≤ 57
Childcare	28.1	50	35 / 40	47 / 52	35 / 38	47 / 50	35 / 39	45 / 49	32 / 40	44 / 52	≤ 40	≤ 49
Educational	25.1	55	48 / 51	60 / 63	39 / 51	51 / 63	53 / 60	63 / 70	≤ 50	36 / 62	≤ 46	36 / 55
Recreational	25.1	60	49 / 51	61 / 63	37 / 49	49 / 61	57 / 64	67 / 74	≤ 53	38 / 65	≤ 44	34 / 53
	26.2	60	43 / 49	55 / 61	35 / 45	47 / 57	41 / 45	51 / 55	39 / 47	51 / 59	≤ 48	≤ 57

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-200 – Number of non-residential receivers over the noise management level – Cut and cover portals and Ernest Street bridge work

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU2H_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	5	0	0	0	0	0	1	0	0
WFU2H_02	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	6	0	0	0	0	0	0	0	0
WFU2H_03	Typical	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0
	Worst-case	1	0	0	1	0	0	3	0	0	5	0	0	1	0	0	0	0	0
WFU2H_04	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	3	0	0	0	0	0	1	0	0
WFU2H_05	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0
WFU2H_06	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	3	0	0	0	0	0	0	0	0
WFU2H_07	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	2	0	0	0	0	0	0	0	0
WFU2H_08	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
WFU2H_09	Typical	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0
WFU2H_10	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0
WFU2H_11	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.11 Zone 3 (Miller Street to Willoughby Road) construction works (WFU3I)

The key activities of the proposed construction works include:

- Widening of Willoughby Road off ramp
- Widening of Warringah Freeway northbound and Brook Street off ramp
- Widening of Warringah Freeway northbound approach to Brook Street
- Widening for new Warringah Freeway southbound lanes
- Widening of Warringah Freeway northbound lanes.

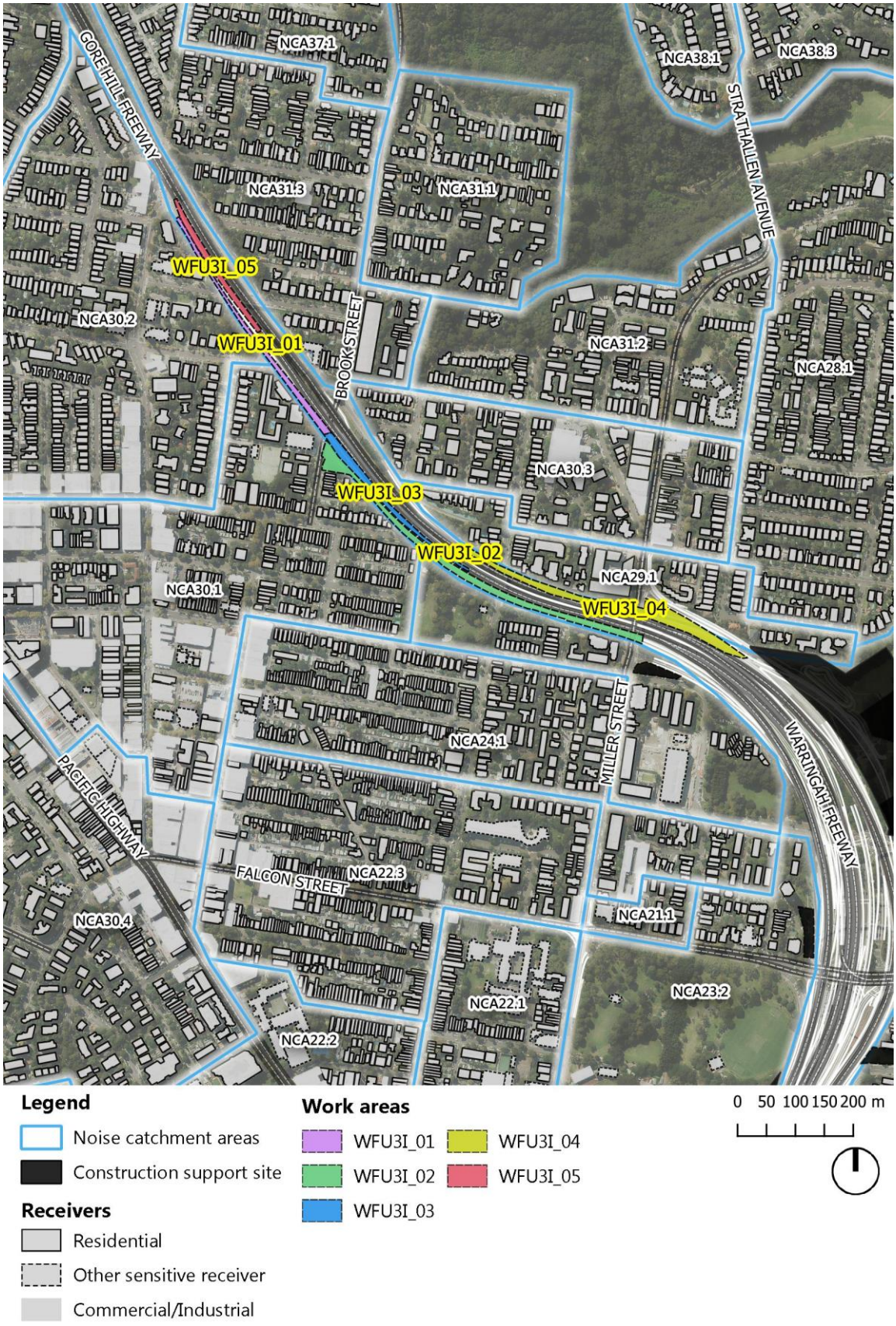
The location of the works area, and the surrounding noise-sensitive receivers are presented in Figure 5-27.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-201. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-201 – Zone 3 construction works (WFU3I) – indicative duration of construction work

Works area reference	Stage	Duration
WFU3I_01	Warringah Freeway northbound widening works	6 months
WFU3I_02	Warringah Freeway northbound widening works	6 months
WFU3I_03	Warringah Freeway northbound widening works	6 months
WFU3I_04	Warringah Freeway southbound widening works	6 months
WFU3I_05	Warringah Freeway southbound widening works	6 months

Figure 5-27 – Zone 3 construction works (WFU3I) - assessment work areas



5.9.2.11.1 Construction hours and durations

A large amount of the proposed works would be carried out during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-202.

Table 5-202 – Required out of hours work – Zone 3 construction works (WFU3I)

Works area reference	Required OOHW	Percentage of program days OOHW is required	Justification
WFU3I_01	1. Works adjacent to/within live traffic corridor	10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during construction/demolition of bridge elements. 2. Large load lifts over existing roads 3. Impact on road network performance/safety from oversized loads
WFU3I_02		10	
WFU3I_03	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor	10	
WFU3I_04	1. Works adjacent to/within live traffic corridor	10	
WFU3I_05	1. Oversized item delivery and installation 2. Concrete pours in/adjacent to road corridor	10	

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the mitigation and management measures recommended to specifically mitigate the OOHW noise impacts.

5.9.2.11.2 Construction assessment scenarios

The airborne noise assessment of the Miller Street to Willoughby Road works was separated into five works areas. Each work area was assessed against both standard construction hours and OOHW.

Presented in Table 5-203 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further

explanation of assessment scenarios). Where plant items are not operating simultaneously, or for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-203 – Assessed construction activities - Zone 3 construction works (WFU3I)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU3I_01	Utilities modification works	110	120	Earthworks	116	119
WFU3I_02	Demolition (rock hammering)	109	121	Earthworks	116	119
WFU3I_03	Utilities modification works	110	120	Concrete pours	110	114
WFU3I_04	Demolition (rock hammering)	109	121	Demolition (rock hammering)	109	121
WFU3I_05	Utilities modification works	110	120	Demolition (rock hammering)	109	121

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.11.3 Construction noise prediction summary

Table 5-204, Table 5-205 and Table 5-207 present the predicted noise levels from construction activities and compares them to the NMLs. Table 5-206 and Table 5-208 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

During standard construction hours, the key activity that has been assessed is rock hammering associated with demolition or utility modification works and results are as follows:

- The predicted noise levels generally do not exceed the NMLs for standard construction hours, except for NCAs 24.1, 25.1, 28.1, 29.1, 30.1, 30.2, 30.3, 31.1, 31.3 and 37.1
- The highest predicted noise levels vary for each works area as the areas are long and extend along different sections of the Warringah Freeway. Receiver buildings in NCAs 25.1, 29.1, 30.1, 30.3 and 30.2 have the highest predicted noise levels as they are directly adjacent to the works areas, when the use of rock hammers are required in close proximity
- Over the entire works stage, during typical activities, up to 10 receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when works are in close proximity to nearby receiver buildings. However, during periods of worst-case construction activities there is the potential for this to increase to 60 different receiver buildings

- During standard construction hours, the highest noise impacts could be highly intrusive (> 20 dB(A) exceedance) for up to six of the closest receiver buildings in NCAs 25.1 and 30.1.

During OOHW, the key activities that have been assessed are earthworks or rock -breaking activities associated with excavation works adjacent to the Warringah Freeway. Results of the assessment are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 30.1, 25.1, 29.1, 30.2, 30.3, and 31.3
- During the night period, around 200 to 700 receiver buildings are predicted to be noise affected during the typical earthworks. During periods of worst-case activities associated with excavation works such as rock hammering, (WFUI_01, 02, 04, 05) the number is predicted to increase to 3100 to 3700 receiver buildings. For WFU3I_03 during concrete pours, around 650 receiver buildings are predicted to exceed the NML. However, during periods of worst-case works this number of receiver buildings is predicted to increase to around 1100
- The highest predicted impacts during the WFU3I_02 stage are at up to eight receiver buildings, which are predicted to exceed the NML by greater than 25 dB(A) which is considered to be highly intrusive.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers

- Three childcare centre receivers by up to 18 dB(A) across NCAs 25.2, 30.2 and 36.1
- Nine educational receivers by up to 23 dB(A) across NCAs 22.3, 25.1, 30.1, 30.2, 31.2 and 31.3
- Three places of worship by up to 11 dB(A) across NCAs 28.1, 30.1 and 30.2
- Three recreational receivers by up to 15 dB(A)
- One hotel by up to 22 dB(A) in NCA 30.1
- 11 commercial premises by up to 5 dB(A).

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night time construction works would be from the use of rock hammer/s during road tie-ins or road excavation/trenching works. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow for an assessment of the potential for sleep disturbance from OOHW. Results of the assessment are as follows:

- The predicted noise levels show exceedances of the sleep disturbance screening levels during worst-case and typical activities.

- During typical operations, predicted noise levels from air-brakes or metal-on-metal bangs of other equipment exceed the awakening reaction level during any one set of works at around 10 to 100 receiver buildings.
- During the worst-case individual stage, up to 1745 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level and up to 289 receiver buildings are predicted to exceed the awakening reaction level.

Summary of residual impacts and additional mitigation and management measures

Due to the nature of the road construction works adjacent to and within the Warringah Freeway live traffic corridor, which would have to take place under an ROL, there are limited available noise source and noise path mitigation measures available during OOHW.

Careful use of close-proximity temporary noise barriers could provide some noise reduction to receivers close to the works, as there are stages where the adjacent residential suburbs are at or below the road surface levels. However, in many other cases the residential receivers are located higher than the road surface, minimising the benefits of fixed noise mitigation measures.

For receivers further away, any on-site fixed mitigation measures would have limited effectiveness and so have not been included in the modelling. The effectiveness of programming of noise-intensive activities, along with correct site planning, and any potential temporary mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.11.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-204 for residential receivers during standard construction hours
- Table 5-205 for residential receivers during works outside of standard construction hours
- Table 5-207 for non-residential receivers.

The construction NMLs for all the nearest affected residential receivers are presented in Appendix B.1; for all other non-residential receivers see section 3.4.1.

The numbers of receivers predicted to exceed NMLs during each stage and time period are summarised in Table 5-206 and Table 5-208. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-204 – Predicted construction noise levels – standard hours (residential receivers)

Major works area/assessment reference				WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	NML										
Wollstonecraft	22.2	75	62	< 35	42 / 45	< 35	40 / 46	32 / 35	42 / 45	32 / 38	45 / 50	< 35	41 / 43
	30.4	75	68	30 / 36	42 / 48	≤ 36	41 / 49	35 / 38	45 / 49	33 / 38	45 / 51	31 / 35	41 / 45
Waverton	15.1	75	52	< 35	38 / 40	< 35	34 / 38	< 35	37 / 39	< 35	39 / 43	< 35	< 35
North Sydney - south west	15.3	75	52	< 35	37 / 39	< 35	37 / 41	< 35	36 / 37	< 35	41 / 44	< 35	37 / 38
North Sydney - north west	21.1	75	63	< 35	41 / 44	< 35	40 / 48	< 35	41 / 44	36 / 46	48 / 58	< 35	42 / 43
	21.2	75	63	< 35	40 / 42	< 35	40 / 45	< 35	40 / 42	33 / 37	46 / 50	< 35	38 / 39
	22.1	75	62	< 35	44 / 47	≤ 37	42 / 50	32 / 35	42 / 45	34 / 41	46 / 54	< 35	42 / 43
	23.2	75	71	32 / 35	44 / 47	32 / 39	46 / 52	35 / 38	45 / 48	38 / 47	50 / 59	< 35	43 / 45
Neutral Bay	17.4	75	65	< 35	43 / 45	< 35	43 / 47	< 35	43 / 45	35 / 39	47 / 52	< 35	40 / 42
	23.1	75	71	< 35	43 / 45	34 / 40	47 / 53	33 / 35	44 / 46	37 / 44	50 / 57	< 35	41 / 42
Crows Nest	22.3	75	62	35 / 40	48 / 52	≤ 41	40 / 54	35 / 39	45 / 50	31 / 46	44 / 59	34 / 36	44 / 46
	24.1	75	66	38 / 45	50 / 57	48 / 54	61 / 67	40 / 49	50 / 59	46 / 55	59 / 67	38 / 41	49 / 52
	30.1	75	68	40 / **78**	52 / **90**	43 / **84**	52 / **90**	59 / **77**	67 / **85**	46 / 60	58 / 73	48 / 60	58 / 71
Cammeray	25.1	75	68	37 / 42	49 / 55	42 / **77**	55 / **90**	44 / 52	54 / 63	49 / 65	62 / **77**	36 / 39	47 / 49
	28.1	75	57	36 / 40	49 / 52	35 / 46	48 / 59	37 / 40	47 / 51	54 / 56	67 / 68	34 / 36	44 / 46
	29.1	75	74	43 / 52	56 / 65	43 / 65	56 / **78**	51 / 66	61 / **77**	44 / 84	56 / **90**	42 / 46	53 / 56
	30.3	75	68	40 / 56	52 / 68	53 / 64	66 / **77**	51 / 67	62 / **78**	42 / 59	54 / 72	43 / 50	54 / 60
	31.2	75	66	37 / 50	50 / 63	≤ 46	≤ 59	39 / 51	49 / 61	≤ 43	40 / 56	36 / 40	46 / 51
Cremorne	26.1	75	68	≤ 35	43 / 45	34 / 39	47 / 52	34 / 36	44 / 46	38 / 44	50 / 56	< 35	40 / 42
	27.1	75	59	< 35	43 / 45	33 / 38	46 / 51	< 35	43 / 44	36 / 42	49 / 54	< 35	39 / 40
Naremburn	30.2	75	68	35 / 73	48 / **85**	40 / 52	53 / 65	45 / 52	55 / 63	37 / 43	50 / 56	56 / 72	67 / **82**
	31.1	75	66	≤ 49	41 / 61	36 / 48	49 / 61	45 / 51	55 / 61	33 / 41	46 / 53	34 / 42	44 / 52
	31.3	75	66	46 / 65	58 / **77**	32 / 54	45 / 67	45 / 58	56 / 68	34 / 42	46 / 55	50 / 66	60 / **77**
	32.1	75	69	36 / 42	48 / 55	31 / 36	44 / 49	34 / 37	44 / 47	< 35	43 / 47	38 / 43	49 / 54
	37.1	75	55	36 / 44	48 / 56	30 / 36	43 / 49	34 / 37	44 / 47	< 35	41 / 45	39 / 45	50 / 55

Major works area/assessment reference				WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	NML										
Artarmon	33.2	75	65	< 35	42 / 45	31 / 35	44 / 48	35 / 37	45 / 47	< 35	44 / 47	32 / 35	43 / 45
	34.1	75	54	< 35	42 / 44	< 35	41 / 43	< 35	40 / 41	< 35	37 / 39	34 / 35	44 / 46
Willoughby	36.1	75	60	38 / 42	50 / 54	31 / 35	44 / 48	34 / 36	44 / 46	< 35	41 / 44	39 / 42	50 / 53
Northbridge	38.1	75	62	34 / 38	46 / 51	32 / 38	45 / 51	38 / 40	48 / 50	31 / 36	43 / 48	35 / 38	46 / 48
	38.2	75	62	32 / 35	44 / 47	32 / 35	45 / 48	36 / 37	46 / 48	< 35	42 / 45	34 / 36	44 / 46
	38.3	75	62	32 / 35	44 / 48	31 / 36	44 / 49	37 / 39	47 / 49	30 / 35	43 / 48	< 35	43 / 45

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-205 – Predicted construction noise levels – outside standard hours (residential receivers)

Major works area/assessment reference						WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Wollstonecraft	22.2	75	63	61	43	< 35	41 / 44	< 35	38 / 44	32 / 35	36 / 38	32 / 38	45 / 50	< 35	42 / 43
	30.4	75	57	52	41	30 / 36	41 / 47	≤ 36	39 / 47	35 / 38	38 / 42	33 / 38	45 / 51	< 35	42 / 46
Waverton	15.1	75	47	46	43	< 35	36 / 39	< 35	32 / 36	< 35	< 35	< 35	39 / 43	< 35	< 35
North Sydney - south west	15.3	75	47	46	43	< 35	36 / 38	< 35	35 / 39	< 35	< 35	< 35	41 / 44	< 35	37 / 38
North Sydney - north west	21.1	75	58	54	46	< 35	40 / 43	< 35	38 / 46	< 35	35 / 37	36 / 46	48 / 58	< 35	42 / 44
	21.2	75	58	54	46	< 35	39 / 41	< 35	38 / 43	< 35	34 / 36	33 / 37	46 / 50	< 35	39 / 40
	22.1	75	57	52	41	< 35	42 / 46	≤ 37	40 / 48	32 / 35	36 / 39	34 / 41	46 / 54	< 35	42 / 44
	23.2	75	66	59	49	32 / 35	43 / 46	32 / 39	44 / 51	35 / 38	39 / 41	38 / 47	50 / 59	< 35	44 / 45
Neutral Bay	17.4	75	60	59	50	< 35	41 / 43	< 35	41 / 45	< 35	36 / 38	35 / 39	47 / 52	< 35	41 / 42
	23.1	75	66	59	49	< 35	42 / 44	34 / 40	46 / 51	33 / 35	37 / 39	37 / 44	50 / 57	< 35	41 / 43
Crows Nest	22.3	75	63	61	43	35 / 40	46 / 51	≤ 41	38 / 52	35 / 39	38 / 43	31 / 46	44 / 59	< 35	45 / 47
	24.1	75	57	52	41	38 / 45	49 / 56	48 / 54	59 / 65	40 / 49	44 / 53	46 / 55	59 / 67	37 / 40	49 / 52
	30.1	75	61	57	42	40 / **78**	51 / **89**	43 / **84**	52 / **90**	59 / **77**	63 / **81**	46 / 60	58 / 73	47 / 59	59 / 71
Cammeray	25.1	75	63	61	43	37 / 42	48 / 53	42 / **77**	53 / **88**	44 / 52	47 / 56	49 / 65	62 / **77**	35 / 37	47 / 50
	28.1	75	61	54	42	36 / 40	47 / 51	35 / 46	47 / 58	37 / 40	40 / 44	54 / 56	67 / 68	< 35	45 / 47
	29.1	75	63	60	48	43 / 52	55 / 64	43 / 65	54 / **77**	51 / 66	55 / 70	44 / **84**	56 / **90**	41 / 44	53 / 57
	30.3	75	52	50	42	40 / 56	51 / 67	53 / 64	64 / 75	51 / 67	55 / 71	42 / 59	54 / 72	42 / 48	54 / 61
	31.2	75	69	68	52	37 / 50	48 / 61	≤ 46	≤ 57	39 / 51	43 / 54	≤ 43	40 / 56	34 / 39	47 / 51
Cremorne	26.1	75	63	59	46	< 35	42 / 44	34 / 39	45 / 50	34 / 36	38 / 40	38 / 44	50 / 56	< 35	41 / 42
	27.1	75	54	53	44	< 35	42 / 44	33 / 38	44 / 49	< 35	36 / 38	36 / 42	49 / 54	< 35	40 / 41
Naremburn	30.2	75	63	61	43	35 / 73	46 / **84**	40 / 52	51 / 63	45 / 52	49 / 56	37 / 43	50 / 56	55 / 70	67 / **83**
	31.1	75	61	54	42	≤ 49	40 / 60	36 / 48	47 / 59	45 / 51	48 / 55	33 / 41	46 / 53	32 / 41	45 / 53
	31.3	75	61	54	42	46 / 65	57 / **76**	32 / 54	43 / 65	45 / 58	49 / 62	34 / 42	46 / 55	48 / 65	61 / **77**
	32.1	75	64	60	45	36 / 42	47 / 53	31 / 36	42 / 47	34 / 37	38 / 41	< 35	43 / 47	37 / 42	49 / 54
	37.1	75	50	49	39	36 / 44	47 / 55	30 / 36	41 / 47	34 / 37	38 / 41	< 35	41 / 45	38 / 44	50 / 56
Artarmon	33.2	75	60	58	45	< 35	40 / 44	31 / 35	42 / 46	35 / 37	38 / 41	< 35	44 / 47	< 35	43 / 46
	34.1	75	49	49	42	< 35	41 / 43	< 35	39 / 41	< 35	< 35	< 35	37 / 39	< 35	45 / 46

Major works area/assessment reference						WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
		HNA	Day (O)	Eve	Ngt										
Willoughby	36.1	75	55	53	43	38 / 42	49 / 53	31 / 35	42 / 46	34 / 36	38 / 40	< 35	41 / 44	38 / 41	50 / 53
Northbridge	38.1	75	57	53	42	34 / 38	45 / 49	32 / 38	43 / 49	38 / 40	41 / 44	31 / 36	43 / 48	34 / 36	46 / 49
	38.2	75	57	53	42	32 / 35	43 / 46	32 / 35	43 / 46	36 / 37	39 / 41	< 35	42 / 45	< 35	45 / 47
	38.3	75	57	53	42	32 / 35	43 / 46	31 / 36	42 / 47	37 / 39	40 / 43	30 / 35	43 / 48	< 35	43 / 45

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-206 – Highest noise level envelope – Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU3I_01	Typical	2	7	0	0	10	7	0	0	22	17	2	0	354	224	39	7	455	60
	Worst-case	17	63	9	2	91	52	7	1	204	115	22	2	1853	1009	276	56	702	103
WFU3I_02	Typical	10	18	7	0	20	18	7	0	24	23	8	0	340	213	35	25	418	107
	Worst-case	60	71	27	6	68	55	25	3	212	91	28	8	1748	1042	271	68	630	144
WFU3I_03	Typical	2	15	0	0	17	15	0	0	28	17	2	0	369	272	44	15	402	68
	Worst-case	24	47	15	0	30	23	2	0	51	32	7	0	499	511	78	25	590	102
WFU3I_04	Typical	7	9	0	0	10	9	0	0	15	10	1	0	413	220	20	3	411	64
	Worst-case	29	95	10	1	264	95	10	1	410	201	15	1	1574	1721	372	41	1745	289
WFU3I_05	Typical	0	3	0	0	3	2	0	0	16	6	0	0	139	83	13	2	160	19
	Worst-case	5	29	3	0	44	34	3	0	98	71	11	0	1949	960	121	31	961	95

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Highest noise envelope
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-207 – Predicted construction noise levels – standard hours (non-residential receivers)

Major works area/assessment reference			WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity			Typical	Worst-case	Typical	Worst-case	Typical	Worst-case	Typical	Worst-case	Typical	Worst-case
Location of noise-generating works within works area relative to receiver			Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
Childcare	22.3	50	< 35	38 / 39	< 35	41 / 44	< 35	37 / 38	35 / 37	47 / 50	< 35	37 / 38
	23.2	50	< 35	43	< 35	44 / 45	< 35	42 / 43	37 / 39	50 / 51	< 35	40
	30.2	50	36 / 55	49 / 68	44 / 46	57 / 59	45 / 46	55 / 57	40 / 41	52 / 53	45 / 53	55 / 63
	32.1	50	< 35	44 / 46	< 35	46 / 47	34 / 35	44 / 45	< 35	43 / 44	35 / 36	45 / 46
	33.2	50	< 35	44 / 45	< 35	44 / 45	< 35	43	< 35	43	37	47 / 48
	36.1	50	38 / 39	51 / 52	< 35	46	34 / 35	44 / 45	< 35	43 / 44	41 / 42	51 / 52
Commercial	30.2	70	44 / 63	56 / 75	40 / 42	53 / 55	41 / 42	51 / 53	35 / 36	48 / 49	55 / 63	66 / 73
	30.3	70	32 / 40	45 / 53	43 / 48	56 / 61	36 / 44	46 / 54	51 / 60	64 / 72	35 / 37	46 / 47
Educational	22.1	55	35	47 / 48	34 / 35	47 / 48	37	47 / 48	40 / 41	52 / 54	< 35	44 / 45
	22.3	55	35 / 36	47 / 48	37 / 39	50 / 52	36 / 37	46 / 47	42 / 44	54 / 56	36	46
	25.1	55	< 35	43 / 44	< 38	34 / 51	33 / 35	44 / 45	44 / 51	57 / 63	< 35	41 / 42
	28.1	55	< 35	42 / 43	35 / 37	48 / 50	< 35	42 / 43	38 / 41	50 / 53	< 35	37 / 38
	30.1	55	≤ 45	38 / 57	< 44	37 / 57	40 / 47	50 / 58	34 / 36	47 / 49	39 / 41	49 / 51
	30.2	55	≤ 46	39 / 58	38 / 40	51 / 53	40 / 42	51 / 52	36 / 37	48 / 49	35 / 43	45 / 53
	31.2	55	40 / 43	53 / 55	38 / 41	51 / 54	40 / 42	51 / 53	44 / 46	56 / 59	36 / 37	47 / 48
	31.3	55	56 / 66	69 / 78	47 / 50	60 / 63	54 / 56	64 / 66	40 / 41	52 / 54	46 / 55	57 / 65
Other sensitive receiver	21.2	50	< 35	41 / 42	< 35	45 / 46	< 35	41	35 / 36	48 / 49	< 35	40
	30.1	60	51 / 70	64 / 83	51 / 71	64 / 84	64 / 72	74 / 82	41 / 44	54 / 56	37 / 39	48 / 50
Place of worship	21.1	55	< 35	38 / 39	< 35	44 / 45	< 35	41 / 42	38 / 40	51 / 53	< 35	38 / 39
	24.1	55	39 / 41	52 / 53	36 / 40	49 / 53	41 / 43	51 / 53	37 / 41	49 / 54	36 / 37	46 / 47
	28.1	55	36 / 37	48 / 49	39 / 41	52 / 54	38 / 39	49	41 / 44	54 / 57	< 35	44
	30.1	55	≤ 45	38 / 57	< 43	36 / 56	39 / 46	49 / 57	40 / 43	53 / 55	39 / 41	49 / 51
	30.2	55	34 / 53	47 / 66	40 / 42	53 / 55	41 / 43	52 / 53	36 / 37	49 / 50	48 / 55	58 / 66

Major works area/assessment reference			WFU3I_01		WFU3I_02		WFU3I_03		WFU3I_04		WFU3I_05	
Typical/worst-case activity noise intensity			Typical	Worst-case	Typical	Worst-case	Typical	Worst-case	Typical	Worst-case	Typical	Worst-case
Location of noise-generating works within works area relative to receiver			Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near	Far/Near
Receiver type	NCA	NML[6]	Predicted noise levels, $L_{Aeq\ (15\ minutes)}$									
Recreational	25.1	65	42 / 43	54 / 56	49 / 67	62 / 80	57 / 58	67 / 69	55 / 62	68 / 74	40	50 / 51
	30.1	65	36 / 55	49 / 68	38 / 59	51 / 72	50 / 57	59 / 66	37 / 40	50 / 52	43 / 45	53 / 55

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-208 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU3I_01	Typical	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
	Worst-case	11	0	0	1	1	0	3	0	1	2	0	0	1	1	0	0	0	1
WFU3I_02	Typical	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
	Worst-case	0	0	0	1	0	0	2	0	0	2	1	0	1	0	0	0	0	1
WFU3I_03	Typical	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
	Worst-case	0	0	0	1	0	0	1	1	0	3	0	0	1	0	0	0	0	1
WFU3I_04	Typical	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Worst-case	1	0	0	2	0	0	3	0	0	0	1	0	1	0	0	0	0	0
WFU3I_05	Typical	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Worst-case	10	0	0	1	1	0	2	0	0	0	0	0	0	1	0	0	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.12 Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J)

The Western Harbour Tunnel Falcon Street off ramp cut and cover works are to be located at the Ridge Street north construction support site (WHT9), directly adjacent to the Warringah Freeway and Ridge Street at North Sydney, as shown in in Figure 5-28. The location of the works area, and the surrounding noise-sensitive receivers is presented in Figure 5-28.

The key activities of the proposed construction works at the Ridge Street north construction support site (WHT9) include construction of the Western Harbour Tunnel off ramp and cut and cover structure, and the road integration works with the Warringah Freeway.

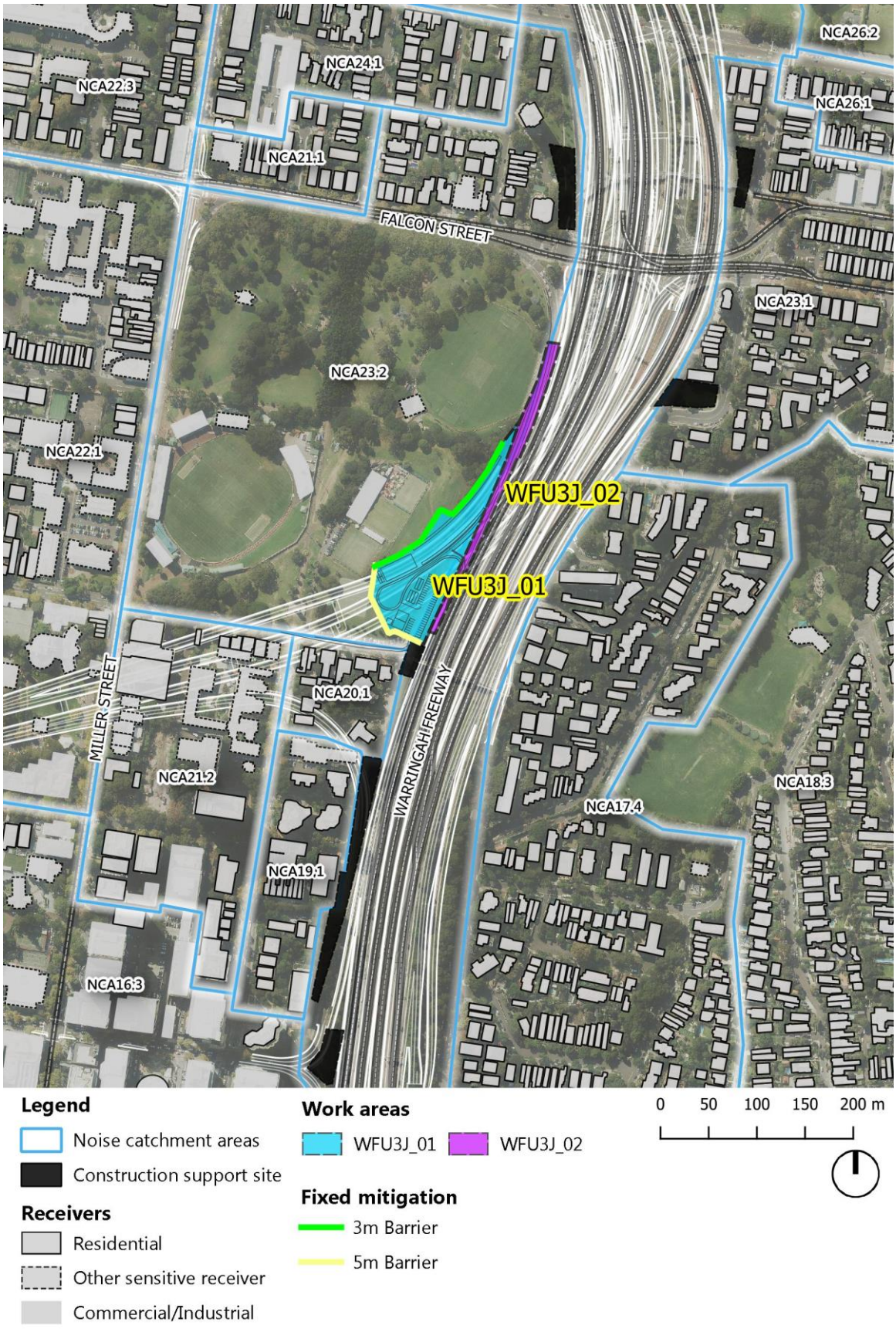
The Cammeray Golf Course construction support site would be used to support the works. However, the works would also be supported by the establishment of areas for laydown, offices and toilets within the Ridge Street north construction support site (WHT9) footprint.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-209. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-209 – Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J) – indicative duration of construction work

Works area reference	Stage	Duration
WFU3J_01	Site establishment and tunnel structure works	18 months
WFU3J_02	Road integration works	

Figure 5-28 – Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J) - assessment work areas



5.9.2.12.1 Construction hours and durations

Works for this major works area would generally be carried out during standard construction hours; however, deliveries of large items (eg. piling rigs and cut and cover large structural items) and road tie-in works would be carried out during night time road closures, as the works would require occupancy of the Warringah Freeway carriageways.

It is noted that over the allocated construction stage timeframes presented in the table above, OOHW would only be required for a smaller portion of these overall timeframes. The estimated period of required OOHW over the total construction timeframe and the justifications for the OOHW are presented in Table 5-210.

Table 5-210 – Required out of hours work – Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J)

Works area reference	Required OOHW	Percentage of program days OOHW is required[1]	Justification
WFU3J_01	1. Works adjacent to/within live traffic corridor. 2. Oversized item delivery and installation	< 10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Large load lifts over existing roads 3. Impacts on road network performance/safety from oversized loads
WFU3J_02	1. Works adjacent to/within live traffic corridor.	< 10	1. ROL required to minimise impacts on road network performance, worker safety and road user safety 2. Impacts on road network performance/safety from oversized loads

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

In addition to the above key OOHW, associated utility and sewage infrastructure modifications may be required as part of the works. These works would likely be carried out of hours due to ROL requirements.

Section 6.4 outlines the specific mitigation and management measures recommended to approach the OOHW noise impacts.

5.9.2.12.2 Construction assessment scenarios

The airborne noise assessment for the Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J) works was separated into two works areas. Each work area was assessed against both standard construction hours and OOHW.

Presented in Table 5-211 are the assessed activities for each works area, which represent the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant listed in Appendix F represent the reasonable 'typical' and 'worst-case' case equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items are not operating simultaneously, or where they operate for reduced times in the 15 minute period, noise impacts could be lower than predicted.

Table 5-211 – Assessed construction activities - Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J)

Assessment Scenario Reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)	
	Activity	Typical	Worst-case	Activity	Typical	Worst-case
WFU3J_01	Earthworks	116	119	Deliveries (oversized)	110	111
WFU3J_02	Demolition (rock hammering)[2]	109	121	Pavement/road modification works	110	120

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

2. These works take place within the WFU3J_01 boundary, as works within the WFU corridor are likely to be required outside of standard construction hours, during an ROL.

Fixed mitigation measures

Construction noise barriers along the southern and western boundaries of the construction support site to minimise noise impacts on receivers in NCA20.1 has been incorporated into the noise modelling. As the residential receivers overlook the site from multi-storey buildings, any barrier would have to be higher than three metres in order to break line of sight to the construction activities within the construction support site.

The minimum five metre high solid noise barrier was assumed to be installed along the southern boundary facing Ridge Street and a minimum three metre high solid noise barrier the length of the construction support site western boundary facing St Leonards Park, as presented in Figure 5-28.

5.9.2.12.3 Construction noise prediction summary

Table 5-212, Table 5-213 and Table 5-215 present the predicted noise levels from construction activities and compares them to the NMLs. Table 5-214 and Table 5-216 present the indicative number of receiver buildings that exceed the NMLs in each NCA and the number of receivers that are potentially noise affected over the entire duration of the works stage.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

During standard construction hours, the key activity that has been assessed is earthworks, along with rock hammering activities associated with demolition or road interface works. Results of the assessment considering the onsite noise mitigation measures are as follows:

- The predicted noise levels generally do not exceed the NMLs for standard construction hours, except for NCAs 17.4 and 20.1
- The highest predicted noise levels are for receiver buildings in NCA17.4 across the Warringah Freeway, and onsite mitigation measures help to protect receiver buildings in NCA 20.1 directly across Ridge Street when the bulk excavation works are taking place
- Over the entire works stage, works are only predicted to exceed the NML during worst-case works, with typical activities achieving the NML
- No receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) as a result of the works
- During standard construction hours, the highest noise impacts are predicted to be clearly audible (< 10 dB(A) exceedance) for up to six of the closest receiver buildings in NCAs 17.4 and 20.1.

During OOHW, the key activities that have been assessed are and oversized deliveries and associated crane operations required for the cut and cover works (WFU3J_01) and rock hammering associated road tie in and pavement modification works on the Warringah Freeway (WFU3J_02).

The results of the assessment are as follows:

- The highest predicted noise levels occur for receiver buildings in NCAs 17.4, 20.1, 23.1 and 23.2
- For works within the Ridge Street north construction support site, during the night period up to 22 receiver buildings are predicted to exceed the NMLs during typical works. However, during the worst-case oversized delivery activities this is predicted to increase to around 33 receiver buildings
- For the road integration works on the Warringah Freeway (WFU3J_02), during the night period up to 30 receiver buildings are predicted to exceed the NMLs during typical works. However, during the worst-case road work using concrete saws or rock hammers this is predicted to increase to around 1220 receiver buildings
- The highest predicted impacts during the WFU3J_02 stage exceed the NML by greater than 16 dB(A) at 12 receiver buildings, which would be considered moderately intrusive.

Non-residential receivers

Construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- One childcare centre receiver with a marginal exceedance of 1 dB(A) in NCAs 16.3

- One educational receiver by up to 2 dB(A) which has buildings located in NCAs 21.2
- Two recreational area receivers by up to 20 dB(A) in NCA 23.2
- One theatre receiver by up to 5 dB(A) in NCA 21.2.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

The most likely source of potential sleep disturbance from the night construction works would be from air-brakes or metal-on-metal bangs during oversized deliveries. Maximum noise levels have been predicted to the nearest affected residential receiver buildings to allow for an assessment of the potential for sleep disturbance from OOHW. Results of the assessment are as follows:

- The predicted noise levels exceed the sleep disturbance screening level during worst-case and typical activities
- For works within the construction site, during typical operations the sleep disturbance screening levels are not exceeded, while during worst-case activities during oversized deliveries, this may increase to four receiver buildings
- During road integration works within the Warringah Freeway, up to 23 receiver buildings are predicted to exceed the L_{Amax} sleep disturbance screening level during worst-case works and up to five receiver buildings are predicted to exceed the awakening reaction level.

Summary of residual impacts and additional mitigation and management measures

As the Ridge Street north construction support site would predominately be a standard construction hours construction works site, the predicted noise levels show that most of the noise impacts can be mitigated by on-site noise barriers.

However, during the Warringah Freeway road integration works (WFU3J_02), where works would have to take place under an ROL, there is limited available noise source and noise path mitigation measures available during OOHW. During these works residential receivers nearby would be noise affected.

Careful use of close-proximity temporary noise barriers could provide some noise reduction to close receivers, as there are stages where the adjacent residential suburbs are at or below the road surface levels. However, in many other cases the residential receivers are located higher than the road surface, minimising the benefits of fixed noise mitigation.

For receivers further away, any fixed mitigation on-site would have limited effectiveness and so have not been included in the modelling. The effectiveness of programming of noise-intensive activities, along with correct site planning, and any potential temporary mitigation measures would be reviewed during detailed design. The construction mitigation and management measures outlined in section 6.2 are to be incorporated, where feasible and reasonable, as part of the preparation of a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.12.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-212 for residential receivers during standard construction hours
- Table 5-213 for residential receivers during works outside of standard construction hours
- Table 5-215 for non-residential receivers.

The construction NMLs for all the nearest affected residential receivers are presented in Appendix B.1, and for all other non-residential receivers see section 3.4.1.

The number of receivers predicted to exceed NMLs during each stage and time period are summarised in Table 5-214 and Table 5-216. Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The highest 'typical' noise levels predicted for all stages assessed within the major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-212 – Predicted construction noise levels – standard hours (residential receivers)

Major works area/assessment reference				WFU3J_01		WFU3J_02	
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	NML				
Wollstonecraft	22.2	75	62	42 / 44	45 / 47	30 / 35	42 / 47
	30.4	75	68	41 / 43	44 / 46	< 35	42 / 45
North Sydney - south west	15.3	75	52	40 / 42	43 / 45	< 35	41 / 45
North Sydney - north west	19.1	75	62	43 / 52	46 / 55	42 / 43	54 / 55
	20.1	75	62	43 / 62	46 / 65	32 / 51	44 / 63
	21.1	75	63	40 / 46	43 / 49	≤ 36	34 / 48
	21.2	75	63	43 / 53	46 / 56	42 / 43	54 / 55
	22.1	75	62	44 / 48	47 / 51	30 / 39	42 / 51
	23.2	75	71	38 / 50	41 / 53	≤ 42	40 / 54
North Sydney - east	17.3	75	65	46 / 48	49 / 51	34 / 39	46 / 51
Neutral Bay	17.4	75	65	54 / 63	57 / 66	43 / 56	55 / 68
	18.3	75	64	47 / 51	50 / 54	36 / 41	48 / 53
	23.1	75	71	45 / 54	48 / 57	42 / 48	54 / 60
Crows Nest	22.3	75	62	41 / 44	44 / 47	< 35	40 / 46
	24.1	75	66	41 / 46	44 / 49	≤ 37	36 / 49
Cammeray	28.1	75	57	38 / 40	41 / 43	< 35	40 / 44
	30.3	75	68	38 / 39	41 / 42	< 35	39 / 42
Cremorne	26.1	75	68	43 / 46	46 / 49	31 / 39	43 / 51

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A).
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-213 – Predicted construction noise levels – outside standard hours (residential receivers)

Major works area/assessment reference						WFU3J_01		WFU3J_02	
Typical/worst-case activity noise intensity						Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver						Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Suburb	NCA	Noise Management Level				Predicted noise levels, $L_{Aeq\ (15\ minutes)}$			
		HNA	Day (O)	Eve	Ngt				
Wollstonecraft	22.2	75	57	52	41	37 / 39	38 / 40	33 / 38	43 / 48
	30.4	75	63	61	43	35 / 37	36 / 38	33 / 36	43 / 46
North Sydney - south west	15.3	75	47	46	43	34 / 36	35 / 37	31 / 36	41 / 46
North Sydney - north west	19.1	75	57	57	50	39 / 48	40 / 49	48 / 49	58 / 59
	20.1	75	57	57	50	38 / 57	39 / 58	41 / 60	51 / 70
	21.1	75	58	54	46	36 / 41	37 / 42	≤ 40	36 / 50
	21.2	75	58	54	46	37 / 47	38 / 48	42 / 44	52 / 54
	22.1	75	57	52	41	40 / 44	41 / 45	32 / 41	42 / 51
	23.2	75	66	59	49	30 / 43	31 / 44	42 / 56	52 / 66
North Sydney - east	17.3	75	60	59	50	38 / 40	39 / 41	37 / 41	47 / 51
Neutral Bay	17.4	75	60	59	50	46 / 55	47 / 56	47 / 60	57 / 70
	18.3	75	59	57	48	41 / 45	42 / 46	40 / 45	50 / 55
	23.1	75	66	59	49	38 / 47	39 / 48	49 / 55	59 / 65
Crows Nest	22.3	75	57	52	41	36 / 39	37 / 40	33 / 39	43 / 49
	24.1	75	61	57	42	35 / 41	36 / 42	32 / 46	42 / 56
Cammeray	28.1	75	52	50	42	33 / 35	34 / 36	33 / 37	43 / 47
	30.3	75	63	61	43	< 35	< 35	< 35	41 / 44
Cremorne	26.1	75	63	59	46	36 / 40	37 / 41	35 / 43	45 / 53

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A).
4. Construction noise level cells are shaded based on the 'Near' level: Green is < 5 dB(A) above NML, Yellow is 6-15 dB(A) above NML, Orange is 16-25 dB(A) above NML., Purple is >25 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-214 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU3J_01	Typical	0	0	0	0	0	0	0	0	0	0	0	0	20	2	0	0	0	0
	Worst-case	0	5	0	0	2	0	0	0	2	0	0	0	30	3	0	0	4	0
WFU3J_02	Typical	0	0	0	0	2	0	0	0	3	0	0	0	18	12	0	0	18	**2**
	Worst-case	0	6	0	0	10	11	0	0	18	14	0	0	1045	163	12	0	18	**5**

Notes
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-215 – Predicted construction noise levels – standard hours (non-residential receivers)

Major works area/assessment reference			WFU3J_01		WFU3J_02	
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	Typical[1]	Worst-case[2]
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	Far/Near[3]	Far/Near[3]
Receiver type	**NCA**	**NML[6]**	**Predicted noise levels, $L_{Aeq\ (15\ minutes)}$**			
Childcare	16.3	50	42 / 46	45 / 49	32 / 39	44 / 51
Educational	21.2	55	43 / 54	46 / 57	43 / 44	55 / 56
Other sensitive receiver	21.2	50	41 / 51	44 / 54	41 / 43	53 / 55
Recreational	23.2	60	53 / 65	56 / 68	41 / 55	53 / 67
Place of worship	23.1	71	36 / 45	39 / 48	33 / 38	45 / 50

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2.
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A).
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML. A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-216 – Number of non-residential receivers over the noise management level

Assessment reference	Typical/worst-case activity noise intensity	Commercial[1]			Childcare			Educational			Recreational[1]			Places of worship			Other sensitive receivers[1]		
		1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
WFU3J_01	Typical	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0
WFU3J_02	Typical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Worst-case	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	1	0	0

Notes:
1. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
2. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
3. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
4. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.13 Western Harbour Tunnel motorway control centre (WFU3K)

The Western Harbour Tunnel motorway control centre is to be located at Artarmon, at the Waltham Street construction support site (WHT11), directly adjacent to the Gore Hill Freeway on Waltham Street, within the Artarmon industrial area, as shown in Figure 5-29 and Figure 5-30. It is located outside of the main Warringah Freeway Upgrade surface road works construction extent. The location of the works area and surrounding noise-sensitive receivers is presented in Figure 5-29 and Figure 5-30.

The key activities of the proposed construction works for the Western Harbour Tunnel motorway control centre and the Waltham Street construction support site (WHT11) include:

- Construction of a new motorway control centre on Waltham Street, Artarmon at the Waltham Street construction support site (WHT11)
- Trenching along the Gore Hill Freeway and Warringah Freeway road reserves to accommodate a communication connection link connecting the Western Harbour Tunnel with the motorway control centre.

Construction offices and support would be located within the construction support site.

The approximate durations for the key construction activities within the major works area are outlined in Table 5-131. These durations are indicative only and may change during the detailed design and construction planning.

Table 5-217 – Western Harbour Tunnel motorway control centre (WFU3K) – indicative duration of construction work

Works area reference	Stage	Duration
WFU3K_01	Motorway control centre building construction works	18 months
WFU3K_02	Utilities trenching works from Artarmon to Cammeray	6 months

Figure 5-29 – Western Harbour Tunnel motorway control centre (WFU3K) - assessment work areas

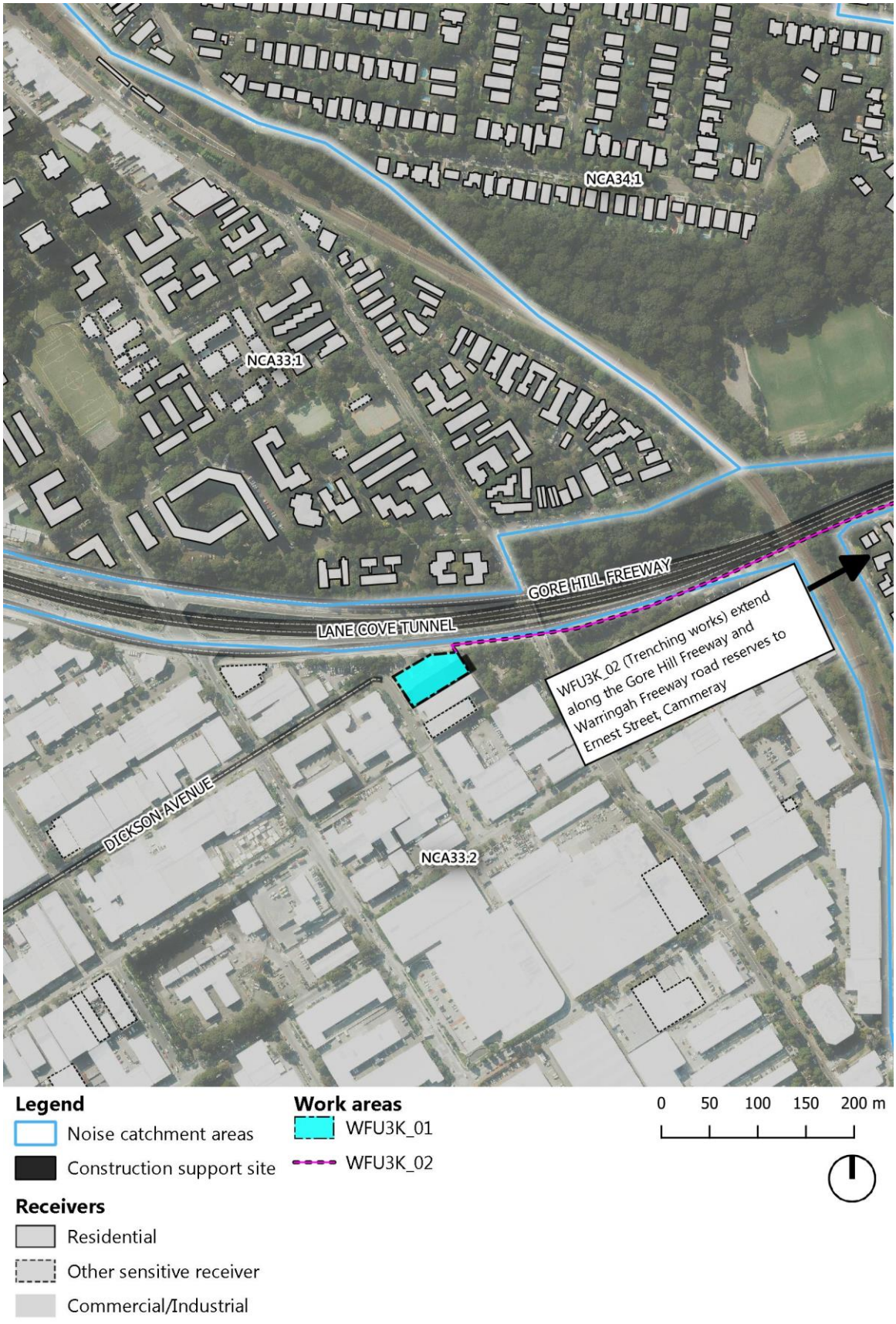
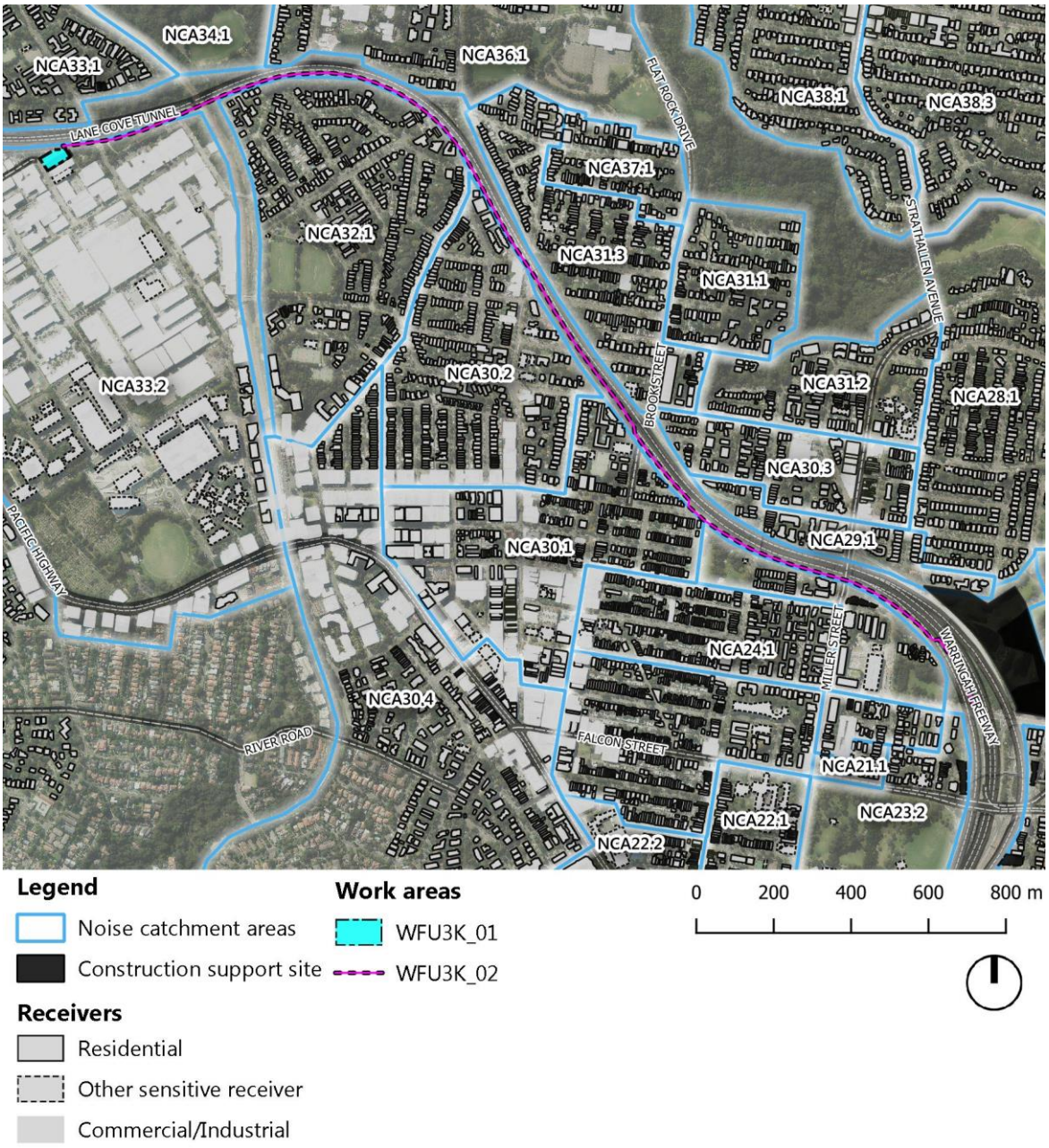


Figure 5-30 – Western Harbour Tunnel motorway control centre (WFU3K) work areas (trenching works)



5.9.2.13.1 Construction hours and durations

The majority of the construction works associated with the construction of the Western Harbour Tunnel motorway control centre at the Waltham Street construction support site (WHT11) would occur during standard construction hours.

A large amount of the trenching works for communication connection cable trenching would occur along the shoulder of the Warringah Freeway. This may need to be completed during night time road closures as it would require occupancy of the road corridor.

The OOHW required for trenching would only be required for a smaller portion of the overall allocated construction stage timeframes presented in the table above. The estimated period of required OOHW over the total construction timeframe, and justifications for the OOHW are presented in Table 5-132.

Table 5-218 – Required out of hours work - Western Harbour Tunnel motorway control centre (WFU3K)

Works area reference	Required OOHW	Percentage of program days OOHW is required[1]	Justification
WFU3K_01	Works limited to standard construction hours		
WFU3K_02	1. Works adjacent to/within live traffic corridor	30	1. ROL required to minimise impacts on road network performance, worker safety and road user safety during communication connection cable trenching.

Notes: 1. Based on an estimated number of days of the overall stage duration that may require OOHW, rounded up to the nearest 10 per cent. Estimated period of OOHW would be refined during detailed design stage.

Section 6.4 outlines the mitigation and management measures recommended to specifically address the OOHW noise impacts.

5.9.2.13.2 Construction assessment scenarios

The airborne noise assessment of the Western Harbour Tunnel motorway control centre was separated into two sets of works, one for the construction of the motorway control centre at Artarmon (WFU3K_01), and the other for the associated communication cable trenching works (WFU3K_02). Presented in Table 5-133 are the assessed activities for each works area, which represents the reasonable most intensive noise activity required as part of the works. However, the type of plant and equipment used throughout the stage would vary depending on the construction activities being carried out.

The equipment/plant modelled are listed in Appendix F and represent the reasonable 'typical' and 'worst-case' equipment/plant operating simultaneously in any 15 minute period (refer to section 4.2.3 for further explanation of assessment scenarios). Where plant items do not operate simultaneously or operate for less than a 15 minute period, noise impacts would be lower than predicted.

Table 5-219 – Assessed construction activities – Western Harbour Tunnel motorway control centre (WFU3K)

Works area reference	Standard hours works	SWL level range, $L_{Aeq\ 15\ minute}$ dB(A)[1]		Out-of-hours works	SWL level range $L_{Aeq\ 15\ minute}$ dB(A)[1]	
	Assessed activity	Typical	Worst-case	Assessed activity	Typical	Worst-case
WFU3K_01	Erection of structural steelwork	111	117	-	-	-
WFU3K_02	-	-	-	Utilities modification works	110	120

Notes: 1. The activity SWL includes the adjustments for quantity of equipment assumed operating, equipment usage factor, and penalties for annoying characteristics in accordance with the ICNG. Refer to Appendix F for a description of the assumed equipment/plant that are operating.

5.9.2.13.3 Construction noise prediction summary

Table 5-134, Table 5-135 and Table 5-137 present the predicted noise levels from construction activities and compare them with the NMLs for standard construction hours. Table 5-136 and Table 5-138 present the indicative number of receiver buildings that exceed the NMLs in each NCA, and the number of receivers that are potentially highly noise affected.

The receiver building counts presented in this assessment are based on the reasonably highest noise levels that would occur throughout a works stage, when the construction works are closest to each receiver building. This is defined as the highest noise level envelope and explained in detail in section 4.2.3.3.1. In practice, during any individual period of construction works (ie. on any individual night) the number of receiver buildings impacted would be less than the numbers presented in the tables below.

Residential receivers

During standard construction hours, predicted noise levels do not exceed NMLs, except for during worst-case works for some receiver buildings in NCAs 33.1 which are located on the northern side of the Gore Hill Freeway, on the opposite side of the Gore Hill Freeway from the work area:

- The highest predicted noise levels during the motorway control centre construction works would impact receiver buildings in NCAs 33.1
- Over the entire works stage, during typical construction activities noise impacts are not predicted to exceed the NML at residential receiver buildings. Worst-case works are predicted to exceed the NML at nine receiver buildings by up to 6 dB(A)
- Over the entire works stage, during worst-case activities no receiver buildings are predicted to be highly noise affected (ie. >75 dB(A)) when works are in close proximity.

During OOHW, the key activities that are required is the trenching from the motorway control centre site (WFU3K_02) to Cammeray. These works would take place adjacent to the Warringah Freeway and Gore Hill Freeway. These works would progress along the Warringah Freeway over the program stage, and so as the trenching moves along the Warringah Freeway the impacted receiver buildings would

vary. An assessment of the indicative noise levels that adjacent receiver buildings may be impacted by trenching works associated with WFU3K_02 is presented in section 5.10.1.

Non-residential receivers

As the Western Harbour Tunnel motorway control centre (WFU3K_01) is located within the Artarmon industrial precinct, there are a number of non-residential receivers in close proximity. During standard construction hours, construction noise levels at non-residential receivers are generally predicted to meet the NMLs, except for the following key receivers:

- Three childcare centres located in NCA 33.1 and 33.2, two of which are predicted to exceed the NML during typical works by less than 10 dB(A). However, three are predicted to exceed the NML during the worst-case works, one by around 20 dB(A)
- Two education facilities which have buildings located in NCA 33.1 and 33.2, are not predicted to exceed the NML during typical works, however, during the most noise-intensive worst-case works exceedances of up to 4dB(A) are predicted
- Four commercial receiver buildings and one community centre are predicted to exceed the NML during the works.

Construction mitigation and management measures are provided in section 6 to assist in reducing construction noise impacts to other sensitive receivers.

Sleep disturbance

As part of the Western Harbour Tunnel motorway control centre trenching and utility installation works from Artarmon to Cammeray, the most likely source of potential sleep disturbance from night construction works would be from the use of rock hammers during road modification works. Maximum noise levels at residential receiver buildings adjacent to the Warringah Freeway exceed sleep disturbance screening levels. However, as the works move along, the distance between the receiver and the trenching activities increases, the likelihood of sleep disturbance impacts decreases. An assessment of the noise levels that adjacent receiver buildings may be impacted by trenching works associated Western Harbour Tunnel motorway control centre construction is presented in section 5.10.1.

Summary of residual impacts and additional mitigation and management measures

The motorway control centre construction works are not typically predicted to exceed the NML, except for at a number of nearby non-residential receivers. Trenching works along the Warringah Freeway to connect the motorway control centre to Cammeray would need to take place outside of standard construction hours and are likely to impact noise sensitive receivers adjacent to the Warringah Freeway.

Construction mitigation and management measures outlined in section 6.2 would be adopted, where feasible and reasonable, in a site-specific CNVIS during detailed design to assist in reducing OOHW construction noise impacts to receivers.

Further mitigation measures would be adopted, where feasible and reasonable, specifically for the utility installation trenching works, as outlined in section 6.4.

Due to the extent of noise-intensive construction activities that may be required outside of standard construction hours specific details would be included in the CNMVP about how the project would manage the complex nature of operating a construction worksite within a major Sydney road corridor. The mitigation measures described in section 6.4 would be included where feasible and reasonable to manage construction noise from surface road work activities. Measures that may be adopted during detailed design would include programming, respite protocols and alternative construction activity methodologies. Furthermore, where receiver buildings are still over the NMLs, additional mitigation measures (see section 6.10 of this report), such as respite offers and alternative accommodation, will be adopted in accordance with the CNVG.

All mitigation measures would be adopted with consideration of cumulative and long term noise impacts on receivers. The Warringah Freeway Upgrade surface road works major works areas that may be operating concurrently or consecutively and impacting the same receiver locations will be specifically noted. NCAs that are affected by activities in each work area are shown in Table 5-225 and Table 5-226.

5.9.2.13.4 Construction noise prediction tables

The predicted noise levels are presented in the following tables:

- Table 5-220 for residential receivers during standard construction hours
- Table 5-222 for non-residential receivers.

Predicted noise levels are intended to be conservative and represent reasonable typical and worst-case impacts that could occur during the project. Refer to section 4.2.3 for the surface road upgrade airborne noise prediction methodology.

The construction NMLs for all residential receivers nearby are presented in Appendix B.2, and for all other non-residential receivers in section 3.4.1.

The number of receiver buildings predicted to exceed NMLs during each stage and time period are summarised in Table 5-221 and Table 5-223.

The highest 'typical' noise levels predicted for all stages of a major works areas are presented as noise contour envelopes in Appendix H.2 to give an indication of the likely extent of noise levels at nearby receiver locations.

Table 5-128 provides a key to the cell shading and text formatting used to explain the results in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW. Colours and formatting are based on the highest predicted value, with ranges to show the potential variation in construction noise impacts.

Table 5-220 – Predicted construction noise levels – standard hours (residential receivers), dB(A)

Major works area/assessment reference				WFU3K_01		WFU3K_02
Typical/worst-case activity noise intensity				Typical[1]	Worst-case[2]	
Location of noise-generating works within works area relative to receiver				Far/Near[3]	Far/Near[3]	
Suburb	NCA	Noise Management Level		Predicted noise levels, $L_{Aeq\ (15\ minutes)}$		
		HNA	NML			
Artarmon	NCA33.1	75	65	59 / 65	65 / 71	Standard hours works not proposed

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3.

Table 5-221 – Highest noise level envelope - Number of residential buildings over the noise management level

Assessment reference	Typical / worst-case activity noise intensity	Highly noise affected	Day (standard hours)			Day (outside standard hours)				Evening				Night				Sleep Disturbance	
		> 75 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	1 - 5 dB(A)	6 - 15 dB(A)	16 - 25 dB(A)	> 25 dB(A)	Screening level (L_{Amax})	Awakening (L_{Amax})
WFU3K_01	Typical	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Worst-case	0	9	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WFU3K_02			-			For indicative impacts refer to section 5.10.1.													

Notes:
1. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in 4.2.3.3.2, and demonstrated in Figure 4-8.
2. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
3. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

Table 5-222 – Predicted construction noise levels – standard hours (non-residential receivers), dB(A)

Major works area/assessment reference			WFU3K_01		WFU3K_02
Typical/worst-case activity noise intensity			Typical[1]	Worst-case[2]	
Location of noise-generating works within works area relative to receiver			Far/Near[3]	Far/Near[3]	
Receiver type	**NCA**	**NML[6]**	**Predicted noise levels, $L_{Aeq\ (15\ minutes)}$**		
Commercial / Industrial	33.2	75	62 / 87	68 / 93	Standard hours work not proposed
Childcare	33.1	50	39 / 46	45 / 52	
	33.2	50	40 / 64	46 / 70	
Educational	33.1	55	46 / 53	52 / 59	
	33.2	55	≤ 50	31 / 56	
Other sensitive receiver	33.1	60	48 / 55	54 / 61	

Notes
1. Typical predicted noise levels represent a 'typical' noise-intensive construction scenario without the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
2. Worst-case predicted noise levels represent a 'reasonable worst-case' noise-intensive construction scenario with the loudest plant and equipment items (eg rock hammers or road saws), as described in section 4.2.3.3.2
3. The 'Near' level is the highest predicted noise level that could be expected when works are in close proximity to the nearest noise-sensitive receiver shown in the assessment. The 'Far' noise level is when these works take place at the furthest location in the assessed work area from this same receiver, as described in section 4.2.3.3.3. A range is not presented if noise levels are within 1 dB, or the lower end is less than 30 dB(A)
4. Construction noise level cells are shaded based on the 'Near' level: Light blue is < 10 dB(A) above NML, Mid blue is 11-20 dB(A) above NML, Dark blue is >20 dB(A) above NML, and **bold** text is highly noise affected (HNA) (>75 dB(A)). A full key is presented in Table 5-128
5. Table features are explained further in section 4.2.3.3
6. Other sensitive receivers have a range of NMLs based on the receiver classification as outlined in section 3.4.1.2. The exceedances are based on the respective receiver NML.

Table 5-223 – Number of non-residential receivers over the noise management level

All NCAs	Assessment reference	Typical/worst-case activity noise intensity	Commercial[2]			Childcare			Educational			Recreational[2]			Places of worship			Other sensitive receivers[2]		
			1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)	1 - 10 dB(A)	11 - 20 dB(A)	> 20 dB(A)
Motorway control centre building construction works	WFU3K_01	Typical	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worst-case	3	1	0	2	1	0	1	0	0	0	0	0	0	0	0	1	0	0
Communication cable trenching	WFU3K_02	For indicative impacts refer to section 5.10.1.																		

Notes:
1. For indicative impacts from WFU3K_02, refer to Section 5.10.1.
2. Commercial, industrial, recreational active and passive and other sensitive receivers have been assessed against the respective NMLs, and exceedances have been presented in the count table.
3. 'Typical' and 'Worst-case' case noise assessment scenarios are explained in section 4.2.3.3.2, and demonstrated in Figure 4-8.
4. Refer to the "Required out of hours work" table in the section "Construction hours and durations" of this assessment section for an indication of the duration and how often these noise impacts are expected to occur.
5. An indicative program and timeline is provided at the beginning of this section to provide an indication of the duration of these construction works and the associated construction noise impacts.

5.9.2.14 Cumulative and consecutive major project construction noise impacts – Warringah Freeway Upgrade surface road works

There is potential for cumulative noise impacts on receiver locations in proximity to the Warringah Freeway Upgrade surface road works from other construction projects that are being carried out in the same area at the same time.

For the Warringah Freeway Upgrade surface road works, there are overlaps with the nearby major infrastructure projects presented in Table 5-224, while there is also the potential for cumulative impacts as specific works areas may operate concurrently with the Warringah Freeway Upgrade surface road works.

Table 5-224 – Concurrent construction works near the Warringah Freeway Upgrade surface road works

The project	2020	2021	2022	2023	2024	2025
Warringah Freeway Upgrade surface road works (WFU)						
Cammeray Golf Course construction support site (CGC)						
Other major infrastructure projects						
Cammeray Golf Course construction support site as part of the Beaches Link and Gore Hill Freeway Connection project (CGC-BL)[1]						
Warringah Freeway surface road works as part of the Beaches Link and Gore Hill Freeway Connection project (WFU2H-BL)[1]						
Gore Hill Freeway Connection as part of the Beaches Link and Gore Hill Freeway Connection project (GHC)[1]						
Punch Street construction support site as part of the Beaches Link and Gore Hill Freeway Connection project (AGH)						
Artarmon Substation, Sydney Metro City & Southwest (AS-SM)[3]						
Victoria Cross Station, Sydney Metro City and Southwest (VCX-SM)[2]						
Crows Nest Station, Sydney Metro City and Southwest (CN-SM)[2]						

Notes:
1. Indicative programs have been assumed for the Beaches Link and Gore Hill Freeway Connection project.
2. Refer to Victoria Cross Station and Crows Nest Station, Sydney Metro City and Southwest environmental impact statement. However, it is noted that from 2021 the construction works for the Sydney Metro City and Southwest will likely be tunnels, stations and facilities fit out construction works along with testing and commissioning activities. These are not typically noise intensive works, and as such this would minimise the potentials for cumulative constructions noise impacts from concurrent works.
3. Refer to the Victoria Cross Station and Artarmon Substation Modification Report.

Section 4.2.4.2 outlines the methodology to identify the activities and locations where there is a greater potential of concurrent or consecutive construction noise impacts, as the concurrent sets of works that would occur on any one night would be determined during detailed design.

Table 5-225 and Table 5-226 present all the major works areas and nearby major construction projects and indicates if predicted noise levels during typical construction activities exceed the NMLs in each NCA. When construction works are carried out in more than one major work area at the same time and the works are predicted to exceed the NML in the same NCA, there is potential for cumulative noise impact in that NCA.

Potential consecutive or concurrent construction noise impacts would be managed as outlined in section 6.5 in order to mitigate and manage construction noise fatigue. The CNVMP prepared as part of the detailed design would include these mitigation measures and cumulative noise impacts would be considered further during detailed design where feasible and reasonable. These mitigation measures would be included in the site's detailed design and site specific CNVIS where feasible and reasonable, which would consider cumulative and consecutive construction noise impacts in developing mitigation and management measures. Additional detail and approaches for the Warringah Freeway Upgrade would also be required, as detailed in section 6.4.

Worst-case noise activities have not been included in the cumulative noise assessment, as they are likely to be infrequent and sporadic. It is unlikely that they would occur simultaneously in more than one construction works area. Worst-case impacts have the potential to impact a larger number of NCAs than the typical works presented in Table 5-225 and Table 5-226. For these types of works there is greater chance that the same NCAs may be impacted over consecutive nights, as they are more noise-intensive and affect a larger range of receivers than for typical activities, which would be considered when determining respite provisions. Work would be programmed to provide respite to noise affected receivers (ie. > NML), as outlined and recommended in the CNVG (see Appendix G) and further detailed in section 6. The respite periods would consider concurrent projects.

Refer to section 5.8 for details of the Cammeray Golf Course construction support site.

Table 5-225 – Noise affected NCAs for each major works area – typical activities (standard hours) (Warringah Freeway Upgrade surface road works)

| NCA | Day NML | Western Harbour Tunnel / Warringah Freeway Upgrade | | |

Table 5-226 – Noise affected NCAs for each major works area – typical activities (out of hours work) (Warringah Freeway Upgrade surface road works)

| | | Western Harbour Tunnel / Warringah Freeway Upgrade | | |

5.9.3 Construction road traffic noise

5.9.3.1 Changes in road traffic noise impacts due to Warringah Freeway Upgrade surface road works

As the traffic speeds are likely to decrease from the current posted speeds (80 kilometres per hour) down to either 60 kilometres per hour, or where required 40 kilometres per hour, this would result in a reduction in noise impacts from road traffic during construction.

Based on the distances from the existing carriageways and roads, even where a single carriageway is closed, and all other traffic is redirected onto the other carriageway, the reduced speed would compensate for the consolidation of all traffic into the lanes closest to the receiver. As such, road traffic noise impacts would not be increased as a result of the traffic switching requirements, as presented in Table 5-227.

Table 5-227 – Changes in road traffic noise impacts due to construction works – Warringah Freeway Upgrade surface road works

Existing situation		Reduced speed, and all traffic switched to closest carriageway	Reduced speed, and all traffic switched to closest carriageway	Reduced speed, and all traffic switched to far carriageway	Reduced speed, and all traffic switched to far carriageway
Posted speed	80 km/hr	60 km/hr	40 km/hr	60 km/hr	40 km/hr
Reduction from existing, dB(A)		- 0.4 dB	- 1.8 dB	- 4.3 dB	- 5.8 dB

Notes: 1. Assume distance to closest carriageway is 25 metres and far side is 60 metres
2. Heavy vehicle percentage during the night period is 8.6 per cent
3. Calculated using CoRTN88 algorithm.

5.9.3.2 Heavy vehicle operations associated with the surface works

A relatively small number of construction vehicles are proposed to travel between the Warringah Freeway Upgrade surface road works major works areas, with most construction vehicles travelling directly to each area at the commencement of a shift. The vehicles would mostly travel to or between major works areas via the Warringah Freeway and the major arterial roads, and the Gore Hill Freeway in the case of the Western Harbour Tunnel motorway control centre, where in both cases there is already high traffic volumes and a high proportion of heavy vehicles.

The only exceptions to this where construction vehicles may be required to access the works areas via local roads, which would be in the case of the North Sydney cut and cover works area in St Leonards Park. During site-establishment or demobilisation direct access would not be available for construction vehicles off the Warringah Freeway, and as such during this period access via Ridge Street would be required. However, following the establishment of road access off the Warringah Freeway, the Ridge Street access would only be used intermittently as a secondary access in cases where it is not practicable to access via the Warringah Freeway or for emergency access.

For works that require haulage activities, such as for cut and cover works (eg. Western Harbour Tunnel Falcon Street off ramp cut and cover (WFU3J) and near Ernest Street bridge (WFU2H)), up to 190 daily heavy vehicle movements during standard construction hours are proposed for activities such as spoil handling, with just one heavy vehicle movement per hour during the night period. The existing traffic volumes on the Warringah Freeway are around 100,000 vehicles per day, with greater than eight per cent heavy vehicles.

The construction traffic associated with the Warringah Freeway Upgrade surface road works would not increase the existing traffic noise levels by more than 2 dB(A), since this would require an overall total traffic volume increase of at least 60 per cent or a substantial increase in heavy vehicles.

5.9.3.3 Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites

The minor construction support sites for the Warringah Freeway Upgrade surface road works and Western Harbour tunnel would need to operate outside standard construction hours. All sites would typically have a minor construction support site within the works area for laydown, offices and toilets that would shift as works progress, as well as being supported by the Cammeray Golf Course construction support site.

As these sites would operate out of hours, traffic associated with these sites would need to be limited to minimise impacts on nearby receivers. Presented in Table 5-212 are the proposed vehicle movements for all minor construction support sites and the corresponding predicted road traffic noise impacts.

Where exceedances of the RNP or sleep disturbance screening levels are predicted, further mitigation and management measures would be developed during detailed design once the operations of these sites are known, such as further restrictions of movements and activities that can occur.

Table 5-212 also presents the road traffic noise assessment for the Warringah Freeway Upgrade surface road works minor construction support sites. Based on the proposed construction vehicle movements, no site is predicted to increase road traffic noise levels by more than 2 dB(A) at the nearest affected residential receivers.

Warringah Freeway Upgrade surface road works minor construction support sites that have heavy vehicle movements during the night period have the potential to exceed the sleep disturbance screening levels and awakening reaction levels from air-brake releases or metal bangs associated with the loads being carried. These noise sources would be mitigated and managed as outlined in section 6.2 to minimise the chance of sleep disturbance impacts.

Road traffic noise impacts from Warringah Freeway Upgrade surface road works support activities at Cammeray Golf Course construction support site (CGC/WFU8) are covered in the individual site assessment in section 5.8.

Table 5-228 – Warringah Freeway Upgrade surface road works and Western Harbour Tunnel minor construction support sites – road traffic noise assessment

Minor construction support site	Construction vehicle access road	Road type	Time of day	Base RNP criteria, dB(A)	Proposed construction vehicle movements (Day – 7 am - 10 pm Night – 10 pm - 7 am)		Proposed construction vehicle movements (Day / Night average maximum 1 hour)		Predicted construction road traffic noise level, dB(A)[1,5]	Estimated existing traffic level, dB(A)[2]	Predicted total road traffic noise level, dB(A)	Increase in road traffic noise, dB(A)	Increase greater than 2 dB(A)	Exceedance of sleep disturbance screening level[4]
					Light[3]	Heavy[3]	Light[3]	Heavy[3]						
Ridge Street north (WHT9)	Warringah Freeway	Arterial	Day	60 $L_{Aeq(15hr)}$	95	189	-	-	54.4	77.3	77.3	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	66	8	-	-	45.2	72.6	72.6	0.0	No	Yes
Blue Street (WFU1)	Pacific Highway/ Blue St	Sub-arterial	Day	60 $L_{Aeq(15hr)}$	224	10	-	-	47.2	70.5	70.5	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	80	0	-	-	43.9	65.3	65.3	0.0	No	No
High Street south (WFU2) + High Street north (WFU3)	Alfred St / Pacific Hwy	Sub-arterial	Day	60 $L_{Aeq(15hr)}$	84	26	-	-	49.2	76.0	76.0	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	51	0	-	-	45.3	71.4	71.4	0.0	No	No
Arthur Street east (WFU4)	Arthur Street	Sub-arterial	Day	60 $L_{Aeq(15hr)}$	91	12	-	-	47.8	77.2	77.2	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	30	0	-	-	43.0	72.5	72.5	0.0	No	No
Berry Street east (WFU5) + Berry Street north (WHT8)	Berry St	Arterial	Day	60 $L_{Aeq(15hr)}$	98	44	-	-	53.1	70.5	70.6	0.1	No	-
			Night	55 $L_{Aeq(9hr)}$	48	16	-	-	50.6	65.3	65.4	0.1	No	Yes
Ridge Street east (WFU6)	Ridge St	Local	Day	55 $L_{Aeq(1hr)}$	-[3]	-[3]	5	4	52.0	62.5	62.9	0.4	No	-
			Night	50 $L_{Aeq(1hr)}$	-[3]	-[3]	5	2	49.9	53.6	55.2	1.5	No	Yes
Merlin Street (WFU7)	Alfred St / Merlin St	Local	Day	55 $L_{Aeq(1hr)}$	-[3]	-[3]	10	0	47.8	57.3	57.8	0.5	No	-
			Night	50 $L_{Aeq(1hr)}$	-[3]	-[3]	10	0	47.8	50.6	52.4	1.8	No	No
Jeaffreson Jackson Reserve construction area	Access from Falcon Street	Arterial	Day	60 $L_{Aeq(15hr)}$	53	43	-	-	51.4	71.0	71.0	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	6	0	-	-	39.4	65.0	65.0	0.0	No	No

Minor construction support site	Construction vehicle access road	Road type	Time of day	Base RNP criteria, dB(A)	Proposed construction vehicle movements (Day – 7 am - 10 pm Night – 10 pm - 7 am)		Proposed construction vehicle movements (Day / Night average maximum 1 hour)		Predicted construction road traffic noise level, dB(A)[1,5]	Estimated existing traffic level, dB(A)[2]	Predicted total road traffic noise level, dB(A)	Increase in road traffic noise, dB(A)	Increase greater than 2 dB(A)	Exceedance of sleep disturbance screening level[4]
					Light[3]	Heavy[3]	Light[3]	Heavy[3]						
Merlin Street (north) construction area	Merlin Street	Local	Day	55 $L_{Aeq(1hr)}$	-[3]	-[3]	3	3	51.1	64.3	64.5	0.2	No	-
			Night	50 $L_{Aeq(1hr)}$	-[3]	-[3]	1	0	39.4	57.5	57.6	0.1	No	No
Rosalind Street east (WFU9)	Miller St / Rosalind St	Sub-arterial	Day	60 $L_{Aeq(15hr)}$	124	14	-	-	47.2	67.1	67.1	0.0	No	-
			Night	55 $L_{Aeq(9hr)}$	65	2	-	-	45.4	59.3	59.5	0.2	No	Yes

Notes:

1. Predicted traffic noise levels have been calculated based on noise measurements of similar construction delivery vehicles. Heavy vehicles are based on a medium-rigid delivery heavy vehicle, except for WHT8 and WHT9 where it is assumed the heavy vehicles may be truck and dogs. Light vehicles are based on typical private cars.
2. As the road traffic noise at these residential receivers is controlled by the Warringah Freeway, existing traffic noise levels have been estimated using the operational noise modelling to determine the existing traffic noise levels at the receivers along the construction vehicle access road and determine the receiver which would be the worst affected. Existing traffic noise levels have been determined for the appropriate 15hr/9hr or worst 1 hour assessment periods where applicable.
3. A '-' is included where these counts are no applicable for the assessment of this access road type.
4. Not applicable during daytime
5. Based on the distance from the facade to kerb of the potentially worst affected residential/sensitive receiver adjacent to the access road.

5.9.3.4 Noise impacts from alternative road traffic routes during temporary closure of Warringah Freeway

During the Warringah Freeway Upgrade surface road works, some Warringah Freeway lanes or carriageways would need to be closed for short periods to reduce the risks associated with construction activities close to live traffic and the difficulties associated with safely closing sections of the Warringah Freeway without compromising the integrity of the road network.

Closing carriageways would also allow works such as re-sheeting, bridge span installation, and demolition of kerbs and medians to be done more efficiently and with less disruption to traffic. This approach would also potentially reduce the overall duration of various construction activities and associated noise impacts.

To minimise the impacts of these closures, an extensive communication strategy would be implemented to notify the community and affected motorists of closures and the recommended detour routes. Active traffic management would also be in place during the closure to manage detours and road capacity, where necessary, to maintain traffic flows on key routes and limit traffic volumes diverted to collector and local roads.

Five Warringah Freeway closure scenarios have been assessed:

1. Full northbound and southbound closure
2. Full northbound closure
3. Outer northbound lane closure only
4. Full southbound closure
5. Outer southbound lane closure only.

Road traffic noise levels and relative increases were calculated using the Calculation of Road Traffic Noise (CoRTN88) road traffic noise prediction algorithm. The predicted noise levels consider the vehicle type (light or heavy), speed and the distance to receivers adjacent to the road. The predicted increases in noise levels were based on forecast increases in traffic volumes presented in the traffic assessment for the roads and ramps with the most substantial predicted increases in traffic volumes associated with the detour scenarios.

Predicted changes in road traffic noise levels at receivers adjacent to key one-way roads and ramps are presented in Table 5-229.

Table 5-229 – Predicted night $L_{Aeq(9hour)}$ road traffic noise level increases (in dB(A)) on one-way roads and ramps

One-way road or ramp	Full northbound and southbound closure	Full northbound closure	Outer northbound lane closure only	Full southbound closure	Outer southbound lane closure only
Mount Street southbound on ramp to Western Suburbs (Bradfield)	6.6	0.1	0.0	6.7	2.6
Mount Street southbound on ramp to Eastern Suburbs (Cahill Expressway)	2.6	0.1	0.0	2.5	2.3
Arthur Street southbound (from Berry Street)	6.1	0.6	0.2	6.2	3.0
Arthur Street northbound (Pacific Highway)	4.7	2.1	0.6	4.2	1.4
High Street southbound on ramp	6.3	1.6	0.2	4.3	3.0
Bent Street / Alfred Street southbound, Neutral Bay	16.6	5.1	2.9	16.4	12.6

The assessed one-way roads and ramps are predicted to experience increases in road traffic noise levels of greater than 2 dB(A) during all closure scenarios, except that:

- Closing the northbound and reversible carriageways would result in a less than 2 dB(A) increase in road traffic noise level on all one-way roads and ramps except for Arthur Street northbound and Bent Street/Alfred Street southbound
- Closing the permanent northbound carriageway would increase road traffic noise levels by less than 2 dB(A) along all roads except for Bent Street/Alfred Street southbound
- Closing the permanent southbound carriageway would increase road traffic noise levels by less than 2 dB(A) along the northbound section of Arthur Street.

The predicted noise level increases suggest that receivers exposed to noise from the following roads would notice an increase in road noise levels of more than 2 dB(A) during full closure:

- Mount Street southbound on ramp to Western Suburbs (Bradfield Highway)
- Mount Street southbound on ramp to Eastern Suburbs (Cahill Expressway)
- Arthur Street southbound (from Berry Street)
- Arthur Street northbound (Pacific Highway)
- High Street southbound on ramp
- Bent Street/Alfred Street southbound, Neutral Bay.

Roads that would experience high detoured volumes are part of the arterial road network or are sign-posted as recommended routes towards key destinations. Predicted changes in road traffic noise levels at receivers adjacent to key two-way roads are presented in Table 5-230. The predicted increases are for the receivers most affected by the increased traffic noise, which would typically be the first row of receivers directly adjacent to the subject road.

Table 5-230 – Predicted night time $L_{Aeq(9hour)}$ road traffic noise level increases (in dB(A)) from key two-way roads

Road	Full northbound and southbound closure	Full northbound closure	Outer northbound lane closure only	Full southbound closure	Outer southbound lane closure only
Pacific Highway at North Sydney	8.6	6.6	2.9	5.8	4.2
Cahill Expressway at Circular Quay	4.1	3	3.3	1.5	1.3
Victoria Road at Gladesville Bridge	1.4	0.7	0.2	1.0	0.6
Miller Street at North Sydney	9.8	8.7	4	6.3	3.3
Clark Road at North Sydney	4	1.6	0.8	3.1	2.2
Kurraba Road at Neutral Bay	4.5	2.1	0.9	3.3	2.8
Falcon Street at North Sydney	4.4	3.4	1.3	1.2	0.9
Walker Street at North Sydney	6.3	3.7	2	4.4	2.7
Ridge Street at North Sydney	10	7.2	4.2	7.1	4.7

Road traffic noise levels from the assessed two-way roads are predicted to increase by more than 2 dB(A) during all closure scenarios, except that:

- Closing the permanent southbound carriageway, or closing the southbound and reversible carriageways, would increase road traffic noise levels on Cahill Expressway, Victoria Road and Falcon Street by less than 2 dB(A)
- Closing the permanent northbound carriageways would increase road traffic noise levels on Victoria Road, Clark Road, Kurraba Road, Falcon Street and Walker Street by less than 2 dB(A)
- Closing the northbound and reversible carriageways would increase road traffic noise levels on Victoria Road and Clark Road by less than 2 dB(A)
- Closing all carriageways would increase road traffic noise levels on Victoria Road by less than 2 dB(A).

The predicted noise level increases suggest that receivers exposed to noise from the following roads would notice an increase in road noise levels of more than 2 dB(A) during full closure:

- Pacific Highway at North Sydney
- Cahill Expressway at Circular Quay
- Miller Street at North Sydney
- Clark Road at North Sydney
- Kurraba Road at Neutral Bay
- Falcon Street at North Sydney
- Walker Street at North Sydney
- Ridge Street at North Sydney.

Given that proposed traffic diversions would likely be temporary, there are limited options for installing feasible and reasonable noise mitigation measures to managed noise impacts at sensitive receiver locations along diversion routes. Management and mitigation options would be developed during the detailed design stage considering the various required construction activities that would benefit from closing sections of the Warringah Freeway. These would be developed through further assessment considering community preferences and may include demand management, respite, programming and speed limits.

5.9.4 Construction ground-borne noise

Ground-borne noise levels could be generated by vibration-intensive works at the surface road works and associated minor construction support sites. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise-sensitive receivers. Section 4.3.2 outlines the potential impacts from ground-borne noise generated by surface construction works such as these and how any ground-borne noise generated from these works would be mitigated and managed.

5.9.5 Construction vibration

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

For the Warringah Freeway Upgrade surface road works minor construction support sites no typical vibration intensive activities are proposed. In the case the vibration intensive activities are required, then site-specific buffer distances for these activities (eg. compaction, rock hammering) must be measured on site where plant and equipment are likely to operate close to or within the typical minimum working distances (see Table 4 9). Site-specific buffer distances would then be maintained to comply with relevant vibration limits.

Across the Warringah Freeway Upgrade surface road works it is assumed that vibration-intensive activities such large rock hammers could be used as part of the upgrade works with the minimum working distances of 22 metres for sound structures, 30 metres for unsound structures and 73 metres for human response used to assess potential vibration impacts. A range of other vibration-intensive plant may be used as part of the Warringah Freeway Upgrade surface road works. The typical minimum working distances for other vibration-intensive plant items that may be used in the works are presented in Table 4-11.

The number of receiver buildings that are within the minimum working distances across the major works areas have been assessed and are presented in Table 5-231. Potential vibration impacts to receivers would depend on vibration source levels, the separation distance, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

Table 5-231 – Potential vibration impacts – Warringah Freeway Upgrade surface road works

Vibration-intensive works location	NCA	Within minimum working distance		
		Cosmetic damage		Human response
		Heritage item	Sound structure	
WFU1A	17.4	2	1	24
	20.1	1	2	8
	23.2	4	-	-
WFU1B	16.3	-	-	8
	19.1	1	5	22
	20.1	-	-	4
WFU1C	16.3	-	-	1
	17.3	1	3	54
	17.4	4	4	70
	23.1	-	-	5
WFU1D	16.1	3	-	5
	16.3	-	-	11
	17.2	-	-	1
WFU1E	23.1	-	-	28
	23.2	2	-	11
WFU1F	16.1	3	-	12
	16.3	-	-	5
	17.2	-	-	2
	17.3	-	-	3
WFU1G	16.3	-	-	1
	17.3	-	3	27
	17.4	3	4	68
	23.1	-	-	21

Vibration-intensive works location	NCA	Within minimum working distance		
		Cosmetic damage		Human response
		Heritage item	Sound structure	
WFU2H	23.1	-	2	7
	23.2	-	-	11
	24.1	-	-	12
	25.1		1	21
	26.1	-	-	1
	26.2	1	-	-
	28.1	-	-	6
	29.1	-	4	24
	30.3	-	-	1
WFU3J	20.1	1	3	6
	23.2	6	-	2
WFU3I	24.1	1	-	-
	25.1	-	1	30
	26.2	1	-	-
	28.1	-	-	2
	29.1	2	2	66
	30.1	1	-	88
	30.2	1	-	31
	30.3	-	-	10
	31.3	-	-	24
WFU3K_01	33.1	-	-	2
	33.2	-	1	9
WFU3K_02	Depending on final communication cable trench alignment, refer to section 4.4.1 for the minimum working distances during trenching construction works.			

5.9.5.1 Heritage listed structures

The figures in Appendix L show the relative locations of heritage items nearby to all the assessed major works areas, along with the minimum working distances for vibration impacts.

The heritage items listed in Table 5-232 have been identified as within the unsound structure cosmetic damage minimum working distance. Across the Warringah Freeway Upgrade surface road works it is assumed that vibration-intensive activities such as use of a large rock hammer could form part of the works. This typically has a minimum working distance of 30 metres for unsound structures. Each identified heritage item would need to be assessed in detail during detailed design to determine specific vibration mitigation and management measures, with consideration of the vibration-intensive activities proposed at each site. Up to seven heritage items are identified as within the worst-case minimum working distance for an unsound structure from any individual major works area.

Refer to the Technical working paper: Cultural heritage assessment report and Technical working paper: Non-Aboriginal heritage for the assessment of impacts to heritage items.

Table 5-232 – Heritage receivers within minimum working distance for unsound structures

Name	Significance	Type/Classification[1]	Site Heritage ID	NCA
WFU1A				
W. Tunks Memorial Fountain	Local	Item - Landscape	I1124	23.2
Flat building	Local	Item - General	I0542	17.4
St Leonards Park	Local	Item - Landscape	I0916	23.2
War memorial	Local	Item - Landscape	I1123	23.2
House, sandstone rock wall and cliff face	Local	Item - General	I0735	17.4
'St Malo'	Local	Item - General	I0982	20.1
St Leonards Park	State	State Heritage Act	5062353	23.2
WFU1B				
House	Local	Item - General	I0846	19.1
WFU1C				
Flat building	Local	Item - General	I0542	17.4
House	Local	Item - General	I0794	17.3
House, sandstone rock wall and cliff face	Local	Item - General	I0735	17.4
House	Local	Item - General	I0633	17.4
House	Local	Item - General	I0634	17.4
WFU1D				
Sydney Harbour Bridge approach	State	Item - General	I0530	16.1
Milsons Point Railway Station Group	State	Item - General	I0539	16.1
Sydney Harbour Bridge approaches and viaducts (road and rail)	State	State Heritage Act	5045703	16.1
WFU1E				
Sewer vent	State	Item - General	I0839	23.2
Sewer Vent	State	State Heritage Act	5053880	23.2
WFU1F				
Sydney Harbour Bridge approach	State	Item - General	I0530	16.1
Milsons Point Railway Station Group	State	Item - General	I0539	16.1
Sydney Harbour Bridge approaches and viaducts (road and rail)	State	State Heritage Act	5045703	16.1
WFU1G				
Flat building	Local	Item - General	I0542	17.4
House, sandstone rock wall and cliff face	Local	Item - General	I0735	17.4
House	Local	Item - General	I0633	17.4
WFU2H				
Cammeray Park (including golf course)	Local	Item - Landscape	I0024	26.2
WFU3I				
Cammeray Park	Local	Item - Landscape	I0024	26.2
'Tarella'	State	Item - General	I0001	29.1
St Thomas Rest Park	Local	Item - Landscape	I0180	24.1
Tarella	State	State Heritage Act	5045416	29.1
St Cuthbert's Anglican Church (including	Local	Item - General	I172	30.2

Name	Significance	Type/Classification[1]	Site Heritage ID	NCA
WFU3J				
W. Tunks Memorial Fountain	Local	Item - Landscape	I1124	23.2
St Leonards Park	Local	Item - Landscape	I0916	23.2
War memorial	Local	Item - Landscape	I1123	23.2
Sewer vent	State	Item - General	I0839	23.2
'St Malo'	Local	Item - General	I0982	20.1
Sewer Vent	State	State Heritage Act	5053880	23.2
St Leonards Park	State	State Heritage Act	5062353	23.2
WFU3K				
Note 2				

Notes: 1. Conservation areas have not been considered as they do not form a structure that would be impacted by vibration.

2. WFU3K_01 – No heritage items are identified within the minimum working distances. WFU3K_02 - Depending on final communication cable trench alignment, refer to section 4.4.1 for the minimum working distances during trenching construction works for unsound items as a screening test for heritage items.

Before starting work with the potential to impact on heritage items, all nearby heritage items would be reviewed, structural surveys carried out where required, and appropriately revised minimum working distances and vibration limits determined to prevent cosmetic damage to heritage items.

Vibration monitoring would be carried out to ensure vibration levels do not exceed appropriate vibration limits. Where vibration-intensive works are required to take place within the site-specific and activity specific minimum working distance, then the process outlined in section 6.8 would be followed.

5.9.5.2 Vibration mitigation and management

Further analysis and assessment of potential vibration impact would be carried out during the detailed design phase, when likely plant and equipment, timing and location of works are confirmed.

Due to the varying nature of vibration-intensive activities, cumulative vibration impacts are unlikely to result in increased vibration levels at sensitive receivers. However, all vibration-generating activities would be considered during detailed design and individual activities would not be considered only in isolation.

Vibration mitigation and management measures would be used to minimise any possible impacts on sensitive receivers. The measures adopted for this project where vibration-intensive activities may be required to occur within the minimum working distances are outlined in section 6.8 and would be included in the project CNVMP.

5.10 Other construction activities

5.10.1 Local area and utility adjustment works

Local area and utility adjustment works may be needed as part of establishing construction support sites, such as service and utility identification works, electricity, sewerage, communications and other utility adjustments.

Some areas of work are known and have been assessed as part of the relevant construction support site or surface road work area. Some utilities requirements are still being investigated, so additional works may be needed close to, or further away from, construction support sites. Work locations would be finalised during detailed design.

For this assessment, typical utility and local area work activities have been assessed to describe typical noise levels that would be associated with these works at the nearest sensitive receivers. Typical local area and utility adjustment works are presented in Table 5-233.

Table 5-233 – Assessed local area and utility works

Assumed activity noise level SWL, dB(A)			Plant/equipment item	Number of units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	Penalty[6]	$L_{Aeq15min}$ SWL, dB(A)	L_{Amax} SWL, dB(A)[4]
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity					
Utilities modification (relocation of utilities and services, communication cable trenching)										
110 121 126			Vacuum truck	1	1	108	15	0	108	-
			Ute/ light vehicle	1	1	89	15	0	89	-
			Excavator with bucket	1	1	105	7.5	0	102	120
			Excavator with medium rock hammer			118	7.5	5	120	126
			OR	-	1					
			Road saw			121	5	5	121	126
			Dump truck	1.p.h	1.p.h	108	15	0	103	117
			Enclosed generator/Daymaker	1	1	94	15	0	94	-
Pavement/road modification (remove/construct kerbing or pavement)										
110 120 126			Vacuum truck	1	1	108	15	0	108	-
			Ute/ light vehicle	1	1	89	15	0	89	-
			Excavator with bucket	1	-	105	7.5	0	102	120
			Excavator with medium rock hammer			118	7.5	5	120	126
			OR	-	1					
			Road saw			121	5	5	121	126
			Concrete pump	1	-	103	15	0	103	-
			Enclosed generator/Daymaker	1	1	94	15	0	94	-

Assumed activity noise level SWL, dB(A)			Plant/equipment item	Number of units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	Penalty[6]	$L_{Aeq15min}$ SWL, dB(A)	L_{Amax} SWL, dB(A)[4]
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity					
Paving/asphalting (including concrete sawing)										
109	120	126	Pavement laying machine	-	1	114	15	0	114	-
			Truck	1	1	103	15	0	103	117
			Asphalt truck and sprayer	1	1	103	15	0	103	117
			Roller	1	-	109	7.5	0	106	-
			Concrete saw	-	1	120	5	5	120	126
			Enclosed generator/Daymaker	1	1	94	15	0	94	-

Notes 1. Typical Activity - (eg when the concrete saw/rock hammer is not used)
2. Worst-case (Noise-intensive) - (eg when the concrete saw/rock hammer is used)
3. Maximum instantaneous noise level (eg maximum level an object bangs when it is dropped)
4. L_{Amax} levels only noted for equipment potentially used during the night period
5. Usage factor is the number of minutes in use during typical 15 minute period
6. Penalty applied for impulsive, tonal and other more annoying activities, in accordance with the ICNG.

Table 5-234 presents the typical and worst-case noise levels that would be expected at 10 metres from the works. Around the construction support sites associated with the project, receiver buildings are typically set back by about 10 metres from the nearest road, and so these are the noise levels that would be expected at the closest receiver buildings. The distances where receiver buildings would be considered highly noise affected (ie. >75 dB(A)) are also indicated for the various types of local area and utility adjustment work activities.

The predictions account for distance attenuation and some localised shielding (such as temporary noise barriers, see section 6.4.1) and are expected to be conservative (over-predict) as they do not account for other effects such as ground absorption and terrain effects.

Table 5-234 – Assessment of typical and worst-case local area works noise at the nearest receivers

	Utilities modification / utilities installation		Pavement modification		Paving or asphalting	
	Typical	Worst-case	Typical	Worst-case	Typical	Worst-case
Distance to the highly noise affected level (metres)	13	45	13	40	12	42
$L_{Aeq(15min)}$ noise level at 10 metres (dB(A))	77	88	77	87	76	88
L_{Amax} noise level at 10 metres (dB(A))	84	93	87	93	84	93

Table 5-234 indicates that local area and utility works would typically comply with the highly noise affected level at about 13 metres from the work, or about 45 metres in the worst-case.

In most NCAs, with a standard construction hours NML of 55 dB(A) or more, noise from local area works at the closest receiver buildings would typically exceed the NML by about 25 dB(A) and in the worst-case up to 35 dB(A). The noise levels and exceedances would be less when works occur at greater distances from a receiver than assumed.

Outside standard hours, noise from local area works at the closest receivers would typically exceed the night time NML by about 40 dB(A) and in the worst-case up to about 50 dB(A). This is based on the NML in most NCAs being 40 dB(A) or more.

Works would take place during standard construction hours where feasible and reasonable, and where they do not pose a risk to the public or worker safety. Often ROLs prevent works from occurring before the evening or night period, due to the importance of the road to the functionality of the road network. In these cases, construction works need to occur during the night period, or OOHW Period 2 as indicated in Table 3-2.

These works are typically of short duration, temporary, and progressive works that move along. This means that, as works progress, nearby sensitive receivers would only receive high noise levels for a small time out of the entire works program.

Due to the nature of the paving, asphalting, resurfacing and similar moving construction activities taking place within the Warringah Freeway carriageway there are limited physical noise source and noise path mitigation measures that can be installed during the works. As many of the residential receivers are located in multi-storey buildings, they would overlook the construction works and any fixed mitigation on-site would be very limited. Furthermore, due to the transient nature of these types of construction works, fixed mitigation measures would be of limited effectiveness.

All feasible and reasonable noise mitigation and management measures would be implemented in an effort to meet NMLs during local area works, and residual impacts would be managed in accordance with the CNVG. These measures would be included in the CNVMP.

These works can also include vibration intensive activities. In the case that vibration intensive activities are required, site-specific buffer distances for these activities (eg. compaction, rock hammering) must be measured on site where plant and equipment are likely to operate close to or within the typical minimum working distances (see Table 4 9). Site-specific buffer distances would then be maintained to comply with relevant vibration limits.

5.10.2 Deliveries outside standard hours

Delivery of most plant and equipment to the construction support sites would be carried out during standard construction hours. However, during various stages of construction works, some oversized deliveries would be needed.

Oversized deliveries can cause disruptions to existing traffic on public roads and can be a safety hazard for road users. Therefore, oversized vehicles typically travel during off-peak periods when traffic volumes are lower, to reduce risks to road user and public safety and minimise disruption to the road network. Deliveries may require the use of more than one traffic lane.

5.10.3 Heavy vehicle marshalling areas

Spoil haulage heavy vehicles would likely require marshalling areas to be used when delays are experienced at the tunnel sites. The locations of these staging points are not known at this stage but would be selected during detailed design. As the locations are not known, a quantitative assessment has not been carried out.

During detailed design potential noise impacts from additional heavy vehicle movements on local roads and noise emissions from heavy vehicles within the staging area are to be assessed in accordance with the project approval. This would be addressed in the CNVMP.

Where required, the locations are to be selected away from residential receivers. Where feasible and reasonable, the site layout would maximise the use of on-site or adjacent non-receiver structures to maximise acoustic shielding to nearby noise-sensitive receivers from heavy vehicle idling and accelerating locations.

All drivers would be required to comply with a Heavy Vehicle Code of Conduct, which would include noise management methods such as limiting idling and compression braking, and traffic management practises to minimise noise emissions from vehicles entering and leaving the site. The mitigation and management measures outlined in section 6.2 are also to be used to minimise associated noise impacts.

5.11 Mainline tunnelling construction noise and vibration impacts

5.11.1 Construction ground-borne noise assessment

Ground-borne noise emissions from the mainline driven tunnel construction works were determined by modelling the noise source, tunnel location and depth, and receiver locations, based on the information presented in section 4.3. The indicative tunnel crown depth is presented in Appendix I.

Assessment of the access declines, access or ventilation shafts or ventilation tunnels is presented in the relevant construction support site assessment section.

Ground-borne noise management levels are presented in section 3.4.4.

The estimated number of potentially ground-borne noise affected receiver buildings are summarised in Table 5-235 to Table 5-236 and Appendix J.

5.11.1.1 Roadheader tunnelling

Table 5-235 summarises the number of receiver buildings in each NCA potentially exposed to ground-borne noise levels above the ground-borne noise management levels (GBNMLs) during roadheader tunnelling.

Table 5-235 – Summary of the estimated number of potentially ground-borne noise affected receiver buildings during roadheader tunnelling.

Suburb	NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML) receiver buildings				
		Residential			Other sensitive receivers	Commercial/ Industrial receivers
		> 35 to ≤ 40 dB(A)	> 40 to ≤ 45 dB(A)	>45 dB(A)		
Rozelle	4.4	-	-	-	-	-
	4.5	-	-	-	-	-
	5.3	-	-	-	-	-
	6.1	-	-	-	-	-
	6.2	-	-	-	-	-
	6.3	-	-	-	-	-
	7.1	-	-	-	-	-
	8.1	-	-	-	-	-
Balmain	9.2	-	-	-	-	-
	11.2	-	-	-	-	-
	11.5	-	-	-	-	-
Birchgrove	11.3	-	-	-	-	-
	11.4	-	-	-	-	-
	12.1	-	-	-	-	-
Wollstonecraft	22.2	-	-	-	-	-
Waverton	14.1	4	-	-	-	-
	15.1	9	-	-	-	-
North Sydney - south west	15.3	-	-	-	-	-
	16.3	-	-	-	-	-
North Sydney - north west	19.1	1	1	-	-	-
	20.1	1	-	-	-	-
	21.2	7	-	-	1	-
	22.1	-	-	-	-	-
	23.2	-	-	-	-	-
Neutral Bay	17.4	-	-	-	-	-
	23.1	-	-	-	-	-
Crows Nest	24.1	-	-	-	-	-
Cammeray	25.1	-	-	-	-	-
Cremorne	26.1	-	-	-	-	-
Overall		**22**	**1**	**0**	**1**	**0**

The predicted ground-borne noise levels are presented in Appendix J and Table 5-235 above identifies that there are potential ground-borne noise affected receiver buildings as a result of roadheader tunnelling. This review found that:

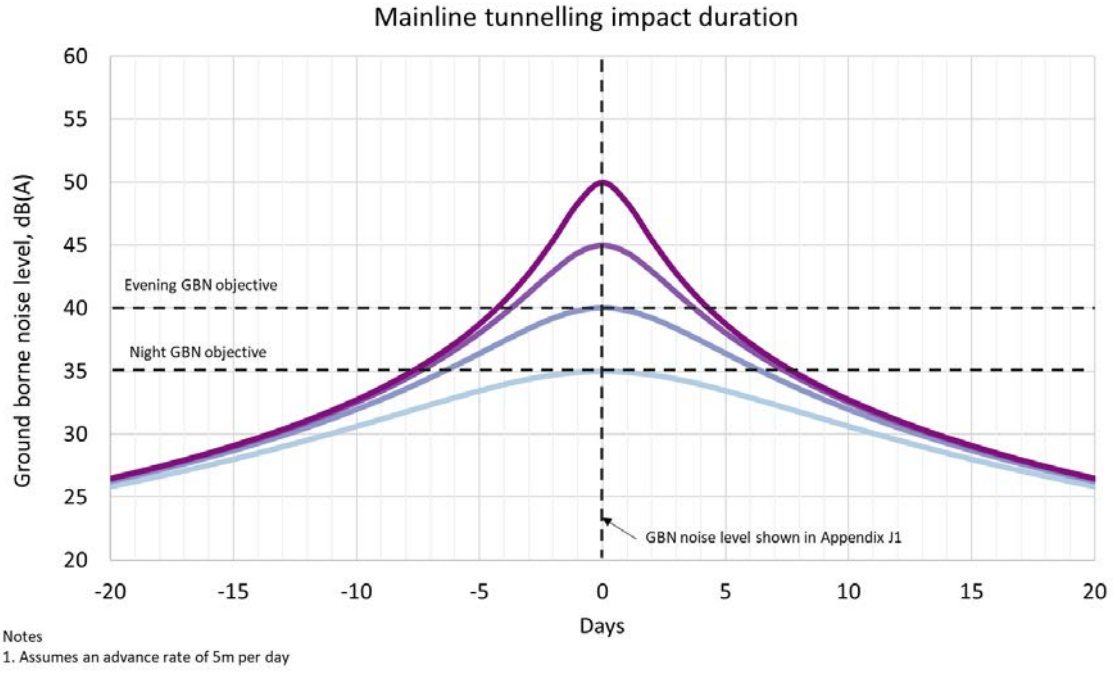
- 23 residential receiver buildings could be ground-borne noise-affected during the night period (above 35 dB(A))
- One residential receiver building could be ground-borne noise-affected during the evening period (above 40 dB(A))
- No residential receiver buildings are predicted to be exposed to ground-borne noise levels above 45 dB(A)
- One other noise sensitive receiver building (theatre) in North Sydney could be expected to be ground-borne noise-affected (ie. above ground-borne noise management level)
- Commercial/industrial premises and all other noise-sensitive receivers are not expected to be ground-borne noise-affected during roadheader tunnelling.

Ground-borne noise affected receiver buildings would require, as a minimum, letterbox notification to advise that tunnelling would be occurring and that noise levels are likely to be clearly audible during tunnelling works.

However, as outlined in section 4.3, as tunnelling progresses, the tunnelling equipment approaches or moves away from individual receiver locations. The predicted noise levels are the peak noise levels that a receiver would be exposed to, such as the noise level at the zero days mark in Figure 5-31. The noise levels are then expected to drop away as the tunnelling moves further away from the receiver, with individual receivers potentially exposed to noise levels above the ground-borne noise management levels for only relatively short periods of time, as shown in Figure 5-31.

Even when the ground-borne noise levels achieve the objectives, they may still be audible or perceivable within residences.

Figure 5-31 – Indicative duration of impacts of ground-borne noise levels from roadheaders



Appendix J.1 presents the predicted highest noise level at 0 days, as the road header passes at the closest distance to each receiver building.

Measures for managing exceedance of the ground-borne noise management levels are identified in section 6. Additional ground-borne noise mitigation measures are presented in section 6.10.2.

5.11.1.2 Rock hammer tunnelling

Table 5-236 summarises the number of receiver buildings in each NCA potentially exposed to ground-borne noise levels above the ground-borne noise management levels (GBNML) during rock hammer excavation works.

The predicted ground-borne noise levels show that there are more receivers likely to be impacted during rock hammering than roadheader tunnelling. Rock hammering is proposed for clearing the bench of tunnel. As this process follows behind the roadheader, there is more scope for rock hammering activities to be programmed to less sensitive periods of the day to reduce noise impact (eg. programmed to standard construction hours, not during the evening or night periods).

In a similar manner to roadheader tunnelling the predicted noise levels are the peak noise levels that a receiver would be exposed to, when the tunnelling is close to the receiver. The noise levels are then expected to drop away as the tunnelling moves further away from the receiver. Individual receivers are potentially only exposed to noise levels above the ground-borne noise management levels for relatively short periods of time when rock hammering occurs.

Table 5-236 – Summary of the estimated number of potentially ground-borne noise affected receiver buildings during rock hammer tunnelling

Suburb	NCA	Number of ground-borne noise affected receiver buildings (ie. above GBNML)				
		Residential			Other sensitive receivers[1]	Commercial/ industrial receivers
		> 35 to ≤ 40 dB(A)	> 40 to ≤ 45 dB(A)	>45 dB(A)		
Rozelle	4.4	-	-	-	-	-
	4.5	14	-	-	-	-
	5.3	-	-	-	-	-
	6.1	52	6	-	-	-
	6.2	90	41	-	-	-
	6.3	-	-	-	-	-
	7.1	-	-	-	-	-
	8.1	64	130	-	-	-
Balmain	9.2	64	107	-	-	-
	11.2	-	-	-	-	-
	11.5	215	3	-	-	-
Birchgrove	11.3	129	41	-	-	-
	11.4	24	22	7	-	-
	12.1	28	42	105	-	-
Wollstonecraft	22.2	14	11	-	-	-
Waverton	14.1	4	8	39	-	1
	15.1	31	32	73	-	-
North Sydney - south west	15.3	15	5	6	8	-
	16.3	3	4	1	2	-
North Sydney - north west	19.1	5	-	6	1	-
	20.1	-	-	12	-	-
	21.2	1	1	8	10	-
	22.1	-	1	13	11	2
	23.2	4	1	1	-	-
Neutral Bay	17.4	5	2	-	-	-
	23.1	13	3	-	-	-
Crows Nest	24.1	1	-	-	-	-
Cammeray	25.1	-	-	-	-	-
Cremorne	26.1	-	-	-	-	-
Overall		**776**	**460**	**271**	**32**	**3**

Notes 1. In some cases, there are multiple buildings across a single noise sensitive receiver such as a school which are identified as potentially ground-borne noise-affected. All buildings are included in the count.

The predicted ground-borne noise levels in Table 5-236 and Appendix J identify that there are potential ground-borne noise affected receivers as a result of rock hammer excavation. The review of predicted to be ground-borne noise levels as a result of rock hammer excavation found that:

- As there are a large number of residential receivers that may exceed either the night period ground-borne noise management level (above 35 dB(A)) or the evening period ground-borne noise management level (above 40 dB(A)), it is likely that rock hammer excavation works would be managed so that they are not carried out during the evening or night periods where the ground-borne noise management levels may be exceeded
- 271 residential receiver buildings could be exposed to ground-borne noise levels above 45 dB(A)
- 32 other sensitive receiver buildings could be ground-borne noise-affected (ie. above ground-borne noise management level)
- Three commercial premises are expected to be ground-borne noise-affected (ie. above ground-borne noise management level) during rock hammer tunnelling activities.

Ground-borne noise impacts would be managed by restricting rock hammer excavation to standard construction hours. The predicted noise levels and land use survey indicate that some areas may be able to be excavated during OOHW periods, where the tunnel is located away from residential receiver buildings which would benefit 24 hour excavation. Where the impacts are on commercial or industrial receiver buildings there may be potential to excavate during OOHW periods to reduce the time of exposure to high noise levels during business hours.

Furthermore, if verification monitoring conducted during the rock hammer tunnelling works determines that ground-borne noise levels inside residential properties are below the predicted noise levels and comply with the ground-borne noise management levels, the rock hammer tunnel excavation may be extended into the OOHW periods. Measures for managing ground-borne noise impacts are provided in section 6.

5.11.2 Construction tunnelling vibration predictions

Vibration generated by tunnelling was estimated based on the tunnel depth and excavation methodology. The indicative tunnel crown depth is presented in Appendix I. Vibration levels were calculated by modelling the vibration source, tunnel location and receiver locations, based on the information presented earlier in section 4.3. Roadheader tunnelling is assumed to occur along the tunnel crown, while bench clearing activities usually occur along the tunnel floor and were assumed to occur at least five metres below the tunnel crown.

Vibration impacts to heritage items have been assessed using a conservative minimum working distance to achieve a screening level of 2.5 millimetres per second PPV. This screening level assumes all heritage items are structurally unsound and that the most sensitive items are located at the closest point to the tunnel. Often higher vibration limits are adopted following review of heritage items and their sensitive

nature, which may involve a structural assessment if required. For this approach, the minimum working distances have been used to identify items that require further investigation.

The number of heritage items that are within the minimum working distances for cosmetic damage from tunnelling vibration are shown in Table 5-237.

The number of receiver buildings where modelling results suggest a risk of human disturbance due to tunnelling construction vibration are also shown in Table 5-237. The risk of human disturbance for receiver buildings is identified based on the minimum working distances presented in section 4.4.1 Table 4-11, which are based on residential receivers. During detailed design, where receiver buildings in proximity to the tunnel are highly sensitive to vibration (eg. hospital operating theatres and precision laboratories where sensitive operations are occurring) a detailed review is to be carried out against the requirement outlined in section 3.4.5. Similarly, where buildings are identified but the use and activities within the occupied buildings are less sensitive to disturbance from vibration impacts (eg. offices, schools, educational institutions and places of worship) then vibration levels may be less than the suitable levels identified in section 3.4.5.

The figures in Appendix K show the mainline tunnel, along with the areas which are within minimum working distances from tunnelling activities for various potential vibration impacts.

Table 5-237 – Assessment of vibration impacts for all receiver types

Suburb	NCA	Number of items / receiver buildings impacted	
		Roadheader tunnelling	Rock hammer tunnelling (benching only)
Risk of structural or cosmetic damage (sound structures)			
	All NCAs	-	-
Risk of structural or cosmetic damage (unsound structures) – Heritage items			
Waverton	14.1	-	1
North Sydney - north west	23.2	-	4
Risk of human disturbance (all occupied receiver buildings included)			
Birchgrove	12.1	-	87
Waverton	14.1	-	42
	15.1	-	63
North Sydney - south west	15.3	-	3
	16.3	-	1
North Sydney - north west	19.1	-	6
	20.1	-	12
	21.2	-	16
	22.1	-	27
	23.2	-	1

Vibration impacts from roadheader tunnelling are predicted to be below the vibration limit for human disturbance at all receivers. Vibration from roadheader tunnelling therefore presents a minor risk of impact.

Vibration from rock hammer excavation of the tunnels may be noticeable inside vibration sensitive premises in the NCAs identified in Table 5-237 above. Occupants of up to 258 occupied receiver buildings fall within the minimum working distance for human response for rock hammer tunnelling. Where building occupants could potentially be impacted by vibration from mainline tunnelling at levels exceeding those identified in section 3.4.5, additional mitigation measures would be provided in accordance with the CNVG, as presented in section 6.

Options for additional mitigation of vibration impacts include notification and respite. Where impacts occur outside standard construction hours, specific notification and alternative accommodation may be offered.

5.11.2.1 Heritage receivers

Refer to the Technical working paper: Cultural heritage assessment report, Technical working paper: Non-Aboriginal heritage and Technical working paper: Maritime heritage for the assessment of impacts to heritage items. The figures in Appendix K show the locations of heritage items near the mainline tunnel, along with the areas which are within minimum working distances from tunnelling activities for various potential vibration impacts.

The heritage items listed in Table 5-238 have been identified as within unsound structure cosmetic damage minimum working distance. Seven heritage items have been identified within the minimum working distance of 20 metres for an unsound structure, for rock hammer bench clearing tunnelling activities.

Each identified heritage item would be assessed in detail during detailed design to determine specific vibration criteria and mitigation and management measures for each item, with consideration of the vibration-intensive activities proposed at each site.

Table 5-238 – Heritage items within minimum working distance for unsound structures

Name	Significance	Type/Classification[1]	Site Heritage ID	NCA
Roadheader tunnelling				
-	-	-	-	-
Rock hammer tunnelling (benching)				
W. Tunks Memorial Fountain	Local	Item - Landscape	I1124	23.2
St Leonards Park	Local	Item - Landscape	I0916	23.2
War memorial	Local	Item - Landscape	I1123	23.2
St Leonards Park	State	State Heritage Act	5062353	23.2
Waverton Park Cave	AHIMS registered site[2]	Shelter with midden	45-6-2181	14.1

Notes: 1. Conservation areas have not been considered as they do not form a structure that would be impacted by vibration.
2. National Parks and Wildlife Act (AHIMS registered site).

5.11.2.2 Railway electricity tunnel – Sydney Harbour

The railway electricity tunnel is a disused tunnel that was designed as a major link in the power supply to the railway and tramway system between Sydney and the North Shore. It was built between 1916 and 1926 and is heritage listed.

The tunnel is lined with concrete, cast iron and rock in various areas. One side of the tunnel was lined with reinforced concrete shelves to house the cables. As the current condition of the tunnel is not known, it is assumed to be an unsound heritage structure and a screening level of 2.5 millimetres per second PPV has been adopted prior to a structural assessment being carried out.

The closest distance from the electricity tunnel to the mainline tunnels is estimated to be 31 metres, as the mainline tunnel crown would be -26 metres AHD and 13 metres horizontally away at the closest point and the railway electricity tunnel is assumed to start at about three metres AHD.

Therefore, the electricity tunnel would not be within the minimum working distances for an unsound structure outlined in Table 4-11 for tunnelling. If vibration-intensive works are proposed within the minimum working distances, then a structural assessment is recommended, and appropriate vibration criteria adopted and monitored prior to vibration-intensive construction works proceeding.

5.11.2.3 Coal Loader Wharf and associated wrecks, Balls Head

The coal loader heritage site is located on Balls Head Drive, Waverton and consists of six buildings of various ages and materials, two large liquid storage tanks and the Coal Loader itself consisting of a storage platform, tunnels, conveying equipment, loading wharf, large mobile crane and controls.

The mainline tunnel would pass under parts of the coal loader heritage area at an estimated -18 metres AHD depth and an estimated 50 metres horizontally from the coal loader structure.

During tunnelling, in particular during benching activities, the structure may be within the minimum working distances outlined in Table 4-11 for tunnelling activities. As such, where work could take place within the minimum working distances for an unsound structure, a structural assessment would be carried out, appropriate vibration criteria adopted and monitored prior to vibration-intensive construction works proceeding.

5.11.2.4 Sydney Metro City & Southwest tunnels

At North Sydney, the mainline tunnel and the Sydney Metro City & Southwest rail tunnels (currently under construction) would cross each other below Miller Street. At the closest point, these tunnels would be separated by around 14 metres, which is within the minimum working distance to assess vibration impacts, as described in section 3.4.5.5.

At this closest distance the vibration generated by the tunnelling works to the Sydney Metro City & Southwest tunnels would be:

- <5 millimetres per second PPV for rock hammer excavation
- <1 millimetre per second PPV for roadheader tunnelling.

The predicted vibration levels at the rail tunnels would be within the minimum structural damage screening criterion for existing rail tunnels, as outlined in section 3.4.5.5. Sydney Metro City & Southwest would be consulted with during detailed design to confirm final tunnel details and vibration limits for rail functionality.

5.12 Blasting

This section documents construction airborne overpressure and ground vibration impacts from blasting.

5.12.1 Overview

Blasting may occasionally be required during mainline tunnelling or excavation works.

There are two main impacts from blasting – overpressure and ground vibration:

- Overpressure travels as an airwave and is able to cause a vibration response in structures such as buildings. It is dominated by low frequencies that are at times inaudible
- Ground vibration is transmitted through the ground that surrounds the blast as a series of waves and can rapidly travel substantial distances, gradually reducing in strength over distance.

It is possible for a blast to be felt, but not heard, due to ground vibration and overpressure.

Ground vibration and overpressure have the potential to cause discomfort or annoyance to sensitive receivers near the blast area. At high levels ground vibration and overpressure have the potential to cause structural damage.

5.12.2 Potential airborne noise and vibration impacts

Blasting may be used as part of the tunnelling methodology for tunnel sections such as the excavation of mainline tunnel benches and cross passages.

Potential vibration and air blast overpressure impacts from blasting would be managed primarily through site and blast-specific assessments. Overpressure and vibration would be predicted during blast design.

It is important that the actual buffer zone around each blast site is identified and appropriate measures are taken to limit blast over-pressure and vibration to acceptable levels at the nearest affected receiver locations. Blast charge masses and configurations would therefore be selected to ensure the objectives identified in section 3.4.6 are not exceeded.

Due to some buildings being close to potential blast locations, a series of initial test blasts at reduced charge would be carried out before any full scale blasting occurs. Vibration and any air blast overpressure and would be measured from test blasts to establish site-specific propagation characteristics and increase the accuracy of blasting predictions. This information would be used to define allowable blast sizes to meet the air blast overpressure and ground vibration limits.

However, as blasting is proposed within the mainline tunnels and cross passages, air blast overpressure and airborne noise impacts would likely be negligible at sensitive receivers nearby to the project.

Table 5-239 provides general guidance for estimating the likely 'minimum distance limits' from blasting in terms of the vibration criteria described above, for a range of blast Maximum Instantaneous Charge (MIC) quantities.

The distance limits relating to vibration are set out in Table 5-239 and have been determined using the formula in Australian Standard 2187.2-2006, which applies to free face blasting in 'average field conditions' and states:

$$V = 1140\left(\frac{R}{Q^{1/2}}\right)^{-1.6}$$

where

V = ground vibration as peak particle velocity in mm/s

R = distance between charge and point of measurement in metres

Q = effective charge mass per delay or maximum instantaneous charge in kilograms

An indication of acceptable blast sizes to satisfy vibration limits set in section 3.4.6 has been determined based on the above algorithms. It is noted that the algorithms are considered conservative. The nominated Maximum Instantaneous Charge (MIC) may vary substantially depending on the geological conditions, local shielding and meteorological factors at the site.

Previously measured blast emissions data indicate a dominant frequency of the vibration signal of a blast event is around between 10 Hz to 30 Hz at an offset of around 50 metres. For the purpose of conservative assessment, the dominant frequency of a blast is assumed to be 10 Hz and peak particle velocities (vector sum) (PPV), instead of peak component particle velocities are considered in this assessment.

Table 5-239 – Summary of typical MIC (kilograms) and compliant separation distance

Blast impact	Receiver	Blast Management Level	Charge separation distance (metres) / MIC (kilograms)					
			1 kg	2 kg	5 kg	10 kg	20 kg	50 kg
Ground vibration	Sound structure[1]	15 mm/s	15	21	33	47	67	106
	Human response – Short term[2]	10 mm/s	19	27	43	61	86	136
	Structurally unsound heritage item	2.5 mm/s	46	65	103	145	205	325

Notes:
1. Based on the vibration limit for cosmetic damage of an un-reinforced or light framed structure (see Table 3-17)
2. Short term is defined as less than 12 months, as per Table J4.5(A) and Table J5.4(A) of AS 2187.2-2006.

The indicative tunnel crown depth is presented in Appendix I, which shows the tunnel depth can typically range between 20 metres to 80 metres. Based on the guidance in AS2187.2-2006, the distances presented in Table 5-239 demonstrate that that for a tunnel depth of 50 metres a MIC of 10 kilograms is predicted to achieve the blast management level of 15 mm/s for a sound structure, while at this depth a MIC of 1 kilogram is predicted to achieve the blast management level of 2.5 mm/s for a unsound structure. However, the vibration levels generated by blasting are dependent on site specific factors, local ground conditions and the blast design and so the MIC that will achieve the vibration management levels at distances from the blasting area can vary from these values.

Considering this, a blast management strategy will be prepared in consultation with the EPA to demonstrate that all blasting and associated activities will be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a significant risk to nearby structures and sensitive receivers. Measures to mitigate and manage impacts from blasting are provided in section 6.

6 Construction noise and vibration mitigation and management approaches

Construction noise and vibration impacts across the project would be reviewed and updated during detailed design to reflect the contractor's preferred constructability approach. Refinements to construction works areas, locations, layouts, equipment, construction methods or construction hours may require specific mitigation and management measures from those outlined in each relevant section. Construction noise and vibration mitigation and management measures would be reviewed during detailed design, with consideration of cumulative and consecutive construction impacts.

The following sections describe proposed approach to mitigate and manage the construction noise and vibration impacts identified in section 5.

Site-specific noise mitigation and management measures have been incorporated as part of each assessment, as outlined in step 4 of the assessment process outlined in Figure 4-1. The assumed mitigation and management measures for each site are outlined in the corresponding section shown in Table 6-1.

Table 6-1 – Assumed site-specific noise treatment and management measures

Location	Report section
Rozelle Rail Yards (WHT1/ROZ)	Section 5.2.1.7
Victoria Road (WHT2/VIC)	Section 5.3.1.7
White Bay (WHT3/WHB)	Section 5.4.1.7
Yurulbin Point (WHT4/YRB)	Section 5.5.1.7
Sydney Harbour Crossing (SHC)	Section 5.6.1.7
Berrys Bay (WHT7/BRY)	Section 5.7.1.7
Cammeray Golf Course (WHT10/CGC)	Section 5.8.1.7
Warringah Freeway Upgrade (WFU)	Section 5.9.2
Warringah Freeway Upgrade minor construction support sites	Section 5.9.2.2

Notes: 1. The assessment of the Warringah Freeway Upgrade also covers a number Western Harbour Tunnel construction sites that interface with the Warringah Freeway. These construction sites include the Berry Street north construction support site (WHT8), the Ridge Street north construction support site (WHT9) and the Waltham Street construction support site (WHT11).

In addition to these, this section outlines the mitigation and management that would be implemented across the project.

6.1 Feasible and reasonable construction noise and vibration mitigation and management

The EPA ICNG outlines how 'feasible' and 'reasonable' mitigation and management measures is a key component of the guideline.

'Feasible' is explained as:

> *work practice or abatement measure {that} is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.*

While 'reasonable' is a more complex issue, which is explained as:

> *Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure. To make such a judgement, consideration may be given to:*

- Noise level impacts (eg. how many people would be impacted by noise levels above the NML? How long would these noise impacts last?)
- Noise mitigation benefits (eg. Would the mitigation measures result in an overall noticeable reduction at receivers? Would the mitigation help many people or just one?)
- Cost effectiveness of noise mitigation (eg. Are there more effective mitigation measures for a similar cost? Is the cost of the mitigation equitable based on the extent of mitigation provided and/or number of receivers benefited?)
- Community views (eg. Liaising with the community to gain preferences on where noise mitigation is installed and what it may look like. Liaising with commercial receivers to locate mitigation that would not interfere with their access. Consulting with the community to determine if they would prefer managed night works and/or more traffic/transport distribution resulting in a longer construction program; or weekend work and/or louder night activities resulting in a shorter construction program).

All construction noise mitigation and management must to take into account concurrent construction works either from other projects or from other nearby project works when assessing the reasonableness of mitigation or management measures.

6.2 Standard mitigation and management measures

Noise management measures in accordance with the CNVG would be implemented for the project, where applicable. Appendix B of the CNVG presents the standard noise and vibration mitigation measures, identifying potentially feasible and reasonable construction noise and vibration mitigation and management measures, which are reproduced in Appendix G.

The CNVMP to be prepared during detailed design would document in more detail how all mitigation measures are to be implemented for this project. Where applicable, additional mitigation and

management measures such as those outlined for the surface road works (section 6.4) would be considered across the construction works associated with the project and adopted where feasible and reasonable. All feasible and reasonable mitigation measures have been included in the assessment of the project's construction noise and vibration impacts. Mitigation measures would be confirmed during detailed design, and appropriate measures would be added when preparing site-specific CNVISs.

6.3 Highly noise affected receivers

Some residential receivers nearest to the tunnel support sites and/or construction work sites may be 'highly noise affected' (ie. exposed to noise levels that exceed 75 dB(A)) as a result of:

- Relocation and protection of existing utility and infrastructure services requiring the use of rock hammers and road/concrete saws
- Vegetation clearing works within construction support sites, including the use of chainsaws or tub grinders
- Early works and site establishment activities requiring rock hammers and pneumatic hammers during the house/ building demolition works
- Cofferdam construction using impact piling and rock hammers
- Bulk excavation works, including the use of rock hammers during rock excavation and blasting
- Road works, including saw cutting of concrete pavement and rock hammers.

Where feasible and reasonable, high noise impact activities would be carried out during standard construction hours to limit the number of highly noise affected receivers, with respite periods, such that:

- High noise impact activities would only be carried out between:
  - 7.00am and 6.00pm Monday to Friday
  - 8.00am and 1.00pm Saturday
- High noise impact activities would be carried out in continuous blocks of up to three hours. Respite from high noise impact activities would be provided between each block for at least one hour. No high noise impact activities would be carried out during this one hour respite period.

During OOHW periods, appropriate respite and additional mitigation measures would be adopted for highly affected receivers in accordance with the CNVG, as outlined in section 6.10.1.

6.4 Surface road works mitigation and management options and opportunities

In addition to the standard CNVG mitigation and management measures outlined in Appendix G, a range of mitigation measures have been considered for the surface road works due to the requirement

for extensive out of hours works. These are to be reviewed and incorporated where reasonable and feasible as part of the CNVMP and OOHW protocol.

These mitigation and management measures also apply for the project for all other construction works across the project, where applicable.

6.4.1 On-site/at-works mitigation and management

Construction works generating moderately intrusive to highly intrusive noise levels would utilise temporary noise screens where feasible and reasonable to provide noise mitigation. Where reasonable and feasible, the screens would be located as close as practicable to the work area to provide shielding of the plant/construction works to receivers. These can be in the form of temporary screens installed for the period of the works, or mobile acoustic screens which move along with the noise-generating plant.

All acoustic screens need to be installed so that they do not contain holes or gaps. In assessing the reasonableness of acoustic screens, the following would be considered:

- Effectiveness of the screen, especially mobile screens, to ensure that line of sight to the critical receivers is being broken
- Usability of the screen does not result in substantially longer noise-generating works
- Whether a small reduction in noise is outweighed by the substantial increase in overall works duration making the use of acoustic screens unreasonable.

Temporary noise screens can provide 5 to 10 dB noise reduction but only where they can break line of sight between the noise source and the impacted receiver.

6.4.2 Community consultation and engagement

Extensive community consultation would be carried out to inform the most effective noise mitigation and management strategy that would suit nearby sensitive receivers during the detailed design process. For example, where high noise impact works may result in a substantially shorter construction period than slightly less noise-intensive activities, the community may prefer to adopt a louder methodology to reduce the overall distribution disruption caused by the construction noise impacts.

6.4.3 Construction programming

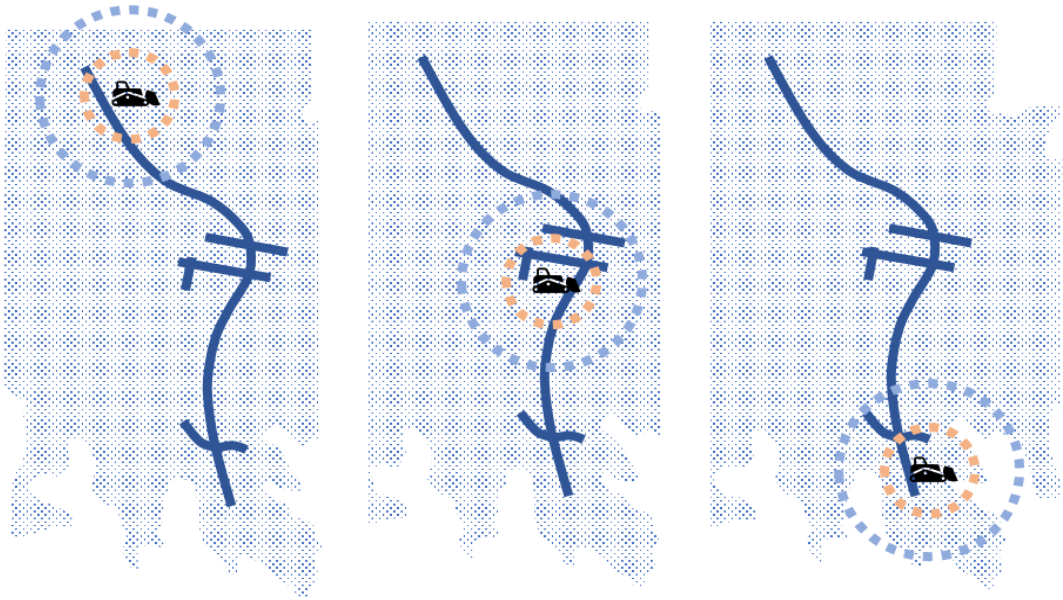
The Warringah Freeway Upgrade surface road works cover a large linear area. Receivers in one suburb may not be noise impacted while works are carried out at the other end of the upgrade works area. This can be used in order to allow multiple consecutive days of OOHW while still providing respite to noise affected (>NML) receivers.

The location and distance between work sites where the same receiver would be noise affected would vary depending on the construction activity being carried out and associated equipment and the extent of the activity work area. Depending on how noise intensive the construction activity is, by moving and

shifting the construction works along the extent of Warringah Freeway Upgrade surface road works or within a major works area, it is possible to provide receivers with respite from construction noise while continuing to undertake project construction works.

This programming and shifting of the works to provide less impact to receivers, while working within the same surface works area is shown in the indicative representation presented in Figure 6-1. This would allow the construction works to continue throughout the week, while providing receivers with respite from construction noise impacts.

Figure 6-1 – Indicative example of construction programming opportunities for providing respite during consecutive days of out of hours work (dotted lines represent the indicative extent of noise impacts)



6.4.4 Out of hours work protocols to provide respite

Roads and Maritime's CNVG recommends the following construction respite periods for OOHW, unless alternative hours can be negotiated with the community:

- Two consecutive evenings or nights per week
- Three evenings or nights per week
- Six evenings or nights per month.

For night works, the above periods would be separated by not less than one week. The above approach has historically been adopted by the NSW Environment Protection Authority for infrastructure projects. This approach is likely to increase the overall duration of the construction stage of the project, which may result in longer periods when construction noise impacts would need to be managed. It is recommended that a more detailed OOHW Protocol be developed and adopted to better manage OOHW construction.

Other major infrastructure projects throughout Sydney have developed OOHW Protocols which classify works based on level and duration of impact, beyond the standard approach in the CNVG. The protocols considered the following to allow OOHW to proceed.

- Programming of works
- Alternative construction techniques/programming
- Alternative plant and equipment
- Community consultation (eg letter box drops, email correspondence, community briefing session)
- Noise monitoring
- Receiver specific notifications
- Receiver specific contact
- Respite periods
- Project specific respite offer (eg good would offer)
- Reasonable temporary relocation offer.

The project would develop an OOHW protocol based on the above considerations, to assist in speeding up the completion of the overall project, minimising the overall duration of noise impacts, while providing respite to impacted receivers during the construction works and ensuring the project construction is completed within a reasonable timeframe.

6.4.5 Limiting the timing of noise-intensive works

Where out of hours work is required and justified, it may be feasible and reasonable to program higher noise impact works during the parts of the OOHW period when ambient noise levels are higher. Lower noise impact activities could then be programmed to the OOHW period where ambient noise levels are lower. The result would be a reduction of overall noise impact whilst still allowing the required OOHW to be completed.

Where feasible and reasonable, higher noise impact works would be programmed to the evening period and lower noise impact works to the night period (see section 3.2 for definition of assessment time periods). However, where OOHW are required and a road occupancy licence (ROL) is not available until the evening period (or later), noise-intensive works may need be carried out during the night period. In these circumstances it can be beneficial if high noise works (eg road sawing and rock hammering) are programmed to the earlier part of the night period, before 11.00pm, as recommended in the CNVG or before 12.00am, to minimise the impacts on nearby residential receivers.

Additional assessment periods called 'shoulder' periods could be considered and used, in accordance with the methodology outlined in the NPfI, such as:

- Shoulder period (night-day) – between 5.00am and 7.00am
- Shoulder period (evening-night) – between 10.00pm and 12.00am.

A review of noise logger data would need to confirm that the existing background noise levels are steadily rising in the early morning night-day transition between 5.00am and 7.00am or are not yet decreasing in the evening-night transition period between 10.00pm and 12.00am before steadily decreasing after 12.00am. This often occurs where the receivers are on or near a busy road network. Once confirmed, NMLs can be established for the shoulder periods to assess impact over the shoulder period. Higher noise impact works can be programmed to the shoulder period, where ROL permits.

A review of the noise logger data for the project confirmed that 22 of the 83 NCAs across the project would benefit from the use of shoulder periods and programming of high noise activities when OOHW are required.

6.4.6 Out-of-hours deliveries

Where feasible and reasonable, delivery of plant and equipment would be carried out during standard construction hours. However, to support the surface road upgrade works, some delivery of material, plant and equipment would be required out of hours due to the extensive works that are required outside standard construction hours.

Oversized delivery vehicles can cause disruptions to traffic flow and can be a potential hazard for road users. There is a need for these vehicles to move during off-peak periods when traffic volumes are typically at a minimum, thereby ensuring safety for the road user and the public and minimising disruption to the road network.

Out-of-hours deliveries (except in emergency situations) would be documented in an OOHW Protocol developed as part of the CNVMP.

6.4.7 Early installation of operational noise mitigation

Early installation of noise mitigation required for the operational stage of the project (see section 7.2.2 and section 7.2.3) can help to reduce the impacts of noise during construction. For road projects such as the project, the final road design is still being developed during early construction stages. This means the operational noise mitigation design would not have been finalised when construction activities commence.

Installing all operational noise mitigation measures identified in section 7.2.2 and section 7.2.3 while the final road design is being developed, could lead to ineffective or inadequate operational noise mitigation in addition to less adequate construction noise mitigation.

The project proposes a staged approach to early installation of operational mitigation. When the final road design is confirmed, operational noise mitigation measures that would also provide a benefit during the construction stage of the project would be identified. These measures would be prioritised for installation so that the noise reduction benefit is experienced during construction.

Early installation of operational noise mitigation measures would form part of the overall construction mitigation and management measures. In some cases alternative mitigation measures can result in the same acoustic outcomes for construction noise affected receivers as what be achieve through the early installation of operational noise mitigation. As such the feasible and reasonable nature of early installation of operational noise mitigation would be considered along with the construction mitigation and management measures that are refined during detailed design.

6.4.8 Warringah Freeway Upgrade noise management

Due to the importance of the Warringah Freeway to the greater Sydney road network there would be a requirement for some of the proposed construction works to take place outside standard construction hours, during periods when nearby residential receivers are likely to be more sensitive to construction noise. Parts of the Warringah Freeway Upgrade construction work would require Road Occupancy Licences (ROL) to allow the works to be carried out within the road corridor. Physical noise mitigation measures are limited within the road corridor due to constraints around the configuration of the worksite and the need to get the road back into service at the end of the ROL work period.

As such, an approach specifically tailored to the Warringah Freeway Upgrade works is being developed by Roads and Maritime in order to manage Warringah Freeway Upgrade works and would be used by the project to manage the complex nature of operating a construction worksite within this major Sydney road corridor. The noise management approach would provide focus on the specific mitigation and management measures required outside of standard construction hours for works in the Warringah Freeway. These measures may be different to those measures outlined in the RMS CNVG.

6.5 Management of concurrent and consecutive major project construction impacts

As outlined in section 4.2.4, there are a number of ways in which cumulative construction noise impacts from concurrent construction projects can result in overall greater construction noise impacts, either in terms of level or overall duration of exposure.

The following specific measures are to be used to mitigate and manage cumulative and consecutive noise impacts along with potential construction fatigue:

- Coordinating work between construction sites to avoid cumulative noise impacts, where feasible and reasonable
- Additional feasible and reasonable at-source mitigation for cumulative construction activities, where programming is not practical to avoid cumulative noise impacts

- Community consultation to gauge key noise impacts and issues and identify any unknown impacts from concurrent or consecutive sets of constructions works
- Consideration of cumulative and consecutive construction noise impacts will feed into the development of noise mitigation and management measures to for the worksites, including coordination between construction projects, where reasonable and feasible.

These mitigation measures would be included in each construction support site's detailed design and site-specific CNVIS. The CNVIS would consider, where feasible and reasonable, cumulative and consecutive construction noise impacts, taking into consideration all other concurrent construction works in the vicinity that may contribute additional noise and not only the major infrastructure project which have been specifically reviewed in this assessment, in developing mitigation and management measures based on up to date consecutive construction projects in proximity to each construction support site. The project CNVMP would include how the above measures would be incorporated at each site.

6.6 Assessing the effectiveness of mitigation measures using spot checks

Spot check measurements are suggested by the CNVG as a way of providing greater confidence in noise predictions and mitigation measures. Spot checks would take place during construction to:

- Understand the range in background noise levels and associated criteria within each NCA, as background noise levels may vary between receiver locations
- Understand the range in background noise levels or the range in construction noise impact between facades on the same building which have different noise exposures
- Verify predicted noise levels at each receiver location
- Provide greater confidence in the effectiveness of mitigation measures to adequately address noise impacts, both at the most affected receiver and across the catchment area.

Spot checks would be included in the CNVMP.

6.7 Management of construction related traffic noise impacts

Potential noise impacts from construction related traffic on public roads would be assessed during detailed design. Management measures would be developed as part of the CNVMP to minimise the potential traffic noise impacts on nearby sensitive receivers, considering the following where feasible and reasonable:

- Limit heavy vehicle movements associated with the project to standard construction hours
- Where out of hours heavy vehicle movements are required, they would be programmed to occur during less sensitive time periods where feasible and reasonable
- Select construction traffic routes to curtail the use of local roads
- Select construction worksite access points away from sensitive receivers

- Develop a Heavy Vehicle Code of Conduct (HVCC) for all drivers to adhere to. The HVCC would require appropriate training of project contractors. It would include noise management methods such as limiting idling and compression braking, and traffic management practises to minimise noise emissions from vehicles entering and leaving the site
- Require delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible
- Limit the use of engine compression brakes at night and in residential areas
- Vehicles should be fitted with a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard
- Where feasible, arrange on-site parking to minimise workers/contractors' vehicles from parking in the surrounding streets.

6.8 Works occurring within the recommended minimum vibration working distance for sensitive receivers

6.8.1 Cosmetic damage

As the construction methodology develops during the detailed design stage of the project, all vibration generating construction activities would be reviewed to determine the risk of cosmetic damage to nearby structures or vibration-sensitive items. Minimum working distances would be established with consideration of:

1. Minimum distance between vibration-generating plant/equipment and the foundations of building/structure being assessed
2. The screening criterion for potentially affected buildings based on:
   - Type of item/building/structure considering the criterion in section 3.4.4
   - Heritage status of item, and importance/difficulty to repair. This step would require input from heritage specialists
   - Structural soundness of the item. This step would require input from a structural engineer.
3. Type of vibration-intensive activity.

If vibration intensive work is proposed to occur within the recommended minimum working distance (refer to Table 4-11 in Section 4.4.1, Appendix K and Appendix L), considering the above the following would be carried out:

- Evaluate whether alternative construction methods, plant or equipment can be utilised for the works and re-assess potential impacts (if required)
- For heritage structures, consult an appropriately qualified structural engineer who is familiar with heritage structures to determine if any proposed relaxation of the initial cosmetic damage screening criterion is applicable and re-assess potential impacts (if required) (See section 6.8.2 for the general approach). Modifications to the vibration criterion for specific heritage

structures would then be approved by the relevant authority or under the environmental protection license as relevant

- For reinforced commercial-type buildings, a higher cosmetic damage screening criterion may be applicable. Re-assess potential impacts (if required) in consultation with a structural engineer and/or review of building condition survey report
- Undertake attended vibration measurements at the commencement of vibration-generating activities to establish site-specific minimum working distances and re-assess potential impacts (if required). This may include further detailed analysis based on the frequency content of the vibration levels
- If there is any risk of exceeding the cosmetic damage objectives (see section 3.4.5.2) after all of the above options have been considered, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the structural/cosmetic damage limits
- If works are proposed within the cosmetic damage minimum working distance, prior to starting work a building/structure condition survey would be carried out on items within the minimum working distances and vibration limits determined to manage cosmetic damage.

6.8.2 Heritage items

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Structural engineering report would be carried out on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. If the item was confirmed as 'structurally sound', the screening criteria from BS7385 Part 2 would be adopted, or
4. If the item was confirmed as 'structurally unsound', the more conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity would be adopted.

6.8.3 Human comfort (response)

Where the predicted vibration levels exceed the human comfort (response) levels presented in section 3.4.5.1, then the additional mitigation measures presented in section 6.10.3 would be implemented (as per section 7.1 and Appendix C of the CNVG) in order to mitigate the potential impacts at sensitive receivers.

6.9 At-source ground-borne noise control and management measures

The following at-source control and noise management measures are recommended to reduce potential ground-borne noise impacts.

Table 6-2 – At source ground-borne noise control and management measures

Control type	Control measure	Typical use
At-source control measures	Limit equipment in use	Only construction equipment needed to undertake a specific construction task would be operated. Equipment not required for the task would be switched off to reduce noise.
	Equipment selection	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable.
	Timing of equipment in use	Where feasible and reasonable, rock hammering would be limited to the least sensitive time periods for the affected receiver. That is, for: • Residential receivers and hotels: rock hammering would only be carried out during standard construction hours: - 7.00am to 6.00pm, Monday to Friday - 8.00am to 1.00pm, Saturday • 'Other' sensitive receivers (eg educational institutions, places of worship) and commercial/industrial premises: The contractor would need to consult with these receivers and meet reasonable and feasible requirements. For example, rock hammering can be carried out during the evening/night period when/if the premises are not in use.
	Respite periods	High ground-borne noise impact activities are carried out in continuous blocks of up to three hours. Respite from high noise impact activities would be provided between each block for at least one hour. No high noise impact activities would be carried out during this one hour respite period. Respite periods may be considered where residential properties are exposed to ground-borne noise in excess of 65 dB(A), in particular where this is likely to occur for 2 days or more.
Noise management measures	Site inductions and toolbox talks	All employees, contractors and subcontractors are to receive a Project induction. The environmental component covered in toolbox talks should include: • the locations of the nearest sensitive receivers • any project specific and standard noise and vibration mitigation and management measures relevant to the works • permissible hours of work • OOHW procedures and any documentation required.
	Community consultation	Inform community of construction activity and potential impacts.
	Noise monitoring	Air blast overpressure, noise and vibration monitoring would be monitored during construction. Any necessary adaptive management requirements would be identified and implemented where reasonable and feasible. Noise monitoring is also to be carried out as spot checks as detailed in section 6.6 to confirm construction noise impacts and the effectiveness of mitigation measures.

6.10 Triggers for additional mitigation measures

Following the implementation of all reasonable and feasible mitigation measures, it is not always possible for the noise impacts to achieve the recommended NMLs or vibration criteria for all impacted receivers. Where this is the case, Appendix C of the CNVG provides details of additional mitigation measures that would be implemented to manage the noise and vibration impacts from the project.

The additional mitigation measures reference tables from Appendix C of the CNVG are presented below, identifying the mitigation measures that are recommended for various noise or vibration exceedances. The range and extent of additional mitigation measures would be refined during detailed design when preparing site-specific CNVISs taking into consideration potential cumulative noise and vibration impacts and nearby concurrent construction works.

6.10.1 Airborne noise

Where applicable Table 6-3 below would be used to determine the appropriate additional noise mitigation measures based on airborne noise impacts.

Table 6-3 – Triggers for additional mitigation measures - airborne noise (Appendix C, CNVG)

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures type[1]	Mitigation levels[2]
Perception	dB(A) above RBL	dB(A) above NML		
All hours				
75 dB(A) or greater			N, V, PC, RO, HA	HA
Standard Hours: Mon - Fri (7.00am- 6.00pm), Sat (8.00am- 1.00pm), Sun/Public holiday (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly Audible	10 to 20	< 10	-	NML
Moderately intrusive	20 to 30	10 to 20	N, V	NML+ 10
Highly intrusive	> 30	> 20	N, V	NML+ 20
OOHW Period 1: Mon - Fri (6.00pm- 10.00 pm), Sat (7.00am- 8.00am and 1.00pm- 10.00pm), Sun/public holiday (8.00am - 6.00pm)				
Noticeable	5 to 10	< 5	-	NML
Clearly audible	10 to 20	5 to 15	N, R1, DR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, N, R1, DR	NML+15
Highly intrusive	> 30	> 25	V, IB, N, R1, DR, PC, SN	NML+25
OOHW Period 2: Mon - Fri (10.00pm- 7.00am), Sat (10.00pm – 8.00am), Sun/public holiday (6.00pm-7.00am)				
Noticeable	5 to 10	< 5	N	NML
Clearly audible	10 to 20	5 to 15	V, N, R2, DR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, IB, N, PC, SN, R2, DR	NML+15
Highly intrusive	> 30	> 25	AA, V, IB, N, PC, SN, R2, DR	NML+25

Notes: 1. The additional mitigation measures have used the following abbreviations: AA = Alternative Accommodation, RO = Respite offer, R1 = Respite Period 1, R2 = Respite Period 2, DR = Duration Respite, V = Verification, PC = Phone calls, IB = Individual briefings, SN = Specific notifications, N = Notification, HA = Highly Affected (> 75 dB(A) - applies to residences only).

2. Table from Appendix C1 of the Roads and Maritime CNVG

6.10.2 Ground-borne noise

Where applicable Table 6-4 below would be used to determine the appropriate additional noise mitigation measures based on ground-borne noise impacts.

Table 6-4 – Triggers for additional mitigation measures – ground-borne noise (Appendix C, CNVG)

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver		Additional mitigation measures	
Perception	**dB(A) above ground-borne NML**	**Type[1]**	**Apply to[2]**
Standard Hours: Mon - Fri (7.00am- 6.00pm), Sat (8.00am- 1.00pm), Sun/Public holiday (Nil)			
N/A	Vibration impacts only applicable during standard hours (Refer to Table 6-5)		
OOHW Period 1: Mon - Fri (6.00pm- 10.00pm), Sat (7.00am- 8.00am and 1.00pm- 10.00pm), Sun/public holiday (8.00 am - 6.00 pm)			
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 (10.00pm- 7.00am), Sat (10.00pm – 8.00am), Sun/public holiday (6.00pm-7.00am)			
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 additional mitigation measures have used the following abbreviations:
AA = Alternative Accommodation, R1 = Respite Period 1, R2 = Respite Period 2, RP = Respite Period, DR = Duration Respite , V = Validation of predicted noise level, PC = Phone calls, IB = Individual briefings, SN = Specific notifications, N = Notification
2. All affected receivers.
3. Table from Appendix C2 of the Roads and Maritime CNVG

6.10.3 Vibration

Where applicable Table 6-5 below would be used to determine the appropriate additional vibration mitigation measures, based on ground-borne vibration impacts.

Table 6-5 – Triggers for additional mitigation measures – vibration (Appendix C, CNVG)

Predicted vibration level at receiver	Additional mitigation measures	
Perception	**Type[1]**	**Apply to[2]**
Standard Hours: Mon - Fri (7.00am- 6.00pm), Sat (8.00am- 1.00pm), Sun/Public holiday (Nil)		
Predicted vibration exceeds maximum levels for human comfort	V, N, RP	All
OOHW Period 1: Mon - Fri (6.00pm- 10.00pm), Sat (7.00am- 8.00am and 1.00pm- 10.00pm), Sun/public holiday (8.00am - 6.00pm)		
Predicted vibration exceeds maximum levels for human comfort	V, IB, N, RO, PC, RP, SN	All
OOHW Period 2: Mon - Fri (10.00pm- 7.00am), Sat (10.00pm – 8.00am), Sun/public holiday (6.00pm-7.00am)		
Predicted vibration exceeds maximum levels for human comfort	AA, V, IB, N, PC, RP, SN	All

Notes: 1. The additional mitigation measures have used the following abbreviations:
AA = Alternative Accommodation, V = Validation of predicted level, PC = Phone calls, IB = Individual briefings, SN = Specific notifications, N = Notification drops, RP = Respite Period
2. All affected receivers.
3. Table from Appendix C3 of the Roads and Maritime CNVG

The following is a summary of the additional noise mitigation measures that would be considered following the implementation of all reasonable and feasible mitigation measures:

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

6.11 Blast mitigation and management

If blasting for mainline tunnel benching or cross passages is included in the detailed design, the CNVMP would include a Blast Management Strategy. The strategy would be prepared in consultation with the EPA. Its purpose would be to demonstrate that all blasting and associated activities would be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a substantial risk impact to residences and sensitive receivers. The strategy will:

- Detail the blasting to be performed including location, method and justification of the need to blast
- Identify any potentially affected noise and vibration-sensitive sites including heritage buildings and utilities
- Establish appropriate criteria for blast overpressure and ground vibration levels at each category of noise-sensitive site
- Detail storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction support site
- Identify hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives
- Determine potential noise and vibration and risk impacts from blasting and appropriate best management practices
- Detail community consultation procedures.

7 Operational noise assessment

Operational road traffic noise impacts were assessed for surface roads associated with the project. Noise modelling predictions were carried out for all noise-sensitive receiver locations. Noise from traffic travelling through the tunnels would be contained within the tunnels and would not impact noise sensitive areas on the surface. Therefore, only operational traffic noise from surface roads and portals to and from the tunnels have been assessed.

Furthermore, operational noise impacts from the proposed operational facilities associated with the project have been assessed for noise-sensitive receivers surrounding the proposed fixed facilities.

7.1 Operational road traffic noise predictions without mitigation

7.1.1 Project only scenario

Road traffic noise associated with the project impacting on noise-sensitive receivers has been predicted for the 'Do Minimum' ('No Build') and the 'Do Something' ('Build') scenarios where no mitigation measures have been implemented, other than the existing measures (eg existing noise barriers) and those that are incorporated into the road design. The modelled scenarios are detailed in Table 4-13.

Detailed noise modelling results for the above scenarios and the assessment against the NCG requirements are provided in Appendix O. The results of the assessment identify the sensitive receivers that would qualify for consideration of additional noise mitigation as a result of the project ('Do Something').

The results of the noise predictions indicate that receivers adjacent to the project are generally impacted by existing road traffic noise levels that exceed the NCG noise criteria levels presented in section 3.5.2.

Table 7-1 presents the number of receiver buildings that have been predicted to exceed the NCG noise criteria levels for the 'Do Minimum' (without the project) and 'Do Something' (with the project) scenarios for the opening year and design year without any mitigation measures implemented.

It is noted that if a receiver is predicted to exceed the NCG noise criteria, it may not necessarily be eligible for additional noise mitigation. Eligibility for additional noise mitigation measures is subject to the processes and criteria discussed in section 4.7.

Table 7-1 – Number of receiver buildings exceeding the NCG noise criteria without mitigation

NCA[1]	2027 'Do Minimum' (without the project)[2]		2027 'Do Something' (with the project)[2]		2037 'Do Minimum' (without the project)[2]		2037 'Do Something' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle								
1.2	1	1	1	3	1	3	2	4
1.3	27	24	27	24	27	24	27	24
1.4	0	0	0	0	0	0	0	0
1.5	82	71	84	75	83	73	85	79
2.1	13	11	12	4	13	12	13	7
3.2	11	12	12	12	12	12	12	13
3.3	64	69	70	79	69	75	78	86
4.1	1	2	1	2	1	2	1	2
4.2	58	67	61	75	63	72	67	90
4.3	66	66	66	65	67	68	67	66
4.4	21	19	21	19	21	19	21	20
4.5	15	10	14	10	18	14	17	13
5.1	0	0	0	0	0	0	0	0
5.2	0	0	0	0	0	0	0	0
5.3	0	0	0	0	0	0	0	0
6.1	0	0	0	0	0	0	0	0
6.2	2	1	2	1	3	2	3	2
7.1	0	0	0	0	0	0	0	0
8.1	0	0	0	0	0	1	0	0
9.1	0	0	0	0	0	0	0	0
TOTAL	**361**	**353**	**371**	**369**	**378**	**377**	**393**	**406**
Warringah Freeway and surrounds								
15.1	0	0	0	0	0	0	0	0
15.2	0	0	0	0	0	0	0	0
15.3	22	9	22	9	24	9	24	9
15.4	5	3	5	1	5	3	7	1
16.1	34	35	37	34	35	36	37	37
16.2	0	0	0	0	0	0	0	0
16.3	20	7	20	8	20	9	20	9
17.1	89	75	71	47	95	82	82	57
17.2	22	23	20	21	23	27	22	21
17.3	156	172	109	100	166	179	115	108
17.4	117	130	61	44	137	149	70	45
18.1	1	2	2	2	2	2	2	2
18.2	7	10	4	5	8	11	7	6
18.3	200	215	25	22	214	226	27	22

NCA[1]	2027 'Do Minimum' (without the project)[2]		2027 'Do Something' (with the project)[2]		2037 'Do Minimum' (without the project)[2]		2037 'Do Something' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
19.1	22	21	22	21	22	21	22	21
20.1	10	10	10	10	10	10	10	10
21.1	12	12	12	12	12	12	14	12
21.2	27	18	27	18	27	18	27	18
22.1	107	87	107	88	107	88	107	88
22.2	45	34	45	35	46	35	46	37
22.3	182	178	182	178	182	178	183	179
23.1	140	138	128	124	143	142	135	129
23.2	24	22	23	21	24	22	23	21
24.1	126	124	125	122	128	126	127	122
25.1	46	46	44	42	48	47	45	44
26.1	31	30	26	24	33	32	28	27
26.2	0	0	0	0	0	0	0	0
27.1	0	0	0	0	0	0	0	0
28.1	25	35	9	5	38	40	11	5
29.1	50	50	50	49	51	51	51	50
30.1	196	178	197	172	200	182	205	175
30.2	69	67	65	58	72	73	71	64
30.3	70	75	68	62	76	76	69	66
30.4	8	8	8	8	8	8	8	8
31.1	29	29	28	28	30	30	29	28
31.2	38	23	36	22	38	26	37	23
31.3	131	130	126	122	137	134	133	127
32.1	146	147	151	144	154	157	160	156
36.1	42	41	42	41	42	41	42	41
37.1	16	14	15	12	16	15	16	13
Total	**2265**	**2198**	**1922**	**1711**	**2373**	**2297**	**2012**	**1781**

Notes:
1. Refer to Appendix B for location of noise catchment areas.
2. Refer to Table 4-13 for a description of the 'Do Minimum' and 'Do Something' operational road traffic noise scenarios.
3. The eligibility requirements for a receiver to qualify for additional noise mitigation is based on the processes and criteria discussed in section 4.7
4. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building. Refer to Appendix O for more detailed operational road traffic noise predictions including predictions for each floor in multi-storey buildings where a separate receiver has been assigned to each floor level of a multi-storey building, for example, assessment of a two-storey residential dwelling covers each of the two levels of the building.

The number of receivers predicted to experience a decrease in traffic noise; experience a minor increase in traffic noise of no more than 2 dB(A); or experience an increase in traffic noise by more than 2 dB(A) due to the project, are presented in Table 7-2 for the project. The results are based on no additional mitigation measures being implemented.

Table 7-2 – Predicted changes in noise levels (2037 'Do Something' – 'Do Minimum')

Study area	Number of receiver buildings					
	<0 dB(A)		0 dB(A) – 2 dB(A)		>2 dB(A)	
	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle	590	442	2498	2647	7	6
Warringah Freeway and surrounds	4644	5486	2066	1224	54	54

Notes:
1. Based on no mitigation measures implemented, except existing noise barriers
2. Includes other sensitive receivers (OSRs) that are non-residential, where applicable
3. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building. Refer to Appendix O for more detailed operational road traffic noise predictions including predictions for each floor in multi-storey buildings where a separate receiver has been assigned to each floor level of a multi-storey building, for example, assessment of a two-storey residential dwelling covers each of the two levels of the building.

From the results presented in Table 7-1 and Table 7-2 above, the following outcomes are identified:

- In the area surrounding the surface connection to City West Link at Rozelle, the project is predicted to typically increase the number of receiver buildings exceeding the NCG noise criteria when compared to the 'Do Minimum' scenario during the day and night periods. This may be due to an increase in forecast traffic volumes as a result of the project, as traffic on surface roads in the area leading to and from the tunnels increases as people travel to and from surrounding areas to utilise the tunnels
- For the Warringah Freeway and surrounds, the project is predicted to typically decrease the number of receiver buildings exceeding the NCG noise criteria when compared to the 'Do Minimum' scenario during the day and night periods. This may be due to the reduction in forecast traffic volumes as a result of the project, as traffic along existing surface roads would move to the proposed tunnels
- On average the project is predicted to result in reduced traffic noise for about 57 per cent of receiver buildings within the NCAs
- An average of about 42 per cent of receiver buildings within the NCAs are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP as a minor impact which is barely perceptible
- An average of one per cent of receiver buildings within the NCAs are predicted to experience increases in traffic noise of more than 2 dB(A) due to the project
- The project is predicted to reduce traffic noise levels for the Warringah Freeway and surrounds at a large number of receiver buildings (average of around 75 per cent), mainly due to traffic being moved to tunnels.

For the majority of receiver buildings within the noise catchment areas there would be either a reduction or relatively minor change in traffic noise levels due to the project. As such, any requirement for additional noise mitigation is likely to be a result of the high existing road traffic noise levels resulting in exceedances of the cumulative limit criterion or traffic noise levels being acute (day $L_{Aeq(15hour)} \geq 65$ dB(A) or night $L_{Aeq(9hour)} \geq 60$ dB(A)).

7.1.1.1 Receivers considered for additional noise mitigation – project only scenario

The results for the number of receiver buildings impacted on and requiring additional noise mitigation for the design year 2037 due to the 'Do Something' scenario are summarised in Table 7-3.

Table 7-3 – Number of receiver buildings impacted due to project for design year 2037 ('Do Something')

Location	Total number of receiver buildings assessed in area	Day period – number of receiver buildings				Night period – number of receiver buildings				Requiring additional noise mitigation[5]
		Exceed NCG noise criteria level [1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 65 dB(A))[4]	Exceed NCG noise criteria level[1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 60 dB(A))[4]	
Area surrounding the surface connection to City West Link at Rozelle	3095	393	2	0	0	406	2	0	0	3
Warringah Freeway and surrounds	6764	2012	35	365	310	1781	39	307	290	424
TOTAL	**9859**	**2405**	**37**	**365**	**310**	**2187**	**41**	**307**	**290**	**427**

Notes:
1. NCG noise criteria level based on 'New Road', 'Redeveloped Road', 'Transition Zone' or 'Relative Increase' criteria as per RNP
2. >2 dB(A) increase based on comparison between 'Do Something' scenario and 'Do Minimum' scenario for the design year 2037
3. Exceedance of NCG noise criteria AND increase of more than 2 dB(A) are required to be eligible for noise mitigation
4. Acute noise levels due to contribution from the project only
5. A receiver building qualifies for noise mitigation if it falls under any of the three NMG noise mitigation triggers (ie. >2 dB(A) increase, exceed cumulative or acute noise) or a multiple of triggers
6. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

The above table shows that out of the 9859 receiver buildings assessed, 427 were identified as eligible for consideration for additional noise mitigation in accordance with the NMG requirements as presented in section 4.7.

The 427 receiver buildings were identified based on the following:

- The predicted 'Do Something' (with the project) traffic noise levels in the design year (2037) would exceed the NCG project road noise criteria and would also increase by more than 2 dB(A) as a result of the project at 37 and 41 receiver buildings during the day and night periods, respectively
- The cumulative limit (5 dB(A) above the NCG project road criterion) is exceeded at 365 and 307 receiver buildings during the day and night periods, respectively
- There are 310 and 290 receiver buildings predicted to experience acute (day $L_{Aeq(15hour)} \geq$ 65 dB(A) or night $L_{Aeq(9hour)} \geq$ 60 dB(A)) noise levels due to the project during the day and night periods, respectively.

It is noted that some receiver buildings eligible for consideration for additional noise mitigation might fall into more than one of the NMG noise mitigation triggers and have multiple triggers. The most common multiple trigger is when an eligible receiver building exceeds the cumulative noise limit and is also exposed to acute noise levels.

7.1.2 Cumulative scenario

Traffic generated by other major road projects has the potential to increase traffic along the project surface roads, resulting in higher noise levels at affected receivers. To address this, an assessment of traffic noise from the 'Do Something - Cumulative' scenario compared to the 'Do Minimum' scenario has been carried out. Cumulative traffic from the following major road projects was included in the 'Do Something - Cumulative' scenario:

- Beaches Link and Gore Hill Freeway Connection
- WestConnex Stages 1, 2 and 3
- Sydney Gateway
- F6 Extension (Stage 1 in 2027; all stages in 2037).

Detailed noise modelling results for the 'Do Something - Cumulative' scenario and the 'Do Minimum' scenario and the assessment against the NCG requirements are presented in Appendix O. The results of the assessment identify the sensitive receivers that would qualify for consideration of additional noise mitigation as a result of the project ('Do Something - Cumulative'). Furthermore, noise contours presenting the traffic noise impacts to ground floor levels (ie. 1.5 metres above ground) of receivers within the noise catchment areas are presented in Appendix P.

Table 7-4 presents the number of receiver buildings that have been predicted to exceed the NCG noise criteria levels for the 'Do Minimum' and 'Do Something - Cumulative' scenarios for the opening year

and design year without any mitigation measures implemented. It is noted that if a receiver is predicted to exceed the NCG noise criteria, it may not necessarily be eligible for additional noise mitigation. Eligibility for additional noise mitigation measures is subject to the processes and criteria discussed in section 4.7.

Table 7-4 – Number of receiver buildings exceeding the NCG noise criteria without mitigation

NCA[1]	2027 'Do Minimum' (without the project)[2]		2027 'Do Something - Cumulative' (with the project)[2]		2037 'Do Minimum' (without the project)[2]		2037 'Do Something - Cumulative' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle								
1.2	1	1	1	4	1	3	3	4
1.3	27	24	27	24	27	24	28	24
1.4	0	0	0	0	0	0	0	0
1.5	82	71	85	79	83	73	85	79
2.1	13	11	12	4	13	12	13	5
3.2	11	12	12	13	12	12	12	13
3.3	64	69	77	85	69	75	85	90
4.1	1	2	1	2	1	2	2	2
4.2	58	67	65	86	63	72	76	96
4.3	66	66	66	65	67	68	67	71
4.4	21	19	21	20	21	19	21	20
4.5	15	10	14	10	18	14	17	13
5.1	0	0	0	0	0	0	0	0
5.2	0	0	0	0	0	0	0	0
5.3	0	0	0	0	0	0	0	0
6.1	0	0	0	0	0	0	0	0
6.2	2	1	2	2	3	2	3	2
7.1	0	0	0	0	0	0	0	0
8.1	0	0	0	0	0	1	0	0
9.1	0	0	0	0	0	0	0	0
TOTAL	**361**	**353**	**383**	**394**	**378**	**377**	**412**	**419**
Warringah Freeway and surrounds								
15.1	0	0	0	0	0	0	0	0
15.2	0	0	0	0	0	0	0	0
15.3	22	9	22	9	24	9	24	9
15.4	5	3	6	1	5	3	7	1
16.1	34	35	35	32	35	36	35	35
16.2	0	0	0	0	0	0	0	0
16.3	20	7	20	8	20	9	20	9
17.1	89	75	69	47	95	82	83	56
17.2	22	23	20	21	23	27	22	21
17.3	156	172	104	98	166	179	115	105
17.4	117	130	63	44	137	149	71	45

NCA[1]	2027 'Do Minimum' (without the project)[2]		2027 'Do Something - Cumulative' (with the project)[2]		2037 'Do Minimum' (without the project)[2]		2037 'Do Something - Cumulative' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
18.1	1	2	1	1	2	2	2	2
18.2	7	10	3	3	8	11	4	5
18.3	200	215	23	21	214	226	23	21
19.1	22	21	22	21	22	21	22	21
20.1	10	10	10	10	10	10	10	10
21.1	12	12	12	11	12	12	13	12
21.2	27	18	27	18	27	18	27	18
22.1	107	87	106	88	107	88	107	88
22.2	45	34	45	35	46	35	46	37
22.3	182	178	182	178	182	178	182	178
23.1	140	138	123	119	143	142	127	119
23.2	24	22	22	20	24	22	23	21
24.1	126	124	124	122	128	126	126	122
25.1	46	46	43	41	48	47	45	42
26.1	31	30	24	22	33	32	26	23
26.2	0	0	0	0	0	0	0	0
27.1	0	0	0	0	0	0	0	0
28.1	25	35	6	5	38	40	9	5
29.1	50	50	49	47	51	51	50	49
30.1	196	178	193	169	200	182	206	172
30.2	69	67	63	52	72	73	69	58
30.3	70	75	66	59	76	76	69	62
30.4	8	8	8	8	8	8	8	8
31.1	29	29	28	27	30	30	28	28
31.2	38	23	32	22	38	26	34	22
31.3	131	130	125	117	137	134	131	122
32.1	146	147	149	136	154	157	161	148
33.2	0	0	0	0	0	0	0	0
36.1	42	41	42	41	42	41	42	41
37.1	16	14	14	10	16	15	15	11
38.1	0	0	0	0	0	0	0	0
38.3	0	0	0	0	0	0	0	0
Total	**2265**	**2198**	**1881**	**1663**	**2373**	**2297**	**1982**	**1726**

Notes:
1. Refer to Appendix B for location of noise catchment areas.
2. Refer to Table 4-13 for a description of the 'Do Minimum' and 'Do Something - Cumulative' operational road traffic noise scenarios.
3. The eligibility requirements for a receiver to qualify for additional noise mitigation is based on the processes and criteria discussed in section 4.7
4. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

The number of receivers predicted to experience a decrease in traffic noise; experience a minor increase in traffic noise of no more than 2 dB(A); or experience an increase in traffic noise by more than 2 dB(A) due to the project, are presented in Table 7-5 for the project. The results are based on no additional mitigation measures being implemented.

Table 7-5 – Predicted changes in noise levels (2037 'Do Something – Cumulative' – 'Do Minimum')

Study area	Number of receiver buildings					
	<0 dB(A)		0 dB(A) – 2 dB(A)		>2 dB(A)	
	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle	509	319	2505	2724	81	52
Warringah Freeway and surrounds	5140	5923	1588	808	36	33

Notes: 1. Based on no mitigation measures implemented, except existing noise barriers

2. Includes other sensitive receivers (OSRs) that are non-residential, where applicable

3. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

From the results presented in Table 7-4 and Table 7-5 above, the following outcomes are identified:

- When considering cumulative traffic from the project and other major road projects, the number of receiver buildings exceeding the NCG noise criteria in the noise catchments surrounding the surface connection to City West Link at Rozelle when compared to the 'Do Minimum' scenario during the day and night periods is predicted to typically increase. The increases may be due to an increase in forecast traffic volumes as a result of the project, as traffic on surface roads in the area leading to and from the tunnels increase as people travel to and from surrounding areas to utilise the tunnels
- For the Warringah Freeway and surrounds, when considering cumulative traffic from the project and other major road projects, the number of receiver buildings exceeding the NCG noise criteria when compared to the 'Do Minimum' scenario during the day and night periods is predicted to typically decrease. The decrease in the number of receiver buildings may be due to the reduction in forecast cumulative traffic volumes as a result of the project and other major road projects, as traffic along existing surface roads moves to the proposed tunnels
- On average the project is predicted to result in a reduction in traffic noise to about 60 per cent of receivers within the study areas
- An average of about 39 per cent of receivers within the study areas are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP to be a minor impact and considered to be barely perceptible
- An average of one per cent of receivers within the study areas are predicted to experience increases in traffic noise of more than 2 dB(A) due to cumulative traffic from the project and other major road projects
- The project is predicted to reduce traffic noise levels for the Warringah Freeway and surrounds at a large number of receiver buildings (average of around 82 per cent), mainly due to traffic moving to tunnels.

For the majority of receiver buildings within the study areas, there would be either a reduction or relatively minor change in traffic noise levels due to the project. As such, any requirement for additional noise mitigation is likely to be a result of the high existing road traffic noise levels resulting in exceedances of the cumulative limit criterion or traffic noise levels being acute (day $L_{Aeq(15hour)}$ ≥ 65 dB(A) or night $L_{Aeq(9hour)}$ ≥ 60 dB(A)).

7.1.2.1 Receivers considered for additional noise mitigation – cumulative scenario

The results for the number of receiver buildings impacted on for the design year 2037 due to the 'Do Something - Cumulative' scenario are summarised in Table 7-6.

Aerial maps identifying the receiver buildings considered for additional noise mitigation are presented in Appendix N.

The difference between the 2037 'Do Minimum' (without the project) and the 2037 'Do Something - Cumulative' (with the project) assessments has been used to determine the additional noise mitigation measures (eg noise barriers, at-property treatment) required as part of the project.

Table 7-6 – Number of receiver buildings impacted due to project for design year 2037 ('Do Something - Cumulative')

Location	Total number of receiver buildings assessed in area	Day period – number of receiver buildings				Night period – number of receiver buildings				Requiring additional noise mitigation[5]
		Exceed NCG noise criteria level [1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 65 dB(A))[4]	Exceed NCG noise criteria level[1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 60 dB(A))[4]	
Area surrounding the surface connection to City West Link at Rozelle	3095	412	65	0	0	419	37	0	0	71
Warringah Freeway and surrounds	6764	1982	25	359	301	1726	25	294	270	407
TOTAL	**9859**	**2394**	**90**	**359**	**301**	**2145**	**62**	**294**	**270**	**478**

Notes:
1. NCG noise criteria level based on 'New Road', 'Redeveloped Road', 'Transition Zone' or 'Relative Increase' criteria as per RNP
2. >2 dB(A) increase based on comparison between 'Do Something - Cumulative' scenario and 'Do Minimum' scenario for the design year 2037
3. Exceedance of NCG noise criteria AND increase of more than 2 dB(A) are required to be eligible for noise mitigation
4. Acute noise levels due to contribution from the project only
5. A receiver building qualifies for noise mitigation if it falls under any of the three NMG noise mitigation triggers (ie. >2 dB(A) increase, exceed cumulative or acute noise) or a multiple of triggers
6. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

The above table shows that out of the 9859 receiver buildings assessed, 478 were identified as eligible for consideration for additional noise mitigation in accordance with the NMG requirements as presented in Section 4.7, due to cumulative traffic from the project and other major road projects.

The 478 receiver buildings were identified based on the following:

- The predicted 'Do Something - Cumulative' (Build) traffic noise levels in the design year (2037) exceeds the NCG project road noise criteria and would also increase by more than 2 dB(A) as a result of the project at 90 and 62 receiver buildings during the day and night periods, respectively
- The cumulative limit (5 dB(A) above the NCG project road criterion) is exceeded at 359 and 294 receiver buildings during the day and night periods, respectively
- There are 301 and 270 receiver buildings predicted to experience acute (day $L_{Aeq(15hour)} \geq$ 65 dB(A) or night $L_{Aeq(9hour)} \geq 60$ dB(A)) noise levels due to the project during the day and night periods, respectively.

It is noted that some receiver buildings eligible for consideration for additional noise mitigation might fall into more than one of the NMG noise mitigation triggers and have multiple triggers. The most common multiple trigger is when an eligible receiver building exceeds the cumulative noise limit and is also exposed to acute noise levels.

Figures showing the location of the receiver buildings identified as eligible for additional noise mitigation are presented in Appendix N. However, for the area surrounding the surface connection to City West Link at Rozelle it is noted that the receivers identified for additional noise mitigation are not presented in the figures due to the following:

- Receivers are being mitigated under the M4-M5 Link's Minister's Conditions of Approval (Condition E87), or
- Potential > 2dB increase in traffic noise due to multiple projects; therefore, traffic noise impacts would be confirmed during further design development.

7.1.3 Area surrounding the surface connection to City West Link at Rozelle do nothing scenario

The area surrounding the surface connection to City West Link at Rozelle would interface with the future M4-M5 Link, which received planning approval in April 2018 and forms part of the overall WestConnex program of works. To investigate the project traffic noise impacts on receivers surrounding the surface connection to City West Link at Rozelle without the approved M4-M5 Link, an additional assessment of traffic noise was carried out.

The purpose of this assessment was to address the issue of multiple separate projects, such as the M4-M5 Link and the Project, each introducing or redistributing traffic across the road network in the area surrounding the Rozelle Interchange. As such, the inclusion of this assessment is to assist in recognising and assessing the cumulative operational traffic noise impacts ("Do Something Cumulative") from the

M4-M5 Link and the Project and comparing it against a scenario where these projects would not be constructed and so would not be operational ("Do Nothing") in the area surrounding the Rozelle Interchange.

The assessment was based on a 'Do Nothing' ('No Build' without the project, Beaches Link and Gore Hill Freeway Connection, WestConnex, Sydney Gateway and the F6 Extension projects) scenario which represents the 'Do Minimum' scenario, but without the WestConnex project implemented and operating, has been carried out. For this assessment, the 'No Build' scenario would be represented by the 'Do Nothing' scenario and, the 'Build' scenario would be represented by the 'Do Something - Cumulative' scenario.

The results of the detailed noise modelling for the 'Do Something - Cumulative' scenario and the assessment against the 'Do Nothing' scenario are provided in Appendix O, specific to the receivers surrounding the surface connection to City West Link at Rozelle.

Table 7-7 presents the number of receiver buildings in the area surrounding the surface connection to City West Link at Rozelle that have been predicted to exceed the NCG noise criteria levels for the 'Do Nothing' and 'Do Something - Cumulative' scenarios for the opening year and design year without any mitigation measures implemented. It is noted that if a receiver is predicted to exceed the NCG noise criteria, it may not necessarily be eligible for additional noise mitigation. Eligibility for additional noise mitigation measures is subject to the processes and criteria discussed in section 4.7.

Table 7-7 – Number of receiver buildings exceeding the NCG noise criteria without mitigation

NCA[1]	2027 'Do Nothing' (without the project)[2]		2027 'Do Something - Cumulative' (with the project)[2]		2037 'Do Nothing' (without the project)[2]		2037 'Do Something - Cumulative' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle								
1.2	1	1	1	4	1	2	3	4
1.3	27	24	27	24	27	24	28	24
1.4	0	0	0	0	0	0	0	0
1.5	76	69	85	79	77	71	85	79
2.1	12	5	12	4	13	5	13	5
3.2	8	10	12	13	9	10	12	13
3.3	53	69	77	85	54	72	85	90
4.1	2	2	1	2	2	2	2	2
4.2	77	107	65	86	78	107	76	96
4.3	71	74	66	65	72	75	67	71
4.4	25	24	21	20	25	24	21	20
4.5	27	26	14	10	27	27	17	13
5.1	0	0	0	0	0	0	0	0
5.2	1	0	0	0	1	0	0	0
5.3	0	0	0	0	0	0	0	0

NCA[1]	2027 'Do Nothing' (without the project)[2]		2027 'Do Something - Cumulative' (with the project)[2]		2037 'Do Nothing' (without the project)[2]		2037 'Do Something - Cumulative' (with the project)[2]	
	Day	Night	Day	Night	Day	Night	Day	Night
6.1	1	1	0	0	1	1	0	0
6.2	5	5	2	2	5	6	3	2
7.1	0	0	0	0	0	0	0	0
8.1	0	0	0	0	0	0	0	0
9.1	0	0	0	0	0	0	0	0
TOTAL	**386**	**417**	**383**	**394**	**392**	**426**	**412**	**419**

Notes:
1. Refer to Appendix B for location of NCAs
2. Refer to Table 4-13 for a description of the 'Do Nothing' and 'Do Something - Cumulative' operational road traffic noise scenarios
3. The eligibility requirements for a receiver to qualify for additional noise mitigation is based on the processes and criteria discussed in section 4.7
4. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

The number of receivers predicted to experience a decrease in traffic noise, experience a minor increase in traffic noise of no more than 2 dB(A), or experience an increase in traffic noise by more than 2 dB(A) due to the project when compared to the 'Do Nothing' scenario, are presented in Table 7-8 for the study area surrounding the surface connection to City West Link at Rozelle. The results are based on no additional mitigation measures being implemented.

Table 7-8 – Predicted changes in noise levels (2037 'Do Something – Cumulative' – 'Do Nothing')

Study area	Number of receiver buildings					
	<0 dB(A)		0 dB(A) – 2 dB(A)		>2 dB(A)	
	Day	Night	Day	Night	Day	Night
Area surrounding the surface connection to City West Link at Rozelle	1399	1709	1229	1228	467	158

Notes:
1. Based on no mitigation measures implemented, except existing noise barriers
2. Includes other sensitive receivers (OSRs) that are non-residential, where applicable
3. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building

From the results presented in Table 7-7 and Table 7-8 above, the following outcomes are identified:

- When considering cumulative traffic from the project and other major road projects the predicted number of receiver buildings exceeding the NCG noise criteria in the area surrounding the surface connection to City West Link at Rozelle when compared to the 'Do Nothing' scenario during the day and night periods typically decreases
- The decrease in the number of receiver buildings may be due to the reduction in forecast cumulative traffic volumes as a result of the project and other major road projects, as traffic on the surface roads would be high if no major road projects were to proceed (ie. 'Do Nothing' scenario)

- On average the project is predicted to result in a reduction in traffic noise to about 50 per cent of receivers within the area surrounding the surface connection to City West Link at Rozelle compared to the 'Do Nothing' scenario
- An average of about 40 per cent of receivers within the area surrounding the surface connection to City West Link at Rozelle are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP to be a minor impact and considered to be barely perceptible
- An average of 10 per cent of receivers within the area surrounding the surface connection to City West Link at Rozelle are predicted to experience increases in traffic noise of more than 2 dB(A) due to cumulative traffic from the project and other major road projects when compared to the 'Do Nothing' scenario.

For the majority of receiver buildings within the area surrounding the surface connection to City West Link at Rozelle there would be either a reduction or relatively minor change in traffic noise levels due to the project and the M4-M5 Link project (including the other stages of WestConnex). As such, any requirement for additional noise mitigation is likely to be a result of the high existing road traffic noise levels resulting in exceedances of the cumulative limit criterion or traffic noise levels being acute (day $L_{Aeq(15hour)} \geq 65$ dB(A) or night $L_{Aeq(9hour)} \geq 60$ dB(A)).

7.1.3.1 Receivers considered for additional noise mitigation – Area surrounding the surface connection to City West Link at Rozelle do nothing scenario

The results for the number of receiver buildings impacted on for the design year 2037 due to the 'Do Something - Cumulative' scenario compared to the 'Do Nothing' scenario are summarised in Table 7-9.

Table 7-9 – Number of receiver buildings impacted due to project for design year 2037 ('Do Nothing' vs 'Do Something - Cumulative')

Location	Total number of receiver buildings assessed in area	Day period – number of receiver buildings				Night period – number of receiver buildings				Requiring additional noise mitigation[5]
		Exceed NCG noise criteria level [1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 65 dB(A))[4]	Exceed NCG noise criteria level[1]	>2 dB(A) Increase & exceed NCG criteria [2,3]	Exceed cumulative noise limit	Experience acute noise levels (≥ 60 dB(A))[4]	
Area surrounding the surface connection to City West Link at Rozelle	3095	412	183	0	0	419	89	0	0	186

Notes:
1. NCG noise criteria level based on 'New Road', 'Redeveloped Road', 'Transition Zone' or 'Relative Increase' criteria as per RNP
2. >2 dB(A) increase based on comparison between 'Do Something - Cumulative' scenario and 'Do Nothing' scenario for the design year 2037
3. Exceedance of NCG noise criteria AND increase of more than 2 dB(A) are required to be eligible for noise mitigation
4. Acute noise levels due to contribution from the project only
5. A receiver building qualifies for noise mitigation if it falls under any of the three NMG noise mitigation triggers (ie. >2 dB(A) increase, exceed cumulative or acute noise) or a multiple of triggers
6. An individual receiver building is considered as a single receiver for the purposes of this assessment; ie. one multi-dwelling residential building = one receiver building.

The above table shows that out of the 3095 receiver buildings assessed in the area surrounding the surface connection to City West Link at Rozelle, 186 were identified as eligible for consideration for additional noise mitigation in accordance with the NMG requirements as presented in section 4.7.

The 186 receiver buildings were identified based on the following:

- The predicted 'Do Something - Cumulative' (Build) traffic noise levels in the design year (2037) exceeds the NCG project road noise criteria and would also increase by more than 2 dB(A) as a result of the project at 183 and 89 receiver buildings during the day and night periods, respectively
- The cumulative limit (5 dB(A) above the NCG project road criterion) is not exceeded at any receiver buildings during the day or night periods
- No receiver buildings are predicted to experience acute (day $L_{Aeq(15hour)} \geq 65$ dB(A) or night $L_{Aeq(9hour)} \geq 60$ dB(A)) noise levels due to the project during the day or night periods.

The assessment to investigate the project traffic noise impacts on receivers surrounding the surface connection to City West Link at Rozelle without the project and WestConnex including the approved M4-M5 Link ('Do Nothing' scenario) found that additional noise mitigation requirements are likely due to the increase in differences in traffic noise levels between the 'Do Nothing' and 'Do Something - Cumulative' scenarios compared to the differences in traffic noise levels between the 'Do Minimum' and the 'Do Something - Cumulative' scenarios.

This is further described by comparing the results in Table 7-6 and Table 7-9, where the number of receiver buildings exceeding the NCG noise criteria and experiencing traffic noise increases of greater than 2 dB(A) are greater for the 'Do Nothing' scenario without the approved M4-M5 Link (and other stages of WestConnex) than for the 'Do Minimum' scenario with the approved M4-M5 Link (and other stages of WestConnex). This indicates that the M4-M5 Link (and other stages of WestConnex) would increase traffic noise levels in the area surrounding the surface connection to City West Link at Rozelle and some receiver buildings may already be treated as part of the M4-M5 Link project prior to the implementation of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

7.2 Operational road traffic noise predictions with mitigation

Section 7.1 documents operational road traffic noise predictions without noise mitigation. The following sections describe the operational road traffic noise mitigation measures that have been assumed for the purpose of the assessment and the receivers potentially eligible for additional noise mitigation.

7.2.1 Quieter pavement surfaces

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

or more closely spaced receivers (ie. facades are separated by less than 20 metres) that exceed the NCG criteria.

As noted in Table 4-14, crumb rubber asphalt (CRA10) has been included in the operational road traffic noise model for some surface roads. This quieter pavement would achieve a 2 dB(A) noise reduction compared to dense graded asphalt (DGA).

The use of quieter pavements would be further investigated during detailed design. The final road pavement surface used for the project would be subject to various requirements besides acoustic benefits, including structural integrity, skid resistance, water dispersion, maintenance and design life.

7.2.2 Noise barriers

A combination of noise barrier and at-property noise treatment can provide the most reasonable overall reduction for an affected community when consideration is given to urban design, visual impact and engineering constraints. It is noted that while most types of at-property noise treatment do not provide any external noise reduction benefits, the achievable internal noise reduction may be higher than for most external noise barrier solutions. The process of deriving the most effective combination of noise barrier height and at-property noise treatment is given in the NMG, whereby the process gives preference to a hierarchy of noise control measures that reduce outdoor noise levels as per the RNP.

When optimising the noise barrier height in the noise abatement design, the process described in the NMG identifies three heights. These are the maximum barrier height, initial design barrier height and design barrier height. The optimising process is completed in three steps:

- **Step 1** – identify the maximum barrier height, which is the barrier height that strives to result in external noise criteria being met at all receivers. Roads and Maritime's policy is that barrier heights above eight metres would not be assessed as part of the noise abatement design
- **Step 2** - define the initial barrier height, which is a height between zero and maximum barrier height, where the trend in noise benefit is characterised by a rapid reduction in the number of properties that are eligible for consideration of additional noise mitigation
- **Step 3** – determine the design barrier height, between the initial barrier and maximum design barrier heights. The design barrier height is identified by also taking into consideration the area of noise barrier and noise reduction benefits across the broader community.

The barrier height forms the acoustic recommendation and is further evaluated in a multi-criteria decision making process to determine the feasible and reasonable combination of noise mitigation measures. As a guide, a noise barrier deduced from this process is considered to be a reasonable noise mitigation option where it is capable of providing a minimum insertion loss of 5 dB(A) for heights up to five metres or 10 dB(A) for heights above five metres and up to eight metres high. Where existing barriers may be increased in height, the higher barrier should provide a minimum insertion loss increase of 2 dB(A) over the existing barrier height to be considered a reasonable noise mitigation option. It is also important to note that where the predicted total diffraction attenuation exceed 20 dB(A) for single

diffraction, further increase in noise barrier height is not considered in the aforementioned process as this level of noise reduction is nearly impossible to attain in practice[1, 2, 3].

Generally speaking, the higher the barrier, the greater the level of noise reduction. However, as identified in Roads and Maritime's *Noise Wall Design Guideline* (March 2016), noise barriers that are excessively high can bring about the potential for visual intrusion, reduction of sunlight, loss of character and view and social alienation, compromising on urban design and resulting in unacceptable visual impacts (Refer to *Technical working paper: Urban design, visual and landscape impact* for an assessment of visual impacts from proposed noise barriers). In addition, a noise barrier that is reasonable may not always be feasible to build, which can be attributed to roadway and stormwater flow obstruction, access requirements, space limitations as well as wind loading and unsuitable ground conditions. As such, the aforementioned non-acoustical design factors are evaluated at each assessed location and the appropriate allowable barrier heights recommended for further consideration during detailed design. Taking into account community preferences, the final design barrier height with acceptable visual impact would be confirmed during detailed design for construction, conforming to Roads and Maritime *Design Specification* QA R271 *'Design and Construction of Noise Walls'*.

Figure 7-1 to Figure 7-3 below show the noise barriers considered in the NMG analysis for the project. The NMG analysis results and recommended maximum allowable barrier height for each location is presented in Table 7-10. The location and extent of noise barriers was determined based on the receivers identified for additional noise mitigation (Refer to section 7.1.2.1 and Appendix N) and in accordance with the NMG barrier analysis process and the requirements of Roads and Maritime *Noise Wall Design Guideline*. A reasonable and feasible assessment of each proposed barrier was carried out taking into account:

- Urban design, overshadowing and visual impacts (Refer to *Technical working paper: Urban design, visual and landscape impact* for an assessment of impacts from noise barriers)
- Impacts to private land
- Future uses and development of land where barrier is proposed
- Constructability and engineering constraints.

Where urban design, overshadowing, constructability and engineering constraints were considered, the barrier analysis process included discussions between Roads and Maritime's design team and the project's urban design specialist.

The NMG barrier analysis results for each of the proposed noise barrier are presented Appendix Q.

It is noted noise barriers would not be reasonable and feasible in the area surrounding the surface connection to City West Link at Rozelle as there are no locations where at least four closely spaced

[1] Table 4.1, Section 4 of RTA 'Environmental Noise Management Manual' (ENMM – Roads and Traffic Authority, 2001).

[2] Attenborough, Keith & M. Li, K & Horoshenkov, Kirill. (2007). "Predicting Outdoor Sound".

[3] ISO/TR 17534-3:2015 'Acoustic – Software for the calculation of sound outdoors – Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1'.

receivers are identified for additional noise mitigation. This is confirmed in the aerial maps presented in Appendix N. Therefore, noise barriers are only recommended for the Warringah Freeway and surrounds.

The barrier heights indicated in Table 7-10 are based on the height above the local ground where the proposed barrier is to be located. Furthermore, receiver counts presented in Table 7-10 refer to receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey dwelling would be represented by two receiver points.

Figure 7-1 – Noise barriers considered in the NMG analysis at Warringah Freeway and surrounds (south)



Figure 7-2 – Noise barriers considered in the NMG analysis at Warringah Freeway and surrounds (centre)



Figure 7-3 – Noise barriers considered in the NMG analysis at Warringah Freeway and surrounds (north)

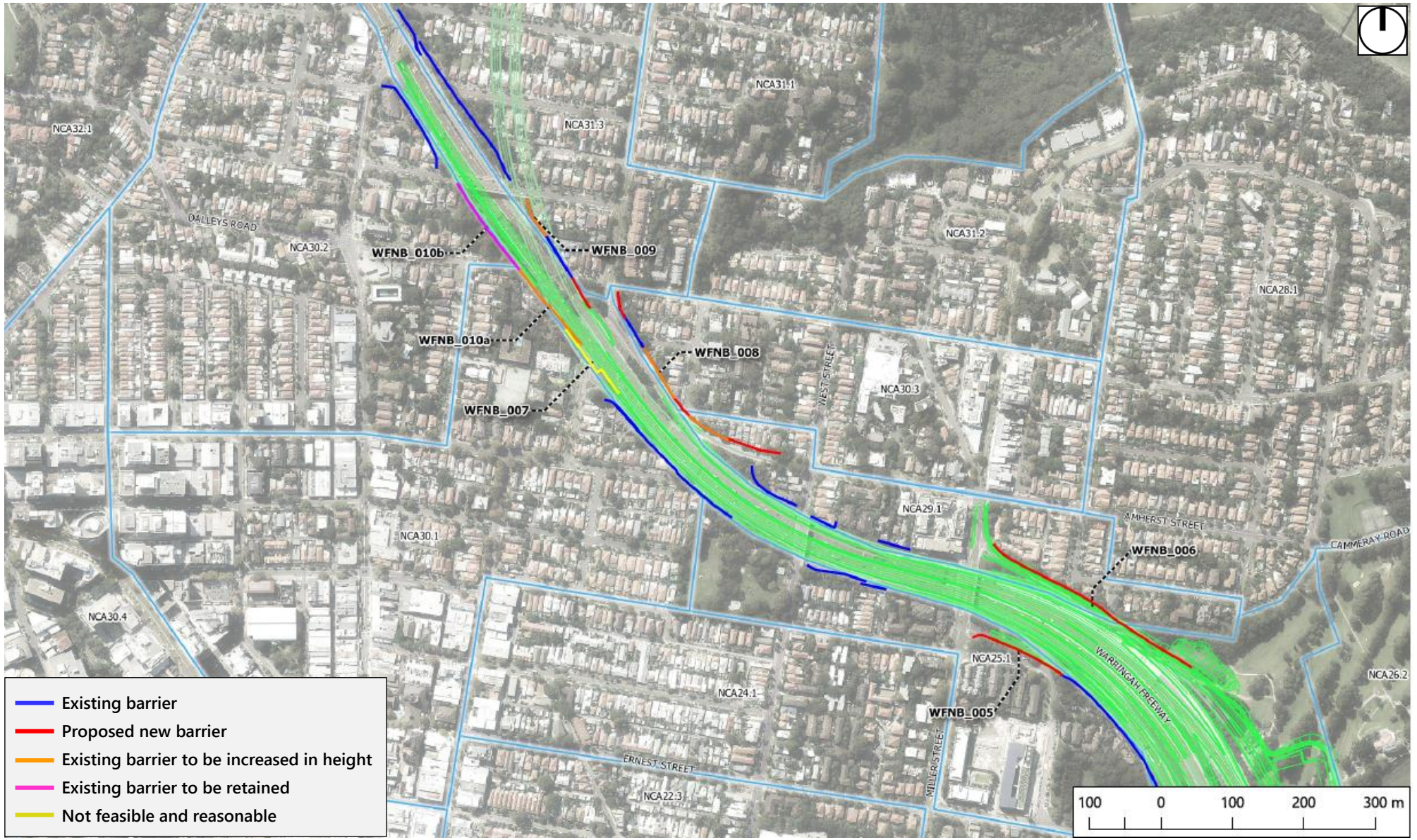


Table 7-10 – Summary of noise barrier analysis

Barrier ID (see Figure 7-1 to Figure 7-3)	NMG noise barrier analysis						Proposed maximum allowable barrier height (m)[2,4]	Comments[3]
	Barrier considered	Approx. length (m)	Design height (m)[1,4]	Total number of benefitting receivers[5]	Triggered receivers[5] with no proposed barrier	Remaining triggered receivers[5] with proposed barrier		
Warringah Freeway and surrounds								
WFNB_001	New	67	7.5	15	19	16	4	Acoustic design barrier height of 7.5 metres would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 4 m would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Therefore, the maximum allowable height of 4 m has been adopted taking into consideration urban design, visual impacts and constructability constraints. The feasibility of a 4 m high barrier on the existing retaining wall, overshadowing and noise mitigation options at this location would be further investigated during detailed design.
WFNB_002	New	92	8	41	26	8	5	Acoustic design barrier height of 8 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 5 m would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Therefore, the maximum allowable height of 5 m has been adopted taking into consideration urban design, visual impacts and constructability constraints. Noise mitigation options at this location would be further investigated during detailed design.
WFNB_003	New	140	6.5	23	6	5	5	Acoustic design barrier height of 6.5 metres would not achieve more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 5 m would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. The maximum allowable height of 5 m has been adopted having regard to urban design and visual impacts and engineering constraints. Final noise mitigation options at this location would be further investigated during detailed design.

Barrier ID (see Figure 7-1 to Figure 7-3)	NMG noise barrier analysis						Proposed maximum allowable barrier height (m)[2,4]	Comments[3]
	Barrier considered	Approx. length (m)	Design height (m)[1,4]	Total number of benefitting receivers[5]	Triggered receivers[5] with no proposed barrier	Remaining triggered receivers[5] with proposed barrier		
WFNB_004	Existing Height: 3.6 m	115	8	15	10	5	Retain existing barrier	Acoustic design barrier height of 8 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 4 m would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. However, increasing the existing barrier height from 3.6 metres to the maximum allowable height of 4 m would not achieve an increase of more than 2 dB(A) in insertion loss. Therefore, the existing barrier is to be retained and would not be increased in height. Noise mitigation options at this location would be further investigated during detailed design.
WFNB_005	New	138	6	6	25	24	5	Acoustic design barrier height of 6 m would not achieve more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 5 m would provide up to 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Therefore, the maximum allowable height of 5 m has been adopted having regard to urban design, visual and overshadowing impacts and would integrate with the surrounding existing barrier. Noise mitigation options at this location would be further investigated during detailed design.
WFNB_006	New	326	7.5	103	8	0	4.5	Acoustic design barrier based on maximum barrier height of 7.5 metres where sufficient benefits are achieved to remove the need for at-property treatment. The barrier would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 4.5 metres, which is also the initial design barrier height, would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Therefore, although the design barrier height of 7.5 metres would provide sufficient benefits, the maximum allowable height of 4.5 metres has been adopted due to urban design and visual impacts to visual receivers along the Miller Street on ramp and along Morden Street. Noise mitigation options at this location would be further investigated during detailed design. At this stage, noise barrier constraints such as constructability and impacts to properties would be further investigated.

Barrier ID (see Figure 7-1 to Figure 7-3)	NMG noise barrier analysis						Proposed maximum allowable barrier height (m)[2,4]	Comments[3]
	Barrier considered	Approx. length (m)	Design height (m)[1,4]	Total number of benefitting receivers[5]	Triggered receivers[5] with no proposed barrier	Remaining triggered receivers[5] with proposed barrier		
WFNB_007	New	-	-	15	30	30	Noise barrier is not recommended	A barrier in this location would not provide acoustic benefits to impacted receivers as the number of receivers identified as eligible for at-property treatment would not reduce by two thirds at any barrier height (ie. no initial design barrier height). Therefore, a barrier in this location is not considered reasonable. Furthermore, a feasibility assessment has concluded that attaching a noise barrier to the existing bridge over Brook Street is not structurally feasible. Therefore, a barrier in this location is not considered structurally feasible due to the insufficient structural capacity to accommodate a noise barrier to be attached to the side of the existing bridge.
WFNB_008	New	295	8	38	31	10	4.5	Acoustic design barrier height of 8 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The maximum allowable height of 4.5 metres would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Therefore, although the acoustic design barrier height would achieve the required insertion loss, the maximum allowable height of 4.5 metres has been adopted due to urban design and visual impacts. Constraints affecting the feasibility of the barrier such as the integration with existing structures, removal of vegetation (eg. well established urban/native trees) as well as urban design and visual amenity impacts would be further investigated during detailed design. It is noted that this noise barrier consists of existing barriers and new barriers to fill in the gaps between the existing barriers.
WFNB_009	Existing Height: 3.6 m Existing private barrier Height: 4.2 m to 6.6 m	104	8	9	26	25	Consistent with existing private barrier height	Acoustic design barrier height of 8 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. Furthermore, increasing the existing barrier height to the design barrier height of 8 m would provide more than 2 dB(A) increase in insertion loss over the existing barrier. Therefore, although the acoustic design barrier height of 8m would achieve the insertion loss requirements, the height of the barrier should be consistent with the lower existing private noise barrier due to urban design, visual amenity impacts such as overshadowing, removal of vegetation and impacts to properties. Final barrier height based on assessment of all potential constraints would be further investigated during detailed design.

Barrier ID (see Figure 7-1 to Figure 7-3)	NMG noise barrier analysis						Proposed maximum allowable barrier height (m)[2,4]	Comments[3]
	Barrier considered	Approx. length (m)	Design height (m)[1,4]	Total number of benefitting receivers[5]	Triggered receivers[5] with no proposed barrier	Remaining triggered receivers[5] with proposed barrier		
WFNB_010a	Existing timber fence Height: approx. 1.8 m	137	7.5	17	15	13	4.5	Acoustic design barrier height of 7.5 metres would provide more than 10 dB(A) insertion loss as required for barriers over five metres. The maximum allowable height of 4.5 metres would provide more than 5 dB(A) insertion loss and would meet the noise performance requirements for barriers up to 5 m in height. Furthermore, increasing the existing timber fence height to the maximum allowable height of 4.5 metres would provide more than 2 dB(A) increase in insertion loss over the existing fence and is considered to be reasonable. Therefore, the maximum allowable height of 4.5 metres has been adopted having regard to urban design, visual and overshadowing impacts. Noise mitigation options at this location would be further investigated in detailed design including the feasibility of construction access to build the barrier.
WFNB_010b	Existing Height: 3 to 3.6 m	-	-	15	6	6	Retain existing barrier	Increasing the existing barrier in this location would not provide acoustic benefits to impacted receivers as the number of receivers identified as eligible for at-property treatment would not reduce by two thirds at any barrier height (ie. no initial design barrier height). Therefore, the existing barrier is to be retained.

Notes:
1. Calculated noise barrier height following the process described in section 8 of the NMG without considering urban design, visual impacts and/or engineering constraints
2. Maximum allowable noise barrier height determined based on urban design, visual impacts and/or engineering constraints
3. Refer to *Technical working paper: Urban design, visual and landscape impact* for an assessment of visual impacts from noise barriers
4. Height of barrier based on the height above the local ground where the proposed barrier is to be located
5. Receiver counts based on receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey residence would be represented by two receiver points

7.2.3 Receiver buildings potentially eligible for consideration of additional noise mitigation

Following the NMG noise barrier analysis presented in Table 7-10, any residual receivers triggered for additional noise mitigation and still exceeding the relevant traffic noise criteria would be potentially considered for at-property treatment. A summary of the number of receiver floors and buildings identified as being eligible for consideration of at-property treatment is presented in Table 7-11. Details of each receiver building are presented in Appendix R.

For non-residential noise sensitive receivers such as schools, hospitals, places of worship and childcare centres equivalent external noise goals based on a 10 dB(A) reduction from external noise levels to internal noise levels when windows are left 20 per cent open, have been conservatively adopted to allow external assessments. Therefore, residual non-residential receivers triggered for additional noise mitigation because they are still exceeding the equivalent external traffic noise criteria, have been identified as potentially eligible for at-property treatment based on this conservative assessment. These non-residential receivers will require further investigation during detailed design to confirm the extent of noise impact and eligibility for consideration of noise mitigation since the difference in noise from outside to inside can increase to more than 30 dB depending on the building type, location of the room within the building, window type and whether the use of the space requires the window to be fully opened, slightly opened or closed.

The number of receiver floors represent individual floor levels of a receiver building. For example, a 10-storey apartment block would have 10 receiver floors and one receiver building. Receiver buildings identified as potentially eligible for at-property treatment are presented on aerial maps in Appendix R.

It is noted that the receiver buildings identified as potentially eligible for at-property treatment in the area surrounding the surface connection to City West Link at Rozelle are not presented in the aerial maps. As mentioned previously, receivers identified as potentially eligible for at-property treatment would be either mitigated under the M4-M5 Link's Minister's Conditions of Approval (Condition E87), or potential increase in traffic noise is more than 2 dB due to multiple projects and mitigation measures would be confirmed during further design development. Table 7-11 does not present a summary of receiver floors and receiver buildings identified as potentially eligible at-property treatment for the area surrounding the surface connection to City West Link at Rozelle.

Table 7-11 – Receiver buildings potentially eligible for consideration of additional noise mitigation

NCA[1]	Number of receiver floors[2]	Number of receiver buildings[3]
Area surrounding the surface connection to City West Link at Rozelle		
At property treatment to be provided under the M4-M5 Link project Minister's Conditions of Approval (Condition E87) or when predicted operational road traffic noise increases greater than 2 dB(A) due to multiple projects. At-property treatment requirements will be confirmed during further design development.		
Warringah Freeway and surrounds		
15.4	1	1
16.1	193	17

NCA[1]	Number of receiver floors[2]	Number of receiver buildings[3]
16.3	43	5
17.1	22	12
17.2	37	10
17.3	86	37
17.4	67	30
18.1	2	1
19.1	55	16
20.1	37	10
21.1	26	11
21.2	49	13
22.1	41	23
22.3	14	5
23.1	64	43
23.2	48	16
24.1	13	5
25.1	43	27
28.1	2	1
29.1	33	20
30.1	35	24
30.2	12	11
30.3	11	11
31.2	3	2
31.3	21	18
TOTAL	**958**	**369**

Notes:
1. Refer to Appendix B for location of noise catchment areas
2. Receiver floors represent the individual floor levels of a multi-level receiver building
3. A receiver building represents the individual building outlines as shown in Appendix R

The number of receivers potentially eligible for at-property treatment would be confirmed at detailed design stage. During detailed design, site inspections of these receivers would be carried out to confirm:

- Internal layout and location of habitable areas
- Construction type of the building structure
- Locations and sizes of windows and doors
- For multi-level apartment buildings, the number of residential dwellings per floor level and the layout of the dwellings.

Given that the predicted traffic noise levels are external levels, the above information would assist in determining a conversion from external to internal levels, which would help determine the appropriate at-property treatment.

7.3 Maximum road traffic noise levels

The maximum noise level results and assessment are presented in Appendix S and a summary is presented in Table 7-12. The results are based on the noise monitoring carried out at the locations listed in Table 2-3, where road traffic noise dominated the noise environment.

Table 7-12 – Summary of measured maximum noise level events

Monitoring location (see Appendix B)	Monitoring period	Total L_{Amax} events during monitoring period	Measured maximum noise level (L_{Amax}), dB(A)	
			Range	Average
L1 – 22 The Crescent, Annandale	19/07/2017 - 27/07/2017	725	75-80	77
L2 – 2/277 Johnston Street, Annandale	19/07/2017 - 27/07/2017	860	74-76	75
L3 – 16 Railway Parade, Annandale	19/07/2017 - 27/07/2017	245	69-73	71
L17 – 6 McDougall Street, Kirribilli	25/08/2017 - 4/09/2017	563	71-74	72
L18 – 1/191-195 Walker Street, North Sydney	21/06/2017 - 30/06/2017	24	83-91	86
L19 – 91 Ridge Street, North Sydney	21/06/2017 - 1/07/2017	65	68-73	70
L21 – 306 Miller Street, North Sydney	20/06/2017 - 2/07/2017	837	74-78	76
L22 – 1/1 Bardsley Gardens, Crows Nest	21/06/2017 - 1/07/2017	608	78-85	80
L23 – 288 Falcon Street, Neutral Bay	25/08/2017 - 4/09/2017	293	83-86	84
L24 – 5 Military Road, Neutral Bay	25/08/2017 - 4/09/2017	631	84-86	85
L25 – 317 Ernest Street, Cammeray	25/08/2017 - 4/09/2017	840	74-77	75
L26 – 225 Ernest Street, Cammeray	25/08/2017 - 4/09/2017	756	73-76	75
L27 – 77 Rosalind Street, Cammeray	8/09/2017 - 19/09/2017	169	70-77	74
L28 – 53 Bellevue Street, Cammeray	8/09/2017 - 19/09/2017	25	73-82	79
L31 – 18/22-24 Donnelly Road, Crows Nest	8/09/2017 - 19/09/2017	152	70-74	72
L32 – 79 Brook Street, Naremburn	20/06/2017 - 2/07/2017	1120	77-81	79

The results presented in Table 7-12 show that maximum noise levels range from 68 dB(A) up to 91 dB(A) at the noise monitoring locations. The higher maximum noise levels were typically at locations near or adjacent to the Warringah Freeway on Walker Street, Falcon Street and Military Road.

Maximum noise levels are typically from passing vehicles with the high levels generally due to heavy vehicles passing the monitoring location.

Future changes in the maximum noise levels and the number of events would depend on changes in traffic volumes and compositions forecast for the project. Changes in road alignment or width, leading to traffic moving closer to or further from the assessment location, would also result in the maximum noise levels and number of events to increase or decrease, respectively.

The project is predicted to increase maximum noise levels and events at the following noise catchment areas (see Appendix B for NCA locations):

- NCA 3.3 – receivers to the west of The Crescent and the City West Link intersection would experience increases in maximum noise levels and the number of events compared to the existing situation. This is due to the realignment of The Crescent, as part of the M4-M5 Link project, towards the west to allow the intersection to include roads leading to and from the portal of the Western Harbour Tunnel
- NCA 4.1, NCA 4.2 and NCA 4.3 – receivers to the north of the City West Link would experience increases in maximum noise levels and the number of events compared to the existing situation due to the widening of the City West Link as part of the M4-M5 Link project. The widening would result in the eastbound carriageway moving closer to receivers in these NCAs and increased traffic movements due to the operation of the Western Harbour Tunnel portal
- NCA 23.1 – receivers to the east of the Warringah Freeway would experience an increase in maximum noise levels and the number of events compared to the existing situation. This is due to the widening of the Warringah Freeway resulting in the southbound carriageway moving closer to the receivers in this NCA.

For the noise catchment areas where maximum noise levels and the number of events would increase due to the project, the affected receivers would likely be considered for additional noise mitigation measures including noise barriers and/or at-property treatment. With the implementation of noise mitigation measures, overall traffic noise levels would reduce, including L_{Amax} noise levels.

Maximum noise levels are not expected to substantially change as a result of the project at other NCAs because no major road realignments or widening are proposed at these areas.

7.4 Operational fixed facilities assessment

Noise impacts from the proposed fixed facilities associated with the project have been determined through noise modelling of the typical plant and equipment likely to be implemented. The noise prediction model is based on calculation methods presented in the International Standard ISO 9613-2 (1996), which incorporates moderately adverse meteorological conditions (ie. wind and temperature inversions) implemented in accordance with ISO/TR 17534-3 (2015).

The fixed facilities are proposed at the following locations:

- Rozelle – Ventilation outlet and motorway facilities at the Rozelle Interchange to be co-located in the M4-M5 Link motorway operations complex including substations and fire pump buildings
- Rozelle – Wastewater treatment plant located at the Rozelle Interchange
- Cammeray – Motorway facility and ventilation outlet at the Warringah Freeway including substations and fire pump buildings. It is noted that the motorway facility would be located adjacent to the Beaches Link and Gore Hill Freeway Connection project motorway facility located within Cammeray Golf Course on Ernest Street, and the ventilation outlets would be located in the centre road reserve of the Warringah Freeway, adjacent to the Ernest Street overpass.

The assessment has been done in accordance with the NPfI and results are presented in the following tables and noise contour maps are presented in Appendix T.

Table 7-13 – Predicted $L_{Aeq,15\ min}$ noise levels from fixed facilities, dB(A)

Location	NCA	$L_{Aeq,15min}$ Project noise levels[1, 2]		Predicted noise level	Exceedance
		Intrusiveness	Amenity		
Rozelle Interchange	NCA 3.2	*49*	***43***	35	-
	NCA 3.3	*49*	***43***	37	-
	NCA 4.2	***42***	*43*	45	3
Warringah Freeway	NCA 26.2	***42***	*43*	40	-
	NCA 26.1	*46*	***43***	38	-
	NCA 23.1	*49*	***43***	39	-
	NCA 23.2	***42***	*43*	39	-
	NCA 24.1	***42***	*43*	37	-
	NCA 25.1	*48*	***43***	36	-
	NCA 29.1	*52*	***43***	35	

Notes: 1. Project noise levels based on night time period
2. **Bold** font represents the Project Noise Trigger Level used for assessment.

The results presented in the above table indicate that noise emissions from the proposed fixed facilities at the Rozelle Interchange would comply with the relevant project noise levels for receivers in NCA 3.2 and NCA 3.3. However, an exceedance has been predicted for the nearest receivers within NCA 4.2.

Noise emissions from the proposed fixed facilities at the Warringah Freeway at Cammeray associated with the project would comply with the relevant project noise levels at the nearest affected receivers within the noise catchment areas surrounding the fixed facilities.

Final noise predictions and assessment of operational fixed facilities would occur during the detailed design of the project, when actual types, makes and models of the plant and equipment are decided and finalised. The assessments would be done in accordance with the requirements of the NPfI and where exceedances are predicted, noise mitigation measures would be designed and installed.

For the motorway control centre located in Artarmon, due to its location and separation distance to residences across Gore Hill Freeway, shielding from buildings, and relatively low noise emissions from mechanical plant, noise levels from the facility are expected to be barely perceivable at the nearest residential premises amongst the prevailing ambient noise. This would also be applicable for the nearby commercial, industrial and childcare centre premises.

7.5 Operational vibration impacts

The potential for operational ground-borne noise and tactile vibration impacts on nearby sensitive receivers from traffic on project surface roads and tunnels has been reviewed. Vibration emissions from traffic travelling on roads typically occur where there are irregularities in the road surface (eg pot holes). As the new and upgraded roads on the surface and in the tunnels associated with the project would be designed and constructed to avoid road irregularities, operational ground-borne noise and tactile vibration impacts from operation traffic are not expected.

Therefore, vibration impacts from traffic travelling on the proposed surface roads, through tunnels and portals are considered negligible and are unlikely to result in ground-borne noise or tactile vibration impacts to sensitive receivers directly adjacent to surface roads, tunnels and portals.

Similarly, vibration from operational fixed facilities is not anticipated to exceed objectives given the distance between these facilities and the nearest sensitive receiver. Therefore, operational vibration impacts have not been considered further in the assessment.

8 Mitigation and management measures

Mitigation and management measures to control noise and vibration impacts of sensitive receivers and structures for both the construction and operational stages of the project have been reviewed, identified and developed. These mitigation and management measures which are presented in Table 8-1 would be incorporated into the project.

Table 8-1 – Noise and vibration mitigation and management measures to be implemented during the construction and operational stages of the project

No.	Impact	Environmental mitigation or management measure	Location
NV1	Construction noise and vibration impacts	A construction noise and vibration management plan will be developed for the project. This plan will: a) Identify relevant criteria and management levels in relation to noise and vibration b) Identify noise and vibration sensitive receivers and features in the vicinity of the project c) Include standard and additional mitigation from the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) and detail how and when these will be applied in the project d) Describe the approach that will be adopted for carrying out location and activity specific constructing noise and vibration impact assessments to assist with designing and selecting of the appropriate mitigation and management measures e) Include protocols that will be adopted to manage works required outside standard construction hours f) Detail the methodology and approach for managing residual construction noise impacts g) Detail the process for managing construction vibration, including heritage structures considering all types of vibration generating works, including blasting h) Outline the procedures and approach for noise and vibration monitoring to be carried out to confirm construction noise and vibration levels in relation to noise and vibration management levels i) Where feasible and reasonable, detail how construction noise impacts from concurrent or consecutive nearby construction works associated with the project will be managed. The construction noise and vibration management plan will be implemented for the duration of construction of the project.	WHT/WFU
NV2	Construction noise and vibration impacts	Detailed Construction Noise and Vibration Impact Statements will be carried out for all construction support sites and major construction works required for the project prior to the commencement of construction. The statements will consider the proposed site layouts and noise and vibration generating activities that would take place during all major stages of the construction support site, assess predicted noise and vibration levels against the relevant management levels, and incorporate feasible and reasonable mitigation and management measures in accordance with the requirements of the *Interim Construction Noise Guideline* (DECC, 2009) and the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016).	WHT/WFU

No.	Impact	Environmental mitigation or management measure	Location
NV3	Construction noise and vibration impacts during out of hours work	An out of hours works protocol will be developed for the construction of the project. The protocol will include: a) Details of works required outside standard construction hours, including acceptable justifications for works outside of standard construction hours, what types of works are allowed to take place outside of construction hours, and justifications of why the activities are required outside standard construction hours b) Details of the assessment and approval process (internal and external) for works proposed outside standard construction hours c) Noise and vibration mitigation and management measures that are to be considered and implemented where appropriate to manage potential impacts associated with works outside standard construction hours d) The noise and vibration impact assessment processes that will be followed to identify potentially affected receivers, clarify potential impacts and determine appropriate mitigation and management measures The protocol will be prepared in consultation with DPIE and the EPA, and independently endorsed. The project protocol will be implemented during the duration of the construction of the project.	WHT/WFU
NV4	Construction noise and vibration impacts	Construction noise and vibration impacts will be monitored periodically throughout all stages of construction to ensure that: a) Impacts are consistent with the noise and vibration levels detailed in the relevant Construction Noise and Vibration Impact Statements b) Noise and vibration impacts are being appropriately managed c) Mitigation measures are effective.	WHT/WFU
NV5	Construction noise and vibration impacts	Where feasible and reasonable, unless compliance with the relevant traffic noise criteria can be achieved, or alternative arrangements have been agreed with affected receivers, construction vehicle movements will not occur on local roads beyond those required for direct access to construction sites.	WHT/WFU
NV6	Construction noise and vibration impacts	Vibration generating activities will be managed through the establishment of minimum buffer distances to achieve screening levels. Where vibration levels are predicted to exceed the screening levels, a more detailed assessment of the impacted structure and attended vibration monitoring will be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment will specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	WHT/WFU
NV7	Construction ground-borne noise impacts	Feasible and reasonable measures will be implemented to minimise ground-borne noise where exceedances are predicted.	WHT/WFU

No.	Impact	Environmental mitigation or management measure	Location
NV8	Construction impacts from surface road works	Mitigation measures will be implemented for surface road works, local area and utility works, where construction activities are predicted to exceed noise management levels at receivers. Where feasible and reasonable the approaches that will be used include: a) Carrying out works during the daytime period when near residential receivers b) Selection of plant and equipment to minimise noise and vibration impacts c) Management of plant and equipment to minimise the generation of noise and vibration impacts d) Community consultation, engagement and notification e) Detailed programming and respite protocols f) Where out of hours works are required, programming the noisiest activities to occur during the less sensitive time periods g) Out of hours works protocols h) Limiting timing of noise intensive work i) Use of portable noise barriers around particularly noisy equipment such as concrete saws and rock hammers in cases where it would effectively reduce noise levels at nearby receivers j) Management of construction traffic to minimise movements during the night periods along local roads k) Establishing minimum vibration buffer distances for vibration intensive works l) Vibration and blasting trials and/or monitoring along with building condition surveys	WHT/WFU
NV9	Construction blasting impacts	A Blast Management Strategy will be prepared in consultation with the EPA to demonstrate that all blasting and associated activities will be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a significant risk impact to structures and sensitive receivers. The strategy will: a) Detail the blasting to be performed including location, method and justification of the need to blast b) Identify any potentially affected noise and vibration sensitive sites including heritage buildings and utilities c) Establish appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site d) Detail storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction support site e) Identify hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives f) Determine potential noise and vibration and risk impacts from blasting and appropriate best management practices g) Detail community consultation procedures.	WHT/WFU

No.	Impact	Environmental mitigation or management measure	Location
NV10	Cumulative construction noise impacts / construction fatigue	Construction noise from concurrent and consecutive construction works will be managed to minimise cumulative construction noise impacts. Where feasible and reasonable the approaches that will be used include: a) Coordinating work between project construction sites and construction works to avoid cumulative noise impacts b) Consideration of additional at source or near source mitigation where construction noise levels may result in cumulative construction noise impacts, where scheduling is not practical to avoid cumulative noise impacts c) Community consultation throughout the project to gauge construction key noise impacts and issues and any unknown impacts from concurrent or consecutive sets of constructions works d) Incorporating additional noise mitigation and management measures with consideration of cumulative and consecutive construction noise impacts based on coordination between projects.	WHT/WFU
NV11	Operational road traffic noise impacts	The operational noise performance of the project will be reviewed during detailed design and operational noise mitigation (low noise pavement, noise barrier, at-property treatment or a combination of treatments) will be confirmed in accordance with relevant policies and guidelines.	WHT/WFU
NV12	Operational road traffic noise impacts	Within 12 months of the commencement of the operation of the project, actual operational noise performance will be compared to predicted operational noise performance (as reviewed during detailed design) to analyse the effectiveness of the operational road traffic noise mitigation measures. Additional reasonable and feasible mitigation will be considered where any additional receivers are identified as qualifying for consideration of noise mitigation under the *Noise Mitigation Guideline* (Roads and Maritime, 2015).	WHT/WFU
NV13	Operational fixed facility noise impacts	Operational fixed facilities will be designed to meet project specific noise criteria derived in accordance with the *Noise Policy for Industry* (EPA, 2017).	WHT/WFU

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Roads and Traffic Authority 2006, *Noise Wall Design Guideline*

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Standards Australia 2006, *Explosives - Storage and use - Part 2 Use of explosives*, AS 2187.2:2006

Standards Australia 2016, *Acoustics - Recommended design sound levels and reverberation times for building interiors*, AS/NZS 2107:2016

Standards Australia 2016, *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, AS 2436:2010 (R2016)

Transport for NSW 2016, *Sydney Metro City & Southwest environmental impact statement – Technical Paper 2: Noise and Vibration*

Transport for NSW 2017, *Sydney Metro Chatswood to Sydenham – Victoria Cross Station and Artarmon Substation modification submission report*

UK Department of Transport 1988, *Calculation of Road Traffic Noise* (CORTN)

Appendix

G

Appendix G

Noise and vibration

Appendices

January 2020

APPENDIX A Technical terms and concepts

A.1 Glossary of terminology

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

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a substantial period of time (that is, wind occurring more than 30 per cent of the time in any assessment period in any season and/or temperature inversions occurring more than 30 per cent of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated.
A-weighted	See dB(A) below
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for 90 per cent of a sample period. This is represented as the L90 noise level (see below).
CNVMP	Construction noise and vibration management plan
CNVIS	Construction noise and vibration impact statement
CNVG	Construction Noise and Vibration Guideline (Roads and Maritime, 2016)
Decibel (dB)	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0 dB The faintest sound we can hear 30 dB A quiet library or in a quiet location in the country 45 dB Typical office space. Ambience in the city at night 60 dB CBD mall at lunch time 70 dB The sound of a car passing on the street 80 dB Loud music played at home 90 dB The sound of a heavy vehicle passing on the street 100 dB The sound of a rock band 110 dB Operating a chainsaw or jackhammer 120 dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz) but is less effective outside these frequencies.
ECRTN	Environmental Criteria for Road Traffic Noise (EPA, 1999)
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
HNA	Highly noise affected

ICNG	Interim Construction Noise Guideline (DECC, 2009)
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Amax}	The A-weighted maximum sound pressure level measured over a given period.
L_{Amin}	The A-weighted minimum sound pressure level measured over a given period.
L_{A1}	The A-weighted sound pressure level that is exceeded for 1 per cent of the time for which the given sound is measured.
L_{A10}	The A-weighted sound pressure level that is exceeded for 10 per cent of the time for which the given sound is measured.
L_{A90}	The level of noise exceeded for 90 per cent of the time. The bottom 10 per cent of the sample is the L90 noise level expressed in units of dB(A).
L_{Aeq}	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
MIC	Maximum instantaneous charge
NCA	Noise Catchment Area. NCAs are logical groupings of noise and vibration-sensitive receivers for the project based on areas with a similar acoustic environment.
NCG	Noise Criteria Guideline (Roads and Maritime, 2015)
NMG	Noise Mitigation Guideline (Roads and Maritime, 2015)
NML	Noise management level
NPfI	Noise Policy for Industry (EPA, 2017)
OOHW or OOH	Out-of-hours works, which is construction works which take place outside of the standard construction hours specified by the NSW Environment Protection Authority (EPA) Interim Construction Noise Policy (ICNG) (2009).
RBL	Rating background level
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
ROL	Road Occupancy Licence
Roads and Maritime	Roads and Maritime Services
RNP	Road Noise Policy (DECCW, 2011)
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of one second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{Aeq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level (SPL or L_p)	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level (SWL or L_w)	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

A.2 Acoustic concepts

A.2.1 Sound and noise

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound. Sound is a vibration that travels as an audible wave of pressure through the air from a source to a receiver location such as the human ear. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) is a unit of measurement used to express the ratio of a quantity to another on a logarithmic scale to make the wide range of sound pressure more manageable.

Sound power is the rate at which a source emits acoustic energy and is unaffected by the environment. It is a property of the source that is emitting acoustic energy.

In contrast, **sound pressure** is the effect, and it is affected by factors associated with the built and natural environment such as distance, direction, obstacles etc. The sound pressure is the acoustic energy or 'noise level' at a distance away from the noise source. The relationship between sound power and sound pressure can be explained by considering the analogy of an electric heater, which radiates heat into a room and temperature is the effect. Like sound pressure, temperature also reduces with distance from the source following the inverse square law.

In this technical working paper, **sound power level** is identified by the symbols **SWL** or $\mathbf{L_w}$, while **sound pressure level** is represented by **SPL** or $\mathbf{L_p}$, and both have the same scientific unit in dB.

A.2.2 Individual's perception of sound

The loudness of sound depends on its sound pressure level. The A-weighted decibel (dB(A)) is generally used for the purposes of environmental noise impact assessment as it has been adjusted to account for the varying sensitivity of the human ear to different frequencies of sound. 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 dB(A) is a good measure of the loudness of environmental noise to the human ear as it considers this frequency dependant sensitivity.

Different noise sources having the same dB(A) level generally sound equally loud. However, the frequency of a sound is what gives it a distinctive pitch or tone – for example, the rumble of distant thunder is an example of a low frequency sound and a whistle is an example of a high frequency sound. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 to 90 dB(A). The following table provide some points of reference, measured in dB(A), of familiar sounds and those from construction activities.

Table A-1 Perception of sound - familiar sounds and construction noise

Common sounds	Construction noise	Sound pressure level
Leaf blower at operator's ear	Concrete saw or jack hammer 7 metres away	90 dB(A)
Airplane cabin during cruise (Airbus 321)	Excavator (with bucket) 7 metres away	80 dB(A)
General traffic noise kerbside next to Military Road	Towable compressor 7 metres away	75 dB(A)
Normal conversation at 1 metre		60 dB(A)
Outdoor air conditioning unit 1 metre away	Towable compressor 50 metres away	55 dB(A)
General office		50 dB(A)
Inside private office	Ground-borne noise from road header tunnel excavation between depths of 20 metres to 50 metres	40 dB(A)
Inside bedroom		30 dB(A)

In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect, whilst a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However, individuals may perceive the same sound differently since many factors can influence an individual's response, including:

- The specific characteristics of the noise (eg. frequency, intensity, duration of the noise event)
- Time of day noise events occur
- Individual sensitivities and lifestyle
- Reaction to an unfamiliar sound
- Understanding of whether the noise is avoidable and the notions of fairness.

A.2.3 Environmental noise assessment indicators

Environmental noise is an accumulation of noise pollution that occurs outside and is most commonly attributed to various modes of transport as well as industrial and construction activities. Environmental noise has been shown to have an adverse effect on the quality of life, especially following long-term exposure. The focus of the present technical assessment is on annoyance and sleep disturbance as they constitute most of the burden related to the impact of environmental noise on health outcomes. Noise annoyance is defined by the World Health Organization as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. Sleep disturbance relates to difficulty with sleep initiation, consolidation as well as awakening and reduced quality of sleep.

In New South Wales, contemporary environmental noise assessment criteria for addressing noise annoyance and sleep disturbance are specified by the Environment Protection Authority (EPA). Potential

road traffic noise impact is assessed in accordance with the NSW Road Noise Policy. For motorway and ventilation facilities that are permanently fixed, and associated noise emissions are long-term in nature, noise criteria have been adopted in accordance with the Noise Policy for Industry. For enabling construction activities which are temporary in nature and highly variable, EPA's Interim Construction Noise Guideline provides the underlying assessment principles for the determination of potential construction noise impact. Each policy/guideline is discussed in detail in the body of this report:

- Section 3.5.2 details the NSW Road Noise Policy
- Section 3.5.4 details the Noise Policy for Industry
- Section 3.4.1 details the EPA's Interim Construction Noise Guideline.

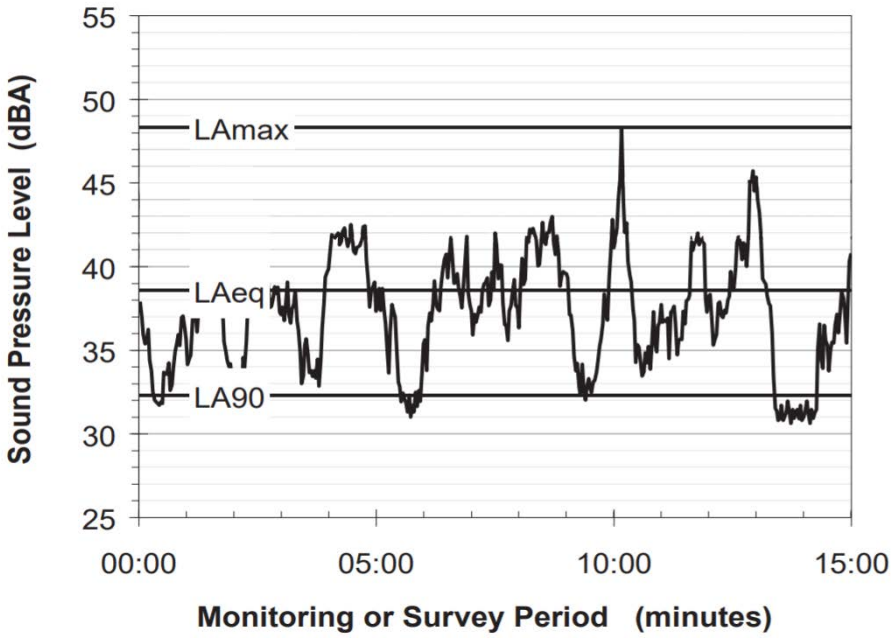
L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as L_{Aeq}. The L_{Aeq} indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence over the L_{Aeq} level than do quieter ones, and activities that last longer in time have greater L_{Aeq} than do shorter ones. An increase in the number of events also increases the L_{Aeq}. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} - It is important to note that L_{Aeq} levels are numerically lower than maximum noise levels (denoted as L_{Amax}). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short-term awakening reaction, potential impact is assessed using the L_{Amax} indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 per cent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

These three noise indicators of L_{Amax}, L_{Aeq} and L_{A90} are presented in Figures A-1 for a sample noise monitoring survey period showing the sound pressure level of a varying noise environment such as environmental noise.

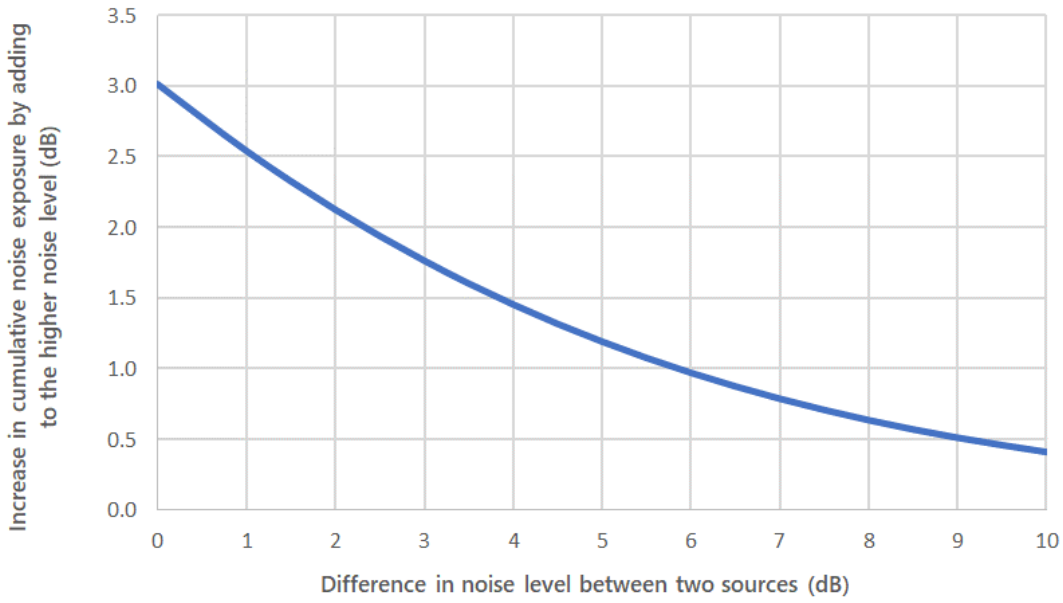
Figure A-1: Environmental noise assessment indicators



A.2.4 Cumulative sound exposure

As illustrated in Figure A-2, for two activities that result in the same amount of acoustical energy or noise level at a receiver location, the cumulative sound exposure level would be 3 dB higher than the level of just one single activity. This is because the decibel (dB) scale is logarithmic. Conversely, if the activity closer to your home results in noise exposure level that is 10 dB higher than the activity occurring further away, the quieter works would contribute very little to the cumulative noise exposure level.

Figure A-2: Difference in noise level between two sources



APPENDIX B Project locations, receivers and noise catchment areas

B.1 Project locations, receivers and NCAs

100 0 100 200 300 400 m

NCA6.4 NCA6.3 NCA11.5 NCA9.2 NCA10.2 NCA8.1 NCA9.1 NCA6.5 NCA6.2 NCA6.1 NCA7.1 NCA7.2 NCA4.4 NCA4.5 NCA10.1 NCA5.3 NCA5.2 NCA4.3 NCA5.1 NCA4.2 NCA4.1 NCA3.4 NCA3.3 NCA3.2 NCA3.1 NCA2.1 NCA1.3 NCA1.2 NCA1.1 NCA1.5 NCA1.4

L41 L8 L10 L9 L7 L6 L4 L3 L5 L2 L1

VICTORIA ROAD
WESTERN DISTRIBUTOR
CITY-WEST LINK ROAD
THE CRESCENT
BRIDGE ROAD
CITY-WEST LINK ROAD
DARLEY ROAD
JAMES STREET
JOHNSTON STREET
MINOGUE CRESCENT

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Rozelle Rail Yards

Consultant:

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

Figure No: TJ500-01-6-3-1-1 020a-1
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LYONS ROAD
VICTORIA ROAD
CITY WEST LINK ROAD
THE CRESCENT
JOHNSTON STREET
WESTERN DISTR

NCA11.4
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA9.2
NCA10.2
NCA6.4
NCA6.3
NCA8.1
NCA9.1
NCA6.2
NCA6.1
NCA7.1
NCA7.2
NCA4.4
NCA4.5
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NCA2.1
NCA3.1
NCA1.2
NCA3.2
NCA1.3
NCA1.5

L41 L8 L10 L9 L7 L6 L4 L3 L5 L2

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Victoria Road

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve
1/418A Elizabeth Street, SURRY HILLS NSW 2010
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L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L41

VICTORIA ROAD
CAHILL EXPRESSWAY
BRADFIELD HIGHWAY
WESTERN DISTRIBUTOR
THE CRESCENT
CITY WEST LINK ROAD
BRIDGE ROAD
PYRMONT BRIDGE ROAD

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
White Bay

Consultant:

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NCA15.1
NCA13.2
NCA15.3
NCA13.1
NCA16.2
L13
NCA12.2
L14
NCA14.1
NCA16.1
L15
NCA15.2
NCA15.4
L12
NCA12.1
L11
NCA11.4
NCA11.5
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA6.4
NCA10.2
NCA9.2

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Yurulbin Point

Consultant:
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NCA22.2 NCA22.1 NCA23.2 L19 L20 NCA21.2 NCA20.1 L18 NCA12.2 NCA13.2 NCA15.1 MILLER STREET NCA19.1 NCA17.4 WARRINGAH FREEWAY NCA18.3 NCA16.3 NCA13.1 NCA15.3 PACIFIC HIGHWAY NCA17.3 NCA16.2 L13 L17 NCA18.2 L14 NCA14.1 NCA17.2 L15 NCA15.2 NCA18.1 HIGH STREET L16 NCA15.4 NCA16.1 L12 NCA12.1 NCA17.1 L11 NCA11.4 BRADFIELD HIGHWAY SYDNEY HARBOUR TUNNEL NCA11.5 NCA11.5 NCA11.3 NCA11.2 NCA11.1

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Berrys Bay

Consultant:

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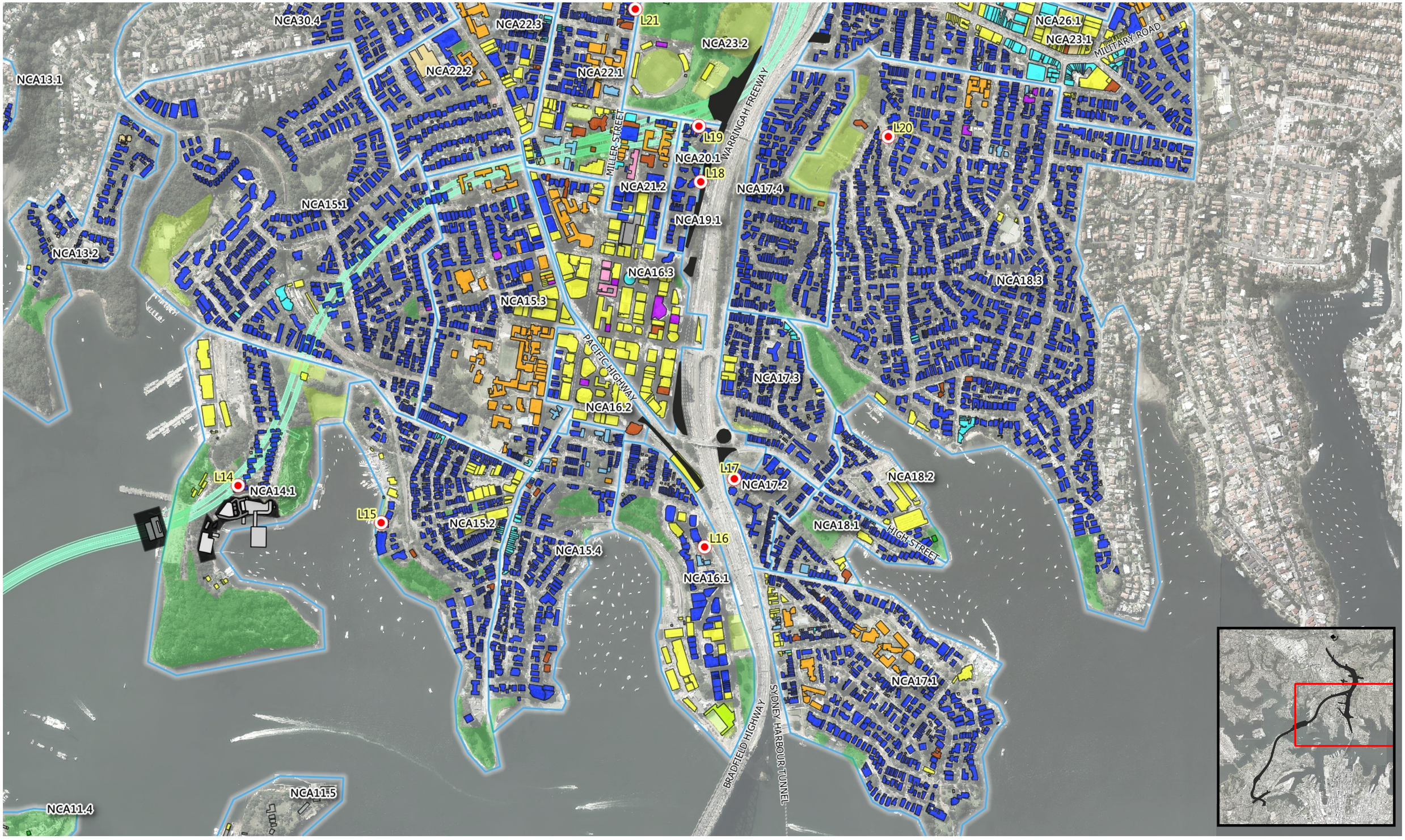

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Warringah Freeway - South

Consultant:

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L28 L29 L27 L30 L26 L25 L22 L24 L23 L21 L19 L20 L18 L17 L14 L15

RIVER ROAD FALCON STREET MILITARY ROAD GERARD STREET BELGRAVE STREET MILLER STREET WARRINGAH FREEWAY PACIFIC HIGHWAY HIGH STREET

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Warringah Freeway - Lower Centre

Consultant:

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Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Warringah Freeway - Upper Centre

Consultant:

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

Figure No: TJ500-01-6-3-1-1 020a-10
Scale: 1:12500
Date: 10.10.2019
Created by: ALE
Rev: R22
Sheet: A3

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100 0 100 200 300 400 m

NCA34.1
NCA33.1
NCA33.2
NCA36.1
NCA38.2
NCA38.3
NCA38.1
NCA37.1
NCA32.1
NCA31.3
NCA31.1
NCA31.2
NCA30.2
NCA30.3
NCA30.1
NCA30.4
NCA29.1
NCA28.1
NCA26.2
NCA24.1
NCA25.1
NCA22.3
NCA22.1
NCA21.1
NCA23.1
NCA23.2

L36 L34 L33 L35 L37 L39 L40 L38 L32 L31 L28 L27 L29 L30 L26 L25

ALPHA ROAD
EASTERN VALLEY WAY
FLAT ROCK DRIVE
STRATHALLEN AVENUE
LANE COVE TUNNEL
GORE HILL FREEWAY
DICKSON AVENUE
BROOK STREET
PACIFIC HIGHWAY
RIVER ROAD
FALCON STREET
MILLER STREET
WARRINGAH FREEWAY

Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Warringah Freeway - North

Consultant:

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

Figure No: TJ500-01-6-3-1-1 020a-11
Scale: 1:12500
Date: 10.10.2019
Created by: ALE
Rev: R22
Sheet: A3

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100 0 100 200 300 400 m



Legend

- Construction support site layout
- Construction site footprint
- Noise catchment boundary
- Noise monitoring location
- Western Harbour tunnel alignment
- Fitout of the M4-M5 Link tunnels

Receiver type

- Residential
- Mixed use
- Commercial/Industrial
- Childcare
- Educational
- Medical
- Place of Worship
- Other noise sensitive receivers
- Recreational - Passive
- Recreational - Active
- Non-receiver building
- Project acquisition
- Other major project acquisition

Client:
Roads and Maritime Services (RMS)

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Building use identification
Waltham Street

Consultant:

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

Figure No: TJ500-01-6-3-1-1 020a-12
Scale: 1:12500
Date: 10.10.2019
Created by: ALE
Rev: R22
Sheet: A3

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B.2 Noise catchment areas details summary

NCA ID	Distance to nearest works area	Nearest works area	Reference suburb (-sub area)	Reference Logger	Noise management level (NML) $L_{Aeq(15min)}$				Screening level
					Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
					Day	Day	Eve	Ngt	Night
1.1	570	Rozelle Rail Yards	Lilyfield	L2	60	55	52	41	51
1.2	210	Rozelle Rail Yards	Lilyfield	L2	60	55	52	41	51
1.3	250	Rozelle Rail Yards	Annandale	L2	60	55	52	41	51
1.4	570	Rozelle Rail Yards	Annandale	L2	60	55	52	41	51
1.5	320	Rozelle Rail Yards	Annandale	L2	60	55	52	41	51
2.1	320	Rozelle Rail Yards	Glebe	L5	61	56	56	50	60
3.1	440	Rozelle Rail Yards	Lilyfield	L3	60	55	55	49	59
3.2	70	Rozelle Rail Yards	Lilyfield	L3	60	55	55	49	59
3.3	50	Rozelle Rail Yards	Annandale	L3	60	55	55	49	59
3.4	170	Rozelle Rail Yards	Lilyfield	L3	60	55	55	49	59
4.1	380	Rozelle Rail Yards	Lilyfield	L6	62	57	57	50	60
4.2	20	Rozelle Rail Yards	Lilyfield	L6	62	57	57	50	60
4.3	<10	Rozelle Rail Yards	Lilyfield	L6	62	57	57	50	60
4.4	260	Victoria Road	Rozelle	L6	62	57	57	50	60
4.5	<10	White Bay	Rozelle	L6	62	57	57	50	60
5.1	400	Rozelle Rail Yards	Lilyfield	L4	59	54	51	42	52
5.2	130	Rozelle Rail Yards	Lilyfield	L4	59	54	51	42	52
5.3	60	Rozelle Rail Yards	Rozelle	L4	59	54	51	42	52
6.1	<10	Victoria Road	Rozelle	L41	73	68	63	48	58
6.2	50	Victoria Road	Rozelle	L41	73	68	63	48	58
6.3	10	Victoria Road	Rozelle	L41	73	68	63	48	58
6.4	10	Victoria Road	Rozelle	L41	73	68	63	48	58
6.5	<10	Victoria Road	Rozelle	L41	73	68	63	48	58
7.1	10	Victoria Road	Rozelle	L8	53	48	46	39	49
7.2	110	Victoria Road	Lilyfield	L8	53	48	46	39	49
8.1	200	Victoria Road	Rozelle	L10	52	47	47	43	53
9.1	20	White Bay	Balmain	L9	59	54	54	51	61
9.2	10	White Bay	Balmain	L9	59	54	54	51	61
10.1	260	White Bay	Pyrmont	L7	58	53	50	49	59
10.2	190	White Bay	Balmain east	L7	58	53	50	49	59
11.1	390	White Bay	Balmain east	L11	50	45	45	42	52
11.2	630	White Bay	Balmain	L11	50	45	45	42	52
11.3	760	White Bay	Birchgrove	L11	50	45	45	42	52

NCA ID	Distance to nearest works area	Nearest works area	Reference suburb (-sub area)	Reference Logger	Noise management level (NML) $L_{Aeq(15min)}$				Screening level
					Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
					Day	Day	Eve	Ngt	Night
11.4	320	Yurulbin Point	Birchgrove	L11	50	45	45	42	52
11.5	390	White Bay	Balmain	L11	50	45	45	42	52
11.5	390	White Bay	Balmain	L11	50	45	45	42	52
12.1	<10	Yurulbin Point	Birchgrove	L12	56	51	50	45	55
12.2	980	Yurulbin Point	Woolwich	L12	56	51	50	45	55
13.1	260	Sydney Harbour south cofferdam	Greenwich	L13	51	46	43	37	47
13.2	370	Sydney Harbour north cofferdam	Wollstonecraft	L13	51	46	43	37	47
14.1	<10	Berrys Bay	Waverton	L14	51	46	42	38	48
15.1	430	Berrys Bay	Waverton	L15	52	47	46	43	53
15.2	290	Berrys Bay	McMahons Point	L15	52	47	46	43	53
15.3	240	Warringah Freeway	North Sydney - south west	L15	52	47	46	43	53
15.4	80	Warringah Freeway	Lavender Bay	L15	52	47	46	43	53
16.1	10	Warringah Freeway	Milsons Point	L16	70	65	65	55	65
16.2	10	Warringah Freeway	North Sydney - south west	L16	70	65	65	55	65
16.3	<10	Warringah Freeway	North Sydney - south west	L16	70	65	65	55	65
17.1	280	Warringah Freeway	Kirribilli	L17	65	60	59	50	60
17.2	<10	Warringah Freeway	Kirribilli	L17	65	60	59	50	60
17.3	10	Warringah Freeway	North Sydney - east	L17	65	60	59	50	60
17.4	40	Warringah Freeway	Neutral Bay	L17	65	60	59	50	60
18.1	200	Warringah Freeway	Kirribilli	L20	64	59	57	48	58
18.2	260	Warringah Freeway	North Sydney - east	L20	64	59	57	48	58
18.3	80	Warringah Freeway	Neutral Bay	L20	64	59	57	48	58
19.1	20	Warringah Freeway	North Sydney - north west	L19	62	57	57	50	60
20.1	<10	Warringah Freeway	North Sydney - north west	L19	62	57	57	50	60
21.1	340	Cammeray Golf Course	North Sydney	L22	63	58	54	46	56
21.2	100	Warringah Freeway	North Sydney	L22	63	58	54	46	56
22.1	290	Warringah Freeway	North Sydney	L21	62	57	52	41	51
22.2	540	Warringah Freeway	Wollstonecraft	L21	62	57	52	41	51
22.3	230	Warringah Freeway	Crows Nest	L21	62	57	52	41	51
23.1	<10	Warringah Freeway	Neutral Bay	L23	71	66	59	49	59
23.2	10	Warringah Freeway	North Sydney	L23	71	66	59	49	59
24.1	10	Warringah Freeway	Crows Nest	L26	66	61	57	42	52

NCA ID	Distance to nearest works area	Nearest works area	Reference suburb (-sub area)	Reference Logger	Noise management level (NML) $L_{Aeq(15min)}$				Screening level
					Standard Hours (RBL + 10 dB)	Outside standard hours: Out of Hours Work (OOHW) (RBL + 5 dB)			L_{Amax} (RBL + 15 dB)
					Day	Day	Eve	Ngt	Night
25.1	<10	Warringah Freeway	Cammeray	L27	68	63	60	48	58
26.1	10	Cammeray Golf Course	Cremorne	L25	68	63	59	46	56
26.2	<10	Cammeray Golf Course	Cammeray	L25	68	63	59	46	56
27.1	210	Cammeray Golf Course	Cremorne	L30	59	54	53	44	54
28.1	20	Cammeray Golf Course	Cammeray	L29	57	52	50	42	52
29.1	<10	Cammeray Golf Course	Cammeray	L28	74	69	68	52	62
30.1	390	Warringah Freeway	Crows Nest	L31	68	63	61	43	53
30.2	770	Warringah Freeway	Naremburn	L31	68	63	61	43	53
30.3	190	Warringah Freeway	Cammeray	L31	68	63	61	43	53
30.4	760	Warringah Freeway	Wollstonecraft	L31	68	63	61	43	53
31.1	640	Warringah Freeway	Naremburn	L32	66	61	54	42	52
31.2	380	Cammeray Golf Course	Cammeray	L32	66	61	54	42	52
31.3	610	Warringah Freeway	Naremburn	L32	66	61	54	42	52
32.1	1320	Warringah Freeway	Naremburn	L35	69	64	60	45	55
33.1	70	Warringah Freeway	Artarmon	L34	65	60	58	45	55
33.2	1450	Warringah Freeway	Artarmon	L34	65	60	58	45	55
33.4	1200	Warringah Freeway	Lane Cove north	L34	65	60	58	45	55
34.1	240	Warringah Freeway	Artarmon	L36	54	49	49	42	52
35.1	1100	Warringah Freeway	Lane Cove north	L33	77	72	68	51	61
36.1	1240	Warringah Freeway	Willoughby	L37	60	55	53	43	53
37.1	1040	Warringah Freeway	Naremburn	L38	55	50	49	39	49
38.1	920	Warringah Freeway	Northbridge	L39	62	57	53	42	52
38.2	1000	Warringah Freeway	Northbridge	L39	62	57	53	42	52
38.3	900	Warringah Freeway	Northbridge	L39	62	57	53	42	52

Notes: 1. As per section 2.3 of the NPfI, as the community generally expects greater control of noise during the more sensitive evening and night time periods than during the less sensitive daytime period, the project noise management levels for evening are set at no greater than daytime level, and the night time is set to be no greater than the day or evening levels.

APPENDIX C Environmental noise monitoring results

Acoustics
Vibration
Structural Dynamics

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Monitoring ID: Location L1
Address: 22 The Crescent, Annandale
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment is dominated by traffic on The Crescent.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	51	45	33	66	65	60

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	68	63	

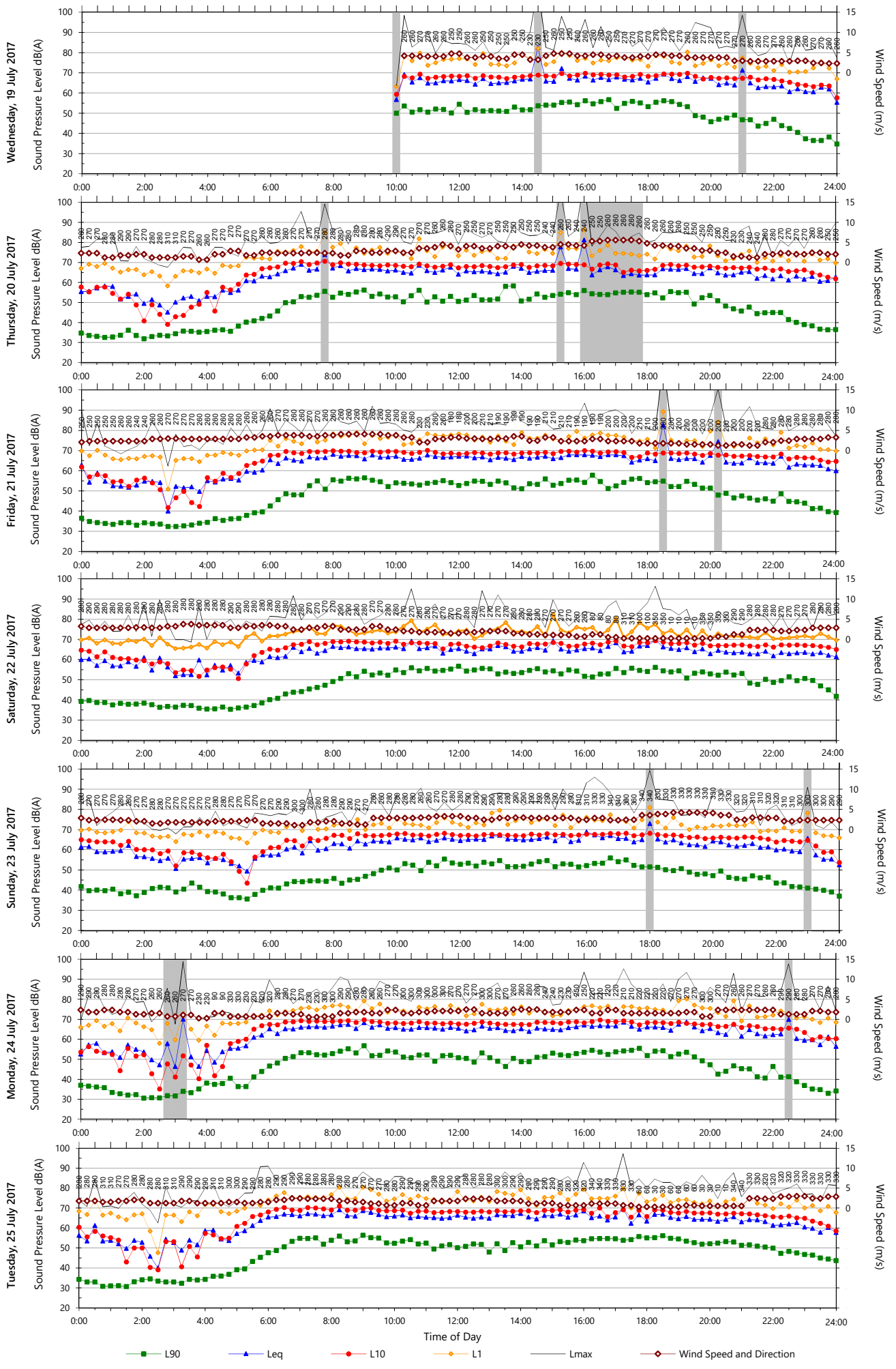
Notes:

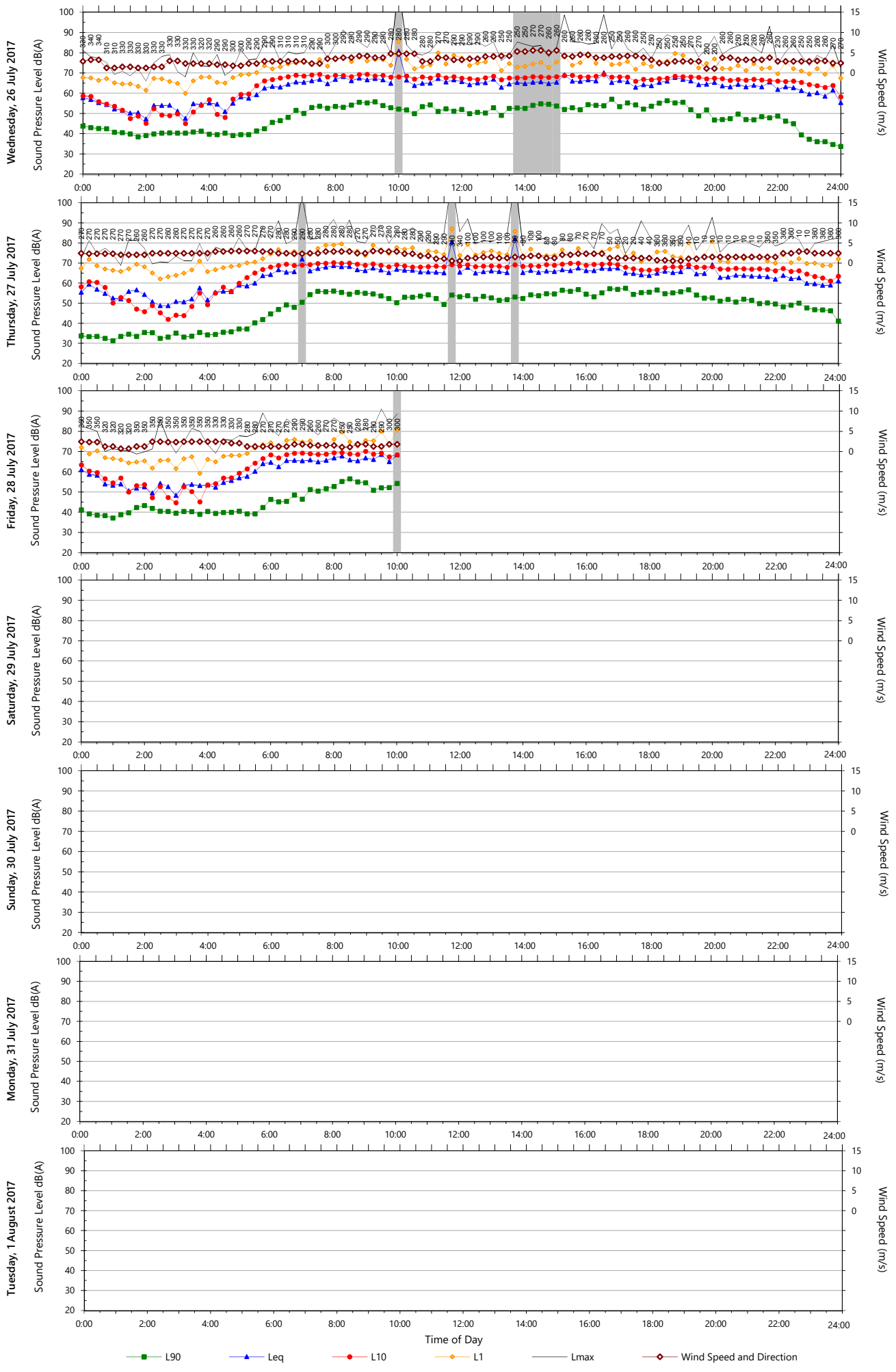
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 26 July 2017
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Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L2
Address: 2/277 Johnston Street, Annandale
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Johnston Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	50	47	36	65	64	59

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	67	62	

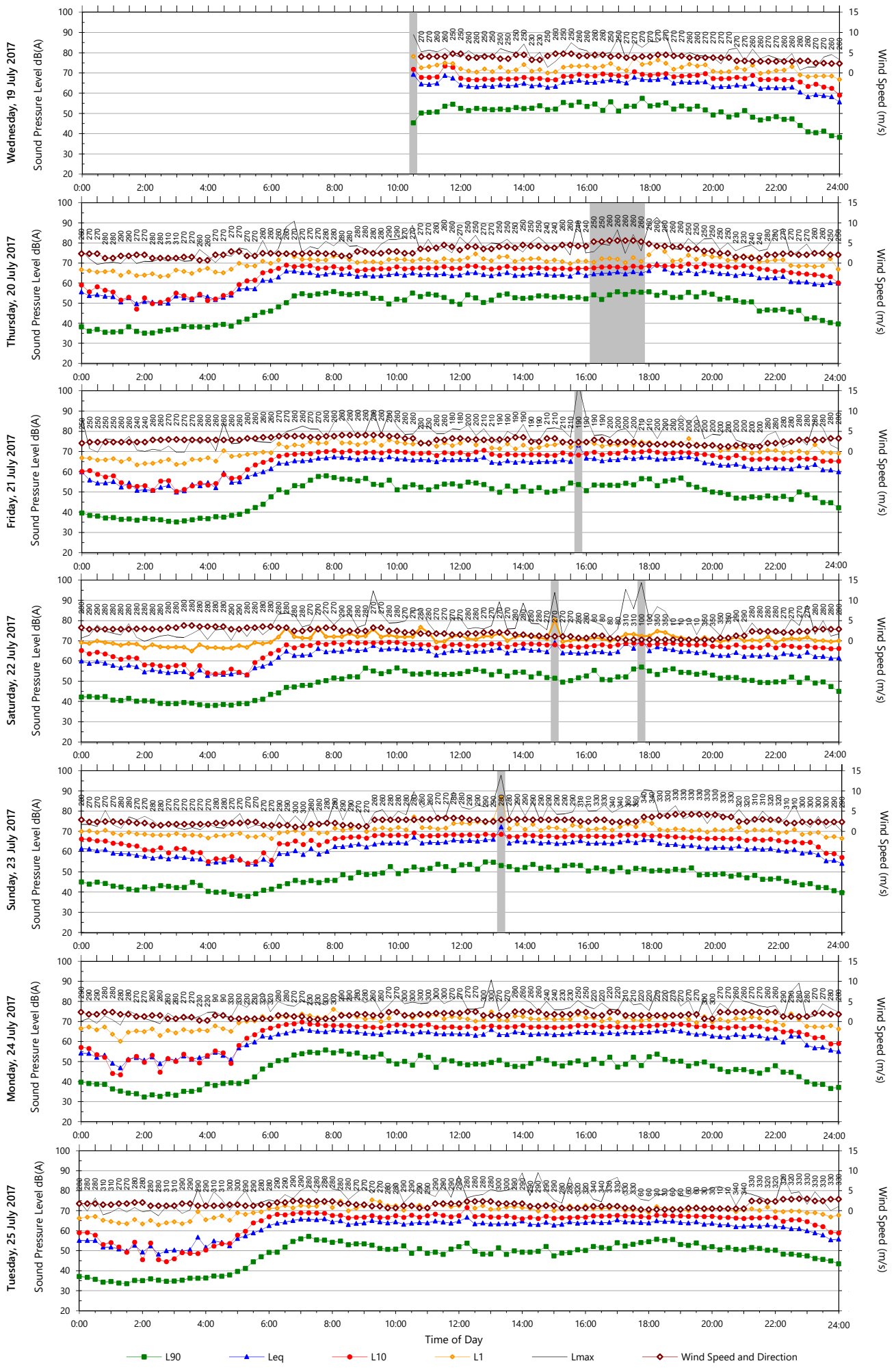
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

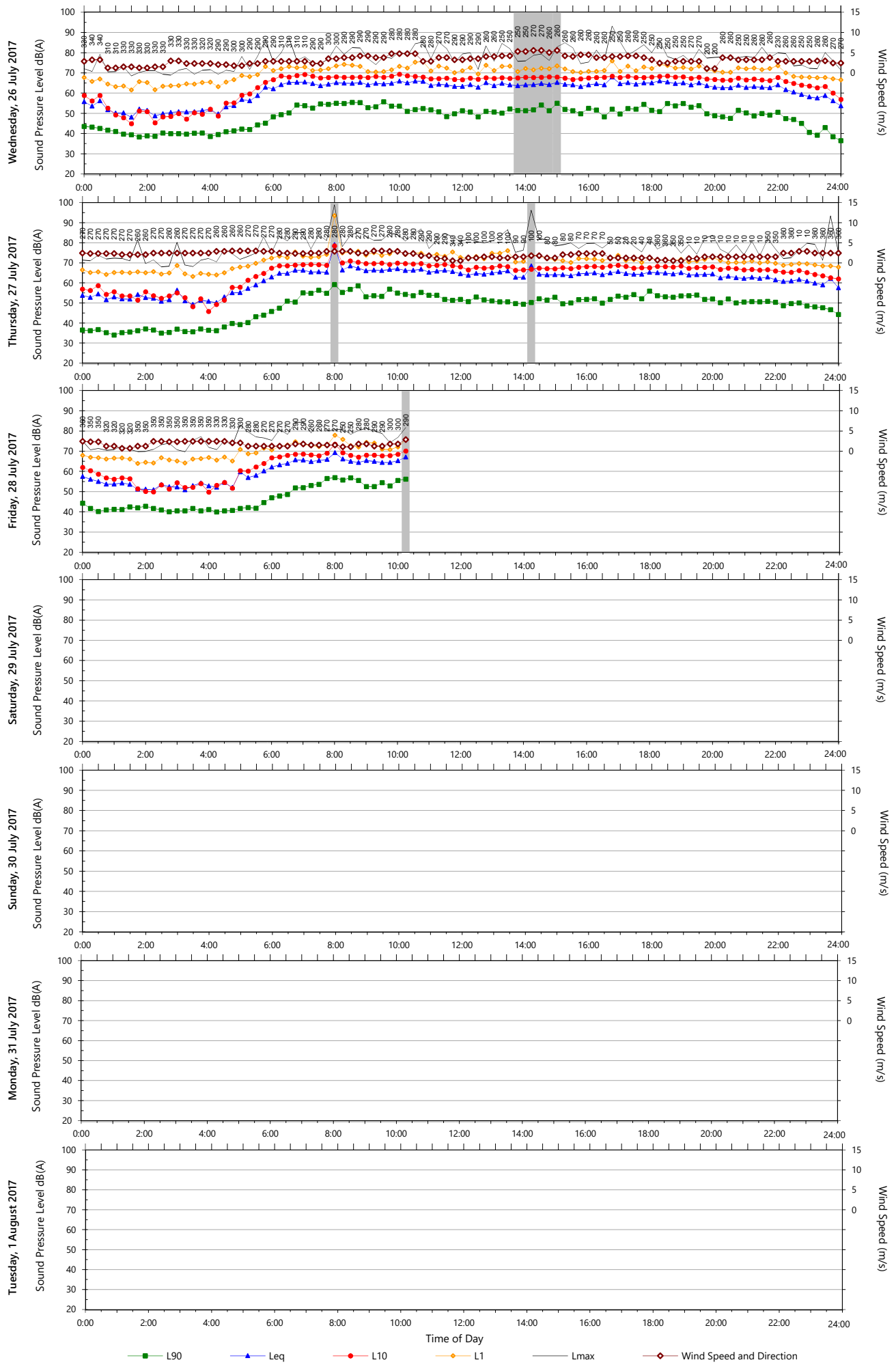
Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results **Location: 2/277 Johnston Street, Annandale**



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Monitoring ID: Location L3
Address: 16 Railway Parade, Annandale
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the City-West Link and rail noise from light rail pass-bys.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	50	51	44	58	58	53

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

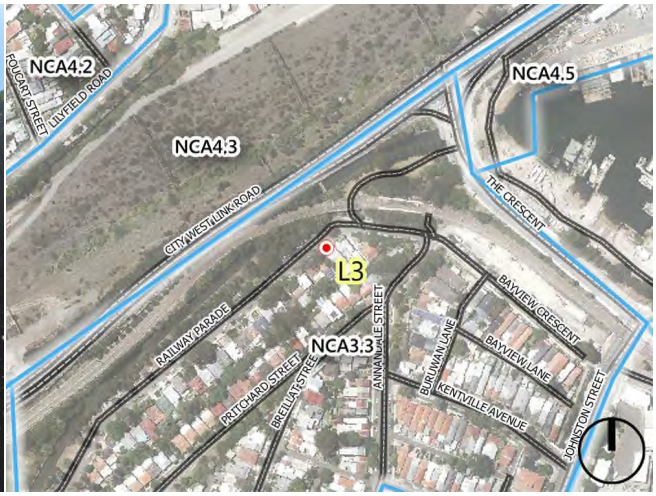
Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	61	56	

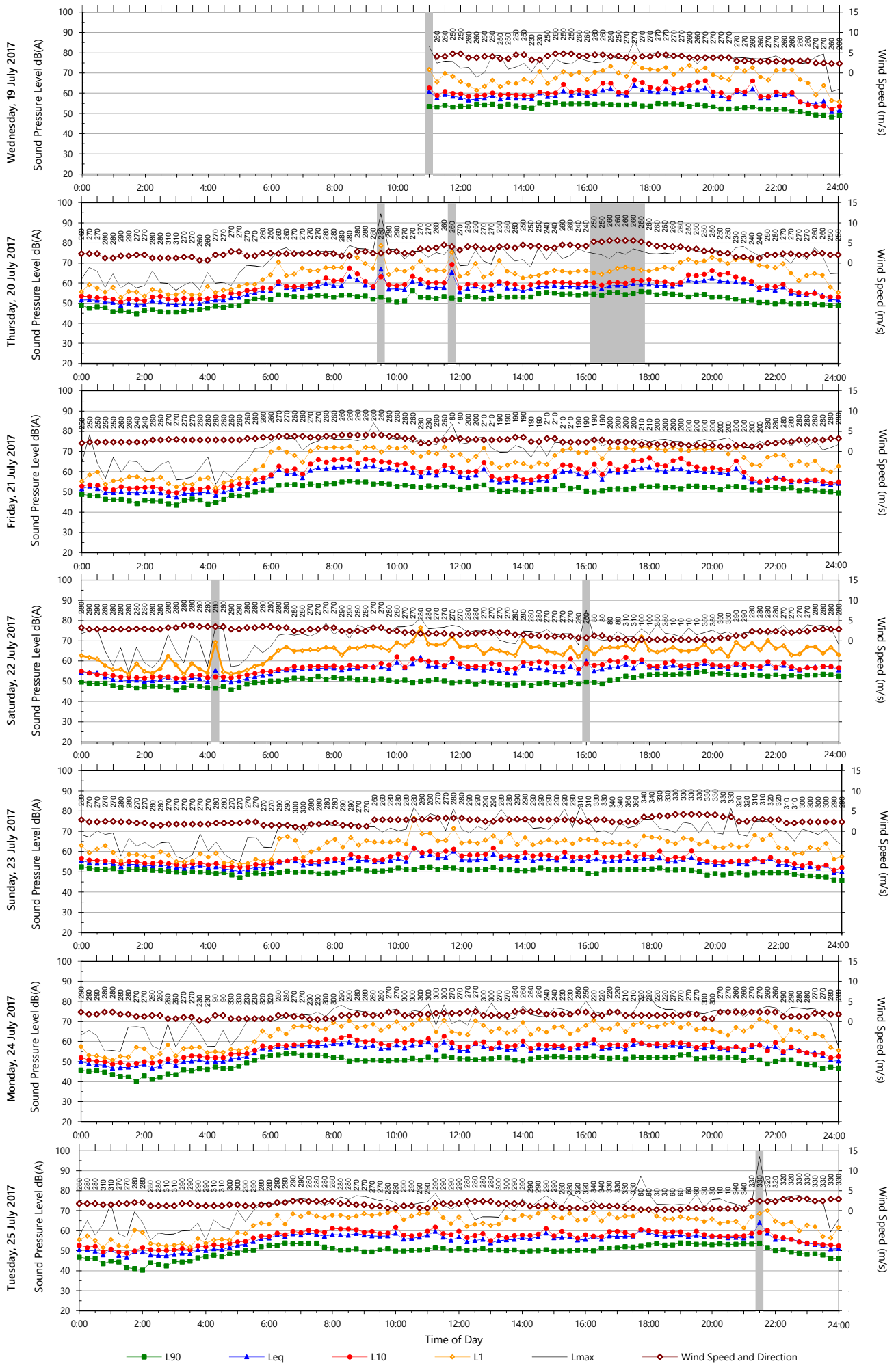
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph



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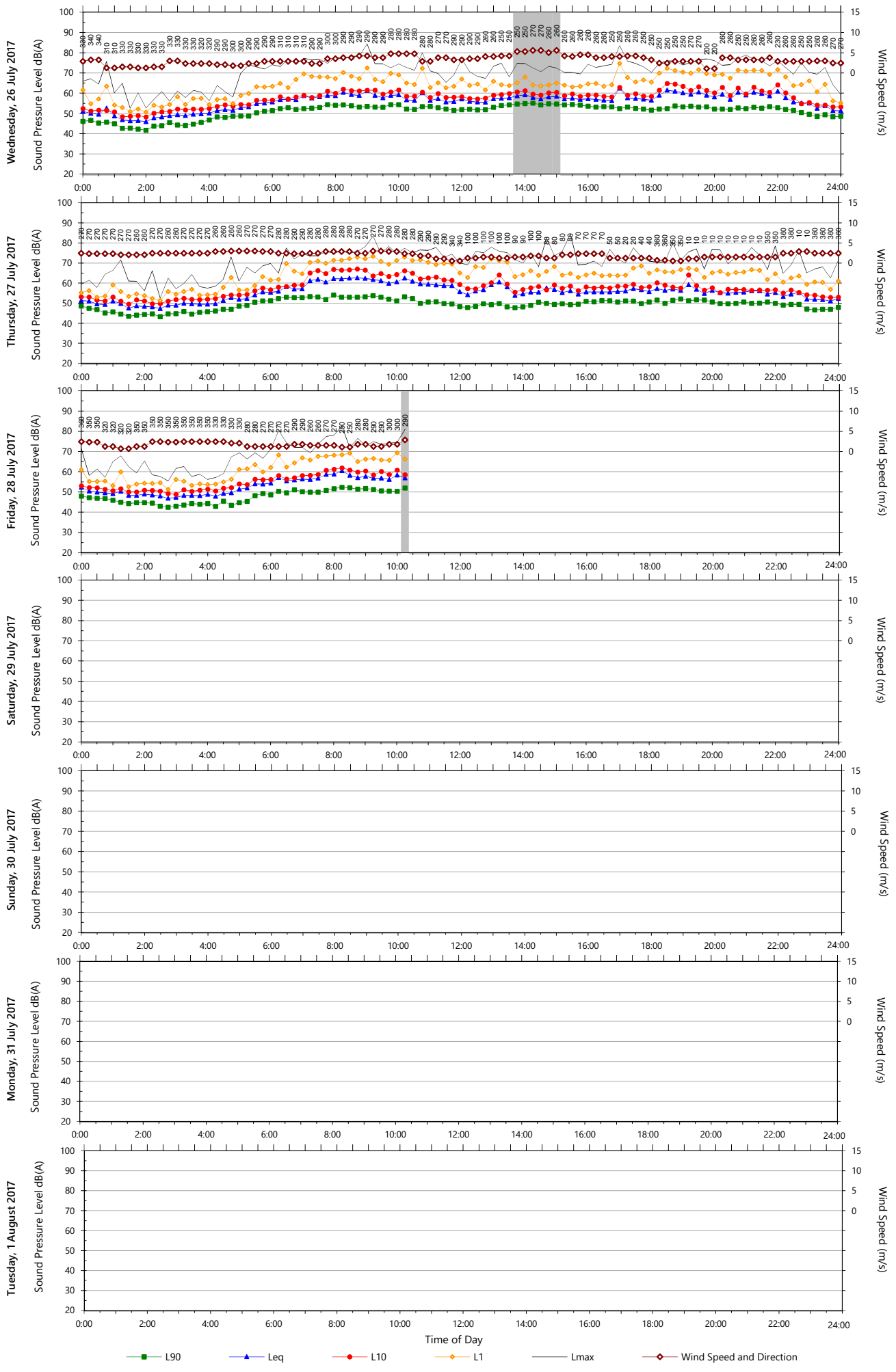
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction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Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Acoustics
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Monitoring ID: Location L4
Address: 109 Denison Street, Rozelle
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds and traffic on Lilyfield Road.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	49	46	37	61	60	53

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

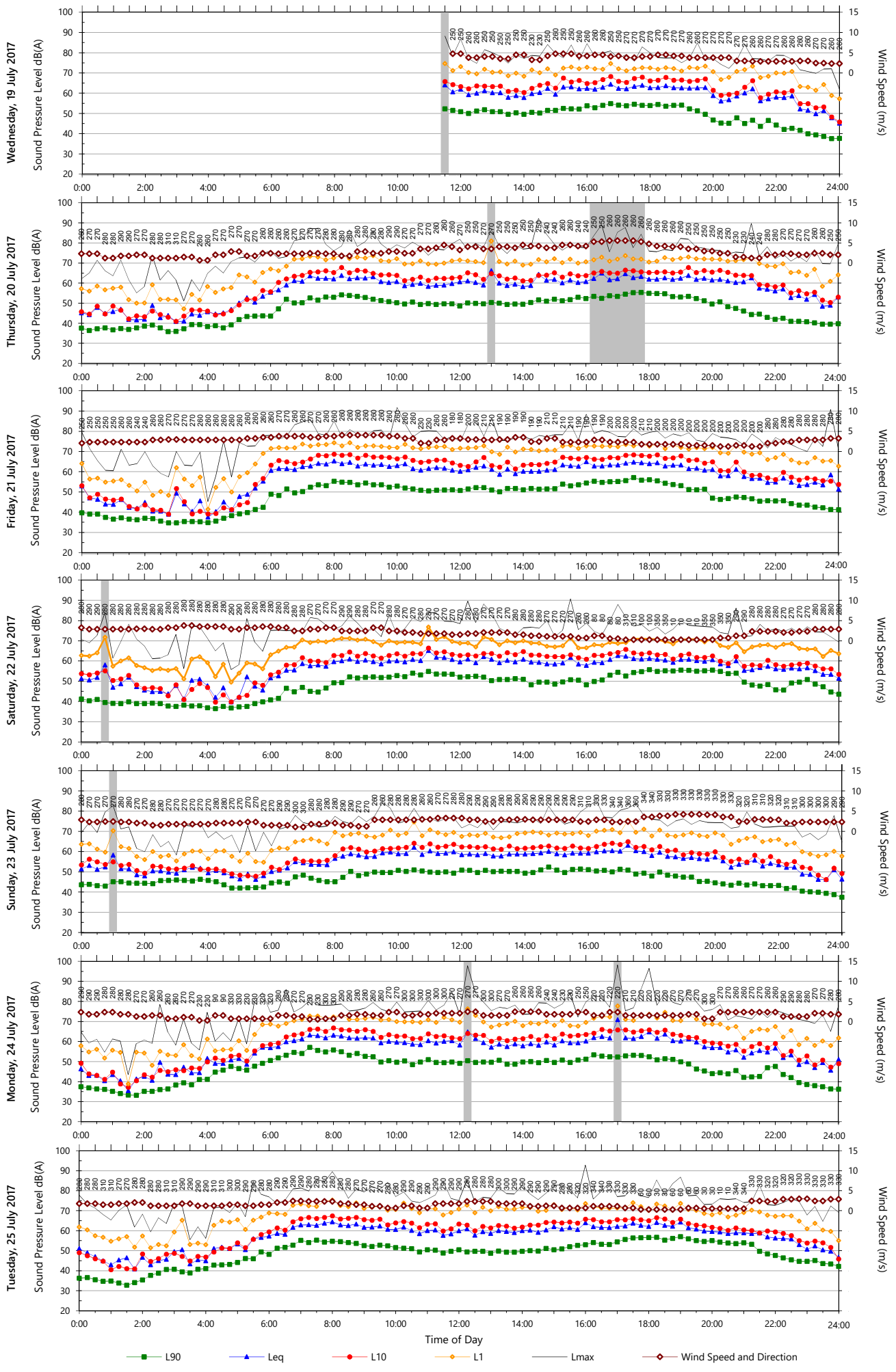
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph



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Monday, 24 July 2017
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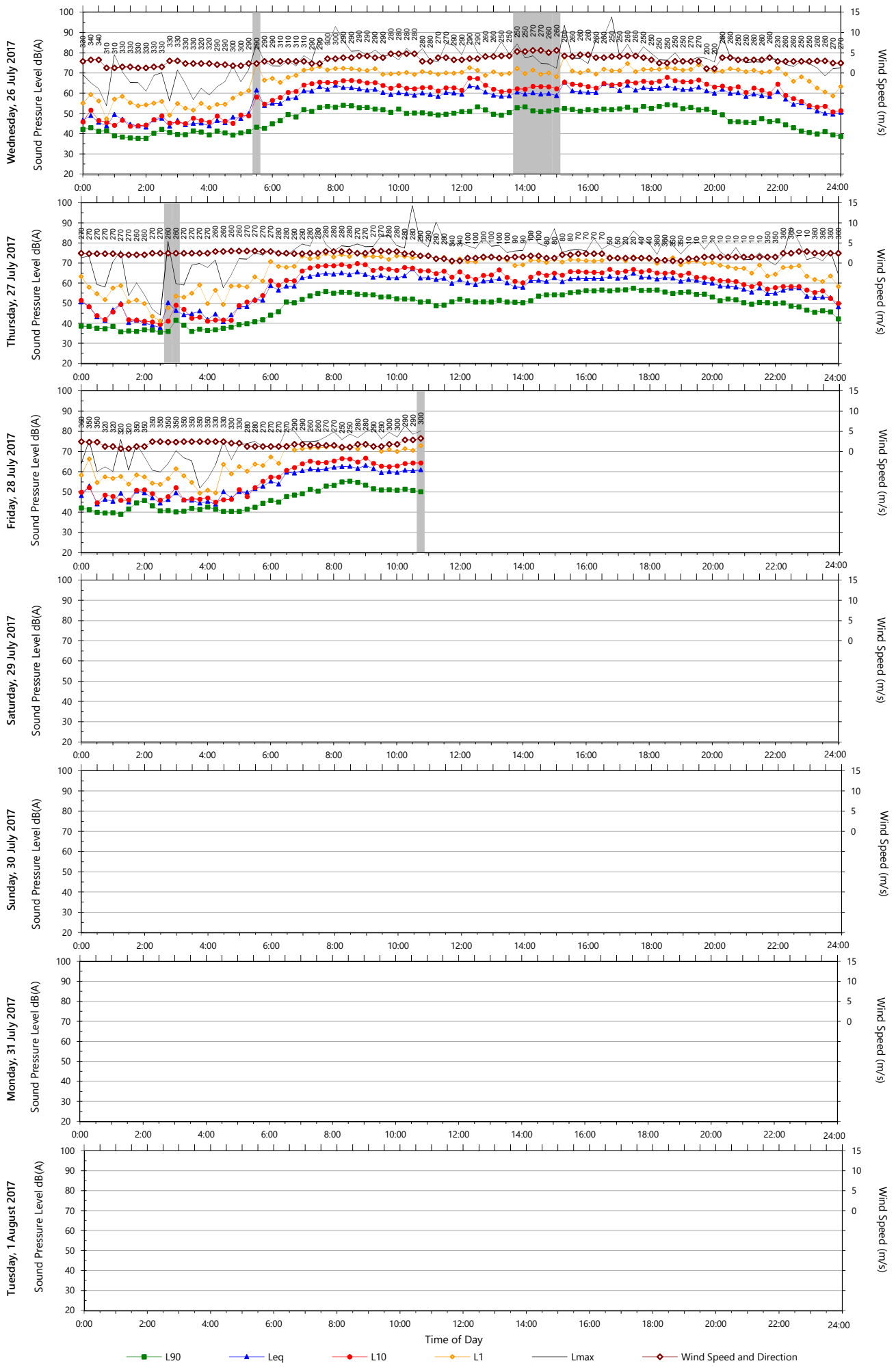
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction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Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L5
Address: 14 Oxley Street, Glebe
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	51	52	45	57	55	52

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

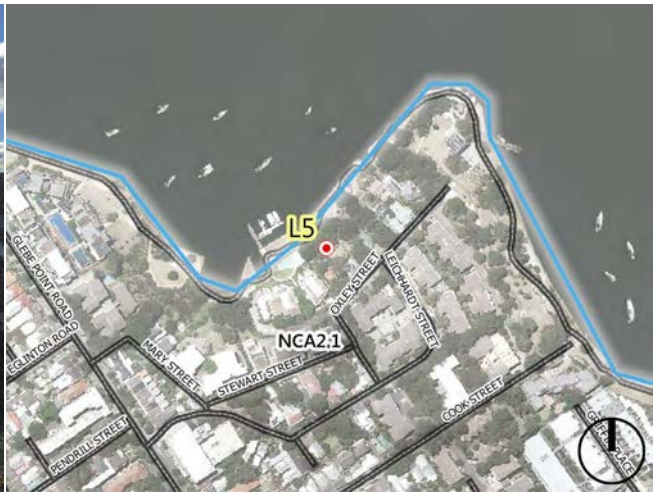
Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

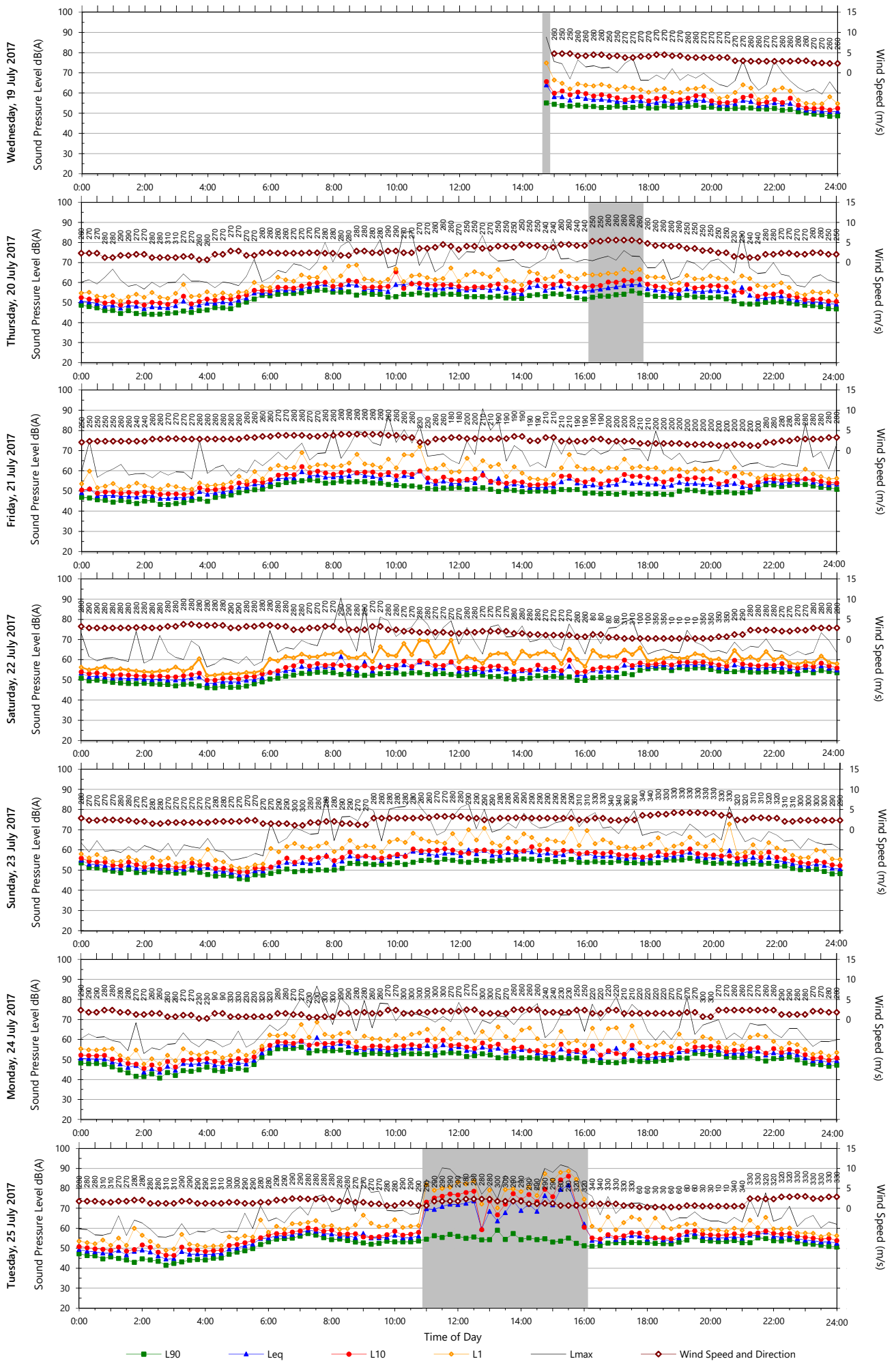
Logger Location	Aerial Photograph



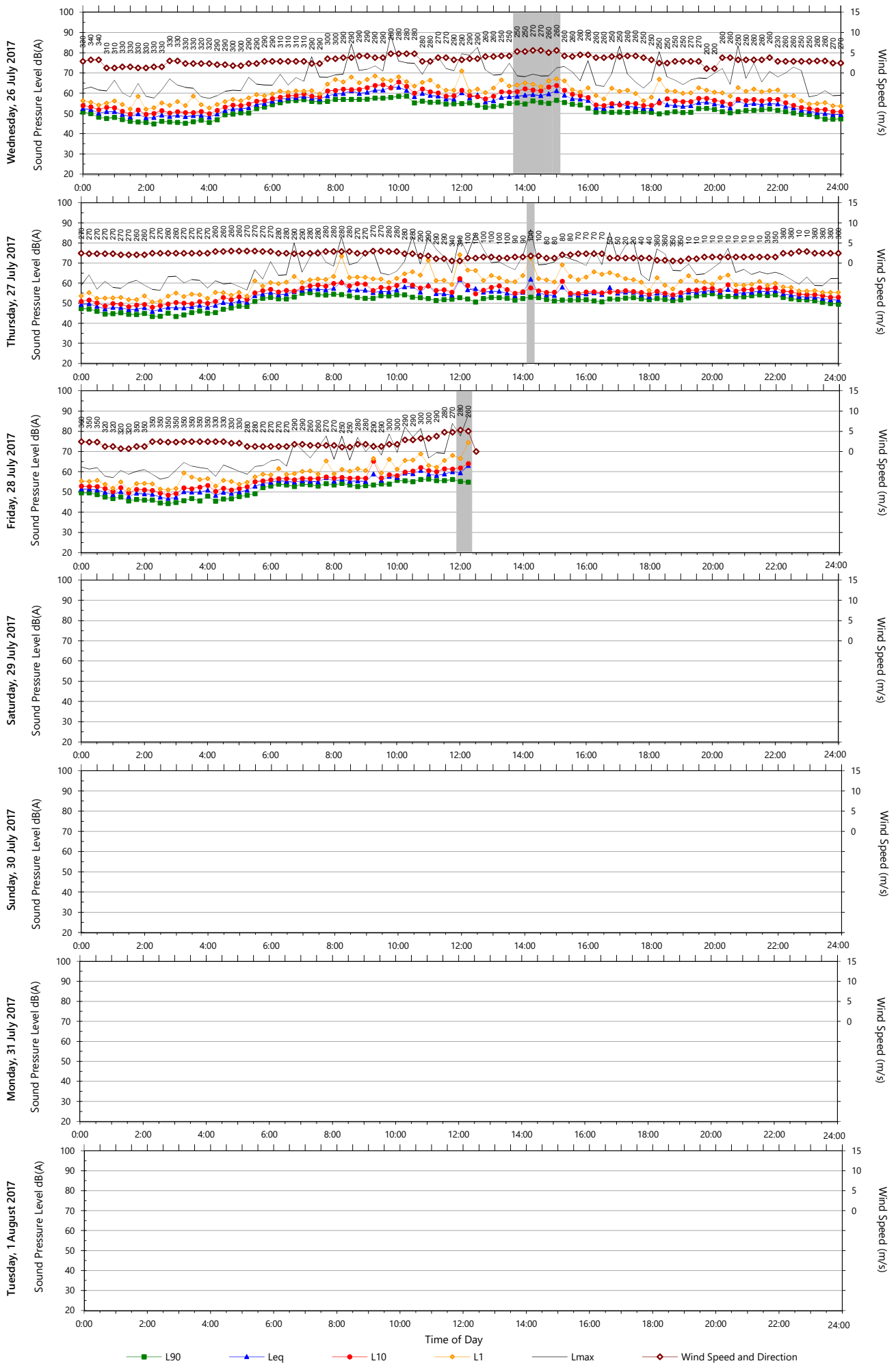


Unattended Monitoring Results

Location: 14 Oxley Street, Glebe



Unattended Monitoring Results **Location: 14 Oxley Street, Glebe**



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Monitoring ID: Location L6
Address: 28 Lilyfield Road, Rozelle
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by traffic on The Crescent.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	52	52	45	58	58	55

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

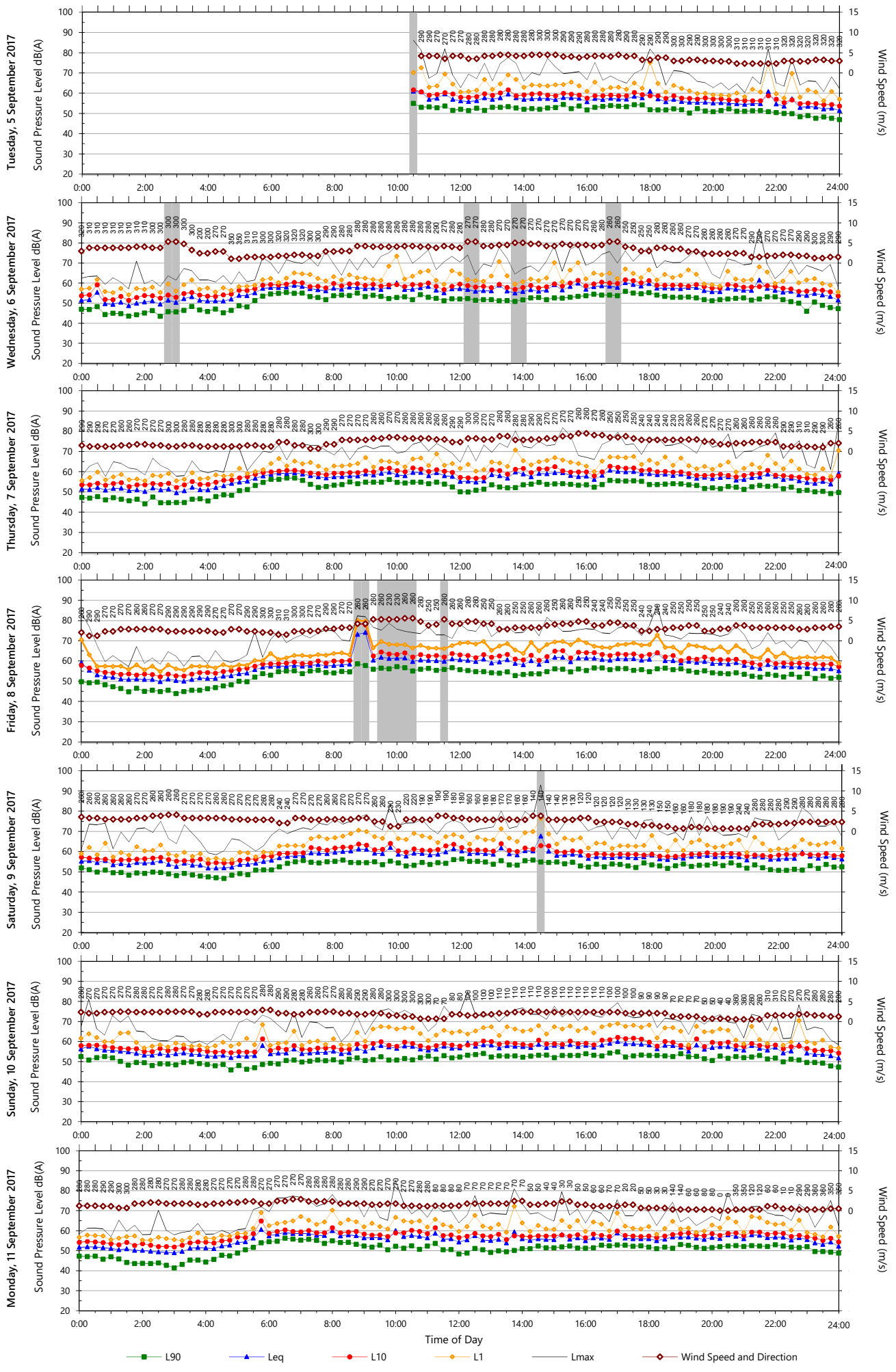
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

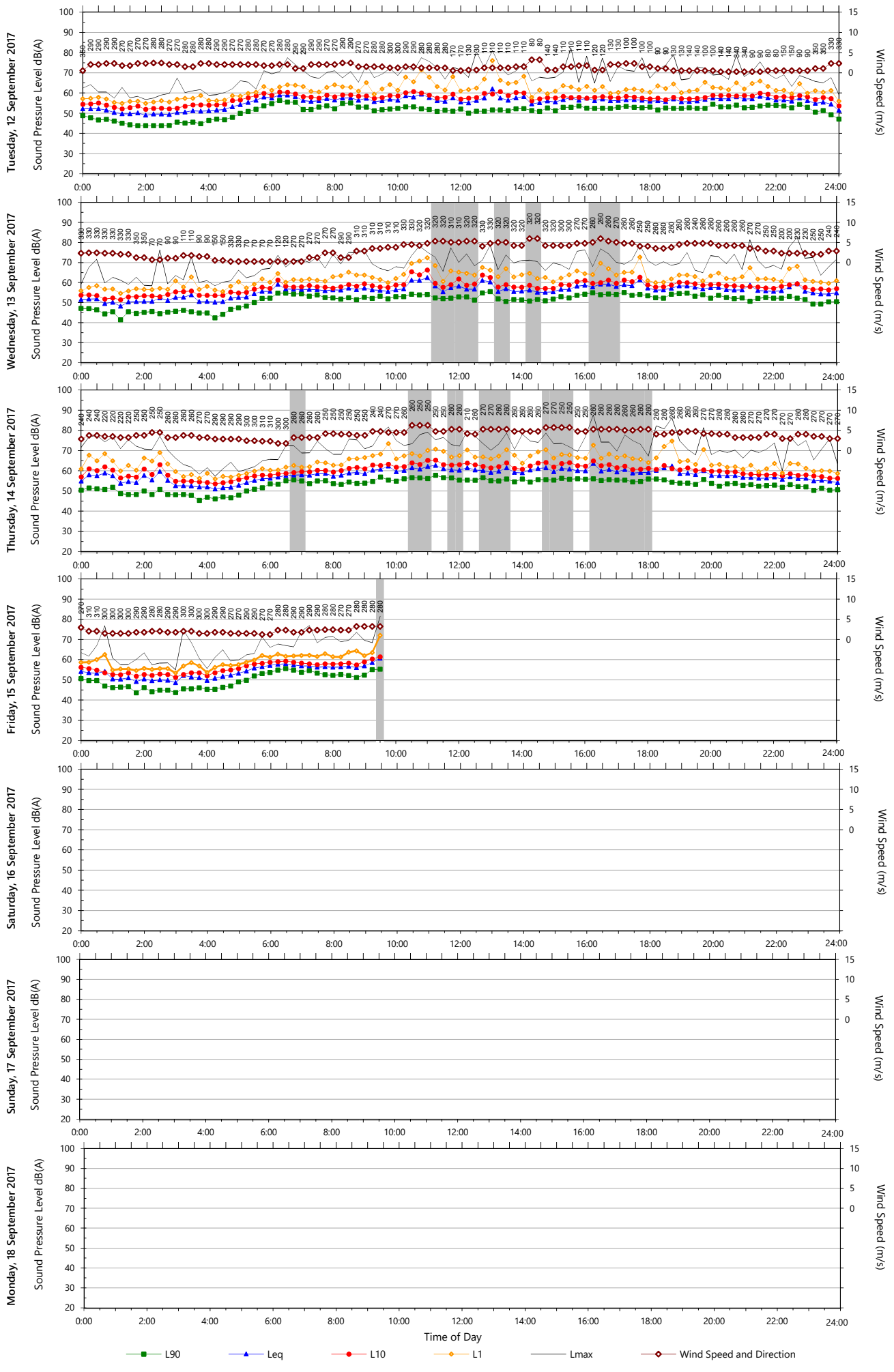
Logger Location	Aerial Photograph






Tuesday, 5 September 2017
Wednesday, 6 September 2017
Thursday, 7 September 2017
Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results **Location: 28 Lilyfield Road, Rozelle**



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Monitoring ID: Location L7
Address: 203/38 Refinery Drive, Pyrmont
Description: Noise monitor located on the northern facade of the second-floor balcony overlooking Jones Bay. Noise environment consists of natural sounds and motor boats from the bay.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	48	45	44	52	49	48

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

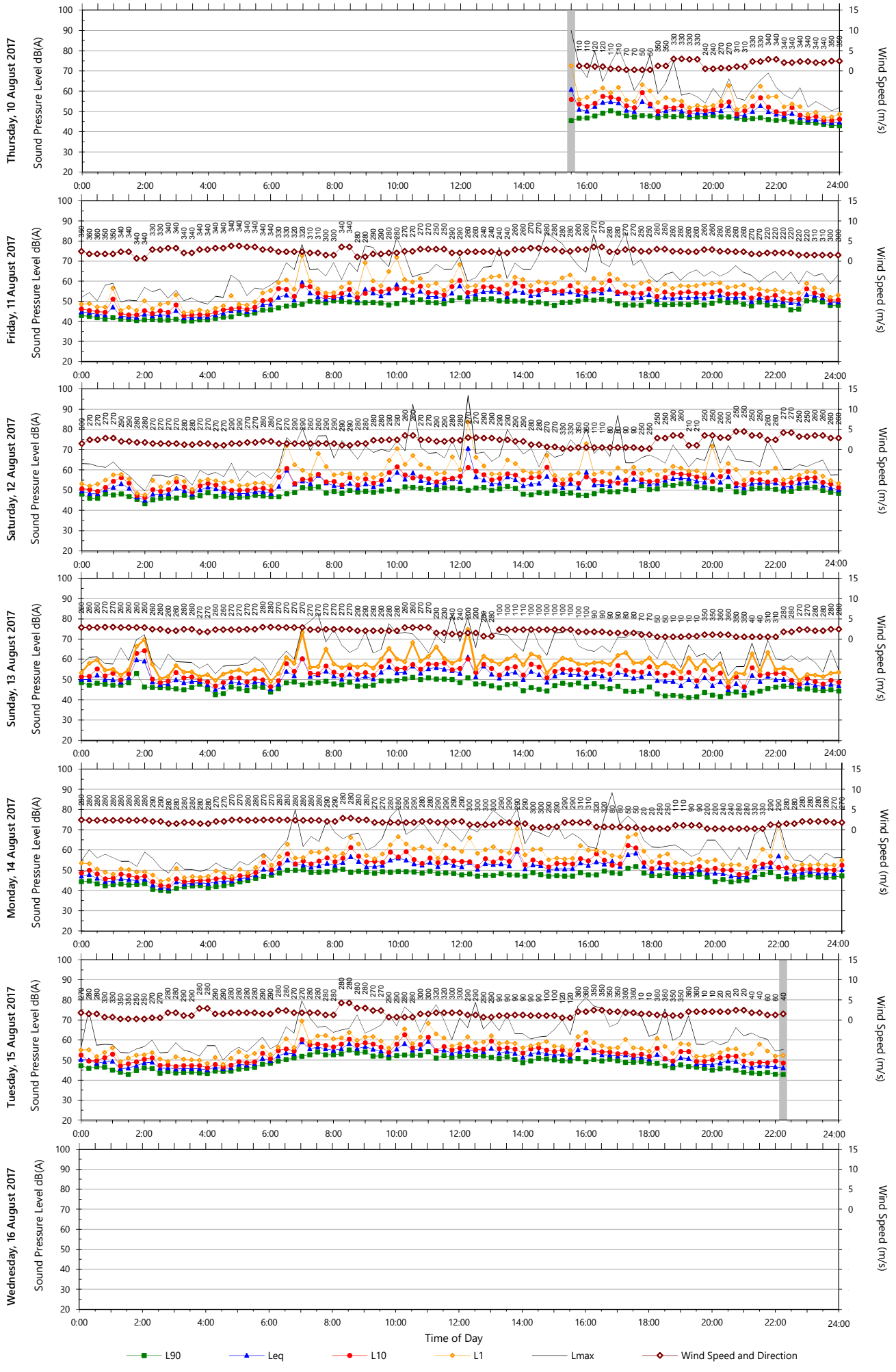
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Thursday, 10 August 2017
Friday, 11 August 2017
Saturday, 12 August 2017
Sunday, 13 August 2017
Monday, 14 August 2017
Tuesday, 15 August 2017
Wednesday, 16 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L8
Address: 31 Cambridge Street, Rozelle
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment consists of natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	43	41	34	57	57	48

Notes:

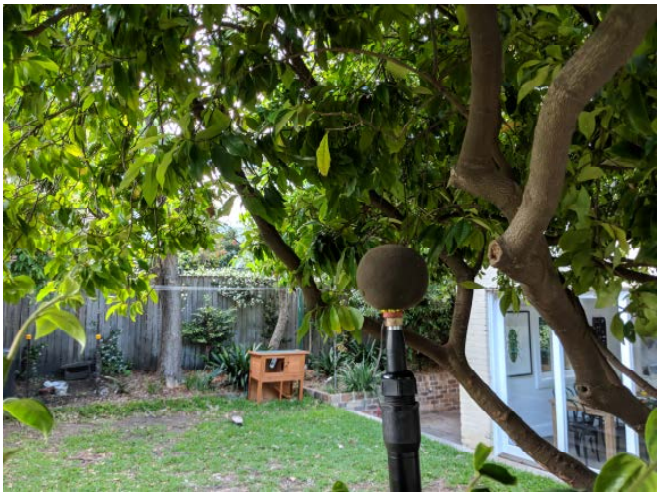
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

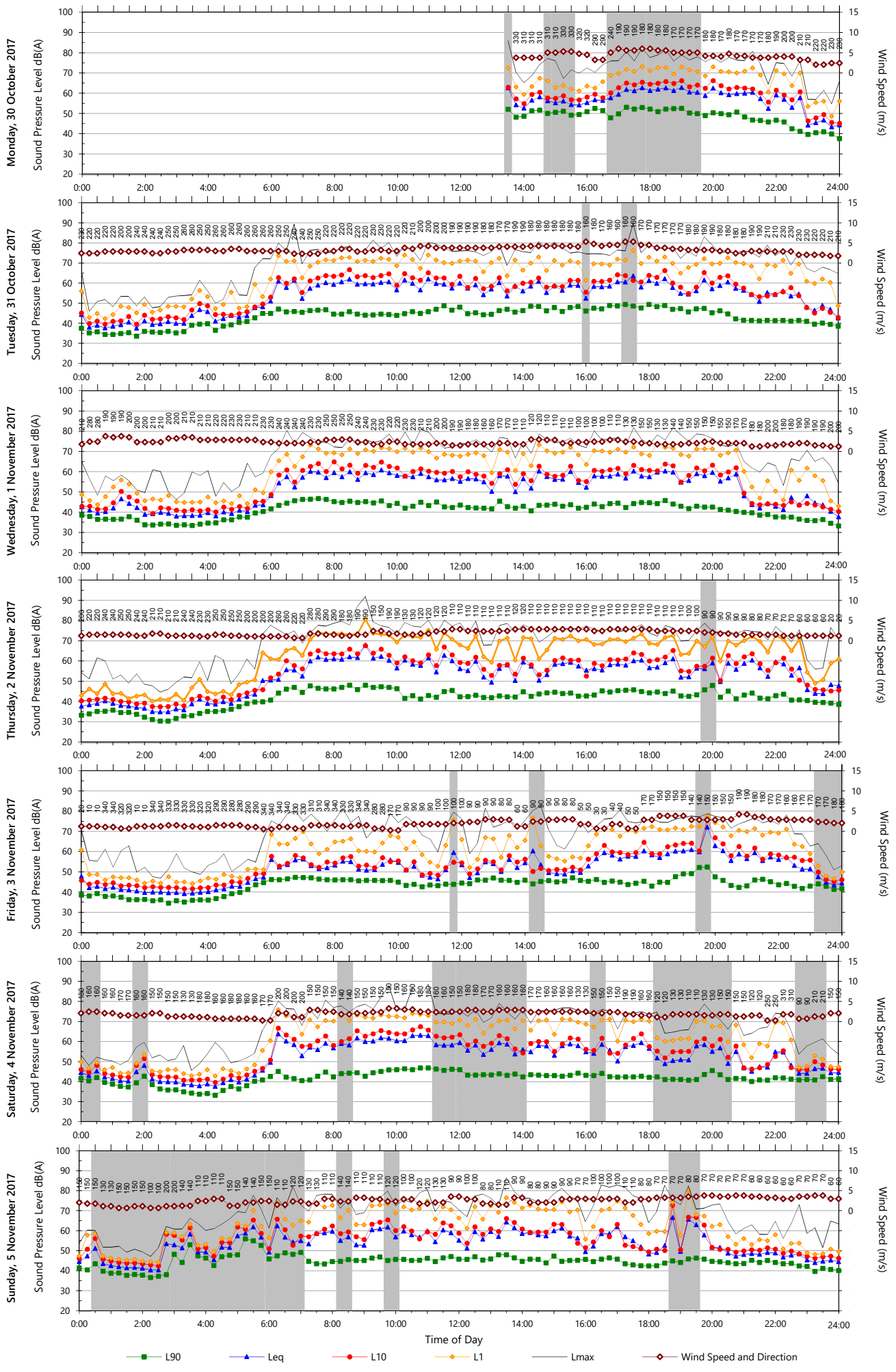
Notes:

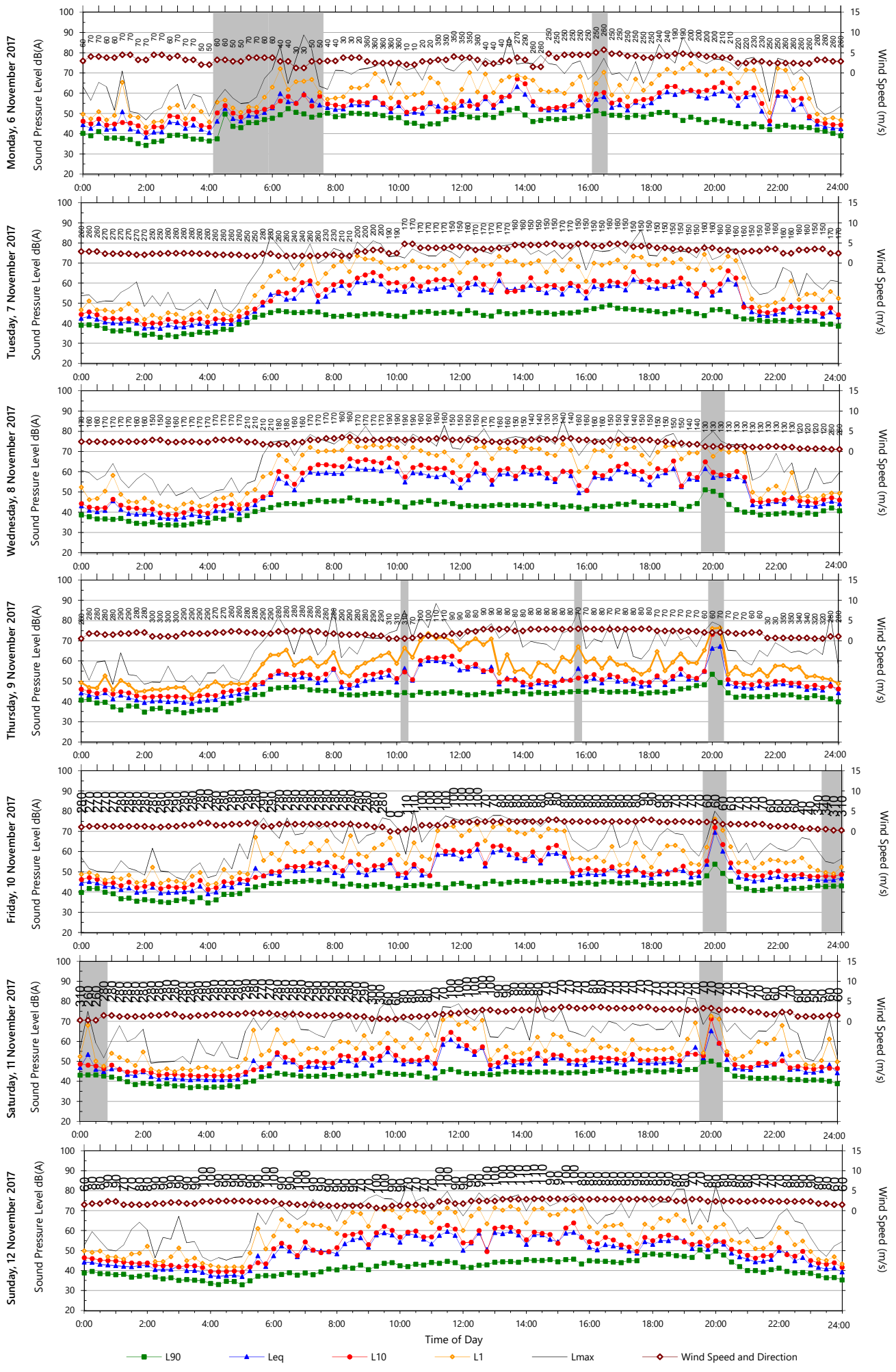
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

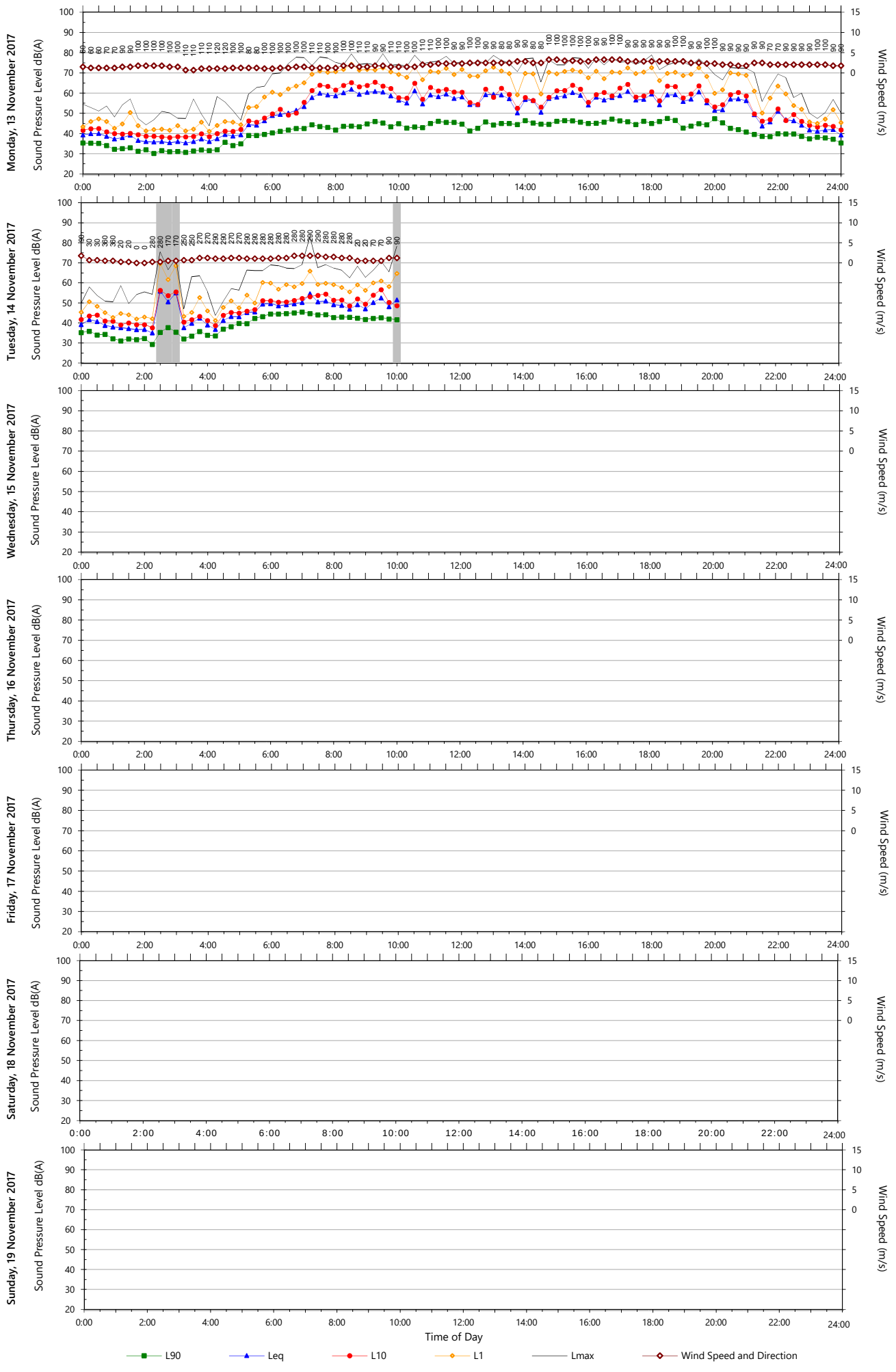
Logger Location	Aerial Photograph






Monday, 30 October 2017
Tuesday, 31 October 2017
Wednesday, 1 November 2017
Thursday, 2 November 2017
Friday, 3 November 2017
Saturday, 4 November 2017
Sunday, 5 November 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Monday, 6 November 2017
Tuesday, 7 November 2017
Wednesday, 8 November 2017
Thursday, 9 November 2017
Friday, 10 November 2017
Saturday, 11 November 2017
Sunday, 12 November 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Monday, 13 November 2017
Tuesday, 14 November 2017
Wednesday, 15 November 2017
Thursday, 16 November 2017
Friday, 17 November 2017
Saturday, 18 November 2017
Sunday, 19 November 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L9
Address: C13/1 Buchanon Street, Balmain
Description: Noise monitor located on the south-eastern facade of the first floor balcony overlooking White Bay. Noise environment consists of natural sounds and some industrial noise from across the bay.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	49	49	46	54	51	49

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

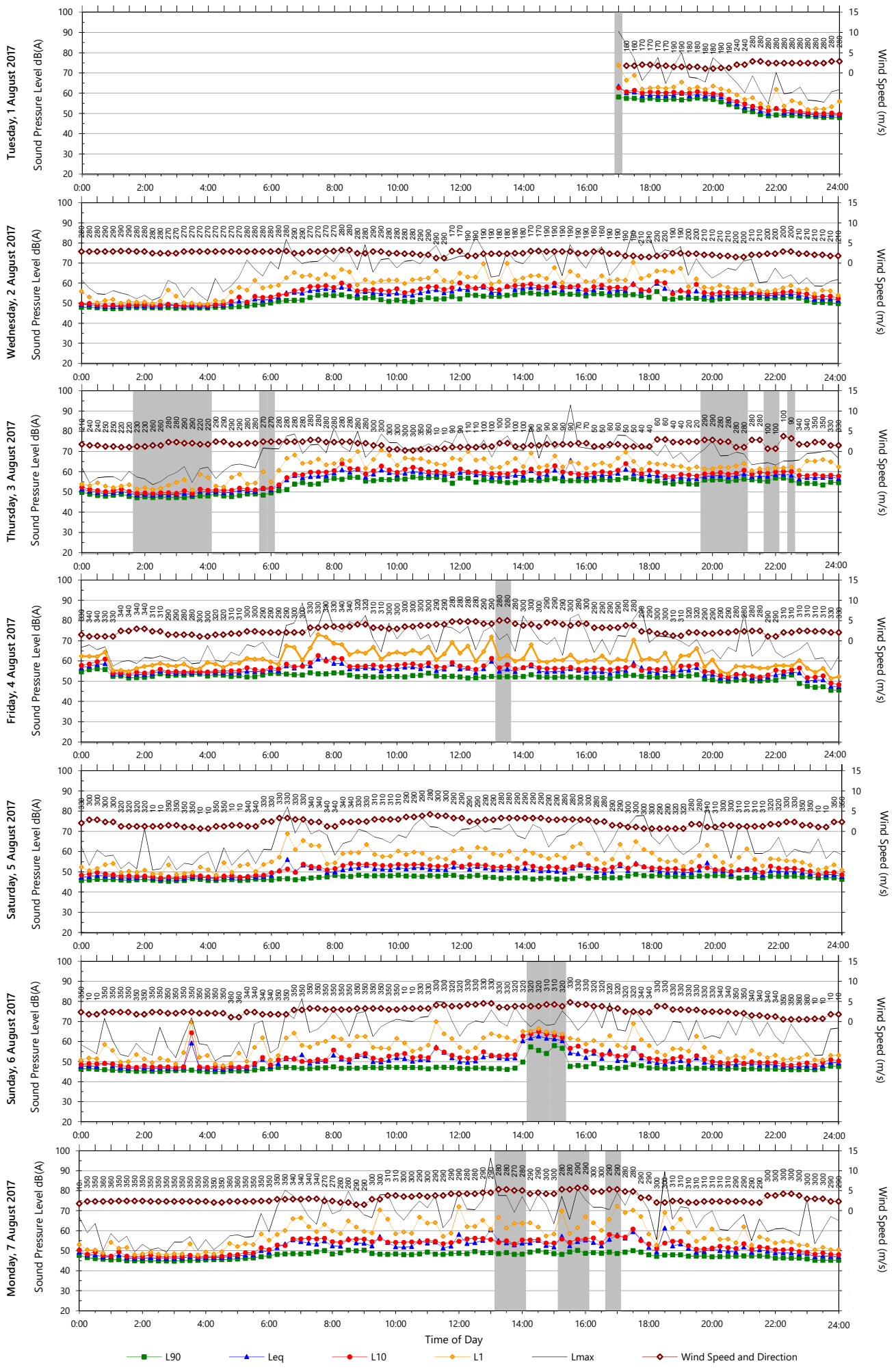
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph

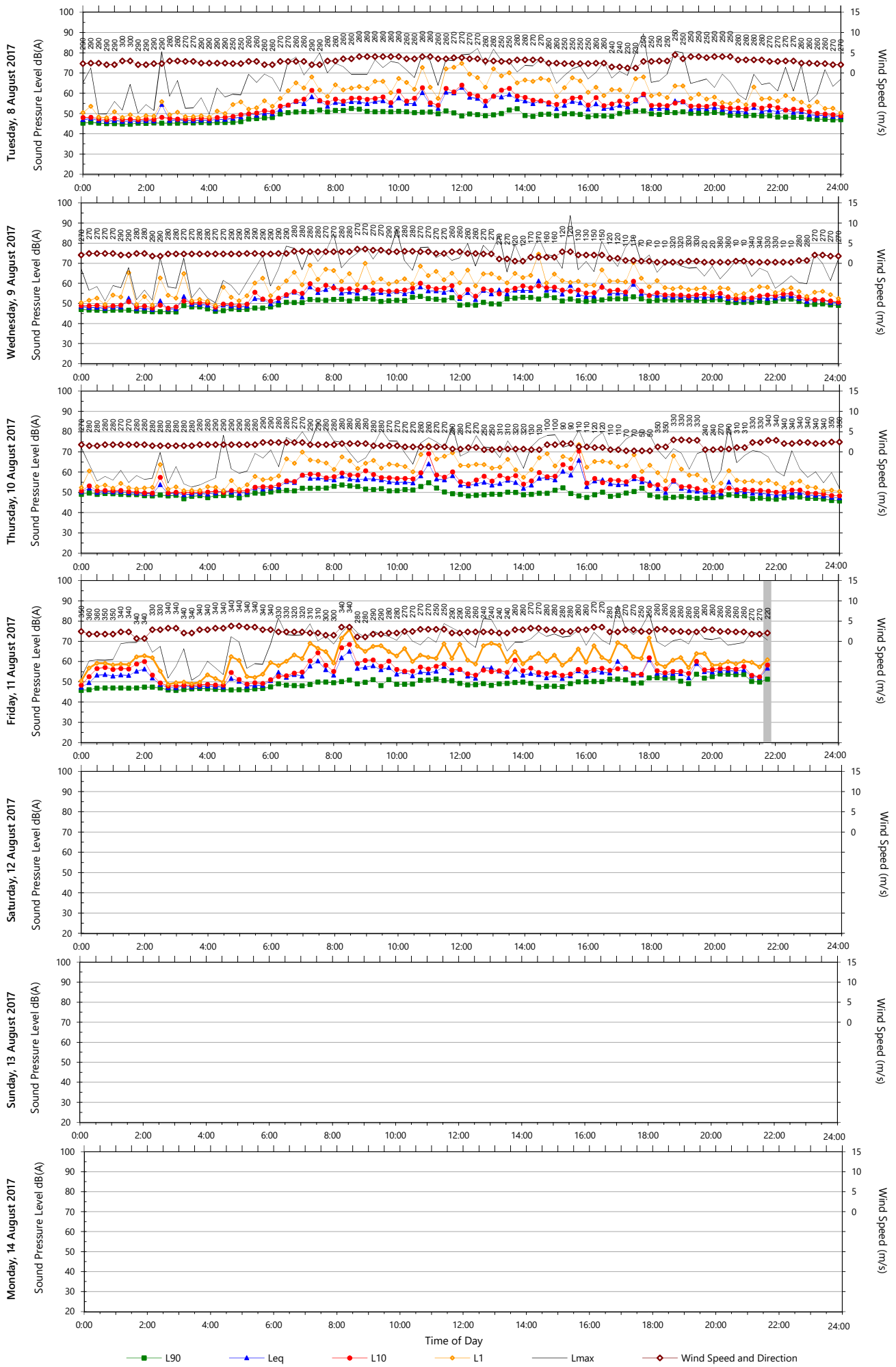




Unattended Monitoring Results **Location: Unit C13, 1 Buchanon Street, Balmain (1F Balcony)**



Unattended Monitoring Results **Location: Unit C13, 1 Buchanon Street, Balmain (1F Balcony)**



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Monitoring ID: Location L10
Address: 23 Smith Street, Rozelle
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds. Traffic noise audible in the distance.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	42	44	38	54	53	48

Notes:

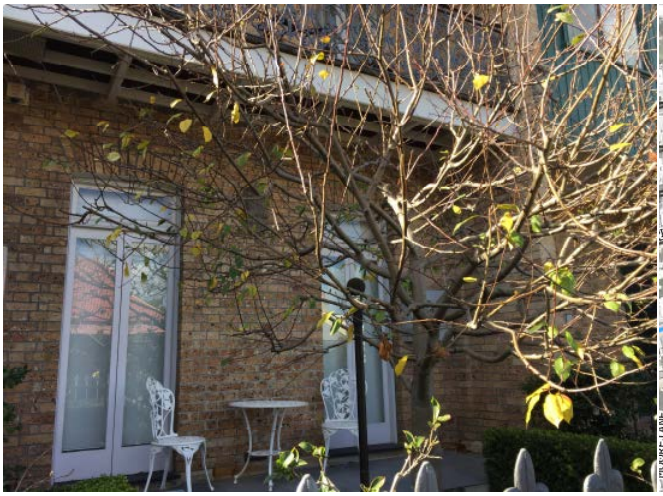
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

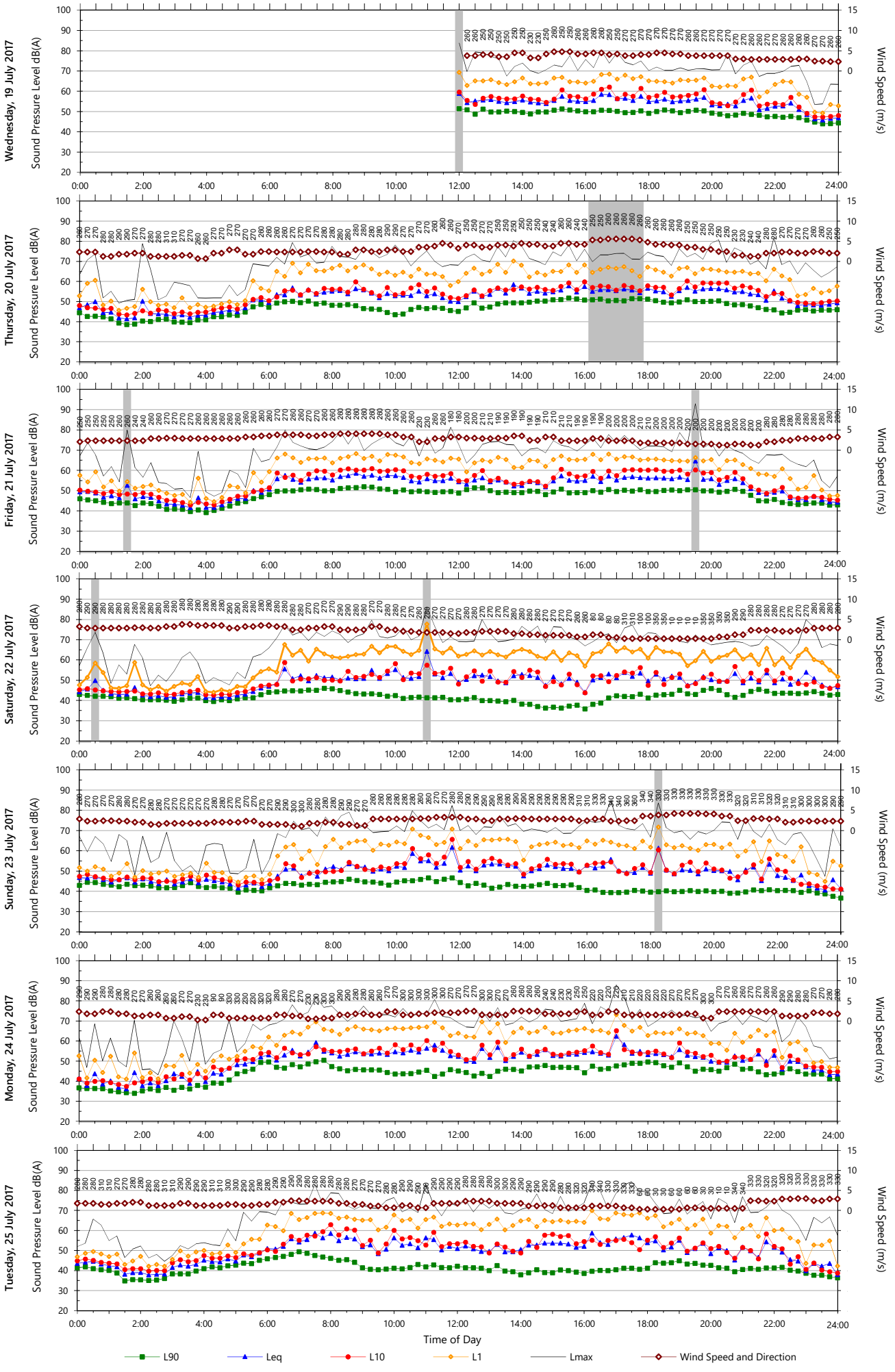
Logger Location	Aerial Photograph



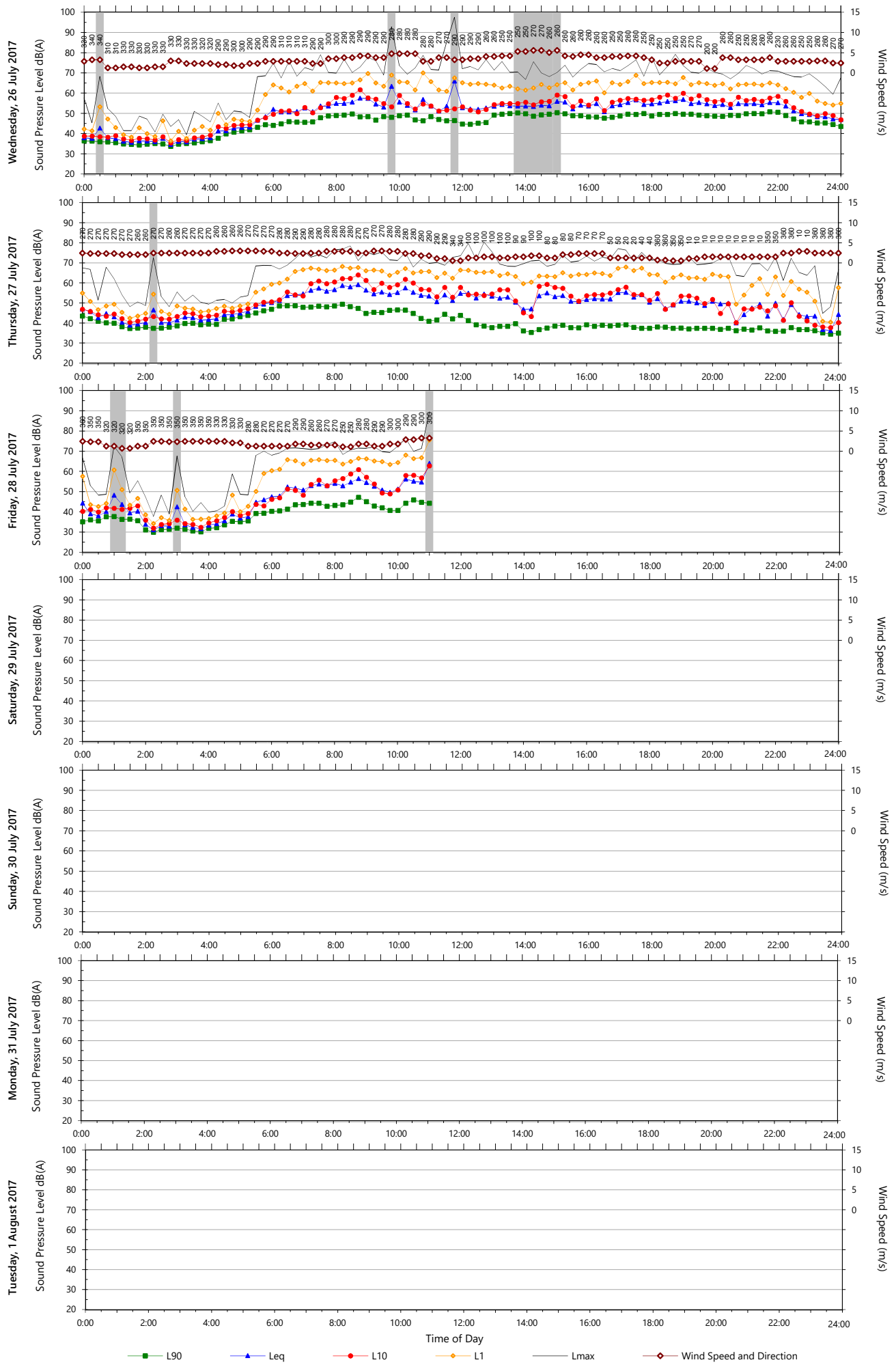


Unattended Monitoring Results

Location: 23 Smith Street, Rozelle



Unattended Monitoring Results **Location: 23 Smith Street, Rozelle**



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Monitoring ID: Location L11
Address: 31 Wharf Road, Birchgrove
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds.

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	40	42	37	52	48	43

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)

	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

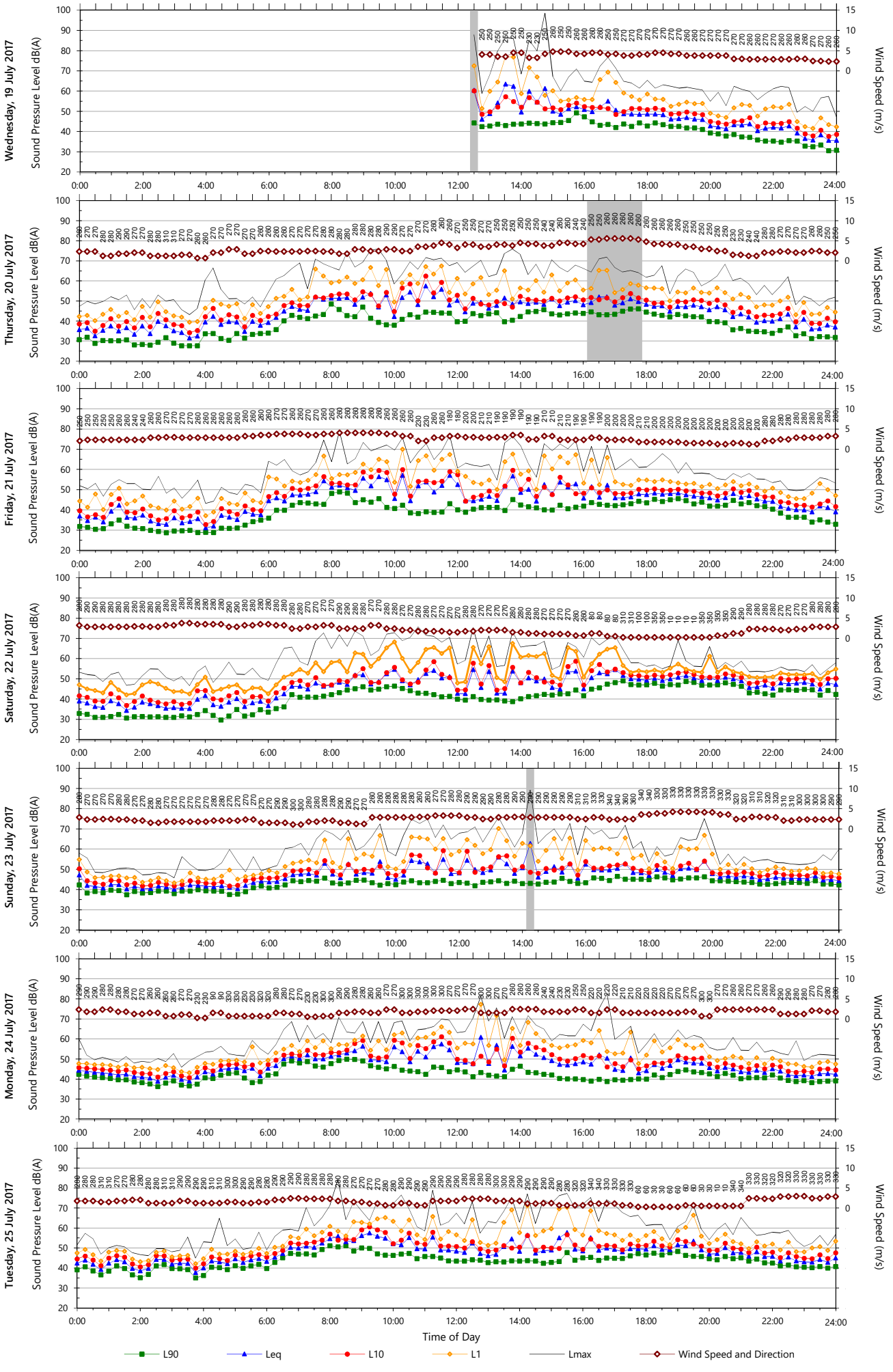
Logger Location	Aerial Photograph





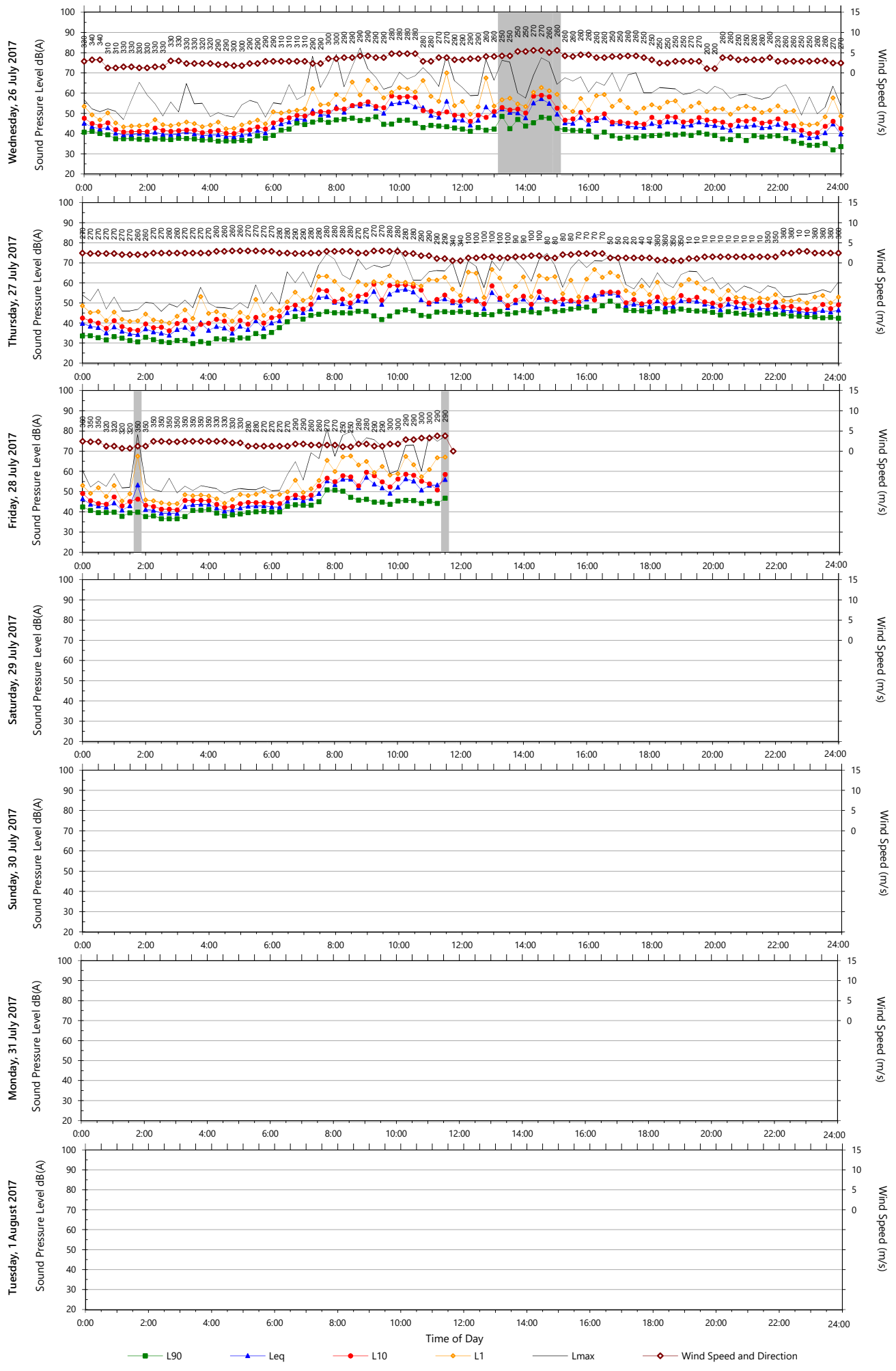
Unattended Monitoring Results

Location: 31 Wharf Road, Birchgrove



Unattended Monitoring Results

Location: 31 Wharf Road, Birchgrove



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Monitoring ID: Location L12
Address: 9 Numa Street, Birchgrove
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds and motor boat pass-bys.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	46	45	40	58	56	53

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

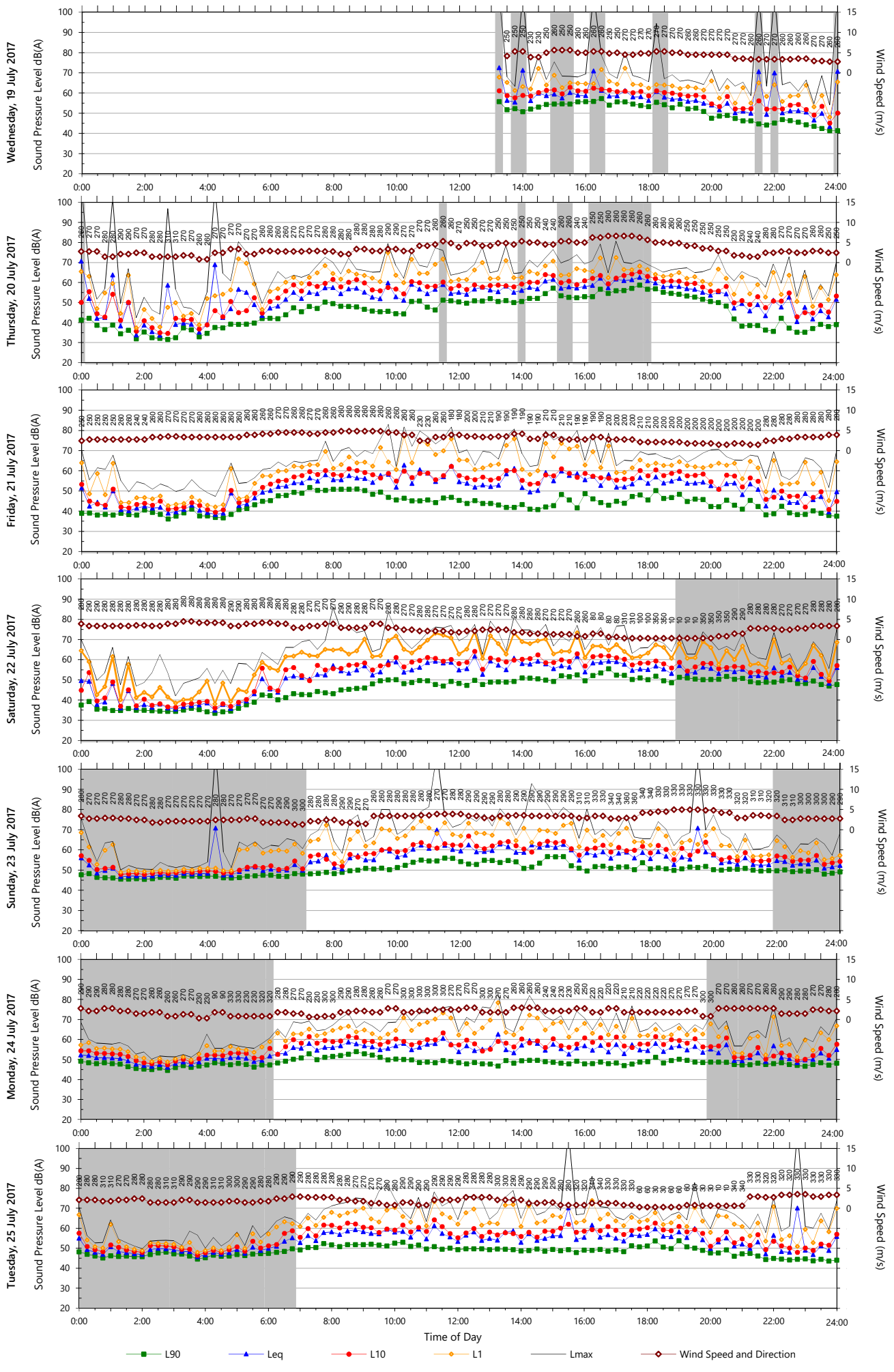
Logger Location	Aerial Photograph





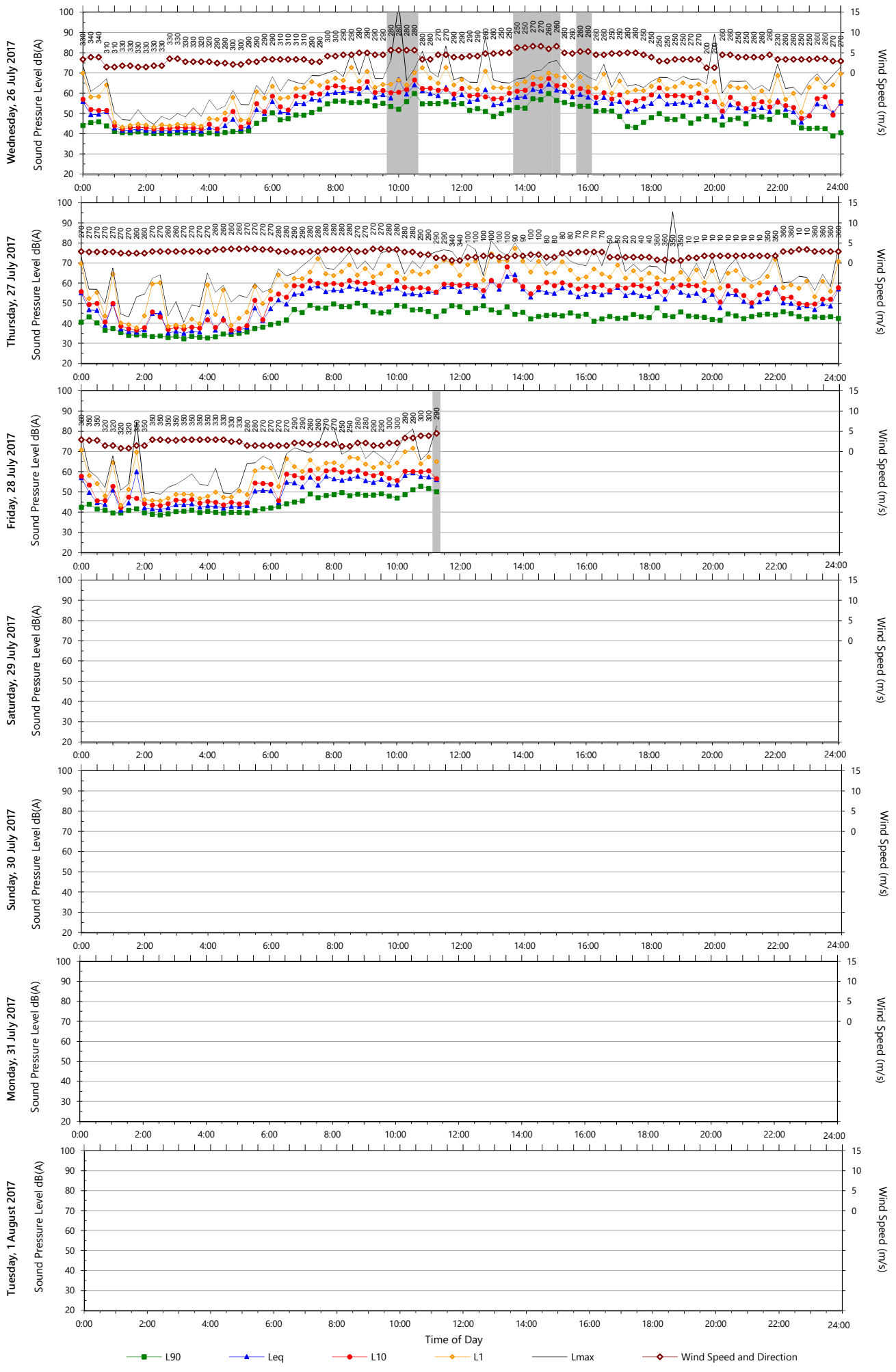
Unattended Monitoring Results

Location: 9 Numa Street, Birchgrove



Unattended Monitoring Results

Location: 9 Numa Street, Birchgrove



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Monitoring ID: Location L13
Address: 6 O'Connell Street, Greenwich
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood and natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	41	38	32	54	49	43

Notes:

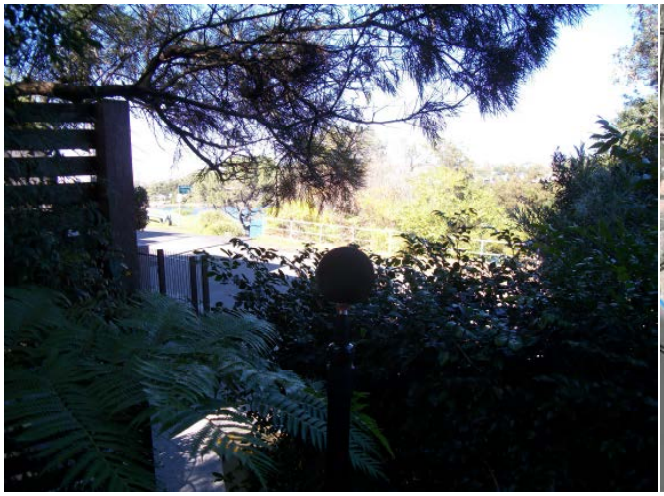
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

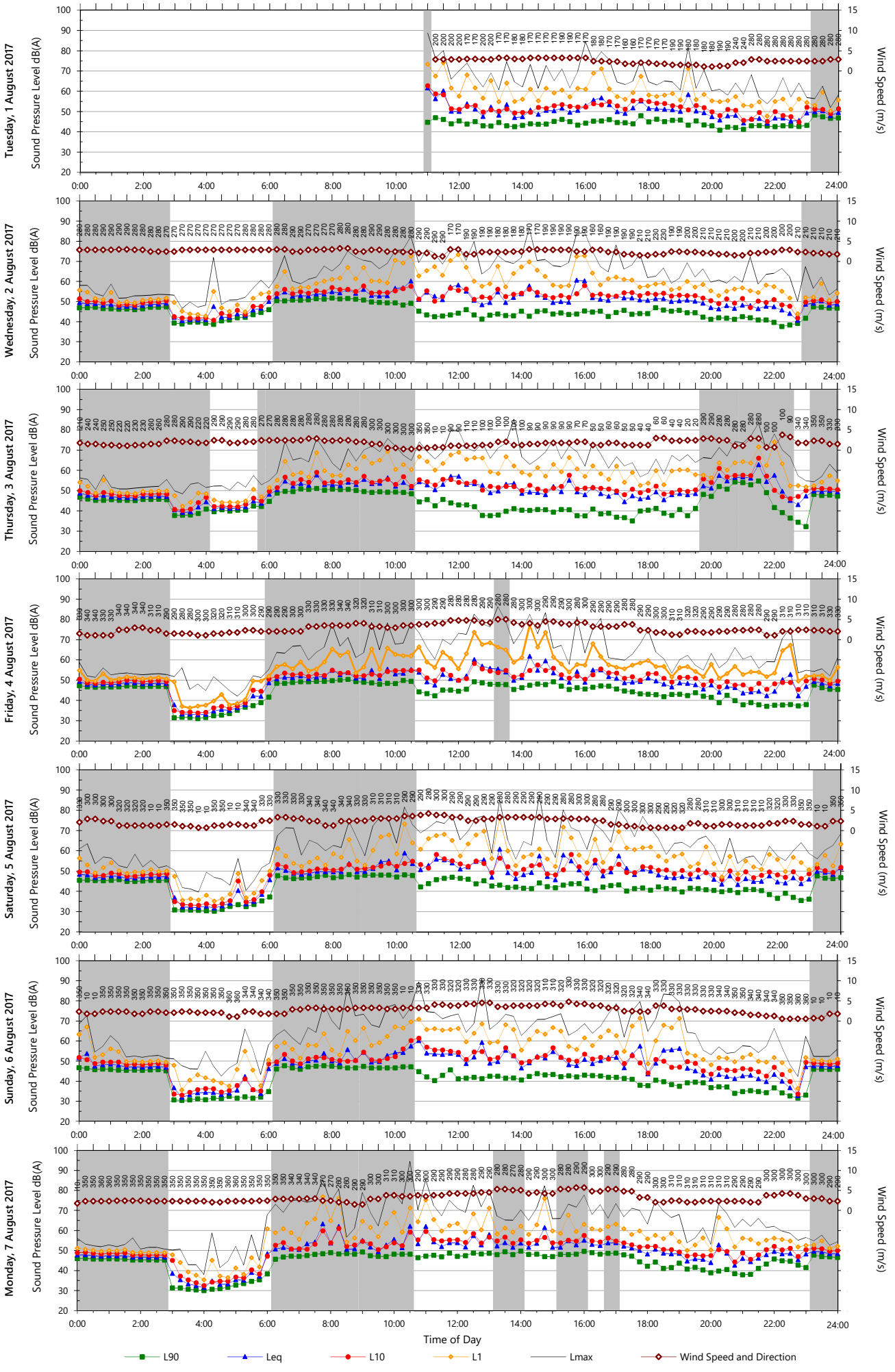
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph

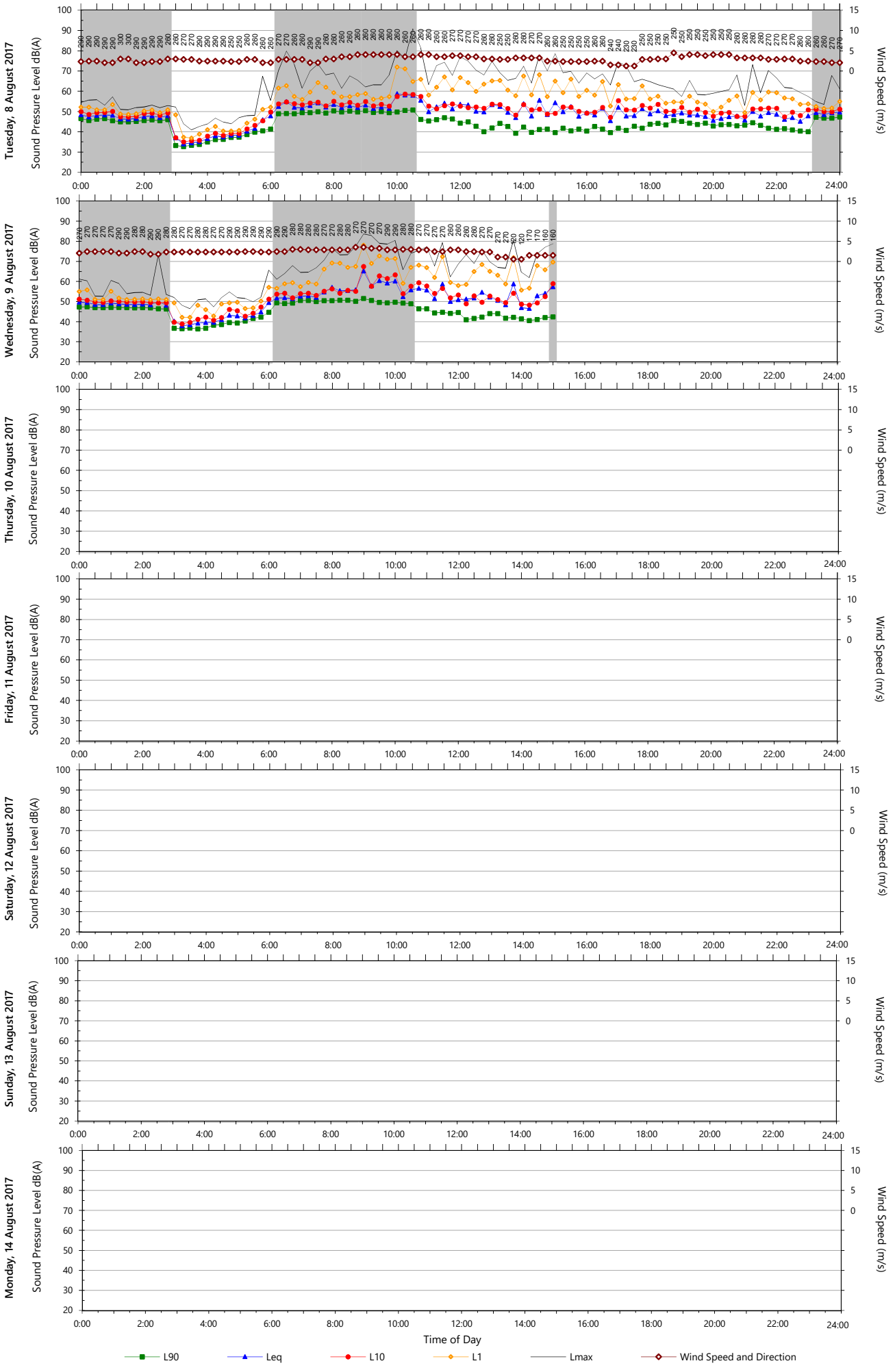




Unattended Monitoring Results **Location: 31 O'Connell St, Greenwich**



Unattended Monitoring Results **Location: 31 O'Connell St, Greenwich**



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Monitoring ID: Location L14
Address: 5 Balls Head Road, Waverton
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	41	37	33	51	47	45

Notes:

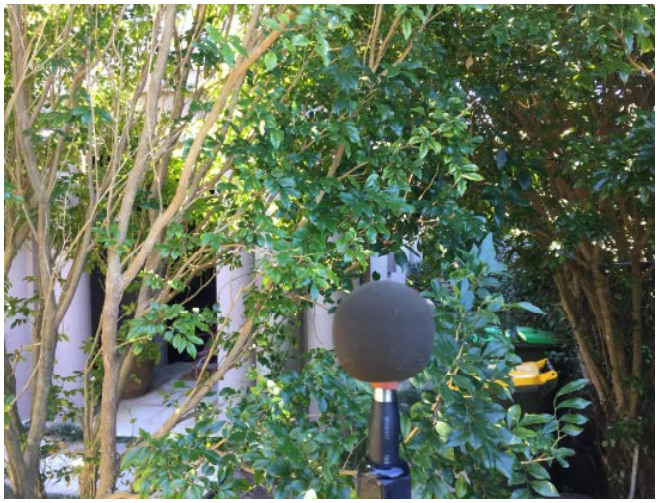
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

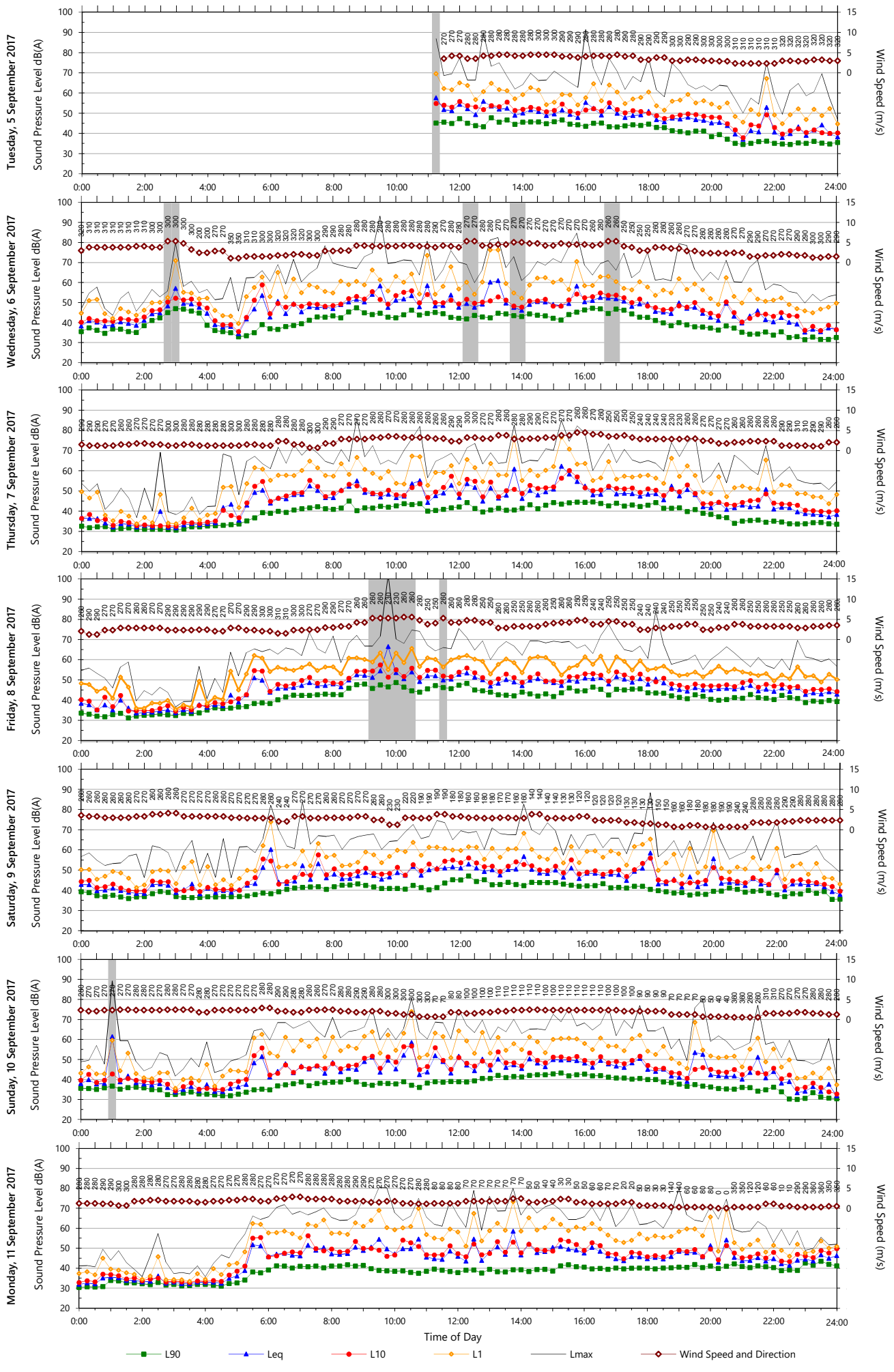
Logger Location	Aerial Photograph





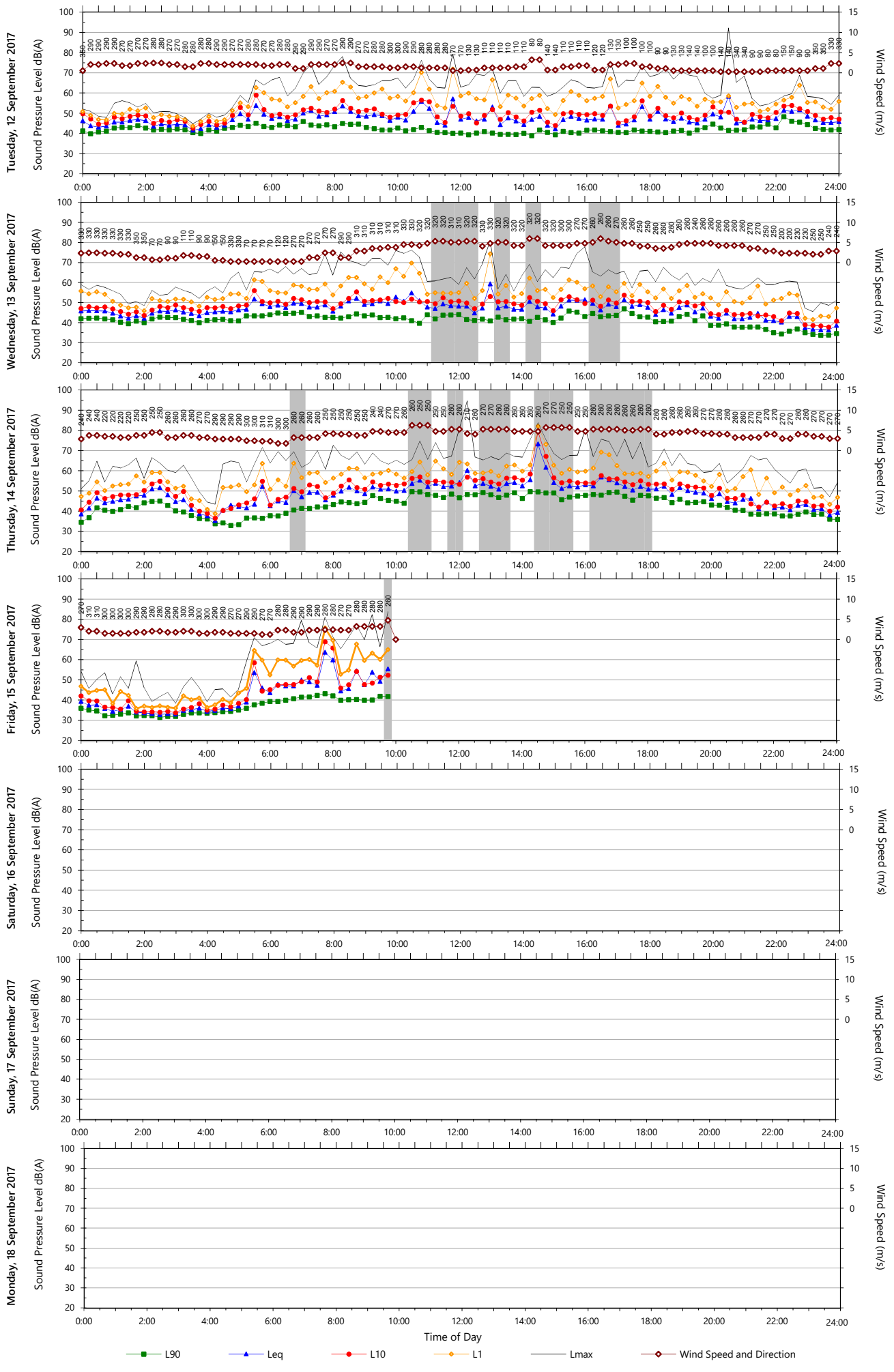
Unattended Monitoring Results

Location: 5 Balls Head Road, Waverton



Unattended Monitoring Results

Location: 5 Balls Head Road, Waverton



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Monitoring ID: Location L15
Address: 1/16 Munro Street, McMahons Point
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by natural sounds and occasional motor boat pass-bys.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	42	41	38	52	46	44

Notes:

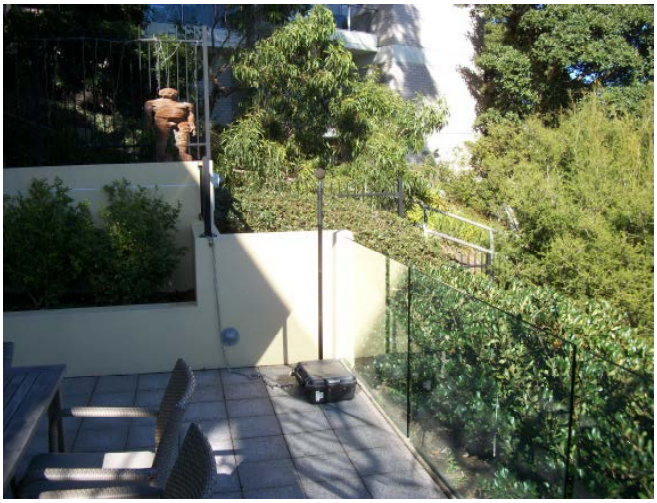
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

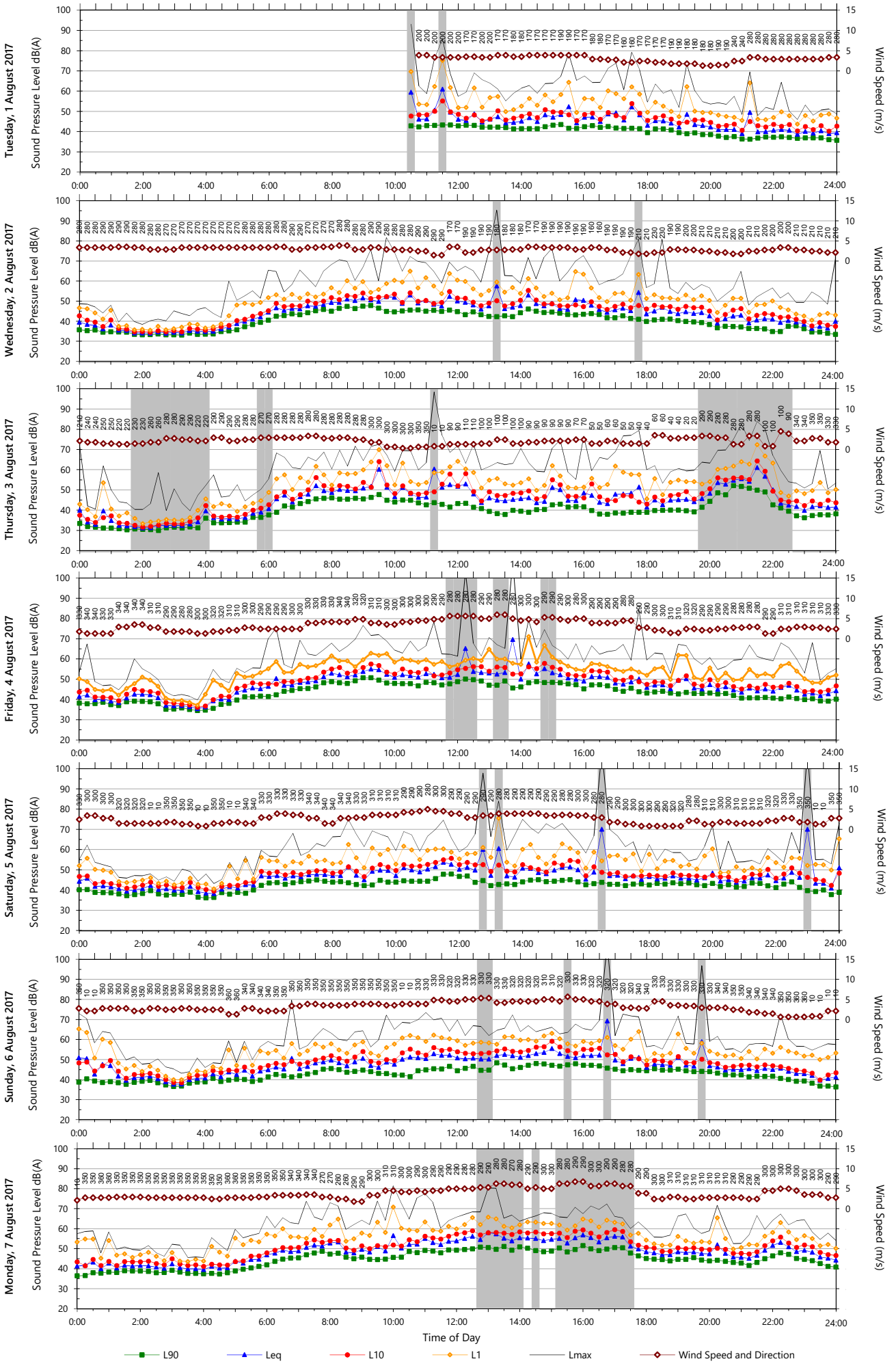
Notes:

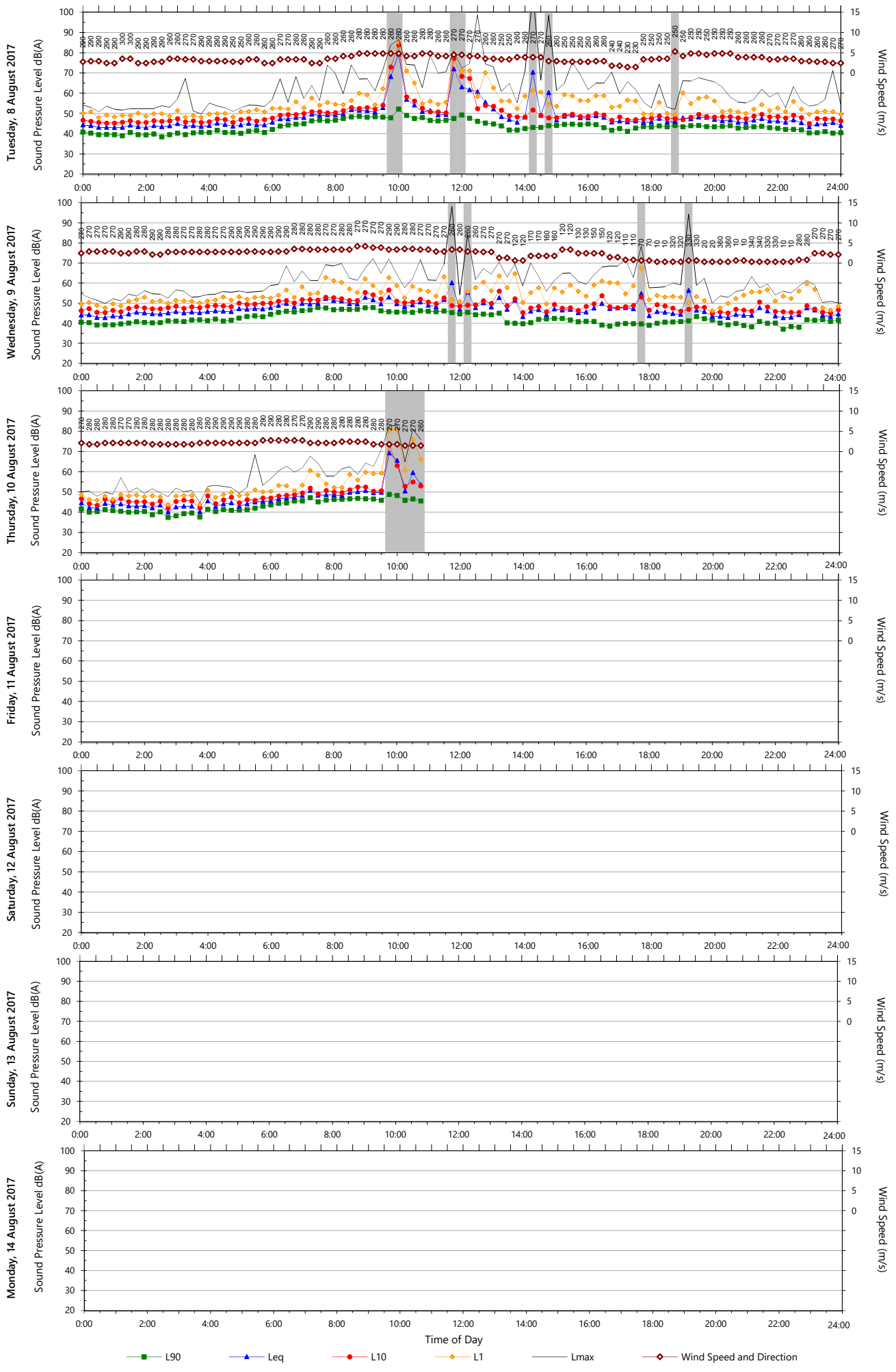
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Tuesday, 1 August 2017
Wednesday, 2 August 2017
Thursday, 3 August 2017
Friday, 4 August 2017
Saturday, 5 August 2017
Sunday, 6 August 2017
Monday, 7 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Tuesday, 8 August 2017
Wednesday, 9 August 2017
Thursday, 10 August 2017
Friday, 11 August 2017
Saturday, 12 August 2017
Sunday, 13 August 2017
Monday, 14 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L16
Address: 401/102 Alfred Street, Milsons Point
Description: Noise monitor located on the eastern facade of the fourth-floor balcony. Noise environment dominated by traffic on the Warringah Freeway and Alfred Street, and rail noise.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	60	60	50	63	62	58

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

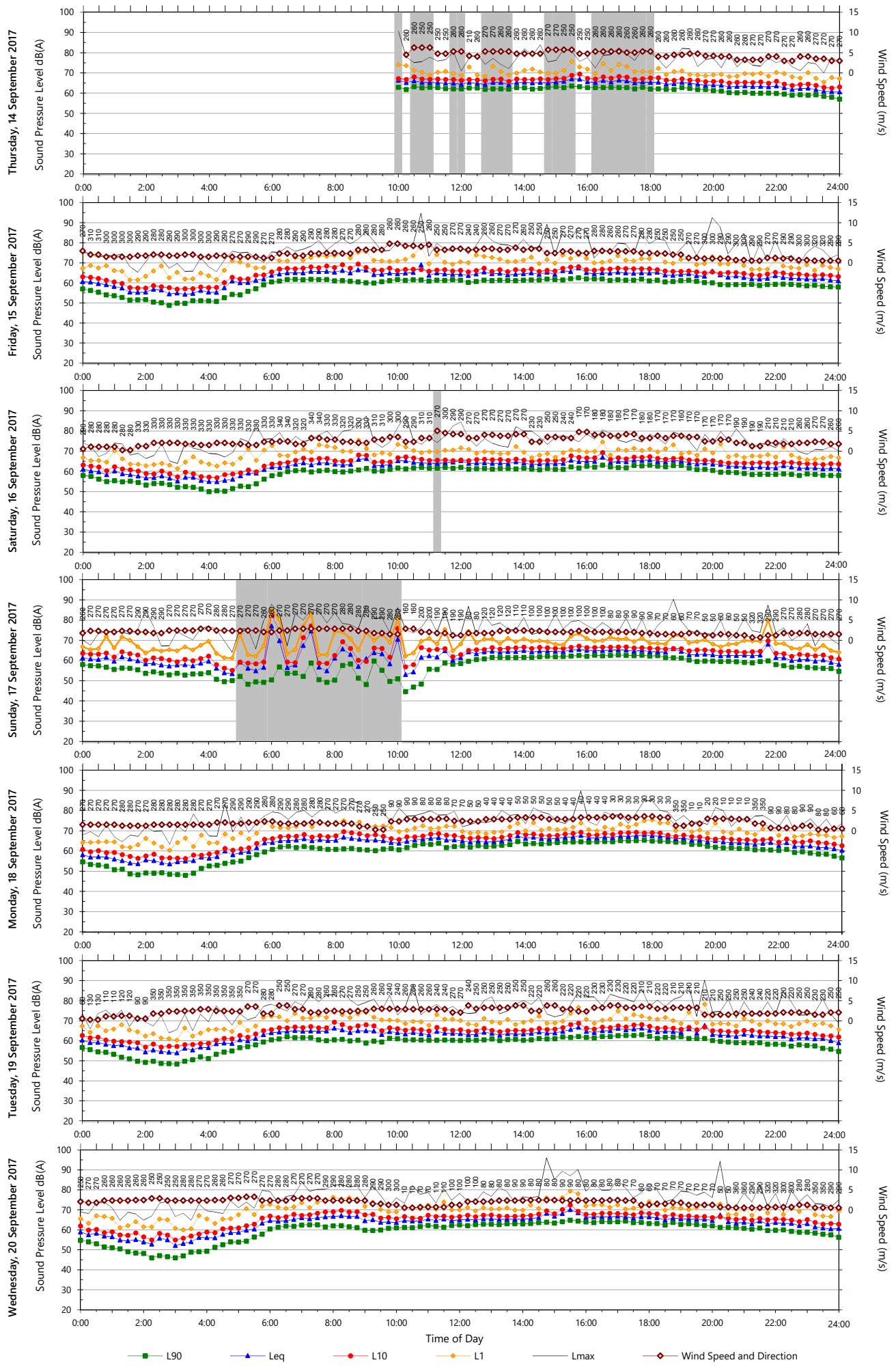
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

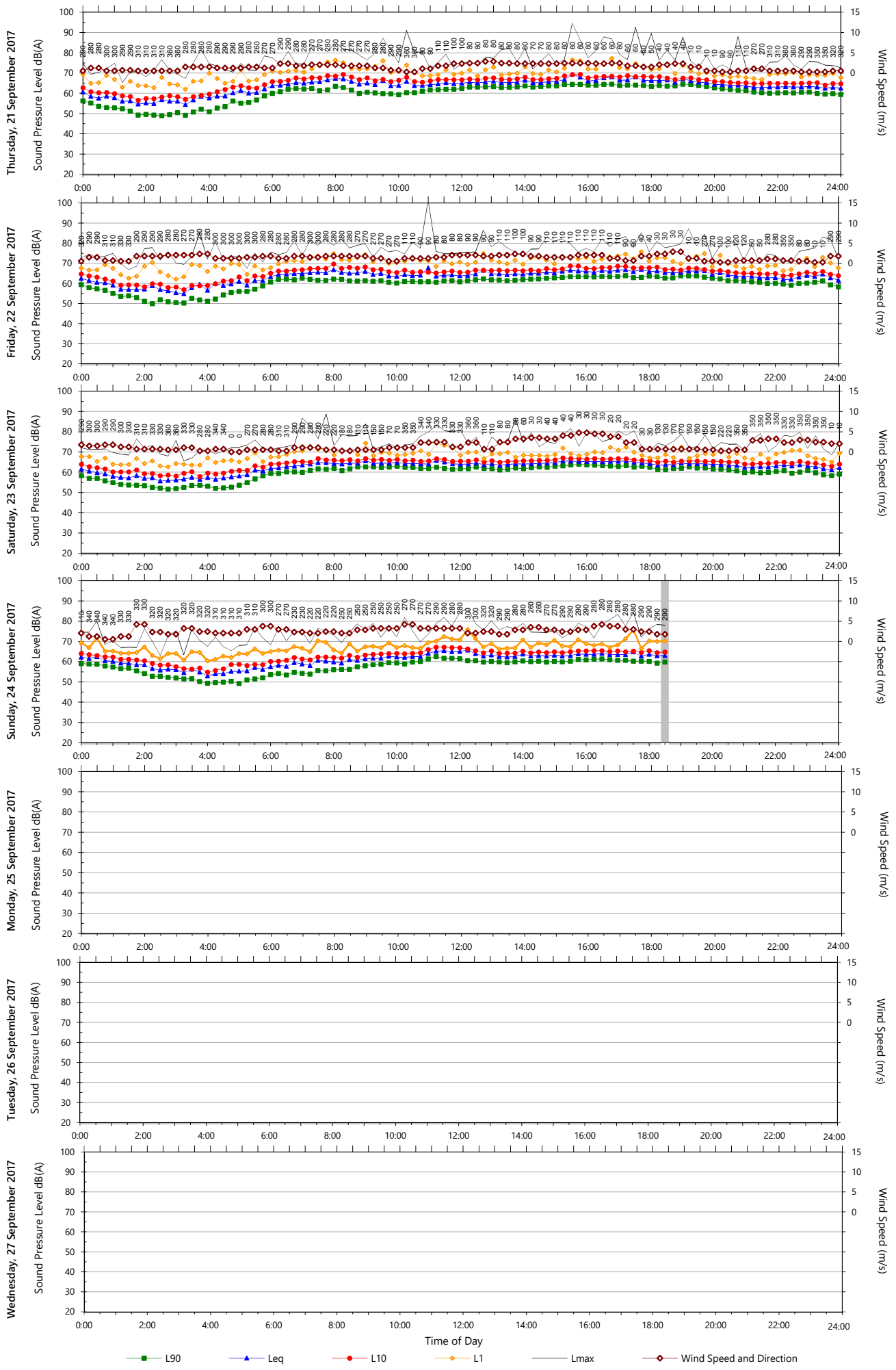
Logger Location	Aerial Photograph






Thursday, 14 September 2017
Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results **Location: Unit 401, 102 Alfred Street, Milsons Point (4F Balcony)**



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Monitoring ID: Location L17
Address: 6 McDougall Street, Kirribilli
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Cahill Expressway/Bradfield Highway and general neighbourhood and natural sounds.

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	55	54	45	60	58	56

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)

	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	62	58

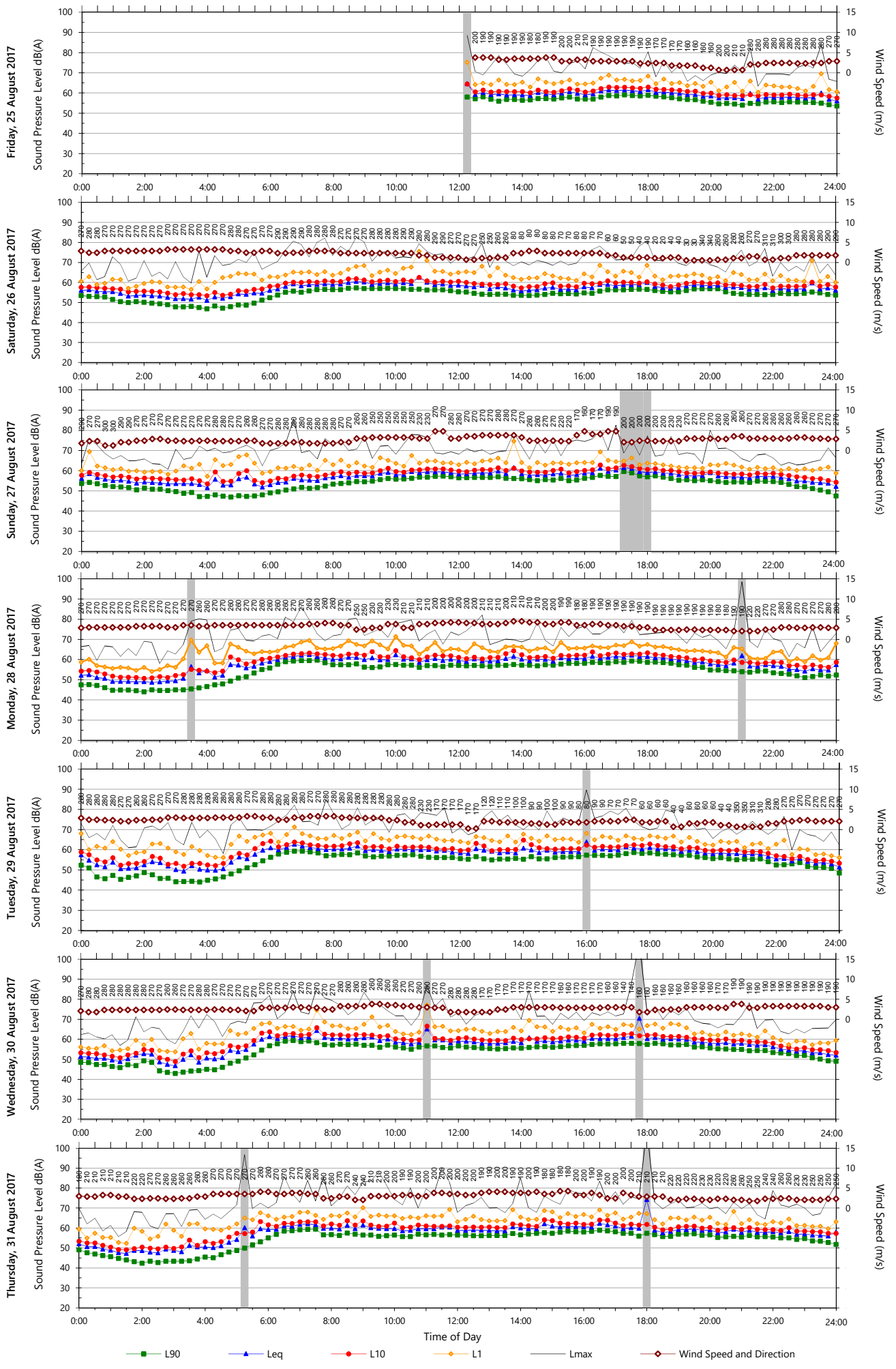
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

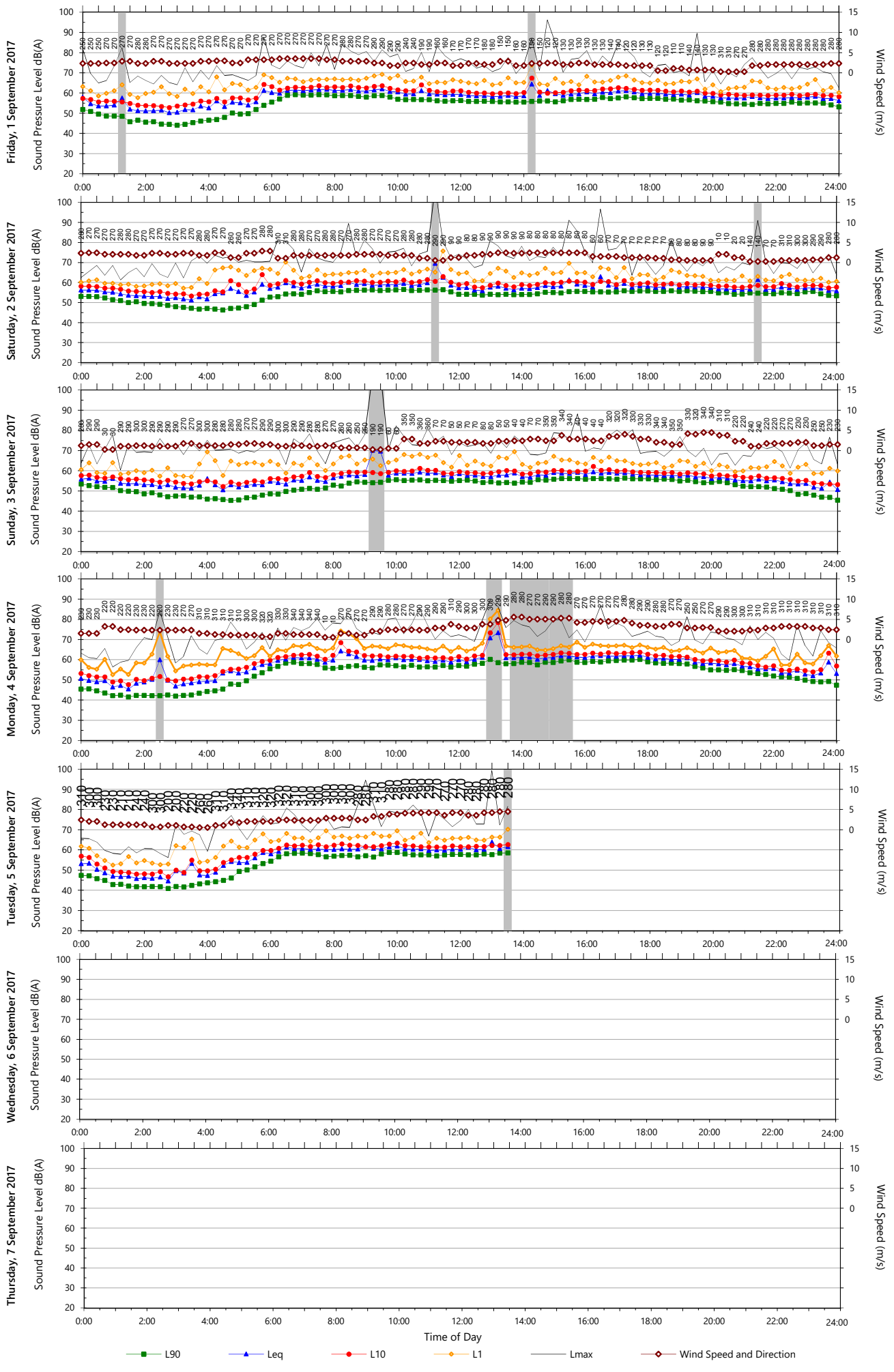
Logger Location	Aerial Photograph






Friday, 25 August 2017
Saturday, 26 August 2017
Sunday, 27 August 2017
Monday, 28 August 2017
Tuesday, 29 August 2017
Wednesday, 30 August 2017
Thursday, 31 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results **Location: 6 McDougall St, Kirribilli**



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Monitoring ID: Location L18
Address: 1/191-195 Walker Street, North Sydney
Description: Noise monitor located on the eastern side of the property, on the ground floor and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	73	71	55	76	75	72

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

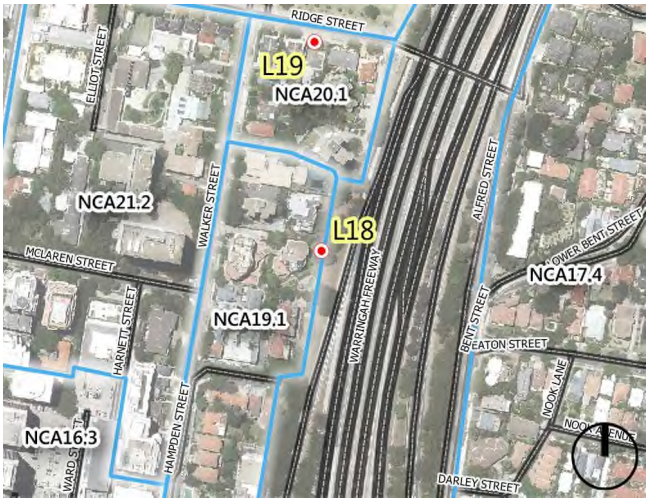
Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	79	74	

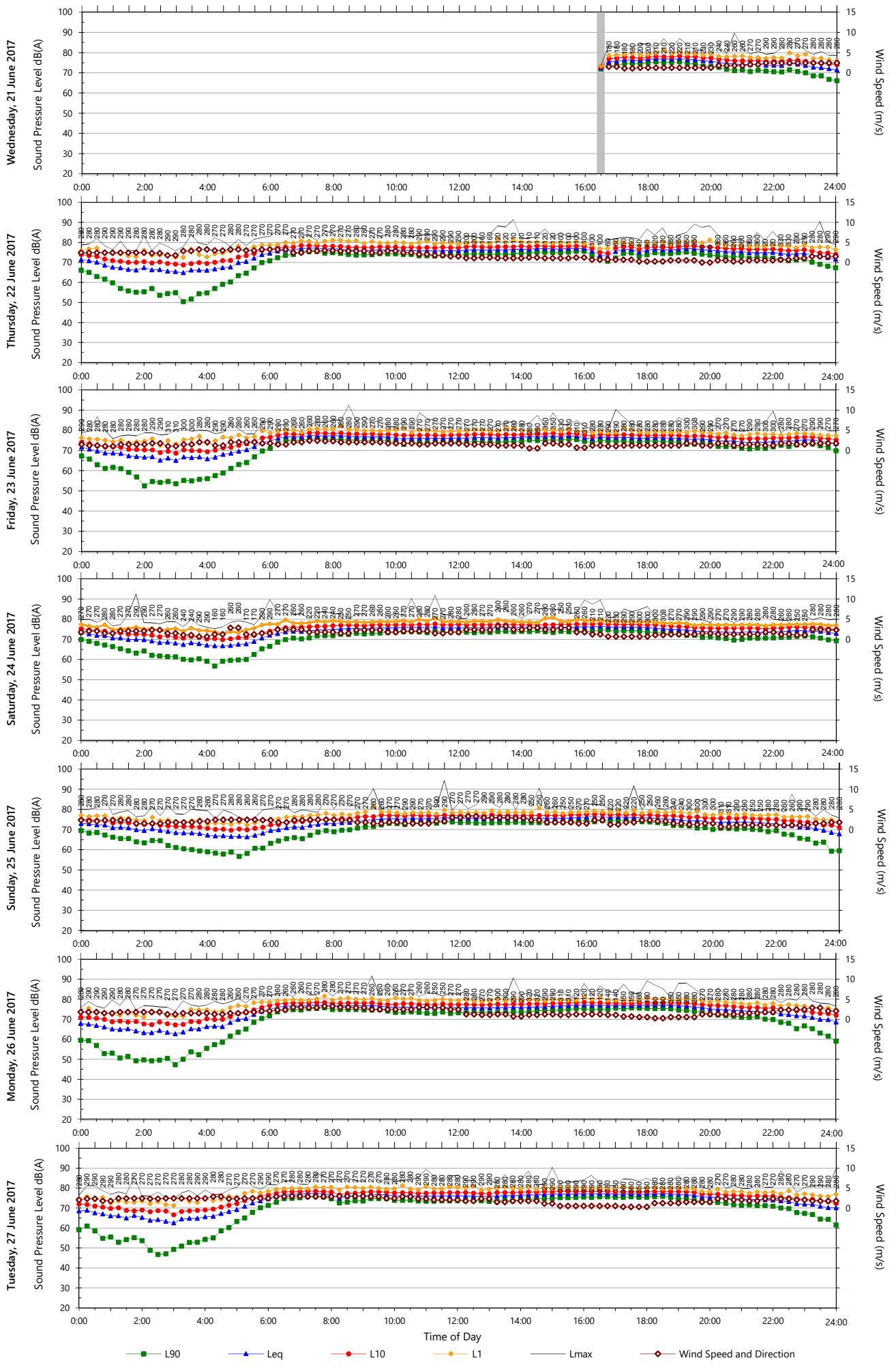
Notes:

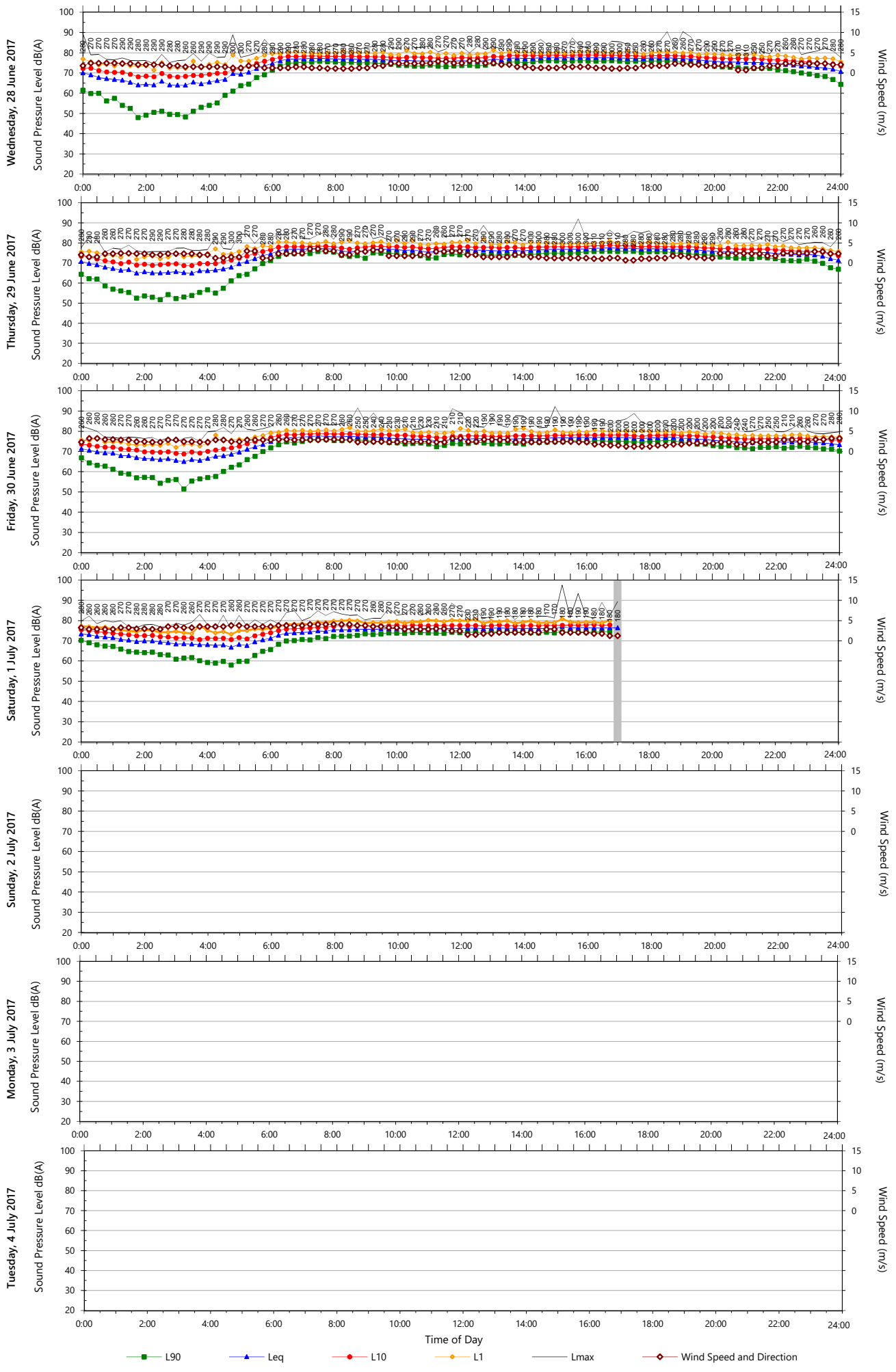
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 21 June 2017
Thursday, 22 June 2017
Friday, 23 June 2017
Saturday, 24 June 2017
Sunday, 25 June 2017
Monday, 26 June 2017
Tuesday, 27 June 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 28 June 2017
Thursday, 29 June 2017
Friday, 30 June 2017
Saturday, 1 July 2017
Sunday, 2 July 2017
Monday, 3 July 2017
Tuesday, 4 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L19
Address: 91 Ridge Street, North Sydney
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	52	52	45	57	57	52

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	60	54	

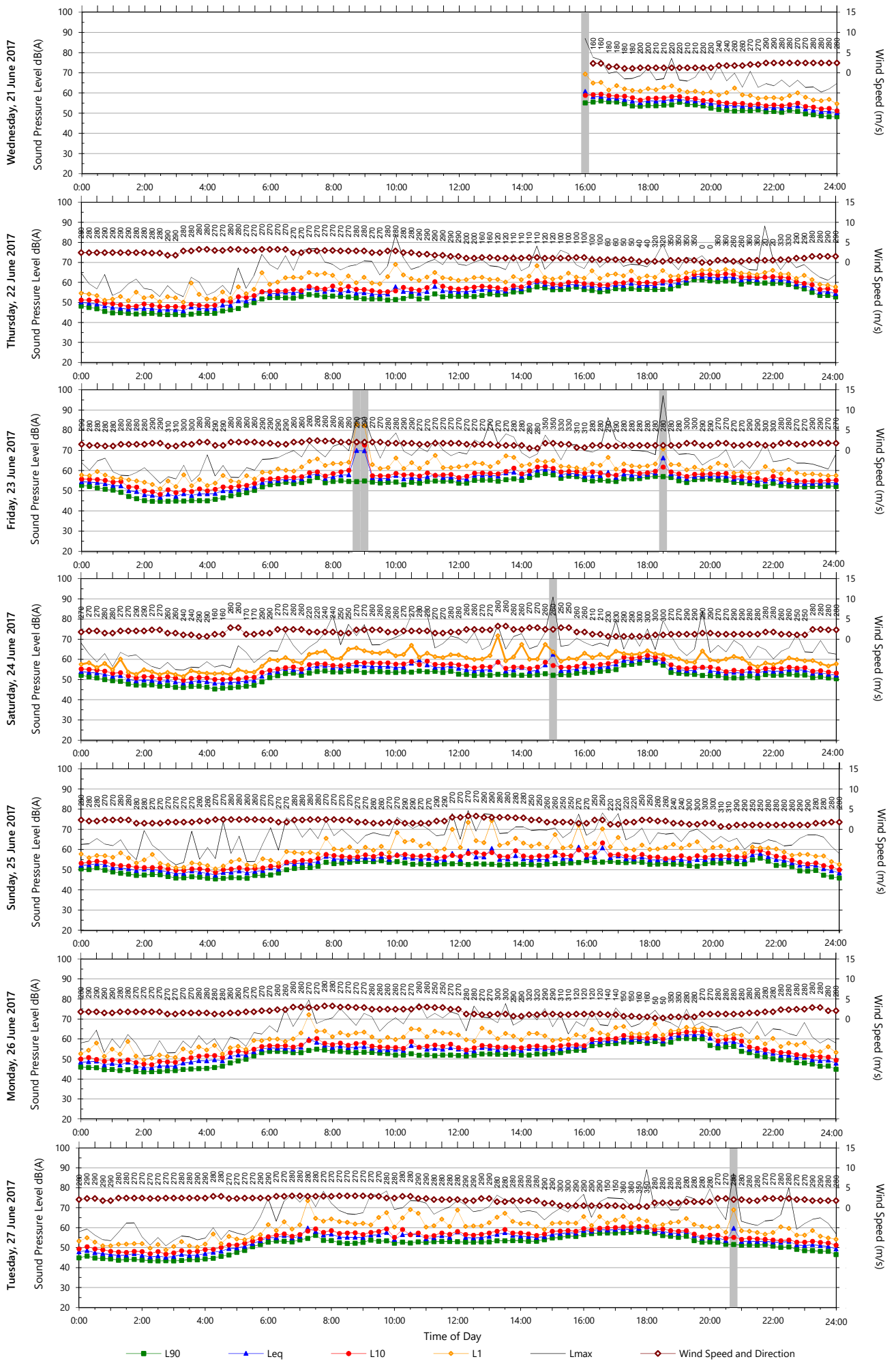
Notes:

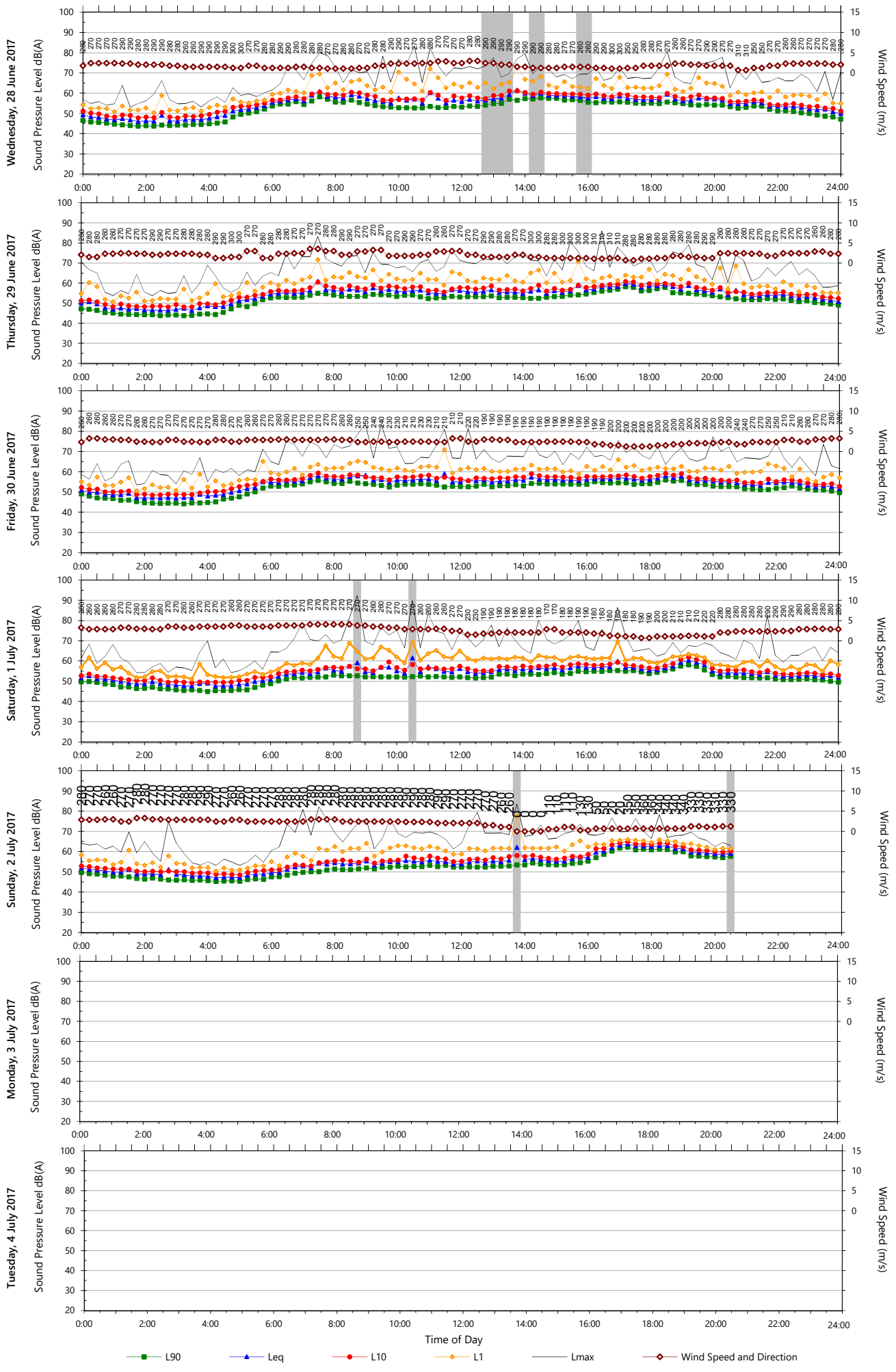
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 21 June 2017
Thursday, 22 June 2017
Friday, 23 June 2017
Saturday, 24 June 2017
Sunday, 25 June 2017
Monday, 26 June 2017
Tuesday, 27 June 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 28 June 2017
Thursday, 29 June 2017
Friday, 30 June 2017
Saturday, 1 July 2017
Sunday, 2 July 2017
Monday, 3 July 2017
Tuesday, 4 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L20
Address: 14 Montpellier Road, Neutral Bay
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	54	52	43	59	57	53

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)

	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

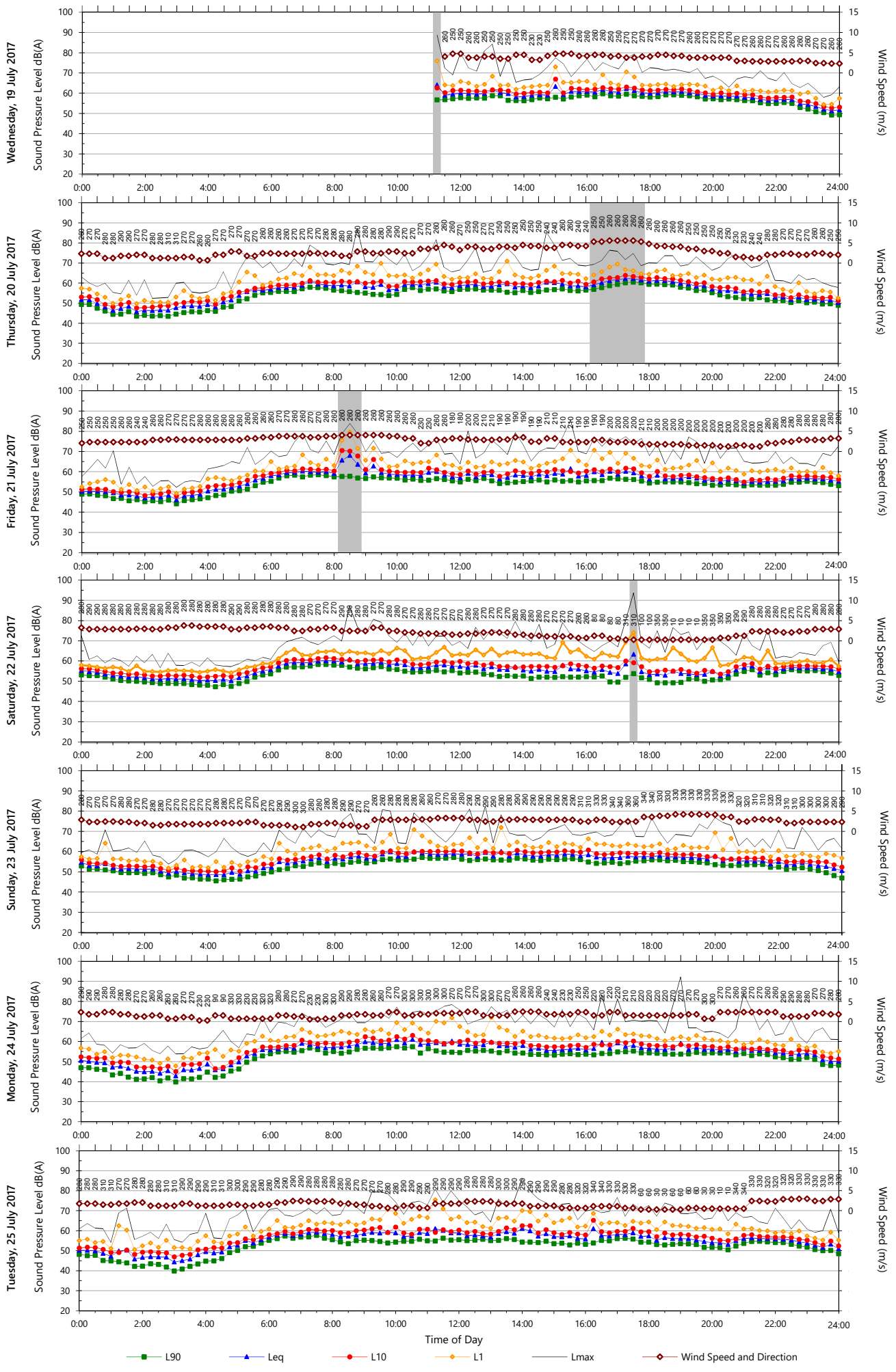
Notes:

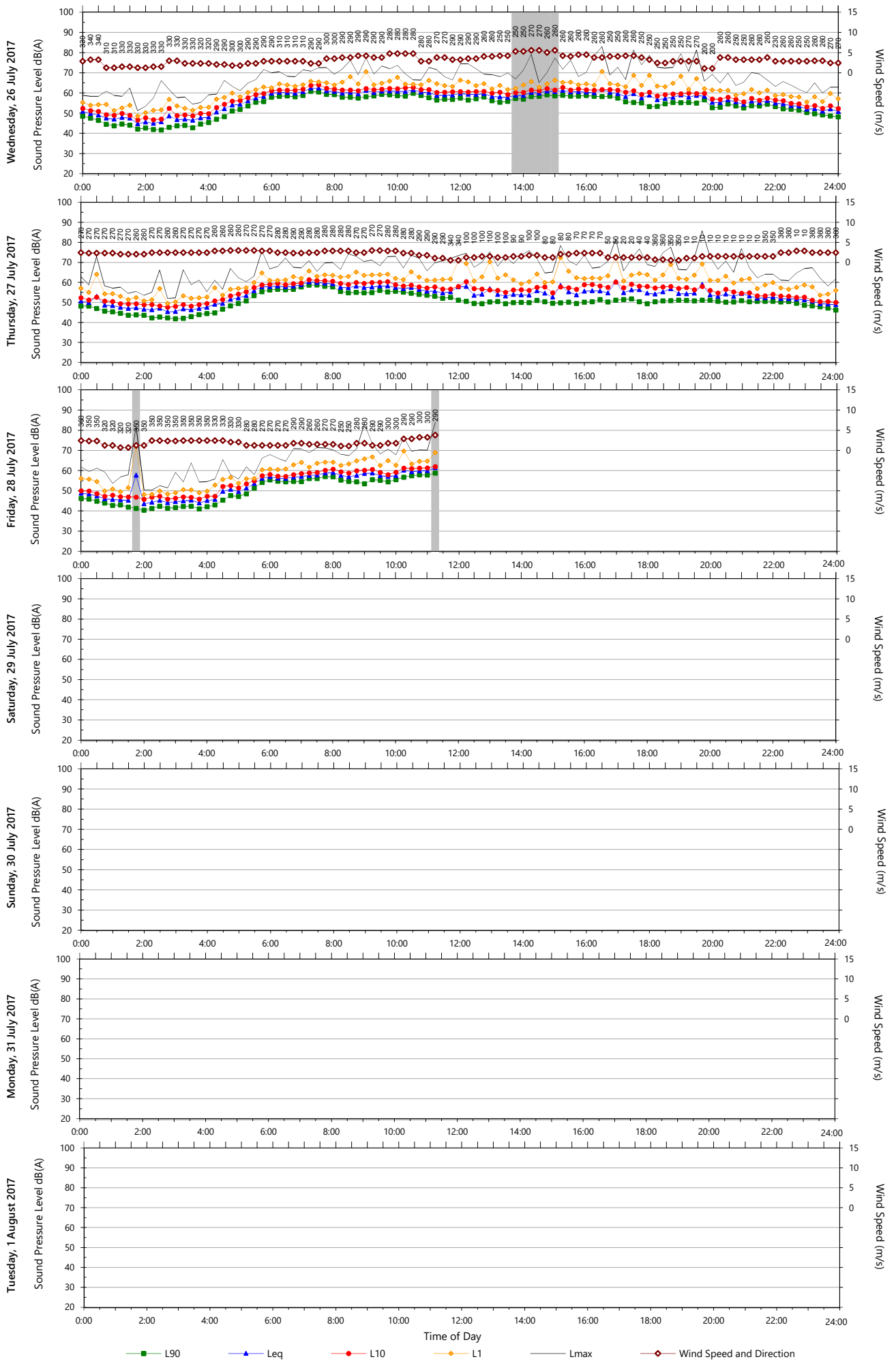
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 26 July 2017
Thursday, 27 July 2017
Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L21
Address: 306 Miller Street, North Sydney
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Miller Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	52	47	36	65	63	58

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

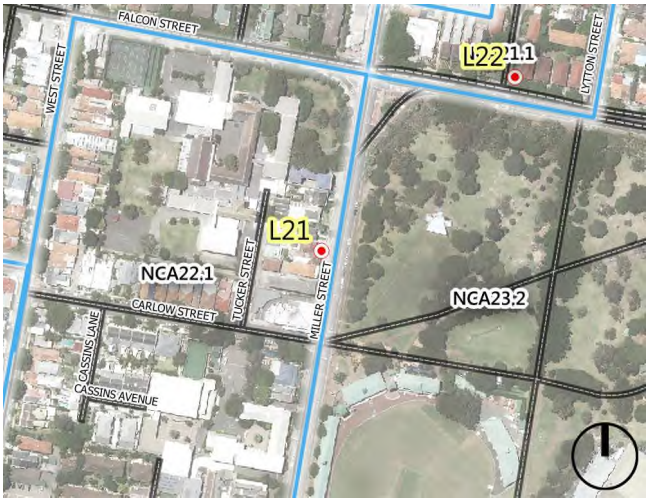
Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	67	61	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

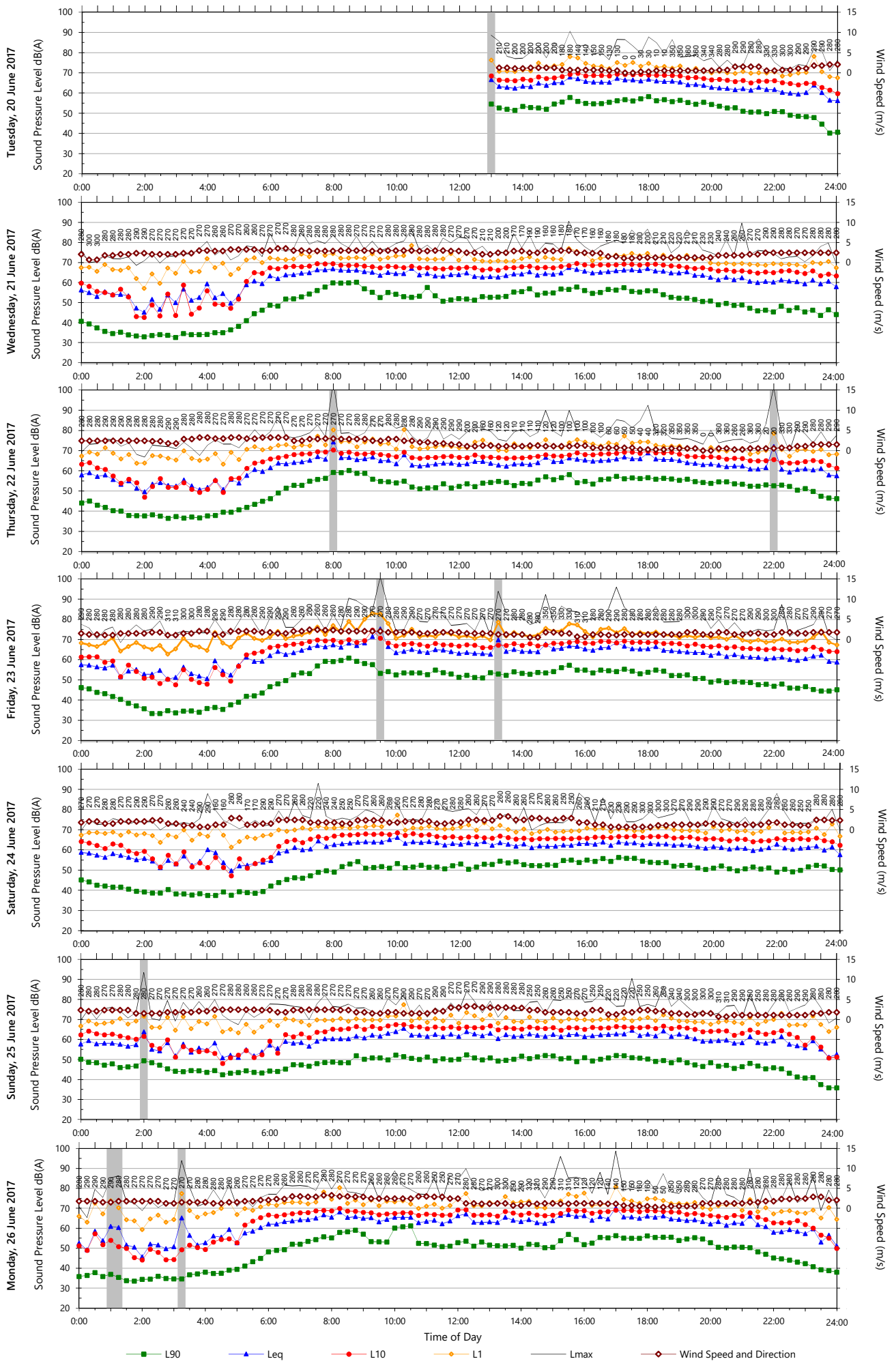
Logger Location	Aerial Photograph

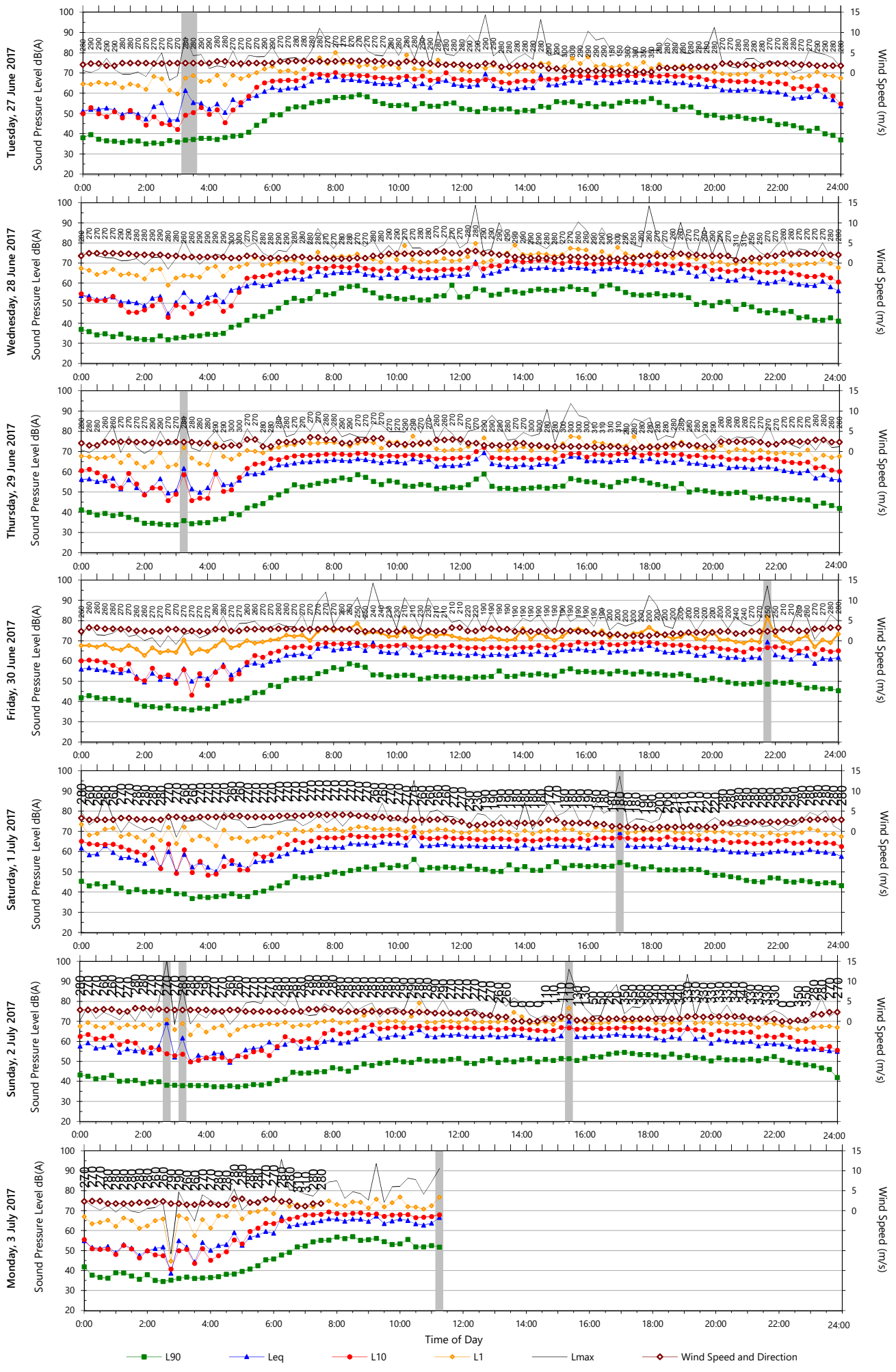




Unattended Monitoring Results

Location: 306 Miller Street, North Sydney




Tuesday, 27 June 2017
Wednesday, 28 June 2017
Thursday, 29 June 2017
Friday, 30 June 2017
Saturday, 1 July 2017
Sunday, 2 July 2017
Monday, 3 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L22
Address: 1/1 Bardsley Gardens, Crows Nest
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Falcon Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	53	49	41	68	67	63

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	70	66

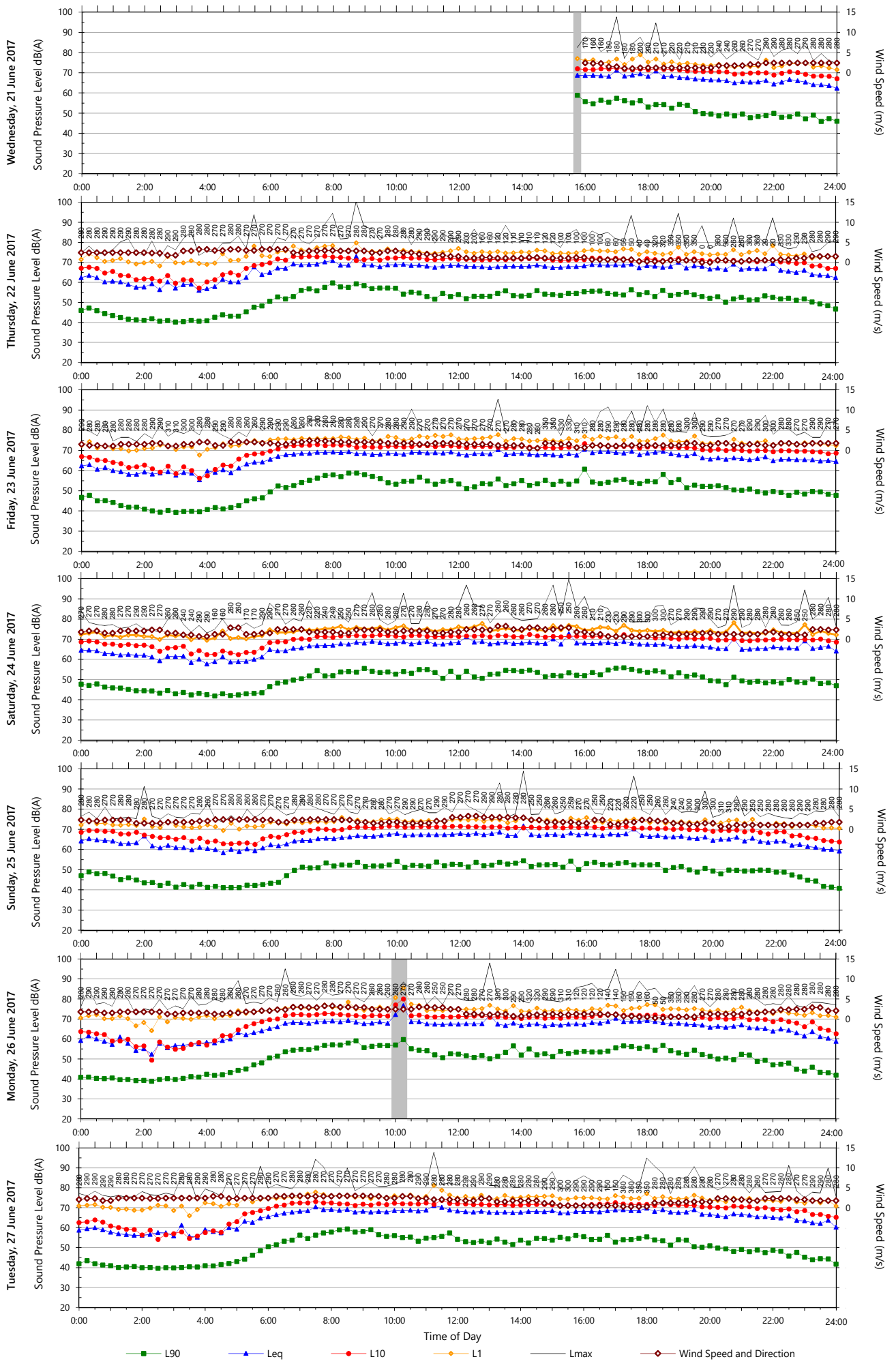
Notes:

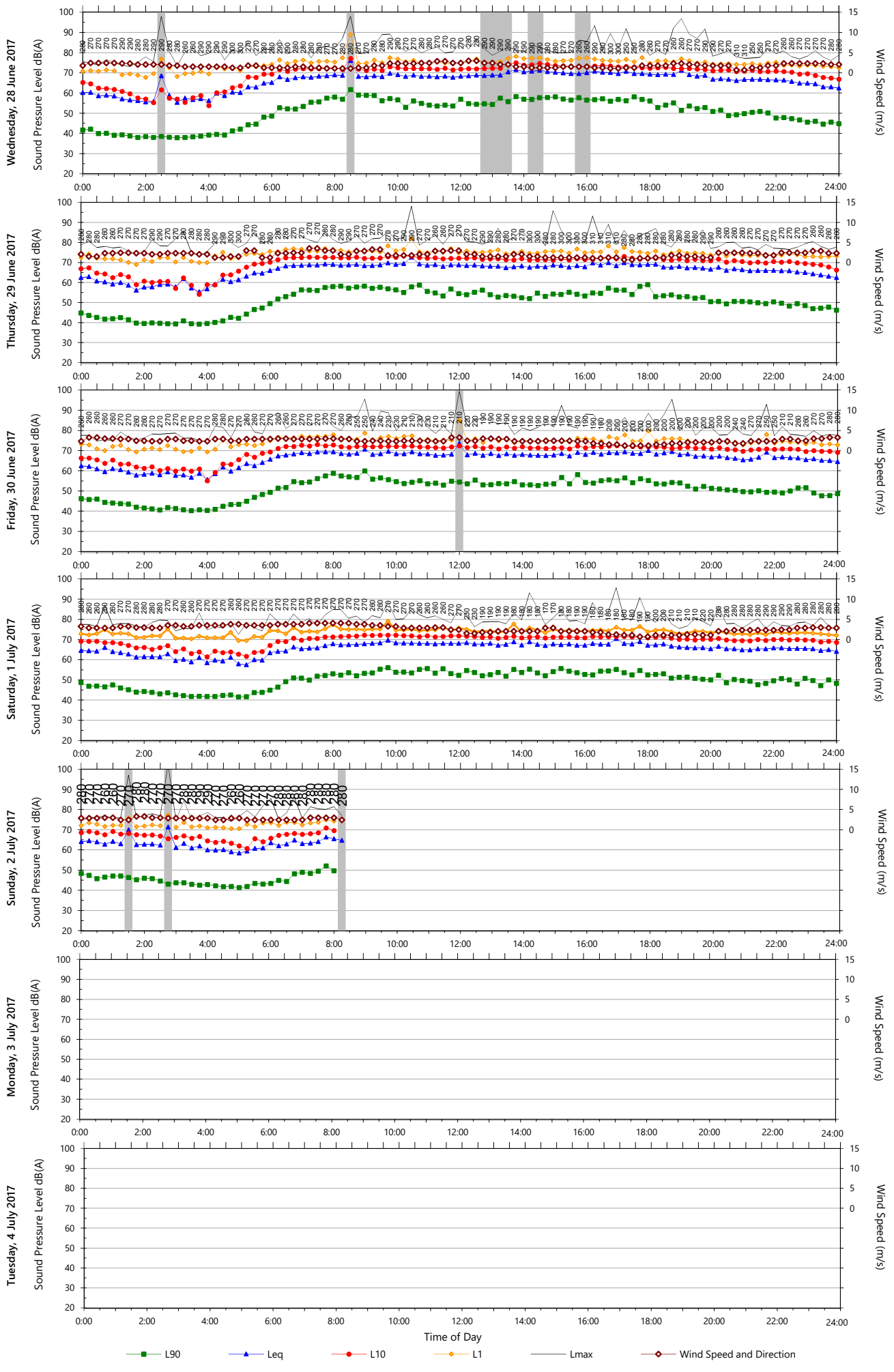
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 21 June 2017
Thursday, 22 June 2017
Friday, 23 June 2017
Saturday, 24 June 2017
Sunday, 25 June 2017
Monday, 26 June 2017
Tuesday, 27 June 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 28 June 2017
Thursday, 29 June 2017
Friday, 30 June 2017
Saturday, 1 July 2017
Sunday, 2 July 2017
Monday, 3 July 2017
Tuesday, 4 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L23
Address: 288 Falcon Street, Neutral Bay
Description: Noise monitor located in the front yard and positioned approximately 1m away from the front facade. Noise environment dominated by traffic on Falcon Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	61	54	44	69	68	65

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	71	68	

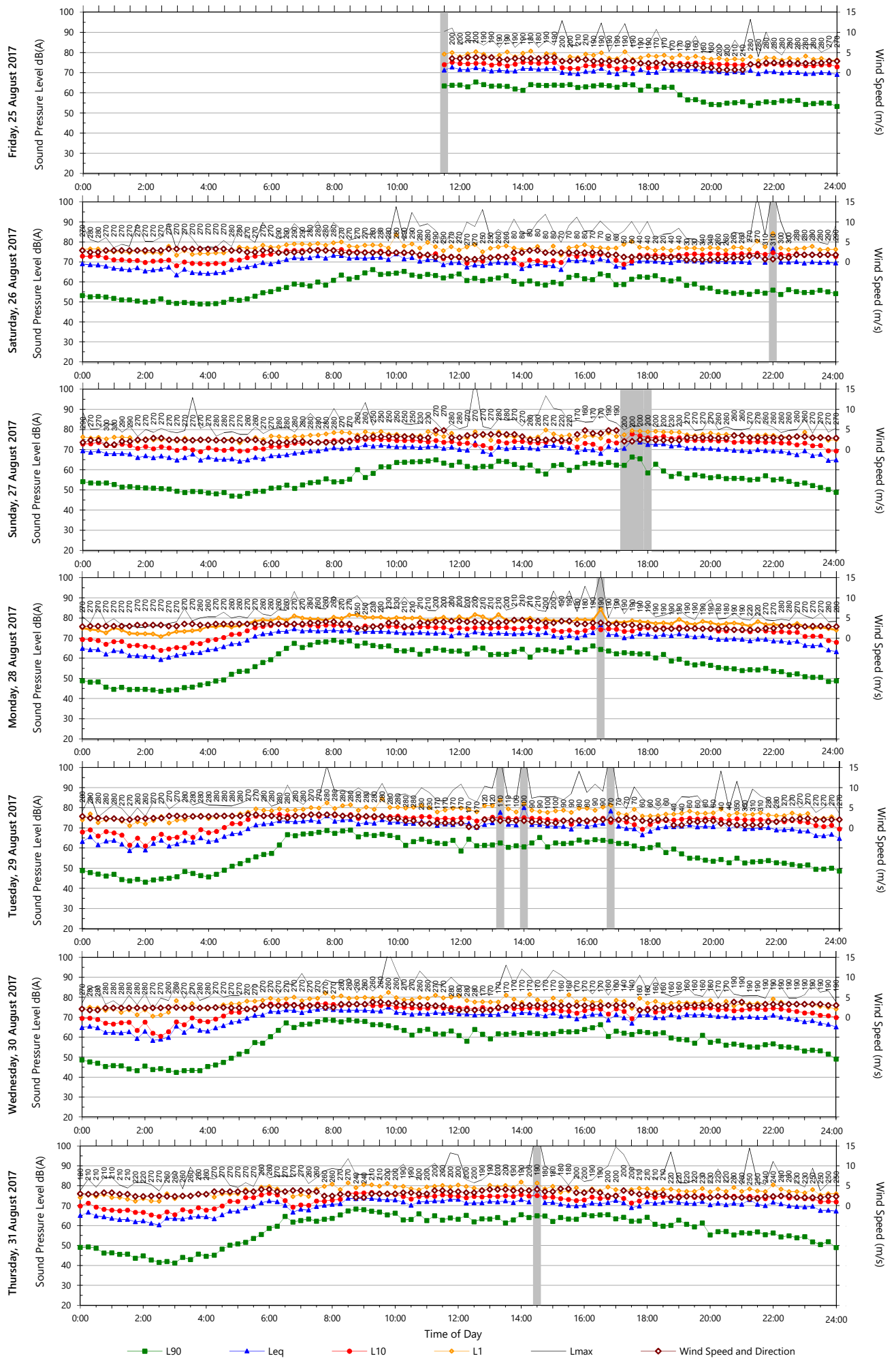
Notes:

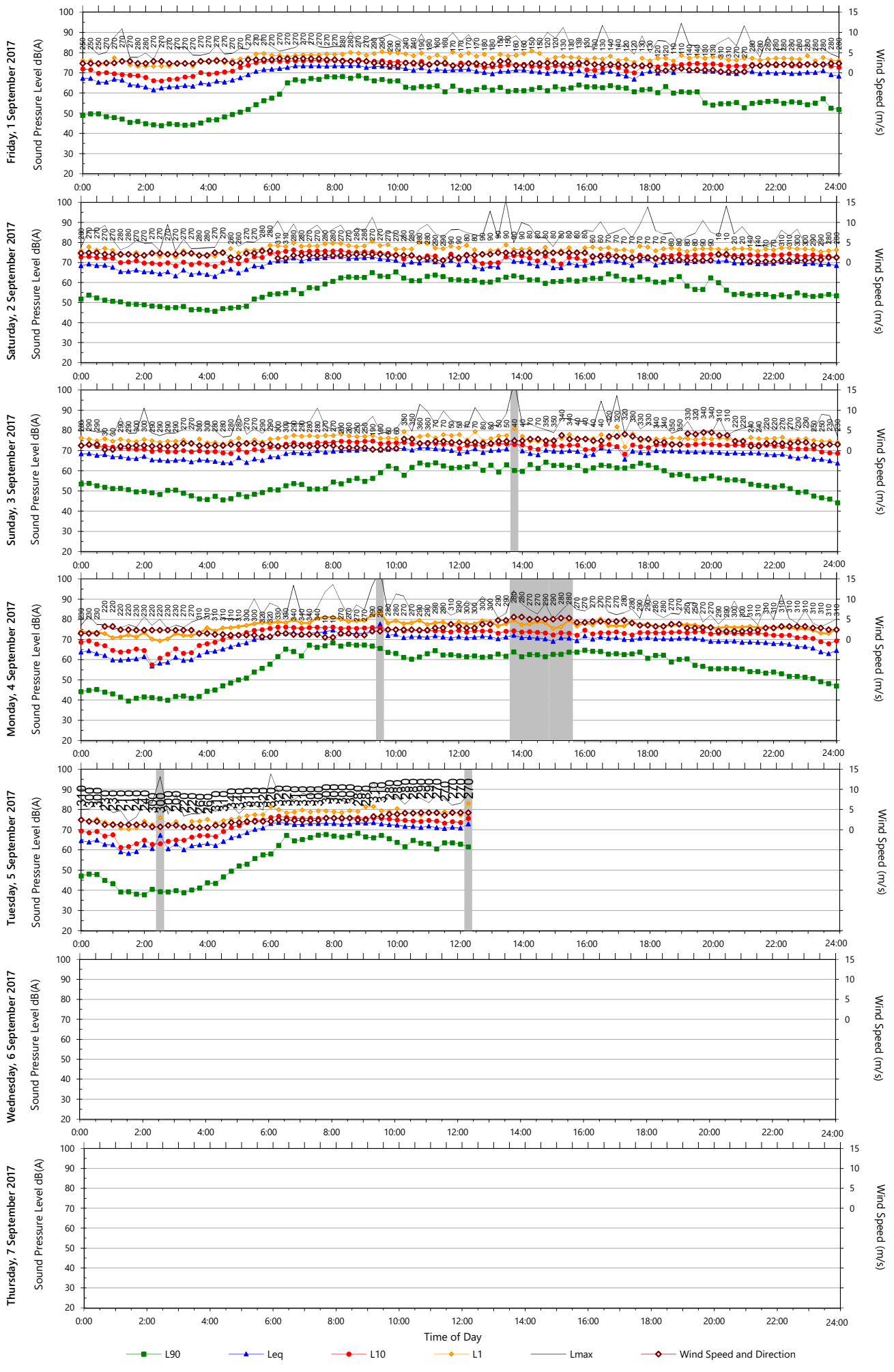
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 25 August 2017
Saturday, 26 August 2017
Sunday, 27 August 2017
Monday, 28 August 2017
Tuesday, 29 August 2017
Wednesday, 30 August 2017
Thursday, 31 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 1 September 2017
Saturday, 2 September 2017
Sunday, 3 September 2017
Monday, 4 September 2017
Tuesday, 5 September 2017
Wednesday, 6 September 2017
Thursday, 7 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L24
Address: 5 Military Road, Neutral Bay
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Military Road.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	58	54	44	72	71	67

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	74	70	

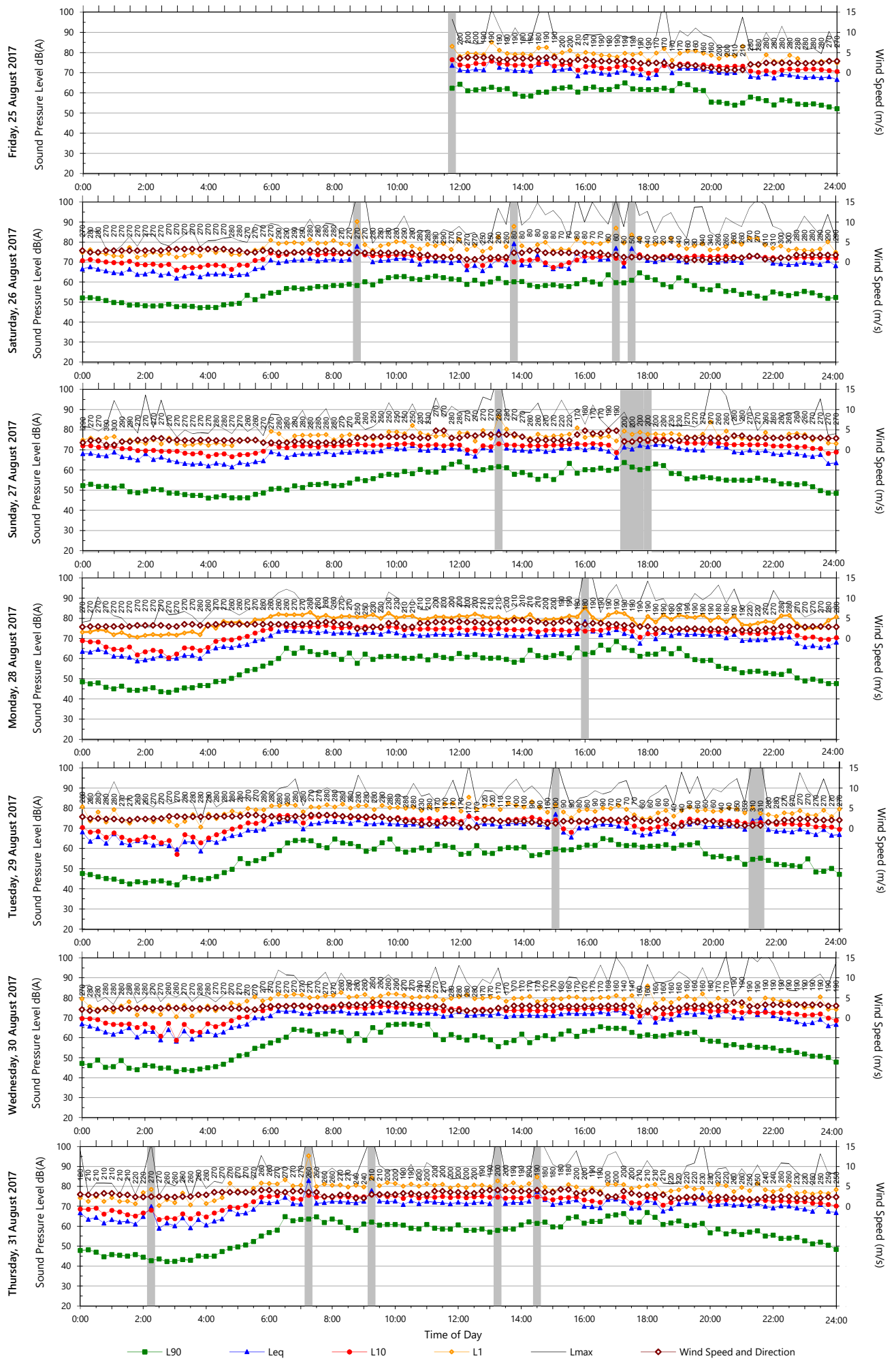
Notes:

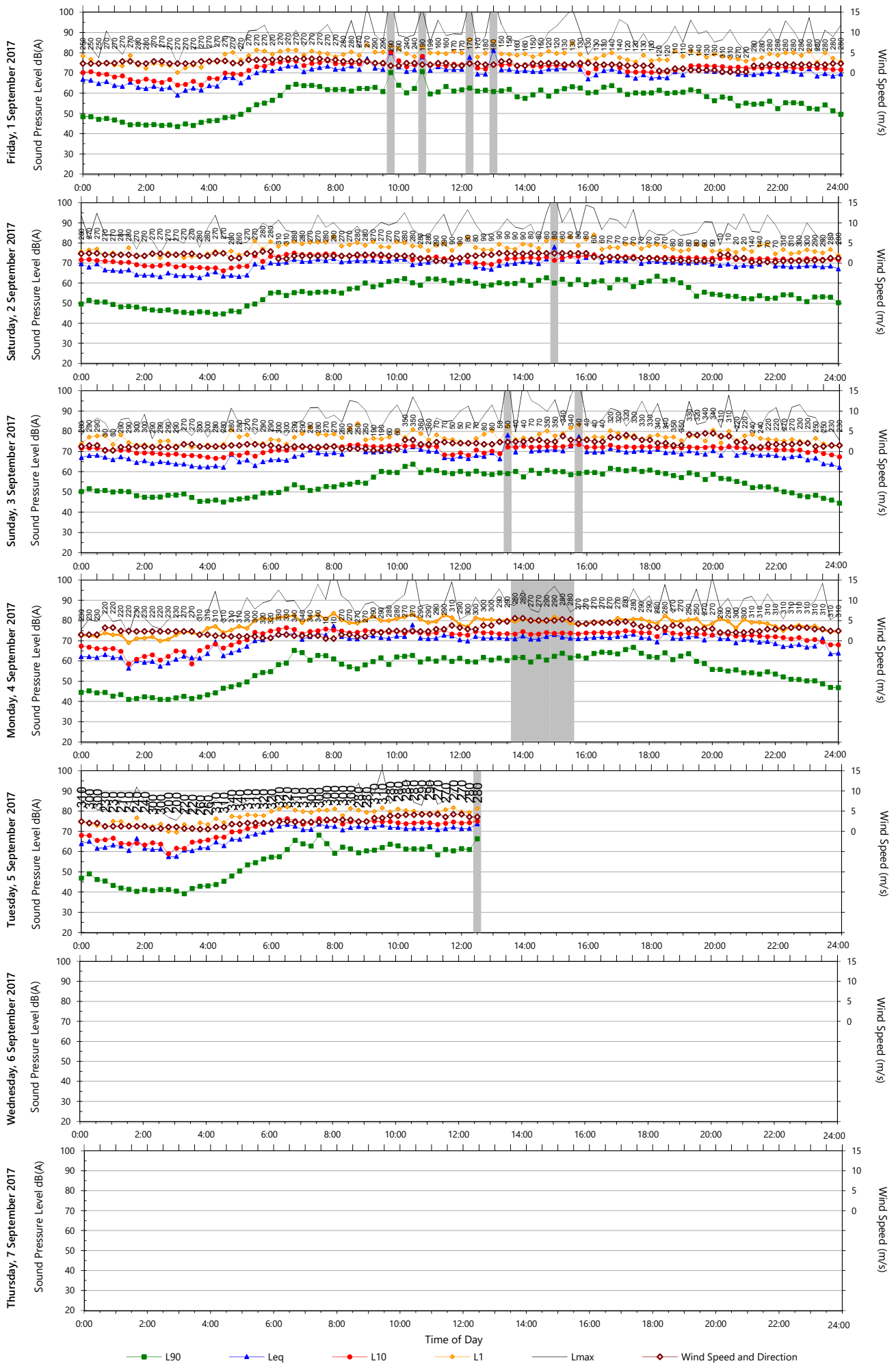
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 25 August 2017
Saturday, 26 August 2017
Sunday, 27 August 2017
Monday, 28 August 2017
Tuesday, 29 August 2017
Wednesday, 30 August 2017
Thursday, 31 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 1 September 2017
Saturday, 2 September 2017
Sunday, 3 September 2017
Monday, 4 September 2017
Tuesday, 5 September 2017
Wednesday, 6 September 2017
Thursday, 7 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L25
Address: 317 Ernest Street, Cammeray
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Ernest Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	58	54	41	69	66	62

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	71	65	

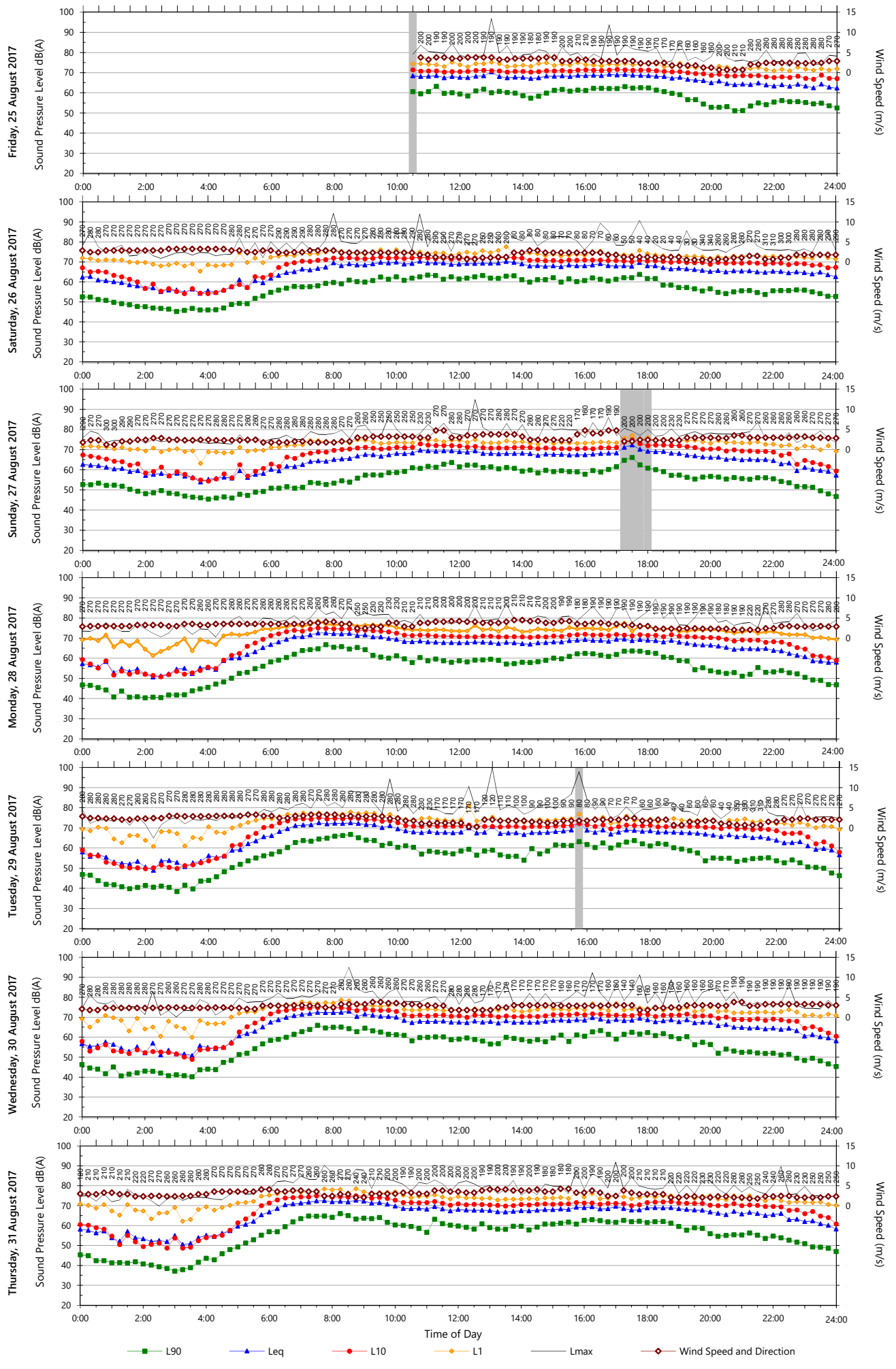
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph

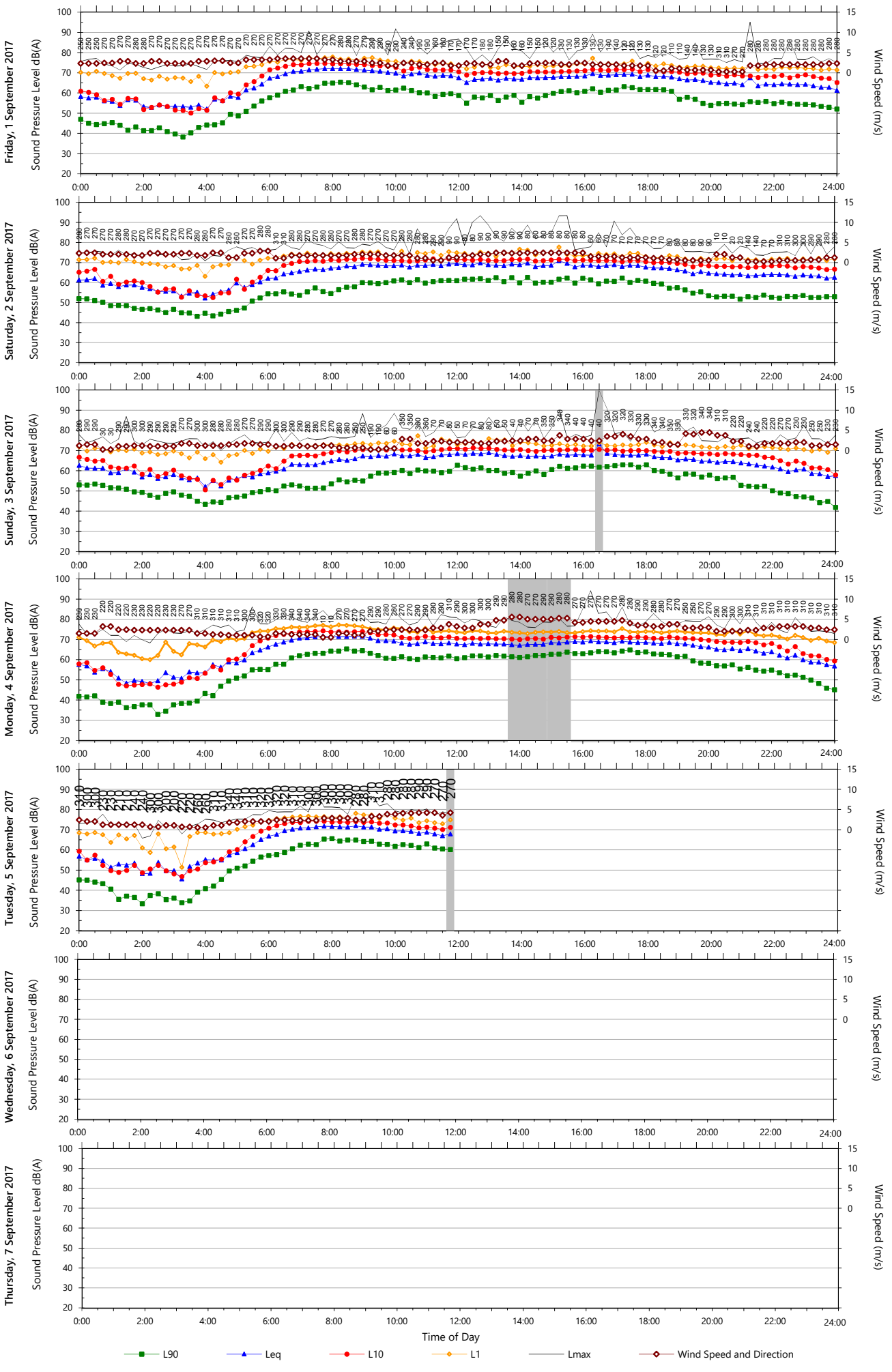





Friday, 25 August 2017
Saturday, 26 August 2017
Sunday, 27 August 2017
Monday, 28 August 2017
Tuesday, 29 August 2017
Wednesday, 30 August 2017
Thursday, 31 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results

Location: 317 Ernest St, Neutral Bay



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Monitoring ID: Location L26
Address: 225 Ernest Street, Cammeray
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Ernest Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	56	52	37	68	66	61

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

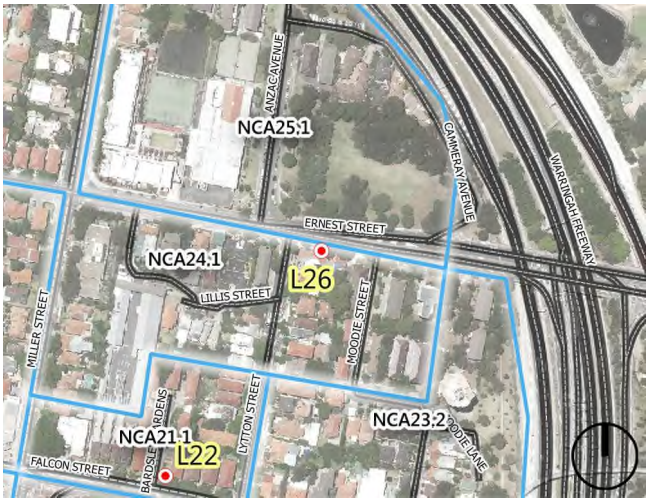
Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	70	64	

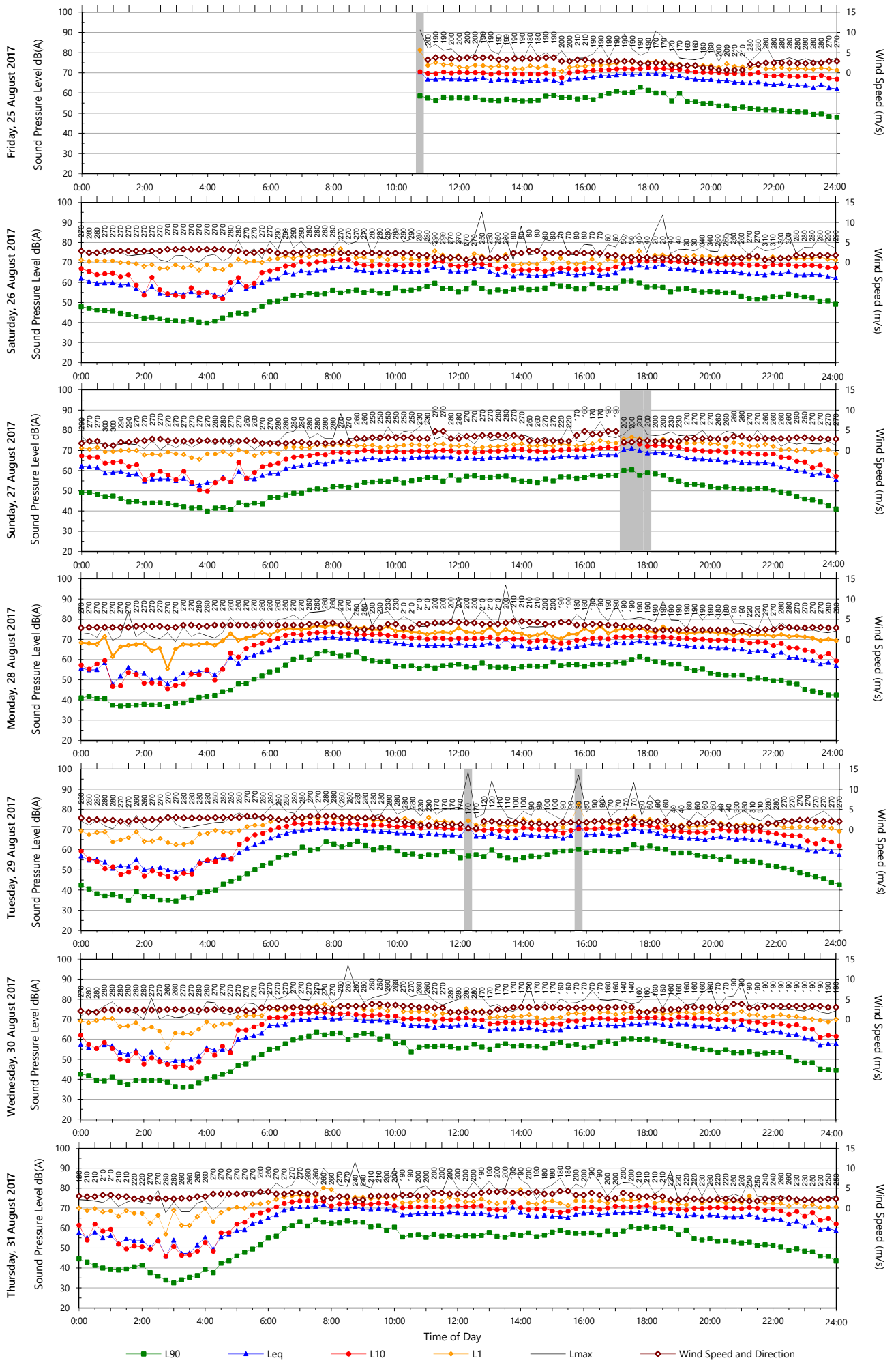
Notes:

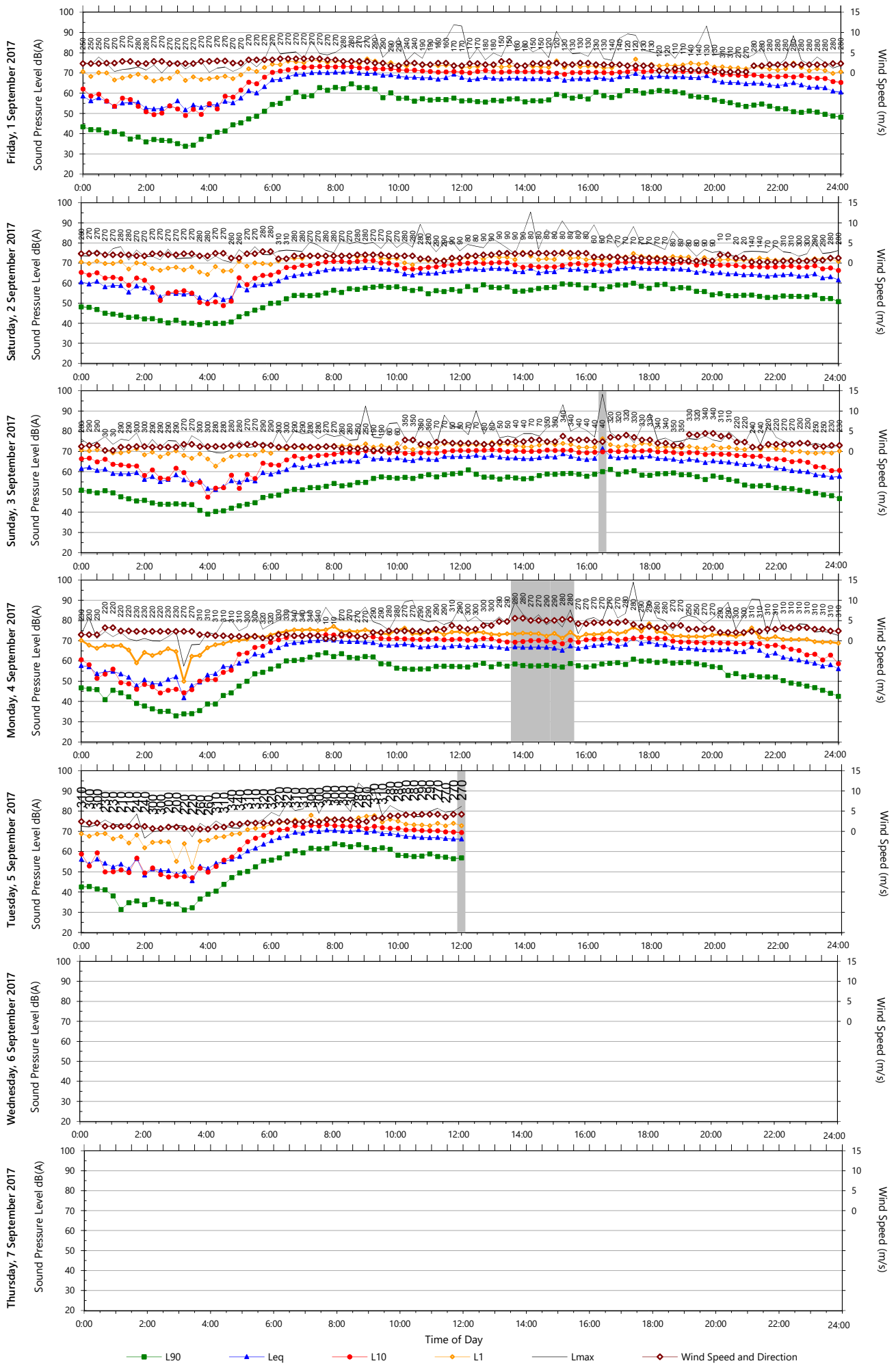
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 25 August 2017
Saturday, 26 August 2017
Sunday, 27 August 2017
Monday, 28 August 2017
Tuesday, 29 August 2017
Wednesday, 30 August 2017
Thursday, 31 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 1 September 2017
Saturday, 2 September 2017
Sunday, 3 September 2017
Monday, 4 September 2017
Tuesday, 5 September 2017
Wednesday, 6 September 2017
Thursday, 7 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L27
Address: 77 Rosalind Street, Cammeray
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	58	55	43	62	60	57

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	64	59	

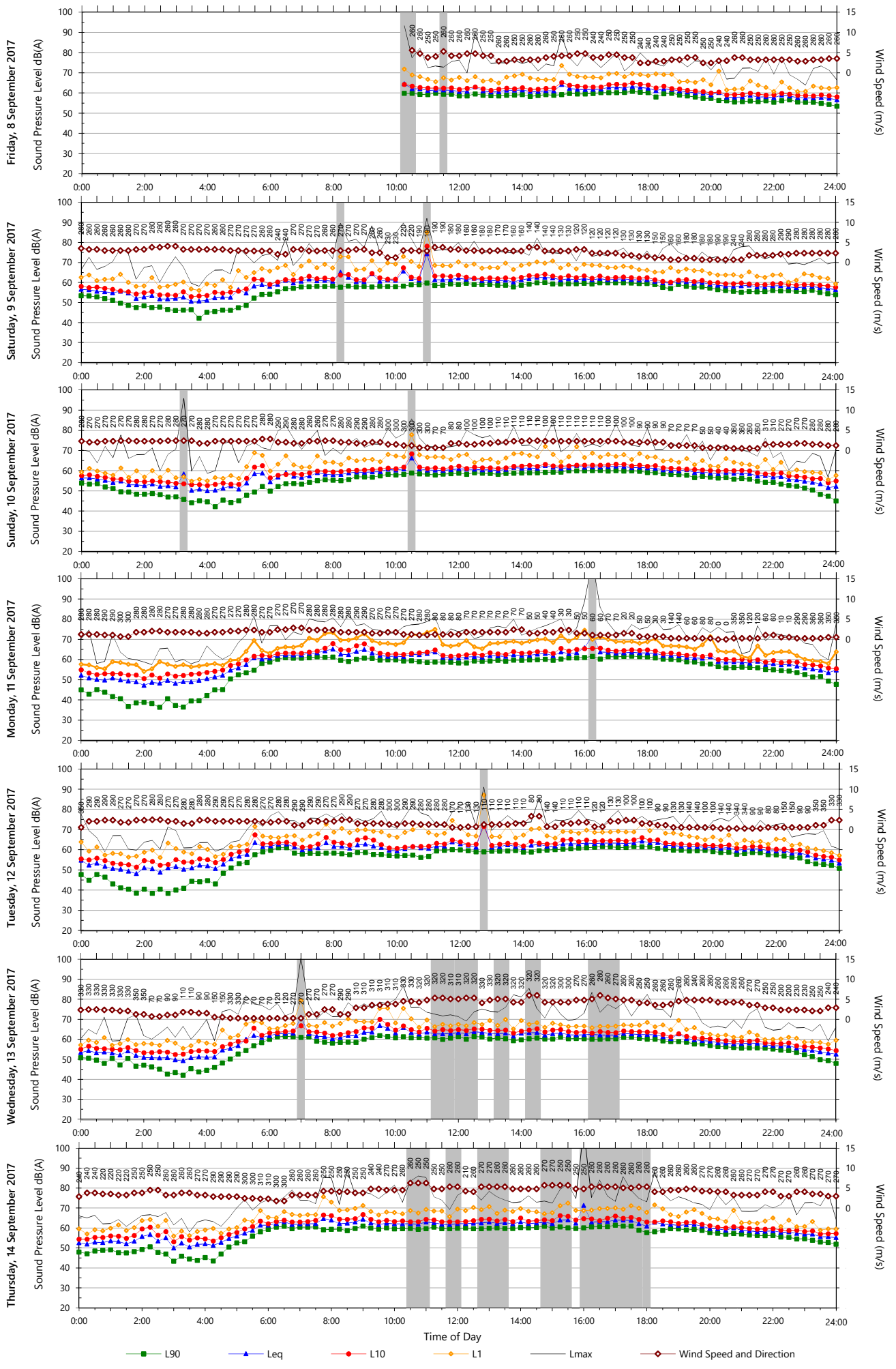
Notes:

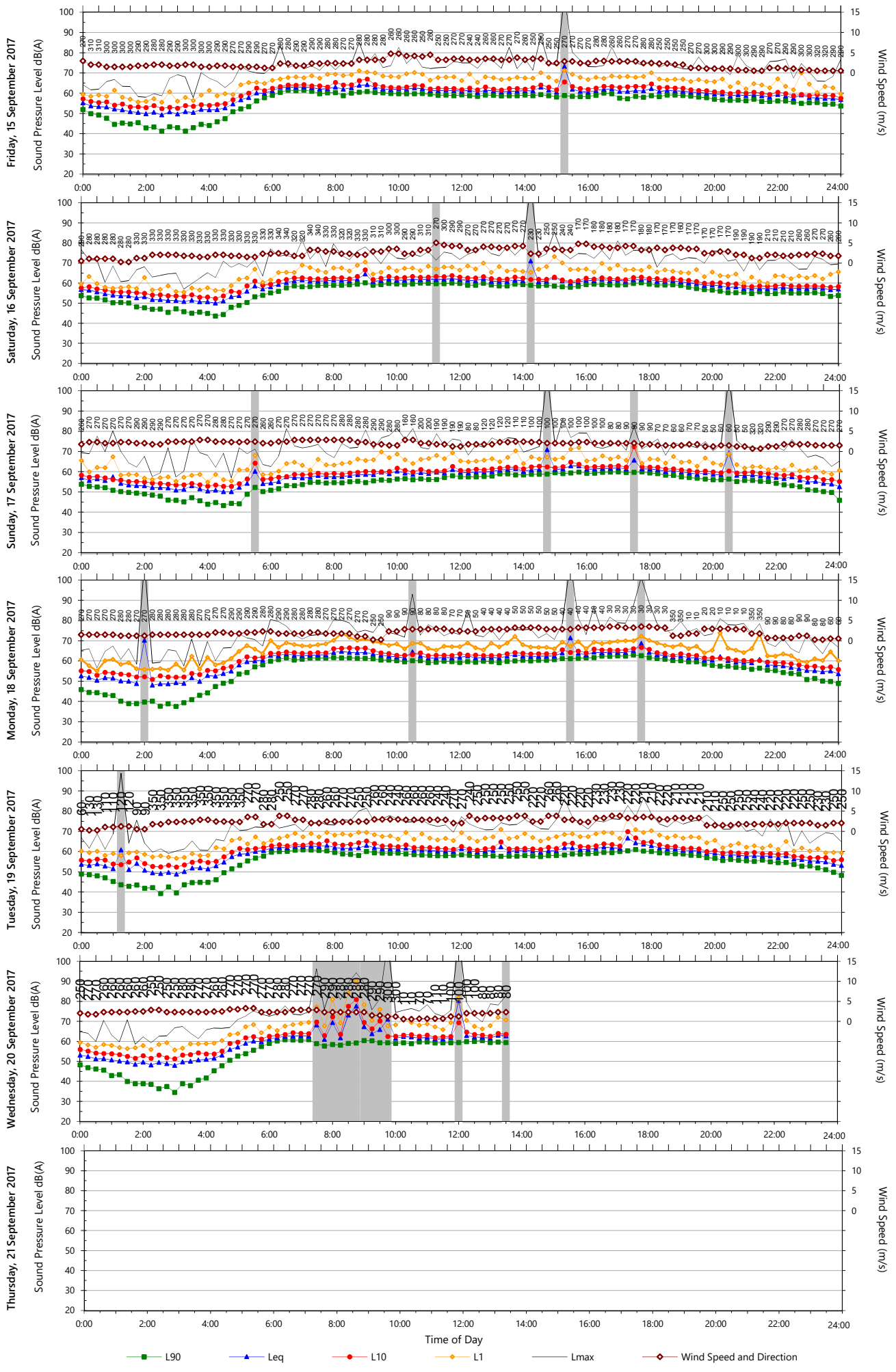
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Thursday, 14 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Thursday, 21 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L28
Address: 53 Bellevue Street, Cammeray
Description: Noise monitor located in the western side yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	64	63	47	67	67	64

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	70	66	

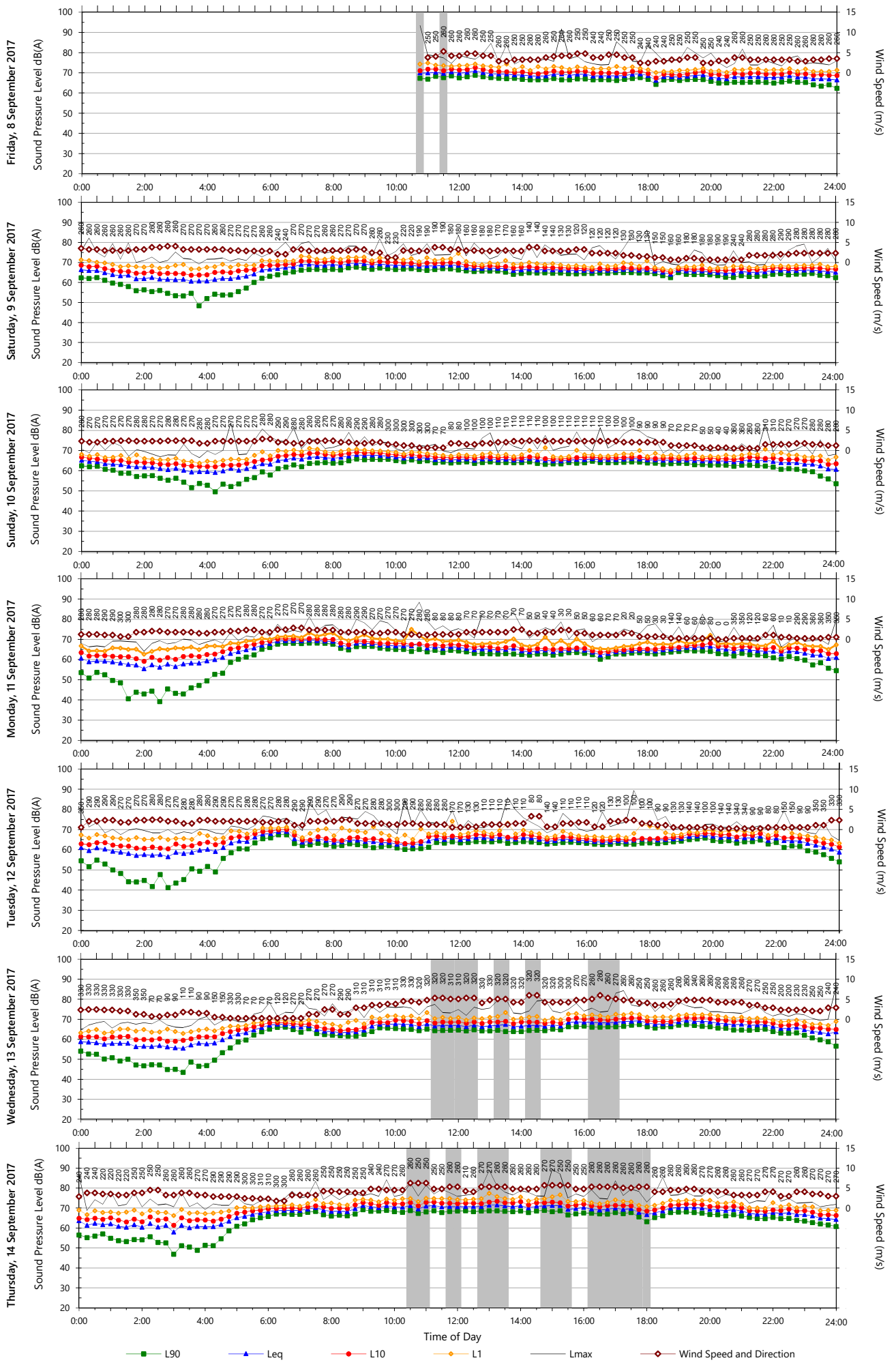
Notes:

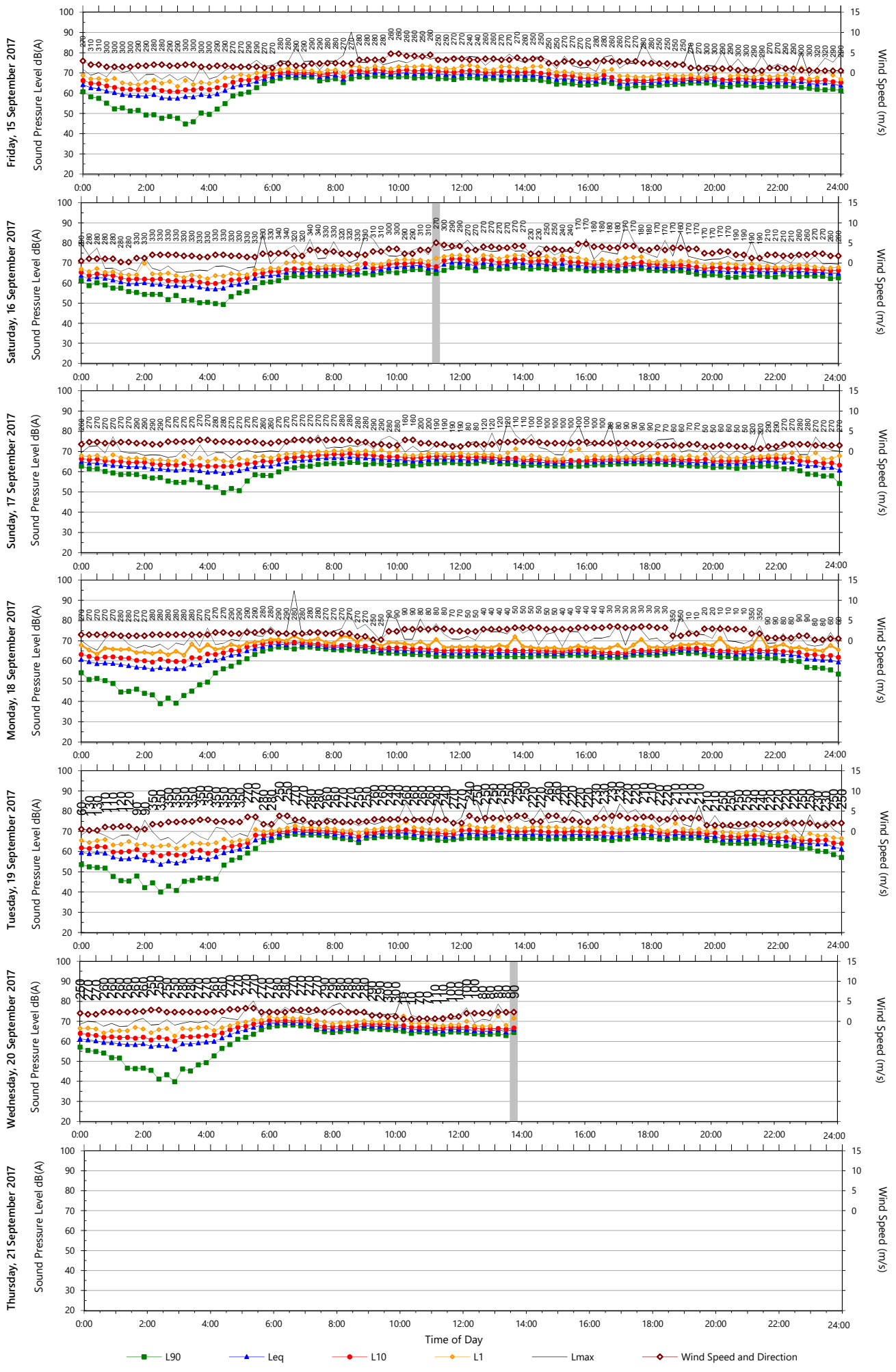
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Thursday, 14 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Thursday, 21 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L29
Address: 12 Warringa Road, Cammeray
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	47	45	37	54	51	48

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

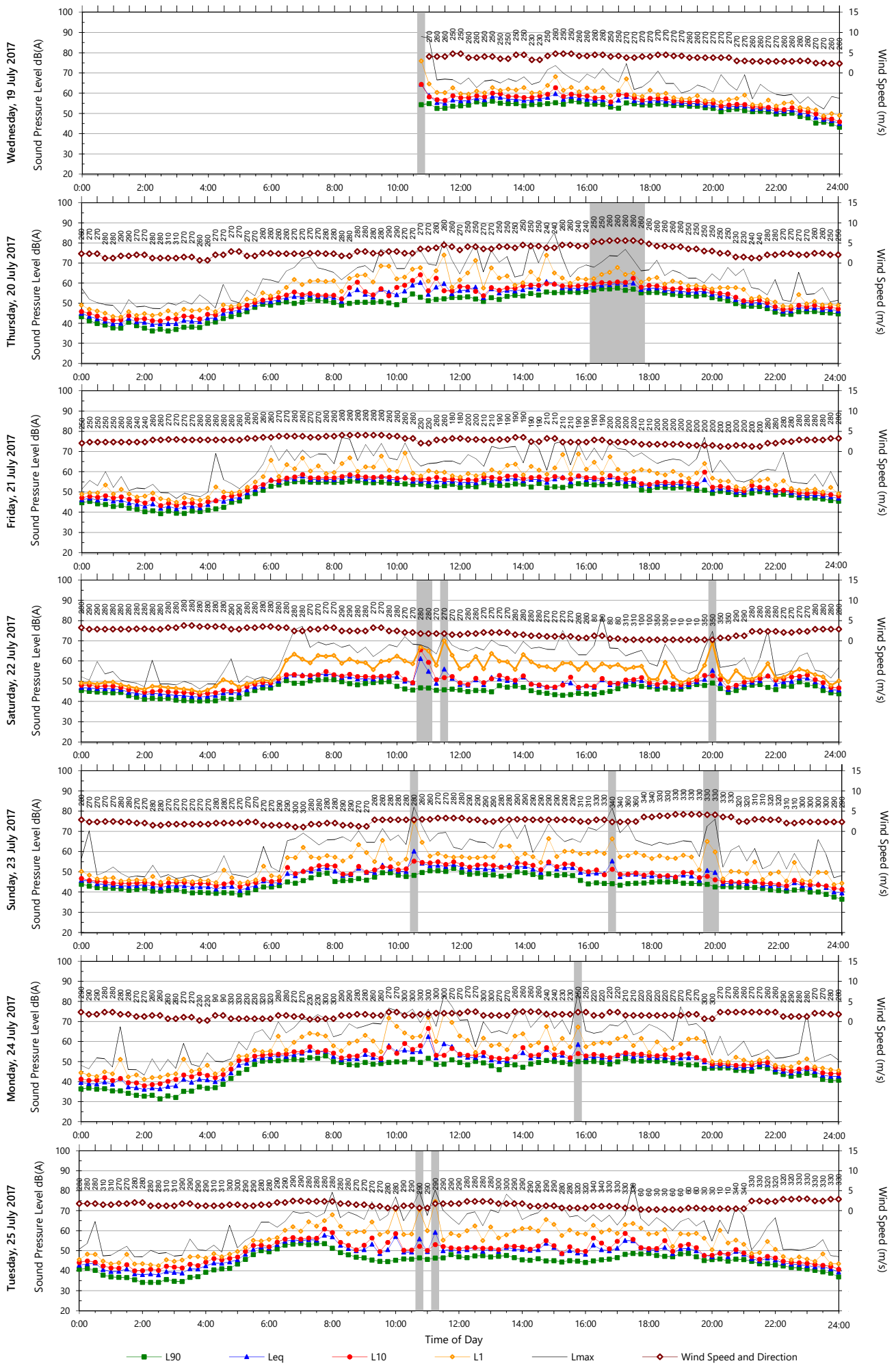
Notes:

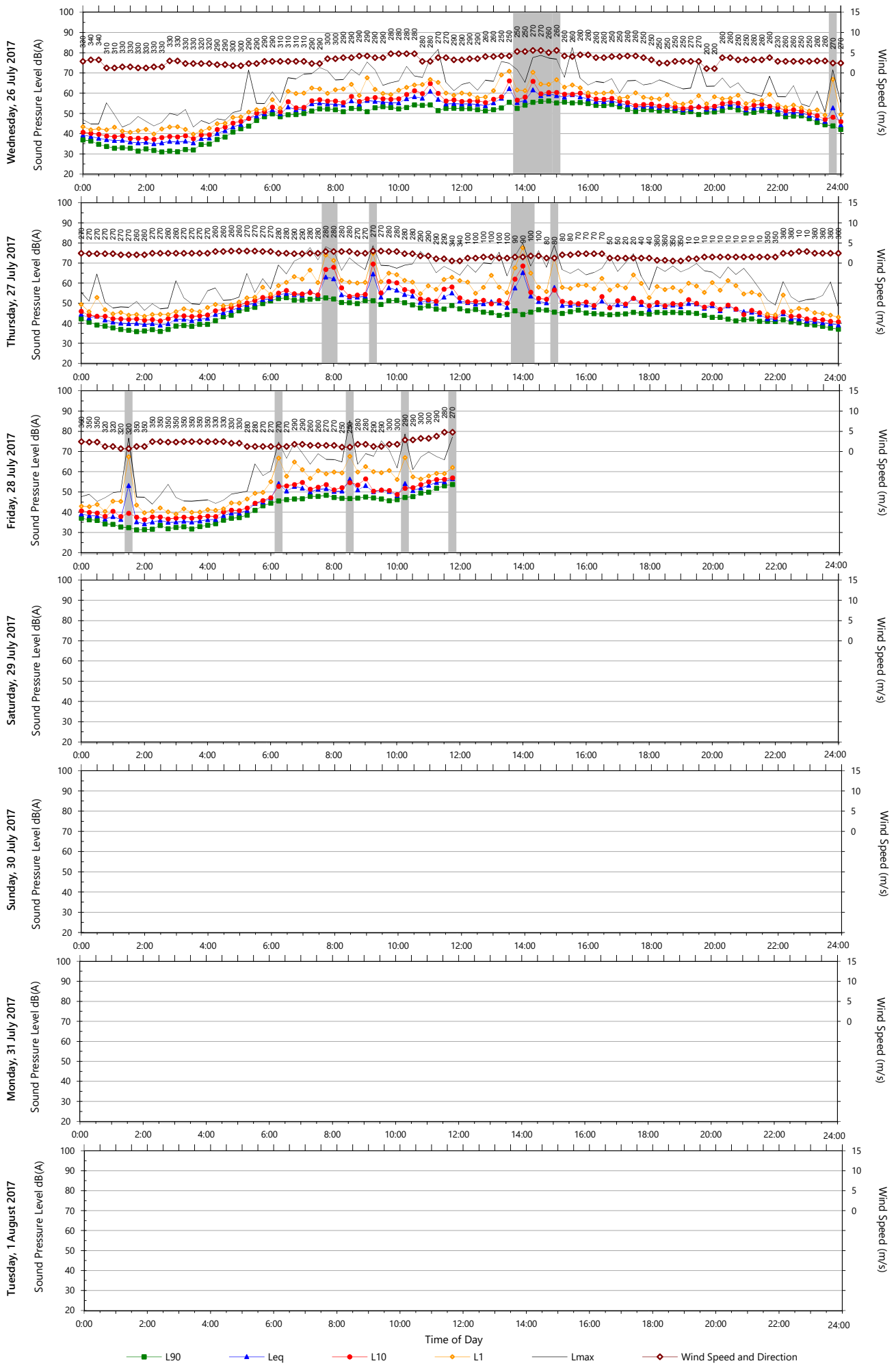
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 26 July 2017
Thursday, 27 July 2017
Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L30
Address: 57 Park Avenue, Cremorne
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by general neighbourhood noise and natural sounds.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	49	48	39	59	57	54

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

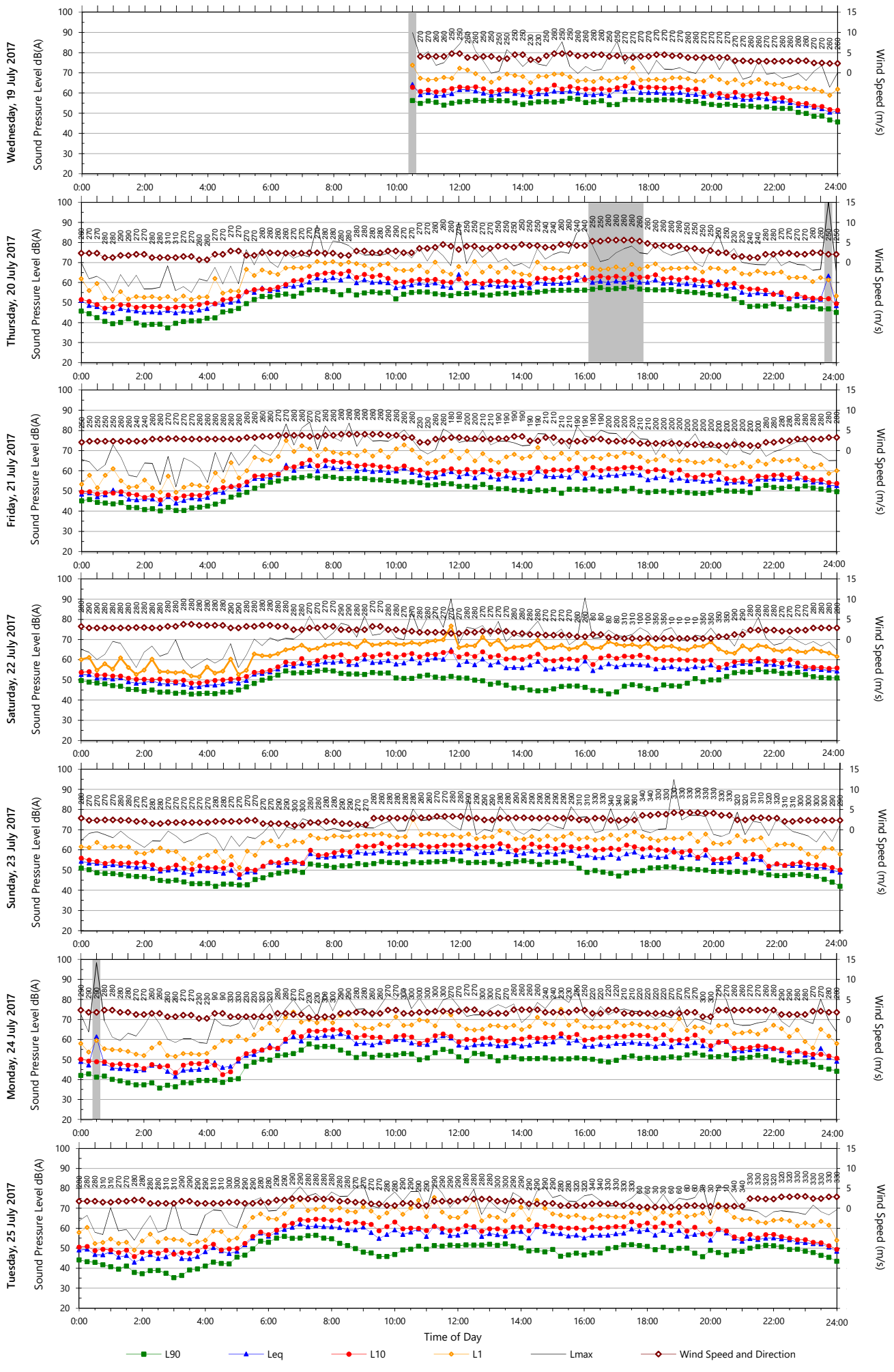
Notes:

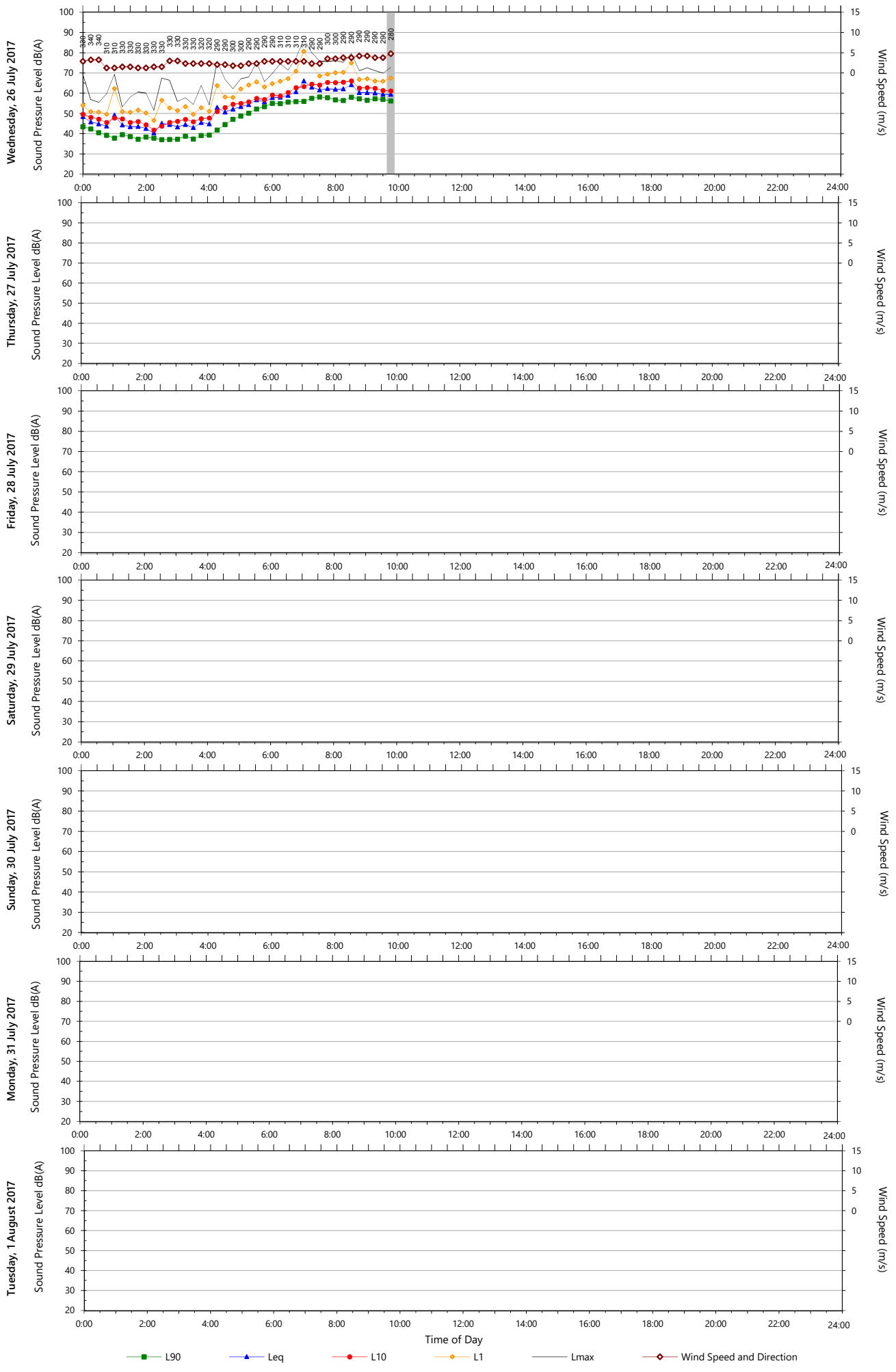
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 26 July 2017
Thursday, 27 July 2017
Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L31
Address: 18/22-24 Donnelly Road, Crows Nest
Description: Noise monitor located in the rear yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	58	56	38	62	61	58

Notes:

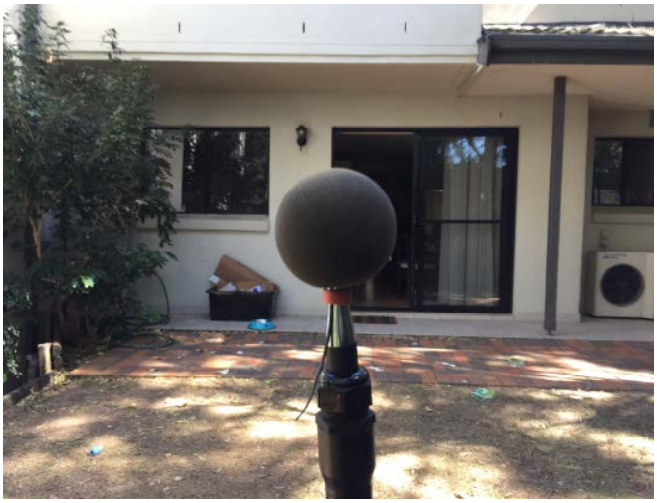
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	65	60

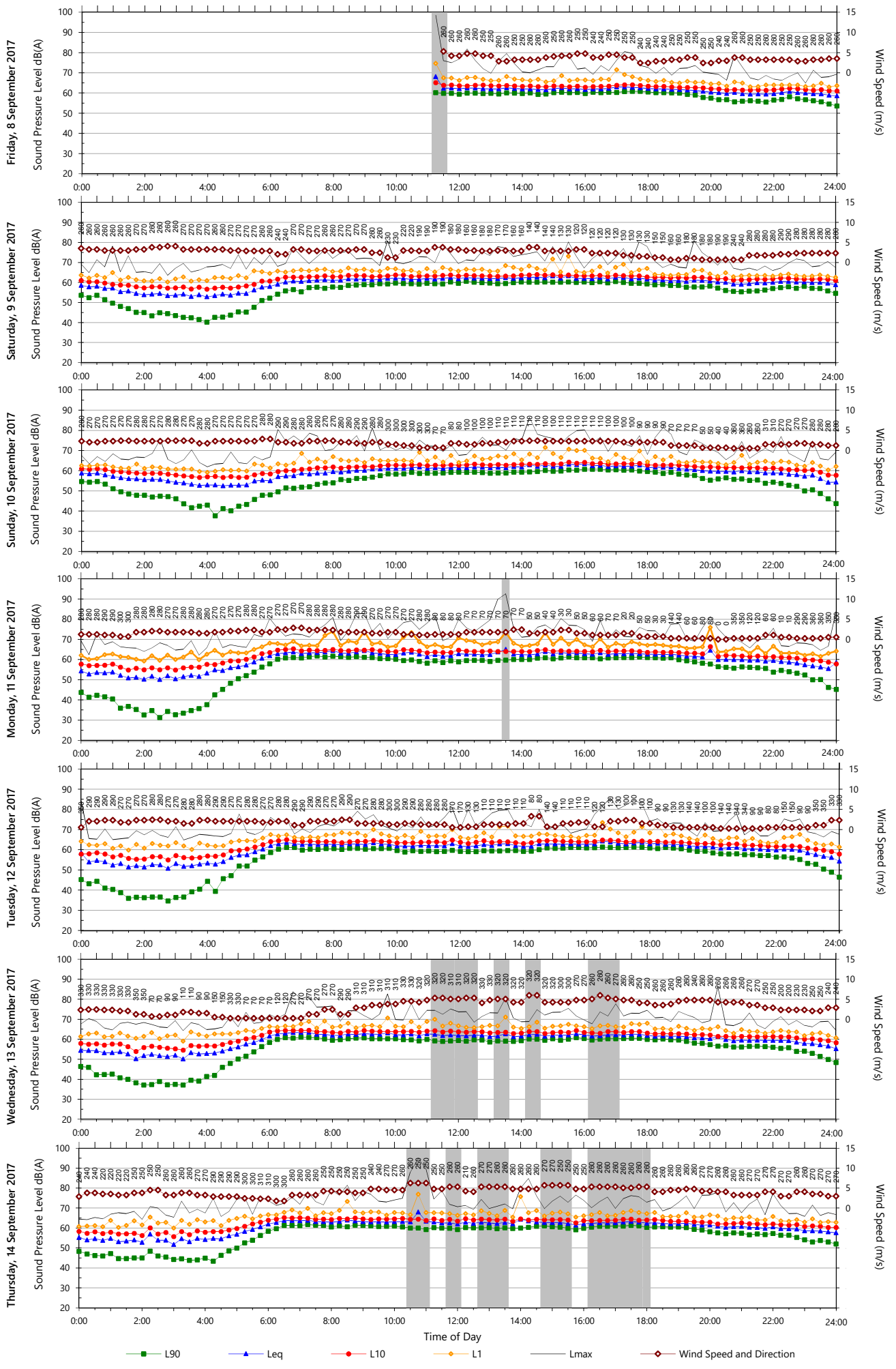
Notes:

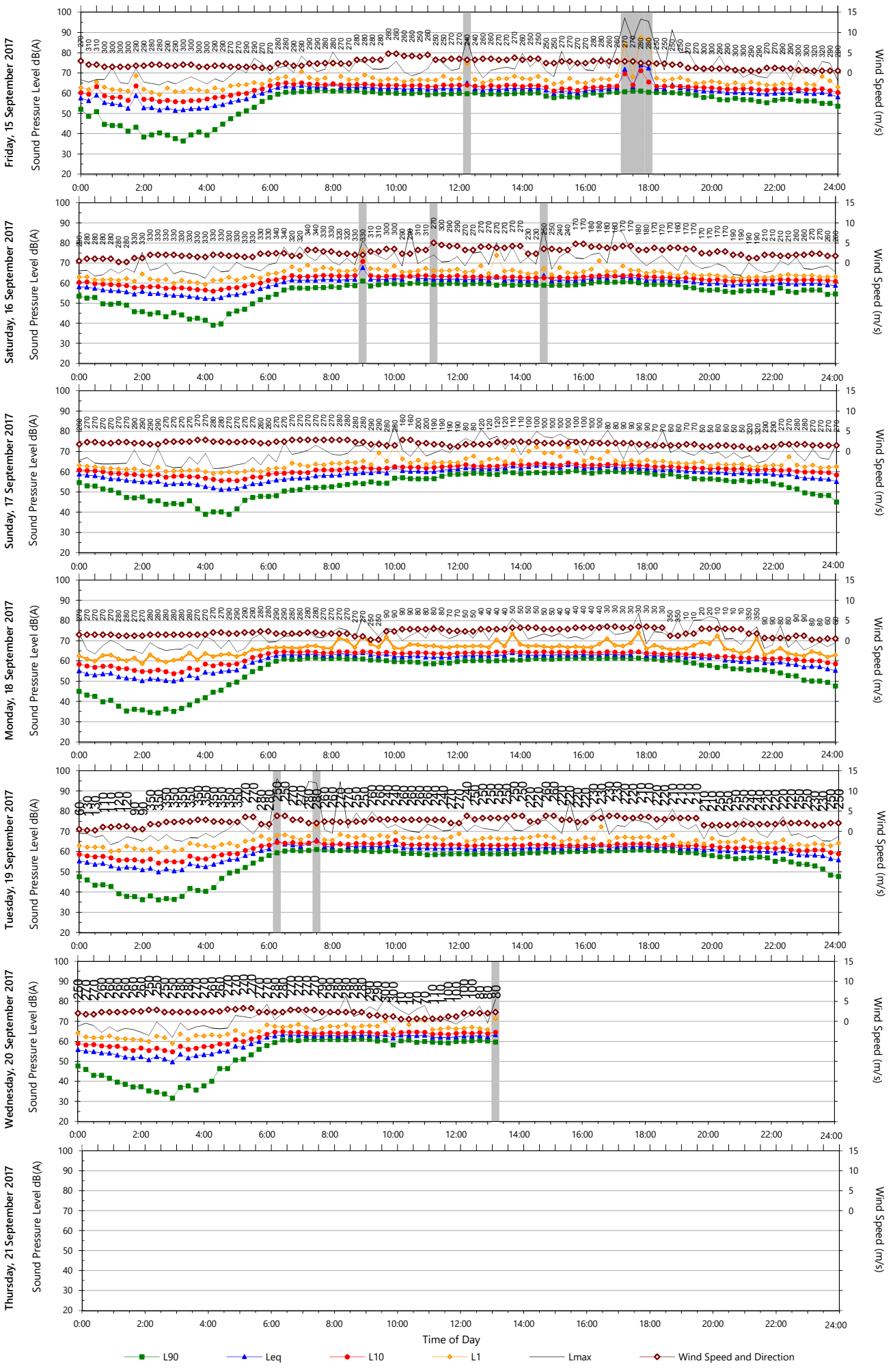
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Thursday, 14 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Thursday, 21 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L32
Address: 79 Brook Street, Naremburn
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Brook Street.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	56	49	37	71	69	65

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	73	67	

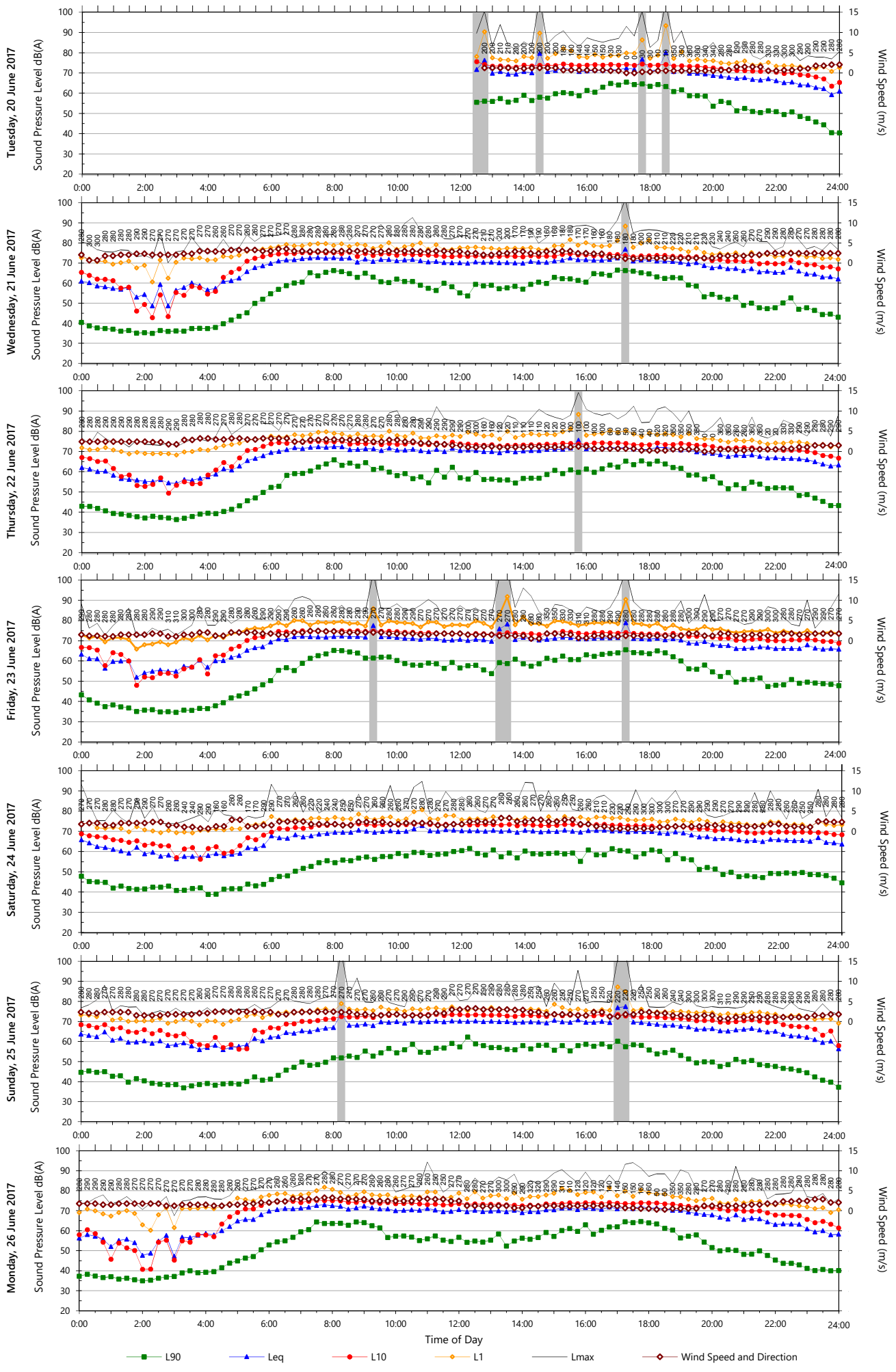
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph

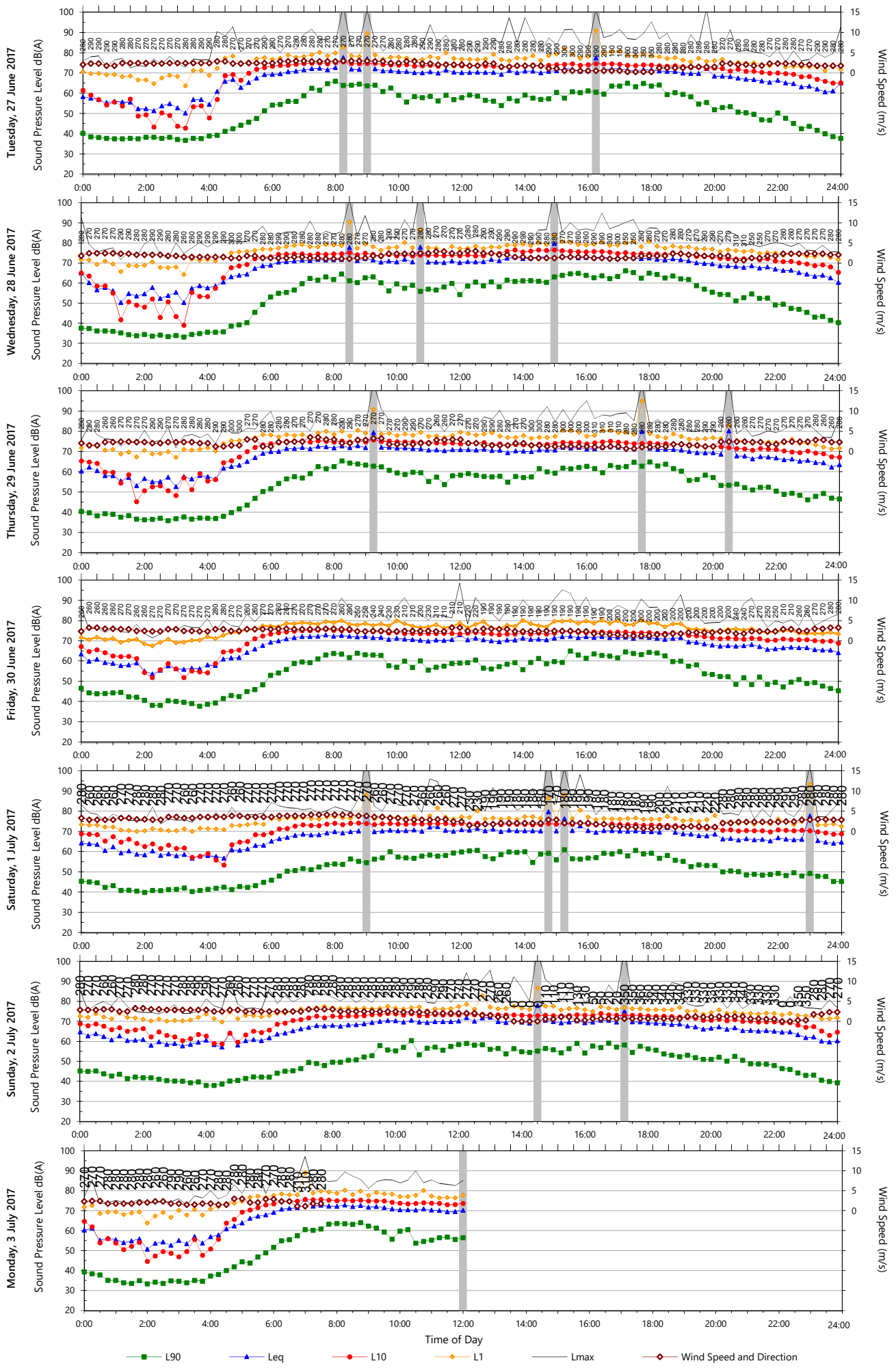





Tuesday, 20 June 2017
Wednesday, 21 June 2017
Thursday, 22 June 2017
Friday, 23 June 2017
Saturday, 24 June 2017
Sunday, 25 June 2017
Monday, 26 June 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results

Location: 79 Brook Street, Naremburn



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Monitoring ID: Location L33
Address: 20/2 Parkes Road, Artarmon
Description: Noise monitor located on the second-floor balcony in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	67	63	46	72	70	67

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

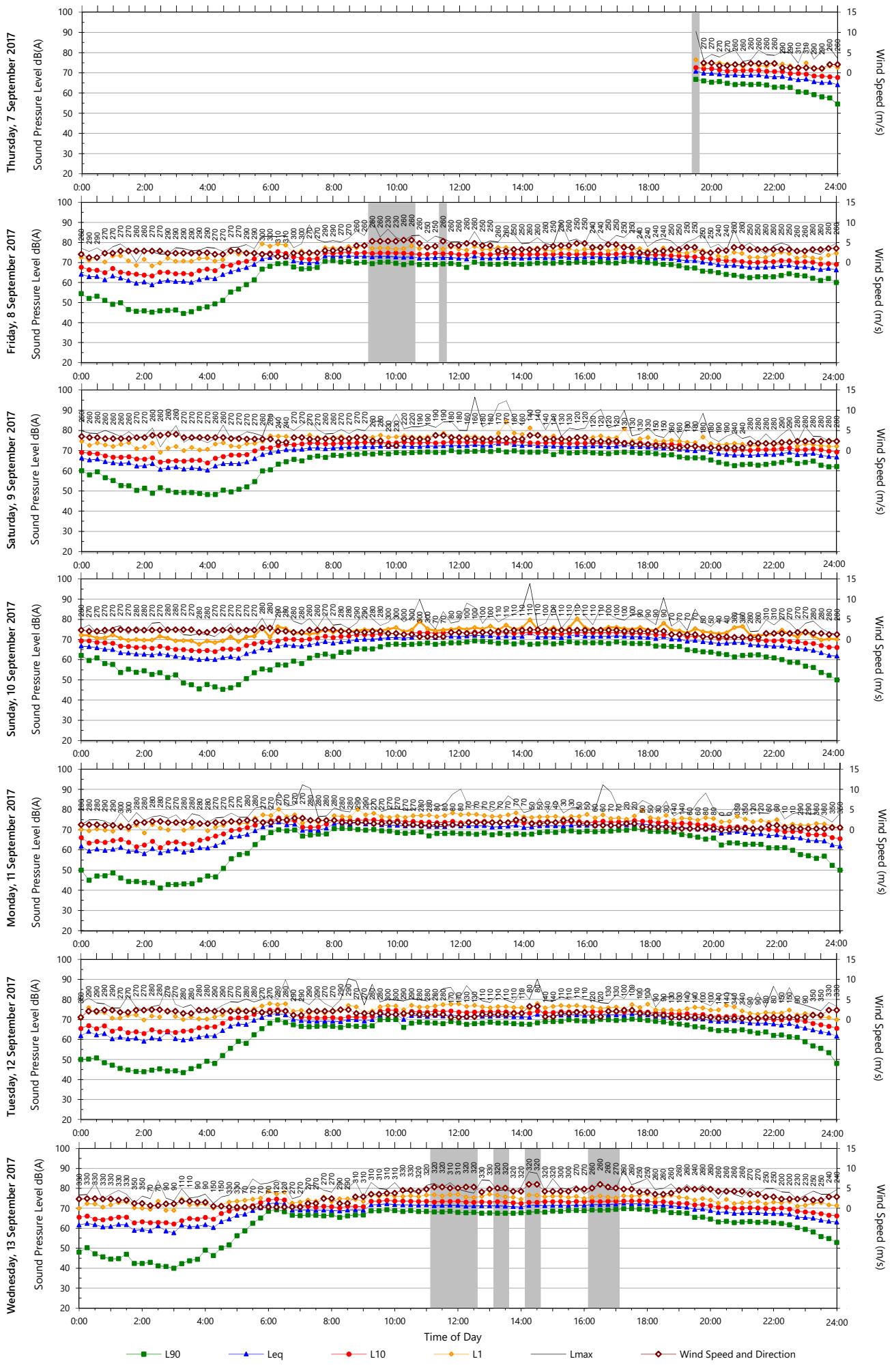
Notes:

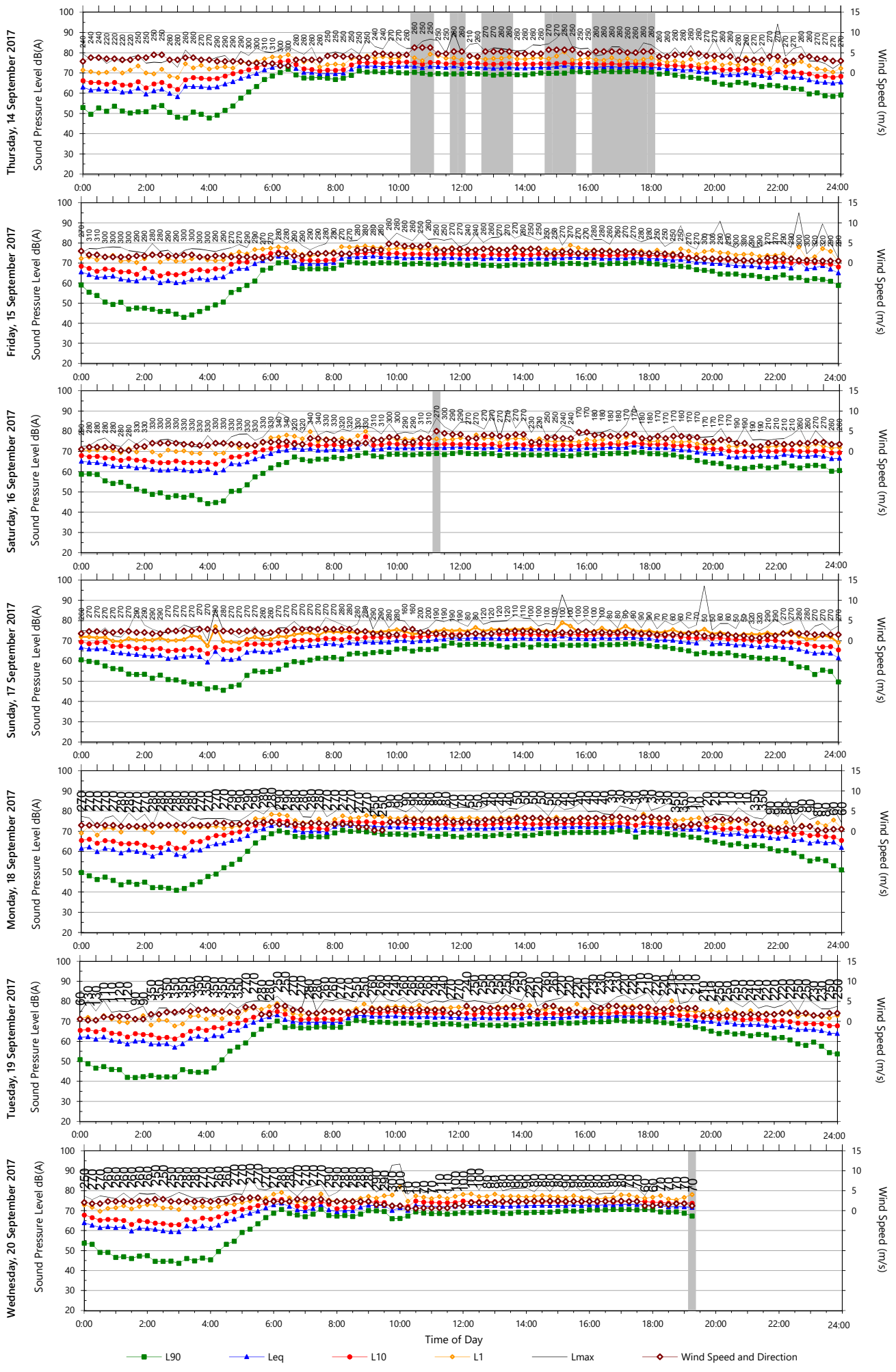
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Thursday, 7 September 2017
Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Thursday, 14 September 2017
Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L34
Address: 3/2 Cleland Road, Artarmon
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	55	53	40	59	58	55

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

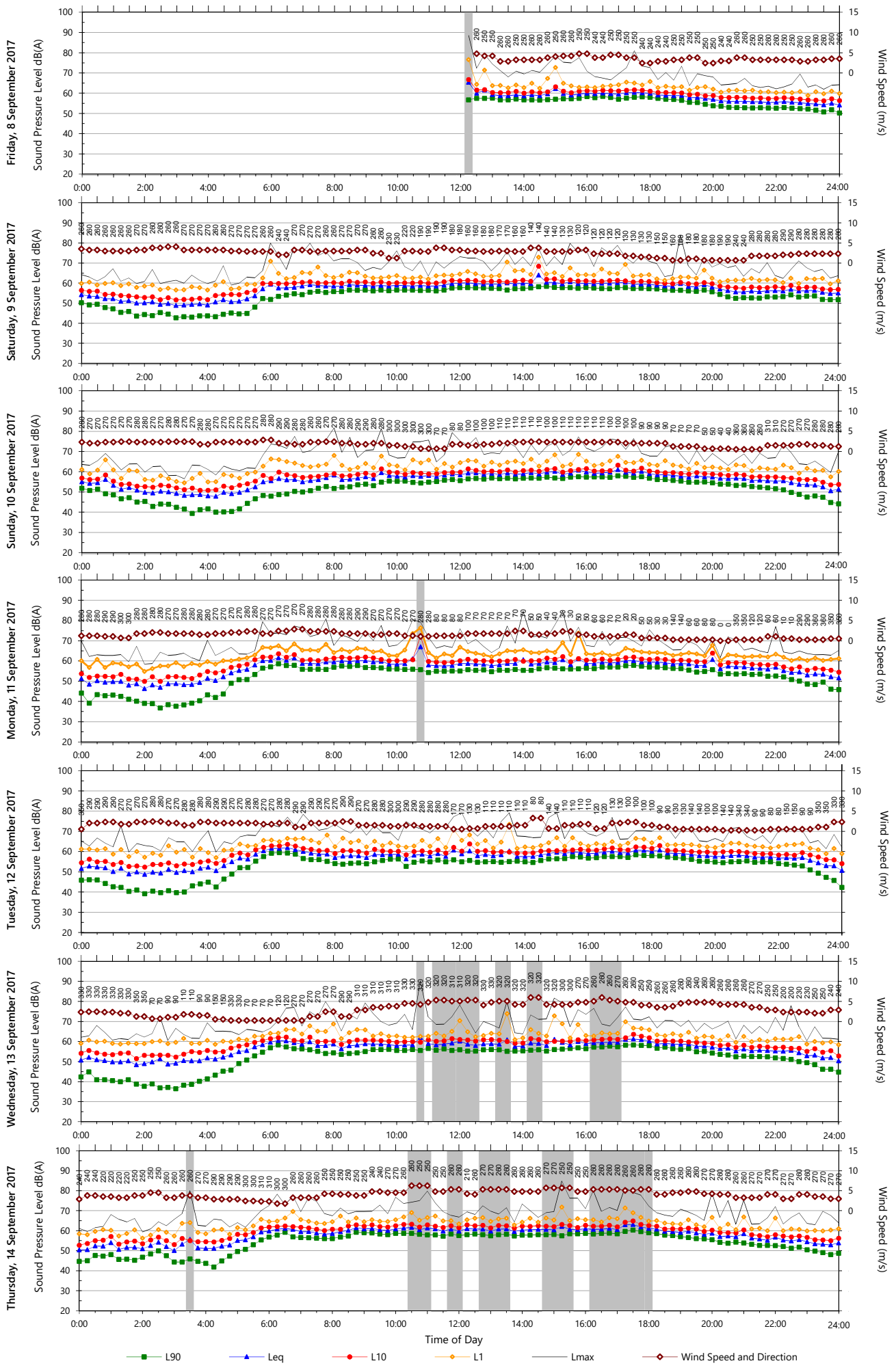
Notes:

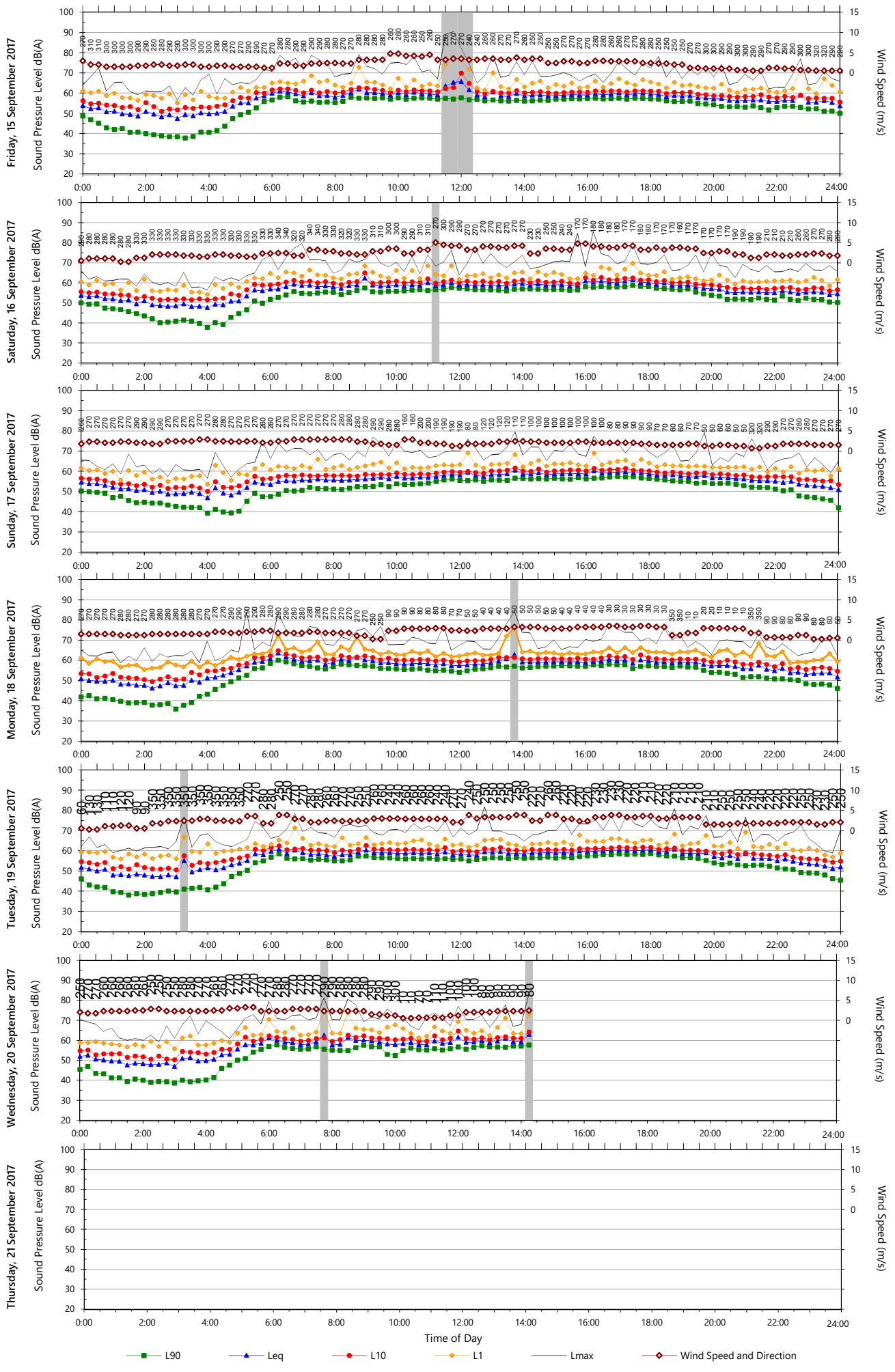
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Thursday, 14 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Thursday, 21 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L35
Address: 1 Chelmsford Avenue, Naremburn
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	59	55	40	63	61	58

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

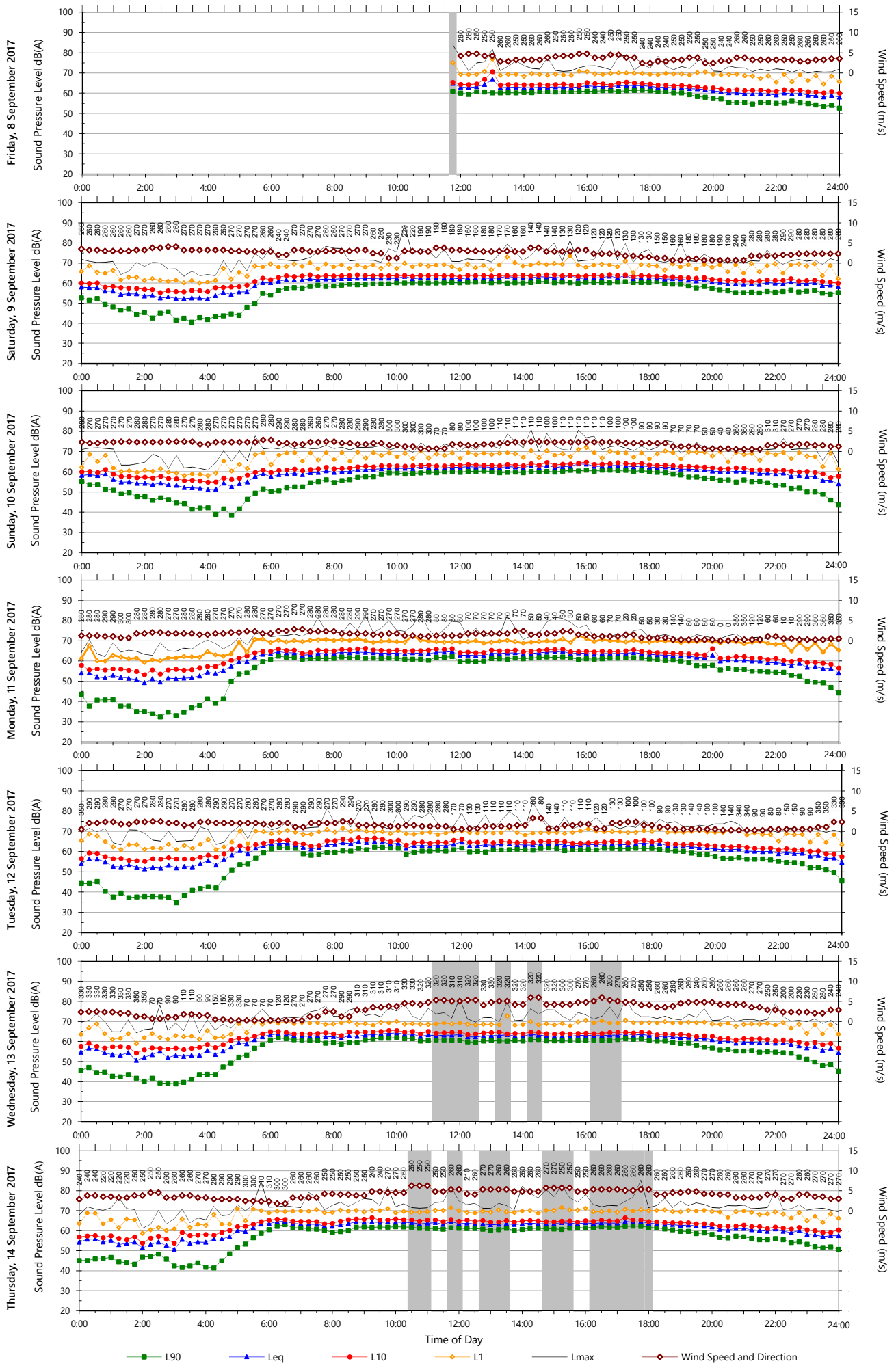
Notes:

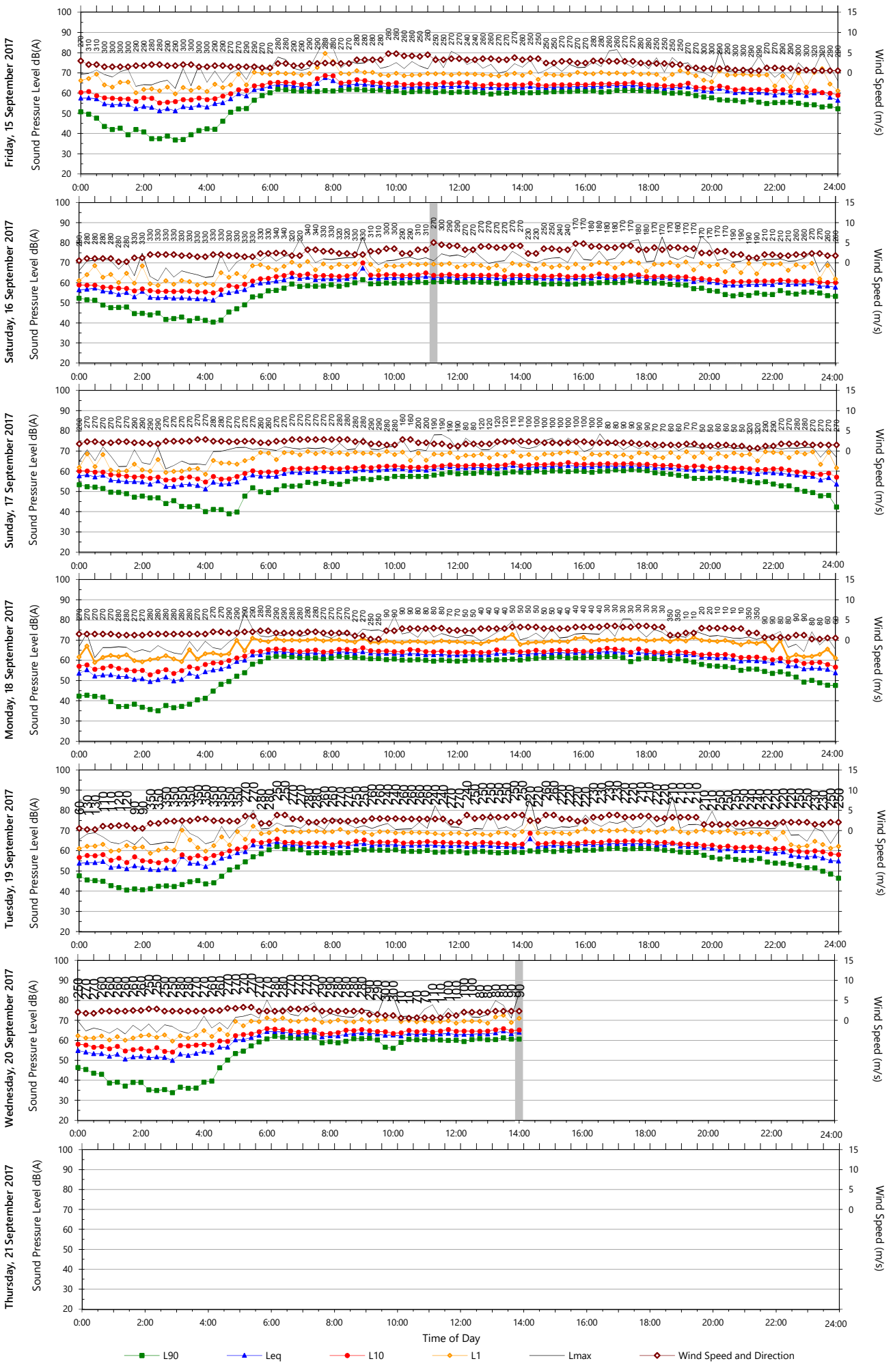
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Friday, 8 September 2017
Saturday, 9 September 2017
Sunday, 10 September 2017
Monday, 11 September 2017
Tuesday, 12 September 2017
Wednesday, 13 September 2017
Thursday, 14 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Friday, 15 September 2017
Saturday, 16 September 2017
Sunday, 17 September 2017
Monday, 18 September 2017
Tuesday, 19 September 2017
Wednesday, 20 September 2017
Thursday, 21 September 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L36
Address: 2 Burra Road, Artarmon
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by noise from nature.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	44	44	37	53	50	46

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

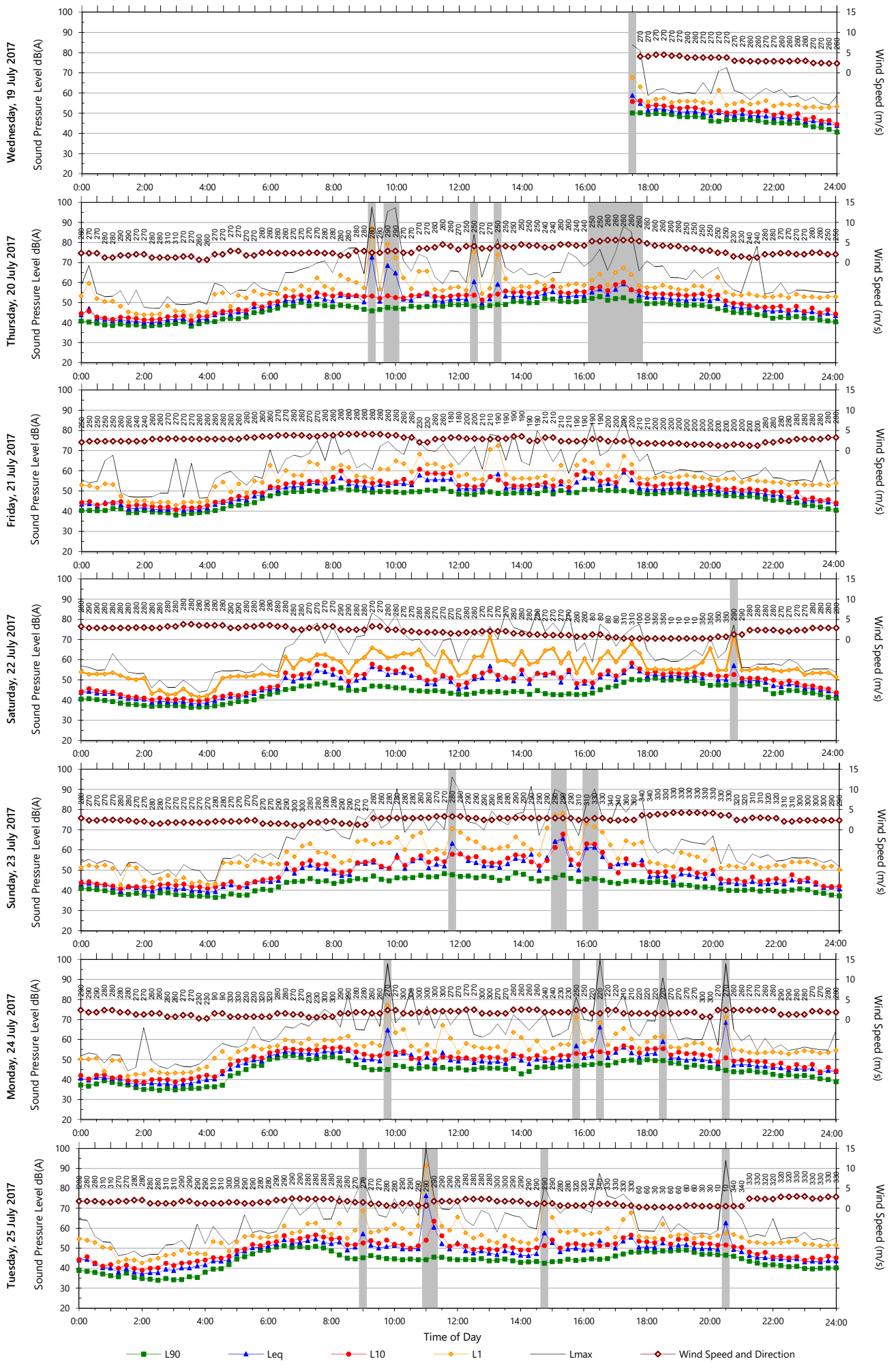
Logger Location	Aerial Photograph





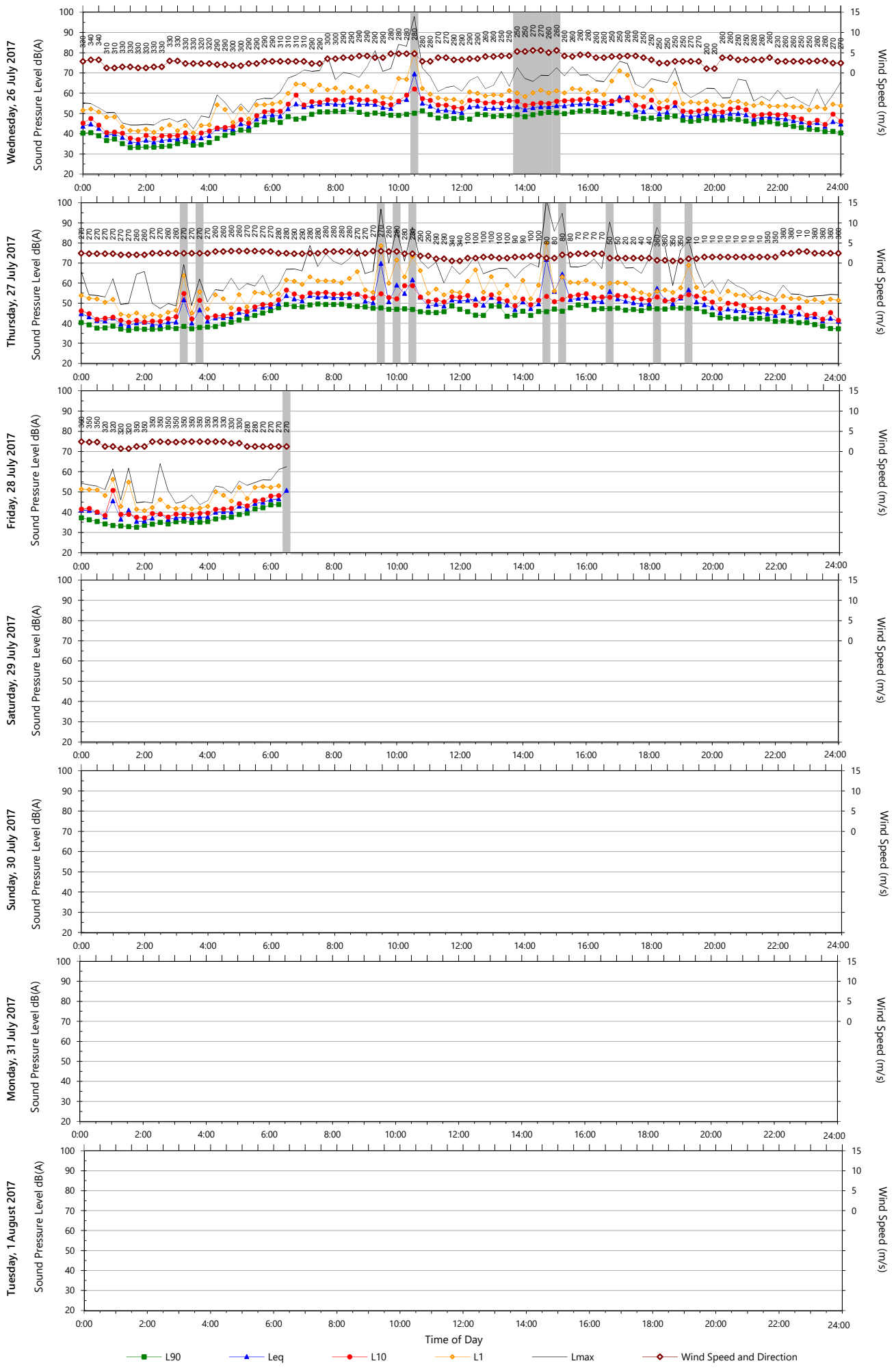
Unattended Monitoring Results

Location: 2 Burra Road, Artarmon



Unattended Monitoring Results

Location: 2 Burra Road, Artarmon



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Monitoring ID: Location L37
Address: 16 Walter Street, Willoughby
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	50	48	38	55	52	49

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)		
	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

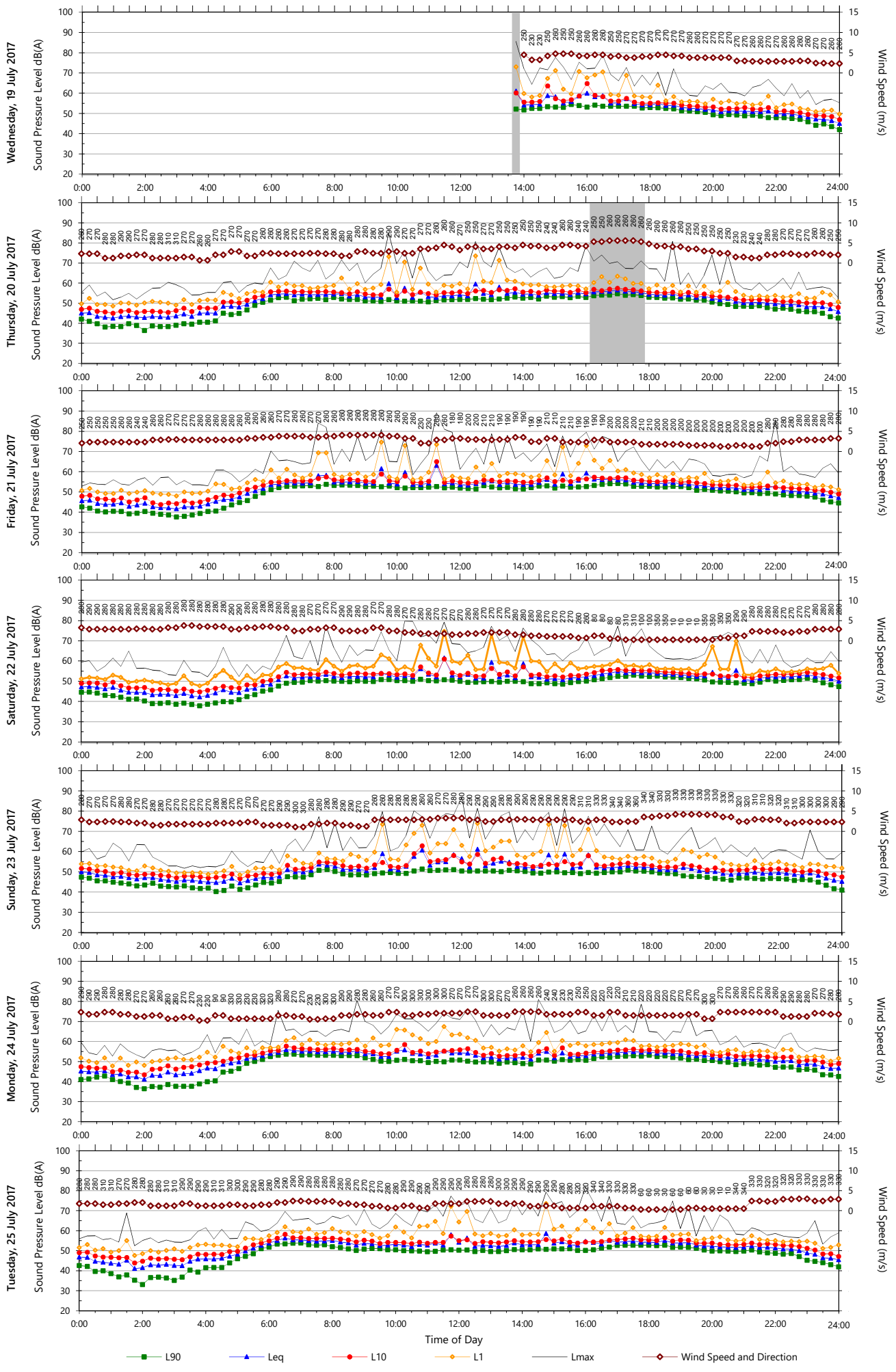
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph

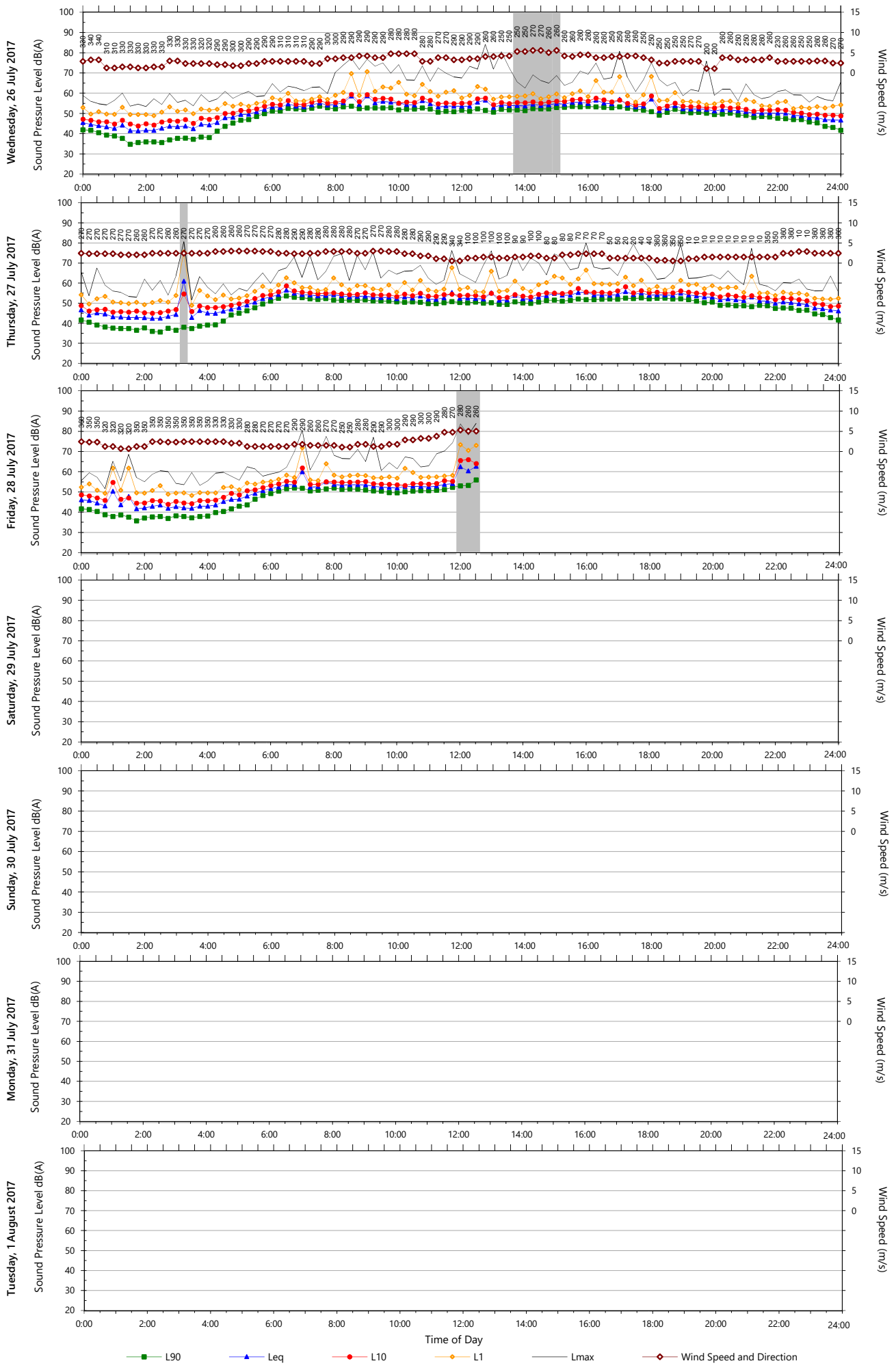





Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results

Location: 16 Walter Street, Willoughby



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Monitoring ID: Location L38
Address: 27 Garland Street, Naremburn
Description: Noise monitor located on the rear balcony and positioned in the free-field. Noise environment dominated by traffic on the Warringah Freeway.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	45	44	34	53	52	48

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

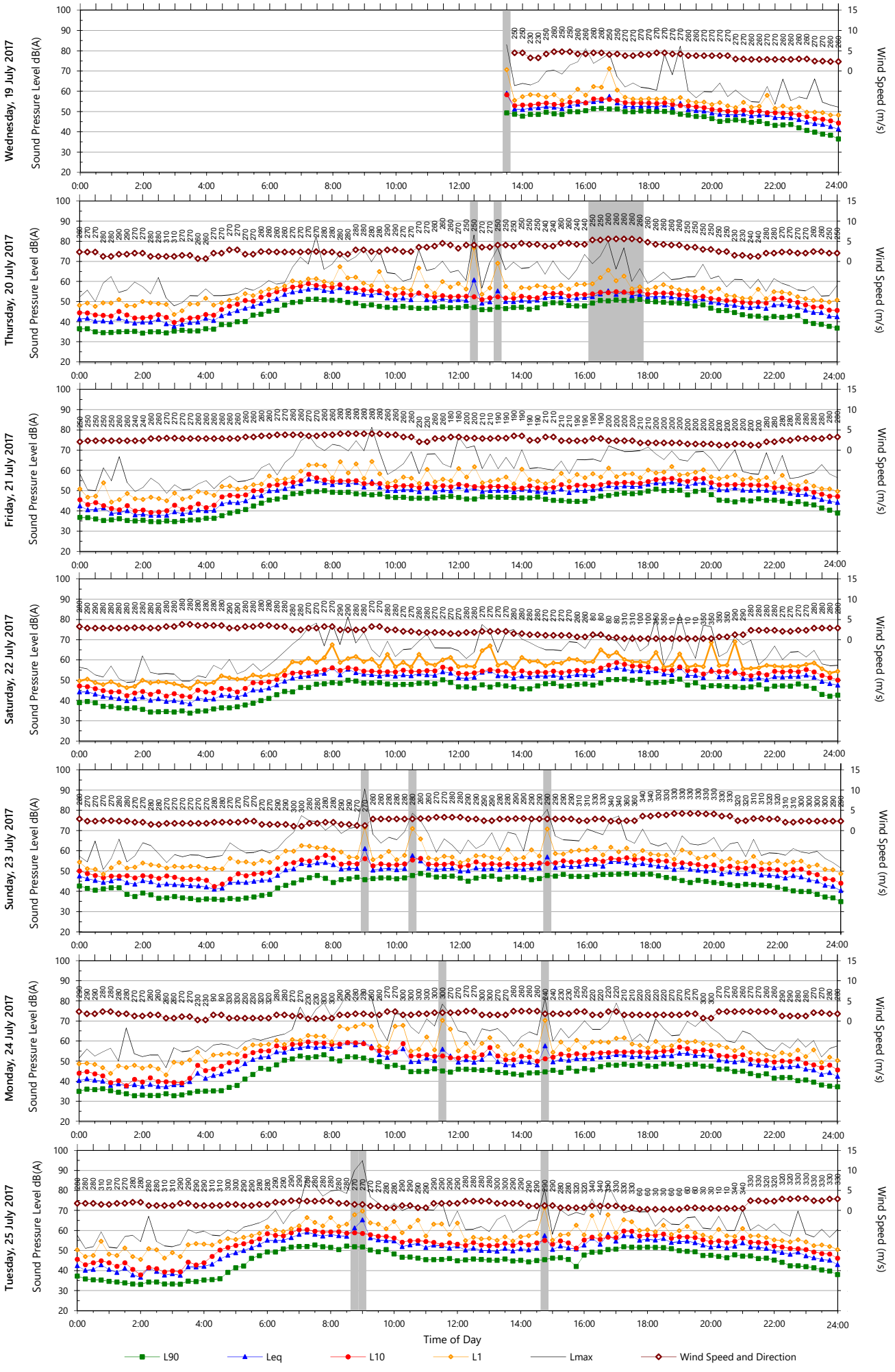
Logger Location	Aerial Photograph

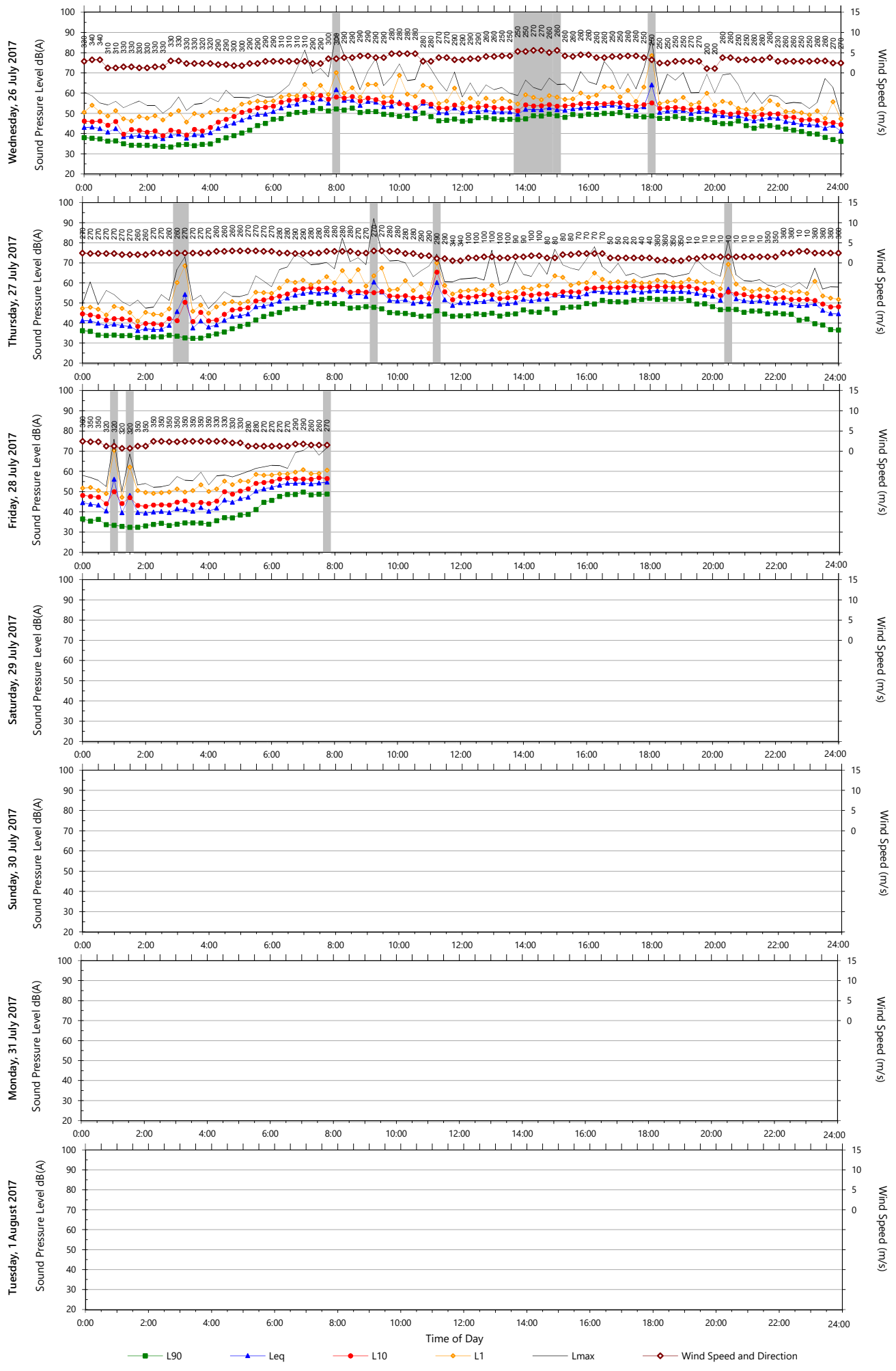




Unattended Monitoring Results

Location: 27 Garland Street, Naremburn




Wednesday, 26 July 2017
Thursday, 27 July 2017
Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L39
Address: 2 Pyalla Street, Northbridge
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by noise from nature.

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	52	48	37	60	56	57

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)			
	L_{Aeq} Noise Levels		
	Day[1]	Night[2]	
Representative Week[3]	-	-	

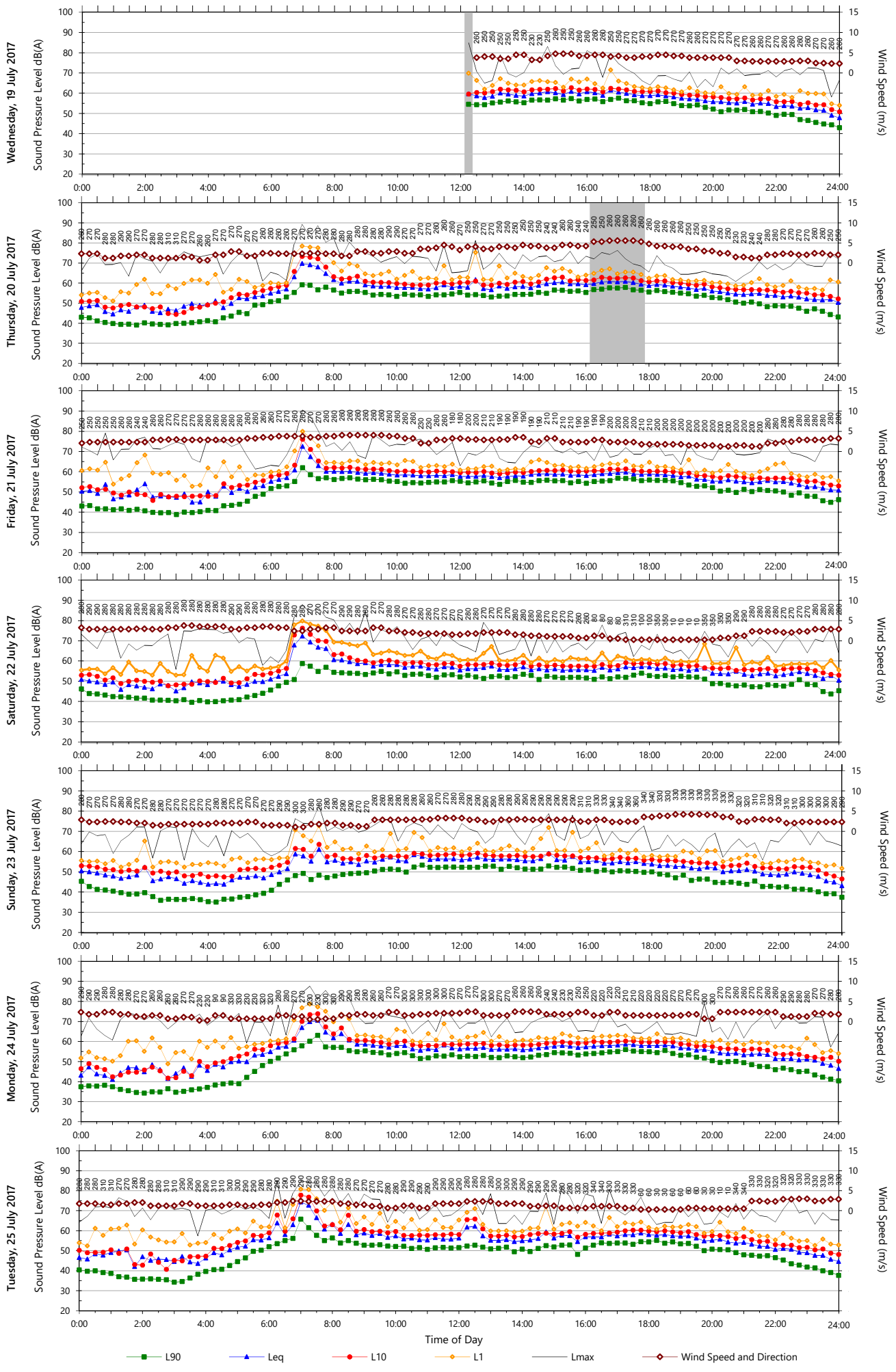
Notes:

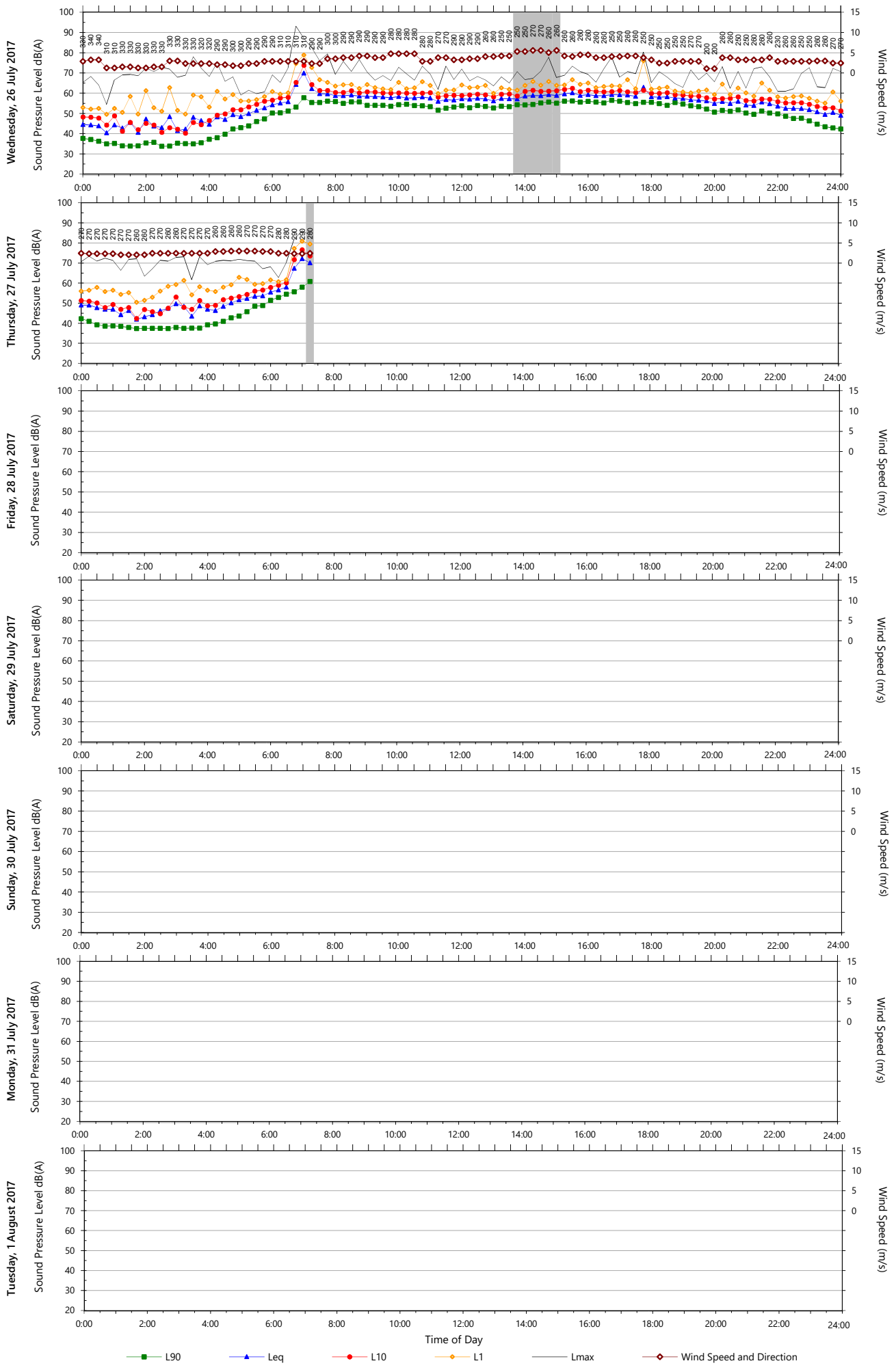
1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction


Wednesday, 26 July 2017
Thursday, 27 July 2017
Friday, 28 July 2017
Saturday, 29 July 2017
Sunday, 30 July 2017
Monday, 31 July 2017
Tuesday, 1 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

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Monitoring ID: Location L40
Address: 375 Sailors Bay Road, Northbridge
Description: Noise monitor located in the front yard and positioned in the free-field. Noise environment dominated by traffic on Sailors Bay Road.

Background & Ambient Noise Monitoring Results

	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	43	40	36	66	63	58

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road Monitoring Results (at one metre from façade)

	L_{Aeq} Noise Levels	
	Day[1]	Night[2]
Representative Week[3]	-	-

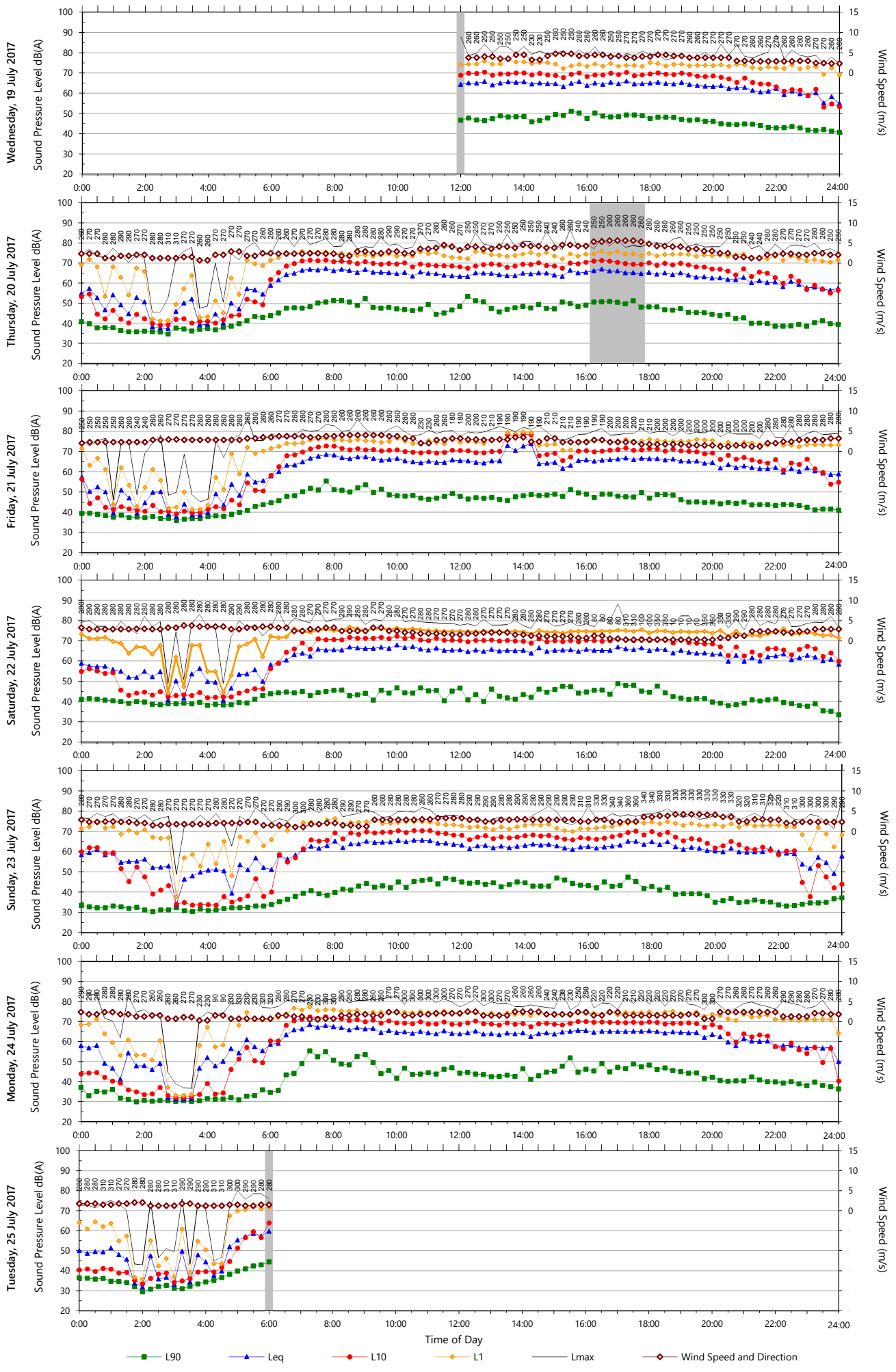
Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Logger Location	Aerial Photograph






Wednesday, 19 July 2017
Thursday, 20 July 2017
Friday, 21 July 2017
Saturday, 22 July 2017
Sunday, 23 July 2017
Monday, 24 July 2017
Tuesday, 25 July 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

APPENDIX D Traffic volumes

D.1 Year 2017 traffic volumes (for validation)

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
Johnston Street (between Rose and Weynton)	NB	471	3.9	47	112	5.3	51
	SB	520	2.8	47	107	2.5	52
The Crescent (north of View St)	NB	383	8.2	40	75	8.7	51
	SB	454	4.4	51	95	8.4	55
The Crescent (north of Johnston St)	NB	854	5.8	44	187	6.7	51
	SB	974	3.5	49	201	5.3	54
City-West Link Road (west of The Crescent)	EB	1695	5.3	54	734	3.3	67
	WB	1950	4.5	62	738	6.7	66
City-West Link Road (east of The Crescent)	EB	2515	3.8	47	867	5.9	55
	WB	2349	4.4	50	872	3.2	58
Warringah Freeway and surrounds							
Warringah Freeway (north of Ernest St)	NB	3565	4.4	77	912	4.8	80
Warringah Freeway (north of Ernest St)	NB	1801	5.3	77	334	5.3	80
	SB	2728	3.4	81	802	5.9	90
Warringah Freeway (north of Ernest St)	SB	2078	6.1	81	459	7.0	90
Ernest Street on/off ramp	NB	42	0.2	77	11	0.3	80
	SB	346	1.3	81	33	1.0	90
Ernest Street off ramp	SB	469	1.8	81	90	1.6	90
Warringah Freeway (south of Falcon St)	NB	3359	4.6	63	823	5.0	73
Warringah Freeway (south of Falcon St)	NB	1409	4.5	63	363	5.4	73
	SB	3091	3.5	68	908	5.6	83
Warringah Freeway (south of Falcon St)	SB	1337	7.0	68	369	6.6	84
Falcon Street off ramp	NB	354	2.6	63	83	3.2	73
Falcon Street off ramp (bus lane)	NB	46	94.3	63	6	86.7	73
Military Road off ramp	NB	1192	3.2	63	469	3.5	73
Falcon Street on ramp	SB	1131	3.5	68	407	3.2	83
Falcon Street on ramp (bus lane)	SB	141	30.1	68	83	7.3	83
Ernest Street (west of Warringah Freeway)	EB	585	3.0	52	101	3.3	54
	WB	651	4.0	53	99	3.9	57

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (east of Warringah Freeway)	EB	734	4.5	50	100	4.2	51
	WB	968	5.1	47	169	5.6	51
Falcon Street (west of Lytton St)	EB	775	6.6	49	176	7.2	53
	WB	833	9.7	52	219	8.7	58
Military Road (east of Short Ln)	EB	2151	8.8	39	648	8.5	47
Falcon Street (east of Warringah Freeway)	WB	1936	8.4	41	657	7.4	51
Miller Street (north of Ridge St)	NB	314	7.1	41	40	13.9	42
	SB	382	5.3	34	78	8.0	38
Warringah Freeway (south of High St)	NB	3069	6.4	60	929	5.1	72
	SB	2533	2.7	63	700	4.7	80
Cahill Expressway (south of High St)	SB	972	13.4	63	322	7.3	80
Mount Street on ramp (south of High St)	SB	489	4.3	63	89	6.0	80
Warringah Freeway (south of Merrenburn Ave)	NB	3442	5.3	86	868	5.9	92
	SB	3102	5.2	82	931	8.3	82
Willoughby Road off ramp	NB	668	2.7	86	177	3.1	92
Willoughby Road on ramp	SB	645	2.6	82	178	2.6	82
Warringah Freeway (east of Miller St)	EB	4389	4.5	87	1218	6.6	93
	WB	4817	4.5	81	1111	4.9	82
Miller Street on ramp	EB	284	2.9	87	79	2.1	92
Miller Street off ramp	WB	354	2.9	81	81	3.0	82
Brook Street (south of Marks St)	NB	788	9.7	47	136	5.5	39
	SB	841	4.6	47	183	5.9	52

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

D.2 Year 2027 (opening year) do minimum traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1278	2.9	70	472	2.7	70
	WB	1234	3.3	70	581	1.6	70
City-West Link Road portals to M4-M5 Link	NB/Entry	494	8.3	80	142	4.3	80
	SB/Exit	439	6.3	80	115	6.5	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1516	3.2	70	526	3.1	70
	WB	1528	4.2	70	662	1.8	70
The Crescent (between City-West Link Road and Victoria Road)	EB	1946	2.6	70	616	2.9	70
	WB	1870	3.4	70	726	1.7	70
Victoria Road (east of The Crescent)	EB	2078	2.9	60	819	2.8	60
	WB	1798	3.2	60	826	1.7	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2867	7.5	80	1126	5.4	80
	WB/Entry	2681	8.3	80	1109	5.2	80
Victoria Road (north of The Crescent)	NB	1230	1.5	60	339	2.0	60
	SB	1396	2.2	60	421	1.8	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1092	1.8	60	292	2.3	60
	SB	1396	2.2	60	421	1.8	60
Victoria Road (between Robert and Gordon Street)	NB	516	1.5	60	159	2.6	60
	SB	717	1.7	60	179	1.9	60
Victoria Road (between Gordon and Evans Street)	NB	530	1.5	60	165	2.6	60
	SB	542	1.4	60	111	1.6	60
Victoria Road (north of Evans Street)	NB	468	1.6	60	111	1.6	60
	SB	552	2.0	60	182	2.8	60
The Crescent (between Johnston Street and City-West Link Road)	NB	940	2.3	50	250	3.6	50
	SB	850	1.7	50	219	1.5	50
The Crescent (between Trafalgar and Johnston Street)	NB	578	1.6	50	123	2.4	50
	SB	551	1.5	50	138	1.1	50
The Crescent (between Nelson and Trafalgar Street)	NB	578	1.6	50	123	2.4	50
	SB	551	1.5	50	138	1.1	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	390	2.9	50	132	3.0	50
	SB	328	1.9	50	90	1.9	50
Johnston Street (between Rose Street and Kentville Avenue)	NB	354	2.5	50	132	3.0	50
	SB	328	1.9	50	90	1.9	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Piper and Rose Street)	NB	381	2.3	50	130	2.9	50
	SB	376	1.9	50	99	1.9	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	3891	4.9	80	1345	3.4	80
	SB	3732	4.6	80	1318	4.4	80
Willoughby Road off ramp	NB	818	11.6	60	367	9.9	60
Willoughby Road on ramp	SB	795	6.0	60	306	4.4	60
Warringah Freeway (south of Brook Street)	NB	4709	6.0	80	1713	4.8	80
	SB	4527	4.9	80	1625	4.4	80
Brook Street off ramp	NB	1037	6.1	60	332	5.7	60
Brook Street on ramp	SB	772	3.5	80	154	3.5	80
Warringah Freeway (east of Miller Street)	WB	5746	6.0	80	2045	4.9	80
	EB	5300	4.7	80	1779	4.3	80
Miller Street off ramp	WB	720	3.4	60	224	4.5	60
Miller Street on ramp	EB	559	3.1	60	115	0.6	60
Warringah Freeway (north of Ernest Street)	NB	4158	4.9	80	1456	4.1	80
Warringah Freeway (north of Ernest Street)	NB	2309	7.3	80	812	6.3	80
	SB	2897	5.7	80	1152	4.9	80
Warringah Freeway (north of Ernest Street)	SB	2962	3.3	80	741	2.8	80
Ernest Street on/off ramp	NB	551	5.8	60	201	2.5	60
	SB	102	2.7	80	0	0	80
Ernest Street on ramp	SB	639	0.9	80	73	0.2	80
Warringah Freeway (south of Falcon Street)	NB	4158	4.9	80	1456	4.1	80
Warringah Freeway (south of Falcon Street)	NB	1667	8.1	80	686	6.3	80
	SB	195	4.5	80	0	0	80
Warringah Freeway (south of Falcon Street)	SB	2036	3.3	80	544	2.5	80
Falcon Street off ramp	NB	375	1.1	60	165	0.4	60
Falcon Street off ramp (bus lane)	NB	32	100	60	4	100	60
Military Road off ramp	NB	1048	3.7	60	499	2.5	60
Falcon Street on ramp	SB	1619	5.1	60	625	4.0	60
Falcon Street on ramp (bus lane)	SB	38	100	60	5	100	60
Berry Street on ramp	NB	1088	1.7	80	364	0.9	80

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Alfred Street off ramp	SB	647	1.7	60	271	1.4	60
Warringah Freeway (south of Mount Street)	NB	4492	5.1	80	1756	4.0	80
Warringah Freeway (south of Mount Street)	NB	2218	7.5	80	887	5.5	80
	SB	296	3.9	70	0	0	70
Warringah Freeway (south of Mount Street)	SB	5262	4.9	80	1847	4.4	80
Cahill Expressway (south of Mount Street)	SB	1087	4.1	70	276	3.5	70
Mount Street on ramp	SB	754	1.6	70	153	2.8	70
Mount Street on ramp (Cahill Expressway)	SB	602	0.5	70	301	0.4	70
Sydney Harbour Tunnel portals	NB/exit	3102	4.6	80	1079	3.6	80
	SB/entry	3049	4.6	80	1002	3.8	80
Warringah Freeway (south of High Street)	NB	1390	6.2	80	677	4.7	80
Warringah Freeway (south of High Street)	NB	2218	7.5	80	887	5.5	80
	SB	341	3.5	70	0	0	70
Warringah Freeway (south of High Street)	SB	2921	4.4	70	998	4.8	70
Cahill Expressway (south of High Street)	SB	1688	2.8	70	577	1.9	70
Pacific Highway off ramp	NB	1478	2.1	60	517	2.6	60
High Street on ramp	SB	688	0.0	70	331	0.1	70
Lavender Street off ramp	NB	366	3.1	70	136	3.1	70
Bradfield Highway (south of Lavender Street)	NB	5451	5.4	70	2217	4.4	70
	SB	3263	4.3	70	998	4.8	70
Cahill Expressway (south of Lavender Street)	SB	2376	2.0	70	908	1.2	70
Ernest Street (west of Warringah Freeway)	EB	384	0.4	50	45	0.3	50
	WB	334	0.5	50	66	0.6	50
Ernest Street (between Miller and West Street)	EB	304	0.4	50	45	0.3	50
	WB	357	0.3	50	90	0.4	50
Ernest Street (between West and Sophia Street)	EB	175	0.4	50	43	0.3	50
	WB	340	0.5	50	68	0.5	50
Ernest Street (between Sophia and Alexander Street)	EB	175	0.4	50	43	0.3	50
	WB	80	0.3	50	17	0.4	50
Ernest Street (east of Warringah Freeway)	EB	891	3.7	50	235	2.1	50
	WB	1031	1.0	50	129	0.3	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (between Merlin Street and Park Avenue)	EB	1089	3.3	50	347	1.6	50
	WB	1037	1.0	50	128	0.3	50
Falcon Street (west of Warringah Freeway)	EB	1027	1.4	60	226	1.0	60
	WB	959	1.0	60	308	0.8	60
Falcon Street (between Miller and West Street)	EB	900	1.4	60	212	0.9	60
	WB	685	1.0	60	229	0.7	60
Falcon Street (between West and Alexander Street)	EB	1035	1.2	60	231	0.9	60
	WB	673	0.9	60	224	0.6	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1016	1.3	60	233	0.9	60
	WB	801	1.0	60	257	0.6	60
Falcon Street (east of Warringah Freeway)	WB	2244	4.9	60	777	4.2	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2213	4.9	60	778	4.1	60
Military Road (east of Warringah Freeway)	EB	2400	3.0	60	806	2.6	60
Military Road (between Watson Street and Ben Boyd Road)	EB	2233	3.1	60	746	2.7	60
	WB	2213	4.9	60	778	4.1	60
Military Road (between Ben Boyd Road and Young Street)	EB	2242	3.1	60	764	2.6	60
	WB	2035	5.2	60	738	4.3	60
Military Road (between Young Street and Wycombe Road)	EB	2068	3.2	60	747	2.6	60
	WB	1865	5.6	60	701	4.5	60
Willoughby Road (north of Warringah Freeway)	NB	1117	9.1	60	412	9.0	60
	SB	1203	4.7	60	384	4.1	60
Willoughby Road (south of Warringah Freeway)	NB	319	2.2	60	59	1.4	60
	SB	429	1.9	60	92	2.5	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	547	3.3	60	128	2.4	60
	SB	526	3.1	60	104	2.8	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	566	2.3	60	117	1.5	60
	SB	431	1.4	60	77	1.8	60
Willoughby Road (between Chandos and Atchison Street)	NB	405	1.5	60	105	1.2	60
	SB	526	1.2	60	126	1.7	60
Willoughby Road (between Atchison and Albany Street)	NB	275	1.5	60	35	0.7	60
	SB	260	1.0	60	39	1.1	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Albany and Holtermann Street)	NB	294	0.7	60	62	0.6	60
	SB	154	0.8	60	39	1.1	60
Willoughby Road (between Holtermann and Falcon Street)	SB	24	0.0	60	4	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	261	4.2	50	73	3.0	50
	WB	131	6.0	50	16	4.1	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	1018	3.9	50	220	2.9	50
	SB	999	6.9	50	346	5.5	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	827	7.1	50	297	5.7	50
	SB	976	3.3	50	227	2.6	50
Brook Street (between Warringah Freeway on and off ramps)	NB	1189	5.4	50	361	5.1	50
	SB	97	4.0	50	28	1.1	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	530	1.7	50	109	1.7	50
	SB	475	2.7	50	108	2.5	50
Chandos Street (between Alexander and Brook Street)	EB	530	1.7	50	109	1.7	50
	WB	475	2.7	50	108	2.5	50
Chandos Street (between Brook Street and Willoughby Road)	EB	395	1.7	50	65	1.9	50
	WB	338	2.4	50	85	2.9	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	452	2.6	50	59	2.4	50
	WB	139	4.4	50	18	8.1	50
Chandos Street (between Oxley and Christie Street)	EB	212	3.3	50	36	2.4	50
	WB	71	5.8	50	3	37.8	50
Alexander Street (between Brook and Albany Street)	NB	215	2.0	50	63	1.5	50
	SB	216	2.9	50	42	1.2	50
Alexander Street (between Albany and Holtermann Street)	NB	222	1.6	50	51	1.2	50
	SB	206	1.7	50	47	0.5	50
Alexander Street (between Holtermann and Ernest Street)	NB	256	1.6	50	62	1.0	50
	SB	335	1.4	50	82	0.7	50
Alexander Street (between Ernest and Burlington Street)	NB	308	1.3	50	72	0.9	50
	SB	293	1.5	50	67	0.8	50
Alexander Street (between Burlington and Falcon Street)	NB	336	1.6	50	76	0.9	50
	SB	318	1.4	50	74	0.7	50
Alexander Street (between Falcon Street and Pacific Highway)	NB	339	1.2	50	69	0.9	50
	SB	174	1.3	50	36	1.0	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Albany Street (between Alexander Street and Willoughby Road)	EB	75	0.4	50	23	0.3	50
	WB	80	2.4	50	3	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	132	0.8	50	23	0.3	50
	WB	262	0.8	50	30	0.4	50
Albany Street (between Oxley Street and Pacific Highway)	EB	353	2.3	50	91	2.2	50
	WB	411	2.0	50	81	2.0	50
Amherst Street (west of West Street)	EB	469	1.4	60	109	1.2	60
Amherst Street (between West and Miller Street)	EB	334	1.1	50	103	2.1	50
	WB	93	0.1	50	27	0.0	50
West Street (between Amherst and Ernest Street)	NB	95	2.7	50	29	6.9	50
	SB	318	1.7	50	61	2.0	50
West Street (between Ernest and Falcon Street)	NB	214	1.6	50	31	6.2	50
	SB	299	1.7	50	60	2.0	50
West Street (between Falcon and Ridge Street)	NB	66	5.3	50	16	11.5	50
	SB	297	2.2	50	70	2.4	50
West Street (between Ridge and Church Street)	NB	96	2.8	50	16	2.7	50
	SB	207	1.4	50	42	1.3	50
West Street (between Church Street and Pacific Highway)	NB	96	2.8	50	16	2.7	50
	SB	207	1.4	50	42	1.3	50
Miller Street (between Pine and Amherst Street)	NB	931	3.8	50	268	5.3	50
	SB	907	2.6	50	182	0.8	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	831	3.4	50	235	4.4	50
	SB	892	2.7	50	156	0.8	50
Miller Street (between Warringah Freeway on and off ramps)	NB	831	3.4	50	235	4.4	50
	SB	333	2.0	50	42	1.3	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	132	2.9	50	11	0.6	50
	SB	355	1.9	50	42	1.3	50
Miller Street (between Ernest and Falcon Street)	NB	208	1.8	50	37	0.2	50
	SB	328	2.1	50	44	1.1	50
Miller Street (between Falcon and Ridge Street)	NB	227	2.3	50	16	1.5	50
	SB	494	1.7	50	89	1.4	50
Miller Street (between Ridge and McLaren Street)	NB	158	3.2	50	14	9.5	50
	SB	324	1.7	50	58	1.4	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between McLaren and Berry Street)	NB	388	1.5	50	54	2.6	50
	SB	444	1.3	50	77	1.2	50
Miller Street (between Berry Street and Pacific Highway)	NB	629	1.2	40	136	1.5	40
	SB	202	1.9	40	38	1.1	40
Walker Street (between Ridge and McLaren Street)	NB	77	0.8	50	5	1.3	50
	SB	293	1.7	50	59	2.3	50
Walker Street (between McLaren and Berry Street)	NB	149	2.9	50	77	3.7	50
	SB	510	1.4	50	165	1.2	50
Walker Street (between Berry and Spring Street)	NB	494	2.8	50	186	2.5	50
	SB	32	0.2	50	9	0.0	50
Ridge Street (between Walker and Miller Street)	EB	293	1.7	50	59	2.3	50
	WB	77	0.8	50	5	1.3	50
Ridge Street (between Miller and West Street)	EB	96	4.7	50	15	10.0	50
	WB	210	2.8	50	41	2.6	50
McLaren Street (between Walker and Miller Street)	EB	369	0.6	50	60	0.3	50
	WB	234	0.2	50	46	0.4	50
McLaren Street (between Miller and Angelo Street)	EB	171	0.8	50	21	0.9	50
	WB	145	0.2	50	28	0.2	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	171	0.8	50	21	0.9	50
	WB	145	0.2	50	28	0.2	50
Berry Street (between Walker and Arthur Street)	EB	1903	1.3	60	625	0.9	60
Berry Street (between Little Spring and Walker Street)	EB	1080	0.8	40	360	0.6	40
Berry Street (between Denison and Little Spring Street)	EB	1171	0.8	40	384	0.6	40
Berry Street (between Miller and Denison Street)	EB	1055	0.8	40	291	0.7	40
Berry Street (between Pacific Highway and Miller Street)	EB	572	0.8	40	171	0.5	40
Spring Street (between Walker and Little Spring Street)	WB	71	7.5	50	16	16.7	50
Spring Street (between Little Spring and Denison Street)	WB	162	3.6	50	40	7.0	50
Denison Street (between Spring and Berry Street)	NB	71	7.5	50	16	16.7	50
Pacific Highway (between Arthur and Walker Street)	NB	1984	2.3	60	543	3.2	60
	SB	799	1.0	60	278	1.1	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Walker and Miller Street)	NB	1339	1.3	60	334	1.3	60
	SB	399	1.1	60	62	0.9	60
Pacific Highway (between Miller and William Street)	NB	457	1.3	60	78	0.5	60
	SB	366	1.3	60	49	1.0	60
Pacific Highway (between William and Berry Street)	NB	628	1.3	60	125	0.6	60
	SB	366	1.3	60	49	1.0	60
Pacific Highway (between Berry Street and Bay Road)	NB	486	1.2	60	82	0.6	60
	SB	795	0.9	60	177	0.6	60
Pacific Highway (between Bay Road and McLaren Street)	NB	580	1.1	60	92	0.5	60
	SB	768	1.2	60	119	1.0	60
Pacific Highway (between McLaren and West Street)	NB	678	1.0	60	108	0.5	60
	SB	892	1.2	60	129	1.0	60
Pacific Highway (between West Street and Crows Nest Road)	NB	678	1.0	60	108	0.5	60
	SB	781	1.3	60	103	1.1	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	576	1.1	60	78	0.6	60
	SB	781	1.3	60	103	1.1	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	685	1.0	60	84	0.7	60
	SB	869	1.2	60	116	1.1	60
Pacific Highway (between Bruce and Alexander Street)	NB	723	1.2	60	93	0.9	60
	SB	914	1.6	60	127	1.4	60
Pacific Highway (between Alexander and Falcon Street)	NB	444	1.1	60	36	0.9	60
	SB	800	1.5	60	104	1.4	60
Pacific Highway (between Falcon and Hume Street)	NB	563	0.7	60	101	0.5	60
	SB	1087	1.4	60	154	1.3	60
Arthur Street (between Pacific Highway and Mount Street)	NB	541	1.5	40	193	1.6	40
High Street (west of Warringah Freeway)	EB	712	0.1	70	313	0.1	70
	WB	648	1.4	70	185	1.9	70
High Street (east of Warringah Freeway)	EB	978	0.3	50	402	0.2	50
	WB	1114	0.2	50	393	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	769	0.1	50	312	0.1	50
	SB	867	0.2	50	262	0.1	50
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	658	0.1	50	275	0.1	50
	SB	771	0.2	50	220	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Kurraba Road (between Clark Road and Holdsworth Street)	EB	745	0.1	50	279	0.1	50
	WB	755	0.2	50	217	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	567	0.1	50	221	0.1	50
	WB	649	0.3	50	168	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	103	0.4	50	9	1.4	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	103	0.4	50	9	1.4	50
Alfred Street N (between Kurraba Road and High Street)	SB	487	1.9	50	212	1.7	50

Notes: 1. Based on posted speeds.

2. The 2027 (opening year) do minimum scenario includes the full WestConnex (Stages 1, 2 and 3), but without the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.

D.3 Year 2027 (opening year) do something traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1276	3.4	70	507	2.7	70
	WB	1484	3.5	70	660	2.1	70
City-West Link Road portals to M4-M5 Link	NB/Entry	424	7.8	80	129	3.9	80
	SB/Exit	403	5.8	80	104	5.6	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1513	3.5	70	560	3.0	70
	WB	1742	4.0	70	738	2.2	70
City-West Link Road portals to WHT	NB/Entry	631	7.9	80	282	6.0	80
	SB/Exit	849	4.6	80	258	3.5	80
The Crescent (between City-West Link Road and Victoria Road)	EB	1874	2.3	70	588	2.2	70
	WB	1616	3.3	70	651	1.9	70
Victoria Road (east of The Crescent)	EB	1760	2.0	60	687	1.6	60
	WB	1413	2.5	60	662	1.4	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2617	5.9	80	1040	4.4	80
	WB/Entry	2724	6.1	80	1247	3.9	80
Victoria Road (north of The Crescent)	NB	1285	1.7	60	361	2.1	60
	SB	1339	2.3	60	427	2.0	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1150	1.8	60	316	2.3	60
	SB	1339	2.3	60	427	2.0	60
Victoria Road (between Robert and Gordon Street)	NB	564	1.3	60	172	1.6	60
	SB	649	1.5	60	175	1.5	60
Victoria Road (between Gordon and Evans Street)	NB	577	1.3	60	178	1.6	60
	SB	485	1.4	60	110	1.6	60
Victoria Road (north of Evans Street)	NB	397	1.7	60	110	1.6	60
	SB	605	1.7	60	195	1.9	60
The Crescent (between Johnston Street and City-West Link Road)	NB	1218	3.4	50	391	3.2	50
	SB	949	2.3	50	251	1.9	50
The Crescent (between Trafalgar and Johnston Street)	NB	634	2.2	50	174	2.8	50
	SB	557	1.6	50	147	1.4	50
The Crescent (between Nelson and Trafalgar Street)	NB	634	2.2	50	174	2.8	50
	SB	557	1.6	50	147	1.4	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	612	4.5	50	225	3.3	50
	SB	420	3.2	50	114	2.5	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Rose Street and Kentville Avenue)	NB	587	4.6	50	225	3.3	50
	SB	420	3.2	50	114	2.5	50
Johnston Street (between Piper and Rose Street)	NB	608	4.3	50	220	3.3	50
	SB	464	3.1	50	119	2.6	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	3927	6.3	80	1173	4.8	80
	SB	3988	5.9	80	1266	5.1	80
Willoughby Road off ramp	NB	1022	10.0	60	444	7.5	60
Willoughby Road on ramp	SB	1056	7.8	60	385	5.2	60
Warringah Freeway (south of Brook Street)	NB	4949	7.1	80	1617	5.5	80
	SB	5043	6.3	80	1651	5.1	80
Brook Street off ramp	NB	852	8.1	60	240	9.8	60
Brook Street on ramp	SB	661	2.3	80	76	3.6	80
Warringah Freeway (east of Miller Street)	WB	5802	7.3	80	1857	6.1	80
	EB	5704	5.9	80	1726	5.1	80
Miller Street off ramp	WB	551	2.6	60	190	3.6	60
Miller Street on ramp	EB	721	2.8	60	132	0.3	60
Warringah Freeway (north of Ernest Street)	NB	5154	5.1	80	1587	4.8	80
Warringah Freeway (north of Ernest St, WHT exit/entry portal)	NB/exit	1199	14.4	80	460	9.6	80
	SB/entry	850	18.7	80	183	15.2	80
Warringah Freeway (north of Ernest Street)	SB	4778	3.5	80	1459	3.6	80
Ernest Street off ramp	NB	571	2.2	50	184	1.2	50
Ernest Street on ramp	SB	567	1.3	60	26	0.0	60
Warringah Freeway (south of Falcon Street)	NB	3453	5.4	80	1116	4.9	80
Warringah Freeway (south of Falcon Street)	NB	1687	3.5	80	532	2.9	80
	SB	1938	4.3	80	623	4.2	80
Warringah Freeway (south of Falcon Street)	SB	3406	2.7	80	862	3.0	80
Falcon Street off ramp (WHT exit portal)	NB	881	5.2	60	168	6.5	60
Falcon Street off ramp (bus lane)	NB	32	100	60	4	100	60
Military Road off ramp	NB	987	4.1	70	470	2.2	70
Falcon Street on ramp	SB	1637	3.0	80	563	3.4	80

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Falcon Street on ramp (bus lane)	SB	38	100	60	5	100	60
Berry Street on ramp	NB	390	1.5	80	124	1.3	80
Berry Street on ramp (WHT entry portal)	NB	927	4.5	60	191	3.2	60
Alfred Street off ramp	SB	1002	1.8	60	301	1.7	60
Warringah Freeway (south of Mount Street)	NB	5736	4.8	80	1995	4.0	80
Warringah Freeway (south of Mount Street)	SB	5064	3.7	70	1636	4.0	70
Cahill Expressway (south of Mount Street)	SB	916	2.0	70	111	1.0	70
Mount Street on ramp	SB	605	0.3	70	98	1.6	70
Mount Street on ramp (Cahill Expressway)	SB	591	0.4	70	290	0.4	70
Sydney Harbour Tunnel portals	NB/exit	2309	4.9	80	796	3.5	80
	SB/entry	2574	3.8	80	865	3.5	80
Warringah Freeway (south of High Street)	NB	2673	5.7	70	1009	5.0	70
Warringah Freeway (south of High Street)	SB	3095	2.9	70	869	4.2	70
Cahill Expressway (south of High Street)	SB	1506	1.4	70	401	0.6	70
Pacific Highway off ramp	NB	1212	1.5	60	401	2.0	60
High Street on ramp	SB	493	0.0	70	287	0.0	70
Lavender Street off ramp	NB	354	2.8	70	140	2.8	70
Bradfield Highway (south of Lavender Street)	NB	4239	4.2	70	1551	4.0	70
	SB	3095	2.9	70	869	4.2	70
Cahill Expressway (south of Lavender Street)	SB	1999	1.0	70	688	0.3	70
Ernest Street (west of Warringah Freeway)	EB	424	4.0	50	75	2.8	50
	WB	410	0.8	50	91	0.5	50
Ernest Street (between Miller and West Street)	EB	351	4.7	50	73	2.9	50
	WB	416	0.7	50	104	0.5	50
Ernest Street (between West and Sophia Street)	EB	168	0.5	50	46	0.4	50
	WB	371	1.0	50	77	0.7	50
Ernest Street (between Sophia and Alexander Street)	EB	168	0.5	50	46	0.4	50
	WB	168	0.5	50	46	0.4	50
Ernest Street (east of Warringah Freeway)	EB	953	3.1	50	240	1.8	50
	WB	935	1.1	50	98	0.5	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (between Merlin Street and Park Avenue)	EB	1153	2.7	50	355	1.4	50
	WB	977	1.1	50	97	0.5	50
Falcon Street (west of Warringah Freeway)	EB	1249	0.7	60	302	0.6	60
	WB	1522	4.0	60	371	3.9	60
Falcon Street (between Miller and West Street)	EB	1113	0.5	60	263	0.5	60
	WB	836	4.1	60	227	2.6	60
Falcon Street (between West and Alexander Street)	EB	1119	0.5	60	275	0.6	60
	WB	627	2.3	60	189	1.4	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1104	0.7	60	271	0.7	60
	WB	740	1.9	60	226	1.1	60
Falcon Street (east of Warringah Freeway)	WB	2294	4.0	60	768	3.7	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2306	3.9	60	787	3.6	60
Military Road (east of Warringah Freeway)	EB	2463	3.0	60	869	2.1	60
Military Road (between Watson Street and Ben Boyd Road)	EB	2222	3.2	60	769	2.3	60
	WB	2306	3.9	60	787	3.6	60
Military Road (between Ben Boyd Road and Young Street)	EB	2252	3.1	60	790	2.3	60
	WB	2079	4.3	60	732	3.9	60
Military Road (between Young Street and Wycombe Road)	EB	2082	3.3	60	772	2.3	60
	WB	1910	4.6	60	694	4.1	60
Willoughby Road (north of Warringah Freeway)	NB	1147	9.0	60	459	7.1	60
	SB	1274	6.7	60	446	4.9	60
Willoughby Road (south of Warringah Freeway)	NB	269	1.8	60	60	1.4	60
	SB	363	1.9	60	106	2.8	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	542	2.6	60	130	2.3	60
	SB	491	3.2	60	110	3.0	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	543	1.7	60	124	1.4	60
	SB	371	1.8	60	85	2.0	60
Willoughby Road (between Chandos and Atchison Street)	NB	377	1.3	60	101	0.9	60
	SB	432	1.2	60	100	1.7	60
Willoughby Road (between Atchison and Albany Street)	NB	245	1.4	60	35	0.5	60
	SB	200	0.9	60	34	0.4	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Albany and Holtermann Street)	NB	302	0.8	60	63	0.7	60
	SB	141	0.5	60	37	0.3	60
Willoughby Road (between Holtermann and Falcon Street)	SB	35	0.2	60	6	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	321	3.2	50	83	2.9	50
	WB	175	5.8	50	17	4.0	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	1013	3.4	50	171	2.9	50
	SB	960	8.8	50	281	9.1	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	723	10.3	50	223	10.4	50
	SB	921	2.6	50	180	2.5	50
Brook Street (between Warringah Freeway on and off ramps)	NB	1024	7.4	50	267	8.9	50
	SB	123	3.8	50	35	2.1	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	504	1.8	50	89	1.3	50
	SB	455	1.5	50	97	1.6	50
Chandos Street (between Alexander and Brook Street)	EB	504	1.8	50	89	1.3	50
	WB	455	1.5	50	97	1.6	50
Chandos Street (between Brook Street and Willoughby Road)	EB	361	1.8	50	49	1.1	50
	WB	304	0.8	50	73	1.5	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	427	2.3	50	44	2.5	50
	WB	143	1.7	50	29	2.8	50
Chandos Street (between Oxley and Christie Street)	EB	244	2.7	50	38	2.3	50
	WB	87	0.7	50	15	2.5	50
Alexander Street (between Brook and Albany Street)	NB	211	1.8	50	60	1.4	50
	SB	219	2.7	50	44	1.7	50
Alexander Street (between Albany and Holtermann Street)	NB	237	1.6	50	56	1.2	50
	SB	217	1.9	50	55	1.1	50
Alexander Street (between Holtermann and Ernest Street)	NB	257	1.4	50	63	1.0	50
	SB	322	1.5	50	86	0.9	50
Alexander Street (between Ernest and Burlington Street)	NB	311	1.2	50	72	0.9	50
	SB	296	1.7	50	69	0.9	50
Alexander Street (between Burlington and Falcon Street)	NB	332	1.3	50	75	0.9	50
	SB	318	1.3	50	75	0.9	50
Alexander Street (between Falcon Street and Pacific Highway)	NB	326	0.8	50	75	0.6	50
	SB	185	2.4	50	35	1.9	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Albany Street (between Alexander Street and Willoughby Road)	EB	71	0.2	50	23	0.3	50
	WB	89	1.8	50	6	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	115	0.5	50	23	0.3	50
	WB	249	0.8	50	31	0.8	50
Albany Street (between Oxley Street and Pacific Highway)	EB	364	2.4	50	110	1.8	50
	WB	411	2.0	50	84	1.9	50
Amherst Street (west of West Street)	EB	438	1.4	60	112	1.2	60
Amherst Street (between West and Miller Street)	EB	337	1.2	50	107	2.1	50
	WB	84	0.1	50	20	0.0	50
West Street (between Amherst and Ernest Street)	NB	101	3.1	50	36	5.4	50
	SB	283	1.8	50	61	2.0	50
West Street (between Ernest and Falcon Street)	NB	286	6.8	50	63	6.2	50
	SB	305	1.7	50	67	1.8	50
West Street (between Falcon and Ridge Street)	NB	67	6.1	50	19	10.0	50
	SB	300	3.1	50	73	3.7	50
West Street (between Ridge and Church Street)	NB	112	2.7	50	16	2.6	50
	SB	218	1.4	50	45	1.5	50
West Street (between Church Street and Pacific Highway)	NB	112	2.7	50	16	2.6	50
	SB	218	1.4	50	45	1.5	50
Miller Street (between Pine and Amherst Street)	NB	916	3.1	50	251	5.5	50
	SB	920	2.7	50	184	0.6	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	800	2.6	50	207	4.8	50
	SB	942	2.6	50	174	0.5	50
Miller Street (between Warringah Freeway on and off ramps)	NB	814	2.5	50	208	4.7	50
	SB	234	1.8	50	43	1.1	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	330	1.9	50	30	9.8	50
	SB	301	1.4	50	55	1.0	50
Miller Street (between Ernest and Falcon Street)	NB	410	1.9	50	43	6.9	50
	SB	303	1.9	50	52	0.9	50
Miller Street (between Falcon and Ridge Street)	NB	238	2.3	50	43	0.9	50
	SB	681	3.9	50	156	3.8	50
Miller Street (between Ridge and McLaren Street)	NB	116	2.1	50	18	2.3	50
	SB	340	3.4	50	67	3.7	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between McLaren and Berry Street)	NB	351	1.1	50	78	1.7	50
	SB	539	2.5	50	90	2.8	50
Miller Street (between Berry Street and Pacific Highway)	NB	288	1.2	40	65	2.1	40
	SB	160	3.0	40	37	1.5	40
Walker Street (between Ridge and McLaren Street)	NB	127	1.3	50	29	0.6	50
	SB	469	3.7	50	117	3.5	50
Walker Street (between McLaren and Berry Street)	NB	163	1.1	50	61	1.2	50
	SB	610	2.6	50	187	1.9	50
Walker Street (between Berry and Spring Street)	NB	324	3.2	50	83	2.5	50
	SB	10	1.3	50	1	0.0	50
Ridge Street (between Walker and Miller Street)	EB	469	3.7	50	117	3.5	50
	WB	127	1.3	50	29	0.6	50
Ridge Street (between Miller and West Street)	EB	86	1.4	50	16	3.0	50
	WB	209	2.4	50	40	2.5	50
McLaren Street (between Walker and Miller Street)	EB	353	0.7	50	78	1.5	50
	WB	265	0.4	50	60	0.4	50
McLaren Street (between Miller and Angelo Street)	EB	210	1.1	50	19	1.0	50
	WB	158	0.2	50	36	0.2	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	210	1.1	50	19	1.0	50
	WB	158	0.2	50	36	0.2	50
Berry Street (between Walker and Arthur Street)	EB	1892	2.6	60	563	1.6	60
Berry Street (between Little Spring and Walker Street)	EB	1131	2.2	40	356	1.1	40
Berry Street (between Denison and Little Spring Street)	EB	1250	2.1	40	382	1.1	40
Berry Street (between Miller and Denison Street)	EB	929	2.9	40	224	2.2	40
Berry Street (between Pacific Highway and Miller Street)	EB	614	3.0	40	183	1.6	40
Spring Street (between Walker and Little Spring Street)	WB	268	1.5	50	82	2.2	50
Spring Street (between Little Spring and Denison Street)	WB	388	1.5	50	108	1.9	50
Denison Street (between Spring and Berry Street)	NB	268	1.5	50	82	2.2	50
Pacific Highway (between Arthur and Walker Street)	NB	1842	1.4	60	477	2.0	60
	SB	1318	0.9	60	372	0.8	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Walker and Miller Street)	NB	1230	1.0	60	340	1.2	60
	SB	590	1.1	60	90	0.8	60
Pacific Highway (between Miller and William Street)	NB	537	0.3	60	138	0.3	60
	SB	472	0.8	60	77	0.7	60
Pacific Highway (between William and Berry Street)	NB	693	0.8	60	177	0.8	60
	SB	472	0.8	60	77	0.7	60
Pacific Highway (between Berry Street and Bay Road)	NB	428	0.3	60	112	0.3	60
	SB	821	2.2	60	195	1.2	60
Pacific Highway (between Bay Road and McLaren Street)	NB	531	0.3	60	134	0.2	60
	SB	792	2.5	60	146	1.8	60
Pacific Highway (between McLaren and West Street)	NB	645	0.3	60	159	0.2	60
	SB	958	2.3	60	154	1.8	60
Pacific Highway (between West Street and Crows Nest Road)	NB	645	0.3	60	159	0.2	60
	SB	852	2.6	60	125	2.0	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	566	0.3	60	130	0.3	60
	SB	852	2.6	60	125	2.0	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	656	0.3	60	133	0.3	60
	SB	891	2.4	60	124	2.1	60
Pacific Highway (between Bruce and Alexander Street)	NB	693	0.7	60	140	0.6	60
	SB	935	2.8	60	134	2.3	60
Pacific Highway (between Alexander and Falcon Street)	NB	433	0.5	60	77	0.5	60
	SB	816	2.6	60	111	2.2	60
Pacific Highway (between Falcon and Hume Street)	NB	507	1.5	60	90	1.4	60
	SB	1137	1.7	60	162	1.6	60
Arthur Street (between Pacific Highway and Mount Street)	NB	1186	1.0	60	364	1.4	60
High Street (west of Warringah Freeway)	EB	653	1.5	70	186	0.8	70
	WB	879	1.7	70	207	2.2	70
High Street (east of Warringah Freeway)	EB	924	0.4	50	327	0.3	50
	WB	1095	0.2	50	377	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	717	0.2	50	263	0.1	50
	SB	858	0.2	50	252	0.1	50
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	596	0.2	50	226	0.1	50
	SB	749	0.3	50	209	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Kurraba Road (between Clark Road and Holdsworth Street)	EB	678	0.2	50	230	0.1	50
	WB	742	0.3	50	205	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	490	0.2	50	169	0.1	50
	WB	614	0.3	50	154	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	144	0.2	50	24	0.5	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	144	0.2	50	24	0.5	50
Alfred Street N (between Kurraba Road and Mount Street)	SB	54	0.6	60	17	0.7	60
Alfred Street N (between Mount and High Street)	SB	1302	1.4	60	448	1.2	60

Notes: 1. Based on posted speeds.

2. The 2027 (opening year) do something scenario includes the project and full WestConnex (Stages 1, 2 and 3), but without the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.

D.4 Year 2027 (opening year) do something cumulative traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1348	3.8	70	531	2.9	70
	WB	1474	4.0	70	662	2.4	70
City-West Link Road portals to M4-M5 Link	NB/Entry	879	6.8	80	267	3.6	80
	SB/Exit	572	4.1	80	192	4.3	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1650	3.0	70	638	2.8	70
	WB	2083	4.5	70	844	2.3	70
City-West Link Road portals to WHT	NB/Entry	658	8.9	80	298	6.0	80
	SB/Exit	943	5.8	80	281	4.4	80
The Crescent (between City-West Link Road and Victoria Road)	EB	1950	2.0	70	635	2.1	70
	WB	1755	3.3	70	688	1.8	70
Victoria Road (east of The Crescent)	EB	1791	1.6	60	705	1.5	60
	WB	1529	2.6	60	681	1.3	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2533	5.8	80	1031	4.2	80
	WB/Entry	2598	5.5	80	1209	3.6	80
Victoria Road (north of The Crescent)	NB	1291	1.9	60	366	2.2	60
	SB	1321	2.3	60	422	2.0	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1144	2.0	60	320	2.4	60
	SB	1321	2.3	60	422	2.0	60
Victoria Road (between Robert and Gordon Street)	NB	557	1.7	60	182	2.0	60
	SB	634	1.5	60	172	1.6	60
Victoria Road (between Gordon and Evans Street)	NB	570	1.7	60	188	2.1	60
	SB	468	1.5	60	108	1.6	60
Victoria Road (north of Evans Street)	NB	369	1.8	60	108	1.6	60
	SB	596	2.0	60	203	2.3	60
The Crescent (between Johnston Street and City-West Link Road)	NB	1339	4.1	50	446	3.3	50
	SB	995	2.8	50	276	2.4	50
The Crescent (between Trafalgar and Johnston Street)	NB	733	3.0	50	228	2.9	50
	SB	575	1.9	50	164	1.8	50
The Crescent (between Nelson and Trafalgar Street)	NB	733	3.0	50	228	2.9	50
	SB	575	1.9	50	164	1.8	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	634	5.2	50	227	3.6	50
	SB	448	3.8	50	121	3.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Rose Street and Kentville Avenue)	NB	610	5.4	50	227	3.6	50
	SB	448	3.8	50	121	3.1	50
Johnston Street (between Piper and Rose Street)	NB	638	5.1	50	221	3.8	50
	SB	485	3.7	50	125	3.2	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	3780	6.0	80	1098	4.6	80
	SB	4079	5.4	80	1148	5.0	80
Willoughby Road off ramp	NB	1057	4.7	60	435	5.4	60
Willoughby Road on ramp	SB	922	2.9	60	293	2.5	60
Warringah Freeway (south of Brook Street)	NB	4838	5.7	80	1533	4.8	80
	SB	5001	5.0	80	1442	4.5	80
Brook Street off ramp	NB	704	4.1	60	195	4.9	60
Brook Street on ramp	SB	554	1.7	80	80	3.7	80
Warringah Freeway (east of Miller Street)	WB	5541	5.5	80	1728	4.8	80
	EB	5555	4.6	80	1521	4.4	80
Miller Street off ramp	WB	402	2.2	60	136	4.1	60
Miller Street on ramp	EB	494	0.5	60	132	0.3	60
Warringah Freeway (north of Ernest Street)	NB	4601	3.8	80	1399	3.6	80
Warringah Freeway (north of Ernest St, WHT exit/entry portal)	NB/exit	1343	10.2	80	464	8.1	80
	SB/entry	814	16.3	80	160	15.1	80
Warringah Freeway (north of Ernest St, BL entry/exit portal)	NB/entry	564	14.8	80	215	9.7	80
	SB/exit	635	9.3	80	141	11.0	80
Warringah Freeway (north of Ernest Street)	SB	4535	2.6	80	1353	3.1	80
Ernest Street off ramp	NB	330	0.9	50	130	0.6	50
Ernest Street on ramp	SB	317	0.3	60	26	0.0	60
Warringah Freeway (south of Falcon Street)	NB	3302	5.8	80	1102	4.7	80
Warringah Freeway (south of Falcon Street)	NB	1718	3.5	80	562	3.3	80
	SB	1665	3.5	80	556	3.7	80
Warringah Freeway (south of Falcon Street)	SB	3822	3.1	80	964	3.8	80
Falcon Street off ramp (WHT exit portal)	NB	797	3.8	60	172	5.3	60
Falcon Street off ramp (bus lane)	NB	32	100	60	4	100	60
Military Road off ramp	NB	849	1.0	70	390	0.6	70

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Falcon Street on ramp	SB	1633	0.6	80	483	1.1	80
Falcon Street on ramp (bus lane)	SB	38	100	60	5	100	60
Berry Street on ramp	NB	520	2.4	80	162	2.0	80
Berry Street on ramp (WHT entry portal)	NB	862	3.5	60	189	2.5	60
Alfred Street off ramp	SB	1191	2.3	60	320	2.1	60
Warringah Freeway (south of Mount Street)	NB	5349	4.6	80	1892	3.7	80
Warringah Freeway (south of Mount Street)	SB	4960	2.7	70	1540	3.4	70
Cahill Expressway (south of Mount Street)	SB	969	2.8	70	142	2.2	70
Mount Street on ramp	SB	582	0.3	70	98	1.6	70
Mount Street on ramp (Cahill Expressway)	SB	565	0.3	70	281	0.4	70
Sydney Harbour Tunnel portals	NB/exit	1889	3.8	80	656	2.6	80
	SB/entry	2420	2.7	80	768	2.9	80
Warringah Freeway (south of High Street)	NB	2679	6.1	70	1040	4.9	70
Warringah Freeway (south of High Street)	SB	3122	2.2	70	870	3.7	70
Cahill Expressway (south of High Street)	SB	1534	1.9	70	424	1.0	70
Pacific Highway off ramp	NB	1114	1.5	60	373	2.2	60
High Street on ramp	SB	437	0.0	70	249	0.0	70
Lavender Street off ramp	NB	355	2.8	70	139	2.9	70
Bradfield Highway (south of Lavender Street)	NB	4149	4.6	70	1552	4.1	70
	SB	3122	2.2	70	870	3.7	70
Cahill Expressway (south of Lavender Street)	SB	1971	1.5	70	673	0.6	70
Ernest Street (west of Warringah Freeway)	EB	355	0.3	50	63	0.2	50
	WB	383	0.5	50	84	0.4	50
Ernest Street (between Miller and West Street)	EB	314	0.3	50	61	0.2	50
	WB	403	0.5	50	101	0.4	50
Ernest Street (between West and Sophia Street)	EB	138	0.5	50	43	0.3	50
	WB	363	0.8	50	73	0.5	50
Ernest Street (between Sophia and Alexander Street)	EB	138	0.5	50	43	0.3	50
	WB	138	0.5	50	43	0.3	50
	EB	631	0.5	50	174	0.5	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (east of Warringah Freeway)	WB	646	0.4	50	91	0.3	50
Ernest Street (between Merlin Street and Park Avenue)	EB	823	0.6	50	289	0.5	50
	WB	669	0.3	50	90	0.3	50
Falcon Street (west of Warringah Freeway)	EB	1193	0.6	60	275	0.5	60
	WB	1403	2.5	60	352	2.9	60
Falcon Street (between Miller and West Street)	EB	1034	0.4	60	240	0.4	60
	WB	801	2.3	60	214	1.7	60
Falcon Street (between West and Alexander Street)	EB	1065	0.4	60	256	0.5	60
	WB	623	2.1	60	185	1.2	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1035	0.5	60	254	0.5	60
	WB	740	1.6	60	223	1.0	60
Falcon Street (east of Warringah Freeway)	WB	2070	1.1	60	623	1.1	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2094	1.0	60	638	1.0	60
Military Road (east of Warringah Freeway)	EB	2098	1.0	60	684	0.6	60
Military Road (between Watson Street and Ben Boyd Road)	EB	1835	0.9	60	574	0.6	60
	WB	2094	1.0	60	638	1.0	60
Military Road (between Ben Boyd Road and Young Street)	EB	1833	0.9	60	592	0.6	60
	WB	1856	1.0	60	580	1.1	60
Military Road (between Young Street and Wycombe Road)	EB	1670	0.9	60	574	0.5	60
	WB	1691	1.0	60	541	1.1	60
Willoughby Road (north of Warringah Freeway)	NB	1178	4.0	60	441	4.9	60
	SB	1225	2.4	60	376	2.3	60
Willoughby Road (south of Warringah Freeway)	NB	335	1.4	60	71	1.1	60
	SB	518	1.9	60	147	2.7	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	554	2.7	60	141	2.2	60
	SB	577	2.7	60	142	2.2	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	542	1.8	60	132	1.0	60
	SB	408	1.5	60	106	1.6	60
Willoughby Road (between Chandos and Atchison Street)	NB	363	1.1	60	99	0.9	60
	SB	467	1.0	60	118	1.4	60
Willoughby Road (between Atchison and Albany Street)	NB	219	1.3	60	33	0.9	60
	SB	209	0.8	60	40	0.6	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Albany and Holtermann Street)	NB	287	0.6	60	58	0.7	60
	SB	132	0.5	60	43	0.6	60
Willoughby Road (between Holtermann and Falcon Street)	SB	34	0.0	60	7	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	281	4.3	50	92	4.0	50
	WB	121	6.0	50	17	3.3	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	898	2.4	50	157	2.5	50
	SB	795	5.4	50	241	5.3	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	614	5.2	50	174	5.4	50
	SB	876	1.7	50	166	2.2	50
Brook Street (between Warringah Freeway on and off ramps)	NB	892	3.7	50	218	4.5	50
	SB	162	2.0	50	26	1.2	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	484	1.3	50	85	1.4	50
	SB	458	1.1	50	88	1.3	50
Chandos Street (between Alexander and Brook Street)	EB	484	1.3	50	85	1.4	50
	WB	458	1.1	50	88	1.3	50
Chandos Street (between Brook Street and Willoughby Road)	EB	368	1.6	50	52	2.2	50
	WB	336	1.0	50	73	1.6	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	416	2.1	50	52	2.1	50
	WB	147	1.5	50	28	2.2	50
Chandos Street (between Oxley and Christie Street)	EB	223	2.7	50	37	2.4	50
	WB	85	0.9	50	14	2.2	50
Alexander Street (between Brook and Albany Street)	NB	207	1.2	50	55	1.0	50
	SB	212	1.9	50	37	1.2	50
Alexander Street (between Albany and Holtermann Street)	NB	223	1.1	50	52	0.7	50
	SB	212	1.1	50	47	0.6	50
Alexander Street (between Holtermann and Ernest Street)	NB	242	1.0	50	57	0.8	50
	SB	310	1.0	50	83	0.7	50
Alexander Street (between Ernest and Burlington Street)	NB	287	0.8	50	66	0.7	50
	SB	312	1.0	50	70	0.7	50
Alexander Street (between Burlington and Falcon Street)	NB	304	1.1	50	71	0.8	50
	SB	329	0.9	50	78	0.7	50
Alexander Street (between Falcon Street and Pacific Highway)	NB	315	0.6	50	69	0.4	50
	SB	194	1.9	50	37	1.7	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Albany Street (between Alexander Street and Willoughby Road)	EB	69	0.2	50	23	0.3	50
	WB	74	2.0	50	6	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	114	0.4	50	23	0.3	50
	WB	264	0.7	50	28	0.4	50
Albany Street (between Oxley Street and Pacific Highway)	EB	358	2.6	50	101	2.3	50
	WB	406	2.1	50	78	2.3	50
Amherst Street (west of West Street)	EB	438	0.8	60	104	0.8	60
Amherst Street (between West and Miller Street)	EB	307	0.8	50	98	1.2	50
	WB	78	0.0	50	20	0.0	50
West Street (between Amherst and Ernest Street)	NB	113	1.6	50	35	3.0	50
	SB	320	0.9	50	60	1.2	50
West Street (between Ernest and Falcon Street)	NB	265	1.2	50	52	2.1	50
	SB	311	1.1	50	65	1.3	50
West Street (between Falcon and Ridge Street)	NB	69	3.6	50	17	5.7	50
	SB	324	2.4	50	76	2.9	50
West Street (between Ridge and Church Street)	NB	103	2.0	50	14	3.0	50
	SB	227	1.0	50	46	1.1	50
West Street (between Church Street and Pacific Highway)	NB	103	2.0	50	14	3.0	50
	SB	227	1.0	50	46	1.1	50
Miller Street (between Pine and Amherst Street)	NB	712	2.8	50	189	6.0	50
	SB	712	0.7	50	174	0.5	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	599	2.4	50	151	5.8	50
	SB	753	0.7	50	168	0.5	50
Miller Street (between Warringah Freeway on and off ramps)	NB	603	2.4	50	152	5.8	50
	SB	263	1.0	50	37	1.2	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	245	2.3	50	28	11.2	50
	SB	307	0.9	50	50	0.9	50
Miller Street (between Ernest and Falcon Street)	NB	308	2.0	50	43	7.5	50
	SB	310	1.0	50	46	0.9	50
Miller Street (between Falcon and Ridge Street)	NB	229	1.6	50	38	0.8	50
	SB	673	2.1	50	143	2.7	50
Miller Street (between Ridge and McLaren Street)	NB	120	2.9	50	19	3.9	50
	SB	378	2.1	50	67	3.0	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between McLaren and Berry Street)	NB	359	1.5	50	76	2.3	50
	SB	570	1.6	50	90	2.4	50
Miller Street (between Berry Street and Pacific Highway)	NB	299	1.7	40	63	2.6	40
	SB	191	1.7	40	38	1.0	40
Walker Street (between Ridge and McLaren Street)	NB	126	1.0	50	25	0.7	50
	SB	440	2.6	50	108	3.3	50
Walker Street (between McLaren and Berry Street)	NB	175	0.9	50	61	1.5	50
	SB	602	1.8	50	180	1.7	50
Walker Street (between Berry and Spring Street)	NB	367	2.8	50	95	2.6	50
	SB	10	1.4	50	1	0.0	50
Ridge Street (between Walker and Miller Street)	EB	440	2.6	50	108	3.3	50
	WB	126	1.0	50	25	0.7	50
Ridge Street (between Miller and West Street)	EB	89	3.4	50	17	4.7	50
	WB	216	3.2	50	43	4.6	50
McLaren Street (between Walker and Miller Street)	EB	355	1.0	50	76	1.5	50
	WB	260	0.4	50	59	0.4	50
McLaren Street (between Miller and Angelo Street)	EB	200	1.2	50	19	1.0	50
	WB	152	0.2	50	36	0.2	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	200	1.2	50	19	1.0	50
	WB	152	0.2	50	36	0.2	50
Berry Street (between Walker and Arthur Street)	EB	1933	2.3	60	586	1.5	60
Berry Street (between Little Spring and Walker Street)	EB	1148	2.1	40	373	1.2	40
Berry Street (between Denison and Little Spring Street)	EB	1270	2.0	40	399	1.2	40
Berry Street (between Miller and Denison Street)	EB	924	2.8	40	229	2.1	40
Berry Street (between Pacific Highway and Miller Street)	EB	605	3.3	40	190	1.6	40
Spring Street (between Walker and Little Spring Street)	WB	294	1.8	50	92	2.3	50
Spring Street (between Little Spring and Denison Street)	WB	416	1.6	50	118	2.0	50
Denison Street (between Spring and Berry Street)	NB	294	1.8	50	92	2.3	50
Pacific Highway (between Arthur and Walker Street)	NB	1908	1.8	60	477	2.3	60
	SB	1316	0.9	60	368	0.7	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Walker and Miller Street)	NB	1250	1.6	60	331	1.5	60
	SB	595	0.9	60	92	0.7	60
Pacific Highway (between Miller and William Street)	NB	498	0.6	60	127	0.4	60
	SB	436	0.7	60	78	0.7	60
Pacific Highway (between William and Berry Street)	NB	662	1.1	60	169	1.0	60
	SB	436	0.7	60	78	0.7	60
Pacific Highway (between Berry Street and Bay Road)	NB	390	0.5	60	107	0.4	60
	SB	768	2.3	60	207	1.2	60
Pacific Highway (between Bay Road and McLaren Street)	NB	482	0.5	60	126	0.3	60
	SB	715	2.5	60	155	1.6	60
Pacific Highway (between McLaren and West Street)	NB	591	0.4	60	151	0.3	60
	SB	872	2.3	60	163	1.6	60
Pacific Highway (between West Street and Crows Nest Road)	NB	591	0.4	60	151	0.3	60
	SB	749	2.7	60	131	2.0	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	515	0.5	60	122	0.4	60
	SB	749	2.7	60	131	2.0	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	597	0.4	60	123	0.4	60
	SB	780	2.5	60	134	2.0	60
Pacific Highway (between Bruce and Alexander Street)	NB	633	0.6	60	129	0.5	60
	SB	823	2.8	60	143	2.1	60
Pacific Highway (between Alexander and Falcon Street)	NB	385	0.5	60	72	0.5	60
	SB	696	2.8	60	118	2.1	60
Pacific Highway (between Falcon and Hume Street)	NB	469	1.4	60	86	1.1	60
	SB	977	1.5	60	160	1.4	60
Arthur Street (between Pacific Highway and Mount Street)	NB	1137	1.0	60	354	1.5	60
High Street (west of Warringah Freeway)	EB	668	1.4	70	184	0.7	70
	WB	999	2.4	70	224	2.7	70
High Street (east of Warringah Freeway)	EB	889	0.5	50	312	0.3	50
	WB	955	0.2	50	343	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	646	0.2	50	243	0.2	50
	SB	706	0.1	50	215	0.1	50
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	519	0.2	50	204	0.1	50
	SB	594	0.1	50	171	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Kurraba Road (between Clark Road and Holdsworth Street)	EB	601	0.2	50	208	0.1	50
	WB	584	0.1	50	168	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	418	0.2	50	154	0.2	50
	WB	448	0.1	50	116	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	167	0.1	50	23	0.3	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	167	0.1	50	23	0.3	50
Alfred Street N (between Kurraba Road and Mount Street)	SB	76	0.2	60	16	0.4	60
Alfred Street N (between Mount and High Street)	SB	1484	1.9	60	454	1.6	60

Notes: 1. Based on posted speeds.

2. The 2027 (opening year) do something cumulative scenario includes the project, Beaches Link and Gore Hill Freeway Connection, full WestConnex (Stages 1, 2 and 3), Sydney Gateway and the F6 Extension (Stage 1).

D.5 Year 2037 (design year) do minimum traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1370	3.1	70	500	2.8	70
	WB	1294	3.5	70	582	1.9	70
City-West Link Road portals to M4-M5 Link	NB/Entry	616	8.1	80	171	4.2	80
	SB/Exit	501	6.4	80	138	6.9	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1640	3.4	70	568	3.4	70
	WB	1680	4.6	70	684	2.1	70
The Crescent (between City-West Link Road and Victoria Road)	EB	2142	2.8	70	674	3.3	70
	WB	2143	3.6	70	763	1.8	70
Victoria Road (east of The Crescent)	EB	2259	2.9	60	898	3.0	60
	WB	2037	3.2	60	919	1.7	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2909	8.6	80	1112	6.2	80
	WB/Entry	2704	8.8	80	1135	5.7	80
Victoria Road (north of The Crescent)	NB	1481	1.4	60	456	1.6	60
	SB	1634	2.1	60	484	1.7	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1220	1.7	60	332	2.3	60
	SB	1634	2.1	60	484	1.7	60
Victoria Road (between Robert and Gordon Street)	NB	623	1.4	60	184	2.5	60
	SB	911	1.5	60	215	1.7	60
Victoria Road (between Gordon and Evans Street)	NB	647	1.4	60	194	2.4	60
	SB	697	1.4	60	132	1.5	60
Victoria Road (north of Evans Street)	NB	595	1.6	60	132	1.5	60
	SB	655	1.8	60	212	2.6	60
The Crescent (between Johnston Street and City-West Link Road)	NB	1099	2.2	50	294	3.0	50
	SB	1057	1.7	50	266	1.4	50
The Crescent (between Trafalgar and Johnston Street)	NB	680	1.7	50	158	2.1	50
	SB	691	1.4	50	174	1.1	50
The Crescent (between Nelson and Trafalgar Street)	NB	680	1.7	50	158	2.1	50
	SB	691	1.4	50	174	1.1	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	448	2.8	50	146	3.4	50
	SB	397	2.1	50	101	1.9	50
Johnston Street (between Rose Street and Kentville Avenue)	NB	410	2.4	50	146	3.4	50
	SB	397	2.1	50	101	1.9	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Piper and Rose Street)	NB	450	2.1	50	143	3.3	50
	SB	454	2.0	50	109	2.0	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	4143	5.2	80	1449	3.6	80
	SB	4016	4.6	80	1493	4.4	80
Willoughby Road off ramp	NB	825	11.1	60	370	11.0	60
Willoughby Road on ramp	SB	850	4.9	60	328	4.6	60
Warringah Freeway (south of Brook Street)	NB	4968	6.2	80	1819	5.1	80
	SB	4867	4.6	80	1821	4.5	80
Brook Street off ramp	NB	1099	7.4	60	387	5.3	60
Brook Street on ramp	SB	771	4.1	80	154	3.8	80
Warringah Freeway (east of Miller Street)	WB	6066	6.4	80	2206	5.2	80
	EB	5637	4.6	80	1975	4.4	80
Miller Street off ramp	WB	781	2.4	60	241	4.4	60
Miller Street on ramp	EB	586	3.5	60	117	0.7	60
Warringah Freeway (north of Ernest Street)	NB	4295	5.2	80	1587	4.7	80
Warringah Freeway (north of Ernest Street)	NB	2553	7.3	80	861	5.8	80
	SB	3046	5.6	80	1163	5.4	80
Warringah Freeway (north of Ernest Street)	SB	3178	3.4	80	929	2.8	80
Ernest Street on/off ramp	NB	603	6.8	60	260	1.8	60
	SB	117	3.1	80	0	0	80
Ernest Street on ramp	SB	695	1.6	80	94	0.1	80
Warringah Freeway (south of Falcon Street)	NB	4295	5.2	80	1587	4.7	80
Warringah Freeway (south of Falcon Street)	NB	1872	7.9	80	720	5.8	80
	SB	223	4.1	80	0	0	80
Warringah Freeway (south of Falcon Street)	SB	2176	3.3	80	685	2.5	80
Falcon Street off ramp	NB	420	1.1	60	190	0.5	60
Falcon Street off ramp (bus lane)	NB	36	100	60	5	100	60
Military Road off ramp	NB	1096	4.5	60	500	3.1	60
Falcon Street on ramp	SB	1773	5.3	60	667	4.2	60
Falcon Street on ramp (bus lane)	SB	43	100	60	6	100	60
Berry Street on ramp	NB	1085	1.8	80	399	1.0	80

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Alfred Street off ramp	SB	629	2.0	60	251	1.7	60
Warringah Freeway (south of Mount Street)	NB	4725	5.4	80	1878	4.6	80
Warringah Freeway (south of Mount Street)	NB	2475	7.7	80	979	4.7	80
	SB	341	3.7	70	0	0	70
Warringah Freeway (south of Mount Street)	SB	5665	4.9	80	1996	4.5	80
Cahill Expressway (south of Mount Street)	SB	1172	4.2	70	361	3.8	70
Mount Street on ramp	SB	856	1.7	70	175	2.9	70
Mount Street on ramp (Cahill Expressway)	SB	608	0.6	70	318	0.4	70
Sydney Harbour Tunnel portals	NB/exit	3336	5.1	80	1176	4.0	80
	SB/entry	3337	4.7	80	1094	4.1	80
Warringah Freeway (south of High Street)	NB	1389	6.3	80	702	5.7	80
Warringah Freeway (south of High Street)	NB	2475	7.7	80	979	4.7	80
	SB	390	3.4	70	0	0	70
Warringah Freeway (south of High Street)	SB	3134	4.3	70	1077	4.7	70
Cahill Expressway (south of High Street)	SB	1780	3.0	70	678	2.2	70
Pacific Highway off ramp	NB	1645	2.3	60	564	2.8	60
High Street on ramp	SB	800	0.1	70	353	0.1	70
Lavender Street off ramp	NB	390	3.3	70	141	3.6	70
Bradfield Highway (south of Lavender Street)	NB	5900	5.6	70	2386	4.5	70
	SB	3524	4.2	70	1077	4.7	70
Cahill Expressway (south of Lavender Street)	SB	2580	2.1	70	1031	1.5	70
Ernest Street (west of Warringah Freeway)	EB	418	0.4	50	56	0.2	50
	WB	357	0.5	50	69	0.6	50
Ernest Street (between Miller and West Street)	EB	326	0.4	50	56	0.2	50
	WB	374	0.4	50	96	0.4	50
Ernest Street (between West and Sophia Street)	EB	200	0.4	50	43	0.3	50
	WB	372	0.6	50	74	0.7	50
Ernest Street (between Sophia and Alexander Street)	EB	200	0.4	50	43	0.3	50
	WB	85	0.3	50	19	0.3	50
Ernest Street (east of Warringah Freeway)	EB	970	4.4	50	294	1.6	50
	WB	1118	1.5	50	142	0.3	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (between Merlin Street and Park Avenue)	EB	1167	3.8	50	410	1.3	50
	WB	1124	1.5	50	141	0.3	50
Falcon Street (west of Warringah Freeway)	EB	1159	1.2	60	254	1.0	60
	WB	1050	1.0	60	335	0.8	60
Falcon Street (between Miller and West Street)	EB	986	1.2	60	240	0.9	60
	WB	713	1.0	60	246	0.7	60
Falcon Street (between West and Alexander Street)	EB	1128	1.1	60	261	0.9	60
	WB	700	1.0	60	240	0.6	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1122	1.2	60	256	0.9	60
	WB	829	1.0	60	279	0.5	60
Falcon Street (east of Warringah Freeway)	WB	2372	5.4	60	821	4.5	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2349	5.3	60	822	4.5	60
Military Road (east of Warringah Freeway)	EB	2545	3.5	60	866	2.9	60
Military Road (between Watson Street and Ben Boyd Road)	EB	2352	3.6	60	778	3.1	60
	WB	2349	5.3	60	822	4.5	60
Military Road (between Ben Boyd Road and Young Street)	EB	2358	3.6	60	799	3.0	60
	WB	2132	5.8	60	779	4.7	60
Military Road (between Young Street and Wycombe Road)	EB	2169	3.8	60	780	3.0	60
	WB	1948	6.2	60	737	4.9	60
Willoughby Road (north of Warringah Freeway)	NB	1155	8.6	60	418	9.9	60
	SB	1270	4.0	60	401	4.4	60
Willoughby Road (south of Warringah Freeway)	NB	338	2.4	60	63	1.5	60
	SB	428	2.1	60	88	2.6	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	574	3.3	60	136	2.4	60
	SB	536	3.4	60	100	3.1	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	622	2.3	60	124	1.5	60
	SB	457	1.5	60	72	1.7	60
Willoughby Road (between Chandos and Atchison Street)	NB	427	1.6	60	108	1.2	60
	SB	546	1.3	60	126	1.7	60
Willoughby Road (between Atchison and Albany Street)	NB	297	1.6	60	38	0.8	60
	SB	275	1.0	60	37	0.3	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Albany and Holtermann Street)	NB	316	0.9	60	67	0.6	60
	SB	167	0.8	60	34	0.4	60
Willoughby Road (between Holtermann and Falcon Street)	SB	29	0.0	60	3	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	268	4.1	50	78	3.1	50
	WB	141	6.6	50	17	4.4	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	1054	4.4	50	227	3.2	50
	SB	1071	8.1	50	395	5.3	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	894	8.6	50	344	5.4	50
	SB	1004	3.7	50	237	2.8	50
Brook Street (between Warringah Freeway on and off ramps)	NB	1263	6.5	50	414	4.8	50
	SB	104	4.0	50	37	2.0	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	543	1.8	50	117	1.8	50
	SB	482	2.8	50	127	2.7	50
Chandos Street (between Alexander and Brook Street)	EB	543	1.8	50	117	1.8	50
	WB	482	2.8	50	127	2.7	50
Chandos Street (between Brook Street and Willoughby Road)	EB	401	1.7	50	71	1.9	50
	WB	333	2.5	50	94	3.0	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	475	2.7	50	67	2.4	50
	WB	124	5.1	50	20	8.1	50
Chandos Street (between Oxley and Christie Street)	EB	223	3.3	50	38	2.6	50
	WB	51	8.0	50	3	32.1	50
Alexander Street (between Brook and Albany Street)	NB	221	2.1	50	67	1.6	50
	SB	228	3.1	50	54	1.8	50
Alexander Street (between Albany and Holtermann Street)	NB	248	1.4	50	55	1.3	50
	SB	228	1.7	50	57	1.1	50
Alexander Street (between Holtermann and Ernest Street)	NB	277	1.6	50	68	1.1	50
	SB	367	1.4	50	88	0.8	50
Alexander Street (between Ernest and Burlington Street)	NB	334	1.3	50	77	0.9	50
	SB	309	1.5	50	74	0.9	50
Alexander Street (between Burlington and Falcon Street)	NB	375	1.6	50	83	1.0	50
	SB	345	1.4	50	83	0.8	50
Alexander Street (between Falcon Street and Pacific Highway)	NB	382	1.2	50	87	0.8	50
	SB	216	1.3	50	42	1.0	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Albany Street (between Alexander Street and Willoughby Road)	EB	94	0.4	50	24	0.3	50
	WB	106	2.0	50	4	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	145	0.8	50	24	0.3	50
	WB	284	0.8	50	37	0.5	50
Albany Street (between Oxley Street and Pacific Highway)	EB	372	2.4	50	106	2.1	50
	WB	444	2.1	50	90	2.0	50
Amherst Street (west of West Street)	EB	498	1.5	60	116	1.3	60
Amherst Street (between West and Miller Street)	EB	359	1.1	50	100	2.3	50
	WB	105	0.1	50	29	0.0	50
West Street (between Amherst and Ernest Street)	NB	99	2.5	50	32	6.4	50
	SB	337	1.8	50	75	1.8	50
West Street (between Ernest and Falcon Street)	NB	233	1.5	50	35	5.7	50
	SB	319	1.8	50	65	2.1	50
West Street (between Falcon and Ridge Street)	NB	79	4.6	50	19	10.6	50
	SB	320	2.2	50	76	2.4	50
West Street (between Ridge and Church Street)	NB	127	2.8	50	18	3.1	50
	SB	225	1.4	50	46	1.3	50
West Street (between Church Street and Pacific Highway)	NB	127	2.8	50	18	3.1	50
	SB	225	1.4	50	46	1.3	50
Miller Street (between Pine and Amherst Street)	NB	994	3.1	50	284	5.2	50
	SB	964	3.0	50	199	1.0	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	904	2.6	50	252	4.2	50
	SB	955	3.0	50	162	1.1	50
Miller Street (between Warringah Freeway on and off ramps)	NB	904	2.6	50	252	4.2	50
	SB	369	2.1	50	45	1.9	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	156	3.0	50	10	0.6	50
	SB	403	1.9	50	45	1.9	50
Miller Street (between Ernest and Falcon Street)	NB	229	2.0	50	41	0.1	50
	SB	367	2.2	50	49	1.6	50
Miller Street (between Falcon and Ridge Street)	NB	282	2.3	50	17	1.8	50
	SB	583	1.8	50	99	1.7	50
Miller Street (between Ridge and McLaren Street)	NB	190	3.4	50	16	10.9	50
	SB	373	1.8	50	65	1.8	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between McLaren and Berry Street)	NB	422	1.9	50	75	2.4	50
	SB	522	1.4	50	90	1.4	50
Miller Street (between Berry Street and Pacific Highway)	NB	636	1.5	40	167	1.2	40
	SB	230	2.1	40	43	1.7	40
Walker Street (between Ridge and McLaren Street)	NB	103	0.9	50	6	1.1	50
	SB	358	1.7	50	66	2.3	50
Walker Street (between McLaren and Berry Street)	NB	159	3.2	50	66	5.2	50
	SB	541	1.5	50	177	1.3	50
Walker Street (between Berry and Spring Street)	NB	505	3.1	50	188	2.9	50
	SB	38	0.4	50	7	0.8	50
Ridge Street (between Walker and Miller Street)	EB	358	1.7	50	66	2.3	50
	WB	103	0.9	50	6	1.1	50
Ridge Street (between Miller and West Street)	EB	109	5.2	50	16	11.2	50
	WB	245	2.9	50	44	2.9	50
McLaren Street (between Walker and Miller Street)	EB	384	0.8	50	85	0.3	50
	WB	273	0.2	50	58	0.3	50
McLaren Street (between Miller and Angelo Street)	EB	198	0.8	50	26	0.7	50
	WB	170	0.2	50	33	0.2	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	198	0.8	50	26	0.7	50
	WB	170	0.2	50	33	0.2	50
Berry Street (between Walker and Arthur Street)	EB	1972	1.4	60	685	1.0	60
Berry Street (between Little Spring and Walker Street)	EB	1123	0.9	40	392	0.7	40
Berry Street (between Denison and Little Spring Street)	EB	1235	0.9	40	422	0.6	40
Berry Street (between Miller and Denison Street)	EB	1103	0.8	40	318	0.5	40
Berry Street (between Pacific Highway and Miller Street)	EB	596	0.9	40	179	0.5	40
Spring Street (between Walker and Little Spring Street)	WB	86	8.2	50	18	20.5	50
Spring Street (between Little Spring and Denison Street)	WB	198	3.8	50	48	8.3	50
Denison Street (between Spring and Berry Street)	NB	86	8.2	50	18	20.5	50
Pacific Highway (between Arthur and Walker Street)	NB	2147	2.5	60	589	3.4	60
	SB	871	1.1	60	295	1.2	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Walker and Miller Street)	NB	1478	1.4	60	384	1.2	60
	SB	464	1.2	60	72	1.2	60
Pacific Highway (between Miller and William Street)	NB	597	1.2	60	89	0.5	60
	SB	423	1.4	60	57	1.3	60
Pacific Highway (between William and Berry Street)	NB	776	1.2	60	133	0.7	60
	SB	423	1.4	60	57	1.3	60
Pacific Highway (between Berry Street and Bay Road)	NB	633	1.2	60	93	0.6	60
	SB	877	1.0	60	196	0.7	60
Pacific Highway (between Bay Road and McLaren Street)	NB	743	1.1	60	105	0.5	60
	SB	867	1.3	60	139	1.1	60
Pacific Highway (between McLaren and West Street)	NB	864	1.0	60	125	0.5	60
	SB	1016	1.2	60	151	1.1	60
Pacific Highway (between West Street and Crows Nest Road)	NB	864	1.0	60	125	0.5	60
	SB	918	1.4	60	123	1.3	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	748	1.1	60	93	0.7	60
	SB	918	1.4	60	123	1.3	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	863	1.0	60	105	0.6	60
	SB	1012	1.3	60	147	1.1	60
Pacific Highway (between Bruce and Alexander Street)	NB	900	1.2	60	114	0.9	60
	SB	1057	1.7	60	160	1.5	60
Pacific Highway (between Alexander and Falcon Street)	NB	614	1.0	60	46	0.8	60
	SB	937	1.6	60	137	1.4	60
Pacific Highway (between Falcon and Hume Street)	NB	723	0.6	60	116	0.5	60
	SB	1309	1.4	60	183	1.4	60
Arthur Street (between Pacific Highway and Mount Street)	NB	577	1.6	40	207	1.7	40
High Street (west of Warringah Freeway)	EB	776	0.1	70	329	0.1	70
	WB	634	1.8	70	189	2.0	70
High Street (east of Warringah Freeway)	EB	1045	0.3	50	417	0.2	50
	WB	1218	0.2	50	417	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	819	0.2	50	310	0.1	50
	SB	939	0.2	50	274	0.1	50
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	695	0.2	50	270	0.1	50
	SB	831	0.2	50	229	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Kurraba Road (between Clark Road and Holdsworth Street)	EB	806	0.2	50	277	0.1	50
	WB	820	0.2	50	225	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	616	0.2	50	213	0.1	50
	WB	711	0.3	50	175	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	122	0.3	50	13	1.4	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	122	0.3	50	13	1.4	50
Alfred Street N (between Kurraba Road and High Street)	SB	485	2.3	50	213	1.9	50

Notes: 1. Based on posted speeds.

2. The 2037 (design year) do minimum scenario includes the full WestConnex (Stages 1, 2 and 3), but without the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.

D.6 Year 2037 (design year) do something traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1432	3.3	70	574	2.8	70
	WB	1583	3.7	70	720	1.9	70
City-West Link Road portals to M4-M5 Link	NB/Entry	540	7.5	80	153	4.1	80
	SB/Exit	460	5.9	80	125	6.1	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1697	3.4	70	641	3.1	70
	WB	1928	4.3	70	814	2.0	70
City-West Link Road portals to WHT	NB/Entry	814	7.6	80	356	5.3	80
	SB/Exit	1119	4.7	80	304	3.4	80
The Crescent (between City-West Link Road and Victoria Road)	EB	2109	2.3	70	663	2.3	70
	WB	1862	3.1	70	724	1.6	70
Victoria Road (east of The Crescent)	EB	1949	2.0	60	761	1.7	60
	WB	1558	2.4	60	714	1.4	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2682	6.6	80	1036	5.2	80
	WB/Entry	2721	6.8	80	1251	4.7	80
Victoria Road (north of The Crescent)	NB	1470	1.6	60	403	2.1	60
	SB	1546	2.1	60	472	1.6	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1277	1.8	60	348	2.3	60
	SB	1546	2.1	60	472	1.6	60
Victoria Road (between Robert and Gordon Street)	NB	667	1.4	60	195	2.5	60
	SB	816	1.4	60	198	1.5	60
Victoria Road (between Gordon and Evans Street)	NB	691	1.4	60	204	2.4	60
	SB	617	1.4	60	122	1.6	60
Victoria Road (north of Evans Street)	NB	491	1.7	60	122	1.6	60
	SB	710	1.5	60	221	2.6	60
The Crescent (between Johnston Street and City-West Link Road)	NB	1398	3.7	50	460	3.0	50
	SB	1225	2.3	50	295	2.0	50
The Crescent (between Trafalgar and Johnston Street)	NB	742	2.4	50	216	2.5	50
	SB	713	1.6	50	177	1.4	50
The Crescent (between Nelson and Trafalgar Street)	NB	742	2.4	50	216	2.5	50
	SB	713	1.6	50	177	1.4	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	687	4.9	50	254	3.2	50
	SB	544	3.2	50	128	2.7	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Rose Street and Kentville Avenue)	NB	656	5.0	50	254	3.2	50
	SB	544	3.2	50	128	2.7	50
Johnston Street (between Piper and Rose Street)	NB	690	4.7	50	248	3.2	50
	SB	597	3.0	50	132	2.7	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	4317	6.7	80	1335	5.0	80
	SB	4260	6.4	80	1424	5.1	80
Willoughby Road off ramp	NB	1060	10.7	60	450	8.3	60
Willoughby Road on ramp	SB	1146	8.4	60	398	6.1	60
Warringah Freeway (south of Brook Street)	NB	5377	7.5	80	1785	5.8	80
	SB	5406	6.8	80	1822	5.3	80
Brook Street off ramp	NB	957	7.4	60	275	9.2	60
Brook Street on ramp	SB	773	2.4	80	82	3.6	80
Warringah Freeway (east of Miller Street)	WB	6334	7.5	80	2059	6.3	80
	EB	6179	6.3	80	1904	5.2	80
Miller Street off ramp	WB	566	3.5	60	219	3.3	60
Miller Street on ramp	EB	764	2.4	60	164	0.3	60
Warringah Freeway (north of Ernest Street)	NB	5410	5.3	80	1755	5.0	80
Warringah Freeway (north of Ernest St, WHT exit/entry portal)	NB/exit	1490	13.8	80	523	9.4	80
	SB/entry	1080	18.4	80	204	13.0	80
Warringah Freeway (north of Ernest Street)	SB	5045	3.6	80	1623	4.0	80
Ernest Street off ramp	NB	610	3.3	50	214	1.3	50
Ernest Street on ramp	SB	643	2.0	60	30	0.0	60
Warringah Freeway (south of Falcon Street)	NB	3696	5.6	80	1253	5.1	80
Warringah Freeway (south of Falcon Street)	NB	1723	3.8	80	578	3.0	80
	SB	2112	4.8	80	702	4.9	80
Warringah Freeway (south of Falcon Street)	SB	3576	2.6	80	951	3.2	80
Falcon Street off ramp (WHT exit portal)	NB	1072	5.7	60	211	6.2	60
Falcon Street off ramp (bus lane)	NB	36	100	60	5	100	60
Military Road off ramp	NB	1083	4.2	70	483	2.4	70
Falcon Street on ramp	SB	1744	2.7	80	573	3.7	80

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Falcon Street on ramp (bus lane)	SB	43	100	60	6	100	60
Berry Street on ramp	NB	379	1.5	80	141	1.4	80
Berry Street on ramp (WHT entry portal)	NB	1180	5.1	60	253	3.0	60
Alfred Street off ramp	SB	963	1.9	60	294	1.9	60
Warringah Freeway (south of Mount Street)	NB	6123	5.1	80	2174	4.2	80
Warringah Freeway (south of Mount Street)	SB	5468	3.7	70	1809	4.4	70
Cahill Expressway (south of Mount Street)	SB	1002	2.1	70	122	1.1	70
Mount Street on ramp	SB	654	0.3	70	113	1.7	70
Mount Street on ramp (Cahill Expressway)	SB	589	0.4	70	306	0.4	70
Sydney Harbour Tunnel portals	NB/exit	2494	5.4	80	861	4.1	80
	SB/entry	2830	4.1	80	955	4.1	80
Warringah Freeway (south of High Street)	NB	2962	5.7	70	1127	4.8	70
Warringah Freeway (south of High Street)	SB	3291	2.7	70	967	4.4	70
Cahill Expressway (south of High Street)	SB	1591	1.5	70	429	0.6	70
Pacific Highway off ramp	NB	1383	1.4	60	456	2.2	60
High Street on ramp	SB	569	0.0	70	309	0.1	70
Lavender Street off ramp	NB	393	2.8	70	154	3.1	70
Bradfield Highway (south of Lavender Street)	NB	4738	4.2	70	1737	4.0	70
	SB	3291	2.7	70	967	4.4	70
Cahill Expressway (south of Lavender Street)	SB	2160	1.1	70	737	0.4	70
Ernest Street (west of Warringah Freeway)	EB	447	5.2	50	83	3.5	50
	WB	452	0.9	50	100	0.5	50
Ernest Street (between Miller and West Street)	EB	367	6.3	50	80	3.6	50
	WB	448	0.7	50	112	0.5	50
Ernest Street (between West and Sophia Street)	EB	187	0.7	50	48	0.4	50
	WB	406	1.0	50	82	0.8	50
Ernest Street (between Sophia and Alexander Street)	EB	187	0.7	50	48	0.4	50
	WB	187	0.7	50	48	0.4	50
Ernest Street (east of Warringah Freeway)	EB	1019	4.3	50	275	2.1	50
	WB	1057	1.6	50	109	0.5	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (between Merlin Street and Park Avenue)	EB	1220	3.7	50	395	1.6	50
	WB	1097	1.6	50	108	0.5	50
Falcon Street (west of Warringah Freeway)	EB	1409	0.7	60	342	0.6	60
	WB	1774	5.1	60	446	3.8	60
Falcon Street (between Miller and West Street)	EB	1203	0.5	60	298	0.5	60
	WB	931	4.7	60	250	2.9	60
Falcon Street (between West and Alexander Street)	EB	1200	0.5	60	312	0.5	60
	WB	719	2.3	60	205	1.4	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1186	0.7	60	306	0.6	60
	WB	800	2.0	60	247	1.1	60
Falcon Street (east of Warringah Freeway)	WB	2372	4.5	60	808	4.0	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2413	4.4	60	827	3.9	60
Military Road (east of Warringah Freeway)	EB	2633	3.0	60	930	2.3	60
Military Road (between Watson Street and Ben Boyd Road)	EB	2370	3.3	60	827	2.5	60
	WB	2413	4.4	60	827	3.9	60
Military Road (between Ben Boyd Road and Young Street)	EB	2406	3.2	60	850	2.4	60
	WB	2179	4.7	60	766	4.2	60
Military Road (between Young Street and Wycombe Road)	EB	2221	3.4	60	830	2.4	60
	WB	1998	5.1	60	724	4.4	60
Willoughby Road (north of Warringah Freeway)	NB	1196	9.5	60	467	8.0	60
	SB	1357	7.3	60	463	5.6	60
Willoughby Road (south of Warringah Freeway)	NB	291	2.0	60	63	1.6	60
	SB	366	2.4	60	111	2.8	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	577	2.4	60	137	2.4	60
	SB	495	3.0	60	119	3.1	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	602	1.8	60	131	1.5	60
	SB	396	2.3	60	94	2.1	60
Willoughby Road (between Chandos and Atchison Street)	NB	407	1.3	60	102	0.9	60
	SB	435	1.4	60	112	1.7	60
Willoughby Road (between Atchison and Albany Street)	NB	284	1.4	60	36	0.7	60
	SB	206	1.1	60	40	0.3	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Albany and Holtermann Street)	NB	321	0.8	60	67	0.7	60
	SB	153	0.7	60	43	0.3	60
Willoughby Road (between Holtermann and Falcon Street)	SB	41	0.2	60	7	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	337	2.8	50	83	2.9	50
	WB	180	4.6	50	17	4.2	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	1062	3.3	50	179	3.1	50
	SB	1057	8.0	50	310	8.9	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	806	9.3	50	252	10.0	50
	SB	967	2.8	50	188	2.6	50
Brook Street (between Warringah Freeway on and off ramps)	NB	1166	6.6	50	301	8.6	50
	SB	124	3.6	50	38	2.3	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	568	1.6	50	97	1.4	50
	SB	484	1.5	50	109	1.6	50
Chandos Street (between Alexander and Brook Street)	EB	568	1.6	50	97	1.4	50
	WB	484	1.5	50	109	1.6	50
Chandos Street (between Brook Street and Willoughby Road)	EB	419	1.6	50	54	1.1	50
	WB	324	0.8	50	81	1.5	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	488	2.1	50	53	2.4	50
	WB	159	1.8	50	32	2.7	50
Chandos Street (between Oxley and Christie Street)	EB	282	2.6	50	39	2.5	50
	WB	94	0.6	50	17	2.2	50
Alexander Street (between Brook and Albany Street)	NB	217	2.0	50	63	1.6	50
	SB	227	2.8	50	49	1.9	50
Alexander Street (between Albany and Holtermann Street)	NB	269	1.6	50	61	1.3	50
	SB	228	1.9	50	56	1.3	50
Alexander Street (between Holtermann and Ernest Street)	NB	279	1.5	50	68	1.1	50
	SB	340	1.6	50	92	0.9	50
Alexander Street (between Ernest and Burlington Street)	NB	343	1.3	50	79	1.0	50
	SB	312	1.7	50	77	1.0	50
Alexander Street (between Burlington and Falcon Street)	NB	379	1.3	50	82	1.0	50
	SB	346	1.3	50	83	0.9	50
Alexander Street (between Falcon Street and Pacific Highway)	NB	385	0.8	50	89	0.6	50
	SB	257	2.1	50	42	1.9	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Albany Street (between Alexander Street and Willoughby Road)	EB	81	0.4	50	21	0.3	50
	WB	120	1.6	50	7	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	135	0.5	50	21	0.3	50
	WB	264	0.9	50	34	0.7	50
Albany Street (between Oxley Street and Pacific Highway)	EB	386	2.3	50	126	1.8	50
	WB	443	2.0	50	92	1.9	50
Amherst Street (west of West Street)	EB	430	1.3	60	116	1.3	60
Amherst Street (between West and Miller Street)	EB	341	1.1	50	112	2.0	50
	WB	97	0.1	50	22	0.0	50
West Street (between Amherst and Ernest Street)	NB	105	2.3	50	41	5.0	50
	SB	287	1.6	50	65	2.1	50
West Street (between Ernest and Falcon Street)	NB	310	8.2	50	72	6.6	50
	SB	327	1.5	50	70	1.9	50
West Street (between Falcon and Ridge Street)	NB	86	4.3	50	20	10.2	50
	SB	313	3.4	50	77	4.1	50
West Street (between Ridge and Church Street)	NB	165	2.5	50	18	3.1	50
	SB	229	1.5	50	54	1.9	50
West Street (between Church Street and Pacific Highway)	NB	165	2.5	50	18	3.1	50
	SB	229	1.5	50	54	1.9	50
Miller Street (between Pine and Amherst Street)	NB	1000	3.6	50	291	5.1	50
	SB	999	2.4	50	218	0.6	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	911	3.1	50	249	4.2	50
	SB	1024	2.3	50	210	0.5	50
Miller Street (between Warringah Freeway on and off ramps)	NB	928	3.0	50	250	4.2	50
	SB	278	1.8	50	48	1.3	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	434	1.9	50	45	7.2	50
	SB	349	1.5	50	62	1.0	50
Miller Street (between Ernest and Falcon Street)	NB	510	1.9	50	59	5.5	50
	SB	350	2.1	50	62	1.0	50
Miller Street (between Falcon and Ridge Street)	NB	310	2.5	50	47	1.0	50
	SB	788	6.0	50	201	3.6	50
Miller Street (between Ridge and McLaren Street)	NB	137	2.4	50	21	2.4	50
	SB	379	4.8	50	73	4.0	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between McLaren and Berry Street)	NB	397	1.4	50	85	1.9	50
	SB	612	3.3	50	101	3.1	50
Miller Street (between Berry Street and Pacific Highway)	NB	333	1.6	40	72	2.2	40
	SB	151	5.9	40	40	1.7	40
Walker Street (between Ridge and McLaren Street)	NB	188	1.1	50	32	0.8	50
	SB	582	5.5	50	153	3.2	50
Walker Street (between McLaren and Berry Street)	NB	173	0.7	50	70	1.1	50
	SB	664	4.5	50	230	1.8	50
Walker Street (between Berry and Spring Street)	NB	409	3.0	50	100	2.6	50
	SB	12	1.4	50	2	3.6	50
Ridge Street (between Walker and Miller Street)	EB	582	5.5	50	153	3.2	50
	WB	188	1.1	50	32	0.8	50
Ridge Street (between Miller and West Street)	EB	106	1.8	50	20	3.0	50
	WB	264	2.7	50	39	2.3	50
McLaren Street (between Walker and Miller Street)	EB	376	1.3	50	86	1.6	50
	WB	306	0.4	50	71	0.3	50
McLaren Street (between Miller and Angelo Street)	EB	233	1.6	50	21	1.2	50
	WB	191	0.2	50	43	0.1	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	233	1.6	50	21	1.2	50
	WB	191	0.2	50	43	0.1	50
Berry Street (between Walker and Arthur Street)	EB	2134	3.2	60	659	1.6	60
Berry Street (between Little Spring and Walker Street)	EB	1246	2.1	40	400	1.2	40
Berry Street (between Denison and Little Spring Street)	EB	1391	2.0	40	431	1.2	40
Berry Street (between Miller and Denison Street)	EB	1053	2.8	40	260	2.2	40
Berry Street (between Pacific Highway and Miller Street)	EB	656	2.8	40	212	1.6	40
Spring Street (between Walker and Little Spring Street)	WB	282	1.5	50	86	2.5	50
Spring Street (between Little Spring and Denison Street)	WB	427	1.4	50	117	2.1	50
Denison Street (between Spring and Berry Street)	NB	282	1.5	50	86	2.5	50
Pacific Highway (between Arthur and Walker Street)	NB	2055	1.5	60	539	2.1	60
	SB	1360	1.0	60	404	0.9	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Walker and Miller Street)	NB	1393	1.1	60	383	1.3	60
	SB	619	1.6	60	110	1.1	60
Pacific Highway (between Miller and William Street)	NB	657	0.3	60	169	0.3	60
	SB	526	0.8	60	92	1.1	60
Pacific Highway (between William and Berry Street)	NB	819	0.7	60	212	0.8	60
	SB	526	0.8	60	92	1.1	60
Pacific Highway (between Berry Street and Bay Road)	NB	540	0.3	60	132	0.3	60
	SB	904	2.1	60	224	1.3	60
Pacific Highway (between Bay Road and McLaren Street)	NB	669	0.3	60	156	0.3	60
	SB	897	2.4	60	178	1.9	60
Pacific Highway (between McLaren and West Street)	NB	822	0.3	60	186	0.3	60
	SB	1091	2.3	60	186	1.9	60
Pacific Highway (between West Street and Crows Nest Road)	NB	822	0.3	60	186	0.3	60
	SB	1027	2.5	60	149	2.0	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	707	0.4	60	154	0.3	60
	SB	1027	2.5	60	149	2.0	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	802	0.4	60	155	0.3	60
	SB	1073	2.4	60	148	2.1	60
Pacific Highway (between Bruce and Alexander Street)	NB	842	0.7	60	162	0.6	60
	SB	1120	2.7	60	158	2.4	60
Pacific Highway (between Alexander and Falcon Street)	NB	583	0.5	60	92	0.5	60
	SB	989	2.6	60	135	2.2	60
Pacific Highway (between Falcon and Hume Street)	NB	665	1.3	60	106	1.2	60
	SB	1373	1.7	60	197	1.6	60
Arthur Street (between Pacific Highway and Mount Street)	NB	1304	0.9	60	401	1.6	60
High Street (west of Warringah Freeway)	EB	638	1.8	70	198	0.8	70
	WB	944	1.8	70	220	2.4	70
High Street (east of Warringah Freeway)	EB	988	0.4	50	347	0.3	50
	WB	1209	0.2	50	405	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	758	0.2	50	270	0.1	50
	SB	933	0.3	50	268	0.1	50
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	627	0.2	50	230	0.1	50
	SB	815	0.4	50	223	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Kurraba Road (between Clark Road and Holdsworth Street)	EB	740	0.2	50	234	0.1	50
	WB	811	0.4	50	219	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	542	0.2	50	169	0.1	50
	WB	675	0.4	50	166	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	201	0.3	50	24	0.8	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	201	0.3	50	24	0.8	50
Alfred Street N (between Kurraba Road and Mount Street)	SB	84	0.6	60	16	1.1	60
Alfred Street N (between Mount and High Street)	SB	1321	1.4	60	458	1.3	60

Notes: 1. Based on posted speeds.

2. The 2037 (design year) do something scenario includes the project and full WestConnex (Stages 1, 2 and 3), but without the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.

D.7 Year 2037 (design year) do something cumulative traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of M4-M5 Link Connection)	EB	1544	4.0	70	605	3.0	70
	WB	1513	4.5	70	720	2.2	70
City-West Link Road portals to M4-M5 Link	NB/Entry	1166	6.3	80	346	3.6	80
	SB/Exit	660	4.1	80	229	4.3	80
City-West Link Road (between M4-M5 Link portals and WHT portals)	EB	1859	3.0	70	730	2.9	70
	WB	2334	4.7	70	962	2.2	70
City-West Link Road portals to WHT	NB/Entry	849	8.3	80	381	5.4	80
	SB/Exit	1244	5.7	80	330	4.2	80
The Crescent (between City-West Link Road and Victoria Road)	EB	2187	2.0	70	722	2.1	70
	WB	1984	3.3	70	788	1.6	70
Victoria Road (east of The Crescent)	EB	1984	1.6	60	783	1.5	60
	WB	1728	2.5	60	739	1.4	60
Victoria Road portals to Rozelle Interchange	EB/Exit	2579	6.5	80	1018	4.9	80
	WB/Entry	2554	6.2	80	1218	4.1	80
Victoria Road (north of The Crescent)	NB	1545	1.7	60	411	2.2	60
	SB	1529	2.2	60	482	1.5	60
Victoria Road (between Lilyfield Road and Robert Street)	NB	1271	2.0	60	354	2.4	60
	SB	1529	2.2	60	482	1.5	60
Victoria Road (between Robert and Gordon Street)	NB	670	1.7	60	194	2.8	60
	SB	803	1.4	60	199	1.4	60
Victoria Road (between Gordon and Evans Street)	NB	693	1.7	60	203	2.8	60
	SB	605	1.5	60	126	1.5	60
Victoria Road (north of Evans Street)	NB	475	1.8	60	126	1.5	60
	SB	710	1.8	60	219	3.0	60
The Crescent (between Johnston Street and City-West Link Road)	NB	1552	4.2	50	538	3.2	50
	SB	1269	2.7	50	321	2.4	50
The Crescent (between Trafalgar and Johnston Street)	NB	859	3.1	50	285	2.7	50
	SB	730	1.8	50	197	1.7	50
The Crescent (between Nelson and Trafalgar Street)	NB	859	3.1	50	285	2.7	50
	SB	730	1.8	50	197	1.7	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	722	5.4	50	262	3.6	50
	SB	568	3.8	50	135	3.2	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Johnston Street (between Rose Street and Kentville Avenue)	NB	691	5.6	50	261	3.6	50
	SB	568	3.8	50	135	3.2	50
Johnston Street (between Piper and Rose Street)	NB	728	5.2	50	251	3.6	50
	SB	616	3.7	50	138	3.2	50
Warringah Freeway and surrounds							
Warringah Freeway (south of Merrenburn Avenue)	NB	4320	6.3	80	1248	4.7	80
	SB	4448	6.0	80	1347	5.3	80
Willoughby Road off ramp	NB	1088	5.0	60	448	5.8	60
Willoughby Road on ramp	SB	974	3.3	60	325	2.7	60
Warringah Freeway (south of Brook Street)	NB	5408	6.0	80	1697	5.0	80
	SB	5422	5.5	80	1672	4.8	80
Brook Street off ramp	NB	820	4.3	60	228	4.5	60
Brook Street on ramp	SB	703	1.3	80	86	3.7	80
Warringah Freeway (east of Miller Street)	WB	6228	5.8	80	1924	5.0	80
	EB	6125	5.0	80	1758	4.7	80
Miller Street off ramp	WB	431	1.8	60	165	3.6	60
Miller Street on ramp	EB	535	0.5	60	138	0.3	60
Warringah Freeway (north of Ernest Street)	NB	5031	4.0	80	1545	3.8	80
Warringah Freeway (north of Ernest St, WHT exit/entry portal)	NB/exit	1627	10.3	80	545	7.8	80
	SB/entry	1062	16.2	80	199	14.8	80
Warringah Freeway (north of Ernest St, BL entry/exit portal)	NB/entry	609	14.9	80	229	10.1	80
	SB/exit	681	9.5	80	151	11.6	80
Warringah Freeway (north of Ernest Street)	SB	4854	2.6	80	1536	3.4	80
Ernest Street off ramp	NB	385	1.0	50	136	0.7	50
Ernest Street on ramp	SB	405	0.3	60	30	0.2	60
Warringah Freeway (south of Falcon Street)	NB	3673	5.8	80	1223	4.9	80
Warringah Freeway (south of Falcon Street)	NB	1836	3.7	80	597	3.4	80
	SB	1854	3.5	80	641	4.3	80
Warringah Freeway (south of Falcon Street)	SB	4086	3.1	80	1077	3.9	80
Falcon Street off ramp (WHT exit portal)	NB	945	3.8	60	214	5.0	60
Falcon Street off ramp (bus lane)	NB	36	100	60	5	100	60
Military Road off ramp	NB	906	1.1	70	418	0.6	70

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Falcon Street on ramp	SB	1738	0.7	80	501	1.1	80
Falcon Street on ramp (bus lane)	SB	43	100	60	6	100	60
Berry Street on ramp	NB	517	2.5	80	177	2.1	80
Berry Street on ramp (WHT entry portal)	NB	1089	3.3	60	235	2.4	60
Alfred Street off ramp	SB	1207	2.6	60	335	2.4	60
Warringah Freeway (south of Mount Street)	NB	5898	4.7	80	2061	3.9	80
Warringah Freeway (south of Mount Street)	SB	5403	2.7	70	1727	3.7	70
Cahill Expressway (south of Mount Street)	SB	1068	2.8	70	157	2.2	70
Mount Street on ramp	SB	616	0.3	70	112	1.6	70
Mount Street on ramp (Cahill Expressway)	SB	586	0.3	70	296	0.4	70
Sydney Harbour Tunnel portals	NB/exit	2081	4.0	80	708	3.1	80
	SB/entry	2674	2.7	80	863	3.4	80
Warringah Freeway (south of High Street)	NB	3050	6.0	70	1155	4.9	70
Warringah Freeway (south of High Street)	SB	3344	2.2	70	977	3.7	70
Cahill Expressway (south of High Street)	SB	1654	1.9	70	452	1.0	70
Pacific Highway off ramp	NB	1274	1.7	60	421	2.3	60
High Street on ramp	SB	493	0.0	70	273	0.0	70
Lavender Street off ramp	NB	382	3.1	70	152	3.2	70
Bradfield Highway (south of Lavender Street)	NB	4706	4.6	70	1728	4.1	70
	SB	3344	2.2	70	977	3.7	70
Cahill Expressway (south of Lavender Street)	SB	2147	1.5	70	726	0.7	70
Ernest Street (west of Warringah Freeway)	EB	407	0.3	50	74	0.2	50
	WB	424	0.7	50	93	0.4	50
Ernest Street (between Miller and West Street)	EB	337	0.3	50	72	0.3	50
	WB	431	0.5	50	108	0.4	50
Ernest Street (between West and Sophia Street)	EB	156	0.5	50	43	0.3	50
	WB	387	0.8	50	79	0.6	50
Ernest Street (between Sophia and Alexander Street)	EB	156	0.5	50	43	0.3	50
	WB	156	0.5	50	43	0.3	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Ernest Street (east of Warringah Freeway)	EB	729	0.5	50	190	0.5	50
	WB	765	0.4	50	102	0.3	50
Ernest Street (between Merlin Street and Park Avenue)	EB	928	0.6	50	309	0.5	50
	WB	800	0.4	50	102	0.3	50
Falcon Street (west of Warringah Freeway)	EB	1352	0.6	60	294	0.6	60
	WB	1604	2.5	60	409	3.0	60
Falcon Street (between Miller and West Street)	EB	1110	0.4	60	256	0.4	60
	WB	881	2.3	60	243	1.7	60
Falcon Street (between West and Alexander Street)	EB	1139	0.4	60	278	0.5	60
	WB	689	2.0	60	203	1.2	60
Falcon Street (between Alexander Street and Pacific Highway)	EB	1101	0.5	60	274	0.5	60
	WB	796	1.5	60	248	1.0	60
Falcon Street (east of Warringah Freeway)	WB	2150	1.2	60	651	1.2	60
Falcon Street (between Watson Street and Tramway Lane)	WB	2176	1.1	60	665	1.2	60
Military Road (east of Warringah Freeway)	EB	2239	1.0	60	737	0.7	60
Military Road (between Watson Street and Ben Boyd Road)	EB	1965	1.0	60	624	0.6	60
	WB	2176	1.1	60	665	1.2	60
Military Road (between Ben Boyd Road and Young Street)	EB	1957	1.0	60	645	0.6	60
	WB	1916	1.1	60	603	1.2	60
Military Road (between Young Street and Wycombe Road)	EB	1776	0.9	60	625	0.6	60
	WB	1736	1.1	60	560	1.3	60
Willoughby Road (north of Warringah Freeway)	NB	1222	4.2	60	459	5.3	60
	SB	1283	2.8	60	412	2.4	60
Willoughby Road (south of Warringah Freeway)	NB	335	1.5	60	77	1.2	60
	SB	510	2.2	60	153	2.7	60
Willoughby Road (between Merrenburn Avenue and Dalleys Road)	NB	577	2.7	60	150	2.2	60
	SB	619	2.8	60	149	2.4	60
Willoughby Road (between Dalleys Road and Chandos Street)	NB	562	1.8	60	142	1.1	60
	SB	445	1.7	60	112	1.7	60
Willoughby Road (between Chandos and Atchison Street)	NB	389	1.3	60	104	0.9	60
	SB	488	1.2	60	128	1.5	60

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Willoughby Road (between Atchison and Albany Street)	NB	249	1.5	60	36	1.0	60
	SB	232	0.9	60	41	0.7	60
Willoughby Road (between Albany and Holtermann Street)	NB	306	0.7	60	64	0.8	60
	SB	150	0.5	60	45	0.7	60
Willoughby Road (between Holtermann and Falcon Street)	SB	41	0.0	60	6	0.0	60
Merrenburn Avenue (between Willoughby Road and Brook Street)	EB	307	3.8	50	95	3.9	50
	WB	173	4.4	50	17	4.0	50
Brook Street (between Merrenburn Avenue and Flat Rock Drive)	NB	1006	2.2	50	165	2.6	50
	SB	905	5.4	50	268	5.1	50
Brook Street (between Warringah Freeway on ramp and Merrenburn Avenue)	NB	699	5.5	50	201	5.0	50
	SB	933	1.6	50	176	2.2	50
Brook Street (between Warringah Freeway on and off ramps)	NB	1010	4.0	50	250	4.2	50
	SB	136	2.5	50	29	1.3	50
Brook Street (between Warringah Freeway on ramp and Chandos Street)	NB	545	1.3	50	92	1.5	50
	SB	491	1.2	50	99	1.4	50
Chandos Street (between Alexander and Brook Street)	EB	545	1.3	50	92	1.5	50
	WB	491	1.2	50	99	1.4	50
Chandos Street (between Brook Street and Willoughby Road)	EB	406	1.6	50	57	2.2	50
	WB	333	1.1	50	82	1.7	50
Chandos Street (between Willoughby Road and Oxley Street)	EB	455	2.0	50	61	2.0	50
	WB	167	1.6	50	32	2.1	50
Chandos Street (between Oxley and Christie Street)	EB	248	2.6	50	39	2.5	50
	WB	98	1.0	50	17	2.2	50
Alexander Street (between Brook and Albany Street)	NB	212	1.3	50	59	1.1	50
	SB	230	2.0	50	41	1.2	50
Alexander Street (between Albany and Holtermann Street)	NB	246	1.1	50	56	0.8	50
	SB	230	1.0	50	49	0.6	50
Alexander Street (between Holtermann and Ernest Street)	NB	266	1.0	50	63	0.8	50
	SB	339	0.9	50	88	0.7	50
Alexander Street (between Ernest and Burlington Street)	NB	322	0.9	50	74	0.7	50
	SB	339	1.0	50	77	0.7	50
Alexander Street (between Burlington and Falcon Street)	NB	349	1.1	50	80	0.8	50
	SB	364	0.9	50	86	0.7	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Alexander Street (between Falcon Street and Pacific Highway)	NB	384	0.7	50	85	0.4	50
	SB	255	1.7	50	43	1.7	50
Albany Street (between Alexander Street and Willoughby Road)	EB	81	0.5	50	22	0.3	50
	WB	101	2.1	50	7	0.0	50
Albany Street (between Willoughby Road and Oxley Street)	EB	133	0.5	50	22	0.3	50
	WB	292	0.8	50	31	0.4	50
Albany Street (between Oxley Street and Pacific Highway)	EB	377	2.6	50	115	2.3	50
	WB	439	2.2	50	85	2.3	50
Amherst Street (west of West Street)	EB	406	1.0	60	109	0.8	60
Amherst Street (between West and Miller Street)	EB	297	0.9	50	103	1.2	50
	WB	86	0.0	50	22	0.0	50
West Street (between Amherst and Ernest Street)	NB	128	1.2	50	39	2.6	50
	SB	318	1.0	50	66	1.3	50
West Street (between Ernest and Falcon Street)	NB	299	1.1	50	66	1.8	50
	SB	327	1.1	50	70	1.3	50
West Street (between Falcon and Ridge Street)	NB	85	2.9	50	18	5.8	50
	SB	335	2.8	50	83	3.2	50
West Street (between Ridge and Church Street)	NB	157	1.9	50	15	3.2	50
	SB	240	1.0	50	56	1.0	50
West Street (between Church Street and Pacific Highway)	NB	157	1.9	50	15	3.2	50
	SB	240	1.0	50	56	1.0	50
Miller Street (between Pine and Amherst Street)	NB	806	2.5	50	217	5.6	50
	SB	857	0.6	50	181	0.5	50
Miller Street (between Amherst Street and Warringah Freeway on ramp)	NB	696	2.2	50	183	5.1	50
	SB	882	0.6	50	177	0.5	50
Miller Street (between Warringah Freeway on and off ramps)	NB	706	2.2	50	184	5.1	50
	SB	357	0.9	50	40	1.2	50
Miller Street (between Warringah Freeway off ramp and Ernest Street)	NB	325	2.3	50	33	10.4	50
	SB	407	0.7	50	54	0.9	50
Miller Street (between Ernest and Falcon Street)	NB	384	1.9	50	51	6.9	50
	SB	387	0.9	50	54	0.9	50
Miller Street (between Falcon and Ridge Street)	NB	308	1.6	50	41	1.0	50
	SB	792	2.3	50	173	2.8	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Miller Street (between Ridge and McLaren Street)	NB	149	2.8	50	21	4.3	50
	SB	428	2.4	50	77	3.2	50
Miller Street (between McLaren and Berry Street)	NB	417	1.6	50	83	2.4	50
	SB	658	1.9	50	104	2.5	50
Miller Street (between Berry Street and Pacific Highway)	NB	353	1.9	40	70	2.8	40
	SB	202	2.2	40	45	1.0	40
Walker Street (between Ridge and McLaren Street)	NB	186	0.9	50	27	0.9	50
	SB	553	2.4	50	126	3.4	50
Walker Street (between McLaren and Berry Street)	NB	189	0.9	50	70	1.5	50
	SB	672	2.0	50	208	1.8	50
Walker Street (between Berry and Spring Street)	NB	433	3.1	50	113	2.7	50
	SB	16	1.0	50	2	3.6	50
Ridge Street (between Walker and Miller Street)	EB	553	2.4	50	126	3.4	50
	WB	186	0.9	50	27	0.9	50
Ridge Street (between Miller and West Street)	EB	112	3.1	50	21	4.6	50
	WB	274	3.0	50	44	5.0	50
McLaren Street (between Walker and Miller Street)	EB	383	1.4	50	83	1.6	50
	WB	298	0.4	50	70	0.3	50
McLaren Street (between Miller and Angelo Street)	EB	222	1.8	50	21	1.2	50
	WB	174	0.2	50	43	0.1	50
McLaren Street (between Angelo Street and Pacific Highway)	EB	222	1.8	50	21	1.2	50
	WB	174	0.2	50	43	0.1	50
Berry Street (between Walker and Arthur Street)	EB	2148	2.3	60	666	1.6	60
Berry Street (between Little Spring and Walker Street)	EB	1248	2.0	40	418	1.2	40
Berry Street (between Denison and Little Spring Street)	EB	1401	2.0	40	448	1.2	40
Berry Street (between Miller and Denison Street)	EB	1047	2.6	40	262	2.2	40
Berry Street (between Pacific Highway and Miller Street)	EB	654	3.0	40	215	1.7	40
Spring Street (between Walker and Little Spring Street)	WB	300	1.9	50	100	2.5	50
Spring Street (between Little Spring and Denison Street)	WB	453	1.7	50	130	2.2	50
Denison Street (between Spring and Berry Street)	NB	300	1.9	50	100	2.5	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Pacific Highway (between Arthur and Walker Street)	NB	2127	1.9	60	545	2.4	60
	SB	1401	0.9	60	401	0.8	60
Pacific Highway (between Walker and Miller Street)	NB	1431	1.6	60	380	1.6	60
	SB	657	0.9	60	114	0.6	60
Pacific Highway (between Miller and William Street)	NB	605	0.6	60	156	0.4	60
	SB	493	0.7	60	92	0.7	60
Pacific Highway (between William and Berry Street)	NB	778	1.1	60	202	1.0	60
	SB	493	0.7	60	92	0.7	60
Pacific Highway (between Berry Street and Bay Road)	NB	473	0.6	60	126	0.4	60
	SB	842	2.0	60	232	1.2	60
Pacific Highway (between Bay Road and McLaren Street)	NB	577	0.5	60	148	0.4	60
	SB	796	2.2	60	180	1.6	60
Pacific Highway (between McLaren and West Street)	NB	713	0.5	60	178	0.3	60
	SB	979	2.2	60	188	1.6	60
Pacific Highway (between West Street and Crows Nest Road)	NB	713	0.5	60	178	0.3	60
	SB	895	2.5	60	148	2.0	60
Pacific Highway (between Crows Nest and Rocklands Road)	NB	607	0.5	60	147	0.4	60
	SB	895	2.5	60	148	2.0	60
Pacific Highway (between Rocklands Road and Bruce Street)	NB	711	0.5	60	146	0.4	60
	SB	956	2.2	60	151	2.0	60
Pacific Highway (between Bruce and Alexander Street)	NB	749	0.7	60	152	0.5	60
	SB	1002	2.5	60	161	2.2	60
Pacific Highway (between Alexander and Falcon Street)	NB	485	0.5	60	85	0.5	60
	SB	867	2.4	60	137	2.0	60
Pacific Highway (between Falcon and Hume Street)	NB	583	1.2	60	103	1.0	60
	SB	1165	1.5	60	182	1.4	60
Arthur Street (between Pacific Highway and Mount Street)	NB	1250	1.1	60	386	1.6	60
High Street (west of Warringah Freeway)	EB	697	1.5	70	200	0.7	70
	WB	1079	2.5	70	249	2.8	70
High Street (east of Warringah Freeway)	EB	939	0.5	50	336	0.3	50
	WB	1059	0.2	50	373	0.1	50
Clark Road (between High Street and Adderstone Avenue)	NB	654	0.2	50	255	0.2	50
	SB	765	0.1	50	233	0.1	50

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Clark Road (between Adderstone Avenue and Kurraba Road)	NB	522	0.1	50	213	0.1	50
	SB	647	0.1	50	187	0.1	50
Kurraba Road (between Clark Road and Holdsworth Street)	EB	617	0.2	50	217	0.1	50
	WB	634	0.1	50	183	0.1	50
Kurraba Road (between Holdsworth and Ben Boyd Road)	EB	427	0.2	50	158	0.2	50
	WB	499	0.1	50	130	0.1	50
Bent Street (between Falcon Street and Alfred Street N)	SB	191	0.2	50	23	0.3	50
Alfred Street N (between Bent Street and Kurraba Road)	SB	191	0.2	50	23	0.3	50
Alfred Street N (between Kurraba Road and Mount Street)	SB	83	0.2	60	15	0.4	60
Alfred Street N (between Mount and High Street)	SB	1521	2.1	60	483	1.7	60

Notes: 1. Based on posted speeds.

2. The 2037 (design year) do something cumulative scenario includes the project, Beaches Link and Gore Hill Freeway Connection, full WestConnex (Stages 1, 2 and 3), Sydney Gateway and the F6 Extension (all stages).

D.8 Year 2027 (opening year) do nothing traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of The Crescent)	EB	1848	5.5	70	825	4.5	70
	WB	1455	6.3	70	739	3.4	70
The Crescent (between City-West Link Road and Victoria Road)	EB	2413	5.0	70	942	4.6	70
	WB	1848	5.6	70	839	3.3	70
Victoria Road (east of The Crescent)	EB	4288	4.3	60	1738	3.5	60
	WB	3632	4.6	60	1602	3.0	60
Victoria Road (north of The Crescent)	NB	2529	3.3	70	956	2.7	70
	SB	2588	3.1	70	969	2.2	70
Victoria Road (between Lilyfield Road and Robert Street)	NB	2258	3.5	60	795	2.8	60
	SB	2588	3.1	60	969	2.2	60
Victoria Road (between Robert and Gordon Street)	NB	1813	4.1	60	653	3.0	60
	SB	2027	3.5	60	728	2.5	60
Victoria Road (between Gordon and Evans Street)	NB	1824	4.1	60	659	3.0	60
	SB	1859	3.5	60	647	2.5	60
Victoria Road (north of Evans Street)	NB	1815	3.6	60	647	2.5	60
	SB	1808	4.2	60	671	3.1	60
The Crescent (between Johnston Street and City-West Link Road)	NB	745	3.0	50	244	3.0	50
	SB	572	2.4	50	227	1.5	50
The Crescent (between Trafalgar and Johnston Street)	NB	427	1.8	50	98	3.1	50
	SB	381	2.4	50	151	1.1	50
The Crescent (between Nelson and Trafalgar Street)	NB	427	1.8	50	98	3.1	50
	SB	381	2.4	50	151	1.1	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	423	3.5	50	155	2.8	50
	SB	296	1.5	50	86	1.9	50
Johnston Street (between Rose Street and Kentville Avenue)	NB	390	3.1	50	155	2.8	50
	SB	235	1.8	50	86	1.9	50
Johnston Street (between Piper and Rose Street)	NB	421	2.9	50	155	2.7	50
	SB	328	1.5	50	96	1.9	50

Notes: 1. Based on posted speeds.

2. The 2027 (opening year) do nothing scenario is without the project, Beaches Link and Gore Hill Freeway Connection, WestConnex, Sydney Gateway and the F6 Extension.

D.9 Year 2037 (design year) do nothing traffic volumes

Traffic Monitoring Location	Direction	Average hourly traffic from 7.00am – 10.00pm (15 hour)			Average hourly traffic from 10.00pm – 7.00am (9 hour)		
		Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)	Total Vehicles	Percentage Heavy Vehicles	Speed[1] (km/h)
Area surrounding the surface connection to City West Link at Rozelle							
City-West Link Road (west of The Crescent)	EB	1880	5.9	70	831	4.9	70
	WB	1399	7.1	70	730	4.1	70
The Crescent (between City-West Link Road and Victoria Road)	EB	2561	5.2	70	984	4.9	70
	WB	1876	6.0	70	864	3.7	70
Victoria Road (east of The Crescent)	EB	4545	4.6	60	1825	3.9	60
	WB	3739	4.9	60	1700	3.1	60
Victoria Road (north of The Crescent)	NB	2679	3.4	70	1079	2.4	70
	SB	2753	3.5	70	1045	2.7	70
Victoria Road (between Lilyfield Road and Robert Street)	NB	2336	3.8	60	867	2.9	60
	SB	2753	3.5	60	1045	2.7	60
Victoria Road (between Robert and Gordon Street)	NB	1897	4.5	60	715	3.2	60
	SB	2189	3.9	60	782	3.1	60
Victoria Road (between Gordon and Evans Street)	NB	1913	4.4	60	722	3.2	60
	SB	1984	4.1	60	687	3.2	60
Victoria Road (north of Evans Street)	NB	1917	4.2	60	687	3.2	60
	SB	1872	4.5	60	734	3.2	60
The Crescent (between Johnston Street and City-West Link Road)	NB	819	2.8	50	289	3.0	50
	SB	614	2.4	50	270	1.3	50
The Crescent (between Trafalgar and Johnston Street)	NB	432	1.9	50	114	2.9	50
	SB	422	2.6	50	188	0.9	50
The Crescent (between Nelson and Trafalgar Street)	NB	432	1.9	50	114	2.9	50
	SB	422	2.6	50	188	0.9	50
Johnston Street (between Kentville Avenue and The Crescent)	NB	507	3.2	50	186	2.9	50
	SB	313	1.7	50	93	2.0	50
Johnston Street (between Rose Street and Kentville Avenue)	NB	458	2.7	50	186	2.9	50
	SB	227	1.8	50	93	2.0	50
Johnston Street (between Piper and Rose Street)	NB	492	2.5	50	184	2.8	50
	SB	361	1.5	50	100	2.0	50

Notes: 1. Based on posted speeds.

2. The 2037 (design year) do nothing scenario is without the project, Beaches Link and Gore Hill Freeway Connection, WestConnex, Sydney Gateway and the F6 Extension.

APPENDIX E Construction support site assessment activities

E.1 Rozelle Rail Yards construction support site (ROZ)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Site establishment	ROZ_01	Establish site	X	-	Franna crane	1	-	98	102	-
					Bobcat	1	-	107	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
	ROZ_02	Establish construction facilities	X	-	Excavator with bucket	1	-	105	108	-
					Franna crane	1	-	98	102	-
					Concrete agitator	4 p.h.	-	108	-	-
					Concrete pump	1	-	103	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
					Bobcat	2	-	107	-	-
Tunnel fitout and finishing	ROZ_03a	Deliveries	X	X	Truck	Note 2	Note 2	103	117	-
					Franna crane	1	-	98	102	-
	ROZ_03b	Laydown areas	X	-	Site Forklift	1	-	103	-	-
					Ute/light vehicle	4 p.h.	-	89	-	-
					Workshop hand tools	2	-	104	-	-
	ROZ_03c	Spoil handling	X	-	Moxie (spoil out of tunnel)	8 p.h.	-	108	-	-
					Dump truck	Note 2	-	108	117	-
					Front end loader	1	-	110	113	-
Integration road works	ROZ_04	Surface road woks	X	-	Truck	1	-	103	117	-
					Scissor lift	1	-	102	-	-
					Franna crane	1	-	98	102	-
					Roller	1	-	109	-	-
					Pavement laying machine	1	-	114	-	-
					Line marking truck	1	-	108	117	-
Tunnel commission and site rehabilitation	ROZ_05	Restore site	X	-	Front end loader	1	-	110	113	-
					10t dump truck	4 p.h.	-	100	115	-
					Generator (enclosed)	1	-	94	-	-
					Ute/light vehicle	8 p.h.	-	89	-	-
					Backhoe	1	-	100	104	-
					Franna crane	1	-	98	102	-

Notes:
1. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage.

E.2 Victoria Road construction support site (VIC)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Early works	VIC_01	Utility works	X	-	Vacuum truck	1	-	108	-	-
					Excavator with rock hammer	1	-	122	126	YES
Site establishment	VIC_02a	Installation of environmental controls	X	-	Franna crane	1	-	98	102	-
					Bobcat	1	-	107	-	-
					Truck (medium rigid)	8 p.h.	-	103	117	-
	VIC_02b	Demolition of existing structures	X	-	Excavator with bucket	2	-	105	108	-
					Excavator with rock hammer	2	-	122	126	YES
					Truck and dog	4 p.h.	-	108	117	-
	VIC_03	Establishment of construction facilities	X	-	Franna crane	1	-	98	102	-
					Concrete agitator	4 p.h.	-	108	-	-
					Concrete pump	1	-	103	-	-
					Truck (medium rigid)	8 p.h.	-	103	117	-
					Water truck	1	-	98	-	-
					Bobcat	2	-	107	-	-
					Workshop hand tools	2	-	104	-	-
Decline construction	VIC_04	Piling for excavation shaft or spoil shed	X	-	Piling rig - bored	2	-	112	115	-
					Concrete pump	1	-	103	-	-
					Excavator with bucket	2	-	105	108	-
					Concrete agitator	4 p.h.	-	108	-	-
	VIC_05	Decline excavation and construction	X	-	Concrete agitator	4 p.h.	-	108	-	-
					Front end loader	1	-	110	113	-
					Roadheader	-	-	114	-	-
					Tracked mobile drilling rig	-	-	120	-	YES
					Excavator with rock hammer	1	-	122	126	YES
					Truck and dog	8 p.h.	-	108	117	-
					Franna crane	1	-	98	102	-
					Concrete pump	1	-	103	-	-
					Shotcrete rig - compressor	1	-	104	-	-
	VIC_06	Acoustic shed construction	X	-	Elevated work platform	2	-	102	-	-
					Rattle gun	2	-	99	-	-
					Mobile crane	2	-	110	-	-
					Site forklift	1	-	103	-	-
					Truck	4 p.h.	-	103	117	-
					Compressor	1	-	100	-	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Tunnel construction	VIC_07a	General site activities	X	X	Site forklift	1	1[4]	103	-	-
					Workshop hand tools	1	1[4]	104	-	-
					Franna crane	1	-	98	102	-
					Ute/light vehicle	4 p.h.	-	89	-	-
					Workshop compressor	1	1[4]	100	-	-
					Water treatment plant pumps	2	2	82	-	-
					Substation	1	1	80	-	-
	VIC_07b	Deliveries	X	-	Truck	4 p.h.	-	103	117	-
					Franna crane	1	-	98	102	-
	VIC_07c	Tunnelling and support	X	X	Roadheader	UG	UG	114	-	-
					Dust scrubber	UG	UG	-	-	-
					Ventilation fans (mitigated)	Note 1	Note 1	82[1]	-	-
					Concrete pump	UG	UG	103	-	-
					Tracked mobile drilling rig	UG	UG	120	-	YES
	VIC_07d	Tunnel lining (concreting)	X	X	Concrete pump	UG	UG	103	-	-
					Concrete agitator	Note 2	Note 2 and 4	108	-	-
					Pneumatic vibrator	UG	UG	97	-	-
	VIC_07e	Spoil handling in acoustic shed	X	X	Moxie (spoil out of tunnel)	UG	UG	108	-	-
					Front end loader	1	1	110	113	-
	VIC_07f	Spoil haulage	X	-	Dump truck	Note 2	-	108	117	-
Tunnel fitout	VIC_08a	Deliveries	X	X	Truck	4 p.h.	Note 2 and 4	103	117	-
					Franna crane	1	1[4]	98	102	-
					Ventilation fans (mitigated)	Note 1	Note 1	82[1]	-	-
					Water treatment plant pumps	2	2	82	-	-
					Substation	1	1	80	-	-
	VIC_08b	Laydown areas	X	-	Site forklift	1	-	103	-	-
					Ute/light vehicle	4 p.h.	-	89	-	-
					Workshop hand tools	3	-	104	-	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Tunnel commission and site rehabilitation	VIC_09	Decommission-ing and rehabilitation of site	X	-	Front end loader	1	-	110	113	-
					Excavator with rock hammer	1	-	122	126	YES
					10t dump truck	4 p.h.	-	100	115	-
					Elevated work platform	2	-	102	-	-
					Generator (enclosed)	2	-	94	-	-
					Ute/ light vehicle	8 p.h.	-	89	-	-
					Backhoe	1	-	100	104	-
					Franna crane	1	-	98	102	-

Notes:
1. The number of fans is equivalent to the number of roadheaders supported by the site. Individual plant item SWL (LAeq) represents the total combined SWL of all the fans.
2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage
3. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
4. Assumed to take place within the acoustic shed. Deliveries and laydown activities would go directly into and occur within the acoustic shed.

UG = Source located underground and assumed to not contribute to airborne noise emissions.

E.3 White Bay construction support site (WHB)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Early works	WHB_01	Utility works	X	-	Vacuum truck	1	-	108	-	-
					Excavator with rock hammer	1	-	122	126	YES
Site establishment	WHB_02	Installation of environ-mental controls	X	-	Franna crane	2	-	98	102	-
					Bobcat	2	-	107	-	-
					Truck (medium rigid)	8 p.h.	-	103	117	-
	WHB_03	Establishment of construction facilities	X	-	Franna crane	2	-	98	102	-
					Concrete agitator	4 p.h.	-	108	-	-
					Concrete pump	1	-	103	-	-
					Truck (medium rigid)	8 p.h.	-	103	117	-
					Bobcat	4	-	107	-	-
					Workshop hand tools	2	-	104	-	-
Construction of wharf structure	WHB_04	Piling for wharf structure	X	-	Piling rig - bored	2	-	112	115	-
Casting of immersed tube tunnel elements	WHB_05a	Tunnel element production	X	-	Concrete pump	1	-	103	-	-
					Concrete agitator	1	-	108	-	-
					Concrete vibrators	2	-	106	-	-
					Generator (enclosed)	1	-	94	-	-
					Compressor (enclosed)	1	-	90	-	-
	WHB_05b	Deliveries	X	-	Franna crane	1	-	98	102	-
					Truck	4 p.h.	-	103	117	-
	WHB_06	Tunnel element fitout	X	-	Welding equipment	1	-	105	-	-
					Mobile crane	1	-	110	-	-
					Generator (enclosed)	1	-	94	-	-
					Compressor	1	-	100	-	-
					Dump truck	4 p.h.	-	108	117	-
Spoil handling and treatment; and deliveries	WHB_07a	Tunnel and dredged spoil handling	X	-	Front end loader	2	-	110	113	-
					Dump truck	Notes 2 and 3	-	108	117	-
	WHB_07b	Deliveries	X	-	Franna crane	1	-	98	102	-
					Truck	10 p.h.[4]	-	108	117	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Spoil handling and treatment; and deliveries (continued)	WHB_07c	Support Berrys Bay and Yurulbin construction sites	X	X	Truck / Concrete agitator	4 p.h.[4]	Note 2	108	117	-
					Ute/light vehicle	Note 2	Note 2	100	104	-
					Pump	1	-	105	-	-
Site rehabilitation/ landscaping	WHB_08	Decommissi-oning and rehabilitation of site	X	-	10t dump truck	8 p.h.	-	100	115	-
					Elevated work platform	2	-	102	-	-
					Generator (enclosed)	2	-	94	-	-
					Ute/light vehicle	8 p.h.	-	89	-	-
					Backhoe	1	-	100	104	-
					Franna crane	1	-	98	102	-

Notes:
1. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage.
3. Spoil handling heavy vehicle movements have been divided between the White Bay north area of the construction support site which would handle the dredged spoil, and the Glebe Island area of the construction support site which would handle spoil from the tunnelling sites.
4. These are included as part of the overall construction vehicle numbers presented in the construction traffic assessment within the construction support site assessment.

E.4 Yurulbin Point construction support site (YRB)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Early works	YRB_01	Utility works	X	-	Vacuum truck	1	-	108	-	-
					Excavator with rock hammer	1	-	122	126	YES
Site establishment	YRB_02a	Installation of environmental controls	X	-	Franna crane	1	-	98	102	-
					Bobcat	1	-	107	-	-
					Barge	1	-	106	117	-
	YRB_02b	Clearing and grubbing	X	-	Excavator with bucket	1	-	105	108	-
					Chainsaw	1	-	116	-	-
					Tub grinder/mulcher	1	-	119	124	-
	YRB_03	Establishment of construction facilities	X	-	Excavator with bucket	2	-	105	108	-
					Franna crane	1	-	98	102	-
					Concrete agitator	1	-	108	-	-
					Concrete pump	1	-	103	-	-
					Barge	1	-	106	117	-
					Bobcat	2	-	107	-	-
	YRB_04a	Piling for excavation shaft or spoil shed	X	-	Piling rig - bored	2	-	112	115	-
					Concrete pump	1	-	103	-	-
					Excavator with bucket	1	-	105	108	-
					Barge	1	-	106	117	-
					Concrete agitator	1	-	108	-	-
	YRB_04b	Piling for barge shed	X	-	Piling rig	1	-	116	-	-
					Generator (enclosed)	1	-	94	-	-
					Crane	1	-	98	102	-
	YRB_05a	Acoustic shed construction	X	-	Elevated work platform	2	-	102	-	-
					Rattle gun	3	-	99	-	-
					Mobile crane	1	-	110	-	-
					Site forklift	1	-	103	-	-
					Barge	1	-	106	117	-
					Compressor	1	-	100	-	-
	YRB_05b	Barge shed construction	X	-	Rattle gun	1	-	99	-	-
					Crane	1	-	110	-	-
					Compressor	1	-	100	-	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Shaft construction	YRB_06	Shaft excavation and construction in acoustic shed	X	-	Concrete agitator	1	-	108	-	-
					Excavator with bucket	1	-	105	108	-
					Excavator with rock hammer	1	-	122	126	YES
					Tracked mobile drilling rig	-	-	120	-	YES
					Barge	1	-	106	117	-
					Shotcrete rig - compressor	-	-	104	-	-
Tunnel construction	YRB_07a	General site activities	X	X	Site forklift	1	1[3]	103	-	-
					Workshop hand tools	1	1[3]	104	-	-
					Franna crane	1	-	98	102	-
					Workshop compressor	1	1[3]	100	-	-
					Water treatment pumps	2	2	83	-	-
					Substation	1	1	75	-	-
	YRB_07b	Deliveries	X	X	Crane and barge	1	1[2,3]	106	120	-
	YRB_07c	Tunnelling and support	X	-	Roadheader	UG	UG	114	-	-
					Dust scrubber	UG	UG	-	-	-
					Concrete pump	UG	UG	103	-	-
					Tracked mobile drilling rig	UG	UG	120	-	YES
	YRB_07d	Tunnel lining (concreting) deliveries	X	X	Concrete pump	UG	UG	103	-	-
					Concrete agitator	1[3]	1[3]	108	-	-
					Pneumatic vibrator	UG	UG	97	-	-
	YRB_07e	Barge spoil removal in acoustic shed	X	X	Barge	1	-	106	117	-
					Conveyor	1	1	75/ m	-	-
					Front end loader	1	1	110	113	-
Tunnel fitout	YRB_08a	Deliveries by barge	X	X	Crane and barge	1	1[2,3]	106	-	-
					Franna crane	1	-	98	102	-
					Water treatment pumps	2	2	83	-	-
					Substation	1	1	75	-	-
	YRB_08b	Laydown areas	X	-	Site forklift	1	-	103	-	-
					Workshop hand tools	2	-	104	-	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[1]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Tunnel commission and site rehabilitation	YRB_09	Decommission-ing and rehabilitation of site	X	-	Front end loader	1	-	110	113	-
					Backhoe	1	-	100	115	-
					Elevated work platform	2	-	102	-	-
					Generator (enclosed)	2	-	94	-	-
					Barge	1	-	106	117	-
					Franna crane	2	-	98	102	-

Notes:
1. In accordance with the ICNG, a 5 dB(A) 'penalty' applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
2. During night barge movements idling would be minimised and would not occur throughout deliveries, and night delivery activities (i.e. cranes) outside the shed would be minimised.
3. Assumed to take place within the acoustic shed. Deliveries and laydown activities would move directly into the shed and deliveries occur within the acoustic shed.

UG = Source located underground and assumed to not contribute to airborne noise emissions.

E.5 Sydney Harbour Crossing construction support sites (SHC)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Build Sydney Harbour north cofferdam	SHC_01	Piling for cofferdams	X	-	23t hammer piling rig	1	-	129	-	YES
					Compressor	4	-	100	-	-
					Concrete pump	1	-	103	1	-
Build Sydney Harbour south cofferdam	SHC_02	Piling for cofferdams	X	-	23t hammer piling rig	1	-	129	-	YES
					Compressor	4	-	100	-	-
					Concrete pump	1	-	103	1	-
Dewater cofferdams	SHC_03	Pumping water	X	X	Water pump on pontoon (enclosed or treated)	1	1	82	85	-
Excavate cofferdams	SHC_04	Remove soil and rock from cofferdams	X	-	Excavator with hammer	1	-	127	-	YES
					Excavator with bucket	1	-	105	-	-
					Crawler crane on barge	1	-	106	-	-
					Concrete pump	1	-	103	-	-
Cast transition structures	SHC_05	Cast concrete transition structures	X	-	Crane on barge	1	-	106	-	-
					Concrete agitator	1	-	108	-	-
					Concrete pump	1	-	103	-	-
Remove cofferdams	SHC_06	Inundate and remove cofferdams	X	X	Water pump on pontoon (enclosed or treated)	1	1	82	85	-
Prepare foundations	SHC_07	Dredge and place gravel foundations	X	X	Backhoe dredge on barge	1	-	110	-	-
					Trailer suction hopper dredge	-	1	106	110	-
Immerse elements	SHC_08	Immerse and connect tube tunnel elements	X	X	Immersion pontoon, crane/equipment/plant on barge or sea lock barge	2	2	106	120	-

Notes: 1. The number of fans is equivalent to the number of roadheaders supported by the site.

2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage.

3. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.

UG = Source located underground and assumed to not contribute to airborne noise emissions.

E.6 Berrys Bay construction support site (BRY)

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Early works	BRY_01	Utility works (within site)	X	-	Vacuum truck	1	-	108	-	-
					Excavator with rock hammer	1	-	122	126	YES
Site establishment	BRY_02a	Installation of environmental controls	X	-	Franna crane	1	-	98	102	-
					Bobcat	1	-	107	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
	BRY_02b	Clearing and grubbing	X	-	Excavator with bucket	1	-	105	108	-
					Chainsaw	1	-	116	-	-
					Tub grinder/mulcher	1	-	119	124	-
					Dump truck	4 p.h.	-	108	117	-
	BRY_03	Establishment of construction facilities	X	-	Excavator with bucket	1	-	105	108	-
					Franna crane	1	-	98	102	-
					Concrete agitator	4 p.h.	-	108	-	-
					Concrete pump	1	-	103	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
					Water truck	1	-	98	-	-
					Bobcat	2	-	107	-	-
					Workshop hand tools	2	-	104	-	-
	BRY_04a	Piling for excavation shaft or spoil shed	X	-	Piling rig - bored	2	-	112	115	-
					Concrete pump	1	-	103	-	-
					Excavator with bucket	1	-	105	108	-
					Concrete agitator	4 p.h.	-	108	-	-
	BRY_04b	Piling for barge shed	X	-	Piling rig	1	-	116	-	-
					Generator (enclosed)	1	-	94	-	-
					Crane	1	-	98	102	-
Decline construction	BRY_05	Decline excavation and construction	X	-	Concrete agitator	4 p.h.	-	108	-	-
					Front end loader	1	-	110	113	-
					Roadheader	-	-	114	-	-
					Tracked mobile drilling rig	-	-	120	-	YES
					Excavator with rock hammer	1	-	122	126	YES
					Truck and dog	4 p.h.	-	108	117	-
					Franna crane	1	-	98	102	-
					Concrete pump	1	-	103	-	-
					Shotcrete rig - compressor	-	-	104	-	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Decline construction (*continued*)	BRY_06a	Acoustic shed construction	X	-	Elevated work platform	2	-	102	-	-
					Rattle gun	2	-	99	-	-
					Mobile crane	1	-	110	-	-
					Site forklift	1	-	103	-	-
					Truck	4 p.h.	-	103	117	-
					Compressor	1	-	100	-	-
	BRY_06b	Barge shed construction	X	-	Rattle gun	1	-	99	-	-
					Mobile crane	2	-	110	-	-
					Compressor	1	-	100	-	-
Tunnel construction	BRY_07a	General site activities	X	X	Site forklift	1	1[4]	103	-	-
					Workshop hand tools	1	1[4]	104	-	-
					Franna crane	1	-	98	102	-
					Ute/light vehicle	4 p.h.	4 p.h.	89	-	-
					Workshop compressor	2	1[4]	100	-	-
					Water treatment pumps	2	2	71	-	-
					Substation	1	1	73	-	-
	BRY_07b	Deliveries	X	-	Truck	4 p.h.	-	103	117	-
					Franna crane	1	-	98	102	-
	BRY_07c	Tunnelling and support	X	X	Roadheader	UG	UG	114	-	-
					Dust scrubber	UG	UG	-	-	-
					Ventilation fans (mitigated)	Note 1	Note 1	86[1]	-	-
					Concrete pump	UG	UG	103	-	-
					Tracked mobile drilling rig	UG	UG	120	-	YES
	BRY_07d	Tunnel lining (concreting)	X	X	Concrete pump	UG	UG	103	-	-
					Concrete agitator	Note 2	Note 2	108	-	-
					Pneumatic vibrator	UG	UG	97	-	-
	BRY_07e	Deliveries by barge	X	-	Crane and barge	1	-	106	-	-
					Franna crane	1	-	98	102	-
	BRY_07f	Barge spoil handling in acoustic shed	X	X	Barge	1	-	106	117	-
					Conveyor	1	1	75/	-	-
					Front end loader	1	1	110	113	-
					Franna crane	1	-	98	102	-

Site activity	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Tunnel fitout	BRY_08a	Deliveries	X	X	Truck	4 p.h.	Note 2	103	117	-
					Franna crane	1	Note 4	98	102	-
					Ventilation fans (mitigated)	Note 1	Note 1	86[1]	-	-
					Water treatment pumps	2	2	71	-	-
					Substation	1	1	73	-	-
	BRY_08b	Laydown areas	X	-	Site forklift	1	-	103	-	-
					Barge	1	-	106	117	-
					Workshop hand tools	2	-	104	-	-
					Ute/light vehicle	4.p.h.	-	89	-	-
Tunnel commission and site rehabilitation	BRY_09	Decommission-ing and rehabilitation of site	X	-	Front end loader	1	-	110	113	-
					10t dump truck	4 p.h.	-	100	115	-
					Elevated work platform	2	-	102	-	-
					Generator (enclosed)	2	-	94	-	-
					Ute/light vehicle	8 p.h.	-	89	-	-
					Backhoe	1	-	100	104	-
					Franna crane	1	-	98	102	-

Notes:
1. The number of fans is equivalent to the number of roadheaders supported by the site. Individual plant item SWL (LAeq) represents the total combined SWL of all the fans.
2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage.
3. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
4. Assumed to take place within the acoustic shed. Deliveries and laydown activities would go directly into and occur within the acoustic shed.

UG = Source located underground and assumed to not contribute to airborne noise emissions.

E.7 Cammeray Golf Course construction support sites (CGC)

Site activity (Location)	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Site establishment (WHT10 and WFU8)	CGC_01	Utility works	X	-	Vacuum truck	4	-	108	-	-
					Excavator with bucket	7	-	105	108	-
					Bobcat	7	-	107	-	-
	CGC_02a	Installation of environmental controls	X	-	Franna crane	4	-	98	102	-
					Bobcat	4	-	107	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
	CGC_02b	Construction of vehicle access points (two locations)	X	-	Truck	1	-	103	117	-
					Scissor lift	1	-	102	-	-
					Franna crane	1	-	98	102	-
					Line marking truck	-	-	108	117	-
	CGC_02c	Demolition of existing structures	X	-	Excavator with bucket	1	-	105	108	-
					Excavator with rock hammer	2	-	122	126	YES
					Truck and dog	8 p.h.	-	108	117	-
	CGC_02d	Clearing and grubbing works	X	-	Excavator with bucket	2	-	102	108	-
					Elevated work platform	2	-	102	-	-
					Chainsaw	1	-	116	-	-
					Tub grinder/mulcher	1	-	114	124	-
					Dump truck	4.p.h.	-	108	117	-
	CGC_02e	Earthworks	X	-	Bulldozer	2	-	116	-	YES
					Scraper	2	-	110	-	-
					Excavator with bucket	3	-	105	108	-
					Grader	-	-	113	-	-
					Dump truck	8 p.h.	-	108	117	-
					Truck	4 p.h.	-	103	117	-
					Compactor	-	-	108	-	-
					Roller	-	-	109	-	-
					Water truck	1	-	98	-	-
					Road sweeper	-	-	104	-	-
	CGC_02f	Establishment of construction facilities	X	-	Excavator with bucket	2	-	105	108	-
					Franna crane	1	-	98	102	-
					Concrete agitator	4 p.h.	-	108	-	-
					Concrete pump	1	-	103	-	-
					Truck (medium rigid)	4 p.h.	-	103	117	-
					Water truck	1	-	98	-	-
					Bobcat	2	-	107	-	-
					Workshop hand tools	2	-	104	-	-

Site activity (Location)	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Decline construction (WHT10)	CGC_03a	Decline, shed and vent tunnels	X	-	Piling rig - bored	2	-	112	115	-
					Concrete pump	1	-	103	-	-
					Excavator with bucket	1	-	105	108	-
					Concrete agitator	4 p.h.	-	108	-	-
	CGC_03b	Decline and vent tunnel excavation	X	-	Concrete agitator	4 p.h.	-	108	-	-
					Front end loader	1	-	110	113	-
					Roadheader	-	-	114	-	-
					Tracked mobile drilling rig	-	-	120	-	YES
					Excavator with rock hammer	1	-	122	126	YES
					Truck and dog	8 p.h.	-	108	117	-
					Franna crane	1	-	98	102	-
					Concrete pump	1	-	103	-	-
					Shotcrete rig - compressor	1	-	104	-	-
	CGC_03c	Acoustic shed construction	X	-	Elevated work platform	2	-	102	-	-
					Rattle gun	2	-	99	-	-
					Mobile crane	2	-	110	-	-
					Site forklift	1	-	103	-	-
					Truck	4 p.h.	-	103	117	-
					Compressor	1	-	100	-	-
					Ute/light vehicle	10 p.h.	-	89	-	-
Surface road work support (WFU8)	CGC_04a	Construction support site general activities	X	X	Ute/light vehicle	Note 2	Note 2	89	-	-
					Generator (enclosed)	1	-	94	-	-
	CGC_04b	Deliveries	X	-	Truck	12 p.h.	-	103	117	-
					Franna crane	1	-	98	102	-
Tunnel construction (WHT10)	CGC_05a	General site activities	X	X	Site forklift	1[4]	1[4]	103	-	-
					Workshop hand tools	1[4]	1[4]	104	-	-
					Franna crane	1[4]	1[4]	98	102	-
					Ute/ light vehicle	Note 2	Note 2	89	-	-
					Workshop compressor	1[4]	1[4]	100	-	-
					Water treatment pumps	2	2	82	-	-
					Substation	1	1	85	-	-

Site activity (Location)	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Tunnel construction (WHT10) *(continued)*	CGC_05b	Deliveries	X	-	Truck	4 p.h.	-	103	117	-
					Franna crane	1	-	98	102	-
	CGC_05c	Tunnelling and support	X	X	Roadheader	UG	UG	114	-	-
					Dust scrubber	UG	UG	-	-	-
					Ventilation fans (mitigated)	Note 1	Note 1	85[1]	-	-
					Concrete pump	UG	UG	103	-	-
					Tracked mobile drilling rig	UG	UG	120	-	YES
	CGC_05d	Tunnel lining (concreting)	X	X	Concrete pump	UG	UG	103	-	-
					Concrete agitator	Note 2	Note 2 and 4	108	-	-
					Pneumatic vibrator	UG	UG	97	-	-
	CGC_05e	Rock crushing in acoustic shed	X	-	Rock crusher	1	-	117	-	-
	CGC_05f	Spoil handling in acoustic shed	X	X	Moxie (spoil out of tunnel)	UG	UG	108	-	-
					Front end loader	1	1	110	113	-
	CGC_05g	Spoil haulage	X	-	Dump truck	Note 2	-	108	117	-
Tunnel fitout (WHT10)	CGC_06a	Deliveries	X	X	Truck	8 p.h.	Note 2	103	117	-
					Franna crane	1	1[4]	98	102	-
					Ute/light vehicle	Note 2	Note 2	89	-	-
					Ventilation fans (mitigated)	Note 1	Note 1	85[1]	-	-
					Water treatment pumps	2	2	82	-	-
					Substation	1	1	85	-	-
	CGC_06b		X	-	Site forklift	1	-	89	-	-
					Workshop hand tools	2	-	104	-	-
Remove spoil shed, build motorway facility buildings (WHT10)	CGC_07	Facility/ ventilation structure construction	X	-	Concrete pump	1	-	103	-	-
					Concrete agitator	4 p.h.	-	108	-	-
					Pneumatic vibrator	2	-	97	-	-
					Workshop hand tools	4	-	104	-	-
					Generator (enclosed)	2	-	94	-	-
					Ute/light vehicle	12 p.h.	-	89	-	-
					Elevated work platform	1	-	102	-	-
					Franna crane	1	-	98	102	-
		Demolition of structures (non rock hammer)	X	-	Excavator with bucket	1	-	105	108	-
					Excavator with pulveriser	2	-	108	-	-
					Truck & dog	8 p.h.	-	108	117	-

Site activity (Location)	Works ID	Activity / modelled works	Standard construction hours	OOHW	Plant item	Standard - Reasonable worst-case	OOHW - Reasonable worst-case	Individual plant item SWL (L_{Aeq})[3]	Individual plant item SWL (L_{Amax})	Vibration significant plant
Motorway facility building fitout and ventilation outlet (WHT10)	CGC_08	Deliveries to site	X	-	Workshop hand tools	Note 4	-	104	-	-
					Truck	4 p.h.	-	103	117	-
					Ute/light vehicle	4 p.h.	-	89	-	-
					Elevated work platform	1	-	102	-	-
					Franna crane	1	-	98	102	-
Tunnel commission and site rehabilitation (WHT10 and WFU8)	CGC_09	Decommissi-ning and rehabilitation of site (multiple locations)	X	-	Front end loader	1	-	110	113	-
					10t dump truck	4 p.h.	-	100	115	-
					Elevated work platform	2	-	102	-	-
					Generator (enclosed)	2	-	94	-	-
					Ute/light vehicle	12 p.h.	-	89	-	-
					Backhoe	1	-	100	104	-
					Franna crane	1	-	98	102	-

Notes:
1. The number of fans is equivalent to the number of roadheaders supported by the site. Individual plant item SWL (LAeq) represents the total combined SWL of all the fans.
2. Refer to the construction traffic assessment within the construction support site assessment for the number of heavy vehicles assessed during this stage.
3. In accordance with the ICNG, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammer and concrete saw.
4. Assumed to take place within the acoustic shed/building. Deliveries and laydown activities would go directly into and occur within the acoustic shed/building.

UG = Source located underground and assumed to not contribute to airborne noise emissions.

APPENDIX F Surface road works assessment activities

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Mobilisation/demobilisation and site setup (ie. installing construction boundary noise barriers/fences and traffic barriers)									
108	110	117	Truck	1	1	103	15	103	117
			Power hand tools	2	4	101	15	101	116
			Generator (enclosed)	1	2	94	15	94	-
			Elevated work platform	1	1	102	15	102	-
			Franna crane	1	1	98	15	98	102
Support site general activities (ie. general site activities)									
100	105	120	Site forklift	1	1	103	7.5	100	-
			Workshop hand tools	-	1	104	7.5	101	120
			Franna crane	-	1	98	15	98	102
			Ute/light vehicle	4 p.h.	4 p.h.	89	15	89	-
Deliveries (ie. worksite delivery and unloading operation)									
98	104	117	Truck	1	1	103	15	103	117
			Franna crane	1	1	98	15	98	102
Deliveries (oversized) (ie. worksite delivery and unloading operation)									
110	111	117	Articulated truck	1	1	108	15	108	117
			Mobile crane	1	1	110	15	110	-
Utilities modification works (ie. relocation of utilities and services)									
110	120	126	Vacuum truck	1	1	108	15	108	-
			Ute/light vehicle	1	1	89	15	89	-
			Excavator with bucket	1	1	105	7.5	102	108
			Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Dump truck	1	1	108	15	103	117
			Road saw	-	-	121	5	121*	-
			Generator/Daymaker	1	1	94	15	94	-

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Pavement/road modification works (ie. remove/construct kerbing/pavement works)									
110	120	126	Vacuum truck	1	1	108	15	108	-
			Ute/ light vehicle	1	1	89	15	89	-
			Excavator with bucket	1	-	105	7.5	102	108
			Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Concrete pump	1	-	103	15	103	-
Clearing and grubbing works (ie. general land clearing, tree and stump removal, topsoil stripping, loading)									
112	116	124	Excavator with bucket	-	1	105	7.5	102	108
			Elevated work platform	1	1	102	15	102	-
			Chainsaw (electric)	1	1	106	7.5	111*	-
			Tub grinder/mulcher	-	1	119	5	114	124
			Dump truck	4 p.h.	4 p.h.	108	15	108	117
Piling – Bored									
108	117	117	Crane	1	1	98	15	98	102
			Piling rig - bored	1	2	112	15	115	115
			Excavator with bucket	-	1	105	7.5	102	108
			Bobcat	1	1	107	15	107	-
			Concrete agitator	1.p.h	4 p.h.	108	15	108	-
			Concrete pump	-	1	103	15	103	-
			Welding equipment	-	1	105	15	105	-
			Truck	-	1	103	15	103	117
Pile breaking									
113	122	126	Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Bobcat	-	1	107	15	107	-
			Truck	-	1	103	15	103	117
			Compressor	1	2	90	15	90	-
			Jackhammer	1	4	113	5	113*	-

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Concrete formwork and reinforcement									
104	113	116	Power hand tools	2	5	101	15	101	116
			Generator (enclosed)	1	1	94	15	94	-
			Compressor	-	1	100	15	100	-
			Mobile Crane	-	1	110	15	110	-
			Truck	-	1	103	15	103	117
Concrete pours									
112	116	117	Concrete agitator	4 p.h.	10 p.h.	108	15	108	117
			Concrete pump	1	2	103	15	103	-
			Concrete vibrators	2	5	106	15	106	-
			Generator (enclosed)	1	2	94	15	94	-
			Compressor	-	1	100	15	100	-
Shotcrete									
109	112	117	Concrete agitator	1 p.h.	2 p.h.	108	15	108	117
			Shotcrete rig - compressor	1	1	104	15	104	-
Rock drilling									
95	117	124	Tracked mobile drilling rig	1	1	120	7.5	117	124
			Generator (enclosed)	1	1	94	15	94	-
			Compressor	1	1	100	15	100	-
Road furniture installation/modification									
107	114	117	Truck	1	1	103	15	103	117
			Power hand tools	1	2	101	15	101	116
			Elevated work platform	1	1	102	15	102	-
			Concrete core drill	-	1	113	7.5	110	-
			Franna crane	-	1	98	15	98	102
			Line marking truck	-	1	108	15	108	117

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Rock trimming									
116	121	126	Excavator with twin header attachment	1	-	112	7.5	109	-
			Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Bobcat	1	1	107	15	107	-
Rock crushing									
116	116	120	Rock crusher	1	1	118	7.5	115	120
			Excavator with bucket	1	1	105	7.5	102	108
			Tipper truck	4 p.h.	4 p.h.	104	15	104	117
Spoil handling									
104	106	117	Tipper truck	4 p.h.	4 p.h.	104	15	104	117
			Excavator with bucket	0	1	105	7.5	102	108
Earthworks									
116	119	117	Bulldozer	1	1	116	10	114	-
			Scraper	-	-	110	15	110	-
			Excavator with bucket	1	2	105	7.5	102	108
			Grader	-	1	113	15	113	-
			Dump truck	4 p.h.	8 p.h.	108	15	108	117
			Truck	4 p.h.	4 p.h.	103	15	103	117
			Roller	1	1	109	7.5	106	-
			Compactor	-	1	108	15	108	-
			Water truck	1	1	98	15	98	-
Drainage infrastructure									
109	121	126	Backhoe	-	1	100	15	100	104
			Road saw	-	-	121	5	121*	-
			Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Franna crane	1	1	98	15	98	102
			Excavator with bucket	-	1	105	7.5	102	108
			Tracked mobile drilling rig	-	-	120	7.5	117	-
			Compactor	-	1	108	15	108	-
			Concrete agitator	1	1	108	15	108	-
			Truck	4 p.h.	4 p.h.	103	15	103	117

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Noise barrier installations									
111	118	117	Piling rig - bored	-	2	112	15	115	115
			Generator (enclosed)	1	1	94	15	94	-
			Mobile crane	1	2	110	15	110	-
			Concrete vibrators	-	1	106	15	106	-
			Concrete pump	-	1	103	15	103	-
			Welding equipment	-	1	105	15	105	-
			Excavator with bucket	1	1	105	7.5	102	108
			Truck	-	4 p.h.	103	15	103	117
Resurfacing works									
112	118	117	Daymaker	4	4	93	15	93	-
			Pavement profiler	-	-	110	15	110	-
			Dump truck	4 p.h.	12 p.h.	108	15	108	117
			Bobcat	1	2	107	15	107	113
			Pavement laying machine	1	1	114	15	114	-
			Asphalt truck and sprayer	-	-	103	15	103	-
			Roller	-	-	109	7.5	106	-
Paving/asphalting/road surface works (including concrete sawing)									
109	120	126	Pavement laying machine	-	-	114	15	114	114
			Truck	4 p.h.	4 p.h.	103	15	103	103
			Asphalt truck and sprayer	1	-	103	15	103	103
			Roller	1	-	109	7.5	106	106
			Concrete saw	-	1	119	5	119*	126

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Paving/asphalting/road surface works									
109	114	117	Pavement laying machine	-	1	114	15	114	114
			Truck	4 p.h.	4 p.h.	103	15	103	103
			Asphalt truck and sprayer	1	-	103	15	103	103
			Roller	1	-	109	7.5	106	106
Concrete barriers and traffic controls									
99	105	117	Truck	4 p.h.	4 p.h.	103	15	103	117
			Franna crane	-	1	98	15	98	102
			Ute/light vehicle	1	3	89	15	89	-
Erection of structural steelwork									
111	117	117	Truck	4 p.h.	12 p.h.	103	15	103	117
			Mobile crane	1	2	110	15	110	-
			Percussion drill	-	1	110	7.5	112*	-
			Compressor	-	1	100	15	100	-
			Generator (enclosed)	-	1	94	15	94	-
			Daymaker	1	2	93	15	93	-
			Elevated work platform	1	3	102	15	102	-
Erection/removal of precast concrete/large items									
110	111	117	Truck	-	-	103	15	103	117
			Mobile crane	1	1	110	15	110	-
			Daymaker	1	1	93	15	93	-
			Elevated work platform	-	1	102	15	102	-
Demolition (non-rock hammering)									
109	112	120	Excavator with bucket (loading hard materials)	1	1	113	5	108	120
			Franna crane	-	2	98	15	98	-
			Truck and dog	4 p.h.	8 p.h.	108	15	108	117

Assumed activity noise level SWL, dB(A)			Plant/equipment item	No. Units operating during noise-intensive 15 minute period		Individual item sound power levels, dB(A)	Usage factor[5]	$L_{Aeq\ 15\ minute}$ SWL, dB(A)	L_{Amax} SWL[4], dB(A)
Typical activity[1]	Worst-case activity[2]	Maximum instantaneous[3]		Typical activity	Worst-case activity				
Demolition (rock hammering)									
109	121	126	Truck	4 p.h.	4 p.h.	103	15	103	117
			Excavator with medium rock hammer	-	1	118	7.5	120*	126
			Excavator with bucket (loading hard materials)	1	2	113	5	108	120
			Concrete saw	-	-	121	5	120*	-
			General power tools (drill, etc.)	-	1	105	7.5	102	-
			Generator (enclosed)	1	1	94	15	94	-
			Jackhammer	-	1	113	5	113*	-
			Compressor	-	1	100	15	100	-

Notes:
1. Typical activity - (eg when the concrete saw/rock hammer are NOT used)
2. Worst-case (Noise-intensive) - (eg when the concrete saw/rock hammer is used)
3. Maximum instantaneous noise level (eg maximum level an object bangs when it is dropped)
4. L_{Amax} levels only noted for equipment potentially used during the night period
5. Usage factor is number of minutes in use during typical 15 minute period

* = 5 dB(A) annoyance penalty incorporated.

APPENDIX G Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services, 2016) Standard Mitigation Measures

G.1 CNVG Standard Mitigation Measures

Action required	Applies to	Details
Management measures		
Implementation of any project specific mitigation measures required	Airborne noise	Implementation of any project specific mitigation measures required.
Implement community consultation or notification measures	Airborne noise Ground-borne noise Vibration	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work program over night time period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of seven (7) calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required.
Site inductions	Airborne noise Ground-borne noise Vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All project specific and relevant standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise-generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environment incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Airborne noise Ground-borne noise Vibration	Where specified, a noise verification program is to be carried out for the duration of the works in accordance with the CNVMP and any approval and licence conditions.
Attended vibration measurements	Vibration	Where required, attended vibration measurements should be carried out at the commencement of vibration-generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update construction environmental management plans (CEMP)	Airborne noise Ground-borne noise Vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement of activities with the potential to cause property damage.

Action required	Applies to	Details
Source controls		
Construction hours and programming	Airborne noise Ground-borne noise Vibration	Where feasible and reasonable, construction should be carried out during the standard construction hours. Work generating high noise and/or vibration levels should be programmed during less sensitive time periods if practicable.
Construction respite period during normal hours and out of hours work	Airborne noise Ground-borne noise Vibration	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 hours 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 the licence there should be no more than: • Two consecutive evenings or nights per week • Three evenings or nights per week • Six evenings or nights per month. For night works, these periods of work should be separated by not less than one week.
Plant noise levels	Airborne noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in CNVG. Implement a noise monitoring audit program to ensure equipment remains within the more stringent of the manufacturer's specifications or CNVG
Equipment selection	Airborne noise Ground-borne noise Vibration	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable. Ensure plant, including silencers, is well maintained.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case, cannot be used on site unless compliant with the applicable criteria.
Use and siting of plant	Airborne noise Vibration	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised, where feasible and reasonable. Plant used intermittently to be throttled down or shut down when not in use, where feasible and reasonable. Noise-emitting plant to be directed away from sensitive receivers, where feasible and reasonable. Only have necessary equipment on site.
Plan worksites and activities to minimise noise and vibration	Airborne noise Vibration	Locate construction support sites 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 programmed for normal working hours. If the work cannot be carried out during the day, it should be completed before 11.00pm. Where practicable, work should be programmed to avoid major student examination periods when students are studying for examinations such as before or during Higher School Certificate and at the end of higher education semesters. If programmed night work is postponed, the work should be re-programmed and the approaches of the CNVG should apply.

Action required	Applies to	Details
Reduced equipment power	Airborne noise Vibration	Use only the necessary size and power.
Non-tonal reversing alarms.	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction support sites.	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible 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 movement, where feasible and reasonable.
Blasting regime	Airborne noise Vibration	The noise and vibration impact of blasting operations can be minimised by: • Choosing the appropriate blast charge configurations • Ensuring appropriate blast-hole preparation • Optimising blast design, location, orientation and spacing. • Selecting appropriate blast times • Utilising knowledge of prevailing metrological conditions • AS 2187.1 Explosive-Storage, transport and use, Part 2: Use of explosives, provides more detailed advice on ground vibration and airblast overpressure impact minimisation options.
Engine compression brakes	Construction vehicles	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans, etc.	Airborne noise	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities.	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where feasible and reasonable) and consideration of site topography when situating plant.
Receptor controls		
Structural surveys and vibration monitoring	Vibration	Pre-construction surveys of the structural integrity of vibration-sensitive buildings may be warranted. At locations where there are high risk receptors, vibration monitoring should be conducted during the activities causing the vibration.

APPENDIX H Construction predicted airborne noise contours and envelopes

H.1 Construction support site noise contours

NCA7.1
NCA4.4
NCA7.2
NCA5.3
NCA4.5
NCA5.2
NCA4.3
NCA5.1
NCA4.2
NCA4.1
NCA3.3
NCA3.4
NCA2.1
NCA3.2
NCA3.1
NCA1.2
NCA1.5
NCA1.3
NCA1.1

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

Consultant:
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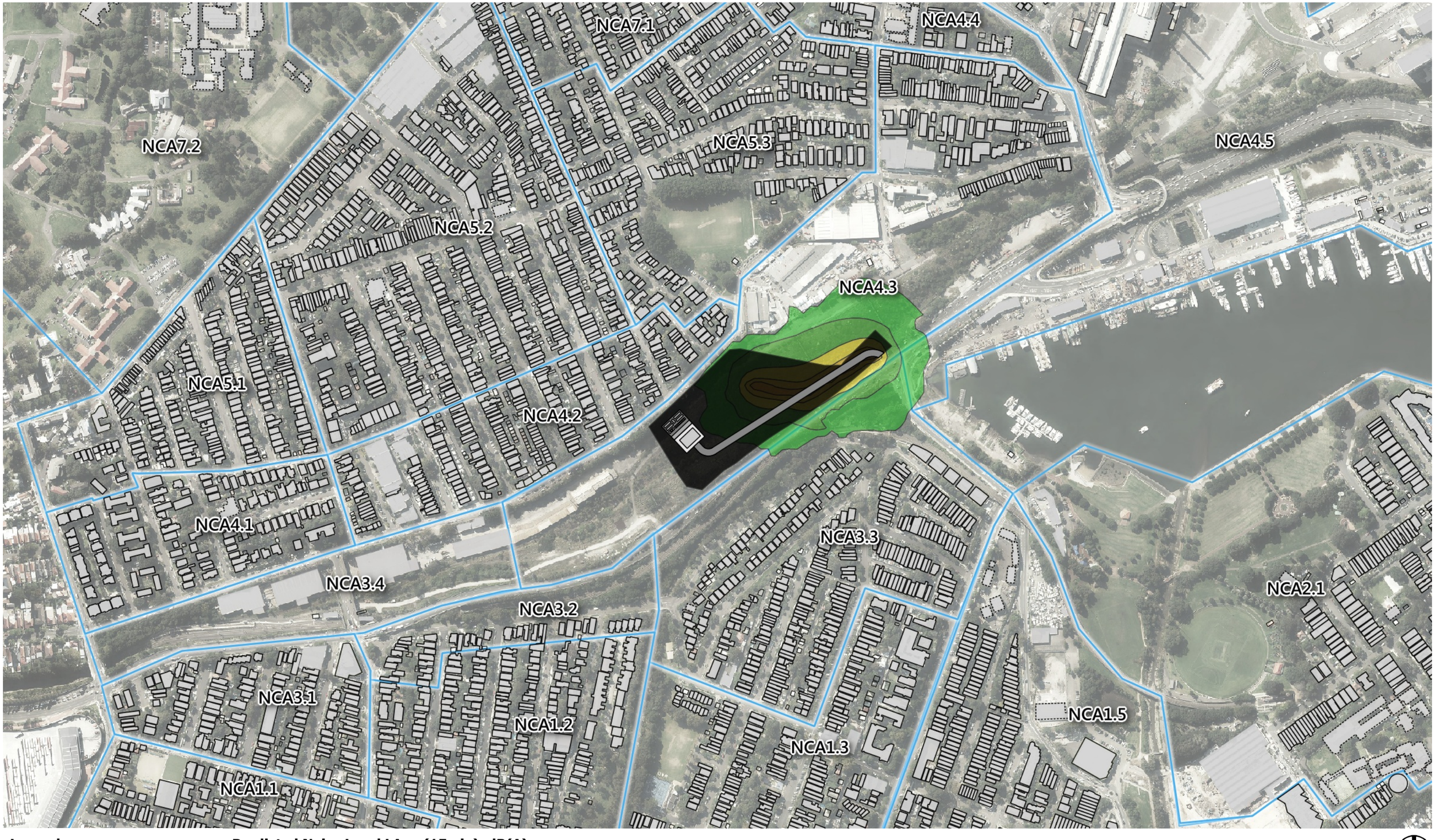
Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Rozelle Rail Yards (WHT1/ROZ)
Construction noise contour
Standard hours - Tunnel fitout and finishing (ROZ_03)

Figure No:	TJ500-01-6-1-4-1 023-1-1(r15)	Created by:	ALe
Scale:	1:5000	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SI|WHT_SB|BLD|ROZ03D|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Project:
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Description:
Rozelle Rail Yards (WHT1/ROZ)
Construction noise contour
OOHW - Tunnel fitout and finishing (ROZ_03)

Figure No:	TJ500-01-6-1-4-1 023-1-1(r15)	Created by:	ALe
Scale:	1:5000	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SL|WHT_SB|BLD|ROZE03N|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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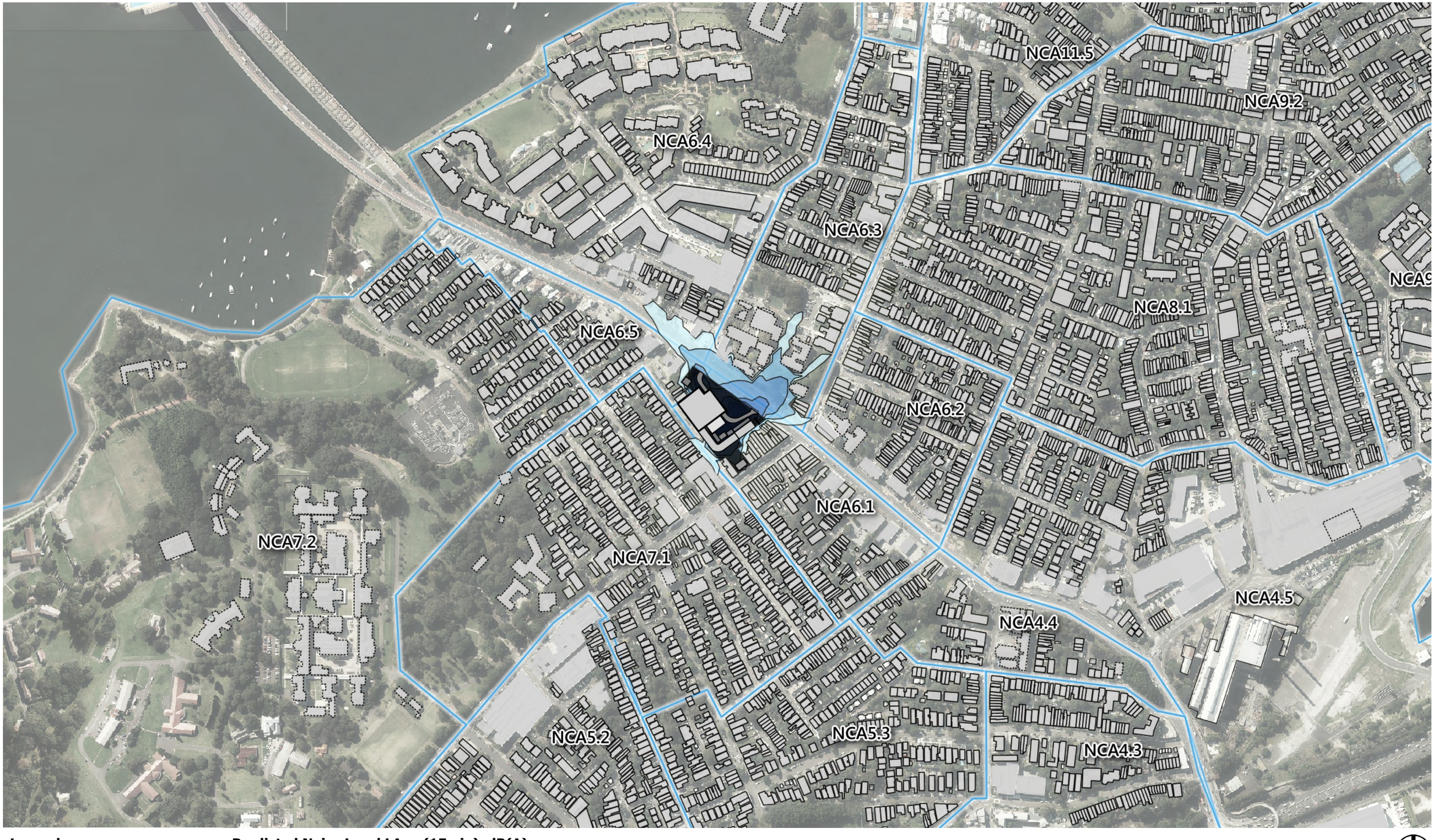
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Victoria Road (WHT2/VIC)
Construction noise contour
Standard hours - Site establishment and demolition (VIC_02)

Figure No:	TJ500-01-6-1-4-1 023-1-2(r15)	Created by:	ALe
Scale:	1:5000	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

..OUTPUTS/1. RESULTS/Balmain_AA/SHP/Noise Contours/Balmain_Var1_Day_Noise_Contour(r2).shp

WHT S1|WHT_SB|BLD|VIC1|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
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Description:
Victoria Road (WHT2/VIC)
Construction noise contour
Standard hours - Tunnelling (VIC_07)

Figure No:	TJ500-01-6-1-4-1 023-1-2(r15)	Created by:	ALe
Scale:	1:5000	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Balmain_AA\SHP\Noise Contours\Update_20191006_Balmain_Var7_Day_Noise_Contour(r3).shp

WHT_SJ|WHT_SB|BLD|VIC2|NCA|Map1|Map2

NCA11.5
NCA9.2
NCA6.4
NCA6.3
NCA8.1
NCA6.5
NCA6.2
NCA6.1
NCA7.2
NCA7.1
NCA4.5
NCA4.4
NCA5.2
NCA5.3
NCA4.3

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Victoria Road (WHT2/VIC)
Construction noise contour
OOHW - Tunnelling (VIC_07)

Figure No:	TJ500-01-6-1-4-1 023-1-2(r15)	Created by:	ALe
Scale:	1:5000	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Balmain_AA\SHP\Noise Contours\Update_20191006_Balmain_Var7_Night_Noise_Contour(r3).shp

WHT_SL|WHT_SB|LD|VIC4|NCA|Map1|Map2

NCA11.1
NCA11.5
NCA10.2
NCA9.2
NCA6.4
NCA6.3
NCA9.1
NCA8.1
NCA6.2
NCA6.1
NCA7.1
NCA10.1
NCA4.4
NCA4.5
NCA5.3
NCA4.3
NCA4.2
NCA2.1
NCA3.3

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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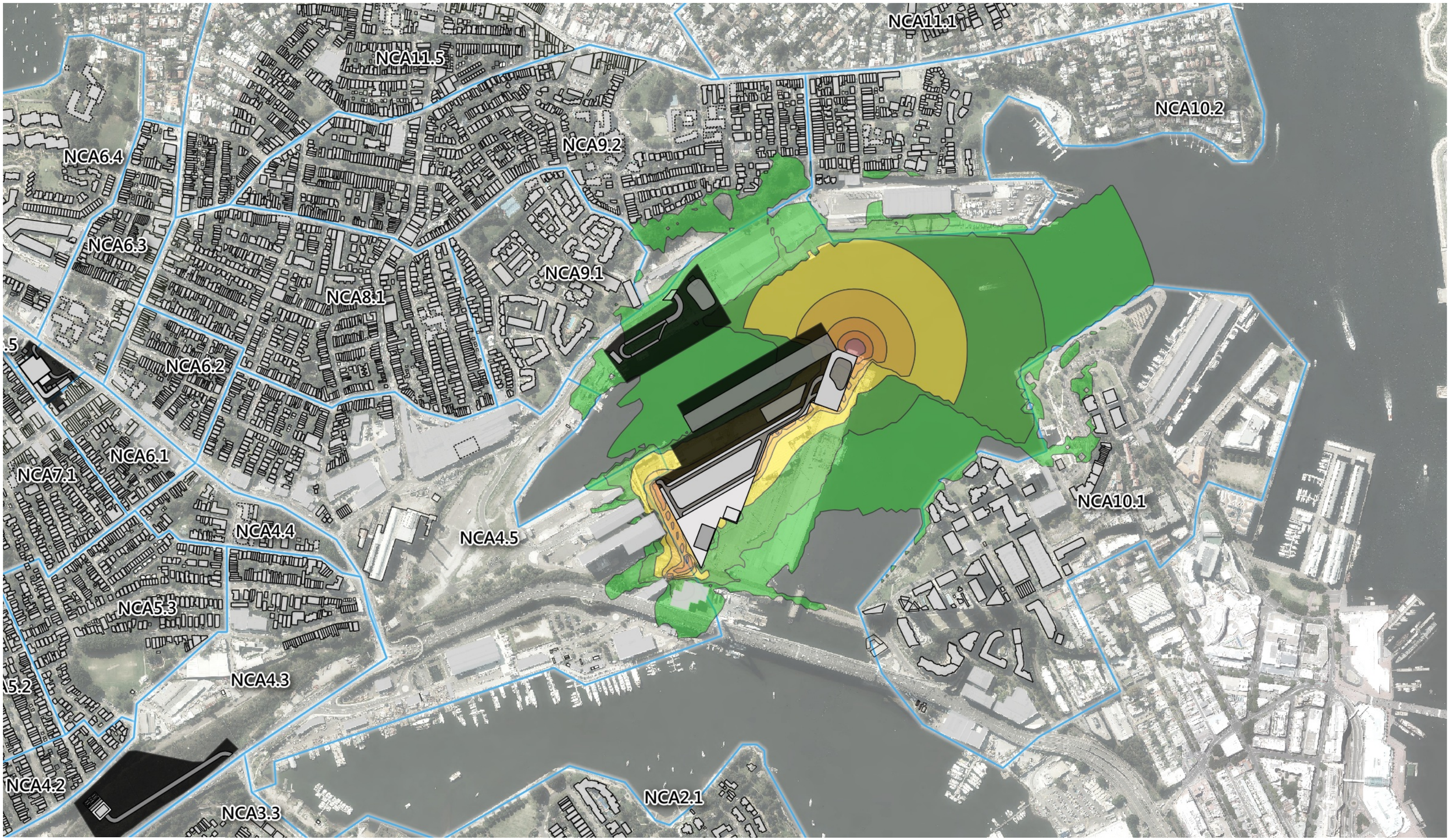
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
White Bay (WHT3/WHB)
Construction noise contour
Standard hours - Spoil handling and support deliveries (WHT_07)

Figure No:	TJ500-01-6-1-4-1 023-1-3(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SU|WHT_SB|BLD|WBY01|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
White Bay (WHT3/WHB)
Construction noise contour
OOHW - Spoil handling and support deliveries (WHT_07)

Figure No:	TJ500-01-6-1-4-1 023-1-3(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SL|WHT_SB|BLD|WBY02|NCA|Map1|Map2

NCA12.2
NCA13.1
NCA13.2
NCA15.1
NCA15.3
NCA14.1
NCA15.2
NCA12.1
NCA11.4
NCA11.5
NCA11.3
NCA11.5
NCA11.2

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

0 150 300 450 600 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Yurulbin Point (WHT4/YRB)
Construction noise contour
Standard hours - Early works (YRB_01)

Figure No:	TJ500-01-6-1-4-1 023-1-4(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS/1. RESULTS/Yurulbin_AA/SHP/Noise Contours/Yurulbin_Var1_Day_Noise_Contour(r3).shp

WHT_SL_YUL|WHT_SB_YUL|BLD|YUR1|NCA|Map1|Map2

NCA12.2
NCA13.1
NCA13.2
NCA14.1
NCA15.1
NCA15.2
NCA15.3
NCA12.1
NCA11.3
NCA11.4
NCA11.5
NCA11.5
NCA11.2

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Project:
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Description:
Yurulbin Point (WHT4/YRB)
Construction noise contour
Standard hours - Tunnelling (YRB_07)

Figure No:	TJ500-01-6-1-4-1 023-1-4(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Yurulbin_AA\SHP\Noise Contours\Update_20191007_Yurulbin_Var7_Day_Noise_Contour(r4).shp

WHT_SL_YUL|WHT_SB_YUL|BLD|YUR2|NCA|Map1|Map2

NCA12.2
NCA13.1
NCA13.2
NCA14.1
NCA15.1
NCA15.2
NCA15.3
NCA12.1
NCA11.3
NCA11.4
NCA11.5
NCA11.5
NCA11.2

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
Roads and Maritime Services

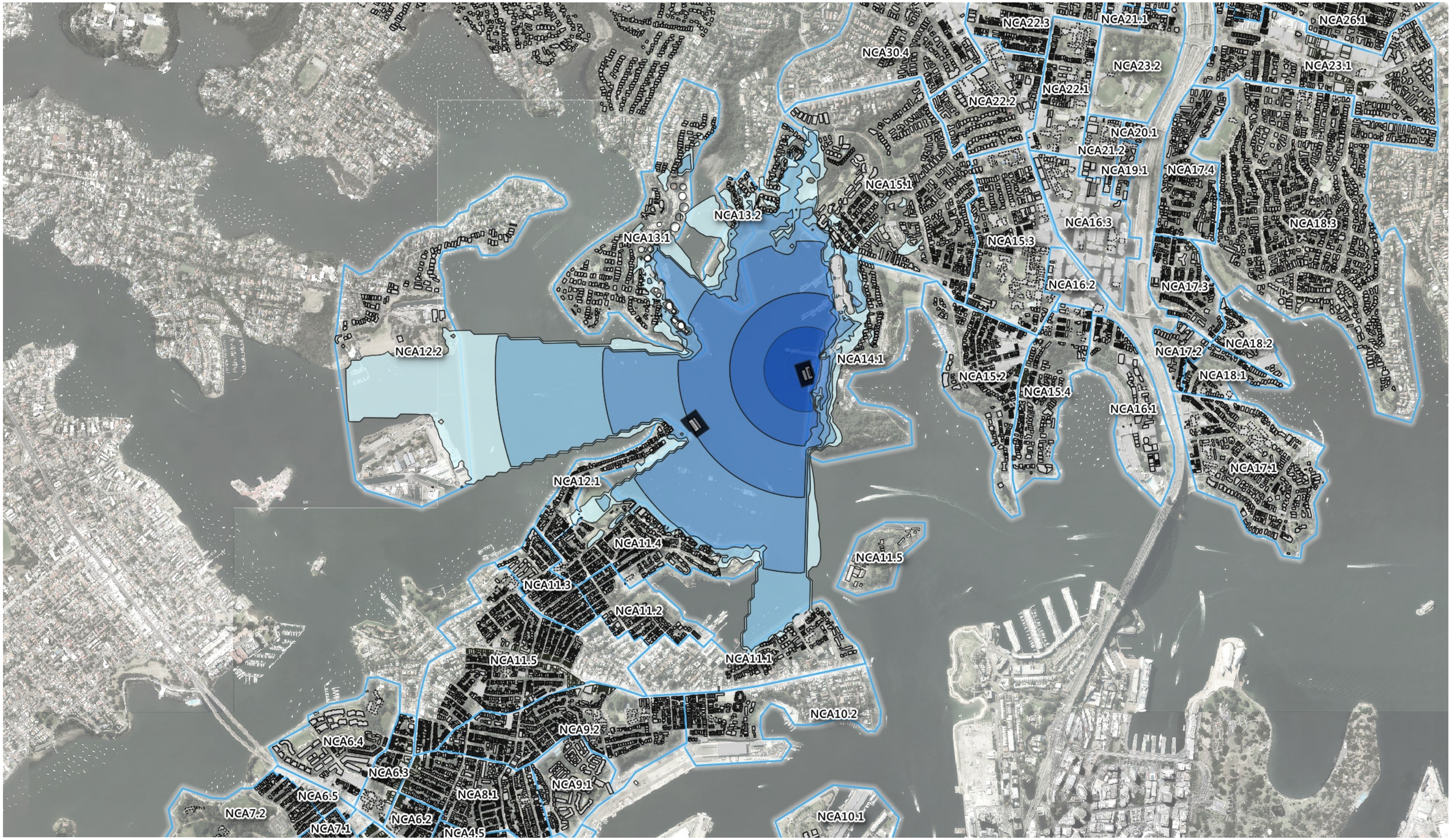
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Yurulbin Point (WHT4/YRB)
Construction noise contour
OOHW - Tunnelling (YRB_07)

Figure No:	TJ500-01-6-1-4-1 023-1-4(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Yurulbin_AA\SHP\Noise Contours\Update_20191007_Yurulbin_Var7_Night_Noise_Contour(r4).shp

WHT_SL_YUL|WHT_SB_YUL|BLD|YUR4|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

Consultant:

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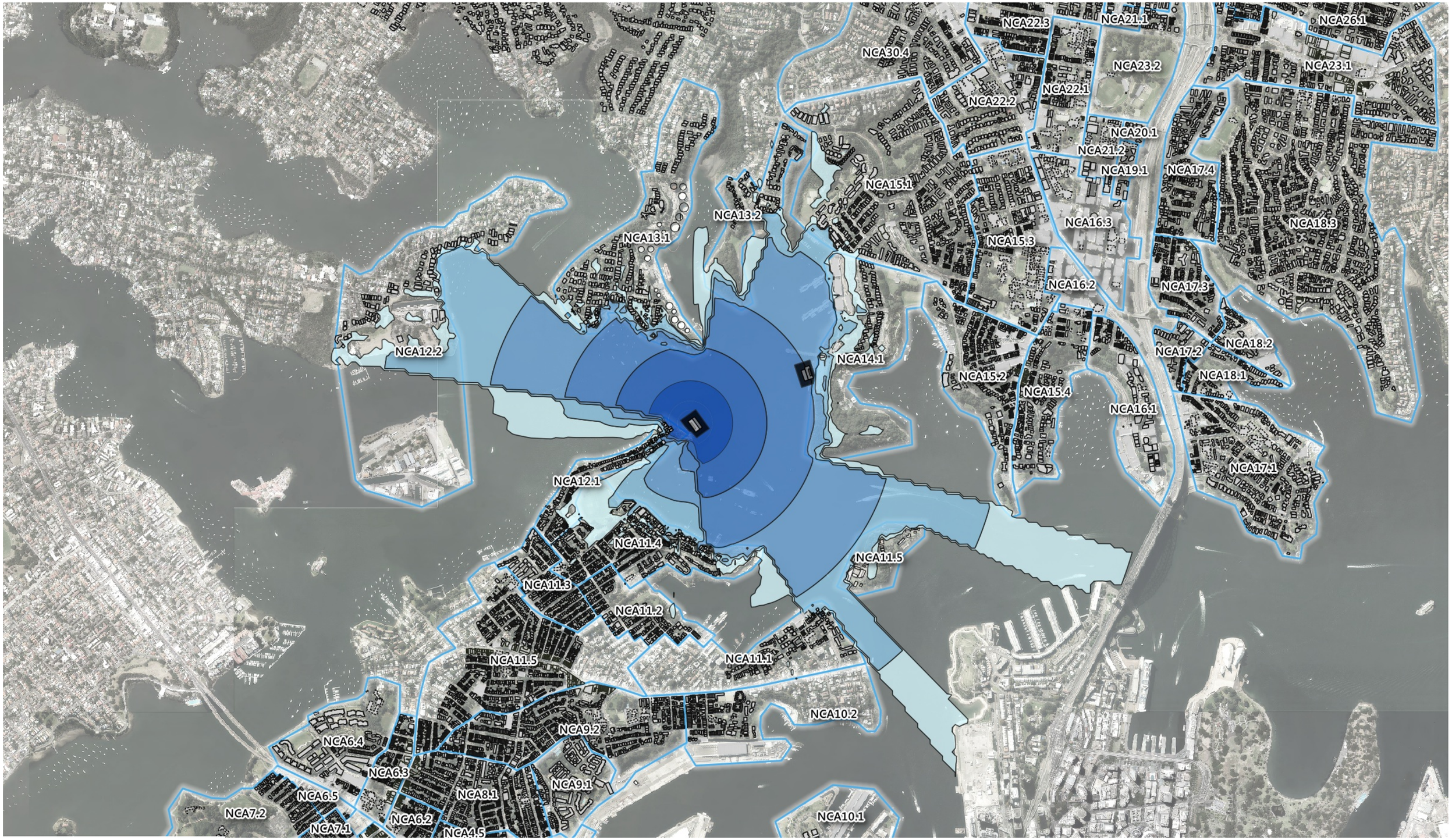
Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
Standard hours - Build cofferdam - Impact Pilling - Sydney Harbour north cofferdam (SHC_01)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SL_WHC|WHT_SB_WHC|BLD|WHC1|NCA_WHT|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 | 55 | 60 | 65 | 70 | 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 250 500 750 1000 m

Consultant:
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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
Standard hours - Build cofferdam - Impact Pilling - Sydney Harbour south cofferdam (SHC_02)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SL_WHC|WHT_SB_WHC|BLD|WHC2|NCA_WHT|Map1|Map2

NCA22.3
NCA21.1
NCA26.1
NCA30.4
NCA23.2
NCA23.1
NCA22.1
NCA22.2
NCA20.1
NCA21.2
NCA19.1
NCA17.4
NCA15.1
NCA13.2
NCA16.3
NCA18.3
NCA13.1
NCA15.3
NCA16.2
NCA17.3
NCA12.2
NCA14.1
NCA18.2
NCA17.2
NCA15.2
NCA18.1
NCA15.4
NCA16.1
NCA12.1
NCA17.1
NCA11.4
NCA11.5
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA10.2
NCA9.2
NCA6.4
NCA6.3
NCA9.1
NCA6.5
NCA8.1
NCA7.2
NCA6.2
NCA10.1
NCA7.1
NCA4.5

WHT_SL_WHC|WHT_SB_WHC|BLD|WH7B|NCA_WHT|Map1|Map2

0 250 500 750 1000 m

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
Standard hours - Prepare foundations (SHC_07)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

NCA22.3
NCA21.1
NCA26.1
NCA30.4
NCA23.2
NCA23.1
NCA22.1
NCA22.2
NCA20.1
NCA21.2
NCA19.1
NCA17.4
NCA15.1
NCA13.2
NCA16.3
NCA18.3
NCA13.1
NCA15.3
NCA16.2
NCA17.3
NCA12.2
NCA14.1
NCA17.2
NCA18.2
NCA15.2
NCA18.1
NCA15.4
NCA16.1
NCA12.1
NCA17.1
NCA11.4
NCA11.5
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA10.2
NCA9.2
NCA6.4
NCA6.3
NCA9.1
NCA6.5
NCA8.1
NCA7.2
NCA6.2
NCA10.1
NCA7.1
NCA4.5

WHT_SL_WHC|WHT_SB_WHC|BLD|WH8B|NCA_WHT|Map2

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 250 500 750 1000 m

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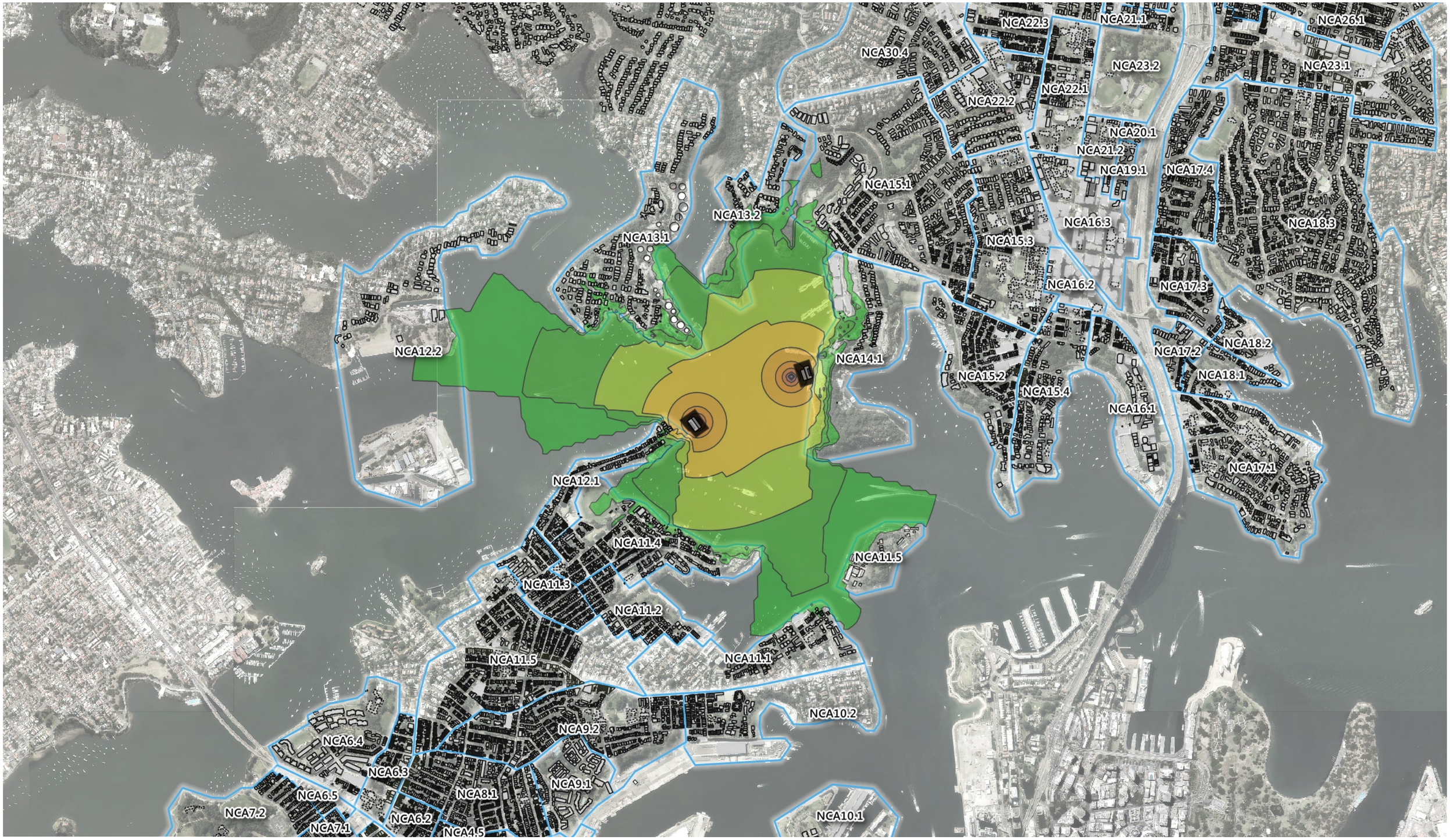
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
Standard hours - Immerse elements (WHC_08)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

35 40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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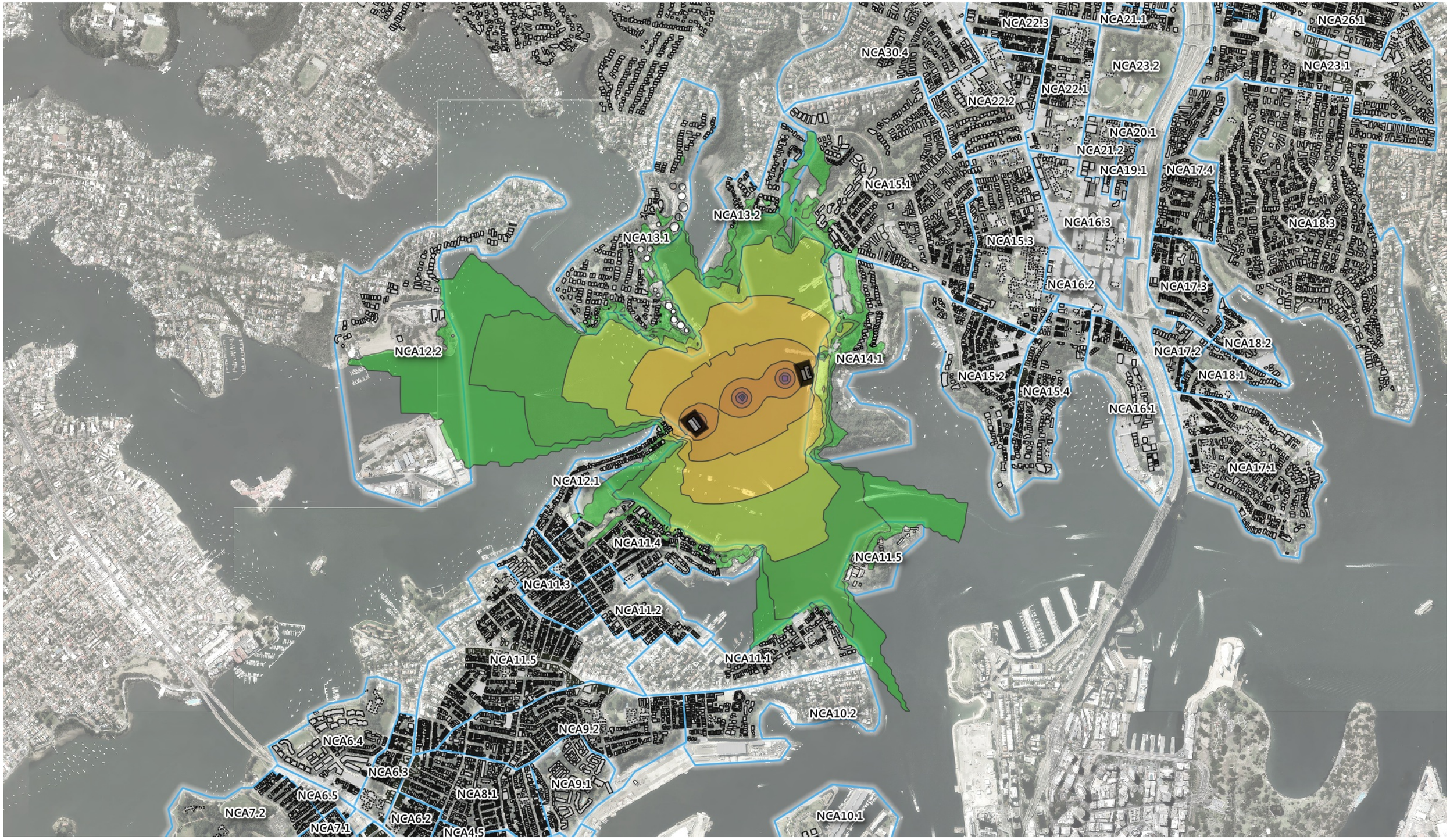
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
OOHW - Prepare foundations (SHC_07)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SL_WHC|WHT_SB_WHC|BLD|WH7A|NCA_WHT|Map1|Map2



WHT_SL_WHC|WHT_SB_WHC|BLD|WH8A|NCA_WHT|Map1|Map2

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

35 40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Project:
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Description:
Sydney Harbour Crossing (WHT5/SHC(S) & WHT6/SHC(N))
Construction noise contour
OOHW - Immerse elements (SHC_08)

Figure No:	TJ500-01-6-1-4-1 023-1-5(r15)	Created by:	ALe
Scale:	1:17500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

NCA13.2
NCA13.1
NCA15.1
NCA16.3
NCA15.3
NCA16.2
NCA14.1
NCA15.2
NCA15.4
NCA16.1
NCA12.1
NCA11.4
NCA11.5

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Berrys Bay (WHT7/BRY)
Construction noise contour
Standard hours - Early works (BRY_01)

Figure No:	TJ500-01-6-1-4-1 023-1-6(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS/1. RESULTS/Berry'sBay_AA/SHP/Noise Contours/BerrysBay_Var1_Day_Noise_Contour(r2).shp

WHT_SL_BRY|WHT_SB_BRY|BLD|BBY1|NCA|Map1|Map2

NCA13.2
NCA15.1
NCA16.3
NCA13.1
NCA15.3
NCA16.2
NCA14.1
NCA15.2
NCA15.4
NCA16.1
NCA12.1
NCA11.4
NCA11.5

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Berrys Bay (WHT7/BRY)
Construction noise contour
Standard hours - Tunnelling (BRY_07)

Figure No:	TJ500-01-6-1-4-1 023-1-6(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Berry'sBay_AA\SHP\Noise Contours\Update20191007_BerrysBay_Var7_Day_Noise_Contour(r4).shp

WHT_SL_BRY|WHT_SB_BRY|BLD|BBY2|NCA|Map1|Map2

NCA13.2
NCA15.1
NCA16.3
NCA13.1
NCA15.3
NCA16.2
NCA14.1
NCA15.2
NCA15.4
NCA16.1
NCA12.1
NCA11.4
NCA11.5

Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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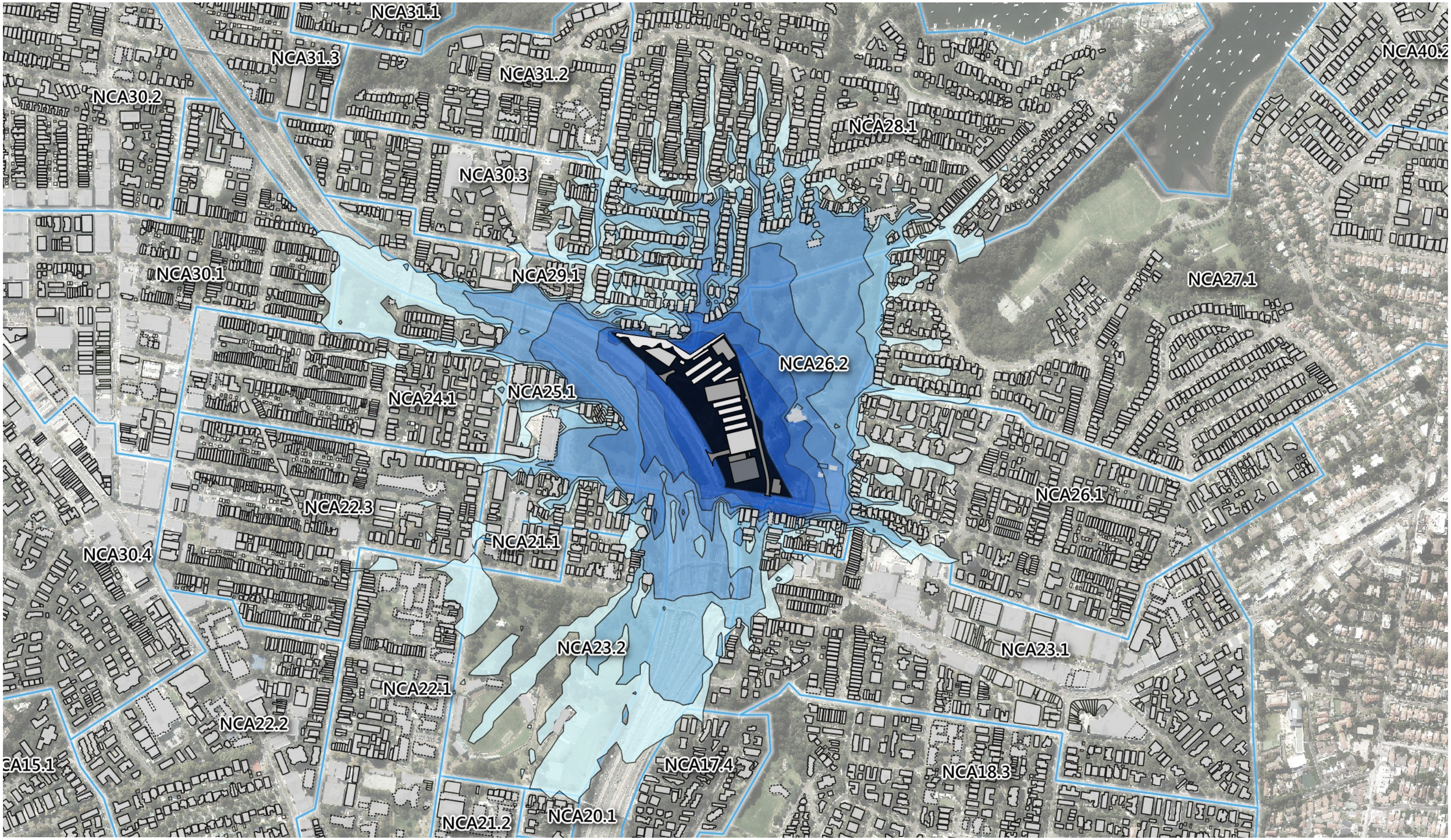
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Berrys Bay (WHT7/BRY)
Construction noise contour
OOHW - Tunnelling (BRY_07)

Figure No:	TJ500-01-6-1-4-1 023-1-6(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

...OUTPUTS\1. RESULTS\Berry'sBay_AA\SHP\Noise Contours\Update20191007_BerrysBay_Var7_Night_Noise_Contour(r4).shp

WHT_SL_BRY|WHT_SB_BRY|BLD|BBY4|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Cammeray Golf Course (WHT10 & WFU8/CGC)
Construction noise contour
Standard hours - Site establishment (CGC_02)

Figure No: TJ500-01-6-1-4-1 023-1-7(r15) Created by: ALe
Scale: 1:7500 Rev: (r15)
Date: 08.10.2019 Sheet: A3

WHT_SI|WHT_SB|BLD|WHT_CGC01|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Cammeray Golf Course (WHT10 & WFU8/CGC)
Construction noise contour
Standard hours - Surface road work support + Tunnelling (CGC04 + CGC05)

Figure No:	TJ500-01-6-1-4-1 023-1-7(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SU\WHT_SB|BLD|WHT_CGC02|NCA|Map1|Map2



Legend

- Construction support site
- Noise catchment boundary
- Site layout

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

0 150 300 450 600 m

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Client:
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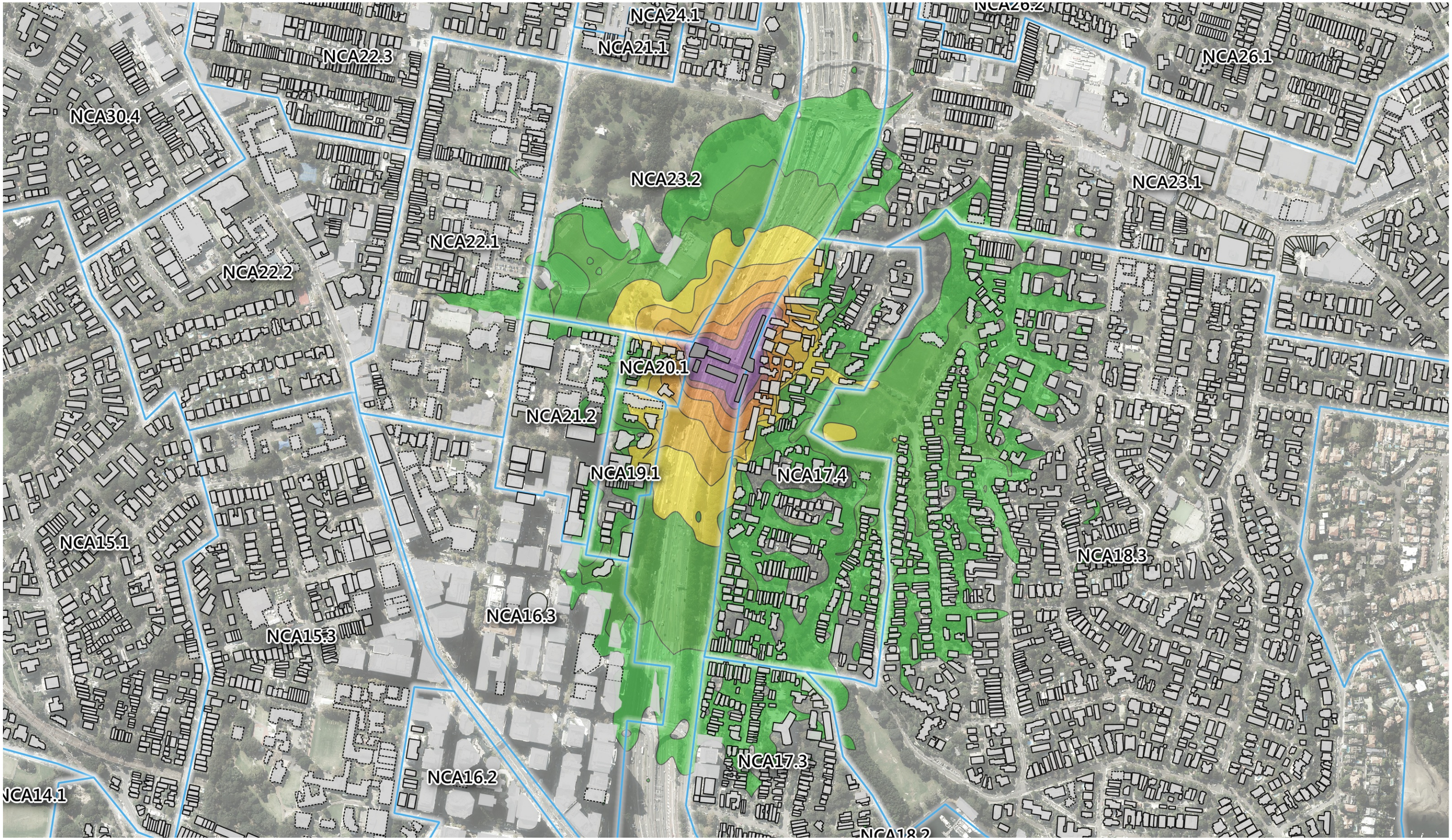
Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Cammeray Golf Course (WHT10 & WFU8/CGC)
Construction noise contour
OOHW - Surface road work support + Tunnelling (CGC04 + CGC05)

Figure No:	TJ500-01-6-1-4-1 023-1-7(r15)	Created by:	ALe
Scale:	1:7500	Rev:	(r15)
Date:	08.10.2019	Sheet:	A3

WHT_SU|WHT_SB|BLD|WHT_CGC03|NCA|Map1|Map2

H.2 Surface road works highest noise level envelopes



Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Project:
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Description:
Highest noise level envelope - Typical
WFU1A - Ridge Street shared user bridge
Out of hours works

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Figure No:	TJ500-01-6-1-3-1 026-1(r19)	Created by:	ALe
Scale:	1:7500	Rev:	R19
Date:	12.11.2019	Sheet:	A3

BLD_thin|WFU1A|NCA_WHT|WFU1A_Contour|MAP1|MAP2

NCA30.1
NCA24.1
NCA22.3
NCA21.1
NCA26.2
NCA27.1
NCA26.1
NCA30.4
NCA23.2
NCA23.1
NCA22.1
NCA22.2
NCA20.1
NCA13.1
NCA21.2
NCA19.1
NCA17.4
NCA15.1
NCA13.2
NCA16.3
NCA18.3
NCA15.3
NCA16.2
NCA17.3
NCA18.2
NCA17.2
NCA14.1
NCA15.2
NCA18.1
NCA15.4
NCA16.1
NCA12.1
NCA17.1
NCA11.4
NCA11.5

BLD_thin|WFU1B|NCA_WHT|WFU1B_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
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Project:
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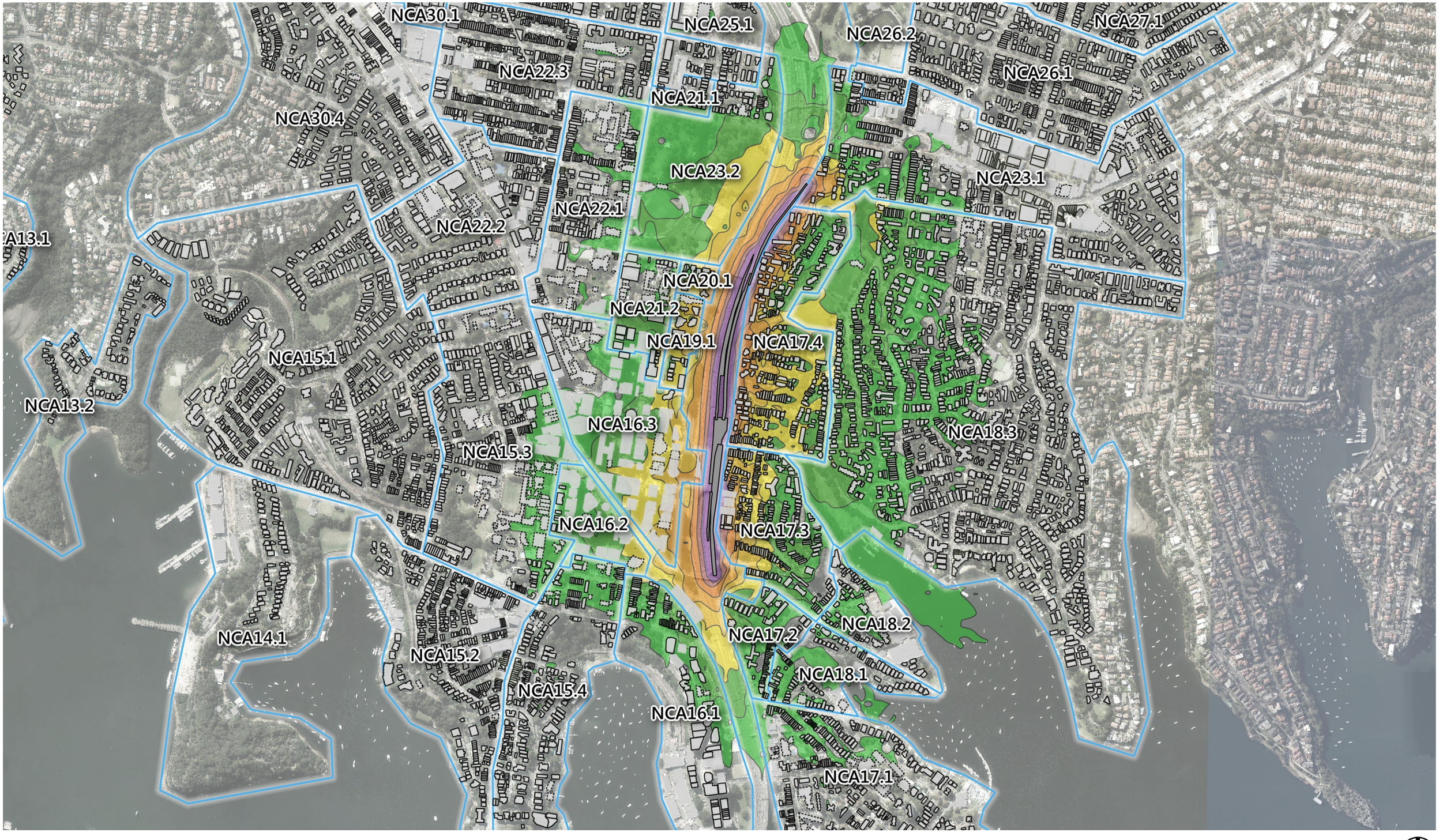
Description:
Highest noise level envelope - Typical
WFU1B - Berry Street entry on ramp works (Berry Street north (WHT8))
Out of hours works

Figure No:	TJ500-01-6-1-3-1 026-2(r19)	Created by:	ALe
Scale:	1:15000	Rev:	R19
Date:	12.11.2019	Sheet:	A3



Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Project:
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Description:
Highest noise level envelope - Typical
WFU1C - Alfred Street north and Mount Street interchange
Out of hours works

Figure No:	TJ500-01-6-1-3-1 026-3(r19)	Created by:	ALe
Scale:	1:13000	Rev:	R19
Date:	12.11.2019	Sheet:	A3

BLD_thin|WFU1C|NCA_WHT|WFU1C_Contour|MAP1|MAP2

NCA22.2
NCA22.1
NCA20.1
NCA21.2
NCA17.4
NCA15.1
NCA16.3
NCA15.3
NCA18.3
NCA16.2
NCA17.3
NCA14.1
NCA18.2
NCA15.2
NCA17.2
NCA15.4
NCA18.1
NCA16.1
NCA17.1

BLD_thin|WFU1D|NCA_WHT|WFU1D_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU1D - Warringah Freeway northbound widening
Out of hours works

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Figure No:	TJ500-01-6-1-3-1 026-4(r19)	Created by:	ALe
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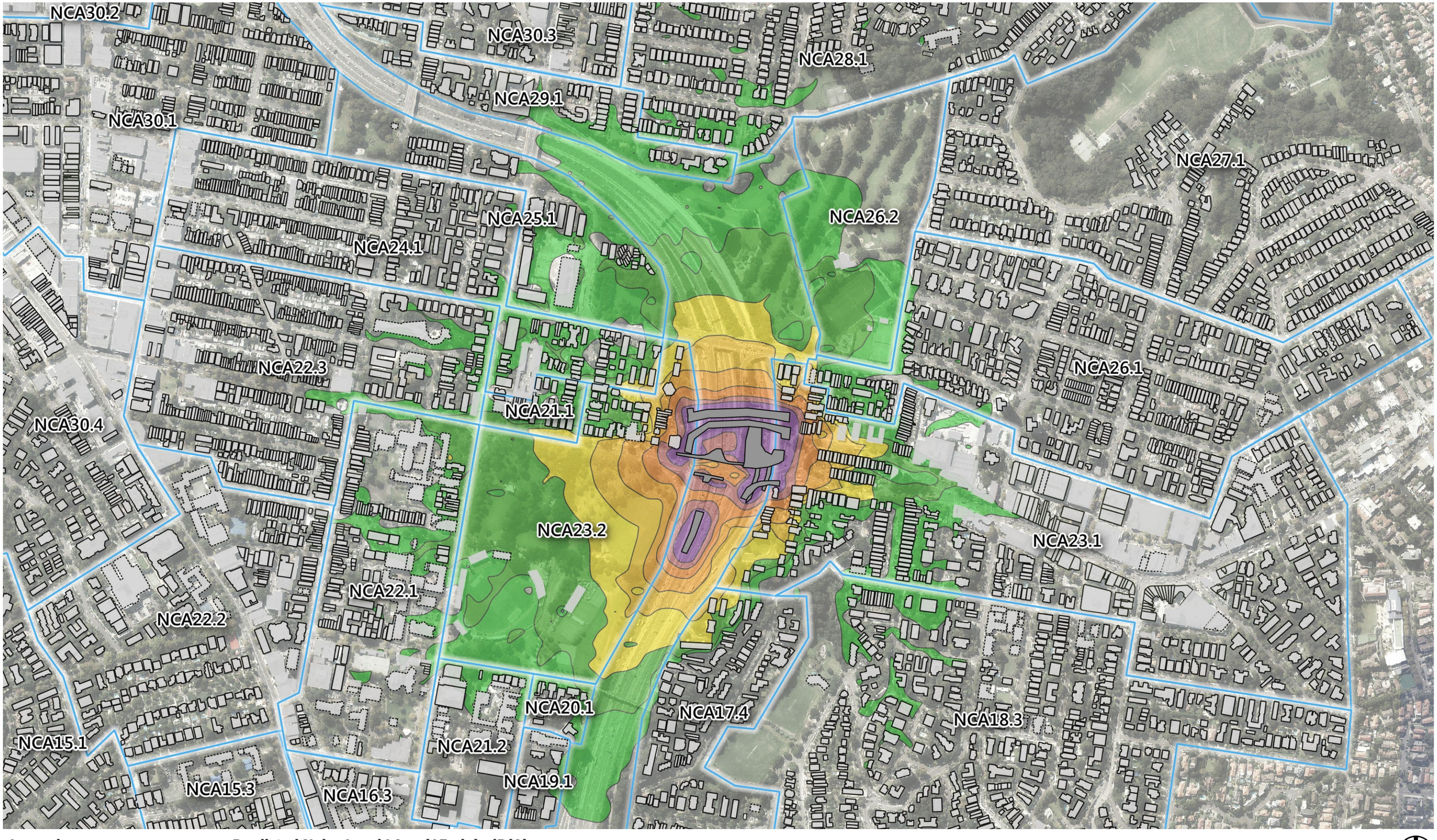
Date:	12.11.2019	Sheet:	A3



Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
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Project:
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Description:
Highest noise level envelope - Typical
WFU1E - Falcon Street Interchange upgrade
Out of hours works

Figure No:	TJ500-01-6-1-3-1 026-5(r19)	Created by:	ALe
Scale:	1:8000	Rev:	R19
Date:	12.11.2019	Sheet:	A3

BLD_thin|WFU1E|NCA_WHT|WFU1E_Contour|MAP1|MAP2

NCA22.2
NCA22.1
NCA21.2
NCA17.4
NCA15.1
NCA16.3
NCA15.3
NCA18.3
NCA16.2
NCA17.3
NCA14.1
NCA18.2
NCA17.2
NCA15.2
NCA15.4
NCA18.1
NCA16.1
NCA17.1

BLD_thin|WFU1F|NCA_WHT|WFU1F_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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

Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU1F - High Street Interchange upgrade
Out of hours works

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Figure No:	TJ500-01-6-1-3-1 026-6(r19)	Created by:	ALe
Scale:	1:7500	Rev:	R19
Date:	12.11.2019	Sheet:	A3

NCA33.2
NCA30.1
NCA29.1
NCA27.1
NCA24.1
NCA25.1
NCA26.2
NCA22.3
NCA26.1
NCA30.4
NCA21.1
NCA23.2
NCA23.1
NCA22.1
NCA22.2
NCA20.1
NCA21.2
NCA13.2
NCA19.1
NCA17.4
NCA15.1
NCA16.3
NCA18.3
NCA15.3
NCA16.2
NCA17.3
NCA14.1
NCA15.2
NCA15.4
NCA16.1
NCA17.2
NCA18.2
NCA18.1

BLD_thin|WFU1G|NCA_WHT|WFU1G_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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P: 02 8218 0500 F: 02 8218 0501

Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU1G - Warringah Freeway southbound widening
Out of hours works

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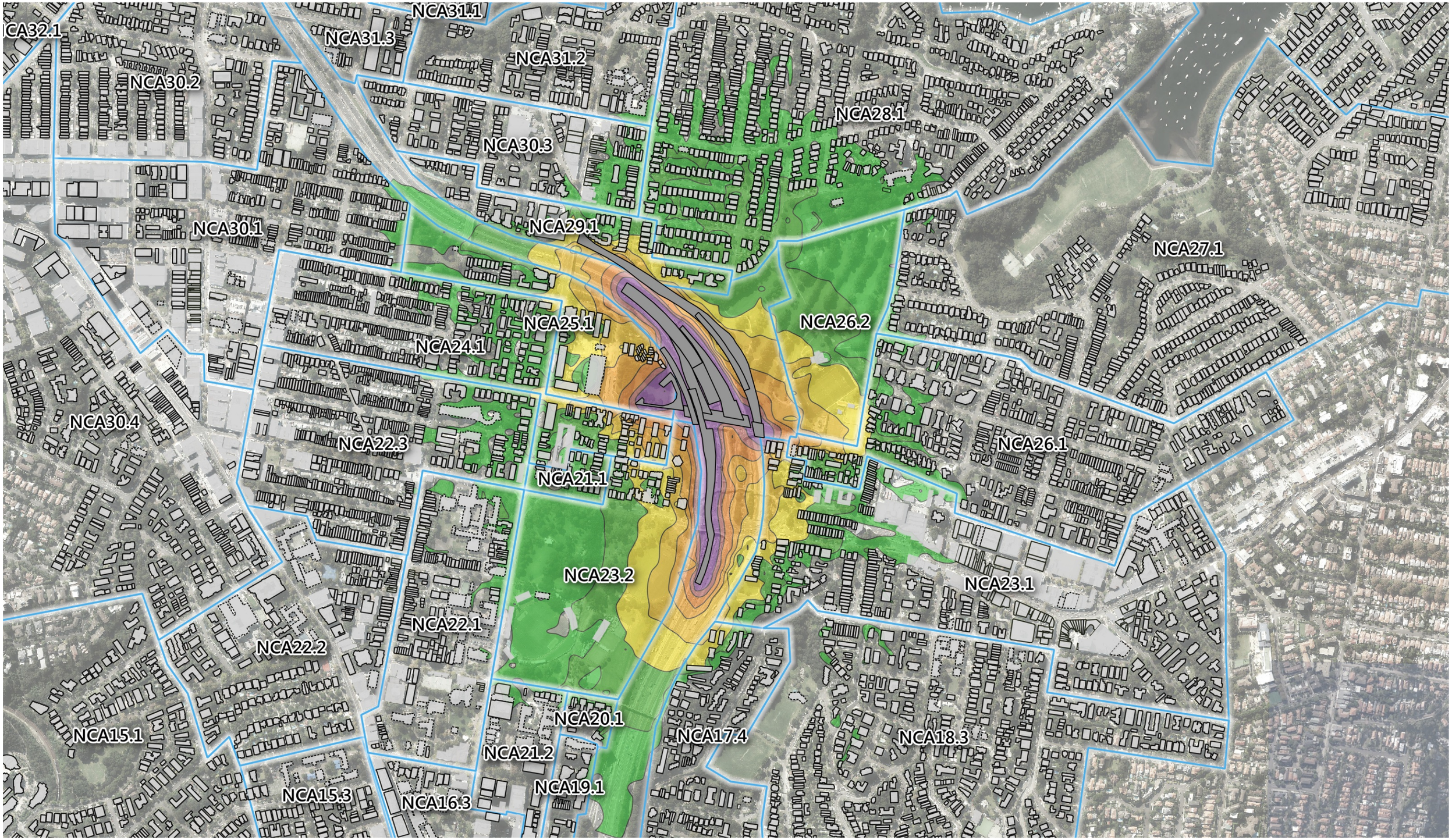
Figure No:	TJ500-01-6-1-3-1 026-7(r19)	Created by:	ALe
Scale:	1:12000	Rev:	R19
Date:	12.11.2019	Sheet:	A3



BLD_thin|WFU2H|NCA_WHT|WFU2H_WHT_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU2H - Zone 2 (Falcon Street to Miller Street)
Out of hours works

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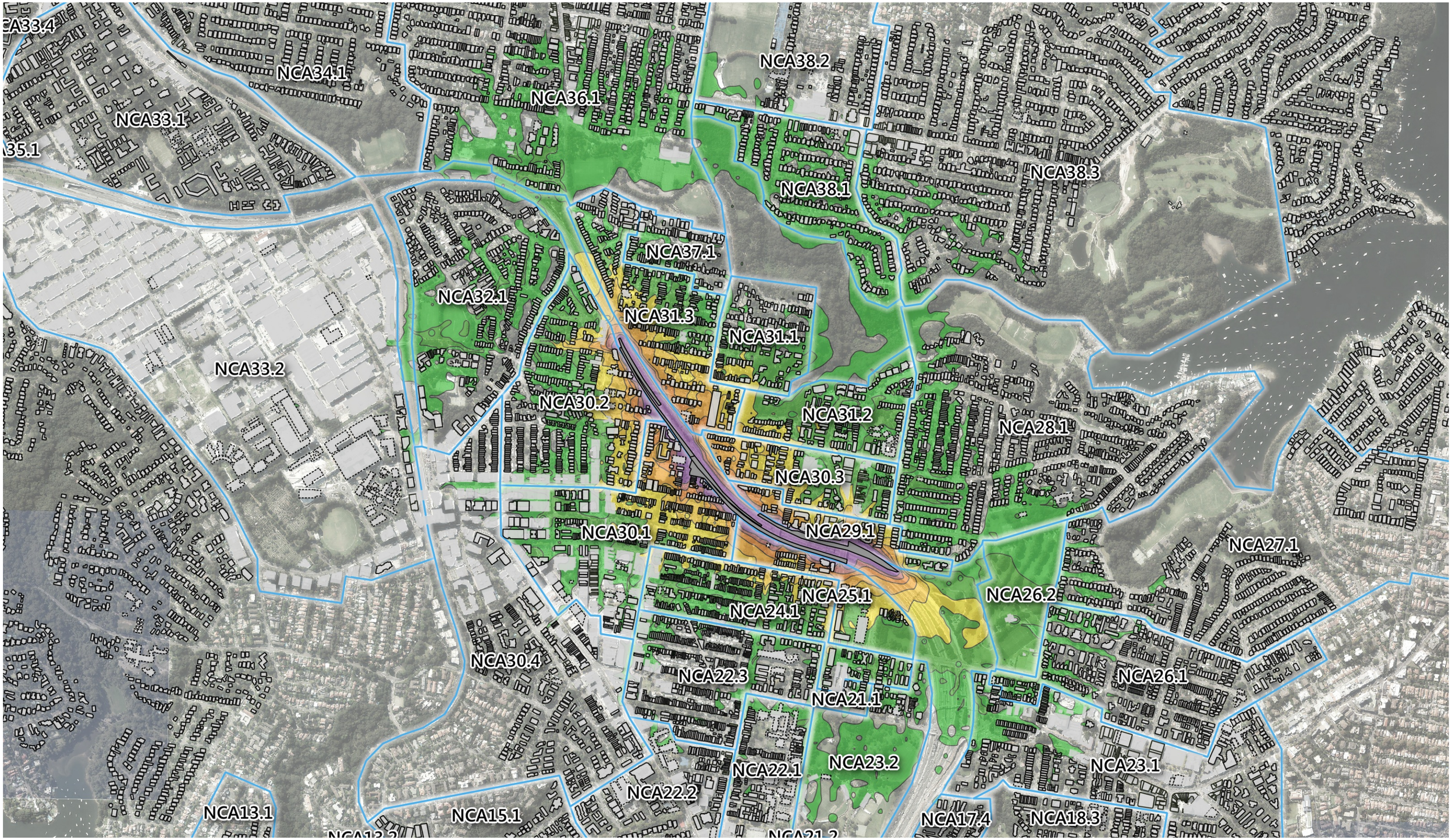
Figure No:	TJ500-01-6-1-3-1 026-8(r19)	Created by:	ALe
Scale:	1:10000	Rev:	R19
Date:	12.11.2019	Sheet:	A3



BLD_thin|WFU3I|NCA_WHT|WFU3I_Contour|MAP1|MAP2

Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
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Description:
Highest noise level envelope - Typical
WFU3I - Zone 3 (Miller Street to Willoughby Road)
Out of hours works

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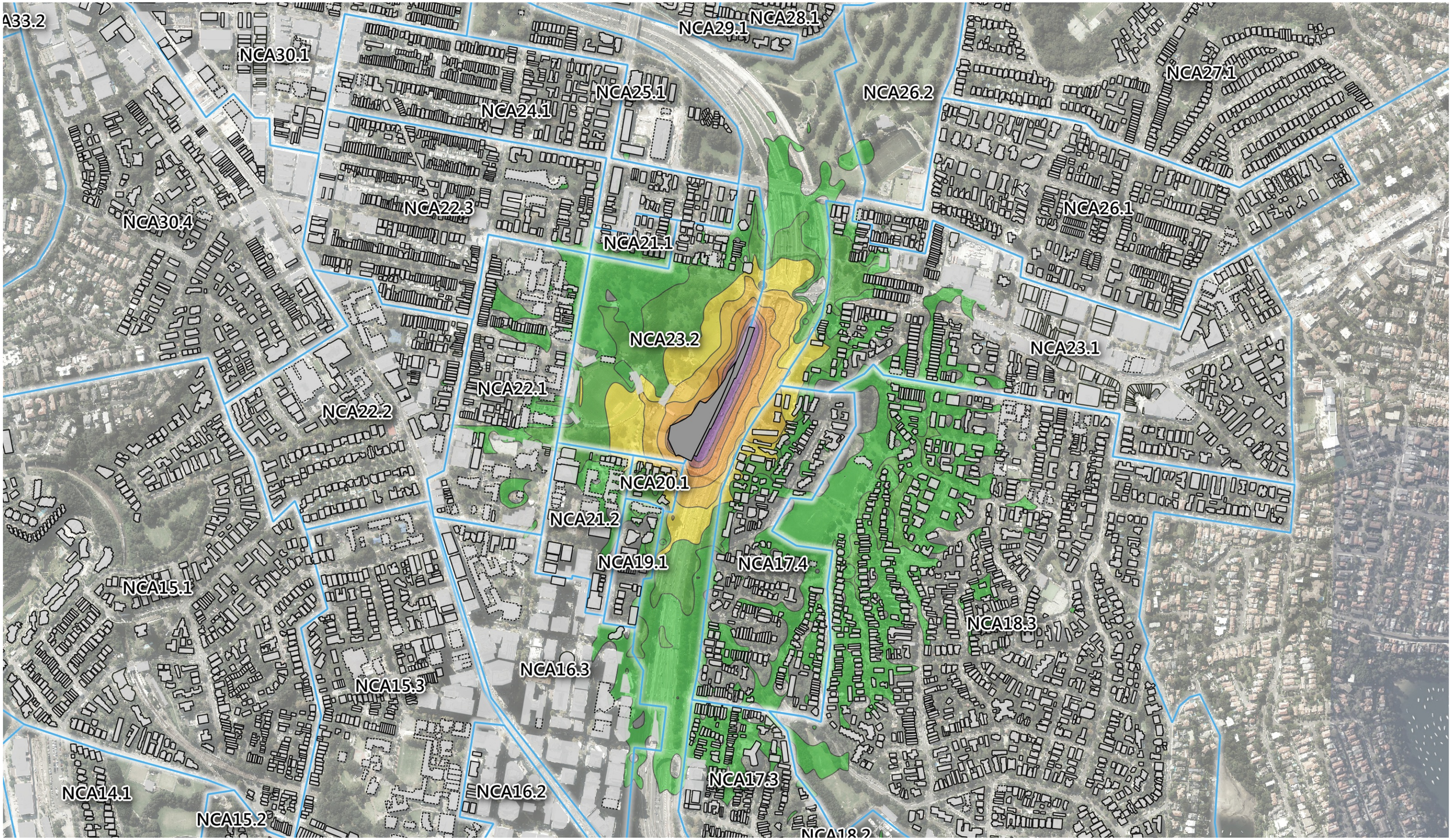
Figure No:	TJ500-01-6-1-3-1 026-9(r19)	Created by:	ALe
Scale:	1:15000	Rev:	R19
Date:	12.11.2019	Sheet:	A3



Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

40 45 50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU3J - Western Harbour Tunnel Falcon Street off ramp cut and cover (Ridge Street north (WHT9))
Out of hours works

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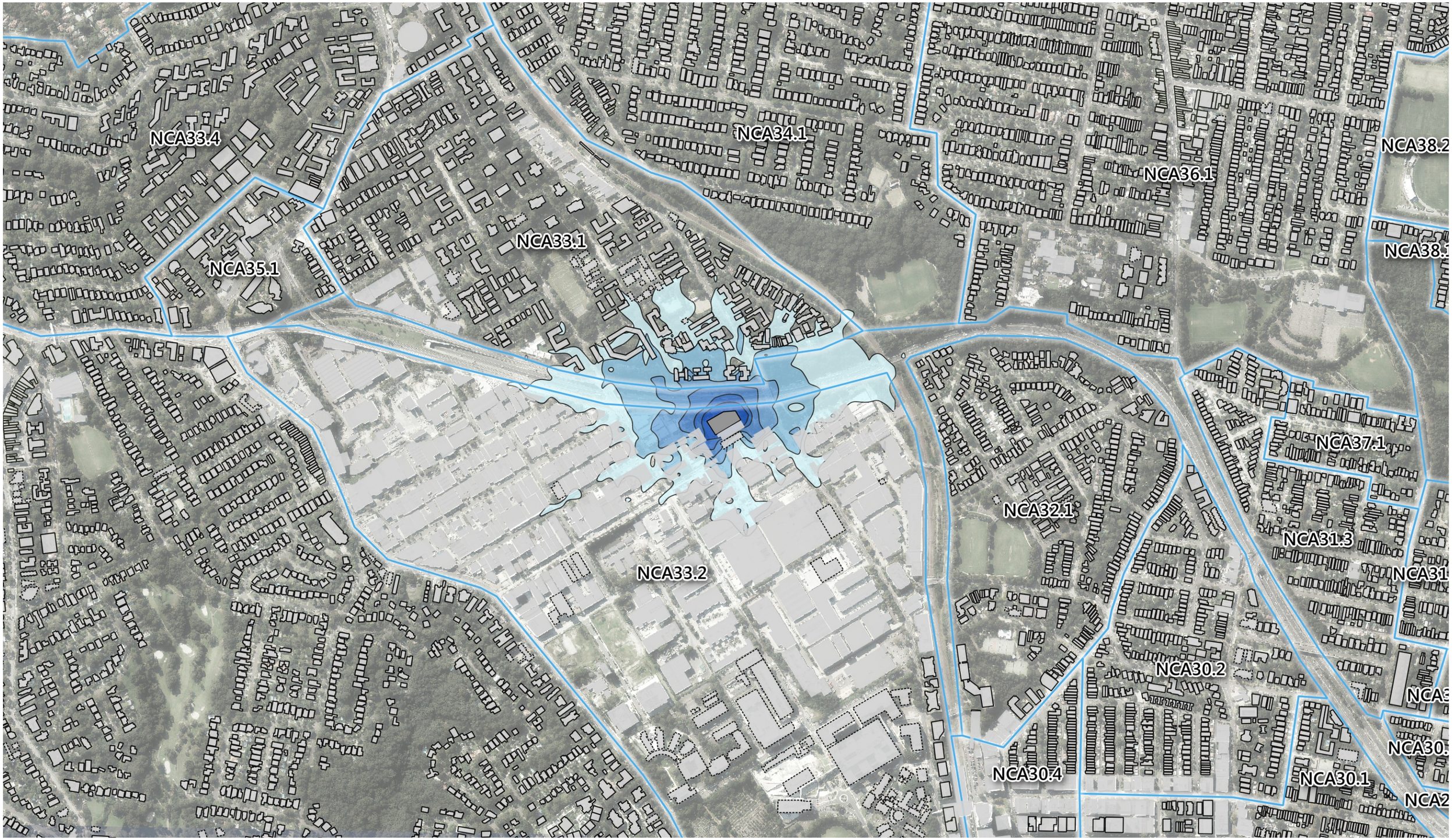
Figure No:	TJ500-01-6-1-3-1 026-10(r19)	Created by:	ALe
Scale:	1:10000	Rev:	R19
Date:	12.11.2019	Sheet:	A3

BLD_thin|WFU3J|NCA_WHT|WFU3J_Contour|MAP1|MAP2



Legend

- Major works area
- Noise catchment boundary

Receiver type

- Residential
- Commercial/Industrial
- Other sensitive receiver

Predicted Noise Level LAeq (15min), dB(A)

50 55 60 65 70 75

0 100 200 300 400 m

NOTE:
1. Noise contours are predicted at the ICNG assessment height of 1.5m above the local ground level, noise levels at greater heights may be different (eg. upper floors of multi-storey buildings).

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Highest noise level envelope - Typical
WFU3K - Western Harbour Tunnel motorway control centre (Waltham Street (WHT11))
Standard hours works

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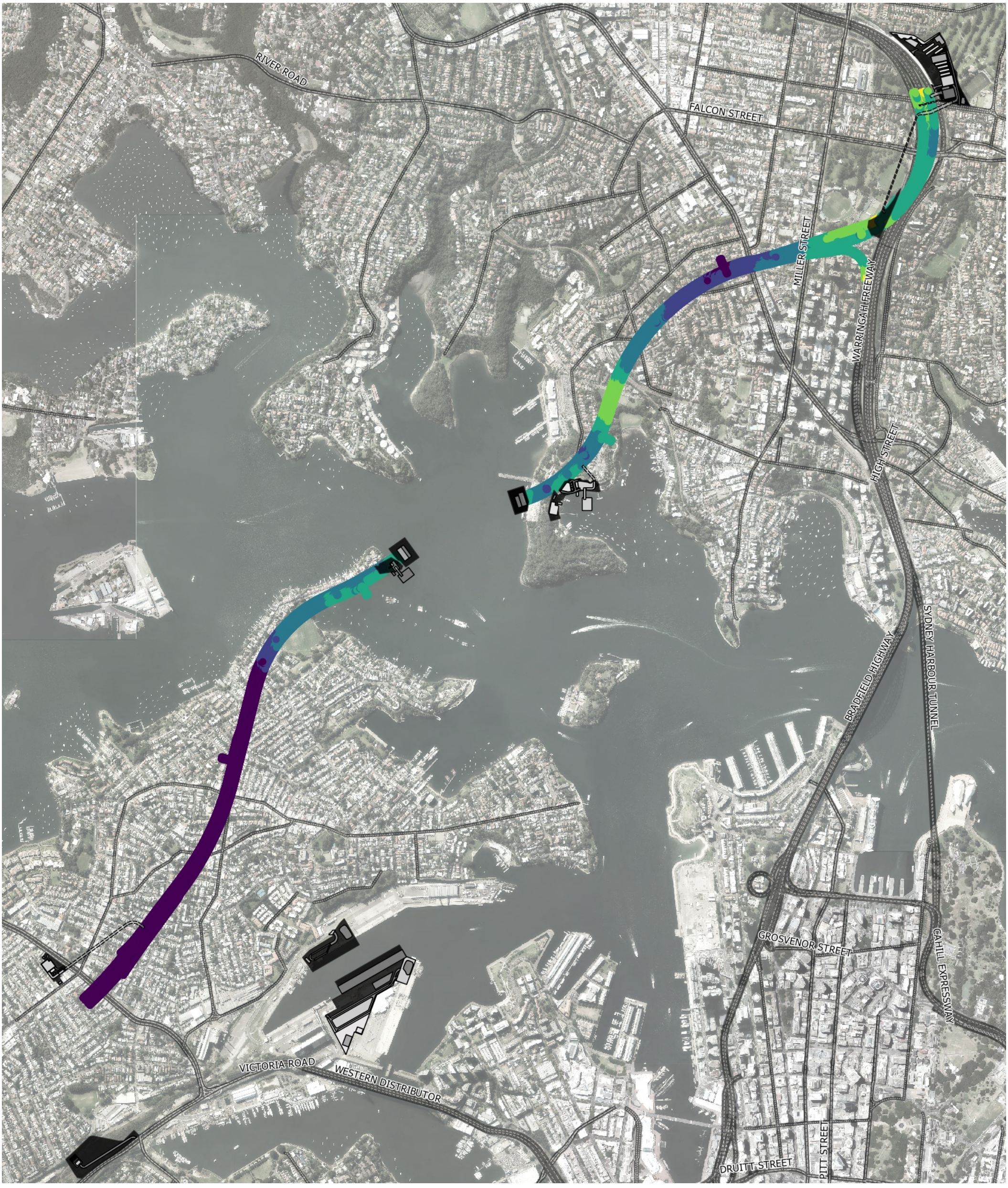
Figure No:	TJ500-01-6-1-3-1 026-11(r19)	Created by:	ALe
Scale:	1:10000	Rev:	R19
Date:	12.11.2019	Sheet:	A3

BLD_thin|WFU3K|NCA_WHT|WFU3K_Contour|MAP1|MAP2

APPENDIX I Mainline tunnel crown depth



Legend

Construction support site

Roads

- Primary Road
- Arterial road
- Sub-arterial road

Tunnel crown depth

- < 10m
- 10m - 20m
- 20m - 30m
- 30m - 40m
- 40m - 50m
- > 50m

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Client:
Roads and Maritime Services

Scale: 1:17000

250 0 250 500 750 m

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Mainline tunnel - Crown depth

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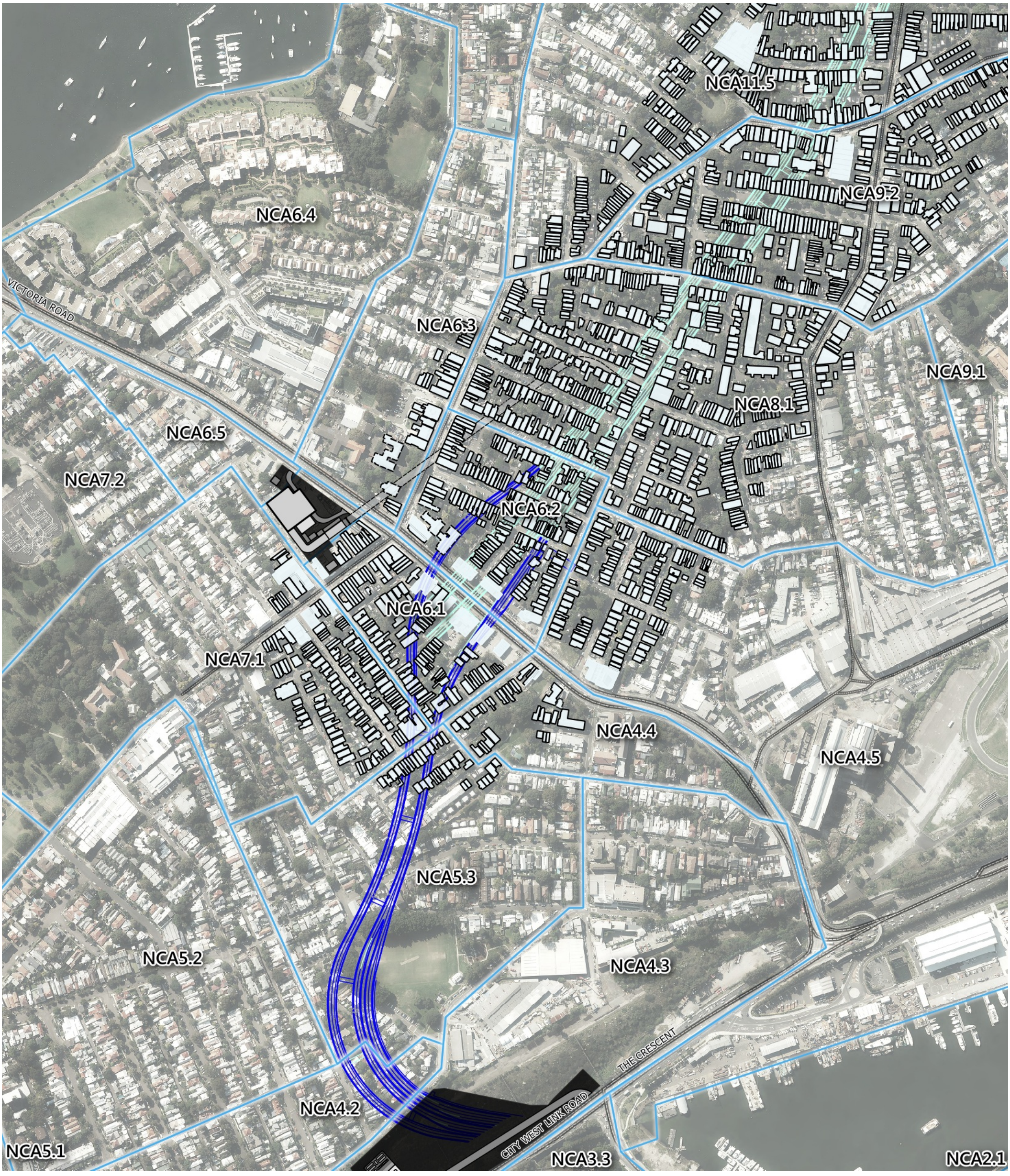
Figure No: TJ500-01-6-1-3-1 028 (r8)
Date: 11-10-2019
Created by: ALE
Rev: R8
Sheet: A3

APPENDIX J Tunnel construction ground-borne noise impacts

J.1 Mainline tunnelling – Roadheader tunnelling – ground-borne noise



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:

RENZO TONIN & ASSOCIATES
inspired to achieve

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

Client:

Roads and Maritime Services

Scale: 1:5000

0 50 100 150 200 m

Project:

Western Harbour Tunnel and Warringah Freeway Upgrade

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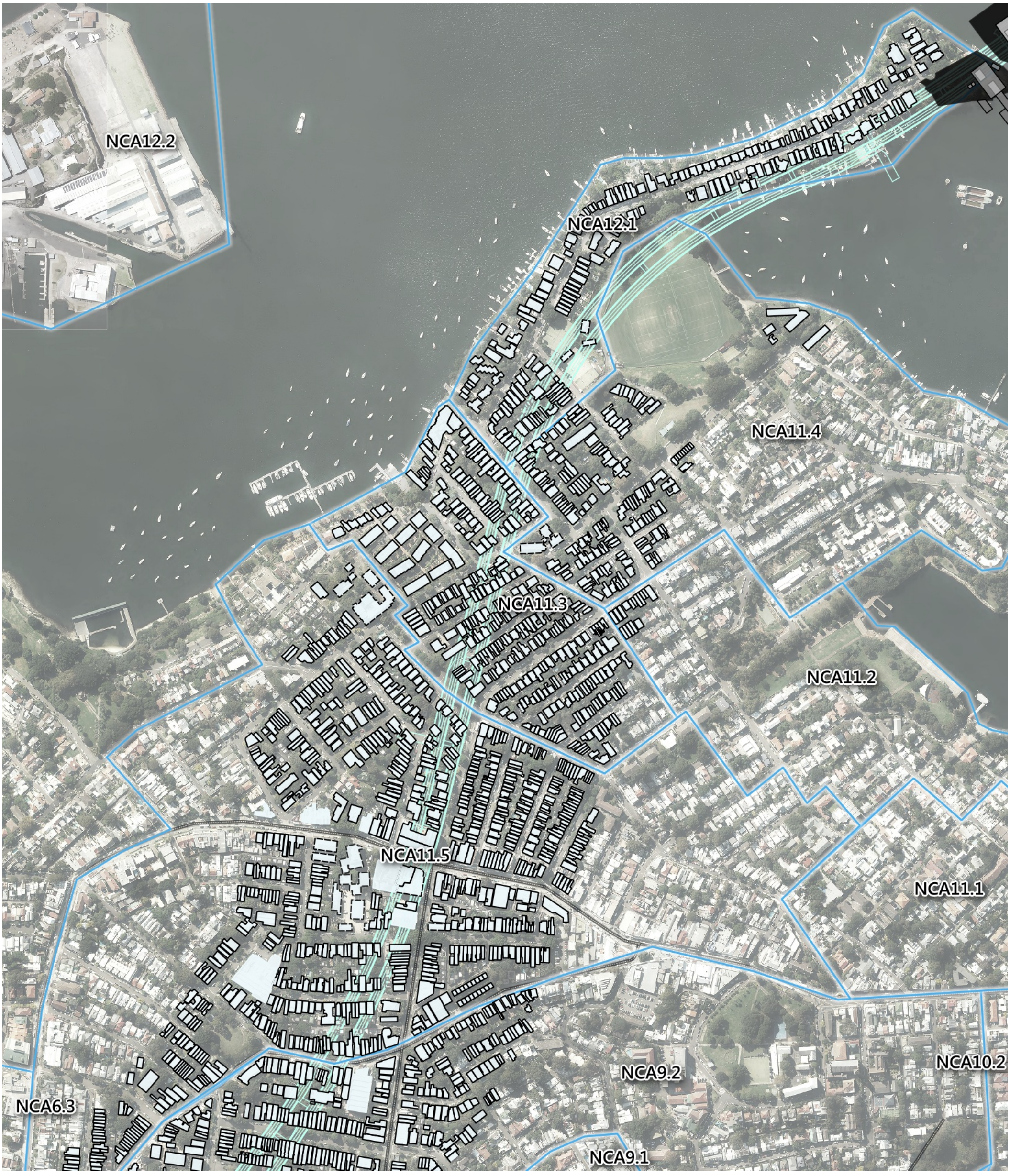
Description:

Tunnelling predicted ground-borne noise level
Mainline tunnelling - Roadheader tunnelling

Figure No:	TJ500-01-6-1-3-1 018-1 (r12)	Created by:	ALE
		Rev:	R12
Date:	11-10-2019	Sheet:	A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

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

Client:
Roads and Maritime Services

Scale: 1:5000

0 50 100 150 200 m

Project:
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Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Roadheader tunnelling

Figure No: TJ500-01-6-1-3-1 018-2 (r12)
Created by: ALE
Rev: R12
Date: 11-10-2019
Sheet: A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:
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Client:
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Scale: 1:5000

0 50 100 150 200 m

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

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Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Roadheader tunnelling

Figure No:	TJ500-01-6-1-3-1 018-3 (r12)	Created by:	ALE
		Rev:	R12
Date:	11-10-2019	Sheet:	A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:
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Client:
Roads and Maritime Services

Scale: 1:5000

0 50 100 150 200 m

Project:
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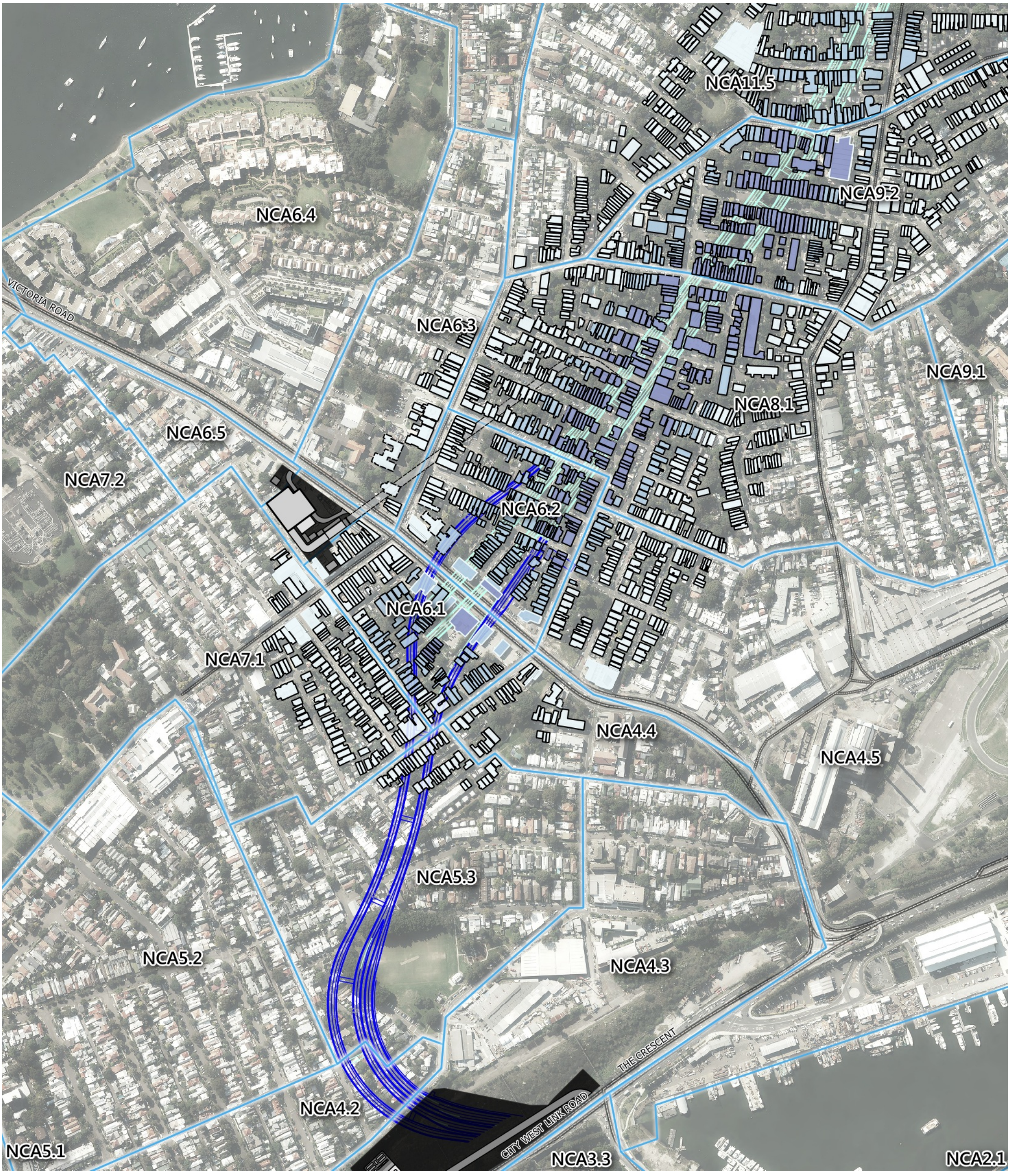
Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Roadheader tunnelling

Figure No: TJ500-01-6-1-3-1 018-4 (r12)
Created by: ALE
Rev: R12
Date: 11-10-2019
Sheet: A3

J.2 Mainline tunnelling – Benching with large rock hammer – ground-borne noise



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:

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inspired to achieve

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P: 02 8218 0500 F: 02 8218 0501

Client:
Roads and Maritime Services

Scale: 1:5000

0 50 100 150 200 m

Project:
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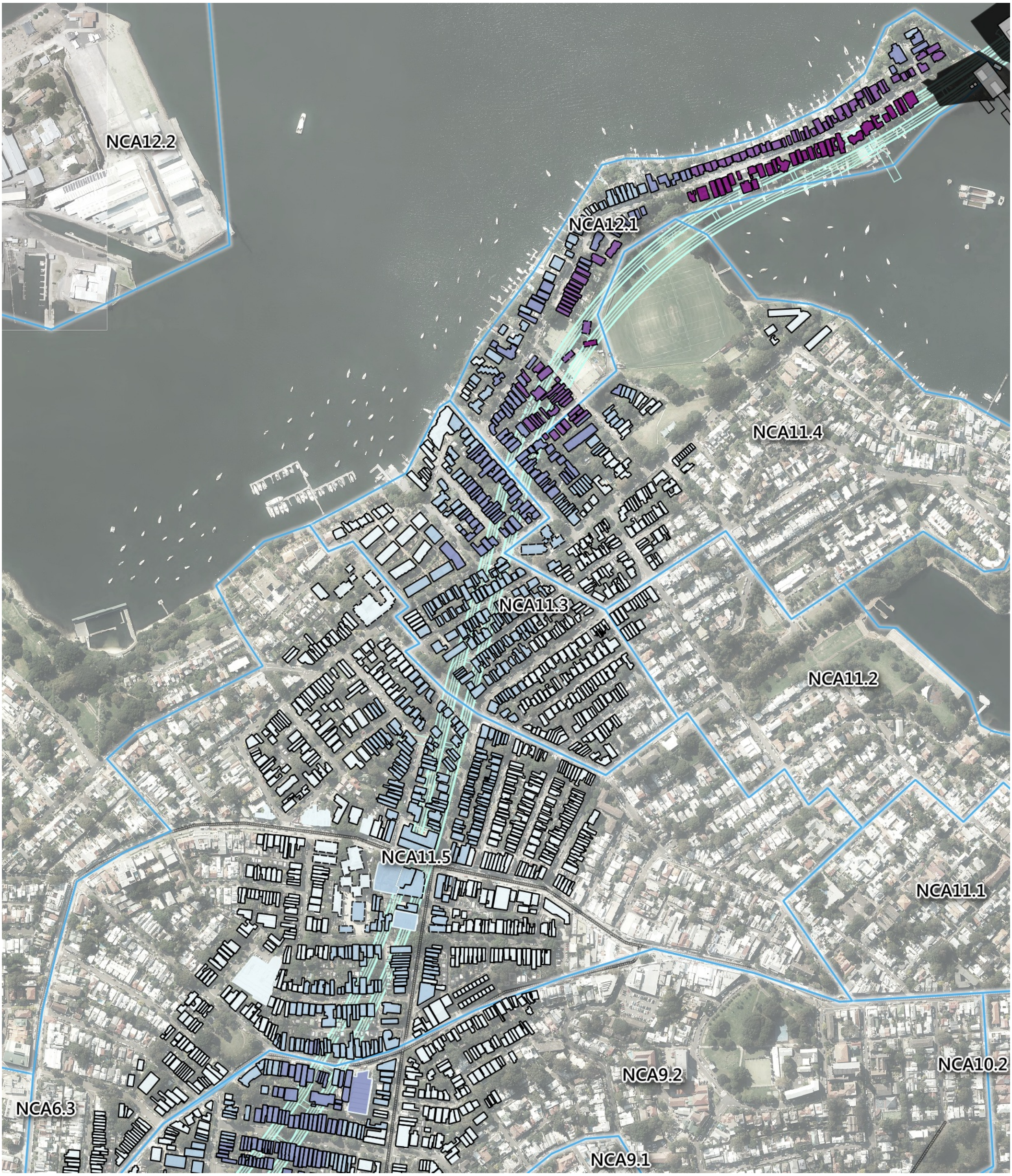
Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Large rock hammer (benching)

Figure No: TJ500-01-6-1-3-1 023-1 (r12)
Created by: ALE
Rev: R12
Date: 11-10-2019
Sheet: A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:

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Client:
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Scale: 1:5000

0 50 100 150 200 m

Project:
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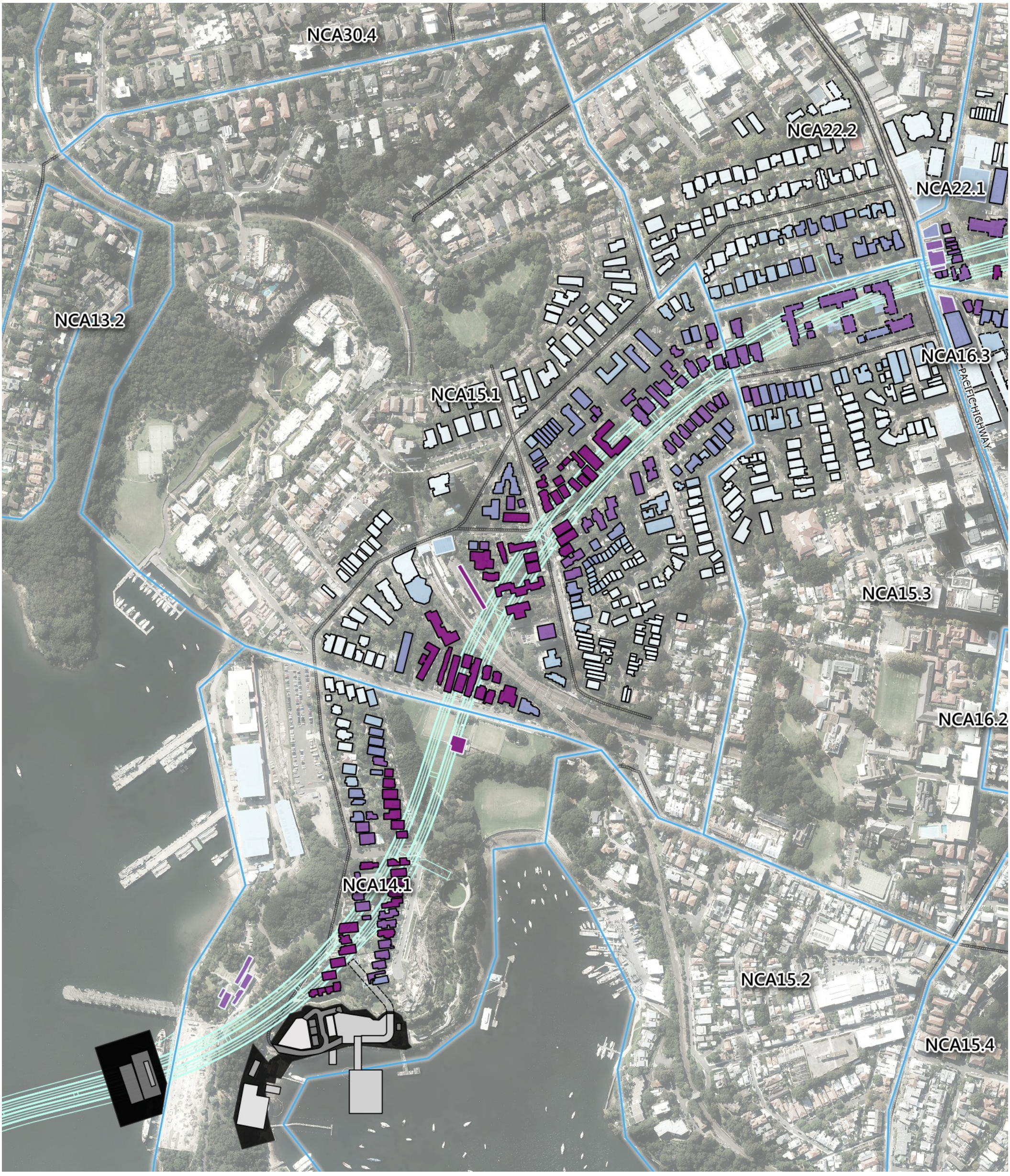
Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Large rock hammer (benching)

Figure No:	TJ500-01-6-1-3-1 023-2 (r12)	Created by:	ALE
		Rev:	R12
Date:	11-10-2019	Sheet:	A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

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Client:
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Scale: 1:5000

0 50 100 150 200 m

Project:
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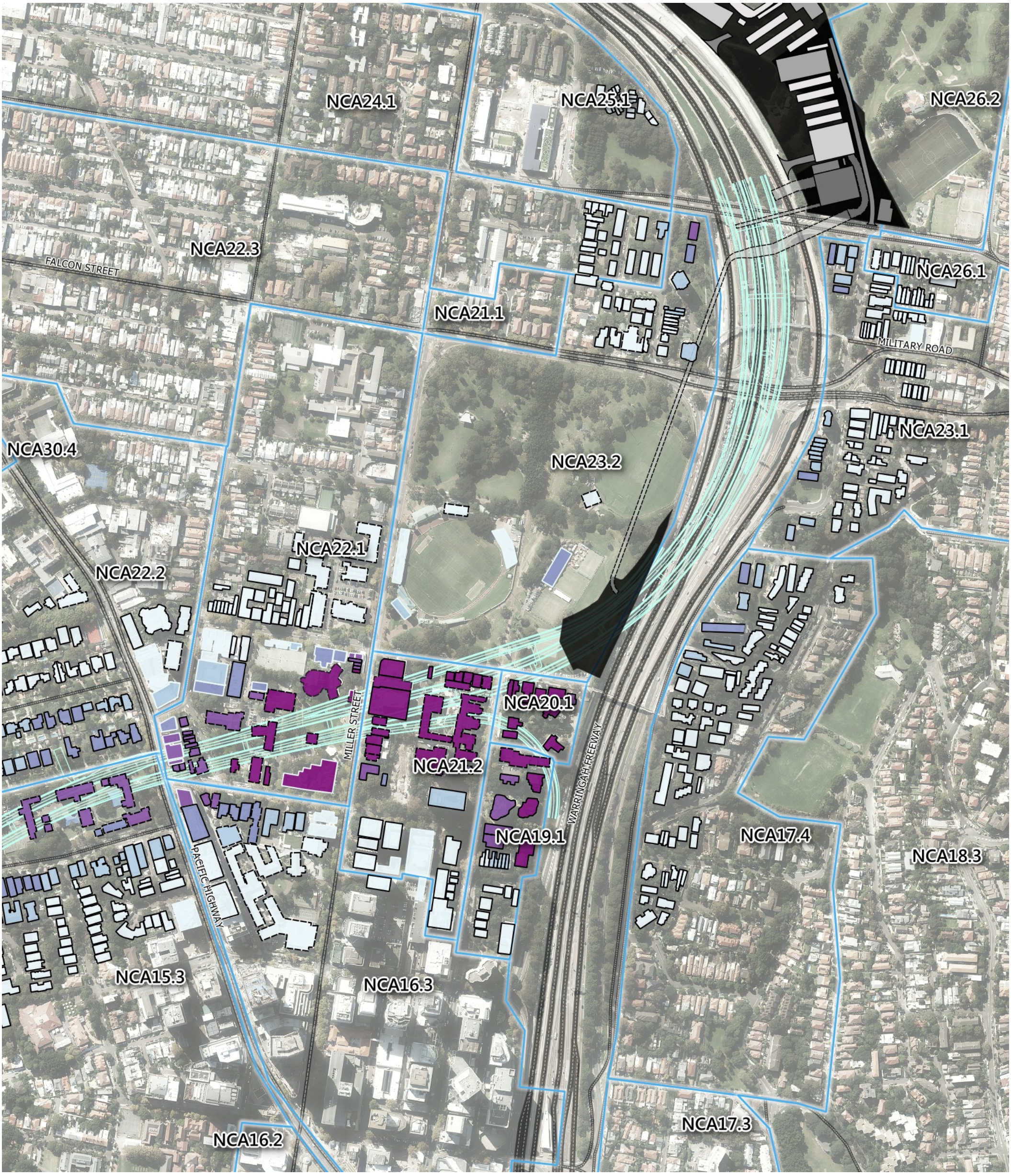
Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Large rock hammer (benching)

Figure No:	TJ500-01-6-1-3-1 023-3 (r12)	Created by:	ALE
		Rev:	R12
Date:	11-10-2019	Sheet:	A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway / Freeway
- Arterial Road
- Distributor road

Receiver type (outline)

- Residential
- Other sensitive receiver
- Commercial/Industrial

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

Consultant:

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P: 02 8218 0500 F: 02 8218 0501

Client:
Roads and Maritime Services

Scale: 1:5000

0 50 100 150 200 m

Project:
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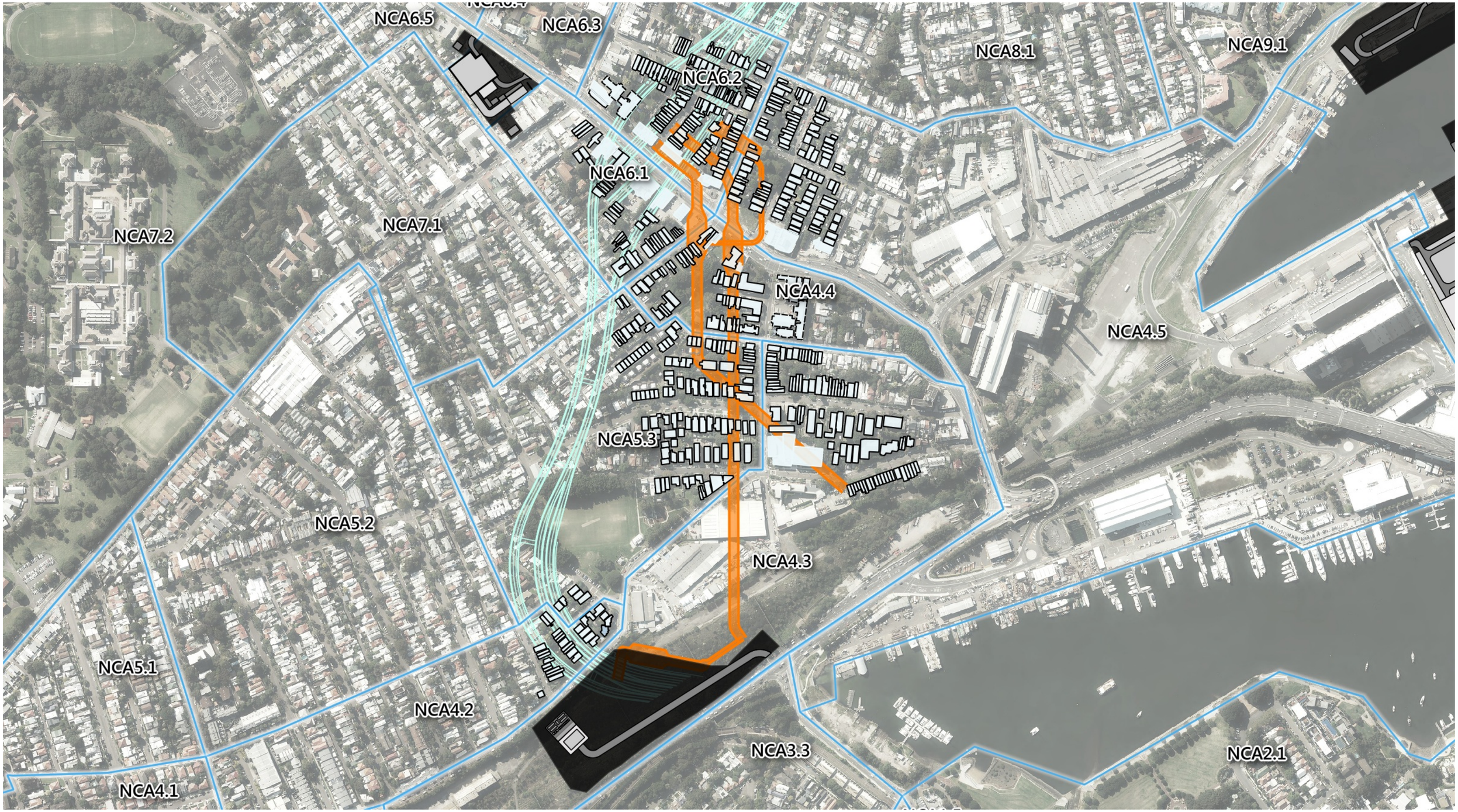
Description:
Tunnelling predicted ground-borne noise level
Mainline tunnelling - Large rock hammer (benching)

Figure No: TJ500-01-6-1-3-1 023-4 (r12)
Created by: ALE
Rev: R12
Date: 11-10-2019
Sheet: A3

J.3 Access decline tunnel construction – Roadheader tunnelling – ground-borne noise



50 0 50 100 150 200 m

Legend

Receiver type (outline)

- Residential
- Commercial
- Other sensitive recevier

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

- Construction site footprint
- Noise catchment boundary
- Tunnel alignment
- Ventilation tunnel

Consultant:
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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Rozelle ventilation tunnel
Ground-borne noise - Ventilation tunnel construction

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Figure No:	TJ500-01-6-1-3-1 026-1 (r14)	Created by:	ALE
Scale:	1:5000	Rev:	R14
Date:	16.10.2019	Sheet:	A3

NCA11.5
NCA9.2
NCA6.4
NCA6.3
NCA8.1
NCA6.5
NCA7.2
NCA6.2
NCA7.1
NCA6.1
NCA4.5

Legend

Receiver type (outline)
- Residential
- Commercial
- Other sensitive recevier

Predicted ground-borne noise level (receiver buildings), dB(A)
- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

- Construction site footprint
- Noise catchment boundary
- Tunnel alignment
- Access decline tunnel

50 0 50 100 150 200 m

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Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Victoria Road (WHT2/VIC)
Ground-borne noise - Access decline tunnel construction

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Figure No:	TJ500-01-6-1-3-1 026-2 (r14)	Created by:	ALE
Scale:	1:2500	Rev:	R14
Date:	16.10.2019	Sheet:	A3

NCA12.1

NCA11.4

50 0 50 100 150 200 m

Legend

Receiver type (outline)

- Residential
- Commercial
- Other sensitive recevier

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

- Construction site footprint
- Noise catchment boundary
- Tunnel alignment
- Access shaft

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P: 02 8218 0500 F: 02 8218 0501

Client:
Roads and Maritime Services

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Yurulbin Point (WHT3/YRB)
Ground-borne noise - Access shaft construction

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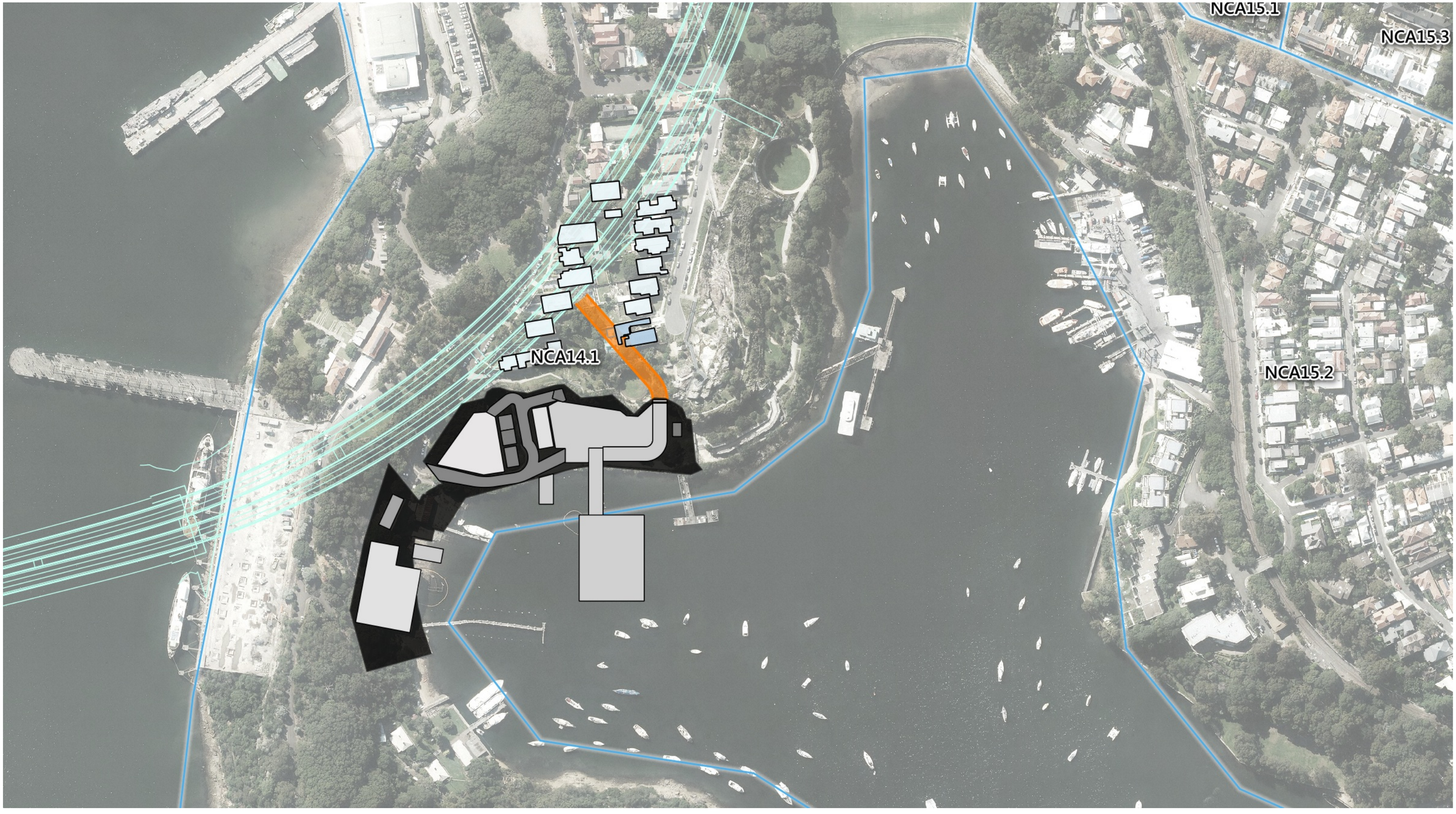
Figure No:	TJ500-01-6-1-3-1 026-3 (r14)	Created by:	ALE
Scale:	1:2500	Rev:	R14
Date:	16.10.2019	Sheet:	A3



Legend

Receiver type (outline)
- Residential
- Commercial
- Other sensitive recevier

Predicted ground-borne noise level (receiver buildings), dB(A)
- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

- Construction site footprint
- Noise catchment boundary
- Tunnel alignment
- Access decline tunnel

50 0 50 100 150 200 m

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Client:
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Project:
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Description:
Berrys Bay (WHT7/BRY)
Ground-borne noise - Access decline tunnel construction

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50 0 50 100 150 200 m

Legend

Receiver type (outline)

- Residential
- Commercial
- Other sensitive recevier

Predicted ground-borne noise level (receiver buildings), dB(A)

- < 35
- >35 to <=40
- >40 to <=45
- >45 to <=50
- > 50

- Construction site footprint
- Noise catchment boundary
- Tunnel alignment
- Ventilation shaft, decline and ventilation tunnel construction

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Description:
Cammeray Golf Course (WHT10/CGC)
Ground-borne noise - Ventilation shaft, decline and ventilation tunnel construction

Figure No:	TJ500-01-6-1-3-1 026-5 (r14)	Created by:	ALE
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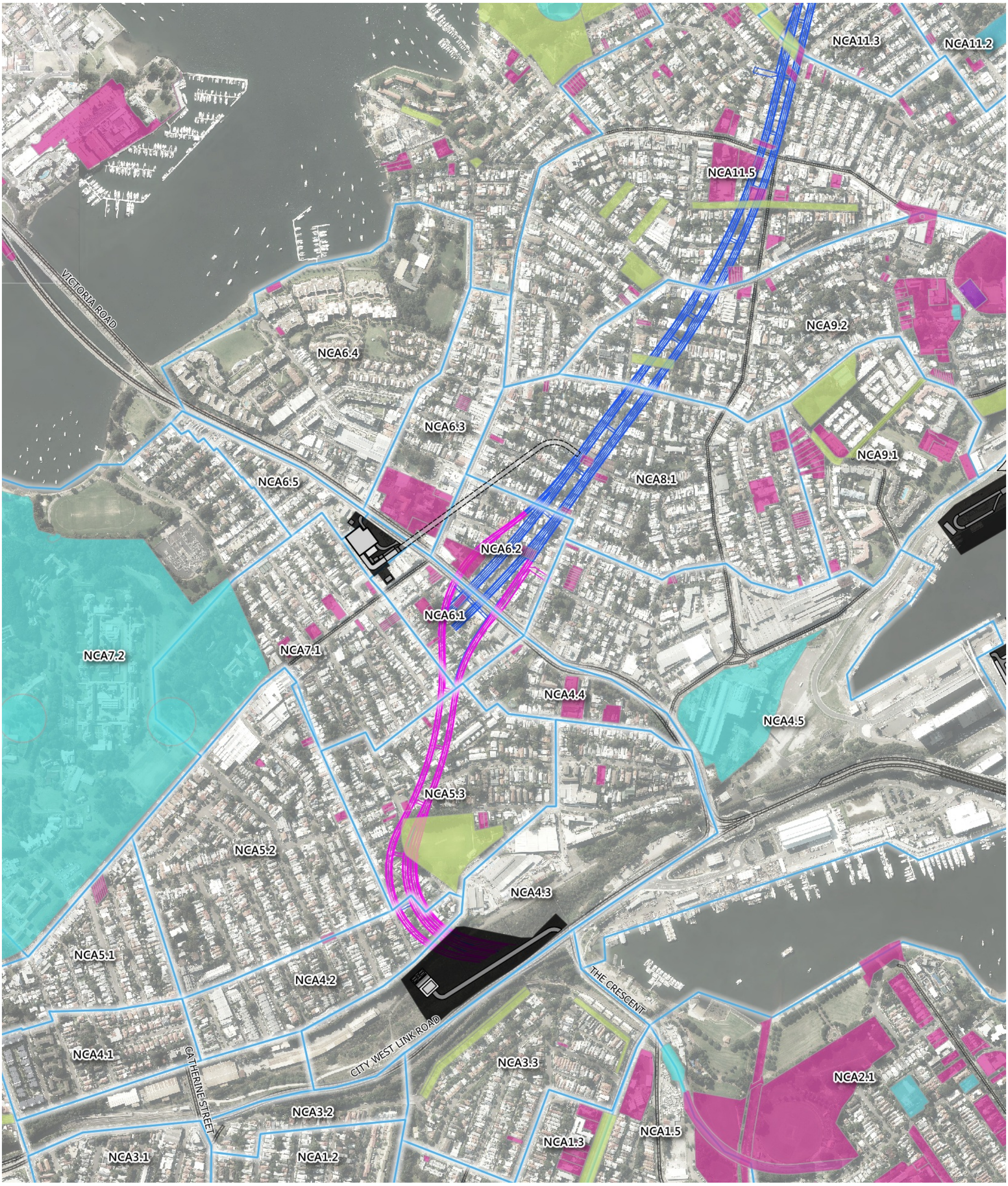
Date:	16.10.2019	Sheet:	A3

APPENDIX K Mainline tunnelling vibration minimum working distance identification

K.1 Mainline tunnelling – Roadheader tunnelling - Vibration minimum working distance identification



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
Roads and Maritime Services

Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Roadheader tunnelling

Scale: 1:7500
0 100 200 300 m

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Figure No:	TJ500-01-6-1-3-1 027a-1 (r10)	Created by:	ALE
		Rev:	R10
Date:	16-10-2019	Sheet:	A3

NCA13.1
NCA12.2
NCA12.1
NCA11.4
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA10.2
NCA9.2
NCA9.1
NCA8.1
NCA6.4
NCA6.3
NCA6.2
NCA4.5
VICTORIA ROAD

Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Roadheader tunnelling

Scale: 1:7500
0 100 200 300 m

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Figure No:	TJ500-01-6-1-3-1 027a-2 (r10)	Created by:	ALE
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Date:	16-10-2019	Sheet:	A3

RIVER ROAD
FALCON STREET
NCA22.3
NCA30.4
NCA23.2
NCA22.1
NCA22.2
MILLER STREET
NCA21.2
NCA15.1
NCA13.2
NCA16.3
NCA15.3
PACIFIC HIGHWAY
NCA16.2
NCA14.1
NCA15.2
NCA16.1
NCA15.4

Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Roadheader tunnelling

Scale: 1:7500
0 100 200 300 m

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Figure No:	TJ500-01-6-1-3-1 027a-3 (r10)	Created by:	ALE
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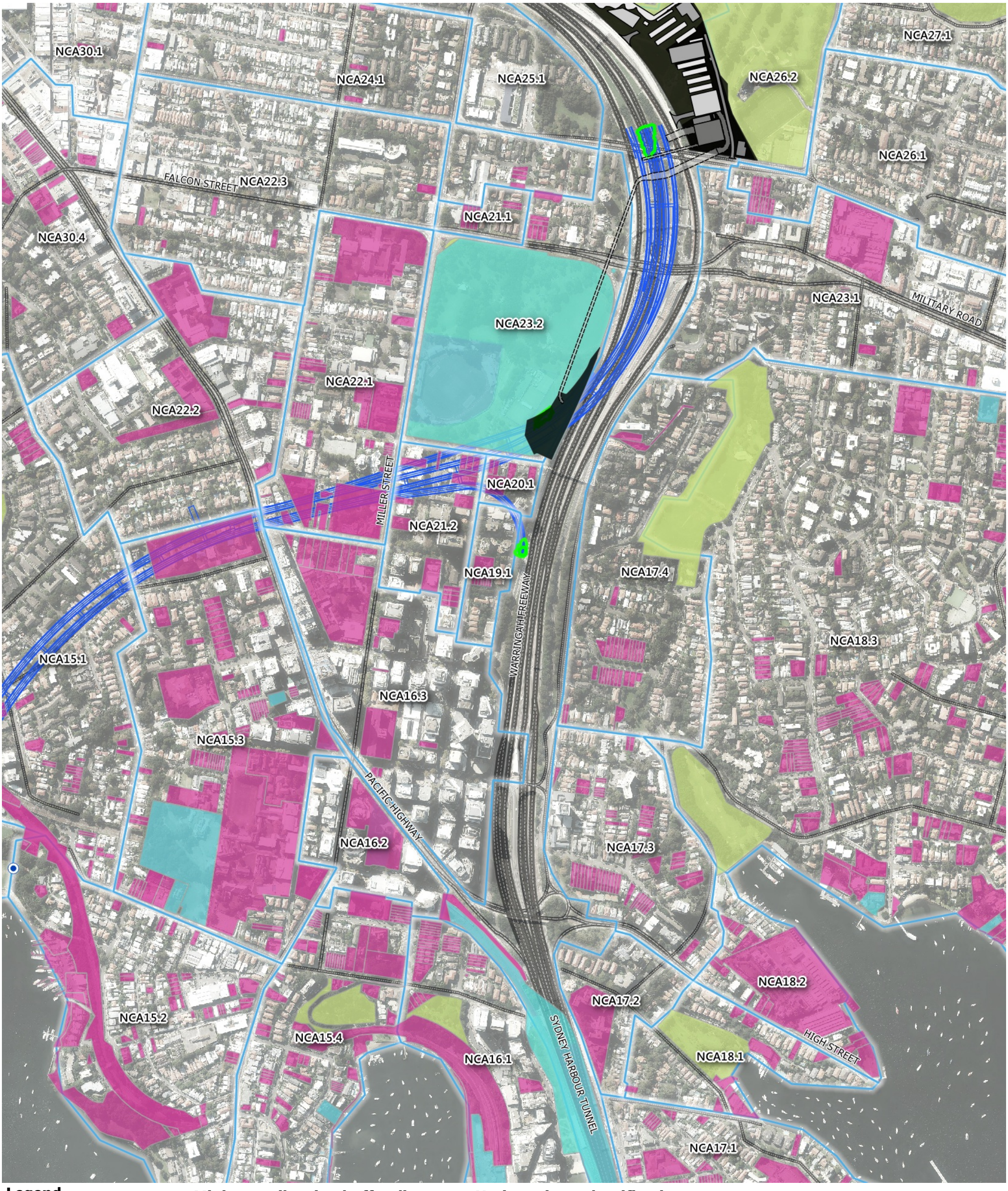
Date:	16-10-2019	Sheet:	A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Scale: 1:7500
0 100 200 300 m

Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Roadheader tunnelling

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		Rev:	R10
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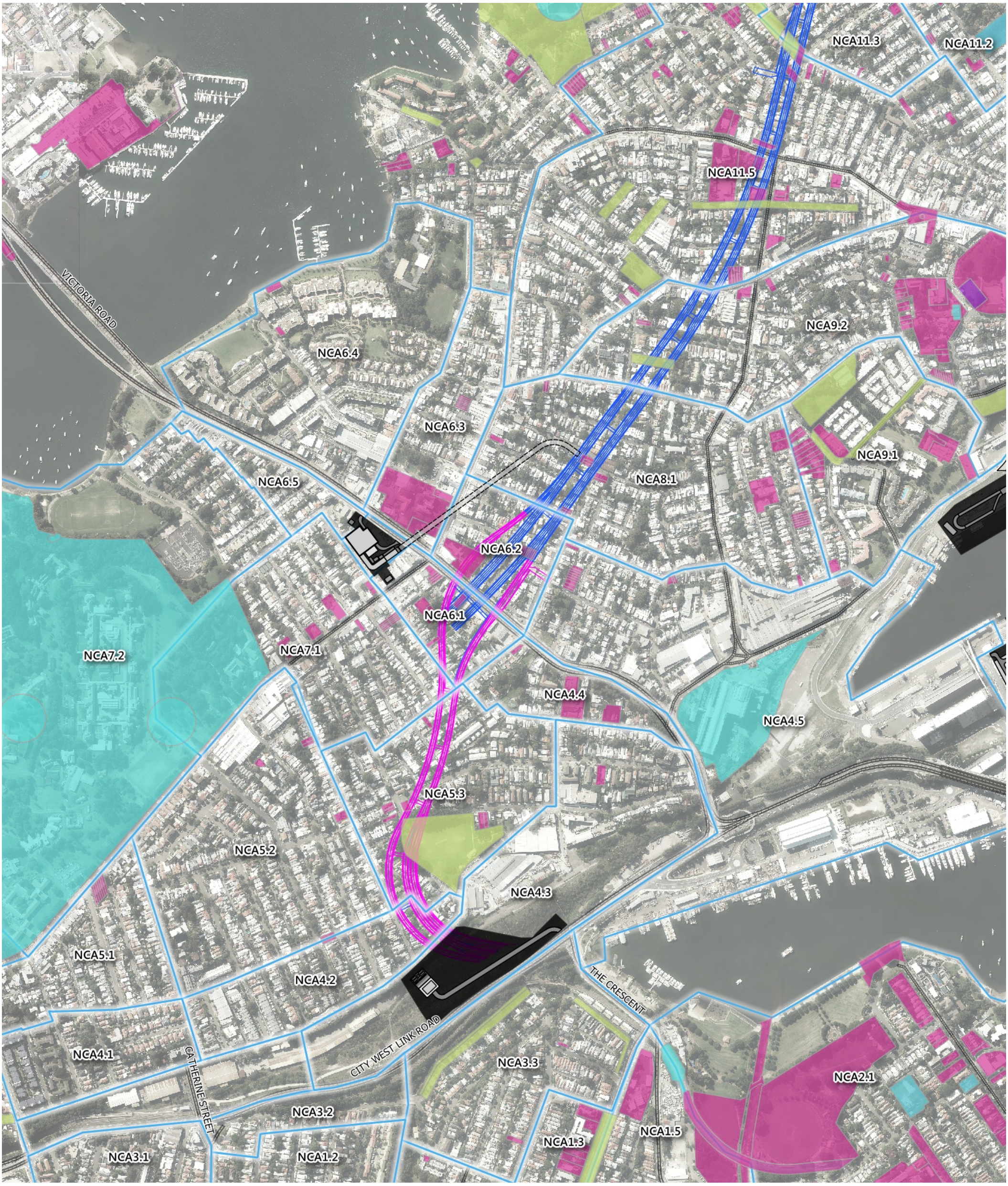
K.2 Mainline tunnelling – Benching with large rock hammer - Vibration minimum working distance identification



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Scale: 1:7500
0 100 200 300 m

Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Rock hammer tunnelling (benching)

Figure No:	TJ500-01-6-1-3-1 027b-1 (r8)	Created by:	ALE
		Rev:	R8
Date:	16-10-2019	Sheet:	A3

NCA13.1
NCA12.2
NCA12.1
NCA11.4
NCA11.3
NCA11.2
NCA11.5
NCA11.1
NCA10.2
NCA9.2
NCA6.4
NCA6.3
NCA9.1
NCA8.1
VICTORIA ROAD
NCA6.2
NCA4.5

Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Scale: 1:7500
0 100 200 300 m

Project:
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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Rock hammer tunnelling (benching)

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Figure No: TJ500-01-6-1-3-1 027b-2 (r8)
Created by: ALE
Rev: R8
Date: 16-10-2019
Sheet: A3

RIVER ROAD
FALCON STREET
NCA22.3
NCA30.4
NCA23.2
NCA22.1
NCA22.2
MILLER STREET
NCA21.2
NCA15.1
NCA13.2
NCA16.3
NCA15.3
PACIFIC HIGHWAY
NCA16.2
NCA14.1
NCA15.2
NCA16.1
NCA15.4

Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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Client:
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Scale: 1:7500
0 100 200 300 m

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Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Rock hammer tunnelling (benching)

Figure No: TJ500-01-6-1-3-1 027b-3 (r8)
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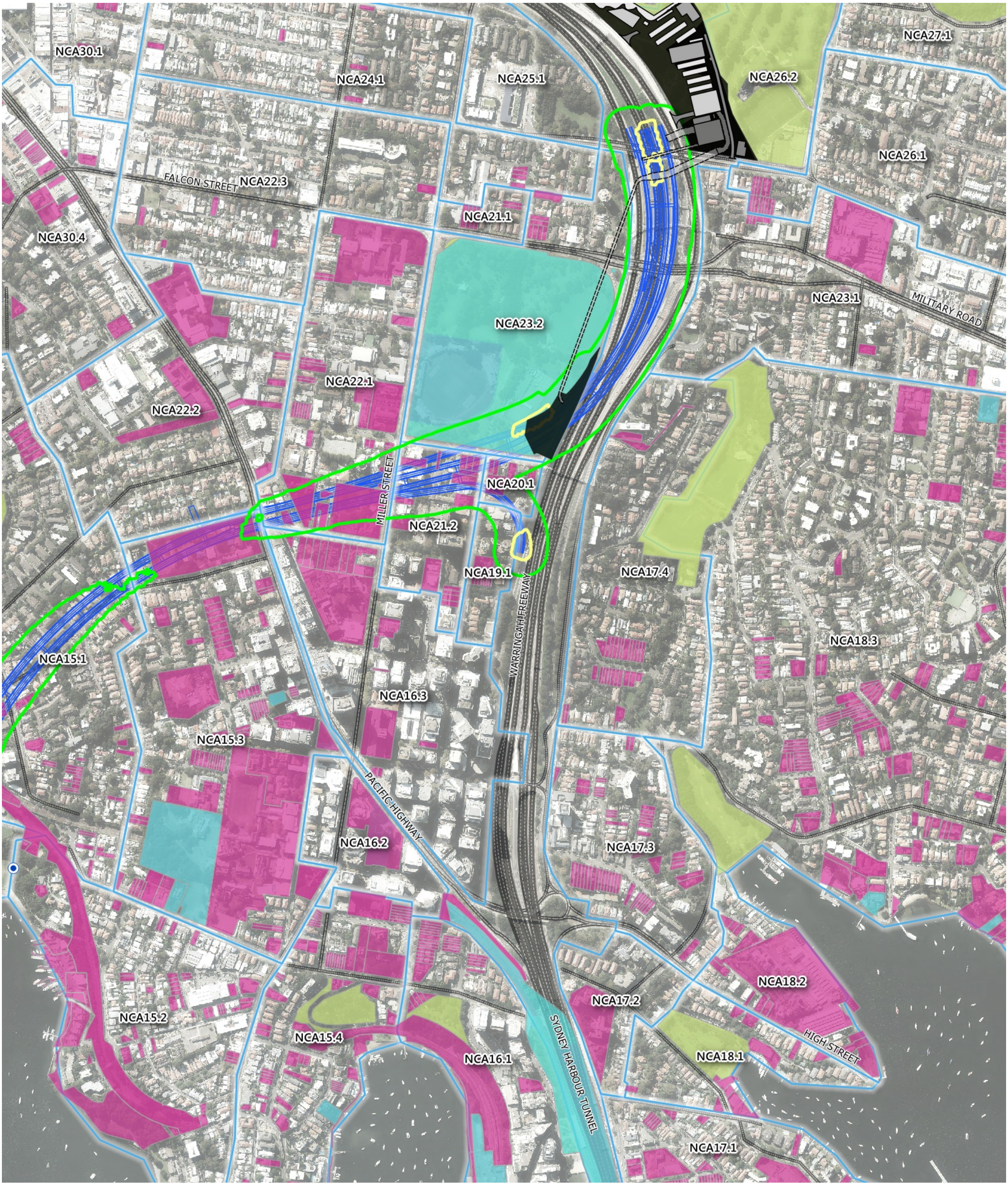
Sheet: A3



Legend

- Construction support site
- Tunnel alignment
- Tunnelling undertaken by M4-M5 project
- NCA boundary
- Motorway/Freeway
- Arterial Road
- Distributor roads

Minimum vibration buffer distance

- Human Response
- Cosmetic Damage - Unsound structure
- Cosmetic Damage - Sound structure

Heritage item classification

- Aboriginal Object
- Item - Archaeological
- Item - General
- Item - Landscape
- State Heritage Act
- Potential archaeological deposits (Aboriginal)
- National Parks and Wildlife Act (AHIMS registered site)
- Listed maritime heritage item

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P: 02 8218 0500 F: 02 8218 0501

Client:
Roads and Maritime Services

Scale: 1:7500
0 100 200 300 m

Project:
Western Harbour Tunnel and Warringah Freeway Upgrade

Description:
Tunnelling vibration ground level minimum working distance contours
Mainline tunnelling - Rock hammer tunnelling (benching)

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